Custom ESS Breakout Board (BOB)

# General

The TAMI CNC project will use the Ethernet Smooth Stepper (ESS) motion controller board. **Problem:** the limit switch signals should go to both the ESS and the motor drivers, but the ESS expects 5V level signals and the motor drivers expect 24V. Also, some additional I/O’s from the ESS to the motor drivers also need translation from 5V to 24V. Existing ESS breakout boards still require non-negligible external circuitry because of this 24V / 5V issue.   
**Solution:** a custom breakout board (BOB) to the ESS.  
Additional advantages: will save work on wiring; easy to put in convenience features (LEDs, test points, override switches etc).

# Specs

### General

* SMD components (0805 and other easy to hand solder parts).
* A 2-layer board should suffice.
* Produce PCB in PCBWay; assemble ourselves.

### Form factor

The BOB will fit **on top of the ESS**. Eagle files (which Altium can import) are available here:  
<https://warp9td.com/index.php/documentation/doc-ess#Mechanical>  
advantages: no interference on connections to ESS, no external cables, smaller solution.

### Power

* The ESS will receive 5V from the DIN rail mount 230V-->5V power supply. It will feed the 5V to the BOB through the headers between them (there are designated pins for that on the ESS headers).
* The ESS requires 500mA max (300mA typical). The BOB is expected to require much less.
* The BOB will also require 24V, which it will receive from a DIN rail mount 230V-->24V supply.

### I/O

* ESS connections:   
  three 26 pin headers that fit the ESS connectors. Each is a female 0.1” header on the bottom side of the BOB.
* Motor drive connections (x3 drives).
  + Connectors: D-type 15-pin. Female on the board, male on the cable. Fill all 15 pins with signals from ESS, even currently unused ones. This allows easy expansion. To save on wiring work, buy these cables:  
    <https://www.digikey.com/products/en?keywords=CS-DSDMDB15MM-005-ND>  
    cut them in the middle to make 2 cables, and solder the motor driver 50-pin connectors on the cut sides (of course, most of the 50 pins are unused for us).
* Signal table:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Motor Driver Signal Name** | **Description** | **Active**  **High / Low** | **Voltage**  **Level** | **Motor Driver Pin #** | **BOB DB15 Pin #** | **Wire Color** |
| +24V IN | 24V input for I/O | N/A | 24V | 1 | 1 | Black |
| SG-0V | Signal Ground | N/A | N/A | 27 | 2 | Brown |
| /SV-ON | Servo Enable | Active Low | 24V | 3 | 3 | Red |
| P-OT | Positive Limit | Active High | 24V | 4 | 4 | Orange |
| N-OT | Negative Limit | Active High | 24V | 5 | 5 | Yellow |
| PULS+ | Step Input | Active High | 5V | 11 | 6 | Green |
| PULS- | Step Input (complement) | Active High | 5V | 12 | 7 | Blue |
| SIGN+ | Direction Input | Active High | 5V | 13 | 8 | Purple |
| SIGN- | Direction Input (complement) | Active High | 5V | 14 | 9 | Gray |
| BK+ | Brake Output  (Z-Axis only) | Active High | Optocoupler Output (30V, 50mA max) | 47 | 10 | White |
| BK- | Brake Output (return) (Z-Axis only) | Active High | Optocoupler Output (30V, 50mA max) | 48 | 11 | Pink |
| N/A | GPIO (unallocated, brought to empty pad) | N/A | N/A | N/A | 12 | Light Green |
| N/A | GPIO (unallocated, brought to empty pad) | N/A | N/A | N/A | 13 | Black-White |
| N/A | GPIO (unallocated, brought to empty pad) | N/A | N/A | N/A | 14 | Brown-White |
| N/A | GPIO (unallocated, brought to empty pad) | N/A | N/A | N/A | 15 | Red-White |

* Front panel connections:
  + All limit inputs (DB9)
  + Brake output to Z-axis
* Mains Relays outputs:   
  several functions require turning 230V on and off from the ESS. This will be performed by relays that sit on a DIN rail. They will be have 24V coils, and the BOB will translate the 5V from the ESS to 24V to drive them.   
  Relays required:
  + Spindle (may be replaced by logic level control)
  + Coolant for spindle
  + Coolant for cutting tool
  + Other general purpose outputs?
* At least some additional signals from the ESS should be brought to screw terminal connectors, for future expansion.

### Additional Features

* Z-Axis Brake: The Z-Axis motor has a brake that runs on 24V (estimated 300-400mA). It will have a relay on the BOB itself that is commanded by 24V from the motor driver (BK+, BK-).
* LEDs for some I/O?
* Switches to force limit switch operation?
* Spindle speed control?
* Test points
  + GND
  + 24V
  + 5V
  + Which additional signals? “All of them” would be very crowded, unless it’s just an unpopulated hole or via.

### Implementation

* TPL7407LA will be used to translate from 5V to 24V, both for the motor driver signals and for the relay driving. The larger, SOIC package will be used.
* Limit switches:
  + Switches are wired as normally-closed (NC).
  + They will pull the signal to 5V. A pull-down resistor will be placed on the BOB.
  + This signal will go to two places:
    - Directly to the ESS
    - To a TPL7407LA input that will translate it to 24V and from there to the motor driver connector.