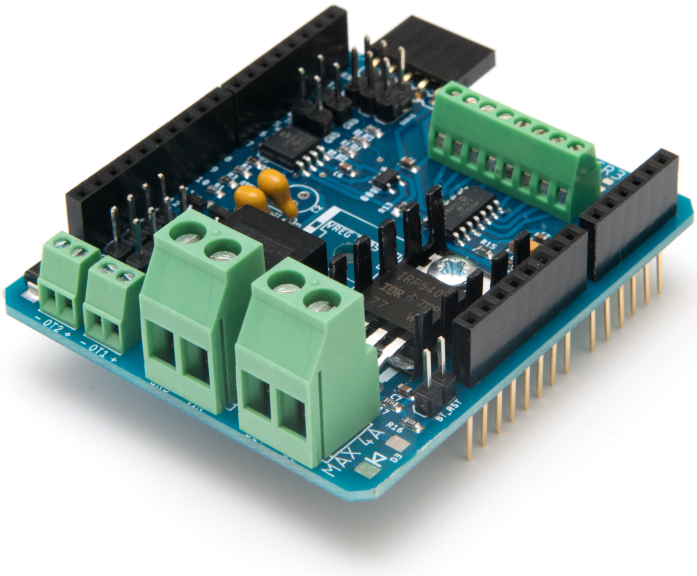
# TC4+ Arduino Shield
# Quick Start Guide

May 23, 2022



## Contents

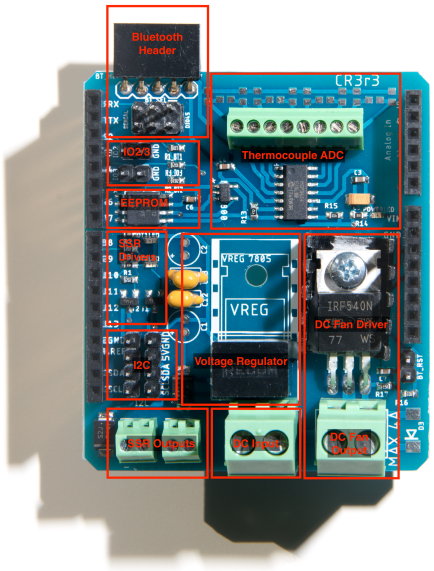



Figure 1: The TC4+ board and its on-board components.

# 1 Overview

The TC4+ is an Arduino shield providing a 4-channel thermocouple interface and driver logic for AC and DC loads. The main components on the board are shown above in Figure 1. The next page shows all connectors and status LEDs schematically. The most important components are:

- 4-channel thermocouple interface using high-resolution ADC with cold-junction compensation for accurate temperature monitoring.
- DC In and DC out screw terminals; voltage regulator to supply the Arduino from DC In; MOSFET to control DC Out.
- OT1 and OT2 screw terminals to control SSRs.

The rest of this guide will briefly describe how to assemble, connect and configure the TC4+ board in common scenarios.
**Important:** This is only a quick start guide, and only about interfacing the TC4+ board. It is not a guide on how to build your own coffee roaster. Do your own research, especially regarding safety. The TC4+ is intended for use by qualified professionals. If you are not qualified to work with mains electricity and in fire safety, get professional help.
**Important:** The TC4+ includes several components that are very sensitive to electrostatic discharge, including the ADC and temperature sensor in the thermocouple interface, and the IRF540 MOSFET for the DC driver. Follow appropriate procedures when handling the TC4+. Failure to do so may result in damage to these components.

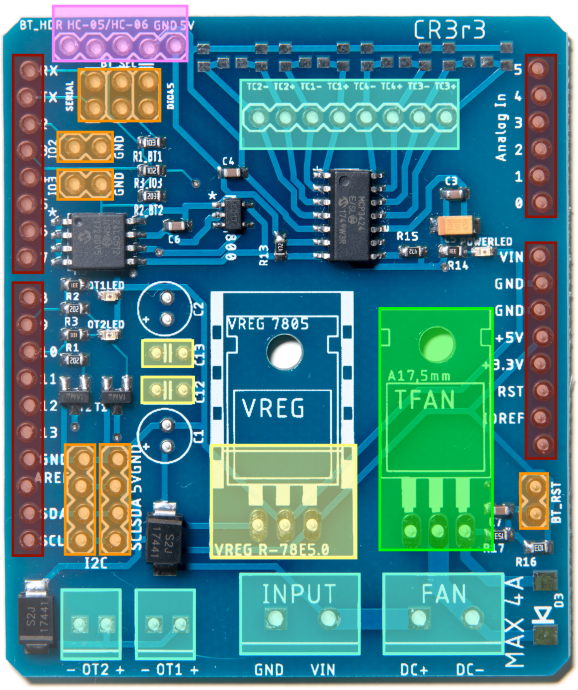



Figure 2: Layout of TC4+ through-hole components (v4 and earlier).

## 2 Assembly (kit version)

If you purchased a TC4+ KIT, it will come with all surface-mount devices soldered, and loose through-hole components which you will have to solder yourself. Figure 2 and Figure 3 show the location of these components in different colours:

- Dark Red: Stackable headers.
- Orange: Male headers; break apart as necessary. [1]
- Orange: Male header 2x1, VREG_EN, near centre of board, not shown on photograph. On v5 and higher only.
- Pink: Angled female header.[2]
- Blue/Turquoise: Screw terminals. [2]
- Yellow, labelled VREG: Voltage regulator. The kit comes with a R-78E5.0 switching regulator.
- Yellow, C12/C13:
  - On version 4 and earlier: 10uf ceramic capacitors. C1/C2 are not used with the R-78E5.0 switching regulator. On newer versions of the board, C12/C13 have an additional third soldering hole to more

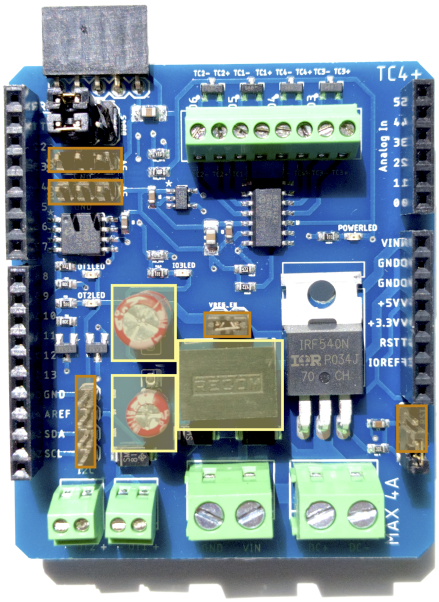



Figure 3: Layout of TC4+ v5 through-hole components. Pin headers and jumpers (marked in orange) and capacitors for voltage regulator (marked yellow) are slightly different than in earlier versions.

easily accommodate capacitors with wide leg spacing. You can use the outer two holes.

  - On version 5: Electrolytic capacitors. C12 is 10nF, C13 is 22nF. **These are polarized:** The positive legs need to go to the two outermost holes. The negative legs should be closer together, and can be either the middler or innermost holes, whichever are easier.

- Green, labelled TFAN: IRF540 transistor. A heatsink or screw are usually not necessary, and not included.

**Notes:** [1] BT_SEL (2x3, top left), BT_RST (1x2, bottom right) and VREG_EN (1x2, center of board) are for jumpers, so male headers are required. For the I2C, IO2 and IO3 headers, a different connector could be used if preferred.
[2] Included connectors are suggestions – any other 2.54mm / 5.08mm spaced header could be used. For the Bluetooth board, an angled female 4/5 pin header will have the Bluetooth module horizontal next to the TC4+ shield. For vertical BT module, use a straight female 4/5 pin header.

# 3 Connecting to your roaster

This section will briefly list how to connect the TC4+ to the most common accessories. Figure 4 shows the location and layout of all connectors and status LEDs on the TC4+. See the end of the section for a complete application example.

## 3.1 Connecting to the Arduino

Stack the TC4+ shield on top of an Arduino Uno R3, or compatible. The long pins on the underside of the TC4+ go into the corresponding headers on the top side of the Arduino.

## 3.2 Connecting thermocouples

The TC4+ provides four thermocouple channels. These are provided in an 8-pin screw terminal near the "north" edge of the board. Due to board layout constraints, the order of the pins is not ascending, but in order CH2-, CH2+, CH1-, CH1+, CH4-, CH4+, CH3-, CH3+. See Figure 5 for details.

Usually, you will want to use one K-type thermocouple probe each to measure bean temperature (BT) and air temperature (ET). Connect ET to channel 1, and BT to channel 2. Positive and negative wires need to be correct - if you see wrong temperature readings, try reversing the wires. If you thermocouple probe comes with a plug, remove it either by unscrewing if possible or else cutting it off.

## 3.3 Connecting to DC power

The DC IN terminal can be connected to a DC power supply. This will supply power to two things: Firstly, to the TC4+ and the connected Arduino. Secondly, to a connected DC motor (or other DC load). If you intend to connect a DC

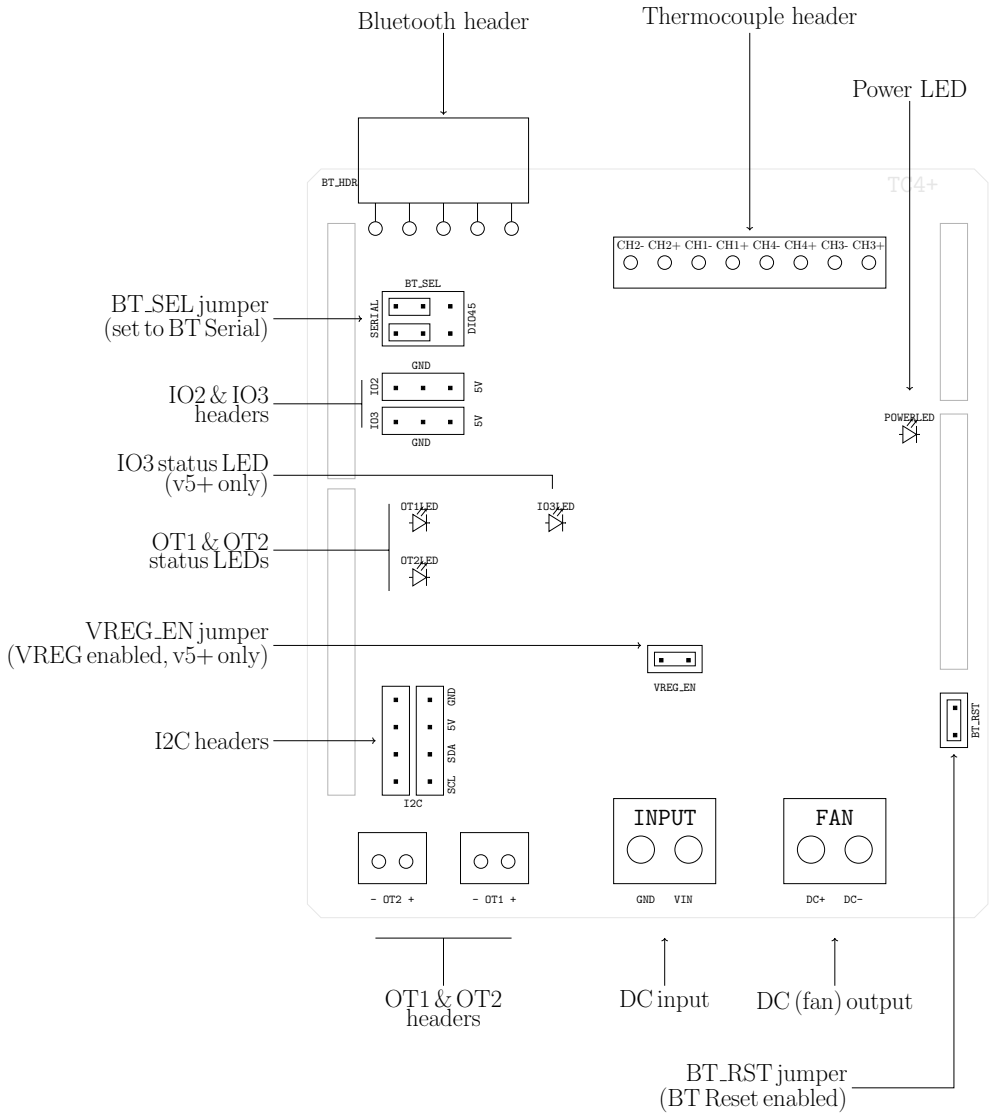



Figure 4: Layout of all connectors, jumpers and status LEDs on the TC4+ board.

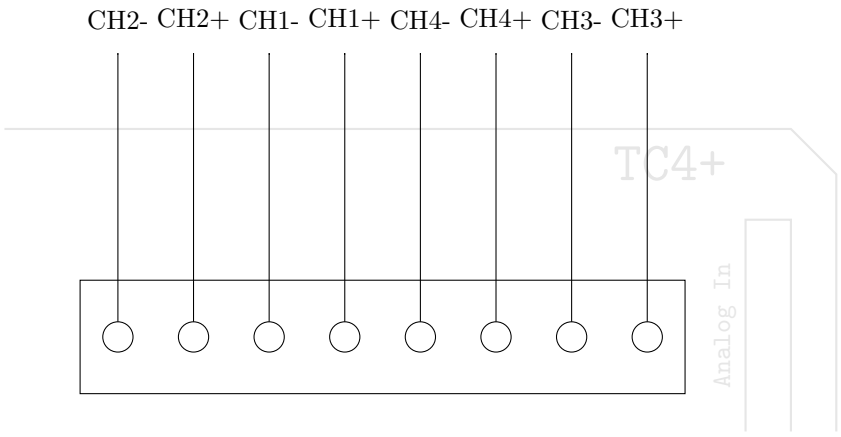



Figure 5: Layout of the thermocouple channels on the TC3 board.

motor, connecting a DC power supply is required. If not, this is optional - the TC4+ and Arduino could alternatively be powered by USB.

The DC power supply should match the voltage of the DC motor. That is, if your motor needs 20V, choose a 20V PSU. The rated current of the PSU must match or exceed the power draw of the motor. If the motor draws 2A, choose a PSU that is rated for at least 2A. The voltage of the PSU should also be within the range of the on-board voltage regulator, which is 7-28V. If you need more for your motor, replace the voltage regulator with an appropriate model.

Connect the power supply to the DC in screw terminal. Take care of correct polarity: Positive goes to VIN, negative goes to GND.

When using the DC IN header, it is recommended to connect to the board using Bluetooth, or if using USB, to use a USB optoisolator.

On v5 and higher of the board, a jumper header is provided next to the voltage regulator (2x1 header near the center of the board) labelled VREG_EN. This can be used to connect or disconnect the voltage regulator. When using USB, it is recommended to disconnect this jumper. When using Bluetooth and thus powering the board from the DC IN header, this jumper must be shorted. On v5 and higher, the onboard voltage regulator feeds 9V into the Arduino's VIN rail rather than 5V into the 5V rail.

## 3.4 Connecting to a DC motor

You can connect a DC load, like a fan motor, to the DC OUT terminal.
**Important:** You must also connect a suitable flyback diode. That is, a diode that is connected across the motor terminals, in opposite direction to usual current flow. See Figure 6. This is to prevent damage to the MOSFET. Either solder an appropriate diode to the motor (preferred), or screw it into the screw terminal together with the motor power cables. (Be careful of correct polarity, or you will create a short!) Make sure the diode is rated appropriately. If your motor was originally connected to a bridge rectifier, you might want to reuse one of the diodes from the rectifier.
**Important:** DC motors can generate a lot of electrical noise, which can affect

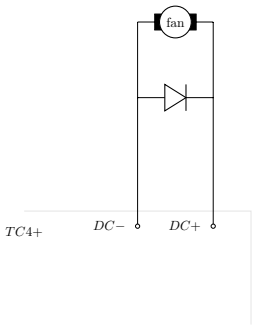



Figure 6: A flyback diode across the motor.

thermocouple readings among other things. If your motor came with capacitors or inductors connected to it, leave those in place, and connect the TC4+ to the entire motor circuit. If you sourced a plain motor, take appropriate steps to filter out noise.

## 3.5 Connecting a heating element

The TC4+ has two SSR drivers which can be used for heating elements. You will need a DC-AC solid-state relay. Connect the DC side to OT1, taking care of correct polarity. Connect the AC side of the SSR to the LIVE AC line going to the heating element.
**Important:** If your popcorn machine came with a thermal fuse, make sure this stays connected in series with the heating element. If it didn't come with one or you sourced your heating element separately, I strongly recommend connecting a suitably placed thermal fuse in series with the heater.
**Important:** Powering your heating element without airflow might result in near-instantaneous overheating.
**Important:** Exercise care when mains voltage is, or might be, present.

## 3.6 Connecting an AC fan

AC fans are slightly more complex to control. There is two options of interfacing with them: A separate PWM dimmer module (recommended), or a zero-cross detector (beyond the scope of this guide).

To control an AC fan via a PWM dimmer module, you will need a PWM dimmer module. One verified option is this: `https://www.tindie.com/products/bugrovs2012/pwm-ac-light-dimmer-module-50hz-60hz`

To connect this, use a three-pin cable to connect the PWM header on the PWM dimmer board to the TC4+. 5V goes to 5V, GND goes to GND. PWM goes to IO3. The AC side of the PWM dimmer board connects to the mains, and to the AC fan, respectively.
**Important:** Exercise care when mains voltage is, or might be, present.

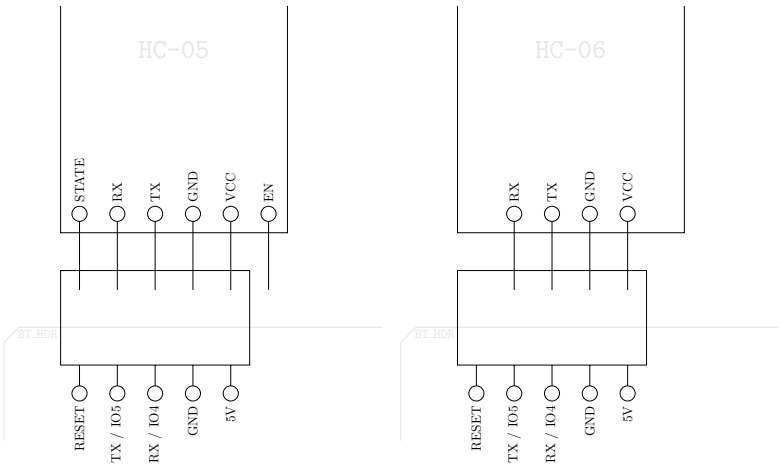



Figure 7: Connection of the HC-05 (left) and HC-06 (right) Bluetooth modules.

## 3.7 Bluetooth Header

The board provides a 5-pin header for a HC-05 or HC-06 Bluetooth module. This allows wireless roast monitoring and control. With a HC-05 (but not HC-06), you can also wirelessly upload Arduino sketches. See Figure 7 for how to connect either module. See the configuration section for details on how to set up the connection.

## 3.8 Application Example

The TC4+ board was designed to simplify control of popcorn machine based home coffee roasters. In such a scenario, the board would be connected as follows.

- The INPUT (GND / VIN) screw terminal connects to a DC power supply unit.
- The FAN (DC+ / DC-) connects to the fan motor. A suitable flyback diode would be soldered directly to the motor terminals.
- Thermocouple channel 1 connects to a thermocouple measuring the temperature of the incoming air (optional).
- Thermocouple channel 2 connects to a thermocouple measuring the temperature inside the roast chamber.
- The Bluetooth header connects to a Bluetooth module.
- The OT1 screw terminal connects to a solid state relay (SSR), which in turn controls the AC live wire going to the heating element. A thermal fuse in series with the heater is strongly recommended.

Figure 8 gives a schematic with all these connections.

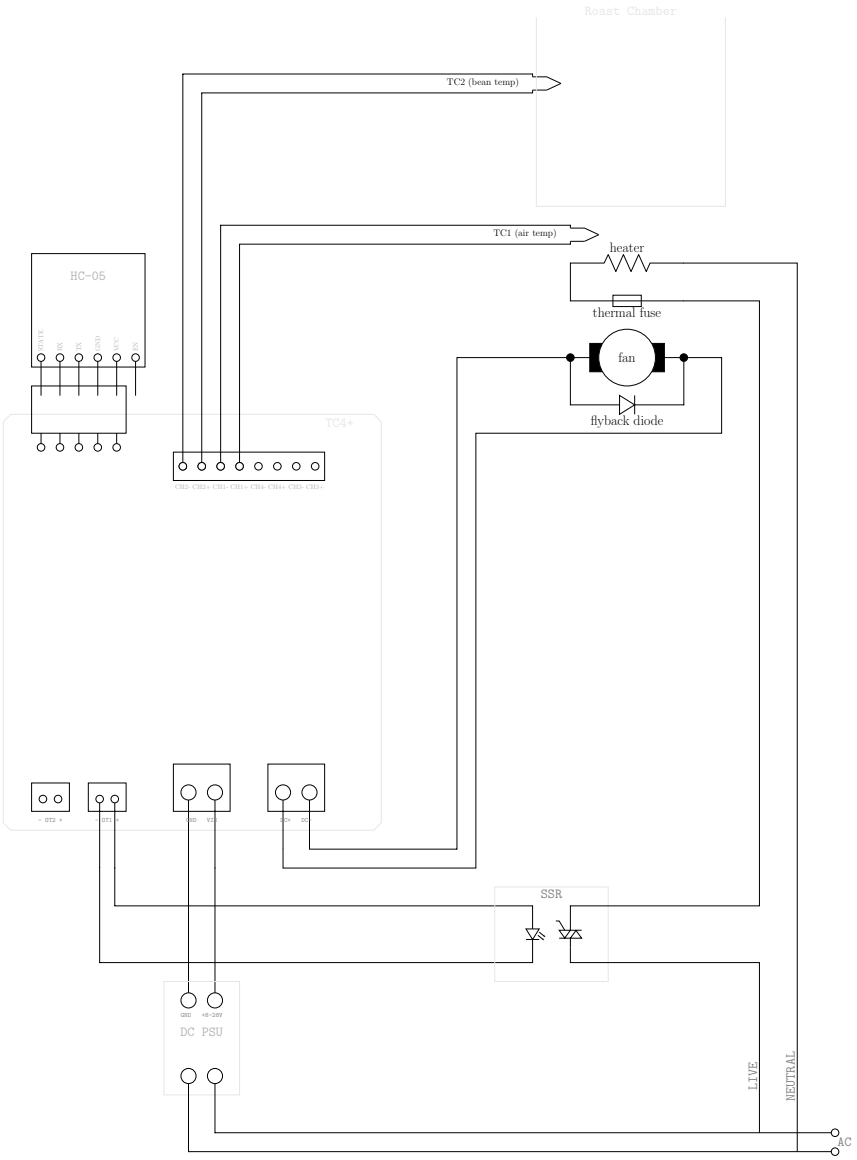



Figure 8: A typical application example of the TC4+ board. This shows the TC4+ board connected to a DC PSU; a fan with flyback diode; a SSR controlling a heater (with thermal fuse); a HC-05 Bluetooth module; and two thermocouples measuring bean and air temperature.

### 3.9 Further Connectors, Jumpers & Status LEDs

Further to the connectors discussed, the TC4+ features the headers, jumpers and status LEDs listed below.

- IO2, IO3 break out the Arduino's IO2 and IO3 ports and GND. Note that IO3 is also connected to the MOSFET. On newer versions of the board, a third pin carrying 5V has been added.
- I2C provides two 4-pin I2C headers for displays etc.
- Arduino stackable headers provide all Arduino pins. Note that IO2, IO3, IO9 and IO10 are in use for IO2, IO3, OT1, OT2, respectively. IO4 and IO5 may be in use for the Bluetooth module.
- BT_SEL and BT_RST jumpers for configuring Bluetooth connection and optional Bluetooth reset circuit.
- Status LEDs for Power On, OT1 and OT2.

# 4 Software

## 4.1 Arduino sketch

The most commonly used Arduino sketch is aArtisanQ_PID, available at `https://github.com/greencardigan/TC4-shield/tree/master/applications/Artisan/aArtisan_PID/trunk/src/aArtisanQ_PID` For all the configurations discussed in this guide, you will want to use this in PWM configuration mode.

## 4.2 Artisan

You will usually want to use Artisan on your host computer, available at `https://artisan-scope.org/`.

## 4.3 Bluetooth module

See separate guide for Bluetooth configuration.