SPARETIMELABS

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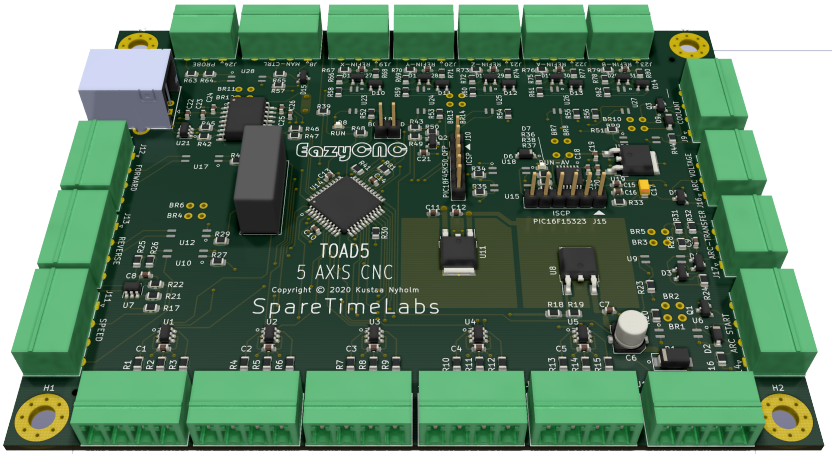
TOAD5 – Manual

Revision 2

for

TOAD5 - RC1

PRELIMINARY – ALL VALUES TO BE CONFIRMED



January 24, 2021

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Disclaimer

EazyCNC is program to control the operation of a CNC-Machine Tool.

TOAD5 is a microprocessor-based controller board for controlling stepper motors.

EazyCNC and TOAD5 are intended for the hobbyist, they are not intended for professional/commercial use.

Any machine tool is potentially dangerous.

All electrical systems have the potential to cause an electric shock or a fire hazard.

All motorized systems can cause serious personal injury or damage to property.

All computer programs have design or implementation flaws (bugs) some of which can cause serious malfunction of the system.

Most countries and states have regulations and standards that govern the design, construction, use, deployment and placing on the market of electrical and mechanical equipment, including the software used to control them.

No safety of design or construction or programming nor warranty is implied, instead it is the responsibility of whoever uses or deploys EazyCNC and/or TOAD5 to ensure that he/she understands the implications of using EazyCNC and/or TOAD5 and to comply with any legislation and codes of practice applicable to his/her country or state. Further it is his/ responsibility to ensure the safety of the system at all times.

If you are in any doubt, you must seek guidance from a professionally qualified expert rather than risk injury or liability to yourself or to others.

SpareTimeLabs or Kustaa Nyholm cannot accept any responsibility resulting from the design, construction or use of EazyCNC and/or TOAD5.

All names of products and trademarks used in this manual are for example purposes only, no endorsement of any of them by SpareTimeLabs nor endorsement of EazyCNC or TOAD5 by their respective owners are implied.

Chapter 1

Foreword

TOAD5 is a project that I share with other willing enthusiasts, it is a from hobbyist to hobbyist product, it is not a commercial effort.

It is aimed at advanced CNC constructors who know what they are doing.

Building a CNC machine is a big undertaking that involves more than superficial understanding of mechanics, electronics and software.

It requires analytical mindset and the ability handle and debug complex systems.

Having said that constructing a CNC system based on TOAD5 and EazyCNC does not require deep knowledge of afore mentioned disciplines, in principle they offer a bolt together electronics solution and ready to run software.

Wishing you luck in this rewarding but sometimes frustrating hobby,

yours Kustaa (*Kusti*) Nyholm

Chapter 2

Safety First!

Machine tools are dangerous!

Always keep that in mind, both when designing and setting up your system and when operating it on a daily-bases.

CNC machine tools are heavy and strong machinery, moving sharp and hot cutting tools or extremely powerful plasma torches under computer control. Computers are complex systems and it is *impossible* to ensure 100% error free and safe operation in every situation. It is perfectly possible that a software design flaw, called bug, cause the system to operate unexpectedly or even run away wild.

Therefore, it is very important to take appropriate precautions for such an eventuality.

Every system needs to have an Emergency switch fitted.

Never let a computer operated machine work without supervision!

A no-voltage release system is also mandatory in any potentially dangerous machinery to prevent accidental re-start after a power out.

The emergency switch needs to be so wired that it will prevent any machine movement and stops spindle or shuts down the torch arc when activated.

The emergency switch needs to be mounted to a place that is easily accessible when operating the machine.

The emergency switch has to be of the latching kind in other words: once activated it must stay activated until manually de-activated.

The operation of the emergency switch should not depend on any software.

Depending on the physical layout and power of your machine movements you need to consider if the emergency switch should be automatically activated whenever you have your hands or limbs inside the working area of your machine.

With some machine configurations it may be preferable not to activate the emergency switch if you

need to pause the system in the middle of machining, for example to change the tool bit because the axes might loose their positions and it maybe acceptable to just ensure that the spindle will not start on its own.

For that purpose a kill switch to the spindle motor controller maybe fitted that will prevent the spindle from running no matter what the control systems does.

Above does not by any means endorse any particular way of ensuring safety and no responsibility or liability is accepted by me. You need to do your own risk and safety assessment and act accordingly.

Chapter 3

Warnings

TOAD5 board contains sensitive CMOS electronics and proper ElectroStatic Discharge (ESD) procedures should be followed when handling the board.

When handling the board observe at least following precaution.

When you pick up the board from for example a table, touch the table first. When you hand over the board to another person use your free hand to touch that person first. With your free hand touch the enclosure first when you are installing the board.

Chapter 4

Introduction to TOAD5

4.1 Overview of a CNC Machining System

This is probably familiar territory for you otherwise you would not be here in the first place but this section is short introduction to tell you where exactly EazyCNC and TOAD5 fits in the big picture.

If you are familiar with EazyCNC / TOAD4, feel free to skip this chapter.

The CNC machining process starts with a design of the part to be machined which is turned into a sequence of instructions to the computer that controls the motors, typically stepper motors, that move the cutting tool (or work piece) via series of gears, belts, pulleys and/or screws. These tool movements are typically called 'axes', for example X-axis, Y-axis etc.

The 'sequence of instructions' is called G-code and it is basically a text file with coordinate points that define the path the cutting tool will make.

G-code can be hand written but is typically generated automatically from a CAD (Computer Aided Design model) of the part using CAM (Computer Aided Manufacturing) software, either directly by the CAD/CAM program or by a program called post-processor.

The G-code file is read by a program that turns the coordinate information and other commands in the G-code file into motor control pulses in real-time observing programmed feed rates and machine parameters such as number of pulses required to move a unit distance.

This is where EazyCNC/TOAD5 comes into picture because EazyCNC is the program that does the G-code interpretation and TOAD5 is a micro controller that does the real-time motor control and interfacing to other auxillery devices and this is the manual that discribes the TOAD5 board.

There is a separate manual for EazyCNC.

Chapter 5

Overview of TOAD5

This chapter gives you an overview of TOAD5 and compares it with TOAD4

5.1 Overview

TOAD5 is a controller board that connects to a computer via USB and controls up to five stepper motors.

It also incorporates inputs for connecting for example reference switches or touch probe and outputs to control for example a milling machine spindle or plasma torch.

Compared to the earlier TOAD4 the main difference is that TOAD5 does not integrate the stepper motor drivers into the board.

This allows flexibility with the choise of drivers, making it possible to use higher current motors or take advantage of the incredibly cheap Chinise driver offerings.

By off loading the drivers TOAD5 makes it possible to use servo motors as long as they conform to the STEP and DIR method of control. Servo motors are superior to stepper motors in every way, except price.

In contrast to TOAD4 which is almost a single board system TOAD5 is more like a breakout board that contains just the heart of a CNC system i.e. the real time micro controller or MCU with protected IO.

5.2 Connections

All the connections to the TOAD5 board are via pluggable screw terminals.

This makes wiring easy and allows easy disconnection for trouble shooting and replacement of the board should that ever become necessary.

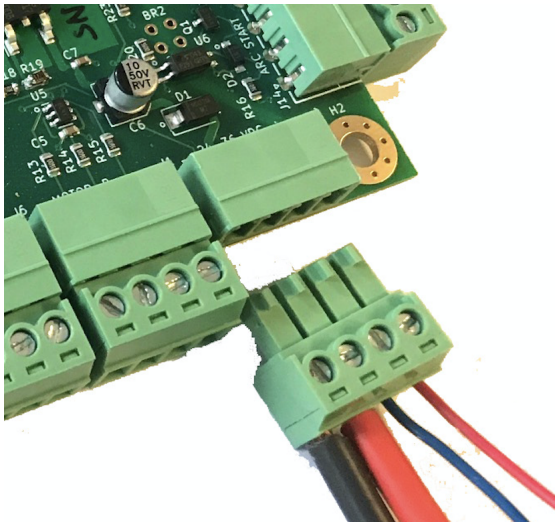

Figure 5.1: Plugable screw terminals are handy

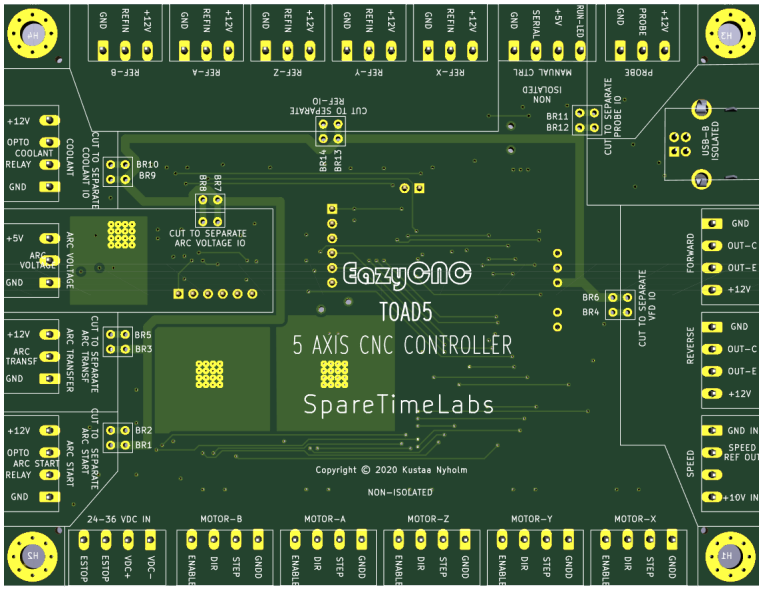

Figure 5.2: All connections are clearly labeled on the bottom side

5.3 Inputs and Outputs

5.3.1 Outputs

TOAD5 supports the following outputs.

- 5 x STEP,DIR and ENABLE outputs for stepper drivers
- COOLANT control output, relay compatible
- FORWARD and REVERSE outpus to control a spindle
- Analogue SPEED (0..10V) output to control spindle speed
- ARC START output for controlling a plasma torch, relay compatible

- RUN LED output

5.3.2 Inputs

TOAD5 supports the following inputs

- DC Power Input (24V - 36V)
- 5 x REFIN switch inputs, compatible with 12 V (PNP/NPN) proximity switches
- Touch PROBE input
- Analogue ARC VOLTAGE input for torch height control
- ARC TRANSFER input to syncronize cut start with arc lightup
- MAN-CTRL connection for Manual Control Panel
- ESTOP input to kill all outputs

5.4 Galvanic Isolation

All the inputs and outpus, including the USB are galvanically isolated from the micro controller.

This is a very important and huge benefit.

A major source of headache for a CNC machine constructor are ground loops and electro magnetic interference (EMI).

Especially USB interface is very sensitive to ground level issues and EMI induced noise.

Isolation goes a long way towards eliminating them.

It also offers some level of protection against damaging the board by wrong electrical connections and electro static discharges (ESD).

Note that this does NOT imply short circuit or overvoltage protection!

The isolation is functional meaning it is not for and does NOT provide electrical safety!

If you need to have safety isolation you need to provide that externally to the TOAD5 board.

All the outputs from the TOAD5, excepting the STEP,DIR and ENABLE for the stepper drivers, are optically isolated.

The reason for excepting those is that most commercial stepper drivers worth their salt have isolated inputs already so there is no need to have double isolation. Also the stepper signals have critical timing constraints and providing high speed isolation is expensive.

TOAD5 also supports a serial interface to connect to a front panel control board for manual control of a spindle. This interface is not isolated because the power to the front panel is supplied by the TOAD5 and so there are no ground loops to worry about and the serial interface is slow and robuts.

Note that while the inputs and outputs are isolated from the microcontroller and hence from the computer connected via the USB, they are not all isolated from each other.

This is because most inputs need an isolated power supply and to make it unnecessary for the constructor of the CNC system to include that TOAD5 provides that isolated power for the inputs, but it would be prohibitively expensive to provide separate power supplies for each inputs, especially when it is usuall not necessary.

However, should the need to arise, isolated external power can be supplied to the the board for most inputs and output by isolating the input/ouputs from each other by cutting traces on the PCB that are provided just for this purpose.

5.5 About Power

The board accepts and needs DC power. This does not need to be voltage regulated , a rectified and filtered output from a 24 VAC transformer is sufficient.

The nominal full spec acceptable DC input range is 28 VDC to 36 VDC.

Below 28 VDC input voltage the +12 V output from the board starts to sink, at 24 VDC the nominally +12 V output is more like 11 V. This should not be problem as in tests relays rated for 24 (!) VDC operation operated down to 10 VDC. In fact the TOAD5 was tested to operate with down to 20 VDC input.

5.6 Input/Output Protection

The relay outputs are protected against inductive kickback.

The neither the relay outputs or the +12V outputs are short circuit protected against ground, but the isolating DC/DC is protected against momemtary shorts so that should help.

The STEP,DIR and ENABLE are ESD protected and current limited against ground.

The opto-ouputs (opto transistor Emitter/Collectors) are not protected.

All the inputs are proctected against ESD.

The DC power input is protected agains reverse polatiry.

Chapter 6

Power and Isolation

6.1 Voltage Regulation

The nominal acceptable input voltage for the board is 24 VDC to 36 VDC.

This means that you can feed the board from a 24 VDC switching power supply or from a 24 AC transformer rectified and filtered.

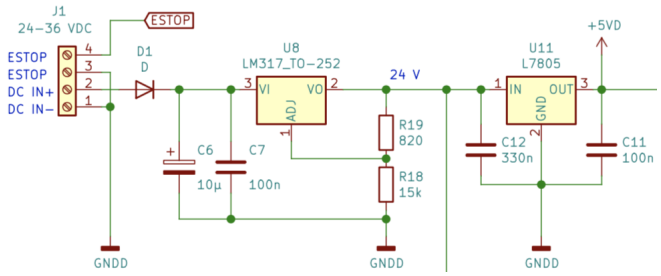

Figure 6.1: The voltage regulation circuitry

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As can be seen the input is protected against reverse polarity by the diode D1 and from thence the internal nominally 24 VDC voltage is derived with the pre-regulator U8/LM317. The purpose of this pre-regulation is twofold, to share the thermal load between the two regulators U8 and U11 and to allow much higher power input voltages.

Below 28 VDC the internal nominal 24 VDC voltage begins to sink but down to 24 VDC input voltage it is high enough to feed the isolation DC/DC converter with in its specification. Below 28 VDC input voltage the +12 V output from the board starts to sink, at 24 VDC the nominally +12 V output is more like 11 V. This should not be problem as in tests relays rated for 24 VDC [sic] operated down to 10 VDC! In fact the TOAD5 was tested to operate with down to 20 VDC input.

On the upper end of the acceptable input voltage range, the actual max voltage that the input regulator on the board take is about 60 VDC. However at above 36V the LM317 regulator may need additional heatsinking.

6.2 Input Current

The board draws an approximate maximum of 180 mA from the PSU (with a 100 mA load on the +12V isolated output). At an ambient temperature of 50 °C the heat sink provided by the copper areas on the PCB are sufficient to cool the voltage regulators at the max input power voltage of 36 VDC.

Sufficient ventilation to the board should be provided but forced cooling with a fan should not be necessary.

The TOAD5 board as such does not draw more than typically 50 mA, but depending on loads connected to the inputs and output this can rise up to 150 mA.

6.3 Isolated +12V Output

The TOAD5 board provides an isolated nominal +12 V to power proximity switches and relays and such. This power is share between all inputs and outputs which are grouped according to function. Special easy to cut bridge traces are provided on the under side of the PCB to facilitate separating the different input and output island if necessary.

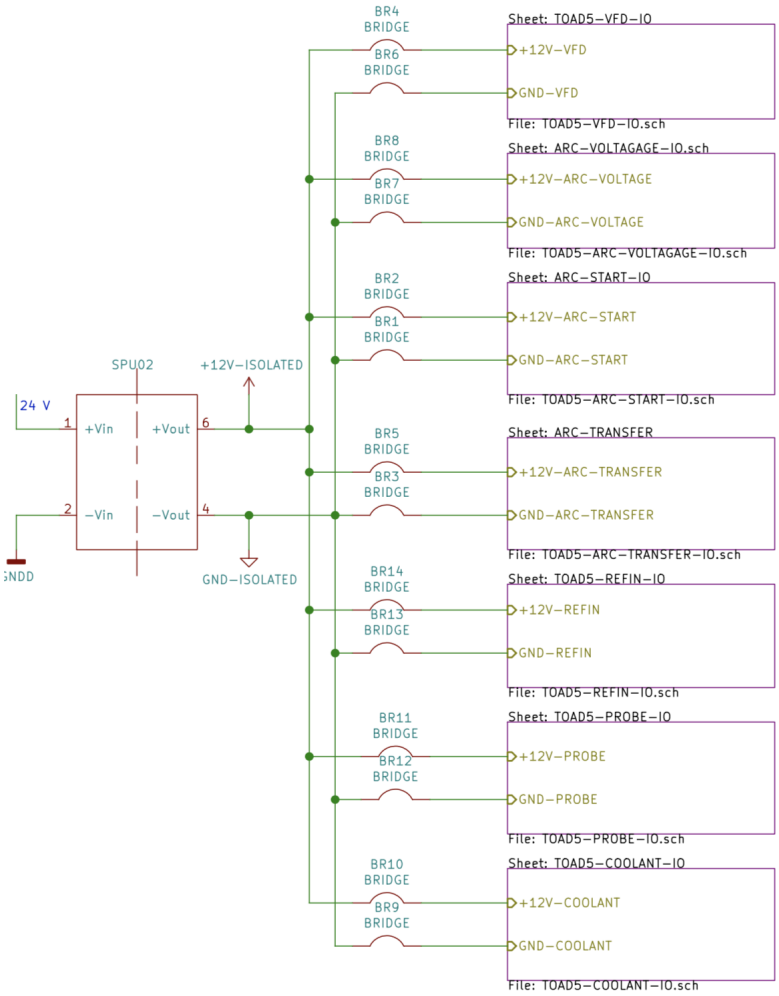


Figure 6.2: The isolated power distribution scheme

This +12 V voltage is not regulated and varies between 10.5 V and 13.2 V depending mostly on the input voltage to the board.

The outputs are protected against momentary short circuit as per the DUP02 DC/DC converter specification.

When planning and connecting inputs and outputs that draw current from the isolated +12 V care must be taken not to exceed 100 mA all together.

This max collective current of 100 mA from the isolated 12 VDC outputs is sufficient to supply most use cases for example five typical Chinese proximity switches and two small 12V relays and touch probe.

If more current is needed, for example to drive larger relays, then it is possible to isolate outputs and provide the extra power from an external power by cutting traces that are provided for that purpose on the PCB board.

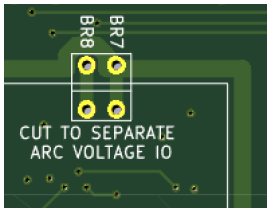


Figure 6.3: Example of where two traces on the PCB can be cut to separate powers

6.4 Isolation

All the inputs and outputs, including the USB are galvanically isolated from the microcontroller.

This is a very important and huge benefit.

Two major sources of headache for a CNC machine constructor are ground loops and electromagnetic interference (EMI).

Especially USB interface is very sensitive to ground level issues and EMI induced noise.

Isolation goes a long way towards eliminating them.

It also offers some level of protection against damaging the board by wrong electrical connections and electrostatic discharges (ESD).

Note that this does NOT imply short circuit or overvoltage protection!

The isolation is functional meaning it is not for and does NOT provide electrical safety!

If you need to have safety isolation you need to provide that externally to the TOAD5 board.

All the outputs from the TOAD5, excepting the STEP, DIR and ENABLE for the stepper drivers, are optically isolated.

The reason for excepting those is that most commercial stepper drivers worth their salt have isolated

inputs already so there is no need to have double isolation. Also the stepper signals have critical timing constraints and providing high speed isolation is expensive.

TOAD5 also supports a serial interface to connect to a front panel control board for manual control of a spindle. This interface is not isolated because the power to the front panel is supplied by the TOAD5 and so there are no ground loops to worry about and the serial interface is low speed, and it is protected and robust.

Most inputs need an isolated power supply and to make it unnecessary for the constructor of the CNC system to include that TOAD5 provides that isolated power for the inputs.

Note that while the inputs and outputs are isolated from the microcontroller and hence from the computer connected via the USB, they are not all isolated from each other. It would be prohibitively expensive to provide separate power supplies for each input, especially when it is usual not necessary.

However, should the need to arise, isolated external power can be supplied to the the board for most inputs and output by isolating the inputs/outputs from each other by cutting traces on the PCB that are provided just for this purpose.

6.5 Input/Output protection

The relay outputs are protected against inductive kickback.

The neither the relay outputs nor the +12V outputs are short circuit protected against ground, but the isolating DC/DC is protected against momentary shorts so that should help.

The STEP, DIR and ENABLE are ESD protected and current limited against ground.

The optically isolated outputs (photo transistor Emitter/Collectors) are not protected.

All the inputs are protected against ESD.

The DC power input is protected against reverse polarity.

Chapter 7

Inputs and Outputs

7.1 J1 – Power Input and ESTOP

Connect a DC power supply between pins 1 and 2 of J1 taking care of the correct polarity. The input is reverse polarity protected but the board will not function if connected the wrong way.

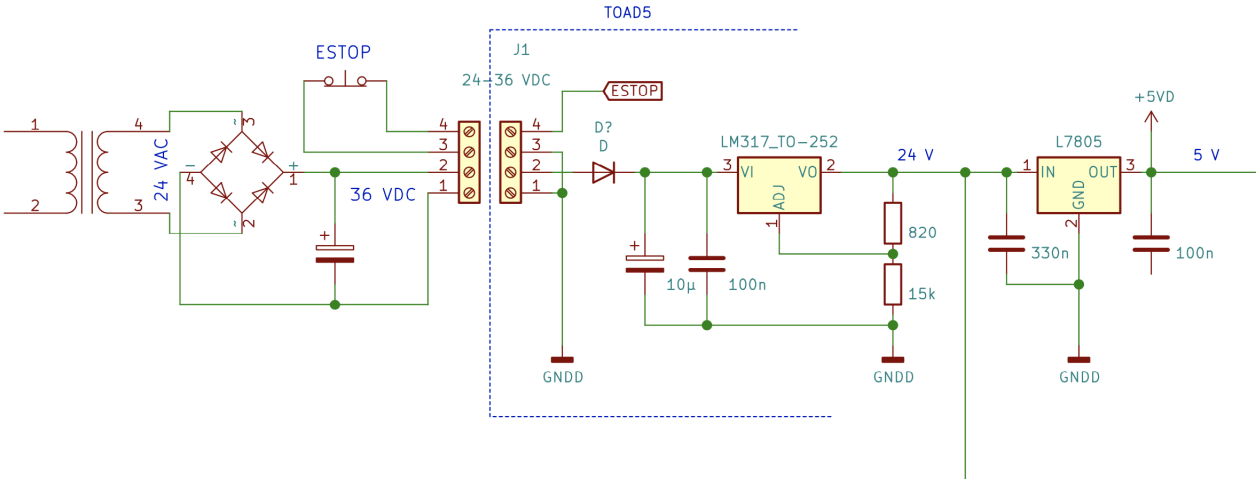


Figure 7.1: Example of minimal connection to the board to make it run

The pin 1 is the ground or negative, as it is in all the connectors on the TOAD5 board.

A normally closed (open on activation) latching type ESTOP switch can be connected to pins 3 and 4 of J1. If this is not used then these two pins should be shorted together as an open circuit will activate the ESTOP functionality that effectively kill everything on the board by holding the MCU in RESET state.

7.2 J8 – RUN LED output & Manual Control Panel

This connector is provided to connect a RUN LED and the optional manual control front panel.

The RUN LED blinks to indicate the state of the microcontroller.

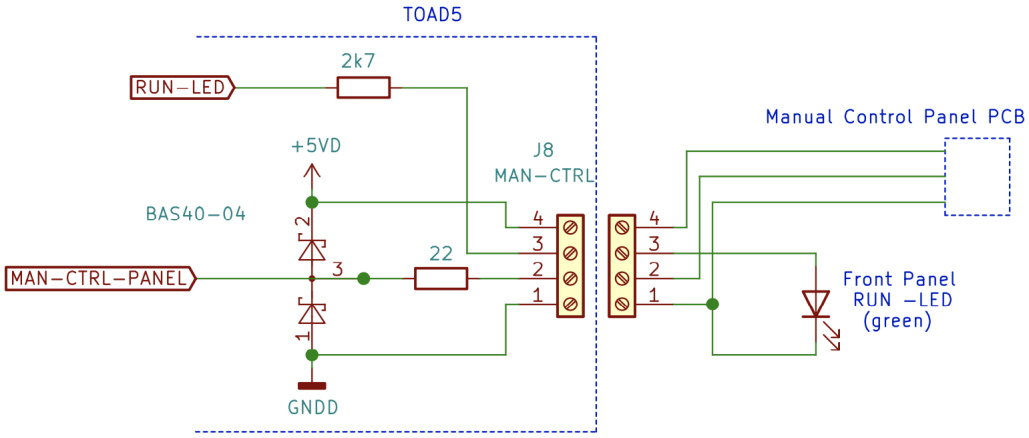


Figure 7.2: An example how to connect a front panel RUN LED

A green LED mounted to an easily observable place on the enclosure should be wired to connector J8, LED anode (long pin) to pin 4 and cathode (short/indicated pin) to pin 1.

A slow blink indicates that the board is 'alive'.

A fast blink indicates that it is connected to a computer via USB.

A fast flicker indicates that EazyCNC is communicating with the board.

The manual control panel is connected to the pins 1,2 and 3 of J18. Note that pin 1 is shared between the manual control panel and the RUN LED because they typically are both mounted to the front panel of the enclosure and thus a single wire is convenient.

There is also a RUN LED on the TOAD5 board, so it is possible to access the system status even without a front panel RUN LED.

7.3 USB interface

The USB is interface is USB 2.0 running at Full Speed (12 Mb/s).

The interface is isolated and ESD protected.

7.4 J2-J6 STEP, DIR and ENABLE outputs

Output signal are provided to control up to five stepper motor modules for the CNC axis X, Y, Z, A and B.

These signal should be wired to the stepper driver modules.

The signals are ground referenced and the ground is provided in pin 1, the other signals are STEP = pin 2, DIR = pin 3 and ENABLE = pin 4.

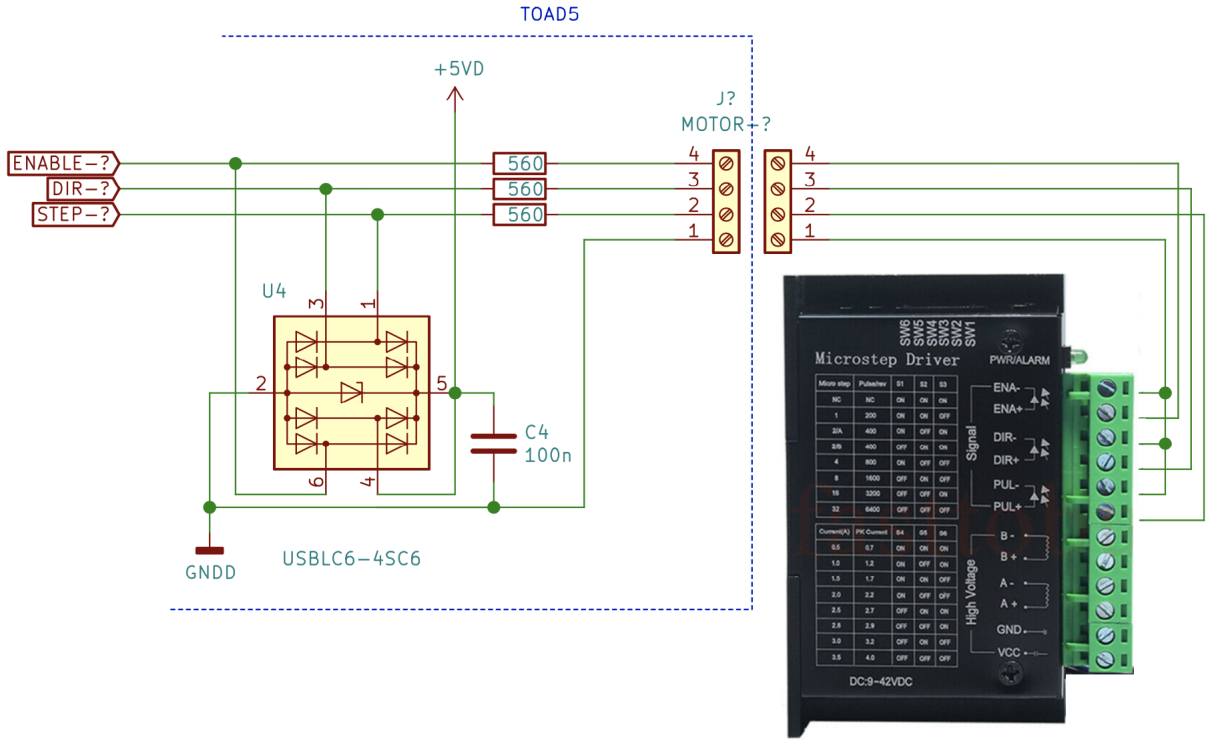


Figure 7.3: An example of connecting the STEP/DIR/ENABLE outputs to a stepper driver module

The outputs are NOT isolated and are current limited by 560 ohm resistors. This provides about 6 mA to a typical opto-isolator input IR LED (in the stepper driver module) with 1.2 V forward voltage, which should more than sufficient and compatible with many stepper driver modules.

Stepping happens on the rising edge of the STEP signal and the pulse length is 20usec. This is an important spec and not all stepper driver modules maybe compatible with that.

The DIR signal changes no closer than after 10 µsec after the step pulse rising edge.

If the stepper drivers do not support and ENABLE signal then this can be left unconnected.

The ENABLE signal is active high.

All the outputs are ESD protected by clamping them to the VDD/VSS voltages on the board.

(In case of doubt about the speed and performance of the opto-isolators on the stepper driver modules it maybe necessary to verify the signal integrity on the stepper driver module opto-isolator output side with oscilloscope. This should rarely be necessary.)

7.5 J9 COOLANT control output

This isolated output is compatible with a relay.

A coolant control relay can be connected between pin 1 (ground) and pin 3 (positive).

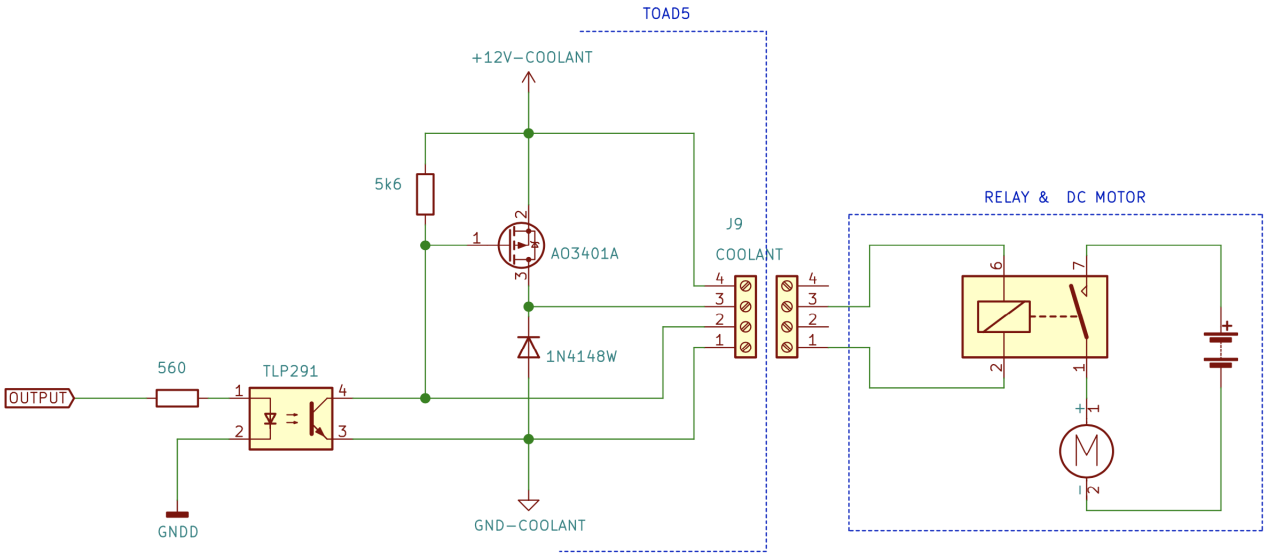


Figure 7.4: An example of connecting a coolant pump via a relay

The output is nominally +12 VDC but with 24 VDC input to the board this can be about 10lower which normal.

The relay output is protected against inductive kickback from the relay coil with a diode between pins 1 and 3.

The maximum allowed coil current is 3 A but the current available from the on-board isolated DC supply is max 100 mA for all output and inputs combined, see the power section.

A typical small Omron relay has a coil resistance of 275 Ohm which results in about 43 mA current (12 V/ 275 Ohm).

If that is exceeded then all the output and inputs will suffer. In that case external power to the relay needs to be provided by isolating this output from the rest of the inputs / outputs by cutting the traces on the PCB provided for this purpose and feeding power for the relay to pin 1 (ground) and pin 4 (+12V).

An external power source and isolating the circuitry from the other outputs / inputs also allows the use of 24 VDC relays. When using an external power supply the abs voltage is 28 V.

Neither the relay output nor the +12V output are short circuit protected against ground, but the isolating DC/DC power supply output is protected against momentary shorts so that should help.

Also the bare opto-isolator output transistor Emitter and Collector are available at the pins 1 and 2 respectively.

7.6 J12/J13 FORWARD / REVERSE output

These outputs are intended to control a Variable Frequency Drive (VFD) to run a milling machine spindle.

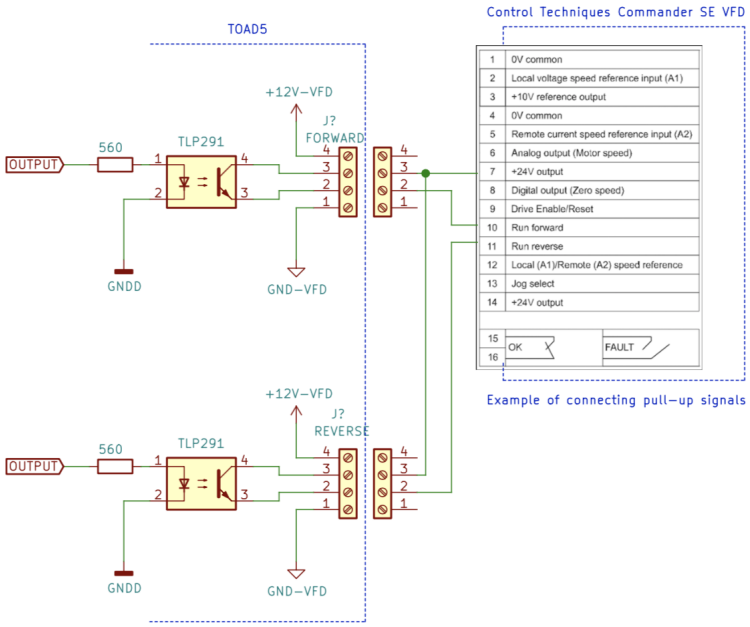


Figure 7.5: An example how to connect a VFD to the FORWARD and REVERSE outputs

There is no provision for a big contactor, such as would be required to run a multi kW motor without a VFD. If that is a requirement then a circuit to control and power such a contactor has to be provided external to the TOAD5 board.

These outputs are uncommitted (not connected to anything else) collectors and emitters of the opto-isolator transistors (NPN). This makes it possible to use them to interface with either pull-high or pull-low to activate VFD inputs.

For pull-high type, wire the pin 3 of J12/J13 to the positive voltage from the VFD typically provided for that purpose and connect the pin 2 from J12/J13 to the forward and reverse inputs of the VFD.

For pull-low type, wire the pin 2 of J12/J13 to the input ground voltage from the VFD and connect the pin 3 from J12/J13 to the forward and reverse inputs of the VFD.

Ground and +12 V from the isolated +12 V on the TOAD5 board is available at pins 1 and 4 respectively, should that prove to be necessary.

The outputs are not protected against ESD, but are not very suspectible to it being unconnected.

The absolute maximum voltage between the Emitter and Collector are 80 V and the maximum current 50 mA. Emitter Collector ON (as opposed to OFF) voltage is max 0.6 V at the recommend max E-C current of 15 mA.

The output is not suitable for inductive loads without additional protection.

The output Collect and Emitter are fully isolated from each other and rest of the inputs/outputs

7.7 J11 SPEED analogue output

This connector outputs an analogue signal from pin 2 of J11 which is ratiometric in relation to the voltage input to the pin 1 (ground) and pin 3 (+10 V).

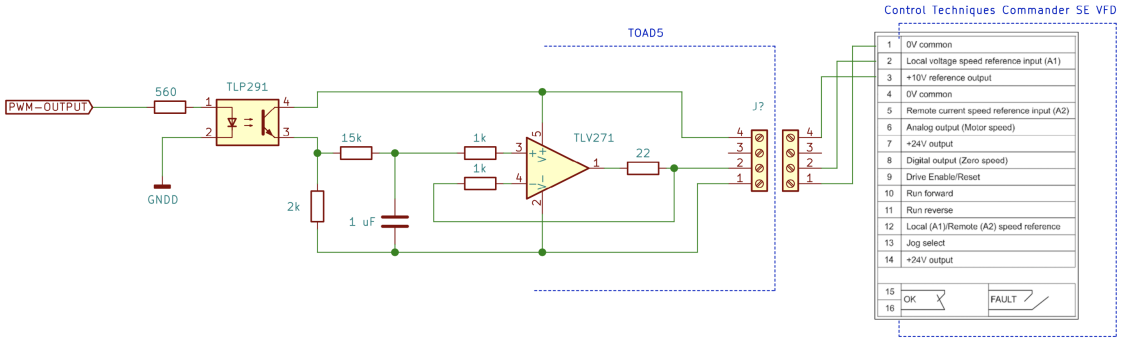


Figure 7.6: An example of connection the SPEED output to a VFD

In other words given a 10V voltage from the VFD this output provides a speed control signal in the range 0 V .. 10 V.

Wire the reference ground and +10 V from the VFD to the pins 1 and 3 respectively and connected the pin 2 to the speed input ref on the VFD.

The absolute maximum voltage to the +10 V input is +16 V.

This analogue output is completely isolated from all other inputs and outputs.

7.8 J11 PROBE input

This probe input is intended for a Renishaw style touch probes with normally closed contact.

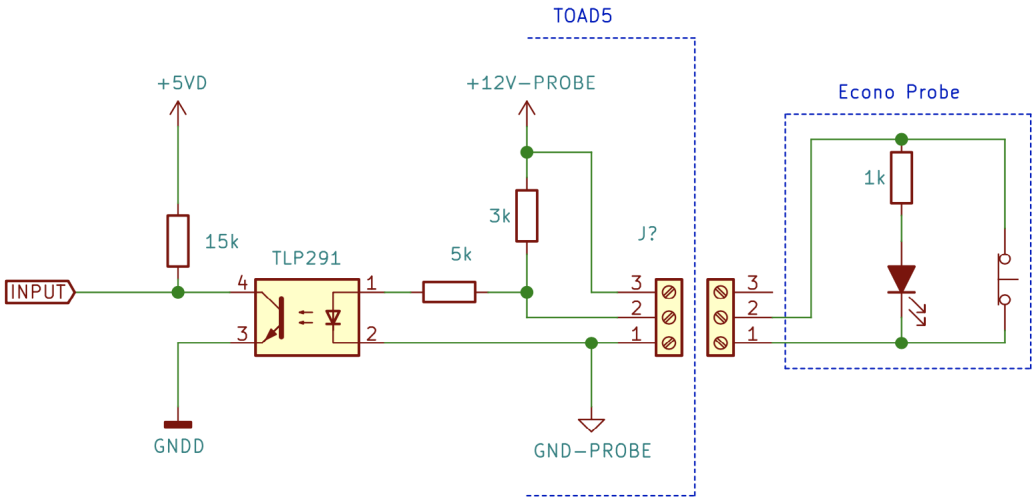


Figure 7.7: An example of connection a touch probe to the PROBE input

Wire the probe (normally closed) contact between pin 1 (ground) and pin 2 (input with pull up).

Some probe designs internally have a LED and a resistor in series parallel to the contact to give a visual indication of the probe activation.

The minimum value for that resistor is 1 kOhm.

For probes that require it +12 volt is available from pin 3 of J11.

7.9 J19 - J23 REFIN inputs

For each CNC axis (X,Y,Z,A,B) a reference (home) axis position input is provided.

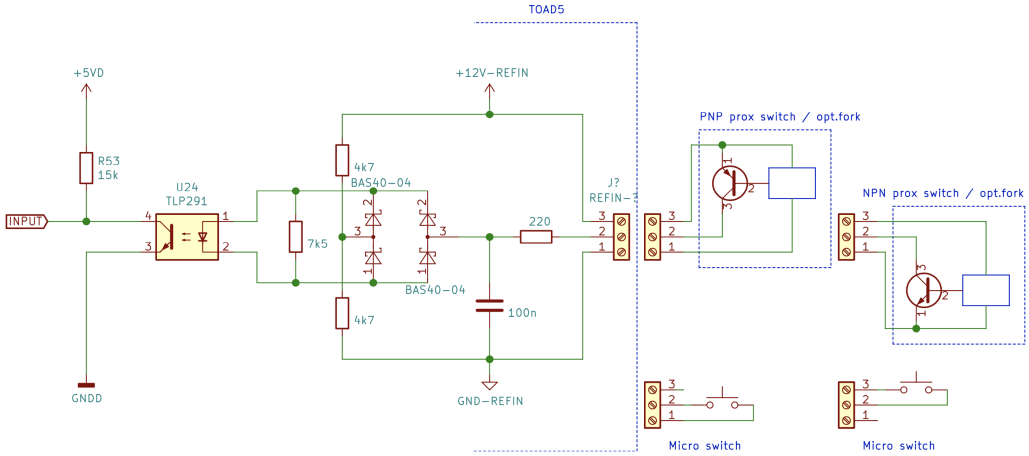


Figure 7.8: Several examples of connecting switches to the REFIN inputs

These input is compatible not only with mechanical switches (normally open or normally closed) but also with electronic switches such as optical fork or proximity sensors.

A mechanical switch can be wired between pin 1 (ground) and pin 2 (input).

Alternatively a mechanical switch can also be wired between pin 3 (+12 V) and pin 2 (IN).

The input circuitry is compatible with both open collector (NPN) or open emitter (PNP) style outputs from the sensor.

Wire the electronic sensor so that the sensor power connector negative and positive go to the pin 1 (ground) and 3 (+12 V) respectively and the output signal from the sensor goes to pin 2 (IN).

7.10 J16 - J23 ARC VOLTAGE analogue input

This is an analogue input intended to monitor the arc voltage of a plasma cutter. This in turn can be used to control the torch height to keep the torch to workpiece distance constant.

The input range is 0 V .. 5 V when referenced to ground. It is feasible also reference the signal to the +5 output in which case the input ranges is -5 V .. 0 V.

Note that by its very nature the arc voltage is a negative potential if the workpiece is the reference.

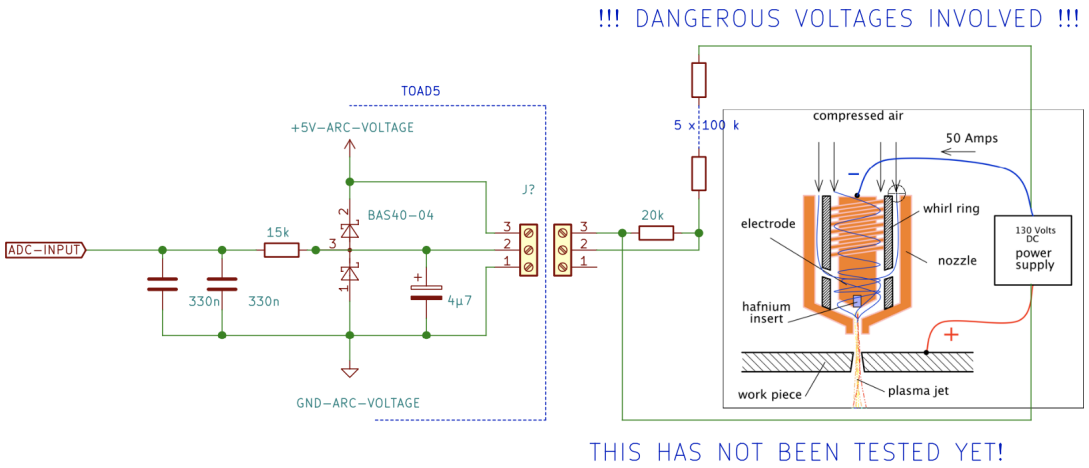


Figure 7.9: An example of connecting a plasma torch to the ARC-VOLTAGE input

Typical plasma arc voltage is in the ballpark on 150 VDC. This something that you do not want to take liberties with.

To be able to measure it needs to be divided by resistor divider.

Some professional plasma power supplies that provide a 'machine' interface have this divider built in. For example Hypertherm Powermax 45 has an internal 50:1 divider which scales the arc voltage nicely to the 5 V range.

If the voltage divider needs to be external to the plasma power supply then a separate and properly isolated enclosure should be provided for it.

The ARC VOLTAGE input is NOT isolated from all the other inputs but in a plasma setup both the ARC START and ARC TRANSFER signal are likely to be connected to relays and if the REFIN inputs are NOT used then it can be considered totally floating.

If necessary the ARC VOLTAGE input circuitry island on the PCB can be totally isolated by cutting the traces provided for that purpose on the board. In which case external +5 V needs to be fed in via the pin 1 (ground) and pin 3 (+5V).

If the traces that feed the ARC VOLTAGE measurement circuit island on the PCB are completely removed by grinding then the island is isolated from the rest of the board via a 1.9 mm creepeage distance on the PCB. The TLP291 opto-isolator is rated for 3750 Vrms, so it is the creepeage distance that counts.

You need to do your own analysis if this is good enough for your particular system and setup.

If above does not make sense to you or you have any doubt about your ability make the system safe seek professional help and don't play with the arc voltage measurement until you are satisfied that the system is safe!

I want to once again emphasize that the isolation on the TOAD5 board is intended to be functional only and not to be relied on for safety.

7.11 J14 ARC START output

This isolated output is compatible with a relay.

A relay can be connected between pin 1 (ground) and pin 3 (positive).

The contact of the relay can then be used to control the plasma cutter power supply.

The circuitry driving this output is similar to the COOLANT output and the description is not repeated here, refer to the description in under COOLANT Output section.

7.12 J17 ARC TRANSFER input

This isolated input can be used to delay the start of torch movement until the plasma arc has transferred to the work piece.

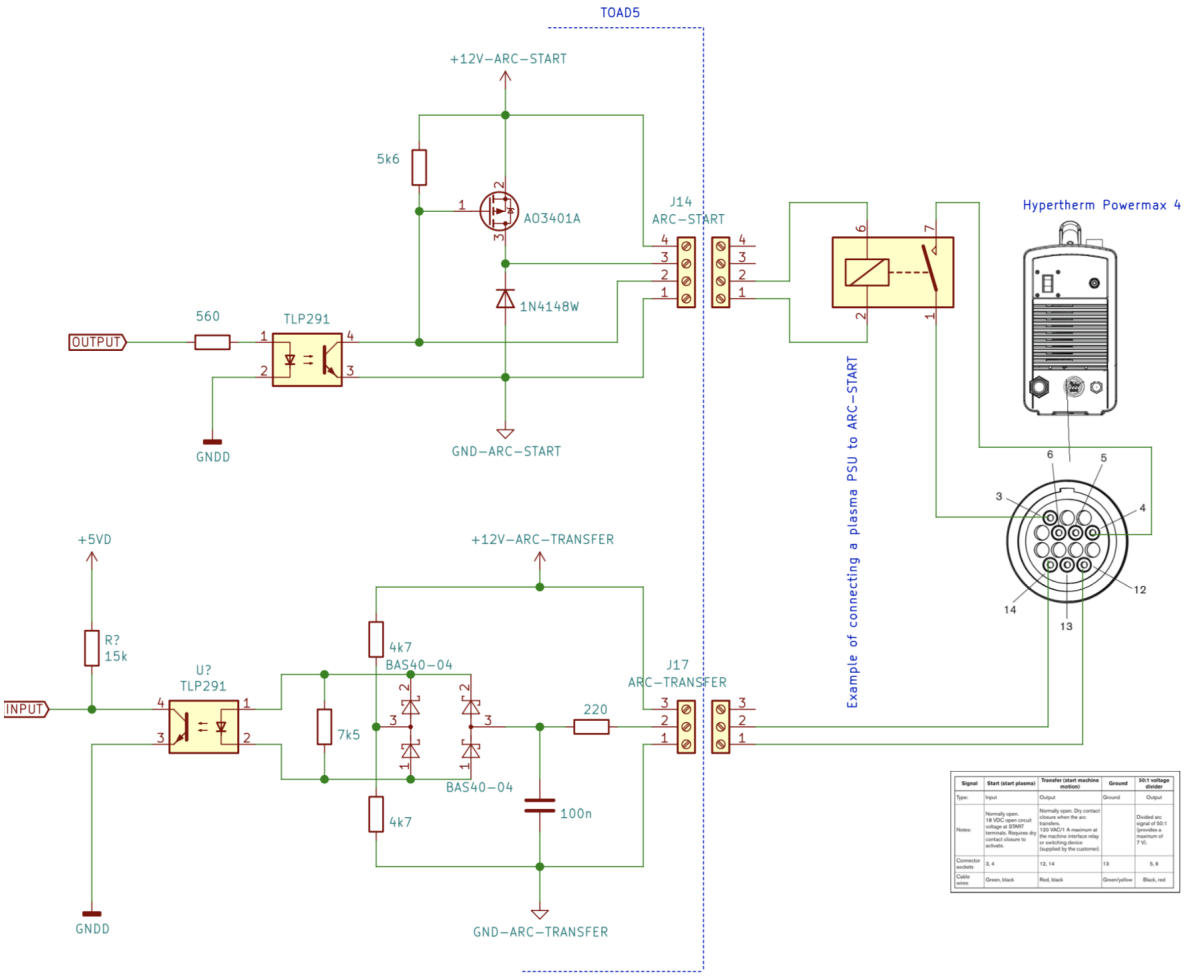


Figure 7.10: An example of connecting a plasma PSU to ARC-START output and ARC-TRANSFER input

Typically plasma power supplies that are equipped with 'machine interface' provide what is called 'dry contact' connection i.e. the contacts of a relay that provide the arc transfer information to the CNC system.

The circuitry for this input is identical to those in the REFIN inputs and the description is not repeated here, refer to the description in under REFIN inputs section.

The 'dry contact' signal from the plasma cutter power supply can be wired to either between pin 1 (ground) and pin 2 (IN) or between pin 3 (+12V) and pin 2 (IN).

7.13 J18 - J23 BOOTLOADER jumper

Typically updating the firmware of the MCU is done through the USB by sending a command from the PC computer to the TOAD5 to enter so called bootloading state.

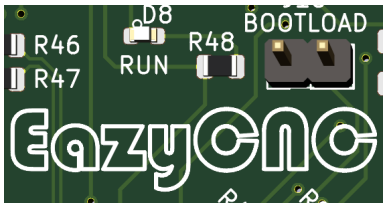


Figure 7.11: The BOOTLOAD jumper

On rare occasion the TOAD5 MCU maybe left in a 'limbo' in which it is not fully programmed and it is not possible to enter the bootloading state via a command from the PC computer.

To get out of this situation a bootloader jumper is available,

Inserting this jumper/bridge into the pins of J18 and power cycling the TOAD5 it will enter bootloading state regardless. To indicate this state the RUN LED is constantly on after power up.

.1 Appendices

Appendix A

Photos

Figure A.1: TOAD5 Delivery

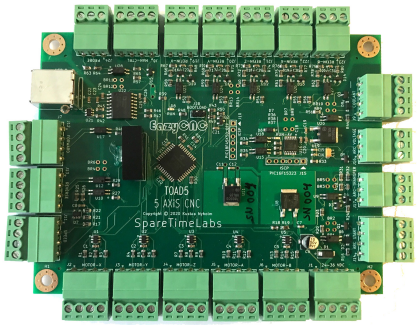


Figure A.2: TOAD5 Component Side

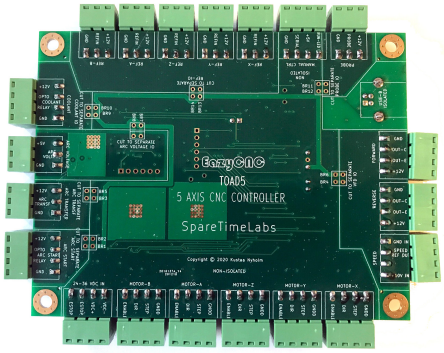


Figure A.3: TOAD5 Component Solder Side

Figure A.4: LJ12A3-4-Z-BX-NPN Proximity Switch

Figure A.5: LJ12A3-4-Z-BY-PNP Proximity Switch

Figure A.6: Econo Probe

Appendix B

TOAD5 Dimension

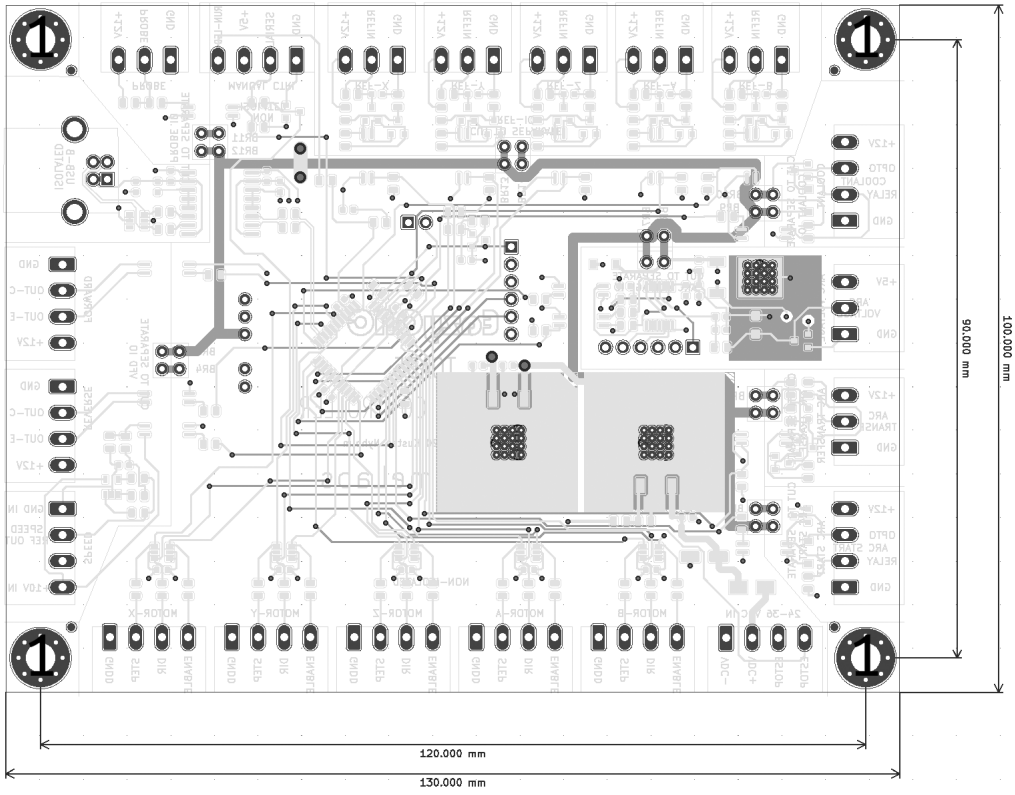


Figure B.1: TOAD5 Board Dimensions

Appendix C

TOAD5 PCB

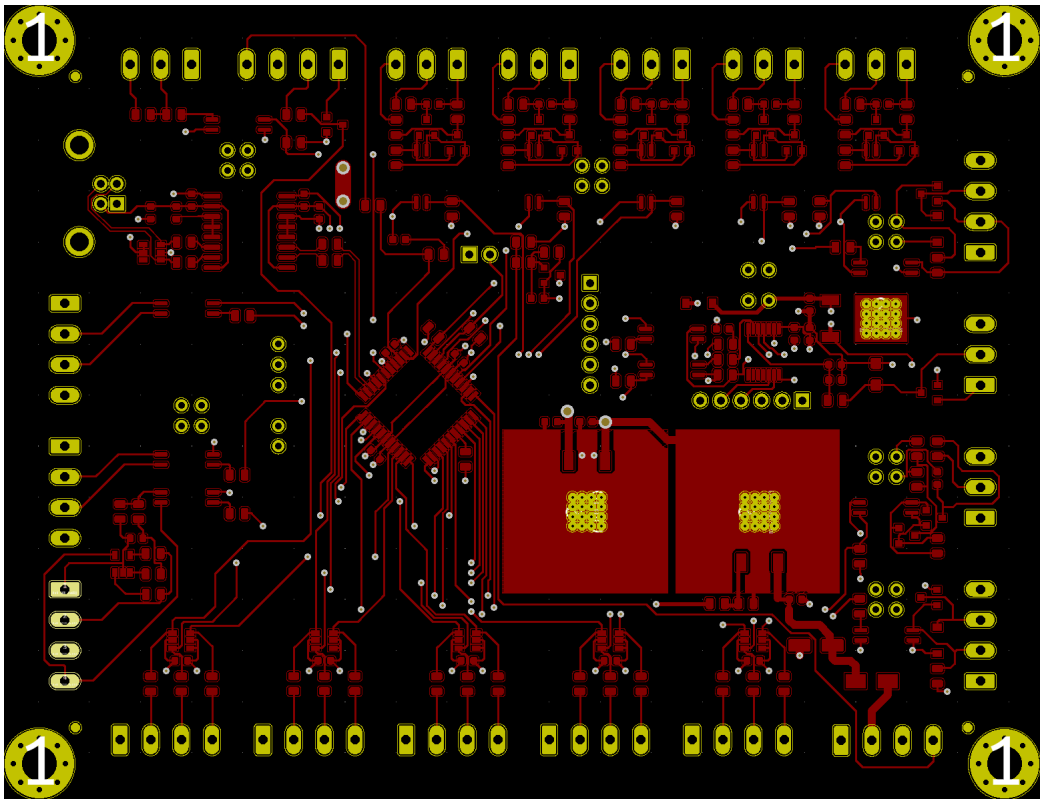


Figure C.1: Top Layer

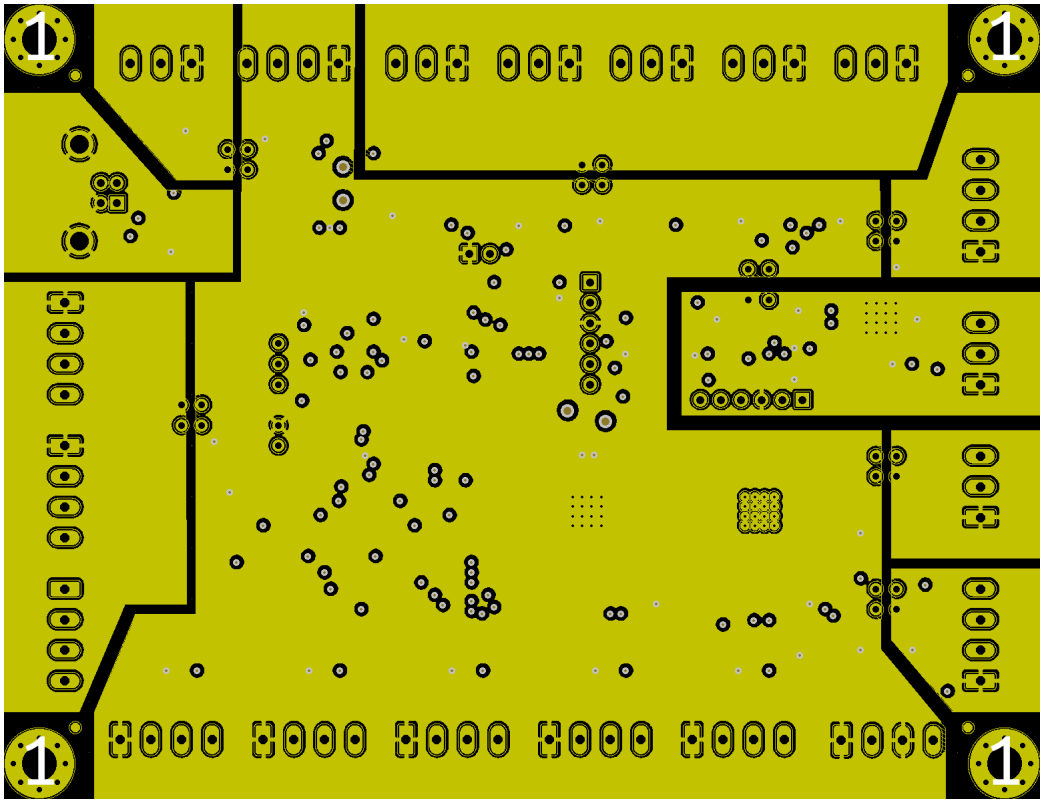


Figure C.2: Ground Plane

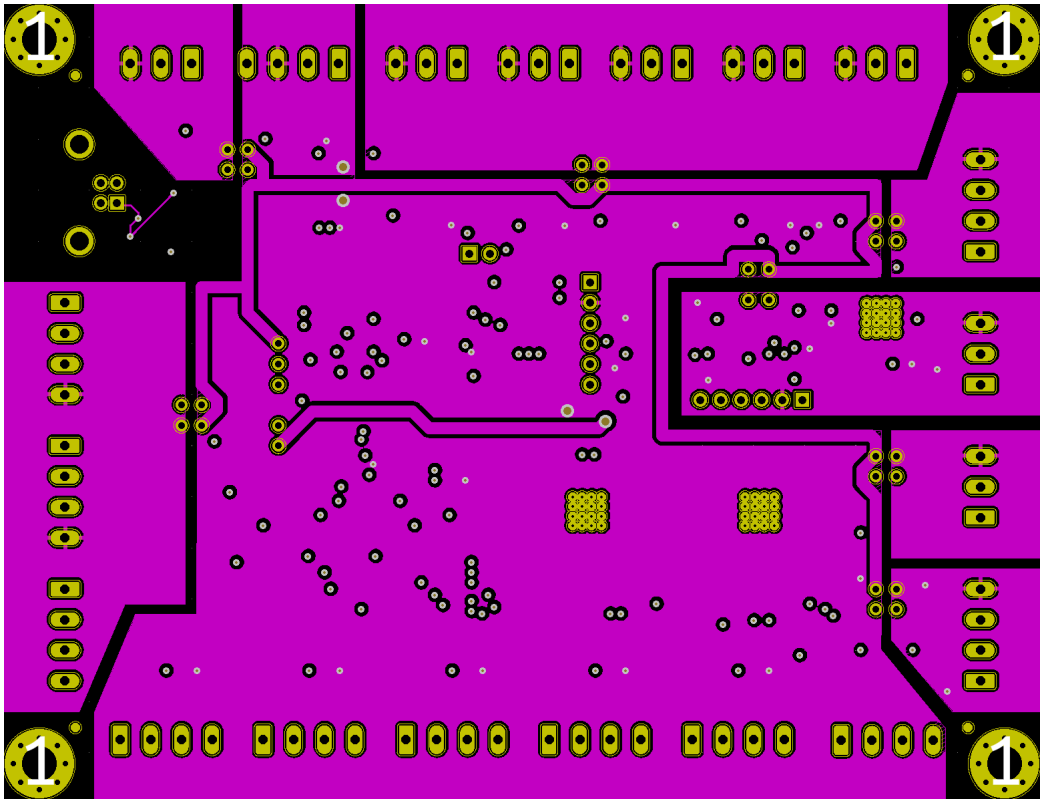


Figure C.3: Power Plane

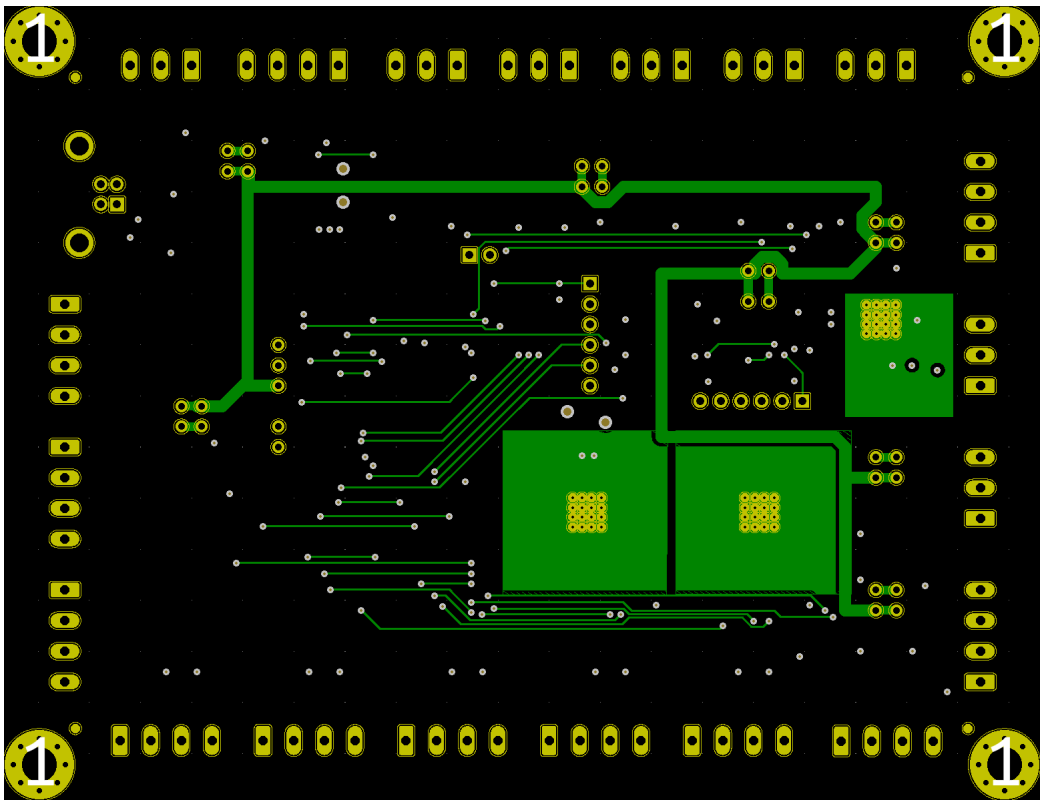


Figure C.4: Bottom Layer

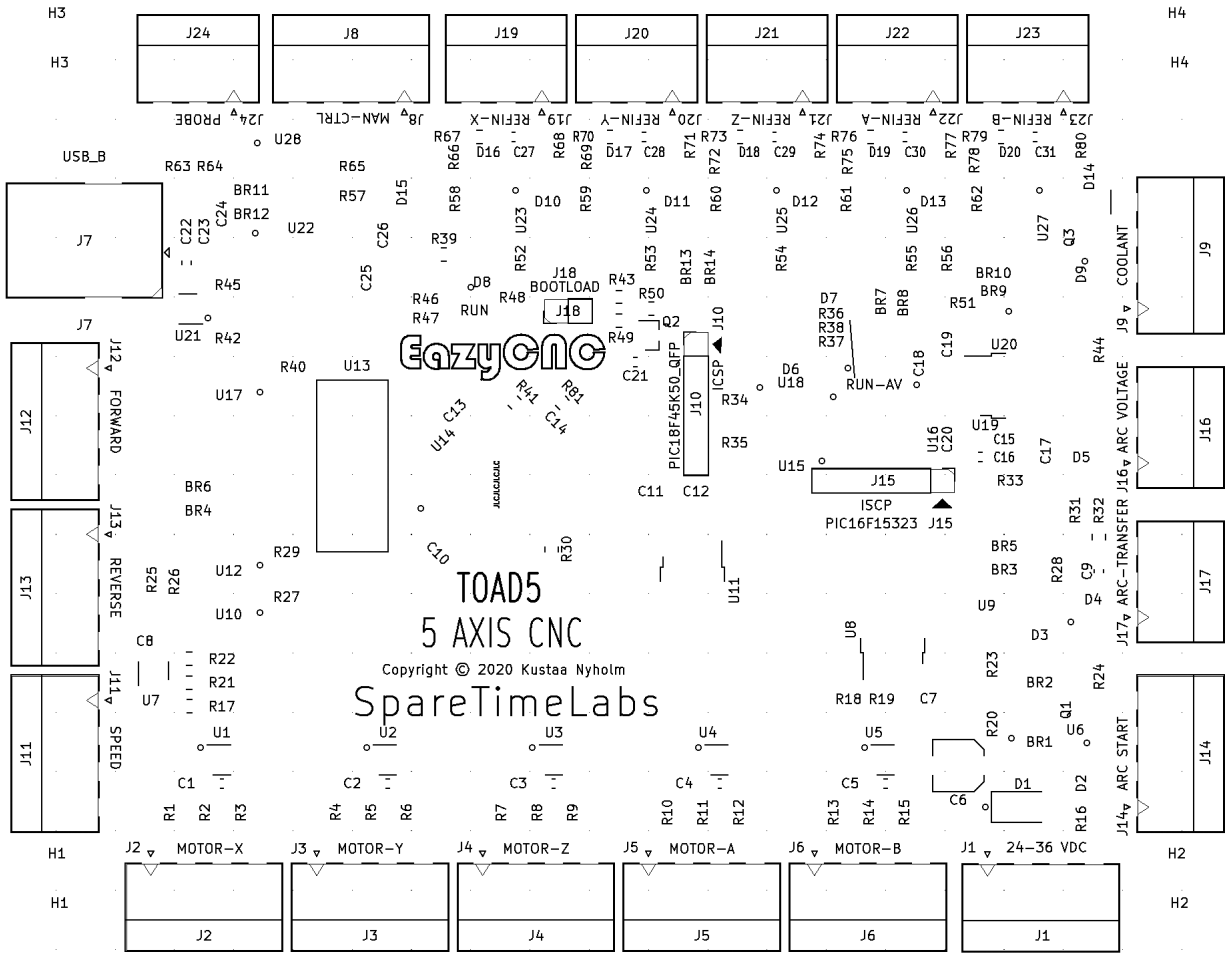


Figure C.5: Front Silk

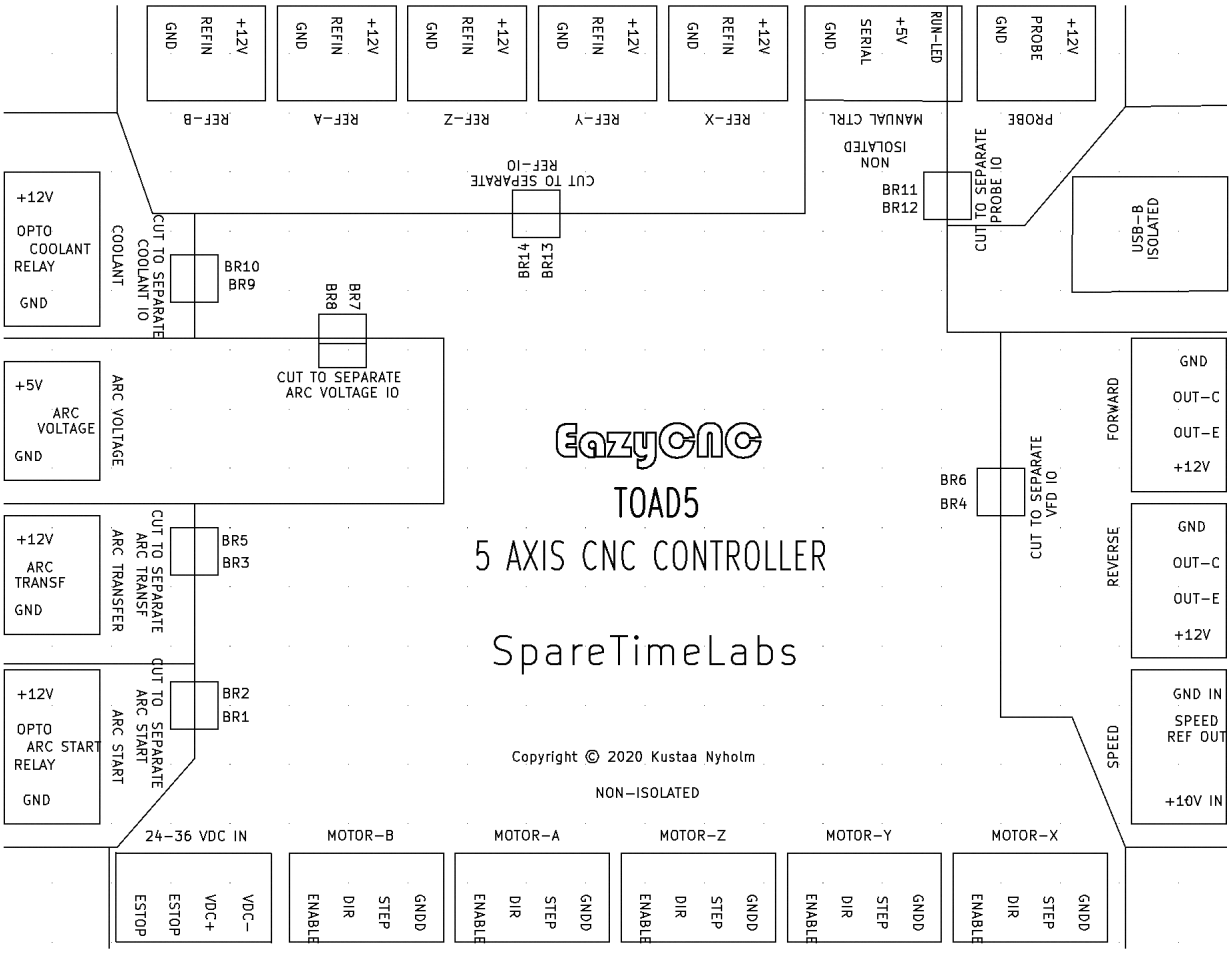
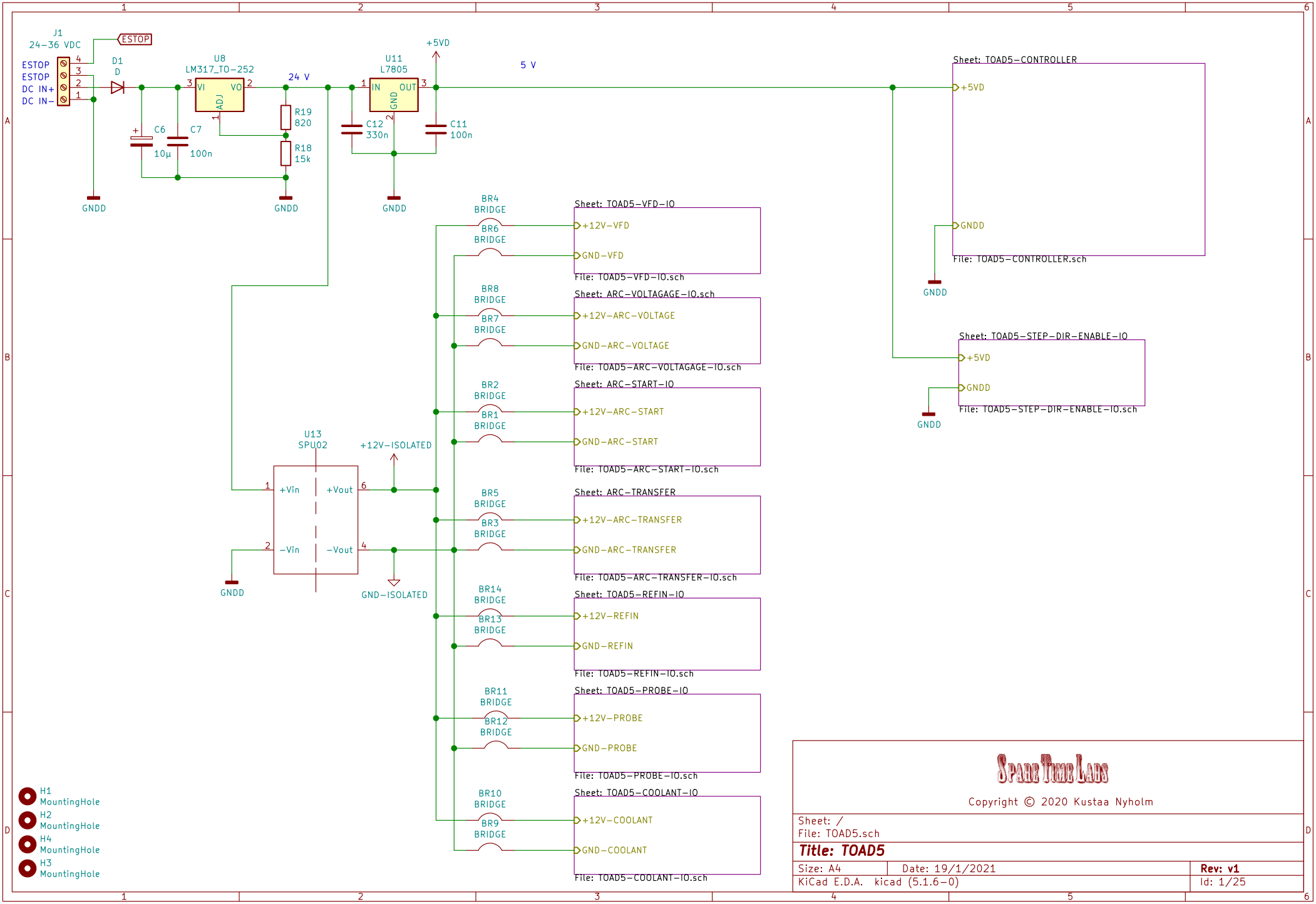


Figure C.6: Bottom Silk

Appendix D

TOAD5 Schematic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ESTOP
ESTOP
DC IN+
DC IN-
D1
D
U8
LM317_TO-252
VI
VO
ADJ
24 V
R19
820
R18
15k
C6
10µ
C7
100n
GNDD
U11
L7805
IN
OUT
GND
+5VD
5 V
C12
330n
C11
100n
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SPU02
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-Vin
+Vout
-Vout
+12V-ISOLATED
GND-ISOLATED
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BR6 BRIDGE
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GND-VFD
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BR7 BRIDGE
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BR1 BRIDGE
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BR5 BRIDGE
BR3 BRIDGE
Sheet: ARC-TRANSFER
+12V-ARC-TRANSFER
GND-ARC-TRANSFER
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BR14 BRIDGE
BR13 BRIDGE
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BR11 BRIDGE
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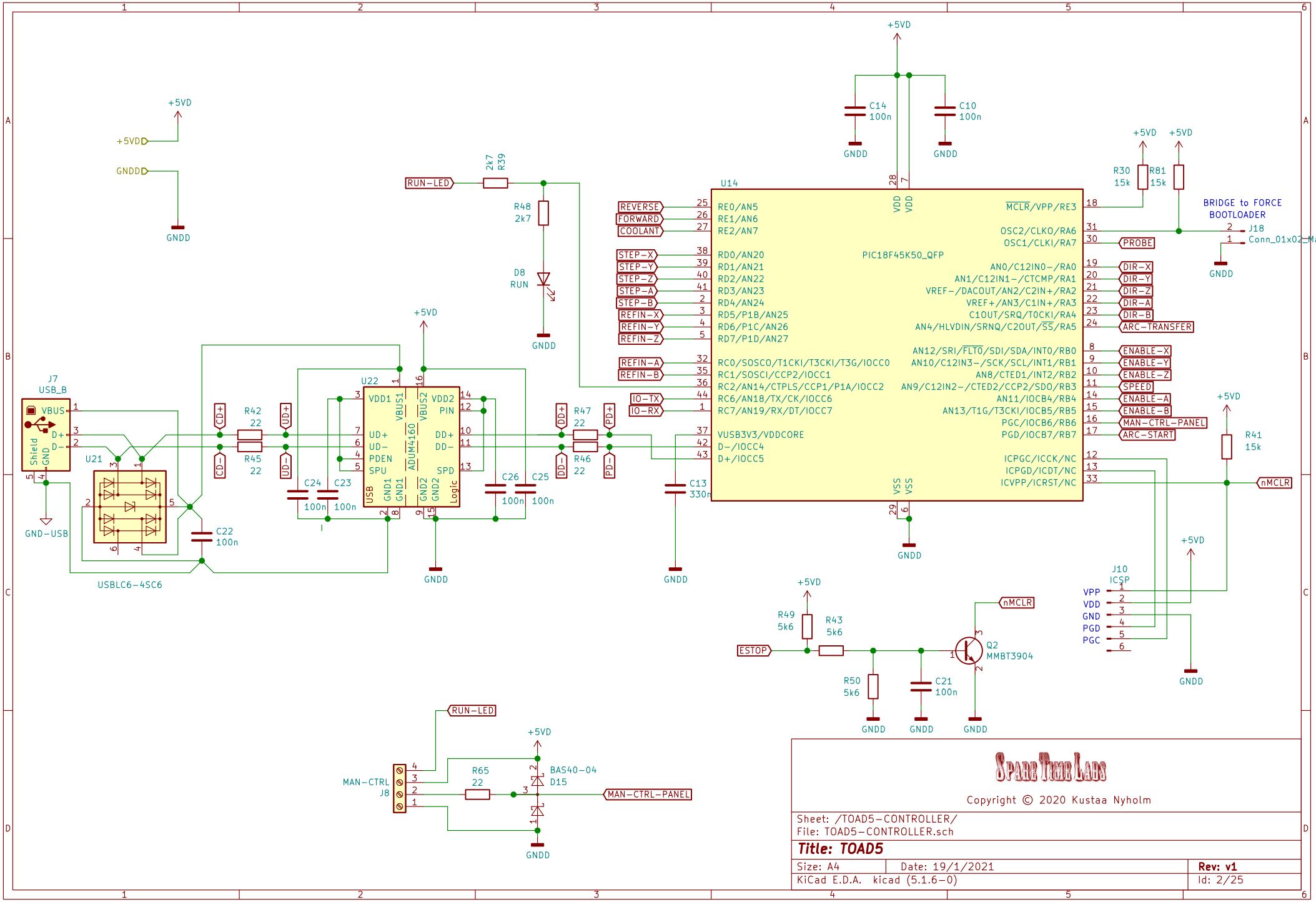
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FORWARD
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STEP-Y
STEP-Z
STEP-A
STEP-B
REFIN-X
REFIN-Y
REFIN-Z
REFIN-A
REFIN-B
IO-TX
IO-RX
RE0/AN5
RE1/AN6
RE2/AN7
RD0/AN20
RD1/AN21
RD2/AN22
RD3/AN23
RD4/AN24
RD5/P1B/AN25
RD6/P1C/AN26
RD7/P1D/AN27
RC0/SOSCO/T1CKI/T3CKI/T3G/IOCC0
RC1/SOSCI/CCP2/IOCC1
RC2/AN14/CTPLS/CCP1/P1A/IOCC2
RC6/AN18/TX/CK/IOCC6
RC7/AN19/RX/DT/IOCC7
VUSB3V3/VDDCORE
D-/IOCC4
D+/IOCC5
MCLR/VPP/RE3
OSC2/CLKO/RA6
OSC1/CLKI/RA7
AN0/C12IN0-/RA0
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VREF+/AN3/C1IN+/RA3
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AN8/CTED1/INT2/RB2
AN9/C12IN2-/CTED2/CCP2/SDO/RB3
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AN13/T1G/T3CKI/IOCB5/RB5
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PGD/IOCB7/RB7
ICPGC/ICCK/NC
ICPGD/ICDT/NC
ICVPP/ICRST/NC
VDD
VSS
PROBE
DIR-X
DIR-Y
DIR-Z
DIR-A
DIR-B
ARC-TRANSFER
ENABLE-X
ENABLE-Y
ENABLE-Z
SPEED
ENABLE-A
ENABLE-B
MAN-CTRL-PANEL
ARC-START
nMCLR
R30
15k
R81
15k
BRIDGE to FORCE BOOTLOADER
J18
Conn_01x02_Male
R41
15k
RUN-LED
R48
2k7
2k7
R39
D8
RUN
J7
USB_B
VBUS
D+
D-
Shield
GND
GND-USB
U21
USBLC6-4SC6
C22
100n
CD+
CD-
R42
22
R45
22
U22
ADUM4160
VDD1
VDD2
VBUS1
VBUS2
UD+
UD-
PDEN
SPU
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DD+
DD-
PIN
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GND2
Logic
C24
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C23
100n
C26
100n
C25
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C13
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DD-
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R46
22
PD+
PD-
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5k6
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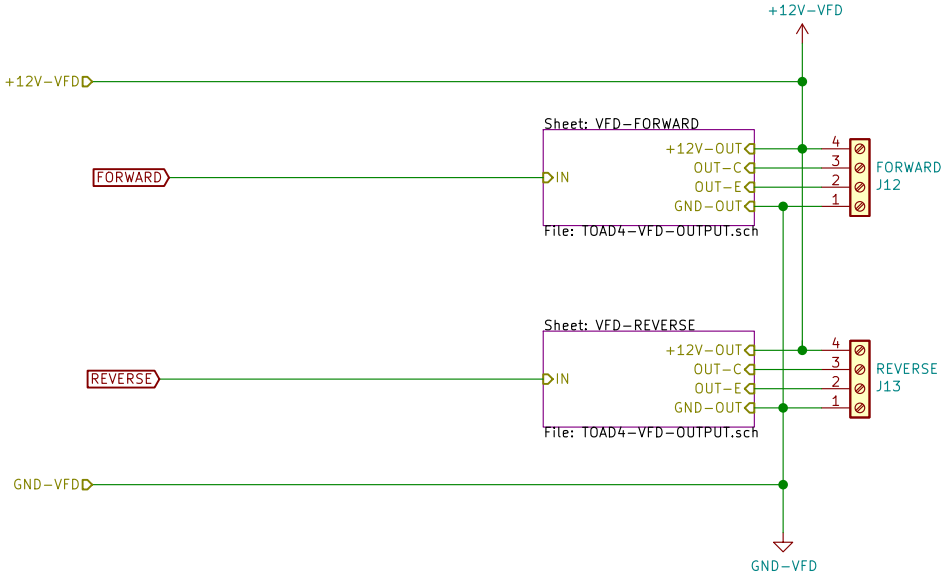

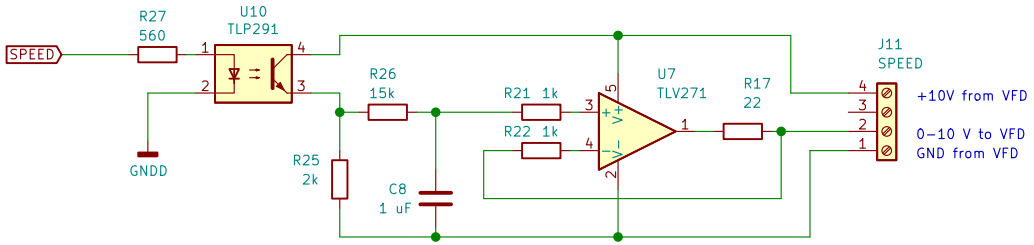

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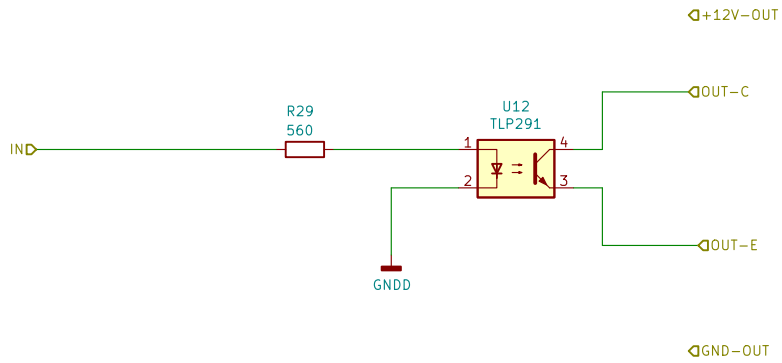

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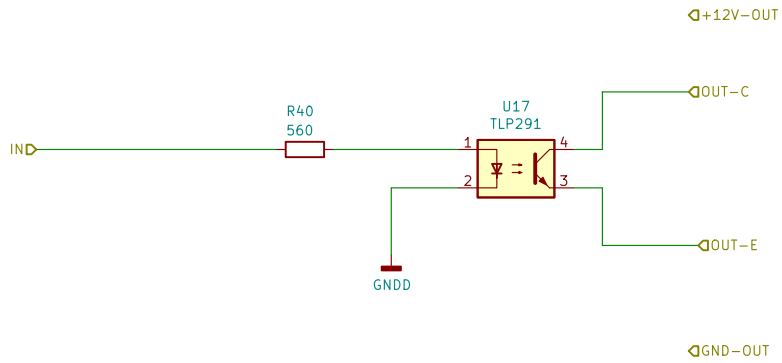

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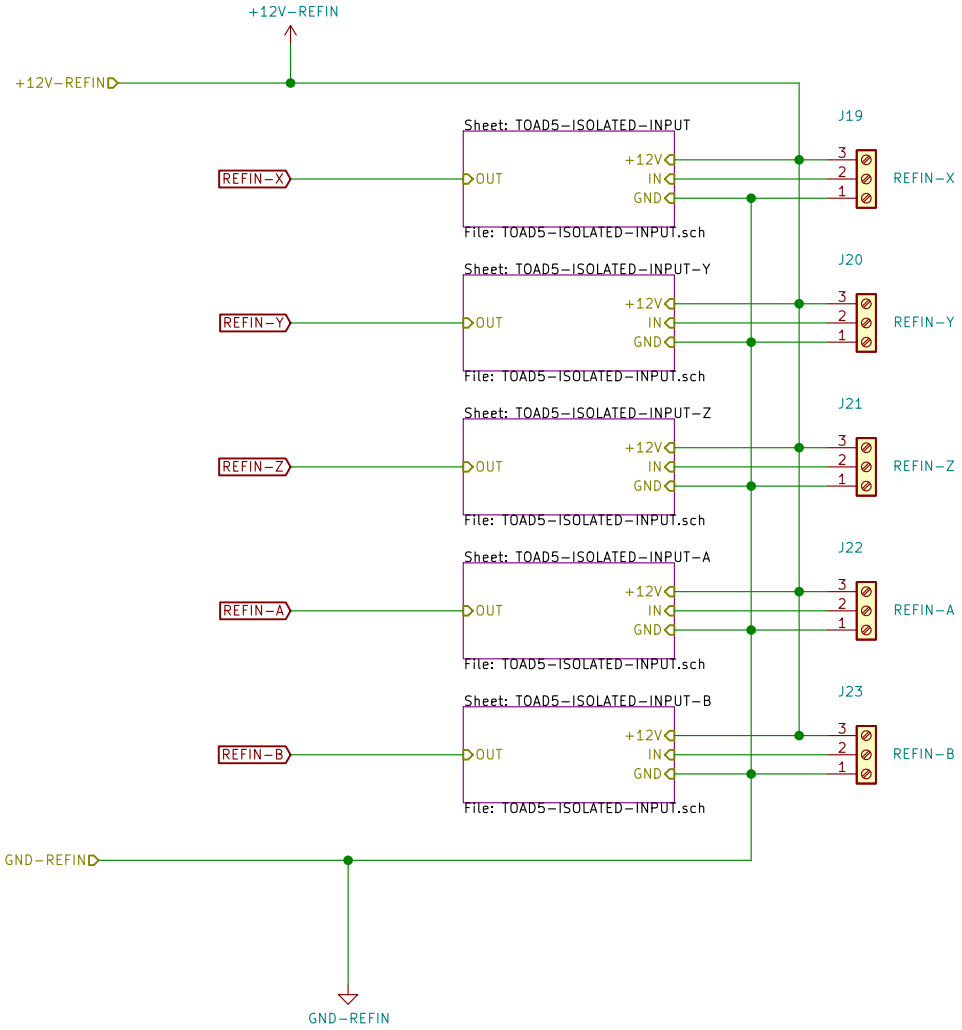

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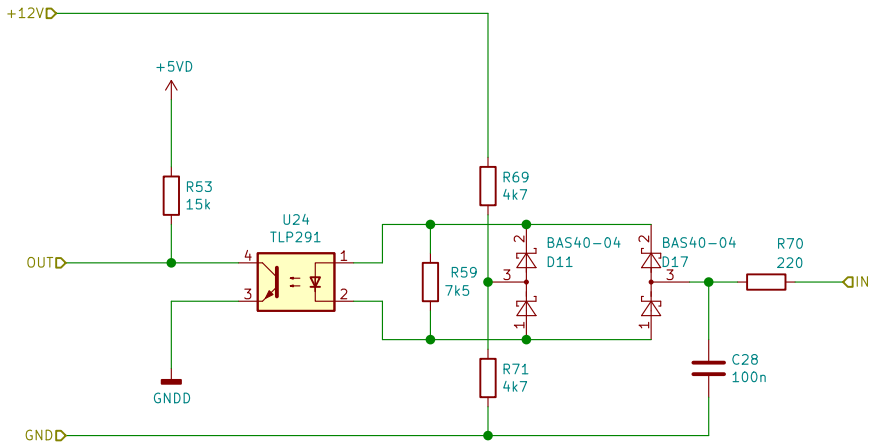

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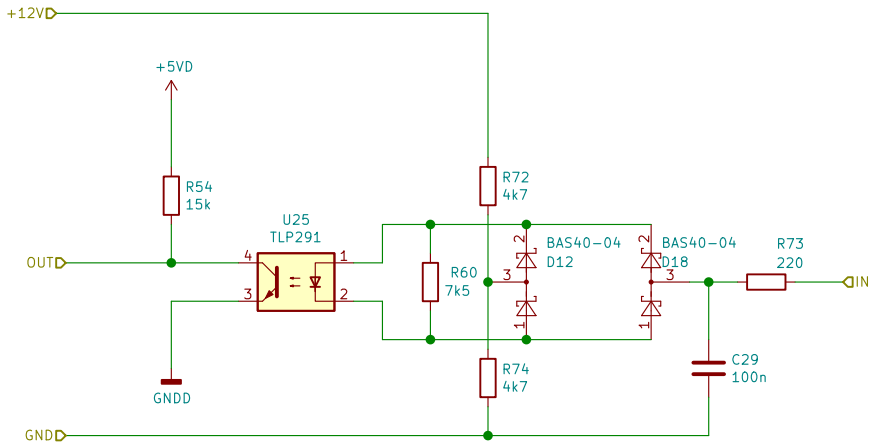

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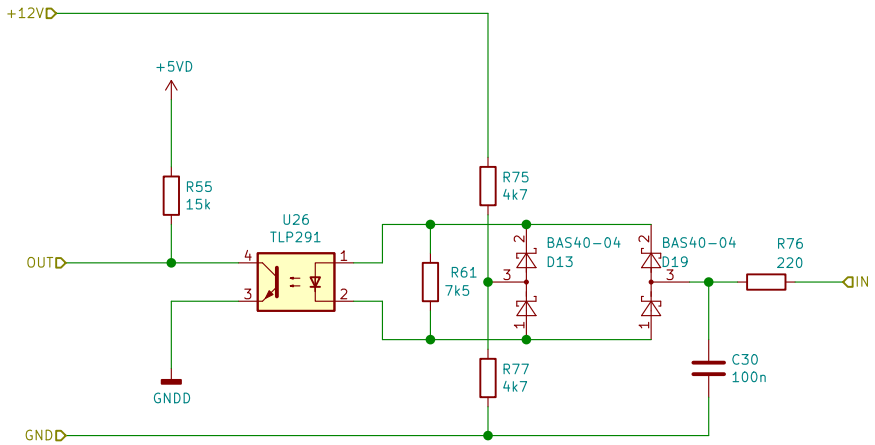

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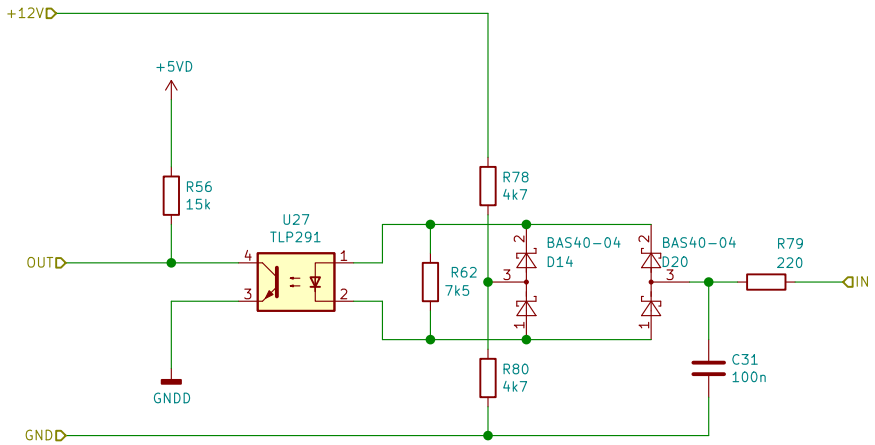

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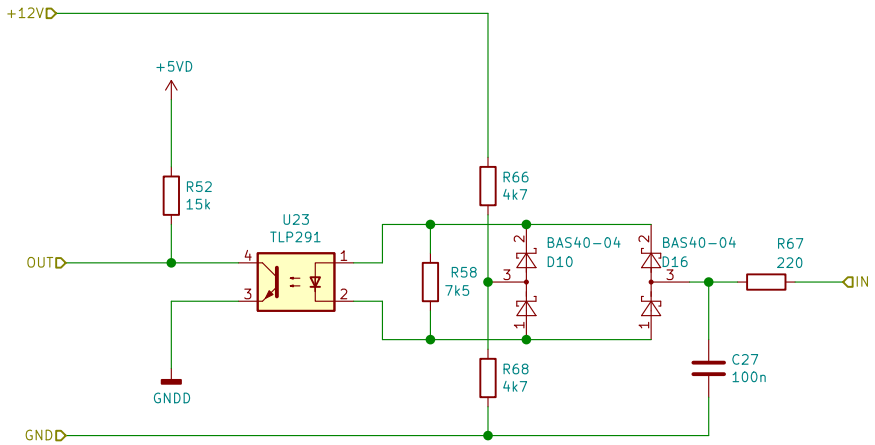

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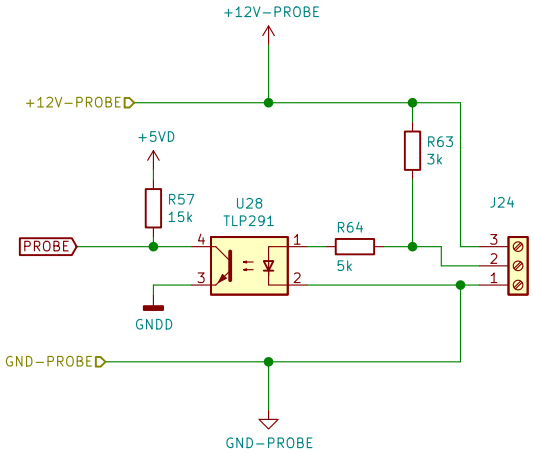

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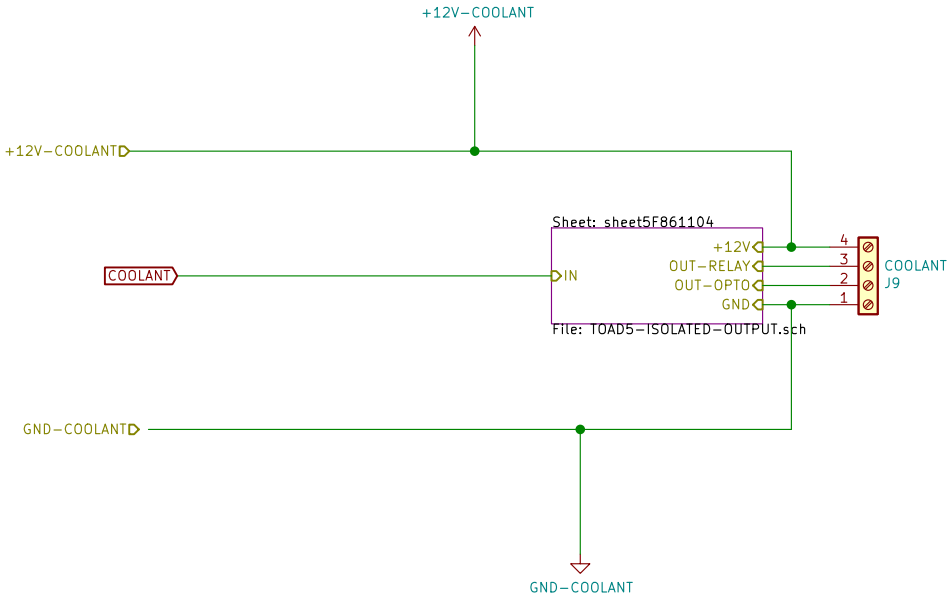

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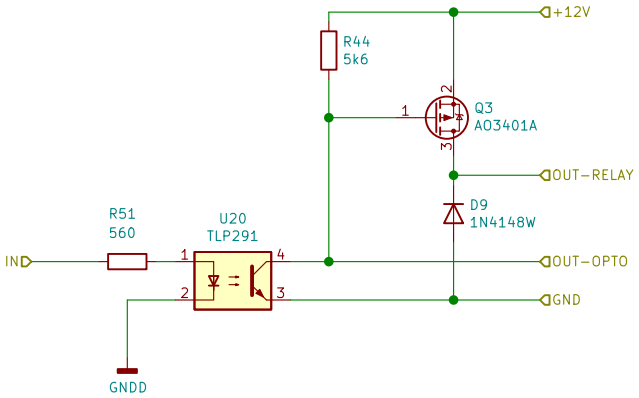

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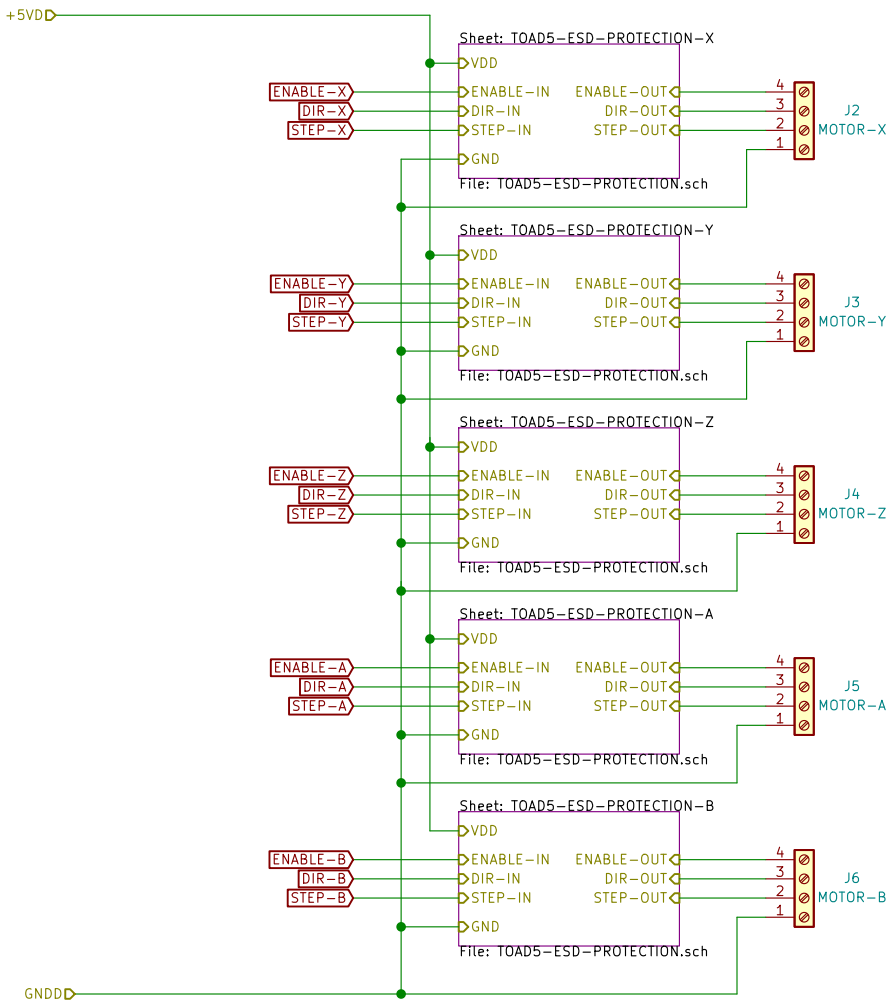

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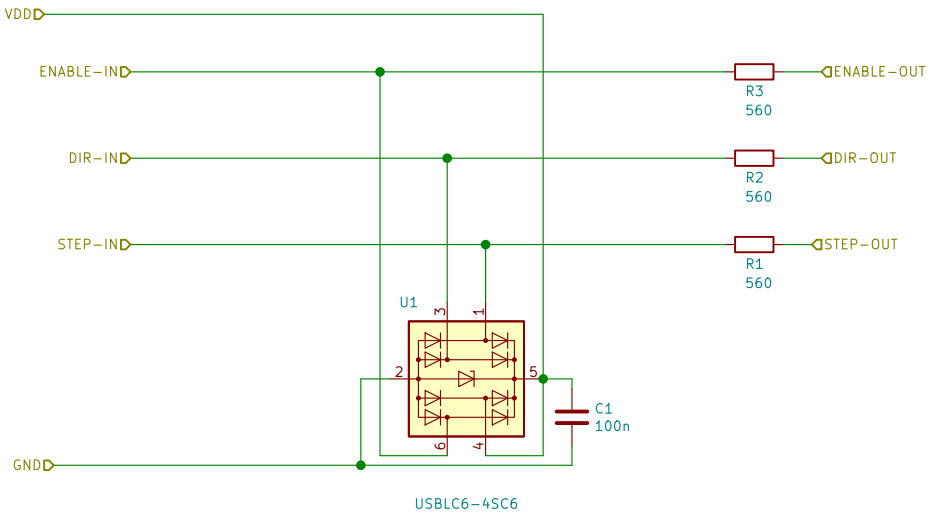

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Title: TOAD5

Size: A4	Date: 19/1/2021	**Rev: v1**
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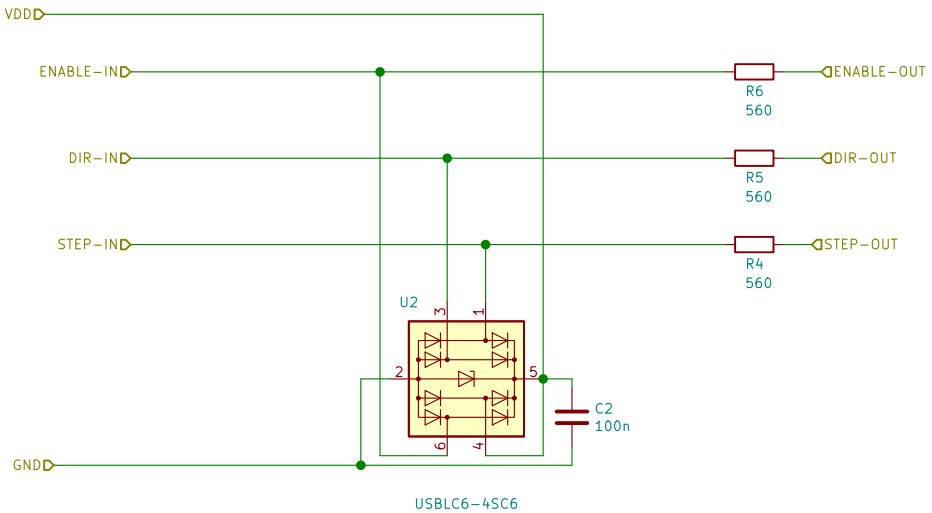

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Title: TOAD5

Size: A4	Date: 19/1/2021	**Rev: v1**
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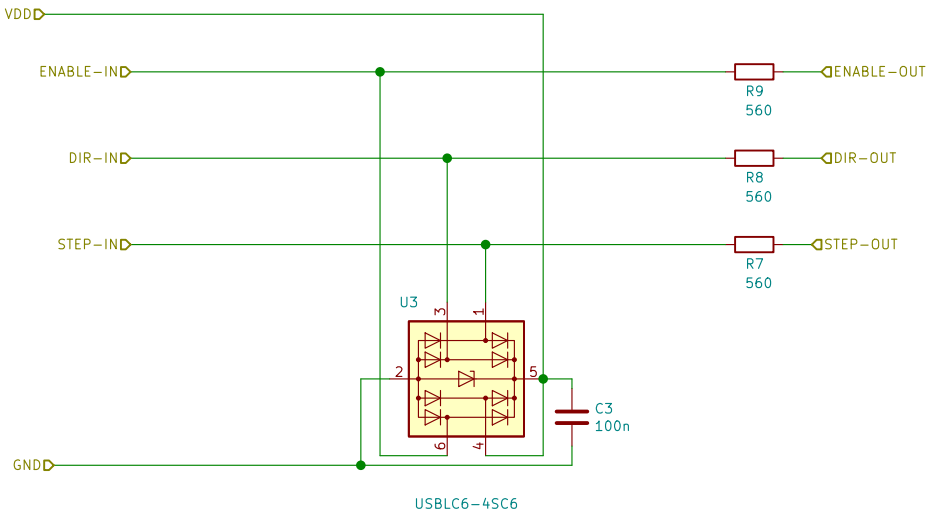

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Title: TOAD5

Size: A4	Date: 19/1/2021	**Rev: v1**
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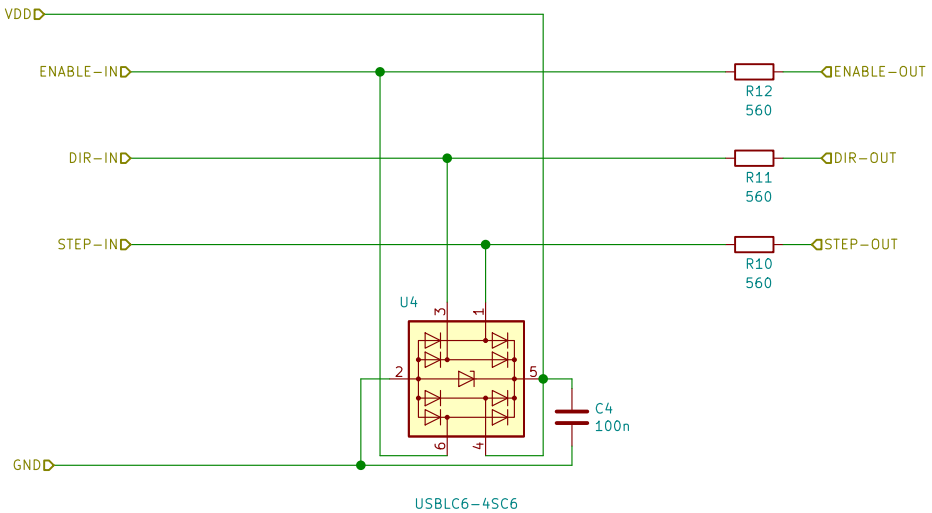

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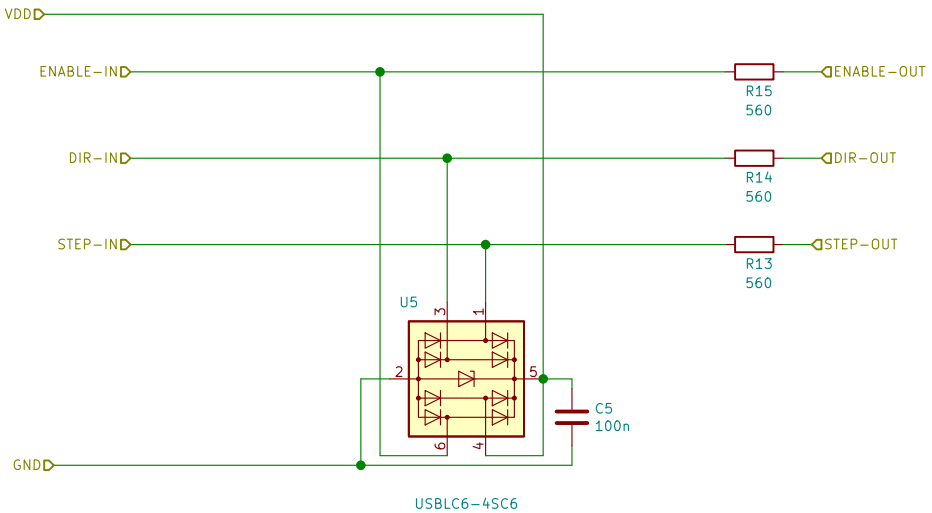
Title: TOAD5

Size: A4	Date: 19/1/2021	**Rev: v1**
KiCad E.D.A. kicad (5.1.6-0)		Id: 19/25



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Title: TOAD5

Size: A4	Date: 19/1/2021	**Rev: v1**
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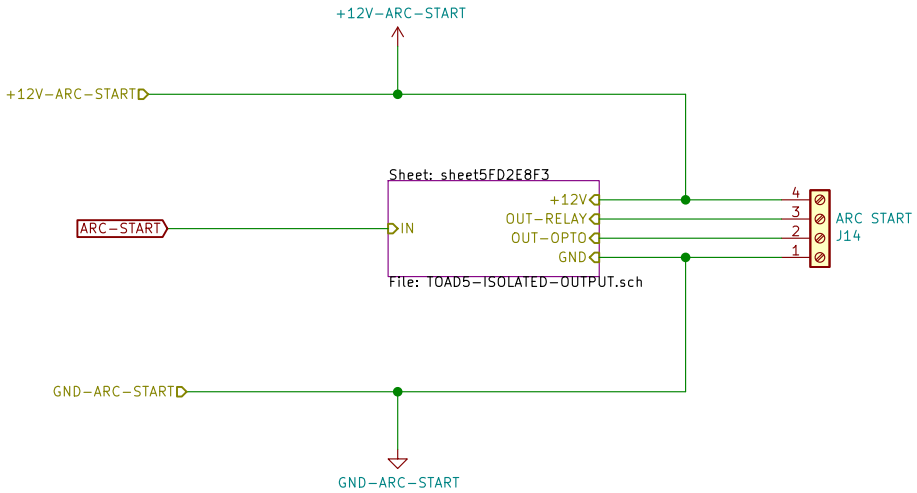

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Title: TOAD5

Size: A4	Date: 19/1/2021	**Rev: v1**
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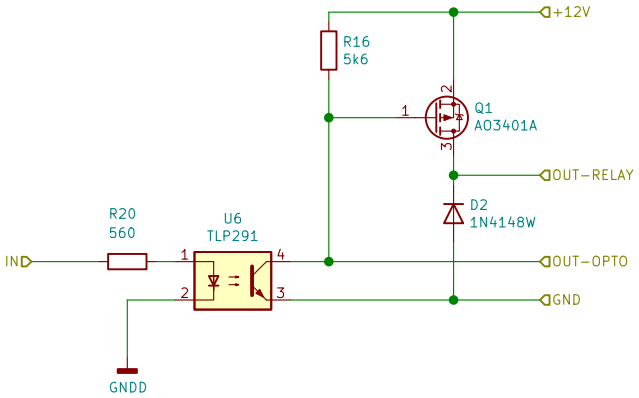

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Title: TOAD5

Size: A4	Date: 19/1/2021	**Rev: v1**
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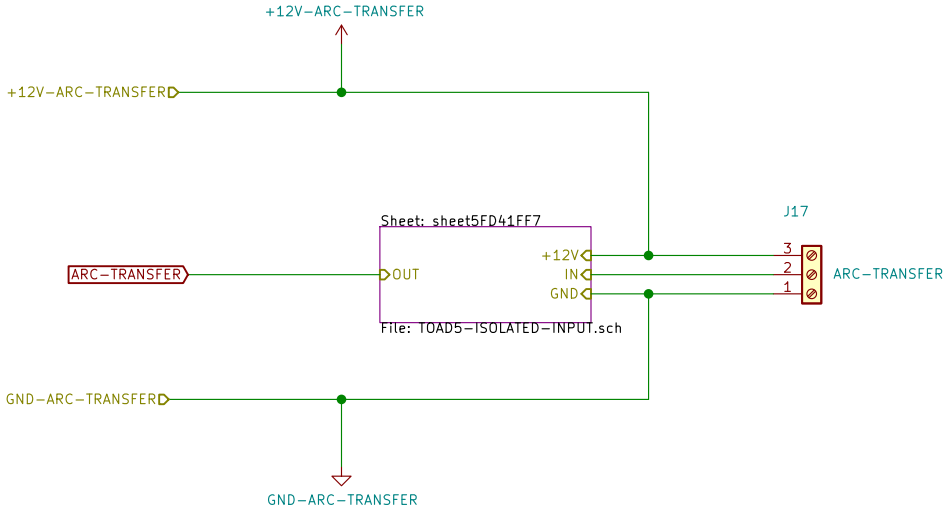

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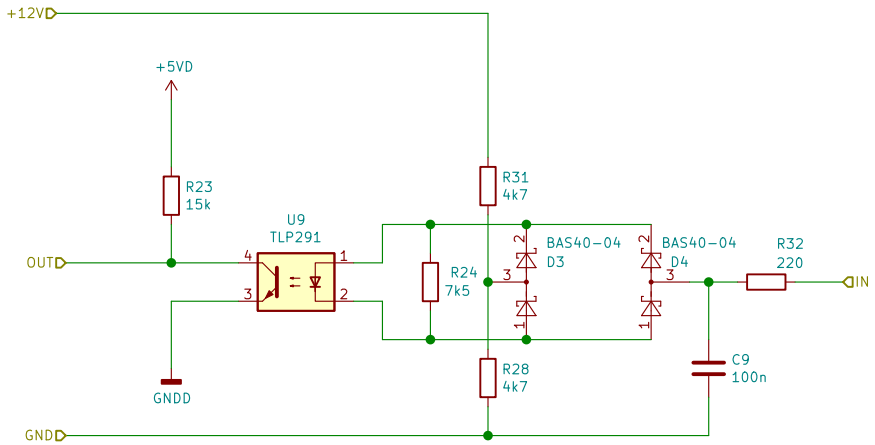
Title: TOAD5		
Size: A4	Date: 19/1/2021	**Rev: v1**
KiCad E.D.A. kicad (5.1.6-0)		Id: 23/25



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Title: TOAD5

Size: A4	Date: 19/1/2021	**Rev: v1**
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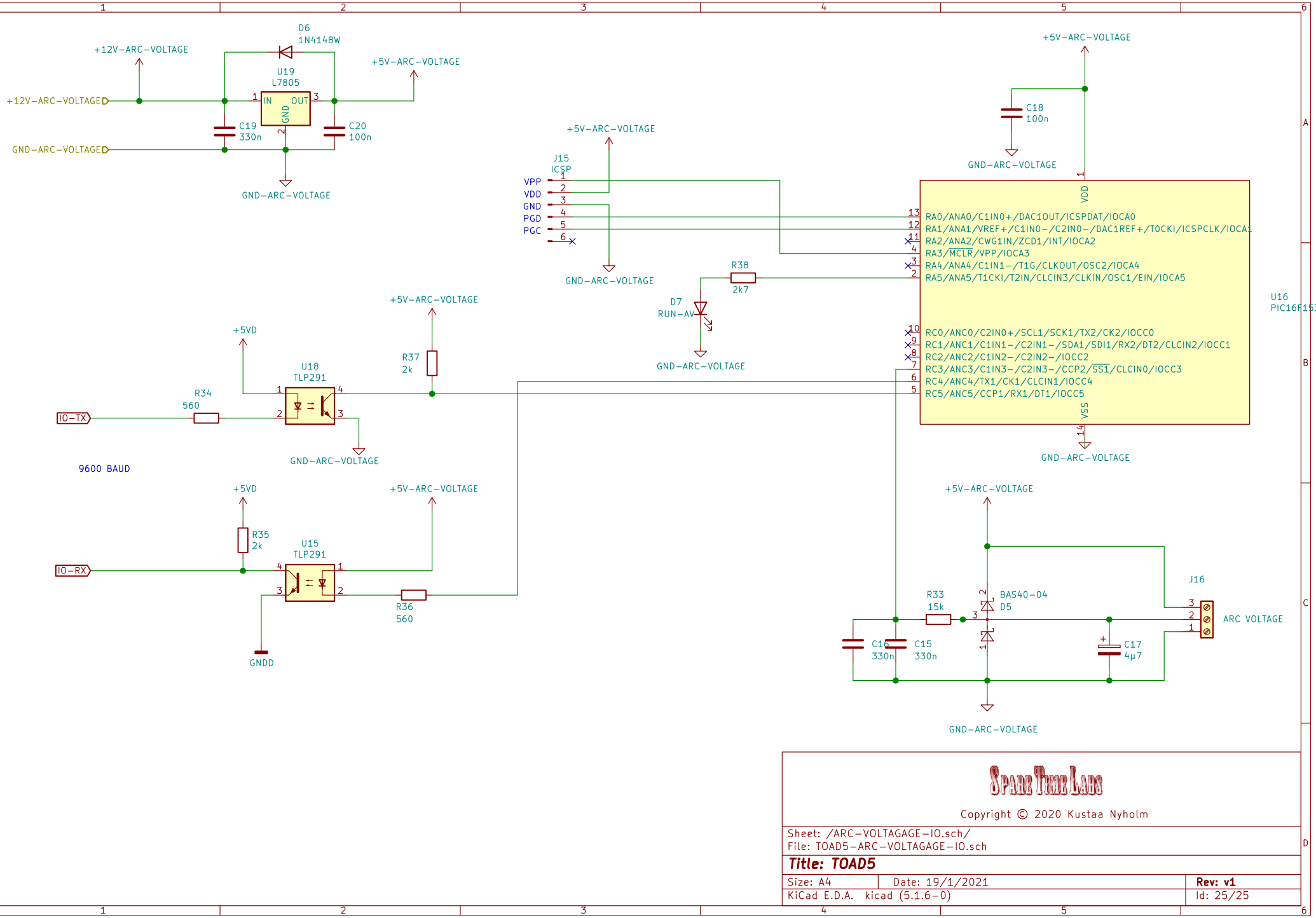

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Title: TOAD5		
Size: A4	Date: 19/1/2021	**Rev: v1**
KiCad E.D.A. kicad (5.1.6-0)		Id: 25/25

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