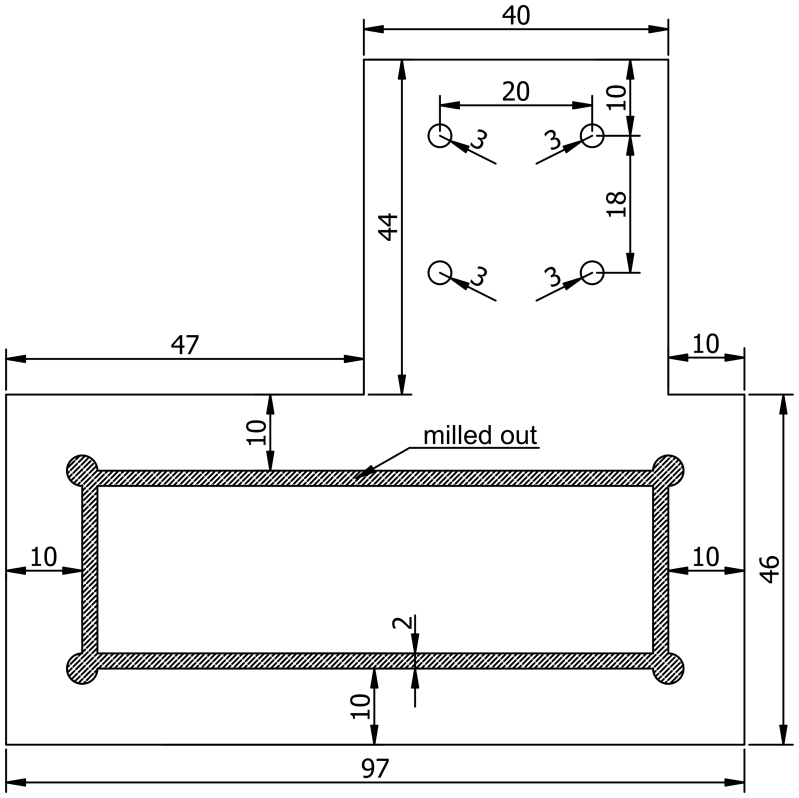
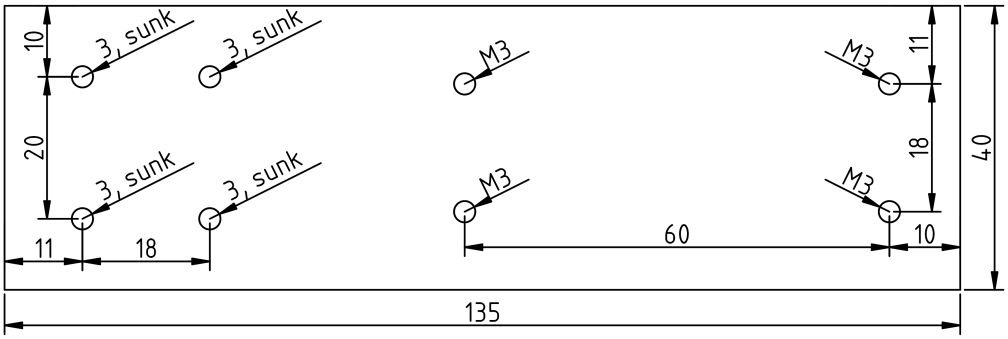
Appendices

A Part drawings

For every hole either the necessary diameter (e.g. 3) or thread dimension (e.g. M3) is listed. All dimensions are in millimetres. Drawings created with QCAD,* see Appendix B.1 for files.

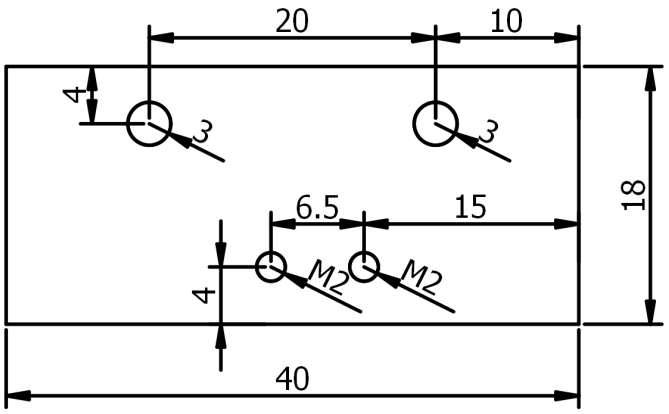


Sample holder. Material: 4 mm aluminium. Shaded area milled to 2 mm.

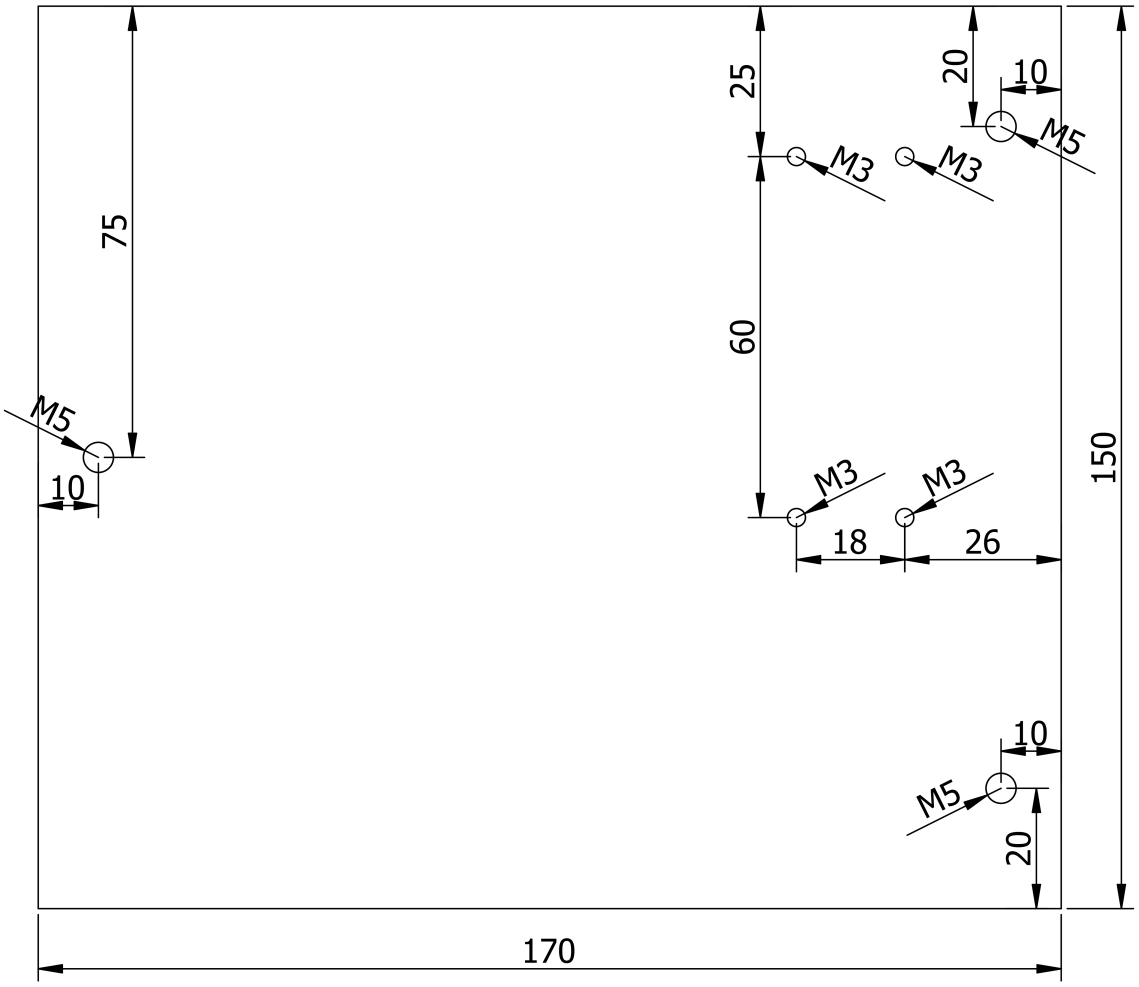


Middle bracket. Material: 10 mm aluminium, milled flat. Holes marked *sunk* may be either countersunk or counterbore depending on hardware.

*www.qcad.org/en/



Endstop switch bracket. Material: 2 mm aluminium. Four pieces necessary.



Base plate. Material: 10 mm aluminium, milled flat.

B Notes for future developers

B.1 Files

The project Github (`www.github.com/xyllian/StepperPlatform`) has the following files attached:

- Arduino IDE code: `PlatformSketch` folder.
- PCB design Eagle files: `Board` folder.
- DXF and PNG drawings: `Drawings` folder.
- The appendices of this report.

B.2 Construction

The build process is fairly straightforward. Take care to position the reference switches in the same position as the prototype to get full range of motion (they should trigger ca. 2 mm from the endstop). Also make sure the motor and ballscrew coupling is attached firmly to the axes. On the prototype the motor axles had to be shortened approximately 5 mm, to not protrude into the spiral section of the coupling. Make sure that the two axes are perpendicular. There is plenty of motion range between the top axis and middle bracket to accommodate this. Using the calibration slide crosshair is a good method to test if properly set. The slide may be attached securely with double sided tape. The sample holder may be improved with a hold down system.

B.3 Using the PCB

Connect the upper axis to the X-labelled connectors and lower axis to the Y-labelled connectors. Motor coil A is blue-red and B is green-black. Reference switch signal is black and negative is blue. Endstop switches may be connected with either polarity. 12 V power is supplied in the middle of the board, maximum 2 A combined. The SERIAL header breaks out pins 0 and 1 on the Arduino Uno. The GPIO header breaks out an unused pin on the Arduino. The dot under the stepper motor driver mounting marks the location of the potentiometer. Set current limit to 1 A by setting V_{ref} to 0.5 V (see `www.pololu.com/product/2133`).

In the `Settings.cpp` file the software behaviour is set. CAMERA header is pulled high for 100 ms when move is completed if `USE_CAMERA` is defined. If `USE_CAMERA` and `LIGHT_ONLY_AT_SHUTTER` is defined the LIGHT header is pulled high from `LIGHT_DELAY` (default 500) milliseconds before to the same delay after the camera header is triggered. If only `USE_CAMERA` is defined the LIGHT header is pulled high when the platform is not sleeping. The LIGHT pin may be used to trigger a transistor or relay to switch on a high power light (which may be powered from the 12 V pins). `maxSpeedum` defines the maximum speed in $\mu m\,s^{-1}$, speed is limited by the Arduino looptime to only slightly higher than 1000. If `DEBUG` is defined the software will send debug data to the serial monitor. To add output to this use the `PRINT()` function in the Arduino code.

B.4 Licensing

The work and code produced by me are free to use for all persons for any purpose. All work is provided as-is and no guarantees are made expressed or implied towards the function, safety, usability or fit for any purpose. Some licensed materials are used. The *AccelStepper* library is owned by Mike McCauley and not free for commercial closed source use. See `www.airspayce.com/mikem/arduino/AccelStepper` for details. The PCB design is made in Eagle Light Edition which is free for non-profit use. For commercial purposes an Eagle Business Light license is currently available for 77.50€, see `www.cadsoftusa.com/download-eagle/freeware` for details.

C Usage instructions

Connect the Arduino via USB. Connect 12 V power to the socket on the green PCB (but not the blue). Open the serial-monitor in the Arduino IDE (top-right corner). The system will send `<ARDUINO IS LIVE>` when ready. (If not using USB, i.e. using the serial pins on the PCB, bridge JUMPER on the PCB to power the Arduino without USB.) The user interface defines four commands:

- `HOME` Commands the platform to calibrate the home position using the reference switches.
- `MOVE X Y` Commands the platform to move to the absolute position *relative to home* of `X` and `Y`. `X` is upper axis, `Y` is lower axis. `X` and `Y` are given as integers in micrometres.
- `INCR X Y` Commands the platform to move a distance `X` and `Y` *relative to the current position.* `X` is upper axis, `Y` is lower axis. `X` and `Y` are given as integers in micrometres.
- `SLEEP` Commands the platform to cut the current to the motors and enter idle. This will lose synchronisation with the motors and thus calibration.

After every move of the platform is completed the system responds by sending `MOVED`, indicating it is ready for further commands. Typical usage pattern is as follows:

1. Send `HOME`. Wait for `MOVED` response.
2. Use `MOVE X Y` and/or `INCR X Y` to study all requested positions. Wait for `MOVED` response between each move.
3. *Optional:* Send `MOVE 0 0` to return the sample. Wait for `MOVED` response.
4. Send `SLEEP` when done with sample. To restart go to step 1.

Any move can be stopped by pressing the STOP-button on the PCB or a (normally open) switch connected to the STOP-header on the PCB. This will disable the system. To reinitiate either press the RESET-button (on the Arduino, below the LED) or restart the serial communication.

If the message `HIT ENDSTOP, STOPPING` is received an endstop switch has been triggered. The maximum travel (approximately 30 mm) has been exceeded and the system was stopped. To reinitiate move the stopped axis off the endstop manually by turning the coupling between the motor and ball-screw. Then press the RESET-button or restart the serial communication. If the message is received without an endstop being hit one or more switches are disconnected. Reconnect the switches to the board and reinitiate.

D Component list

This appendix lists the components used in making the system. Minor parts (such as screws and wires) are omitted. The supplier is specified in parentheses.

- Linear stage 2 pcs: Hiwin KK40-1-P-100-A1-F3 with sensor rail and reference switch (Mekanex)
- Motor/ball-screw coupling 2 pcs: Shaft coupling RB flexible D18L25 4,00/5,00mm (dold-mechatronik on ebay)
- Stepper motor 2 pcs: Wantai Motor 42BYGHM809 (Stegmotor 400 steg/varv bipolär, Electrokit)
- Stepper motor driver 2 pcs: Pololu DRV8825 Stepper Motor Drviver HC (Lawicel)
- Endstop switches 4 pcs: Omron D2F-01L-D (Elfa), wired as Normally Closed
- Micro controller board 1 pcs: Genuino Uno rev3 (Electrokit)
- Power supply 1 pcs: 12 V 5 A DC (Strömförsörjning stabiliserad 12-24V max 5A, Electrokit)
- Circuit board 1 pcs: Manufactured by Eurocircuits with 35 µm copper thickness, see Appendix B.1.
  - 100 µF 50 V capacitor, 2 pcs.
  - 2.1 mm DC Power Jack, 1 pcs.
  - 12 mm × 12 mm tactile (NO) switch, 1 pcs.
  - 1 kΩ resistor, 6 pcs.
  - 5 mm LED, 1 pcs.
  - LED resistor (470 Ω), 1 pcs.
  - 2.54 mm female header 1 × 8, 4 pcs.
  - 2.54 mm male header 1 × 40, 2 pcs.
  - 2.54 mm male header 2 × 4, 1 pcs.
- 2.54 mm female connectors for motors, reference switches, endstop switches.