ToolAuth Hardware | Overview

This device is intended to help simplify the process of setting up and managing tool authorization control, in a shared workshop environment.

Specifically, this is designed for use at MakeHaven, in New Haven, Connecticut, USA from a previous solution. The circuit board shown here includes a place for an ESP32-DEVKITC-V4+ microcontroller (with wifi) to sit into place, and manage the functions of theboard and ultimately control access to power a tool. This schematic is broken into several pages to better clarify the circuit.

Microcontroller

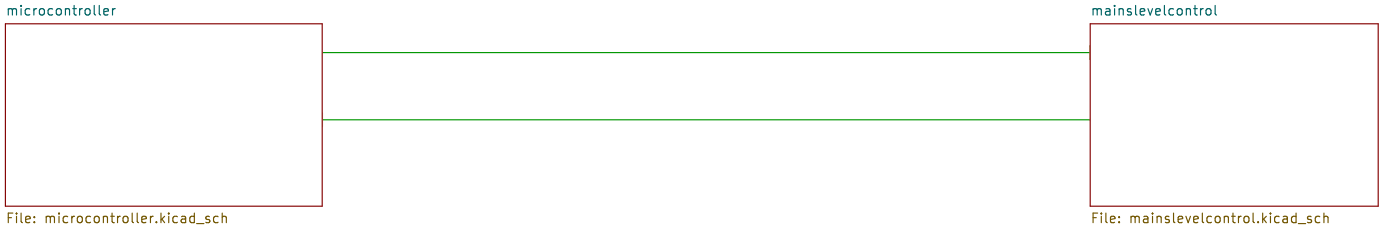
This section of the schematic covers everything that happens at 3.3VDC or 5VDC, including the microcontroller, peripherals, and some of the simple circuits needed to support the operation

Power for this section is provided by a sealed switching transformer soldered onto the board.

Mains Level Control

This section covers everything that happens at the AC power level: anywhere from 100VAC to 240VAC, provided the correct configuration.

There is only a single relay changed to cover voltage this range. All the panel-mount buttons, relays and Emergency Stops that ensure primary function of the tool-control are included here.



Based Around ESP32-DEVKITC-V4+ board

Highest Level Overview
Corey Rice & MakeHaven
Sheet: /
File: mh-custom-v1.3.kicad_sch
Title: ToolAuth Hardware | Overview | ESP32-DEVKITC-V4
Size: USLetter | Date: 2022-10-09 | **Rev: 3**
KiCad E.D.A. kicad (6.0.10) | Id: 1/10

Microcontroller Overview

This shows the relationships between all components running at 3.3VDC or 5VDC on the board. These are all on the 'low voltage' side of the board. These are all united in their service to the ESP32-DEVKITC-V4+ board, but that board itself is removable (for ease of programming and switching out the controller, without needing to rewire the tools).

ESP32 Core

esp32core

File: esp32core.kicad_sch

This shows a component to represent the ESP32-DEVKITC-V4+ board, as it will be seated in place. However, the component itself is not included on the circuit board, instead seating into some breakout headers for easy replacement. This page is for reference only, not design.

ADE7953

ade7953

File: ade7953.kicad_sch

The ADE7953 is a high accuracy current, voltage and power measurement chip that communicates with the ESP32 via I2C. There are three 3.1mm audio jacks to enable connecting CT split-ring clamp sensors. These CT sensors can be clamped around the wires that run power to the tool, to monitor the current and voltage draw throughout use. Additionally, there are a number of jumpers that can be soldered to modify the filtering circuits if necessary.

Breakout Board Connections

breakoutboards

File: breakoutbaords.kicad_sch

These are the connections for I2C, SPI, and the ESP32 headers. There is also a 3.3V linear regulator to power these daughter boards, without placing more draw on the ESP32's onboard linear regulator (this includes powering the ADE7953).

There is also a USB plug to provide access to 5VDC - this is primarily available so a panel mount USB power port can be added. MakeHaven can foresee wanting to add an external ESP32 to control an E-Paper display, and this USB port could provide easy access to power.

Lights, Sounds & Status

lightsounds

File: lightsounds.kicad_sch

This is a collection of the simple circuits that translate between voltage levels, break out the programming buttons for the ESP32, describe the DIP switches for configuration self-description, control the buzzer, and control the indicator LEDs. Many of these circuits use the 3.3V from the ESP32's onboard regulator.

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Sheet: /microcontroller/
File: microcontroller.kicad_sch

Title:

Size: USLetter	Date: 2022-10-09	**Rev: 3**
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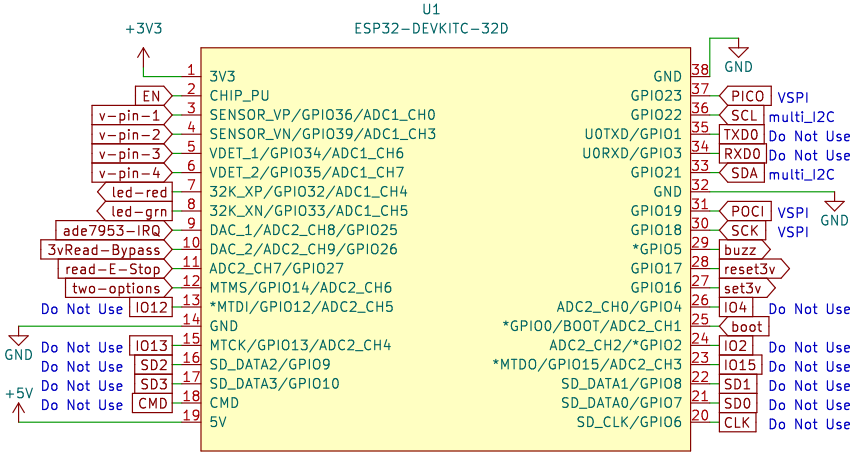
ESP32 DevKitC v4+



This shows a component to represent the ESP32-DEVKITC-V4+ board, as it will be seated in place. However, the component itself is not included on the circuit board, instead seating into some breakout headers for easy replacement. This page is for reference only, not design.

See headers for actual connections
Connections shown, but part excluded from BOM.

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Sheet: /microcontroller/esp32core/
File: esp32core.kicad_sch

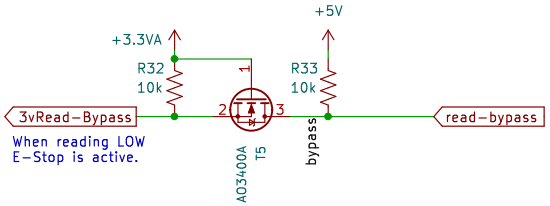
Title: Connections to ESP32 Board

Size: USLetter	Date: 2022-10-09	**Rev: 3**
KiCad E.D.A. kicad (6.0.10)		Id: 3/10

Lights, Sounds & Status

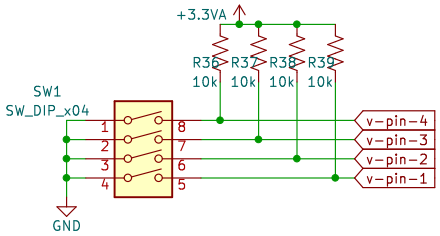
Read the Bypass Key

To have a quick, hardware workaround a bypass locking key is implemented in the 'set' stage 1 relay. This allows the ESP32 to read the state of that key to see if the system is in bypass mode.



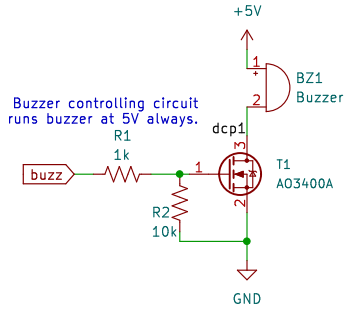
4-DIP Switches

Using a few 'spare' pins, wee can read the state of 4 dip switches to get feedback in software about the board configuration (that we assume is correct)
! see Docs for how to set switches !



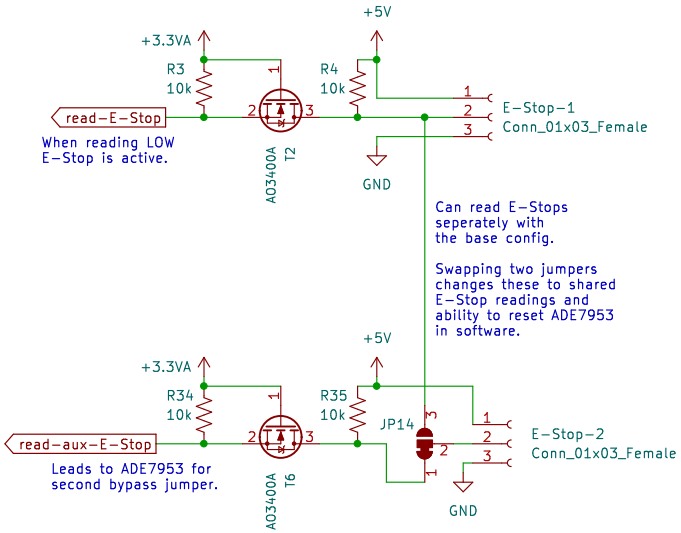
Piezo Buzzer Audio Feedback

A small piezo buzzer is loud enough to provide some auditory feedback through the toolauth box.



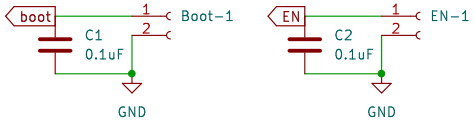
Read the E-Stop

An E-Stop is an essential Safety Measure in any workshop. This is a secondary switch on the E-Stop assembly (totaling 3 switches and an LED in the standard config). This circuit allows the ESP32 to read the state of the E-Stop.
! A second E-Stop low voltage circuit can be put in !
! parallel on one JST if an Auxilary E-Stop in use. !



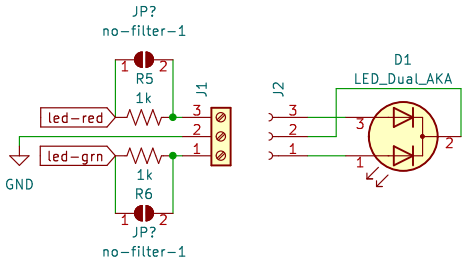
Programming Buttons for ESP32

access to small buttons outside of case [just for easy reprogramming of ESP32]



Panel Mount Status LED

A single panel mounted Red/Green LED will indicate states of the system for every card read. These LEDs are cheap and relatively easy to find in pre-made panel mount packages.



Breakout connections for the EN & Boot pins, for possible panel mount
DIP switches to describe hardware state
Logic Level shifters to read states of E-Stop(s) and Bypass Key
Buzzer and Panel Mount LED for Audio feedback to user

Corey Rice & MakeHaven

Sheet: /microcontroller/lightsounds/
File: lightsounds.kicad_sch

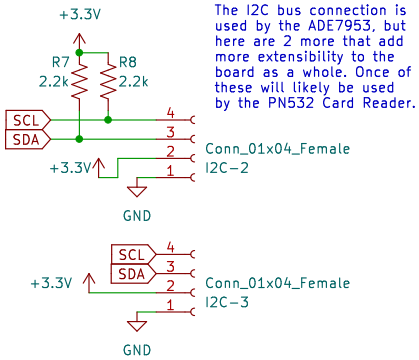
Title: Onboard Lights, Sounds and Logic Level Converters

Size: USLetter	Date: 2022-10-09	**Rev: 3**
KiCad E.D.A. kicad (6.0.10)		Id: 4/10

Breakout Board Connections

It takes more than just one board to make these controllers work.

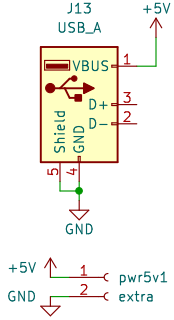
Dual I2C Connections



The I2C bus connection is used by the ADE7953, but here are 2 more that add more extensibility to the board as a whole. Once of these will likely be used by the PN532 Card Reader.

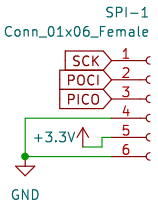
Power-only USB out

For ePaper or other 5V daughter boards that don't need data.



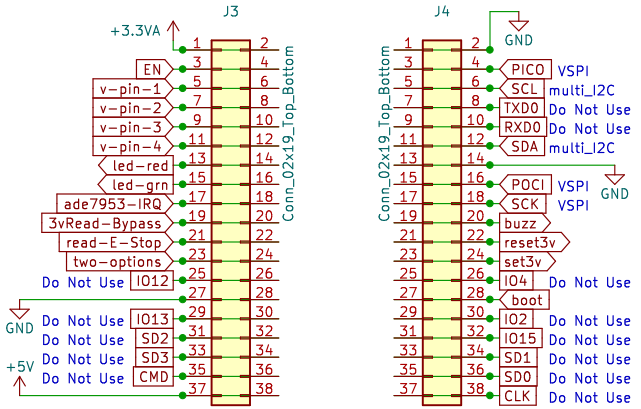
Single SPI Bus

There are only enough pins to cinfigure a single SPI connection by pulling the 'chip select' to GND with all the other pins needed on the board.
For this reason, choose your SPI friends wisely.



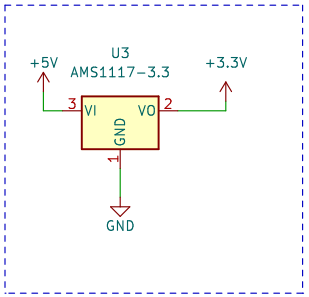
Headers for easy access to all of the ESP32 Pins

All of the connections are broken out to secondary pins, so they can be accessed fairly easily. This will probably not be needed in normal operation, but it definitely helps to diagnose hardware problems or give easy access to the happy matter-hackers that live in our space :)



Linear Regulator

Power demands on the ESP32 can be handled by its own linear regulator. This one is added to handle all breakouts, including the ADE7953, in hopes that the draw of the microcontroller is isolated from these.



A seperate Linear Regulator to better supply 3.3VDC where needed
Headers for the ESP32 to seat into the board
Breakouts for I2C and SPI communication with external boards.

Corey Rice & MakeHaven

Sheet: /microcontroller/breakoutboards/
File: breakoutbaords.kicad_sch

Title: Breakout Connections & Power

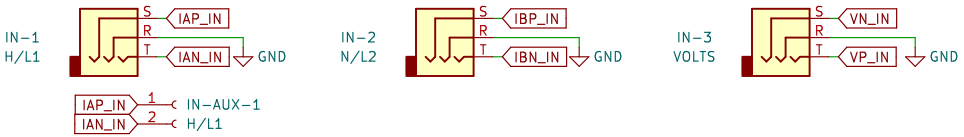
Size: USLetter	Date: 2022-10-09	**Rev: 3**
KiCad E.D.A. kicad (6.0.10)		Id: 5/10

ADE7953 Current Sensor

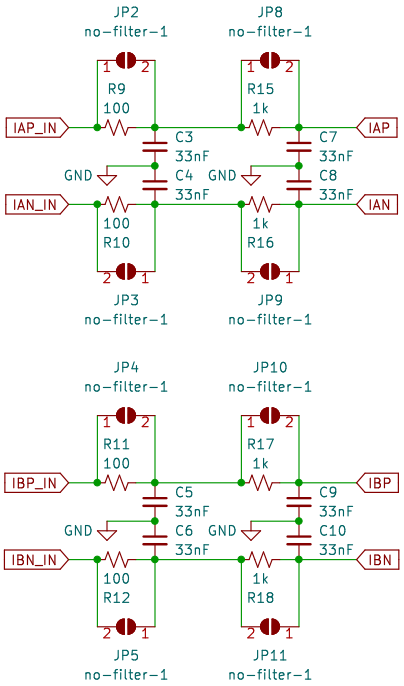
https://www.analog.com/media/en/technical-documentation/data-sheets/ADE7953.pdf

This current sensor was selected because it was known to work with the ESP32 and ESPHome (the main platforms of this project at large. It took several test-boards to get to a useful integration, yet much of this still just follows the documentation linked above. There are jumpers that can be soldered over, if the circuit needs any kind of fine turing from later observations.

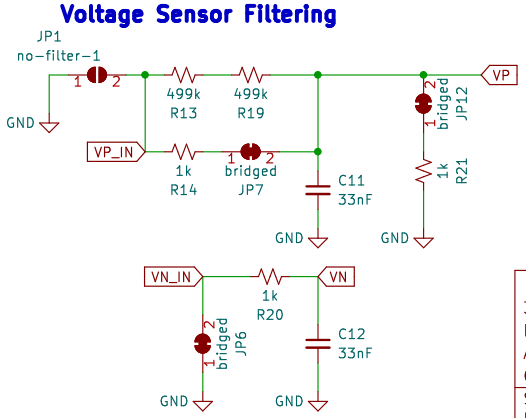
CT Clamp Connectors: 3.5mm Audio & two-pin backup

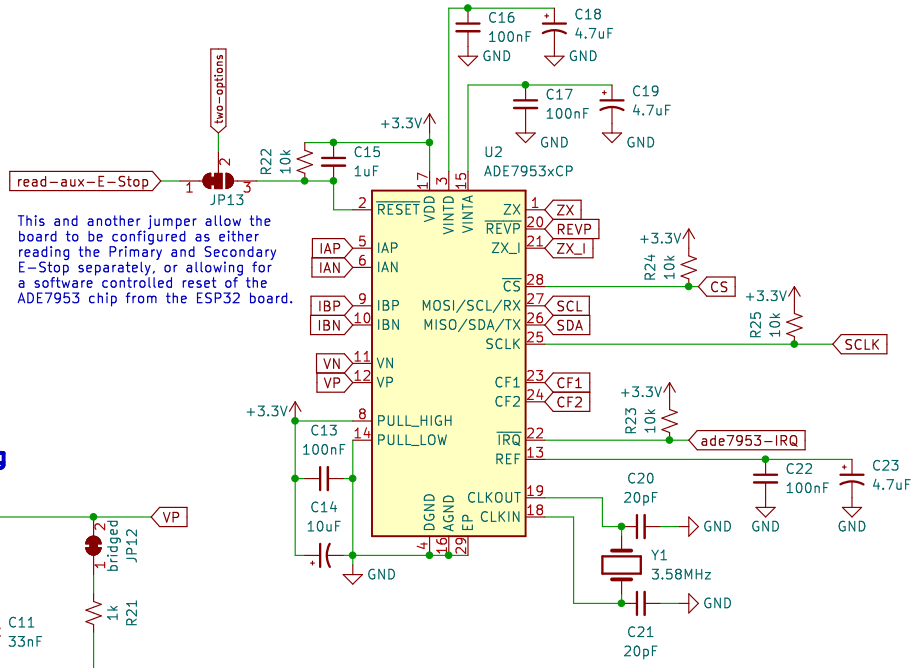


Current Sensors Filtering



Voltage Sensor Filtering





3 connectors added, to read 2 current channels and 1 voltage
Pull-up resistors added to configure chip for I2C communication
ADE7953 implemented as in engineering development board

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Sheet: /microcontroller/ade7953/
File: ade7953.kicad_sch

Title: ADE7953 Current Sensor

Size: USLetter	Date: 2022-10-09	**Rev: 3**
KiCad E.D.A. kicad (6.0.10)		Id: 6/10

Mains Level Control

The original version of these tool controllers (before this design)
required that this mains-level circuit be built by hand, every time.

The goal here is to build a latching relay system from non-latching relays, with the added benefit of available E-Stops.
Although a bit redundant, this design breaks up the control of power-access to a tool into three stages:

--> 1) Small relays that are controlled by a microcontroller, which allow access to use tool

--> 2) A larger relay that is triggered and controls mains-level voltage (also has 110 & 220 versions)

--> 3) An off-board contactor that actually transmits the full power needs of the tool

Stage 1

stage1relays

File: stage1relays.kicad_sch

This includes both logic-level relays circuits.

The page also shows the 5VDC sealed transformer and a simple 'sanity check' power LED :)

Stage 2

stage2relay

File: stage2relay.kicad_sch

This includes the one mains-controlled relay.

Also, the logic of the main latching circuit is outlined on this page.

The fuses are included here.

Stage 3

stage3contactor

File: stage3contactor.kicad_sch

With an off-board contactor this shows the logical loop that connects to the device.

The screw-terminal connectors are also shown on this page.

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Sheet: /mainslevelcontrol/
File: mainslevelcontrol.kicad_sch

Title:

Size: USLetter	Date: 2022-10-09	**Rev: 3**
KiCad E.D.A. kicad (6.0.10)		Id: 7/10

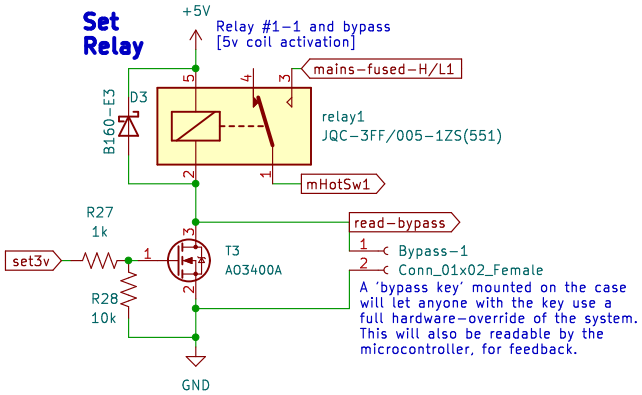
Stage 1 || Control from 5V & 'set' or 'reset' Stage 2 Latch

Relay1 [NOFF 'set' the Stage 2 relay's Latch] {5VDC coil activation}
Relay2 [NON 'reset' the Stage 2 relay's Latch] {5VDC coil activation}

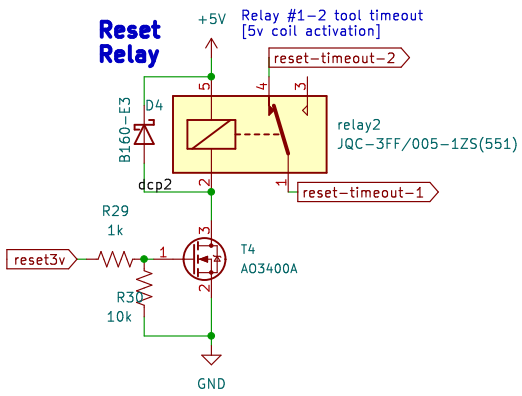
active self-latching of a relay https://electronics.stackexchange.com/questions/223691/self-latching-relay

This stage is responsible for allowing the microcontroller to control the actions of the mains level of power switching.

The 'SET' relay allows the tool to be turned on with the additional press of the green button by the human operator. Bypass locks this relay 'ON'

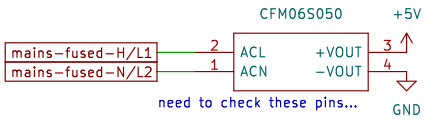


The 'RESET' relay will break the active latch on the Stage 2 relay. This is used as a way to auto shut off the tool - after end of observed current.

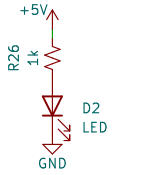


5V supply from mains (in box)

Sealed switching power supply, soldered in place.
Can accept 90-264VAC to generate 5V, up to 6W.
100mV ripple and 78% efficient, by datasheet.



sanity check power LED



A 'sanity check' LED is included to see that 5VDC is functioning
Mains voltage is converted to 5VDC for the microcontroller and more
Twin Stage 1 relays 'set' and 'reset' the Stage 2 latching relay

Corey Rice & MakeHaven

Sheet: /mainslevelcontrol/stage1relays/
File: stage1relays.kicad_sch

Title:

Size: USLetter	Date: 2022-10-09	**Rev: 3**
KiCad E.D.A. kicad (6.0.10)		Id: 8/10

Stage 2 || Core Functions run at full 110–230VAC

Relay 2 [main function] {110VAC or 240VAC coil activation}

active self–latching of a relay https://electronics.stackexchange.com/questions/223691/self–latching–relay

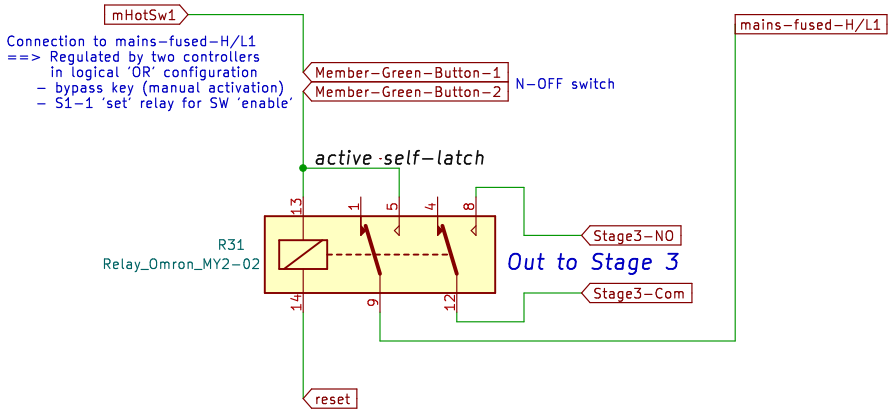
If there is a Stage 3 relay, then Stage 2 relay can have a lowered switching current –> down to approximately 2amps

Provides the majority of the Member's interface experience

The previous Tool–Controller design was just this section of the circuit (with simpler Microcontroller connection).

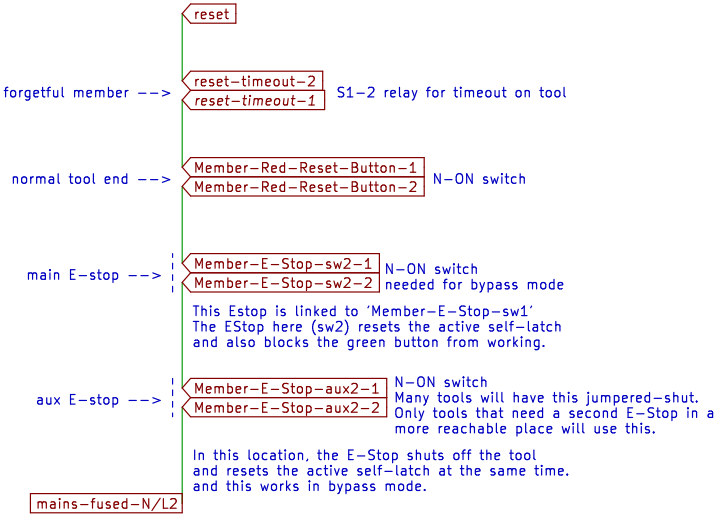
'Set' & 'Latch' circuit on Stage 2 relay

This portion of the circuit allows the Stage 2 Relay to turn on & stay on.
When enabled [by ESP32 or Bypass] a person can turn on the relay with the green button.
Once activated, the link from relay pin 5_to_13 'latch' the relay on while powered, until reset.
The "Can–Turn–On" light will shine if it is possible to 'set' the relay for any reason.
The light is important, because it shows a working system or if bypass mode is enabled by a key.



'Reset' circuit on Stage 2 relay

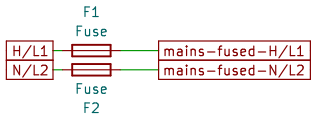
These are all the ways to 'reset' the Stage 2 relay.
[Not including overall loss of power, which also causes reset.]
Normally a member will press the red button. But they may also use the E–Stop to temporarily pause function, or the timeout could trigger automatically if programmed correctly...



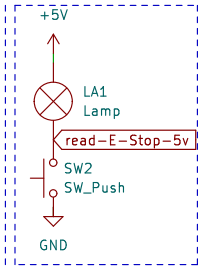
Fuse Protected Power Inputs

Mains power needs connected here, and will power the whole box.
Except, perhaps, the tool. If more exotic power is needed.

Labeled on PCB as H/L1 & N/L2 to cover the bases (that both may be live).



E–Stop on modular, panel–mount button



The E–Stop is connected from a 3–wire header:
>> 5V goes 'above' the incadescent bulb
>> Read goes 'between' E–Stop and switch
>> GND goes 'below' switch

The E–Stop light runs at 5V, and is shown here
becuase it conceptually makes sense on the sheet.

This lamp–to–switch connection is done on the
modular E–Stop switches themselves, not any PCB.

The middle 'read–E–stop' informs the microcontroller.

E–Stop low voltage light & switch logic shown for reference
Fuses added to power inputs, to protect board from improper wiring
Can be interrupted by E–Stops or the S1/'reset' relay
Once activated, relay holds itself open with power

Corey Rice & MakeHaven

Sheet: /mainslevelcontrol/stage2relay/
File: stage2relay.kicad_sch

Title: Stage 2 | Core 'Active Self–Latching' relay

Size: USLetter	Date: 2022–10–09	**Rev: 3**
KiCad E.D.A. kicad (6.0.10)		Id: 9/10

Stage 3 ||Final Contactor & Screw Terminals

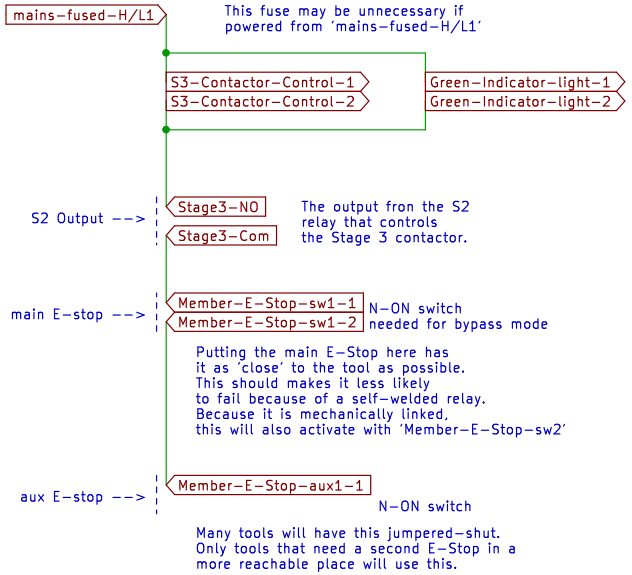
Output to control the Contactor, and a light to show the state.

Control for Final Contactor

With a separate connection, in parallel to everything else, this will power the stage 3 contactor. A green indicator light is used to show the state of power.

The primary E-Stop (sw1) works on this line, to directly cut power to the contactor and by extension the tool. This is mechanically activated at the same time as the sw2 Estop (on page 9) that resets the active latch held on the S2 relay.

The auxilary EStop is also here to ensure it can directly turn-off the tool, and the firmware will reset the S2 relay's active self-latch.



Use this board as Active and Passive door controller

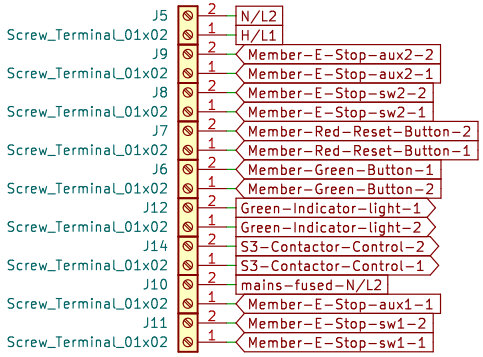
Active Door Control [such as to power a solenoid actvation directly]
***** Used nearly as intended as a tool, follow most labels
***** SW: requires 'set' and 'reset' relays to open/close door
--> Jumper shut as labeled: G.btn, R.btn, (both)EStpA, (both)EStpB
--> Use G.light as normal to indicate when door is open-able
--> Connect solenoid across OUT screw terminals

Passive Door Control [when contact between wires is all that is needed]
***** Includes Green Light for open-able indication (optional)
***** Needs S2 relay installed for the correct voltage
***** SW: requires 'set' and 'reset' relays to open/close door
--> Jumper shut as labeled: R.btn, [top/ starred on bottom] EStpA, EStpB
--> DO NOT connect in any way: G.light, [bottom/ unstarred] EStpA, EStpB
--> Attach the green indicator light in screw terminals labeled: G.btn
    to show when the door is open-able
    **A light or jumper MUST be installed across G.btn terminals
    **Revert to jumper if LED Green light blocks operation of S2 relay
      (or a parallel reverse-bias diode may allow LED light use)
--> Connect door-actvation wires as labled on back of board
    pins labeld with '*DOOR' [bottom] EStpA & [top] OUT

Screw Terminals for all functions

These screw terminals are broken out for all functions.
The terminals are in pairs, and labeled on the board.

Bonus mode: if you want to use this whole board as a low-current AC "smart switch" you can attach an interrupted 'Hot' line across J12-1 and J11-3.
Just don't exceed the limits of Relay 1-2 in Stage 1.



Jumper the EStp3 if there will not be any secondary EStop used
Screw-terminals shown here, to connect to mains-level devices
A fuse is added to protect the board from improper wiring
The contactor actually controls the tool, and is activated from J12 (or J11).

Corey Rice & MakeHaven

Sheet: /mainslevelcontrol/stage3contactor/
File: stage3contactor.kicad_sch

Title: Stage 3 | Contactor to power the Tool

Size: USLetter	Date: 2022-10-29	**Rev: 3**
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