

Assembly Information

Stepper Motor Card >3D-Step<

Rev. 2.7 (last updated 27.12.2005)

Functional Description

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 visualize the actual operating mode and the status of the reference switches.

Exclusion of Liability, EMC (electromagnetic compatibility)

Although all parts of the circuitry have been thoroughly tested NC-Step does not give any warranty or other assurance as to the operation or functionality of the circuitry or the documentation. NC-Step especially takes no responsibility for any damages caused by reproduction, reverse engineering or initial operation of the here described circuits.

The stepping motor power amplifier "3D-Step" is an OEM product made for use in industry, electronic trade and other EMC experienced sectors. According to EMVG §5, section 5 this product does not require CE qualification.

Cabling, used amplifiers, power supply and the surrounding environment are factors that influence the EMC properties of a device. A device using one or more stepper motor power amplifiers must of course be evaluated according to corresponding directives, when CE conformity must be documented. During development all possible means were used to conform to EMC regulations.

Fitting with components

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

- Start with the small components (resistors, diodes, capacitors, ...)
- Be careful to assemble with correct polarity (diodes, electrolytic caps, resistor 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 (high 8-8.5 mm) can be used. Please contact your local supplier.
- The heat sink (type V6717Z, or SK96/84 -> only 84 mm wide) has fitted threads. Before plugging in the L298's, screw the heat sink with the plastic spacers onto the board, then align the ICs and screw them into the heat sink.
- Before final mounting of the L298's it is recommended to apply a thin(!) layer of heat conducting paste to the ICs, to promote heat dissipation.
- In use, depending on the environment, it may be necessary to use an additional fan for cooling. If the casing is already well ventilated, it may not be necessary to use an additional fan, if the board is mounted in the air-stream.

Initial 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 (LPT) 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 apply the operating voltage (15 ... 44V) for the stepper motors.

For the following tests some of the jumpers have to be changed. Normaly this should be done when the power is switched off only. But if the PC is disconnected, the motors are disconnected and only the logic

voltage (5V) is applied, the jumpers may be changed without switching the logic voltage off. After power on all green LEDs and the red NOTAUS (e-Stop) LED should be lit. When both SLEEP jumpers are turned by 90 degree, the green SLEEP LED turns of and the yellow NORMAL LED is lit. After changing the BOOST jumper, the NORMAL LED turns of and the red BOOST LED is lit instead. Now set the NOTAUS jumper back to it's default position.

Now you can adjust the reference voltages for the current regulators with the trimmers R28, R29 and R30. If the NORMAL LED is not lit, change both SLEEP jumpers to the "on low" position (see jumper description for details), BOOST jumper to "disable", disconnect the PC. The reference voltages are measured with respect to ground at R3, R8 and R13 on the side facing towards the trimmers. The set/measured voltage V(ref) has the following interrelation with the motor current:

$$V(\text{ref})=I(\text{motor})\cdot R(\text{sense})\cdot\sqrt{2} \quad (\sqrt{2}=1.41)$$

Therefore V(ref) gives the set value for the current regulator. R(sense) is the respective sensing resistor on the board (0.47 ohms in the standard assembly). For 1A motor current you have to set V(ref) to 0.665V for example. 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 (pin no. 1) 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. Then boot the PC. Always make sure to boot the PC first and start the software. Only then apply 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 if available.

Meaning of 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)
- 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“ (slow decay, default) or „enable chopping“ (fast decay). 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.

Meaning of LEDs

- ENDX: Signals that the limit/reference switch of the X axis is activated. When "normally open" contacts are used instead of "normally closed" contacts, the LED is on all the time except when the switch is activated.
- ENDY, ENDZ, ENDC: Same than for X axis. If no 4th axis is used, ENDC can be used as a general purpose input.
- SLEEP: Signals that the current reduction mode is active. This feature is activated by the PC with the SLEEP input line.
- NORMAL: The motors are powered with the adjusted nominal current
- BOOST: The current boost is active, the motorcurrent is raised to approx. 120%. If your software does not support this feature, the BOOST input has to be disabled (default jumper position). The BOOST function must not be active permanently, because it will overheat the power stages and therefore may destroy them.
- NOTAUS: The NOTAUS (=e-Stop) LED signals that the e-Stop switch is activated. The e-Stop input disables the power stages and is signaled to the PC. The e-Stop switch has to be a "normally closed" contact.

External Connections

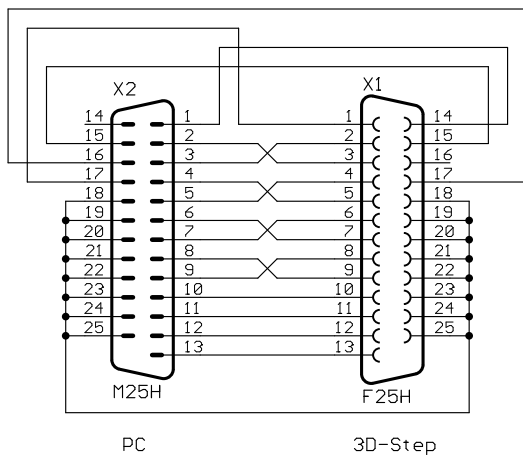
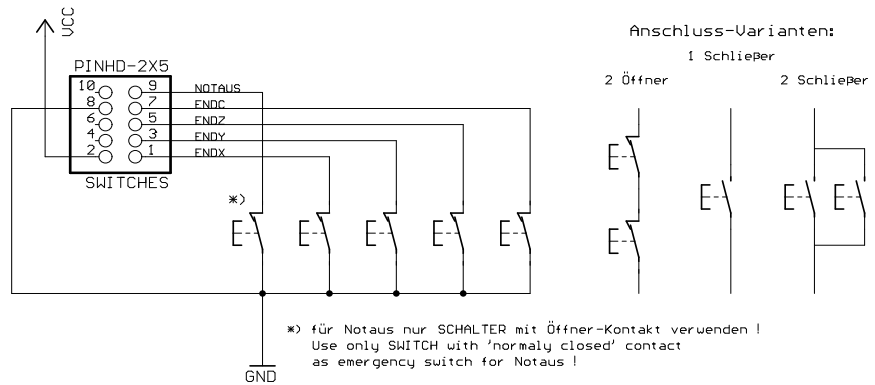
- For connection to the PC use a 26pin ribbon cable. The lead no. 26 can be omitted and be cut shorter. Be careful, however, not to short cut with other components since this lead carries 5 V to eventually supply the optional optocoupler board or other add-ons.

- For connection outside of the housing a 1:1 shielded cable should be used.

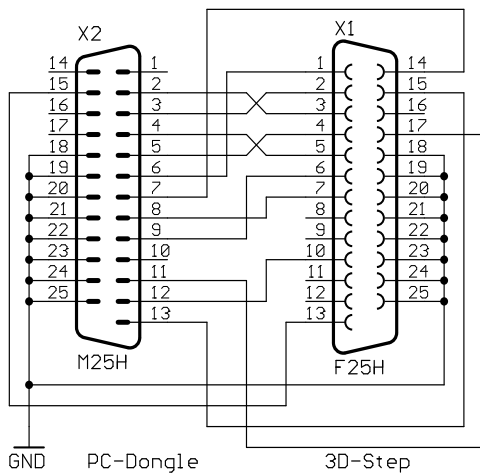
- When using CNC-Profi (also DIN-CNC and SV-plus) or Step4-Software packages, some leads have to be crossed. Please refer to the standard pinout and the documentation of your software. ATTENTION: the numbering corresponds to D-Sub connector, while the pinout in the schematics refer to the flat cable 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. The board will not work without an e-Stop switch connected. For testing purposes the monitoring of the e-Stop switch can be disabled with the NOTAUS jumper.

Connection of limit and reference switches



Adaptor cable for CNC-Profi & DIN-CNC

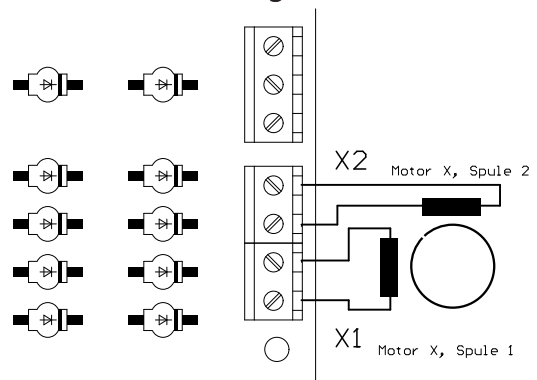


Adaptor cable for Step4

- The connector for the C axis can be used to connect an add-on board for a fourth axis. The Tiny-Step or HP-Step board can be connected directly to this port. Instead of a 4th axis it is of course possible to use a second power stage on one of the existing axes if two motors have to be used in a gantry configuration. In this case the signals for the C axis coming from the PC have to be disconnected and wired to the respecting other axis (X, Y or Z).

- 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

Motor wiring



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.

Additional Hints

- 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 V_{ref} .
- If not all the axes are needed, the respective power ICs (L297/L298) can be omitted. The L297 (IC1) on the X axis must be installed in any circumstances, because this IC generates the clock for all other current regulators!

Problems & 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 V_{ref}

The phase current won't reach its target value or the motor has not enough torque when running:

- Do a check on the reference voltage V_{ref}
- Change the position of the SLEEP jumpers (turn both by 90 degree)
- Instead of phase-chopping try inhibit-chopping
- 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 for Troubleshooting

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 V_{ref} 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.

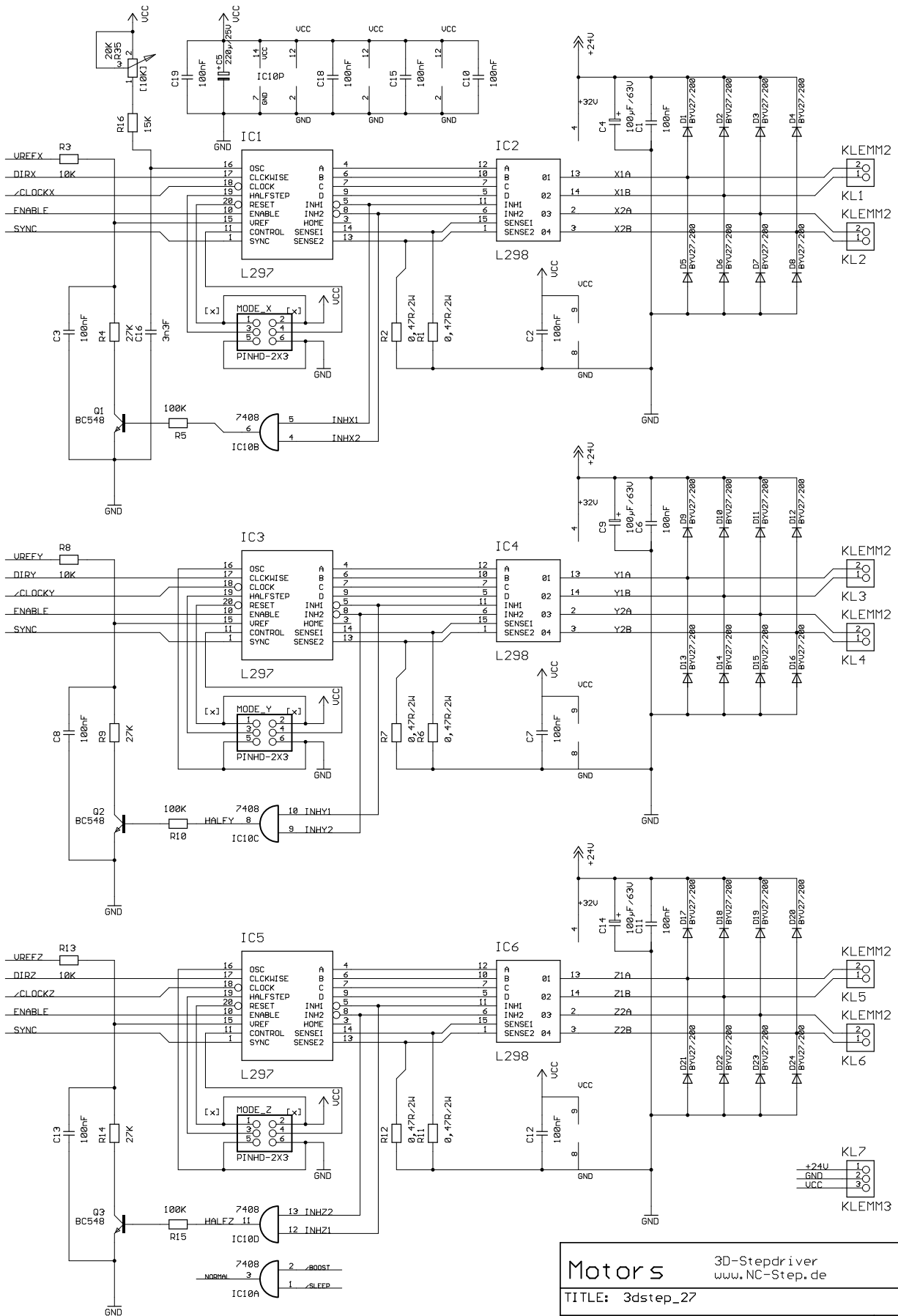
Please read the documentation carefully at first and check the circuitry. You may also visit the NC-Step homepage www.nc-step.de in order to look for hints and bug fixes. If these hints and the additional help at www.NC-Step.de don't answer all your questions, contact me for further help, by email. Please provide a detailed description of the problem and your configuration. (Power supply, used Software a.s.o.) -> E-Mail: Ostermann@NC-Step.de

And now I wish you good luck and good stepping !

T. Ostermann

Technical data

Power Supply (logic):	5 Volt +/- 5%
Rated current (logic, without LEDs):	typically 200 milliamps
Rated voltage (power stage):	10 ... 45 V
Rated current (power stage):	depending on rated voltage and type of stepper motors being used. Maximum over all current 6 amps.
Control:	Pulse/direction, CMOS compatible
Step 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



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

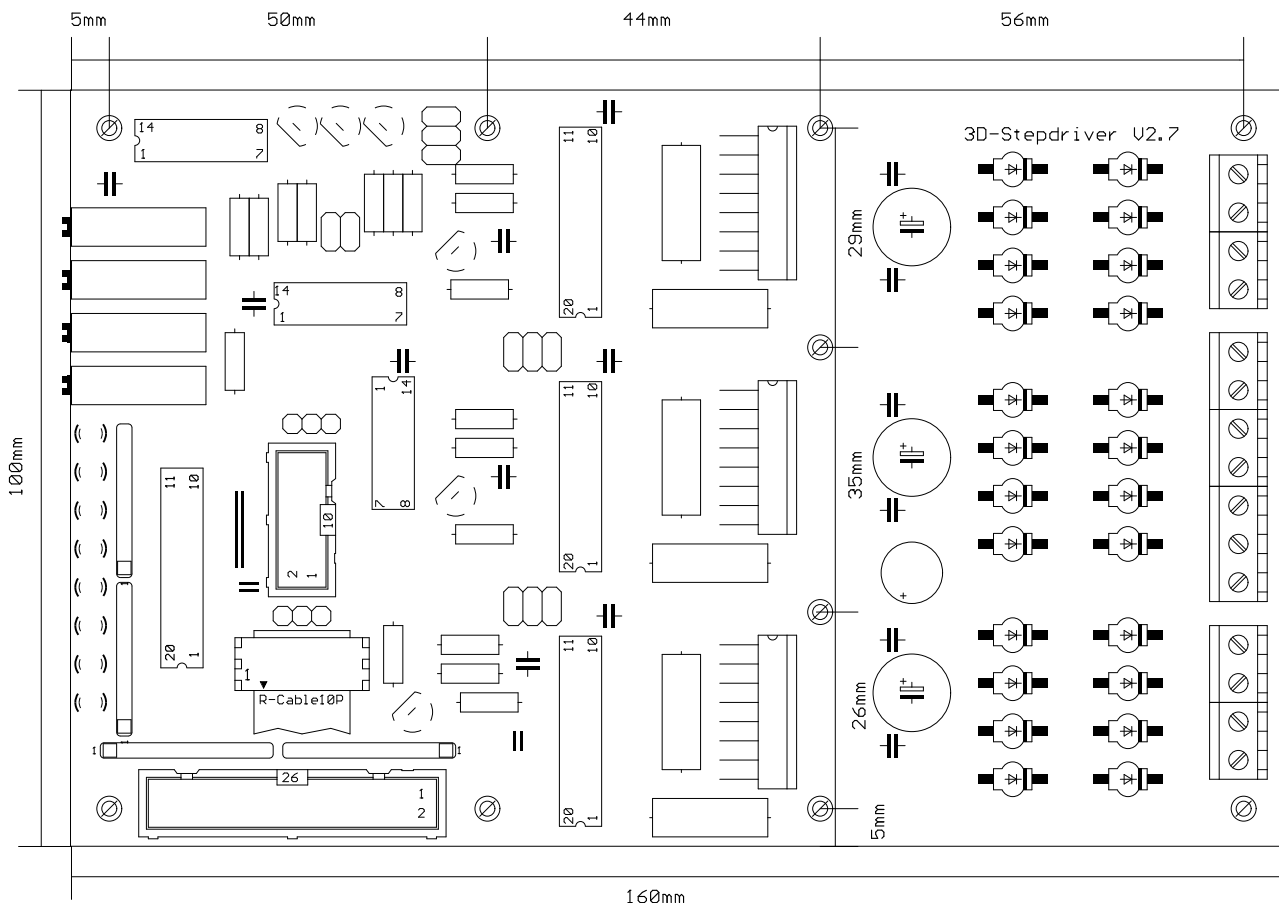
Motors		3D-Stepdriver www.NC-Step.de
TITLE: 3dstep_27		REU: 2.7
Document Number:		
(C) 11/2004 T. Ostermann		
Date: 14.11.2004 19:36:54	Sheet: 1/2	

Pinout

Pin numbering refers 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 (optional limit switch C)	
16	Reset	boost	
17	Select	sleep (default: low active)	
18-25	GND	GND	

Dimensions (in mm)



Notes

Notes

Parts

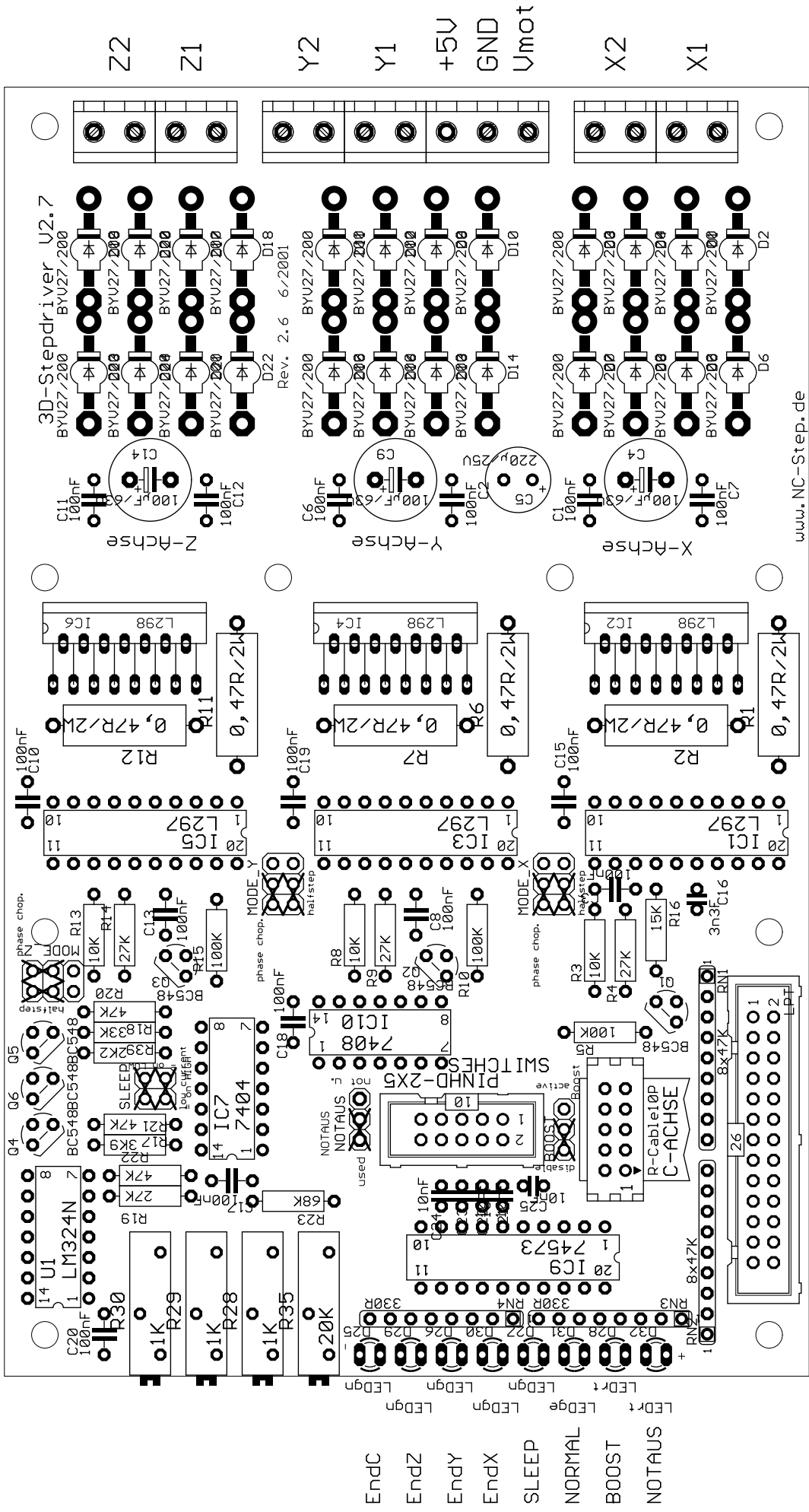
Qty.	Value	Package	Comment	Parts
Bag 1:				
1	2K2	R-10	RESISTOR	R39
1	3K9	R-10	RESISTOR	R17
3	10K	R-10	RESISTOR	R3, R8, R13
1	15K	R-10	RESISTOR	R16
4	27K	R-10	RESISTOR	R4, R9, R14, R19
1	33K	R-10	RESISTOR	R18
3	47K	R-10	RESISTOR	R20, R21, R22
1	68K	R-10	RESISTOR	R23
3	100K	R-10	RESISTOR	R5, R10, R15
2	4x330R	SIL4-8	R-SIL	RN3, RN4
2	8x47K	SIL9-8	R-SIL	RN1, RN2
3	1K	CERMET	CERMET-TRIMMER	R[28..30]
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
6	BC548	TO92/	TRANSISTOR	Q[1..6], (or BC547 or similar)
1	LEDge	LED3E	LED	D31
5	LEDgn	LED3E	LED	D25, D26, D27, D29, D30
2	LEDrt	LED3E	LED	D28, D32

Bag 2:				
24	BYV27/200	D-15	DIODE	D[1..24]
6	0,47R/2W	L<=18mm	RESISTOR	R1, R2, R6, R7, R11, R12
1	74HC04	DIL14	74XX	IC7
1	74HC08	DIL14	74XX	IC10
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			
3	METRIC SCREWS M3x6			
2	METRIC SCREWS M3x16			

Bag 3:				
4	IC-SOCKET	DIL20		
3	IC-SOCKET	DIL14		
2	1X03	PINHD-1X3	PINHEAD	BOOST, NOTAUS, SHAPE
1	2X02	PINHD-2X2	PINHEAD	SLEEP
3	2X03	PINHD-2X3	PINHEAD	MODE_X, MODE_Y, MODE_Z
2	ML10	PINHD-2X5	PINHEAD	C-axis, SWITCHES
1	ML26	PINHD-2X13	PINHEAD	LPT
3	SOCKETS, 8-8,5mm high, 20 pins (for L298)			
2	26pin ribbon cable connector			
1	25pin D-SUB plug, male, for ribbon cable			
11	Jumper			

without bag:

- 1 Heatsink
- 0,5m ribbon cable AWG28, 26 wires.



www.NC-Step.de

- EndC
- EndZ
- EndY
- EndX
- SLEEP
- NORMAL
- BOOST
- NOTAUS