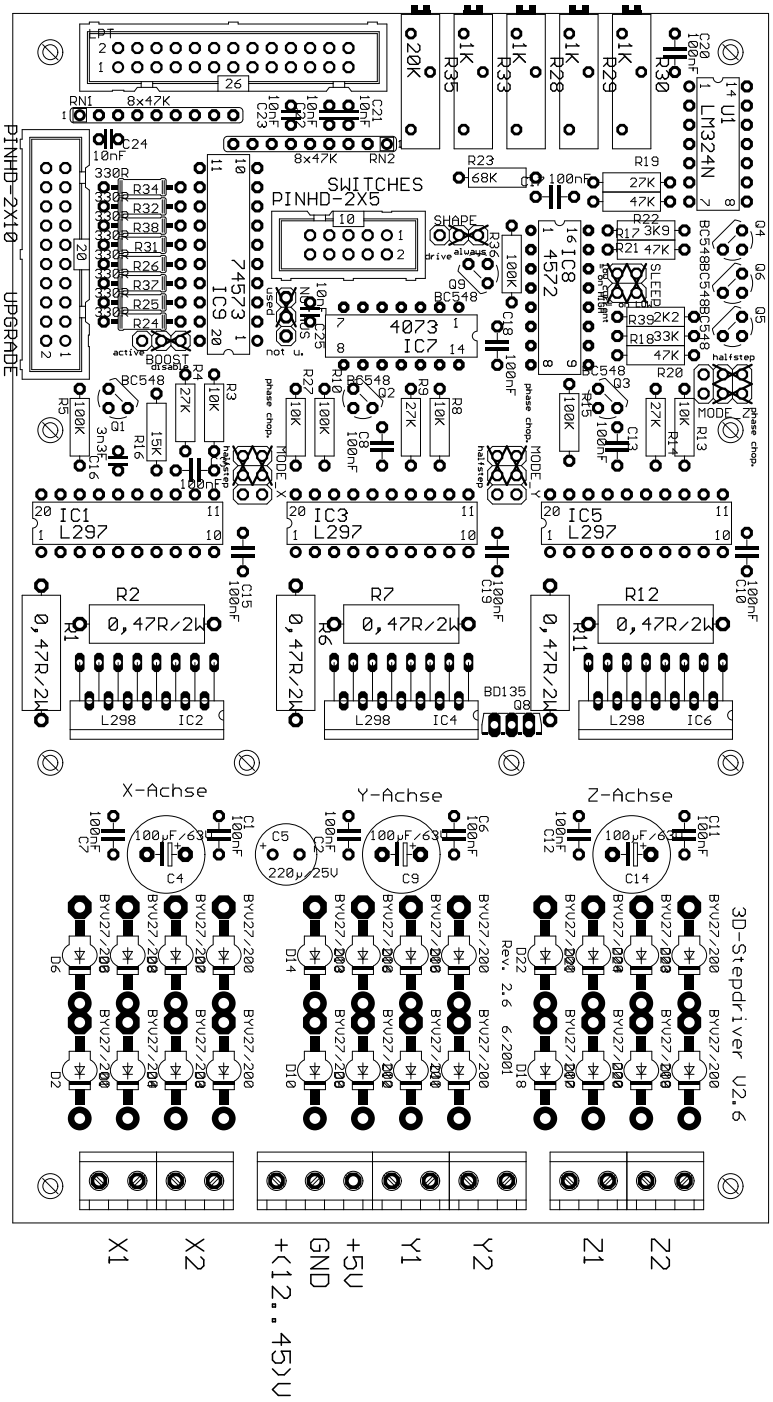


NC-Step

Dipl.-Ing. Thorsten Ostermann

Instructions to build up the

Stepper Motor Controller >3D-Step<

Rev. 2.6 (last change 12.05.2003)

Description of Operation

The 3D-Step controller card enables the operation of 3 (optionally 4) stepper motors via the parallel port of a standard PC. The phase current of the stepper motors can be raised (boost) or reduced (sleep) by approx. 25% depending on the operating mode. In addition four reference switches and one e-stop switch can be connected and looped right through to the PC. The e-stop switch when activated will also cut off the L298 output driver ICs. Several LEDs can be connected in order to visualize the actual operating mode and the reference switches.

Disclaimer, EMC-compliance

Although all parts of the circuitry have been thoroughly tested I do not give any warranty or other assurance as to the operation or functionality of the circuitry or the documentation.
To the full extent permissible by law I disclaim all responsibility for any damages or losses (including, without limitation, financial loss, damages for loss in business projects, loss of profits or other consequential losses) arising from the use or reproduction and/or operation of the presented circuitry.
The stepper motor controller card 3D-Step is an OEM-product for further processing by industry or other in electronics specialized personal. In line with §5 of the EMC-regulation the 3D-Step controller card does not have to carry a CE-Label. Wiring and the individual components being used as well as the complete environment in which the controller card is operated will influence its EMC behaviour. Therefore, if CE-compliance is required, a system in which one or more 3D-Step controller cards have been installed for operation has to be evaluated as a whole unit. Of course, when developing the circuitry for the 3D-Step all possible aspects for an EMC-suitable design have been taken into account.

Equipping the board

When fitting the board with components, make sure to follow the general rules:

- Small components (resistors, diodes, capacitors, …) at first
- Be aware of the polarity for components like diodes, electrolytic capacitors, arrays
- For the diodes D1 … D24 only fast switching diodes of the types BYV27, BYV28, BYW98 that can stand at least 100 V should be used.
- All ICs should be set on sockets for safety reasons. For the L298s single line sockets can be used. Please contact your local supplier.
- The heat sink Type V67162 or SK96/84 is already equipped with a notch at the bottom and front into which metric screws M3 will fit for mounting. Only for the temperature sensor BD135 an individual thread has to be cut unless it will be mounted on a socket as well. The actual circuitry for temperature-control is not implemented on the board. This can be accomplished on the add-on board, which is connected to the upgrade connector. Attention: the distances of pcb-tracks to the two inner drill holes on the board that serve for mounting the heat sink are quite

Ostermann@NC-Step.de • www.NC-Step.de
Postanschrift: Ringstr. 46 • 52078 Aachen

tight. Please make sure to use plastic washers for a safe insulation.
• Before mounting the L298s and the BD135 temperature sensor on to the heat sink apply a thin layer of heat conducting paste on to the contact area to improve the heat conducting capability.
• During operation of the board it may be useful to mount a small CPU-fan onto the heat sink or two of such fans on each side in a push-pull arrangement. If the housing is sufficiently ventilated these fans can be omitted.

Start-up operation

Before the initial operation do a visual test of all the soldering joints and the components. Make sure all ICs have been inserted in the proper orientation. Check for short cuts on the parallel port connector as well as the soldering joints on the L298s.
All potentiometers and jumpers should be set to the default positions according to the layout diagram. At first impress the 5 V DC to power the board circuitry **only**. Leave the stepper motors and the PC disconnected. Don't impress the operating voltage (15 … 44V) for the stepper motors. The reference Voltage for the x-, y- and z-Axes can be adjusted on the cermet trimmers R28, R29, R30. If the add-on board for a fourth axes is connected its reference voltage can be adjusted on R33. To adjust the reference voltage, proceed as follows: set the SLEEP-jumper "ON LOW" (turn both jumpers 90°), set the BOOST-jumper on "DISABLE". The voltage is measured on R3, R8, R13 (on the side which is opposite to the L297) and ground. The relation of the measured voltage V(ref) and the motor current is given by:
V(reference)=I(motor)*R(sense)*sqrt2 (sqrt2=1,41)
With a sensor resistor of 0.47 Ohm (as we use on our board) we would have to adjust for 0.665 V to receive a target value of 1 amp for the phase current of the stepper motor. If the adjustments are done set back the jumpers to the default settings as before.
The chopper frequency can be measured on the sync-pins of the L297, however, be sure not to short cut with pin no.2 !! Default adjustment (16 - 17 kHz) can be changed on R35 in case problems with noise from the stepper motors. ATTENTION: the higher the frequency, the higher the switching losses in the L298 power bridges !
Now you are ready to test the card with the motors. To do this you'll have to connect the card to the LPT- port of the PC. Than boot the PC. Always make sure to boot the PC first and start the software. Only then impress the voltage to power the board and supply the stepper motors. During the boot process of the computer some signal levels might change leading to unexpected reactions of the motors.
For the test itself we recommend the free demo version of PC-NC but you may also write a small program yourself. For the beginning you should start with moderate low supply-voltage of 12 - 15 V for the steppers. This may be taken from a laboratory power supply with current limitation

The different Jumper Positions

e-STOP: *„used" (default)* - an e-stop switch is connected. *„not used"* - monitoring of e-stop is deactivated (only for test purposes recommended)
SHAPE: *„drive"* - when in SLEEP mode SHAPE function is deactivated (to avoid noise). *„always"* (default) - SHAPE always active. SHAPE will improve the torque in half-step mode in raising the phase current by 1.41 (=sqrt2) if only one coil is under current.
BOOST: *„active"* - the BOOST-function will raise the current to 120% of the target current during brake and acceleration (requires support by software being used). *„disable"* (default) - BOOST-function is disabled
SLEEP: *„on high"* (default) or *„on low"*. Determines whether or not the reduction of the current (approx. 25% of the target current) is activated on LOW level or HIGH level. When using CNC-Profi set jumper on "ON LOW"-position (both jumpers 90° turned)
MODE: upper jumper: *„phase chopping"* (default) or *„enable chopping"*. Will influence the way of how the current is controlled. Generally the default position will lead to the better results (for additional information see the application notes of www.st.com).
lower jumper: *„half step"* (default) or *„full step"* operation.
ATTENTION: never leave off one jumper completely.

External connectors

• For connection to the PC use a 26pin ribbon cable. The lead no. 26 can be omitted and be cut shorter. Be careful, however, not to short cut with other components since this lead carries 5 V to eventually supply the optional optocoupler board or other add-ons.
• For connection outside of the housing a 1:1 screened cable should be used.
• When using CNC-Profi (also DIN-CNC and SV-plus) or Step4-Software packages, some leads have to be crossed. Please refere to the standard pinout and the documentation of your software. ATTENTION: the numbering corresponds to d-Sub connector, while the pinout in the schematics refere to the flat cable connector (different numbering of the pins). When using PC-NC no adjustments on the cable are necessary.
• The limit-/or reference switches and the e-STOP switch have to be connected to the SWITCHES port as break contacts to ground. Easiest way is to use a 9 pin ribbon cable to 9pin D-sub and from there use a standard screened 9pin d-sub cable for connection to the machine.
Since the card will not operate without e-STOP this function can be deactivated by jumper setting when testing the board..
• The upgrade connector can be used to connect various LEDs or an add-on board for relays (spindle, coolant, vacuum cleaner etc.), temperature-control and a fourth axis.
• The stepper motors are connected to the terminal blocks. Each pair of connectors (X1X2, Y1Y2, Z1….) is reserved for the two leads belonging to one coil of the steppers. To change the direction of rotation, simply change the polarity of the leads on one coil on the terminal block. When using unipolar stepper motors with 5 or 6 leads, the center taps of the coils won't be used but must be perfectly insulated. Don't connect them to + or ground. Bipolar stepper motors that have 8 wires allowing for connection of two coils in series or parallel. The serial connection will always work, the latter may offer a higher rotational speed for which you have to pay the price of a higher current leading to a lower torque when the phase current exceeds 2 amps. Using this arrangement the coil resistance is cut to half and should not fall below 0.8 Ohms. Once you are above that you may try both options.

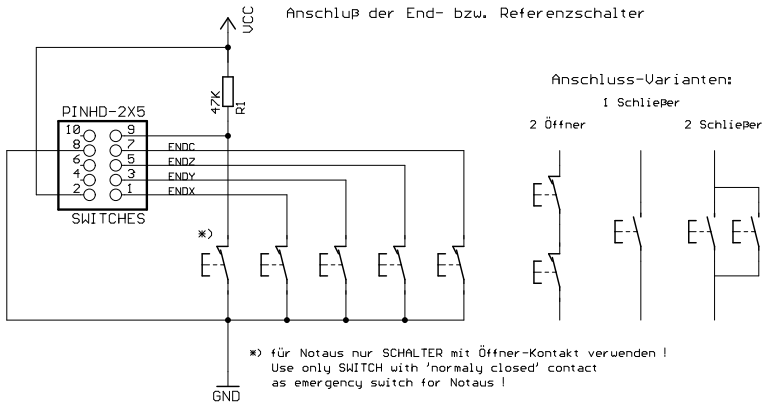
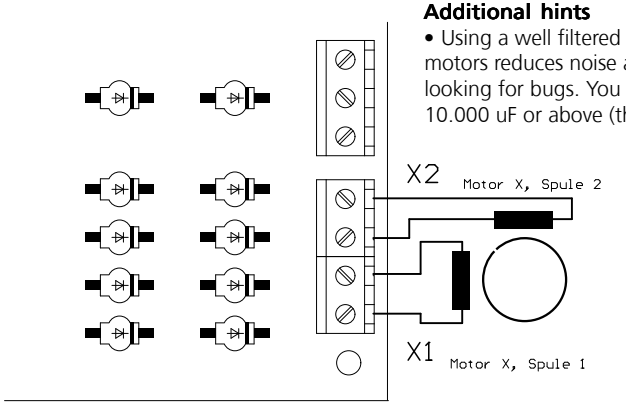


Fig .: Connection of e-STOP and limit switches



Additional hints

• Using a well filtered voltage to supply the stepper motors reduces noise and will save you time when looking for bugs. You are on save grounds using 10.000 uF or above (the more the better)

• In case the phase current of a stepper motor will significantly be lower than 1 amp it may be useful to match the resistors R1, R2, R6, R7, R11 and R12. We recommend 1 Ohm. Of course this new value has to be considered when doing the adjustment for the reference voltage Vref.

• The 330 Ohm resistors should match the LEDs being used. (as a rough approximation: 5V/I(diode)=R, example: 5V/15mamps=330 Ohm). If no LEDs are used these resistors including IC9 can be omitted.

Problems and solutions

There are problems with noise on the steppers:
• Try to vary the chopper frequency on R35
• Instead of phase-chopping you may try inhibit-chopping
• Do a check on the reference voltage Vref
• Change the position of the SHAPE-jumper

The phase current won't reach its target value:
• Instead of phase-chopping try inhibit-chopping
• Do a check on the reference voltage Vref
• Raise the chopper frequency (R35)
NOTE: The phase current control is based on the max. value. The resulting average value will be a little lower.

The stepper motor driving the z-axis won't turn or only turns in one direction:
• The resistor array RN2 has been inserted in the wrong orientation.

Hints when looking for bugs

In case the circuitry doesn't work from the start up or any defect has occurred please find out what the defect is and have it fixed. Then *before connecting the stepper motors* repeat the start up procedure as described above.

The following hints may help you to find a defect:
• Can you measure the correct voltages (between 0 and 1V) on the test points for Vref even when changing the level for SLEEP or BOOST ?
• Is the ENABLE-pin on the L297s (Pin 10) on HIGH level?
• Often the corresponding L297 will also be destroyed if the L298 is blown. In case of doubt you may as well replace both of them.

Please read the documentation carefully at first and check the circuitry. You may also visit the NC-Step homepage www.nc-step.de in order to look for hints and bug fixes. Should this won't help to solve your problems I will give you e-mail support. Please give a detailed description of the problem including the arrangement (used software, power supply etc.) My e-mail address: Ostermann@NC-step.de

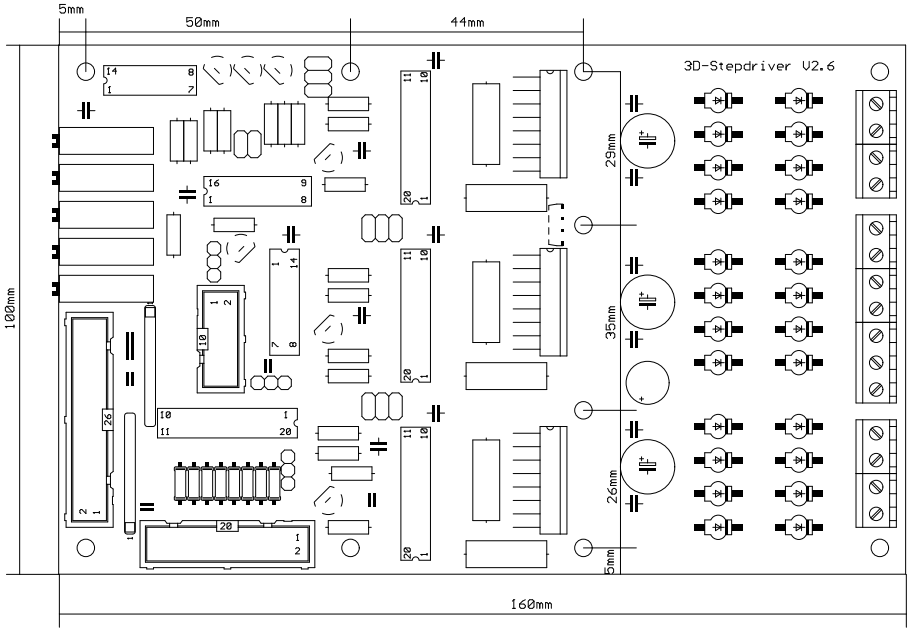
And now I whish you good luck and good stepping !

T. Ostermann

Technical data

Supply (board circuitry)	:	5 Volt +/- 5%
Current (board circuitry, no LEDs)	:	typically 200 milliamps
Rated voltage	:	10 … 45 V
Rated current	:	depending on rated voltage and type of stepper motors being used. Maximum carry current 6 amps.
Control	:	Pulse/direction, CMOS compatible
Resolution	:	Half-/Full-step
Number of axes	:	3 independent axes control allowing for 2 amps phase current per motor
Circuitry	:	Not short-circuit proof
Dimensions	:	100 x 160 mm

Dimensions (in mm)



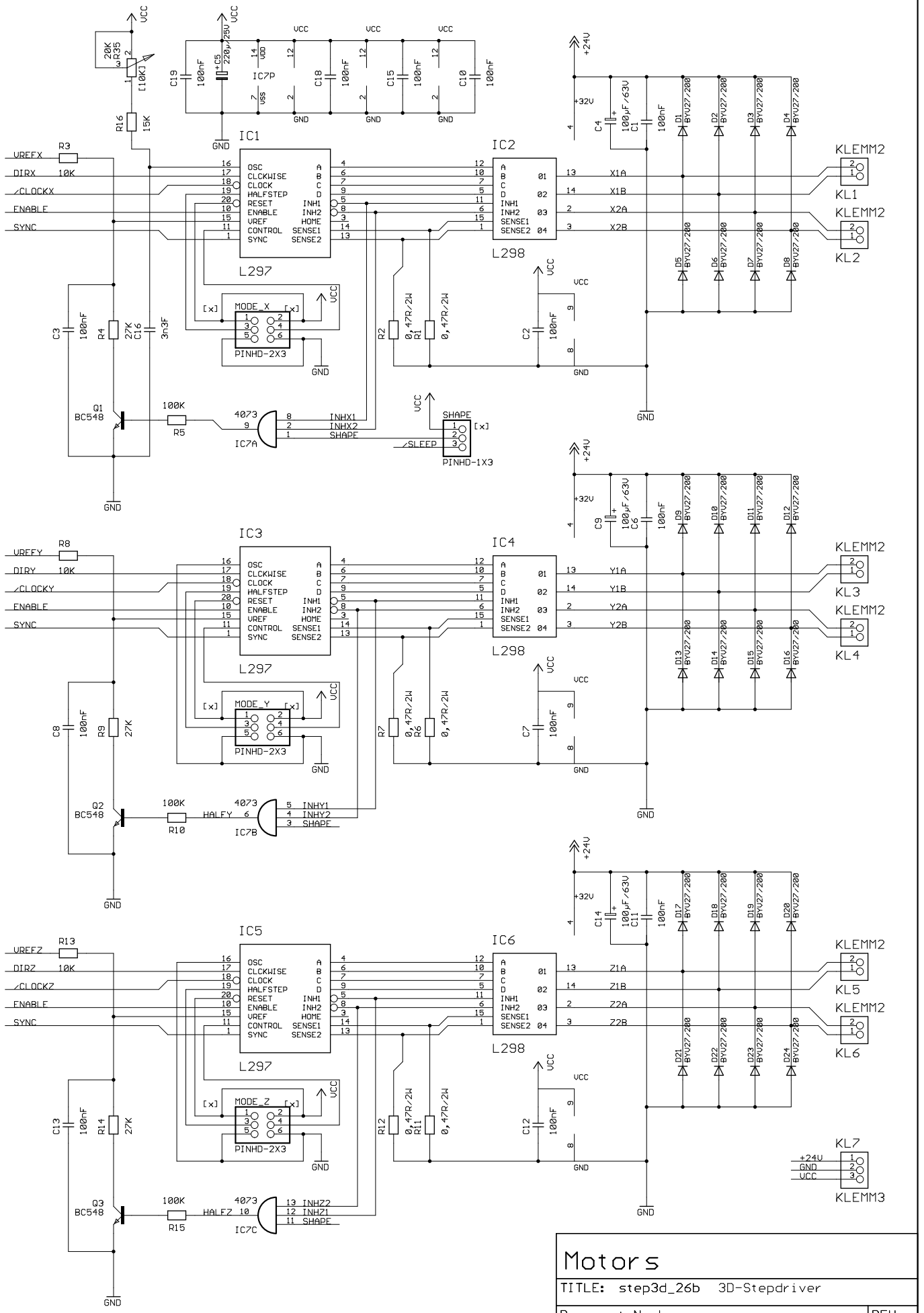
Pinout

Pin numbering referes to standard printer port with 25pin D-SUB connector

pin no.	*standard signal*	*3D-Step*
1	Strobe	spindle
2	Data Bit 0	direction X
3	Data Bit 1	clock X
4	Data Bit 2	direction Y
5	Data Bit 3	clock Y
6	Data Bit 4	direction Z
7	Data Bit 5	clock Z
8	Data Bit 6	not used (optional direction C)
9	Data Bit 7	not used (optional clock C)
10	Acknowledge	limit switch Z
11	Busy	enable
12	Paper Out	limit switch Y
13	Select	limit switch X
14	Autofeed	coolant
15	Error	not used (opttional limit switch C)
16	Reset	boost
17	Select	sleep (default: low active)
18-25	GND	GND

Partlist

Qty	Value	Package	Comment	Parts
8	330R	0207/10	RESISTOR	R24, R25, R26, R31, R32, R34, R37, R38
1	2K2	R-10	RESISTOR	R39
1	3K9	R-10	RESISTOR	R17
4	10K	R-10	RESISTOR	R3, R8, R13, R27
1	15K	R-10	RESISTOR	R16
4	27K	R-10	RESISTOR	R4, R9, R14, R19
1	33K	R-10	RESISTOR	R18
3	47K	R-10	RESISTOR	R20, R21, R22
1	68K	R-10	RESISTOR	R23
4	100K	R-10	RESISTOR	R5, R10, R15, R36
2	8x47K	SIL9	R-SIL	RN1, RN2
4	1K	CERMET	CERMET-TRIMMER	R[28..30], R33
1	20K	CERMET	CERMET-TRIMMER	R35
1	3n3F	RM 2,5mm	CAP	C16
5	10nF	RM 2,5mm	CAP	C21, C22, C23, C24, C25
15	100nF	RM 5mm	CAP	C1..3, C6..C8, C10..13, C15, C17..C20
3	100µF/63V	D 10mm	ELECTROLYTIC CAP	C4, C9, C14
1	220µ/25V	E3,5-8	ELECTROLYTIC CAP	C5
7	BC548	TO92/	TRANSISTOR	Q[1..6], Q9 (or BC547 or similar)
1	BD135	TO126AS	TRANSISTOR	Q8
24	BYV27/200	D-15	DIODE	D[1..24]
6	0,47R/2W	L<=18mm	RESISTOR	R1, R2, R6, R7, R11, R12
1	CD4073	DIL14	40XX	IC7 (CMOS-Logic)
1	CD4572	DIL16	45XX	IC8 (CMOS-Logic)
1	74573	DIL20	74XX	IC9 (74HC, 74HCT, 74LS, ... as available)
1	LM324N	DIL14	OP-AMP	U1
3	L297	DIL-20	STEP-IC	IC1, IC3, IC5
3	L298	MTIWATT	STEP-IC	IC2, IC4, IC6
6	KLEMM2	RM 5.08	CAGE CLAMP	KL[1..6]
1	KLEMM3	RM 5.08	CAGE CLAMP	KL7
2	DISTANCE HOLDER 8mm for M3 screws			
4	METRIC SCREWS M3x6			
2	METRIC SCREWS M3x16			
1	HEAT SINK			
4	IC-SOCKETDIL20			
1	IC-SOCKETDIL16			
2	IC-SOCKETDIL14			
3	1X03	PINHD-1X3	PINHEAD	BOOST, NOTAUS, SHAPE
1	2X02	PINHD-2X2	PINHEAD	SLEEP
3	2X03	PINHD-2X3	PINHEAD	MODE_X, MODE_Y, MODE_Z
1	ML10	PINHD-2X5	PINHEAD	SWITCHES
1	ML20	PINHD-2X10	PINHEAD	UPGRADE
1	ML26	PINHD-2X13	PINHEAD	LPT
3	SOCKETS, 8-8,5mm high, 20 pins (for L298)			
1	26pin ribbon cable connector			
1	25pin D-SUB plug, male, for ribbon cable			
11	Jumper			
0,5m	ribbon cable AWG28, 26 wires			



Defaultwerte sind in [Klammern] angegeben!
Default settings and values are given in [brackets]!

Motors

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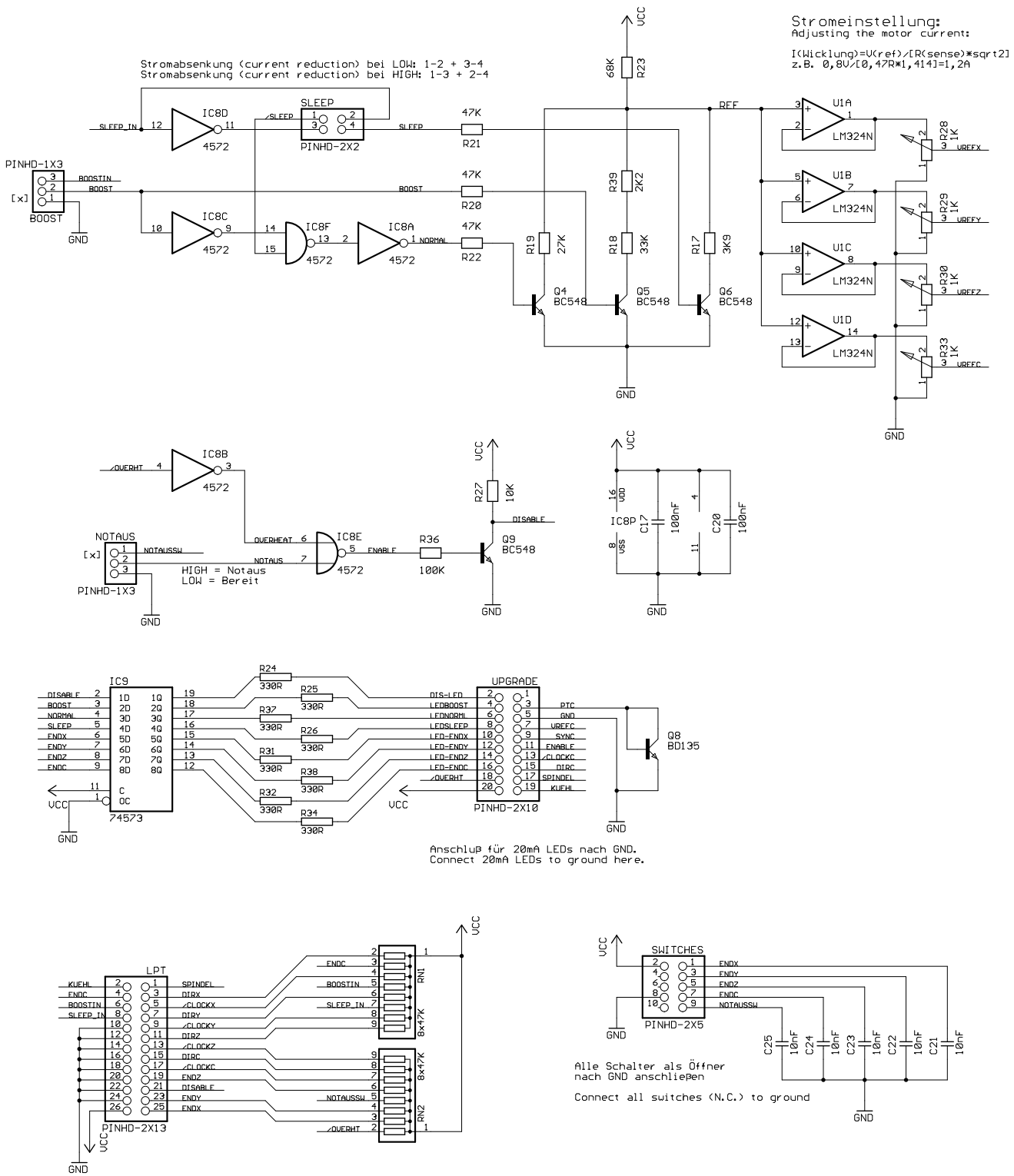

Current & Connections

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