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Assembly Information

Stepper Motor Card >3D-Step<
Rev. 2.8 (last updated 5.1.2013)

Functional Desciption

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 mechapro does not give any warranty or other assurance as to the operation or functionality of the circuitry or the documentation. mechapro 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 (except for LM2574N) should be set on sockets for safety reasons. For the L298s single line sockets (high 8-8.5 mm) can be used. Cut the sockets to the length required. Make sure both socket rows are aligned in the same direction. Do not use precision sockets with turned contacts.
• 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 achive good heat dissipation. No isolating material required between heatsink and L298.

• 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. Leave the stepper motors and the PC disconnected.

At first open JP1 and apply power the board. The right pin on JP1 (in direction of screw terminals) should carry 5V DC with respect to ground. If the voltage is OK (+/-5%), close JP1. 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 and the motors are disconnected, 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 jumpers JP4 (SLEEP) are turned by 90 degree, the green SLEEP LED turns off and the yellow NORMAL LED is lit. After changing the jumper JP3 (BOOST), the NORMAL LED turns off and the red BOOST LED is lit instead. By changing JP2 the DISABLE LED is turned off. Now set the jumpers JP2 and JP3 back to their default positions, while keeping JP4 turned by 90°.

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 JP4 to the "on low" position (see jumper desciption for details), JP3 (BOOST) 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:

$$V(ref)=I(motor)*R(sense)*sqrt2 \ (sqrt2=1.41)$$

Therefor 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!

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 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 WinPCNC 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

JP1: Connection from internal power converter (5V output) to logic supply of the board. Open only for testing during inital startup.

JP2: *„used" (default)* - an e-stop switch is connected. *„not used"* - monitoring of e-stop is deactivated (only for test purposes recommended)

JP3: *„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.
IMPORTANT: Use the BOOST function only when all axes are set to phase currents below 1.5A to avoid overloading the drivers!

JP4: *„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. The polarity is normaly set within the CNC software (WinPCNC, Mach3,...).

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 or in the stepper motor blog (german): www.schrittmotor-blog.de.
lower jumper: *„half step"* (default) or *„full step"* operation. In fullstep mode, stepper motors are more sensitive to resonate, so half step is allways recommended.

ATTENTION: never leave off one jumper completely.

Meaning of LEDs

ENDX: Signals that the limit/reference switch of the X axis is activated. When "normaly open" contacts are used instead of "normaly 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 (pin 17).

NORMAL: The motors are powered with the adjusted nominal current

BOOST: The current boost is active (input to pin 16), the motorcurrent is raised to aprox. 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 therfore 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 "normaly 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 older DOS programms some leads have to be crossed. Please refere to the standard pinout and the documentation of your software. You may also ask for help in our forum. For WinPCNC, PCNC, Mach3 and pcdreh for windows no changes to the wiring are required.

• 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.

Anschluß der End- bzw. Referenzschalter
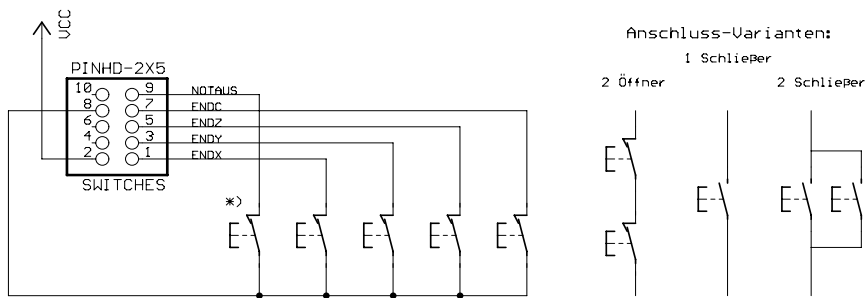
Connection of limit and reference switches

• 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 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.

Motor wiring
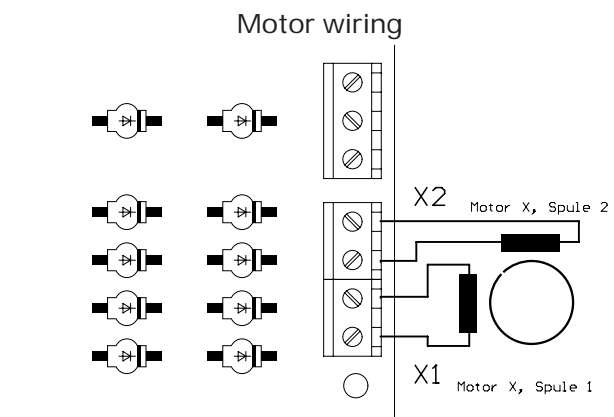
Additional Hints
• In case the phase current of a stepper motor will significantly be lower than 1 amp it may be useful to match the resistors R1, R2, R6, R7, R11 and R12. We recommend 1 Ohm. Of course this new value has to be considered when doing the adjustment for the reference voltage Vref.
• If 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:
• Instead of phase-chopping you may try inhibit-chopping
• Do a check on the reference voltage Vref

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 Vref
• Change the position of the SLEEP jumpers (turn both by 90 degree)
NOTE: The phase current control is based on the max. value. The resulting average value will be a little lower.

The motors don't have any holding torque:
• Check eStop switch or change JP2 (for testing only)
• Check power supply

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 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 mechapro homepage at www.mechapro.de in order to look for hints and bug fixes. If these hints and the additional help at our forum on www.mechapro.de don't answer all your questions, contact us for further help by email. Please provide a detailed description of the problem and your configuration. (type of power supply, used software a.s.o.) -> E-Mail: info@mechapro.de
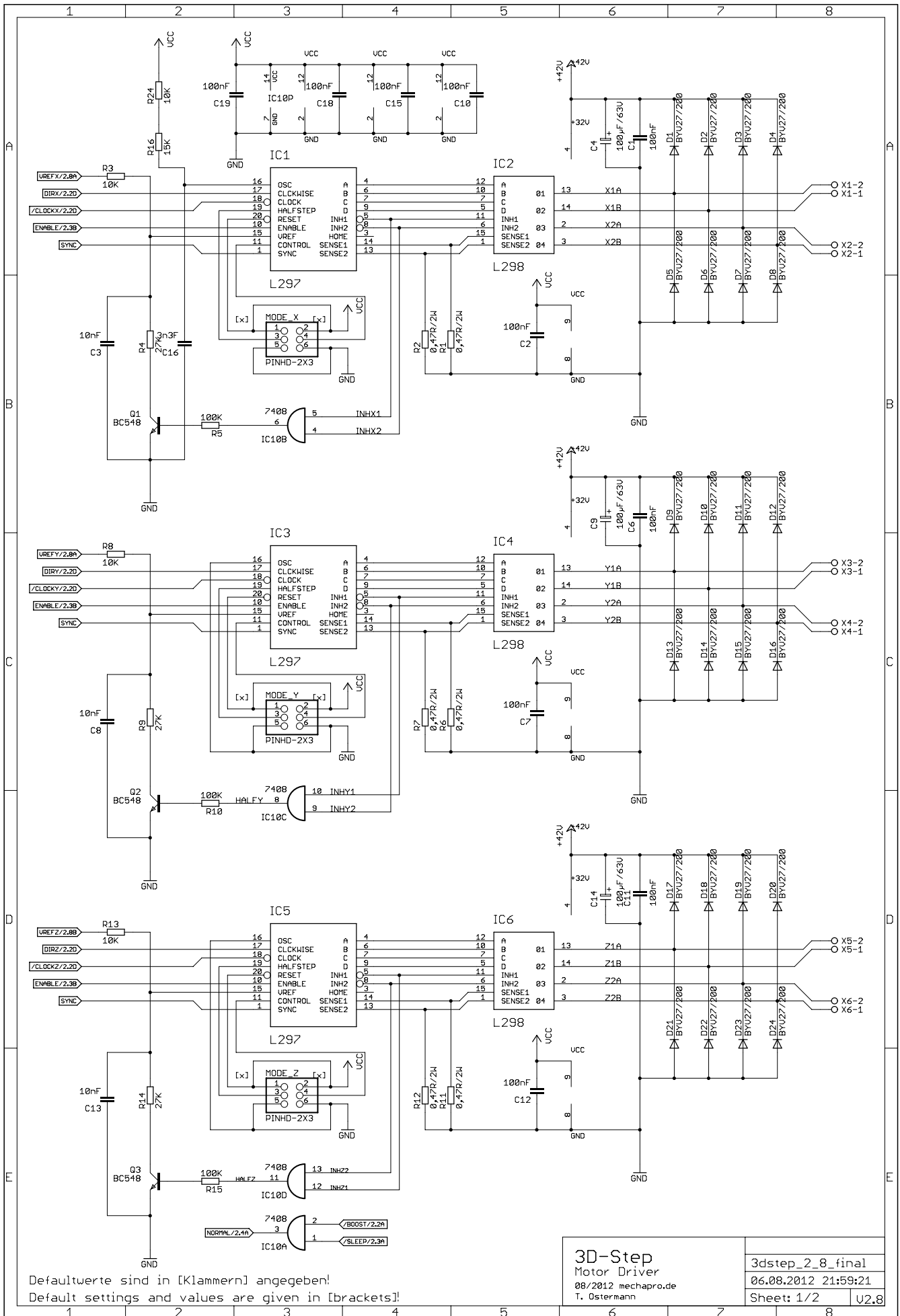
3D-Step
Motor Driver
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Defaultwerte sind in [Klammern] angegeben!
Default settings and values are given in [brackets]!

Stromabsenkung (current reduction) bei LOW: 1-2 + 3-4
Stromabsenkung (current reduction) bei HIGH: 1-3 + 2-4

Stromeinstellung:
Adjusting the motor current:

I(Wicklung)=V(ref)/[R(sense)*sqrt2]
z.B. 0,8V/[0,47R*1,414]=1,2A

HIGH = Notaus
LOW = Bereit

Alle Schalter als Öffner
nach GND anschließen

Connect all switches (N.C.) to ground

3D-Step
Vref, Logic & Connections
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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

Dimensions (in mm)
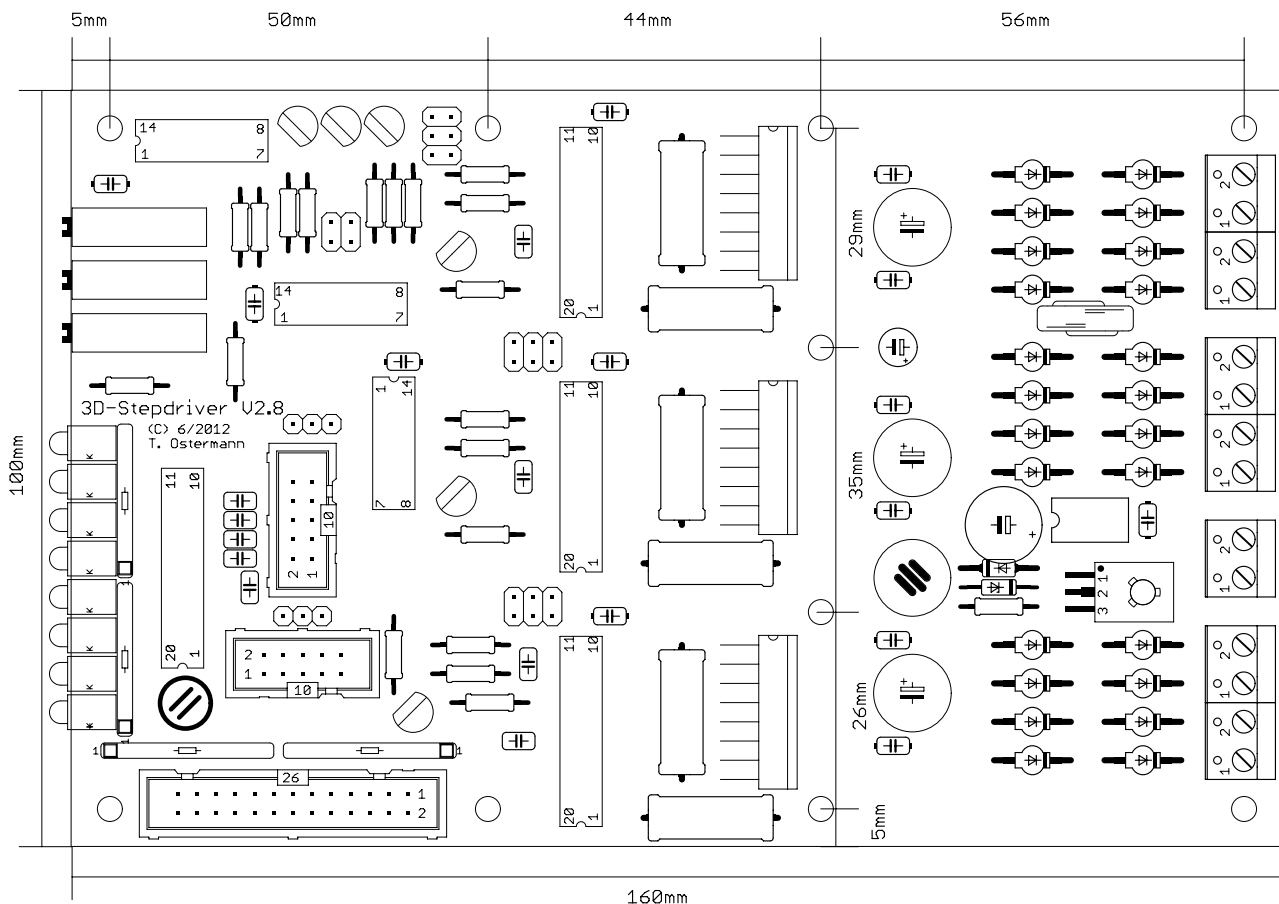
Pinout
Pin numbering referes to standard printer port with 25pin D-SUB connector

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

Notes

Patch for the boards from the first production lot

The following connections have to be made manually due to an error in the layout, e.g. by soldering single wires to the connection points. The pictures are showing the soldering side of the board in the region of IC7 and between Q7 and R25 (placed under the heat sink).

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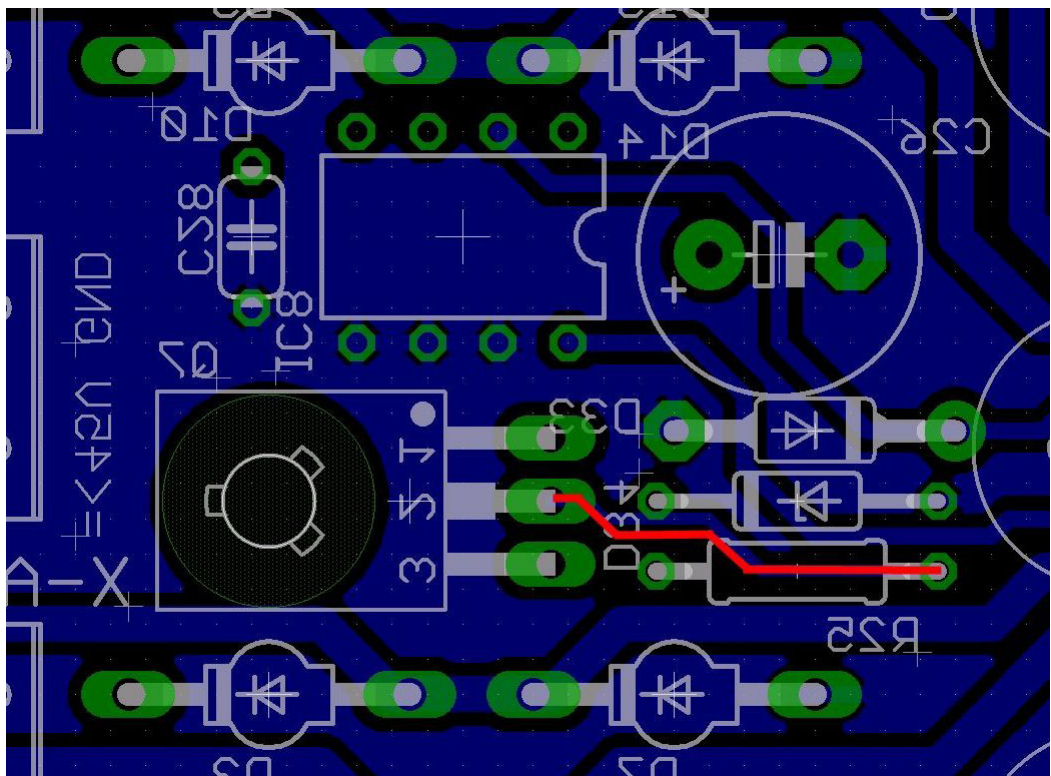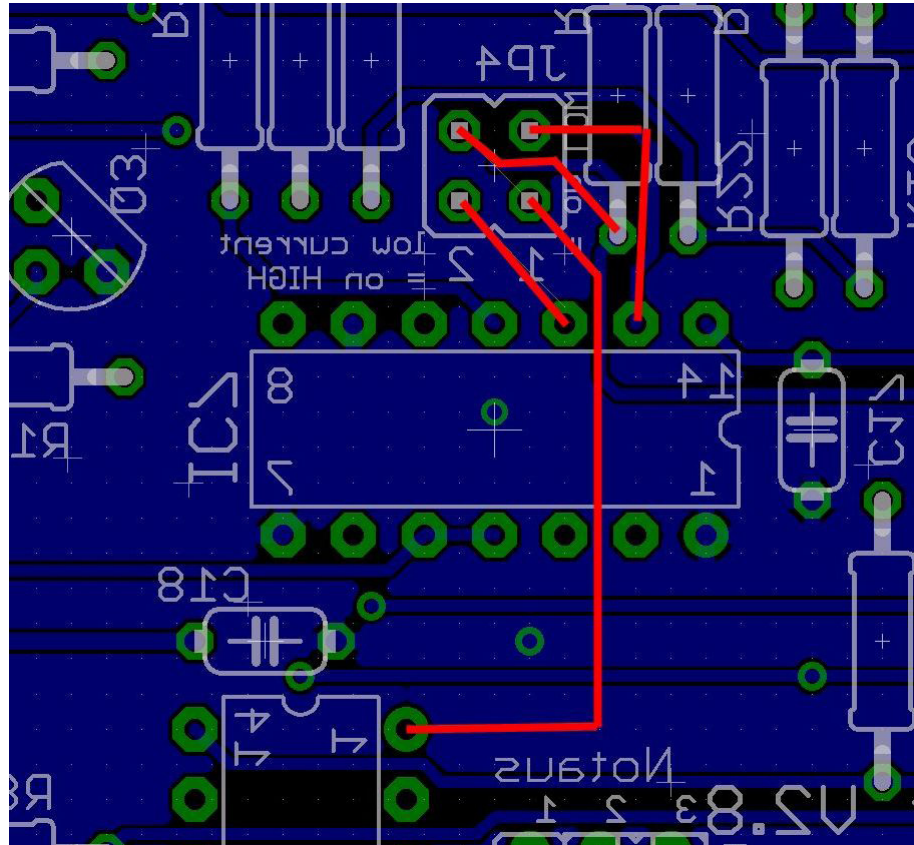
Parts

Qty.	Value	Package	Comment	Parts
	Bag 1:			
1	2K2	R-10	RESISTOR	R39
1	3K9	R-10	RESISTOR	R17
1	4K7	R-10	RESISTOR	R25
4	10K	R-10	RESISTOR	R3, R8, R13, R24
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
1	ZPD39V	DO35	Z-Diode	D34
1	1N5819	SOD81	Shottky-Diode	D33
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	30V	S10K40	Varistor RM7,5	R26
1	3n3F	RM 2,5mm	CAP	C16
8	10nF	RM 2,5mm	CAP	C3, C8, C13, C21..C25
13	100nF	RM 5mm	CAP	C1, C2, C6, C7, C10..13, C15, C17..C20, C28
4	100µF/63V	D 10mm	ELECTROLYTIC CAP	C4, C9, C14, C26
1	220µ/25V	E3,5-8	ELECTROLYTIC CAP	C5
1	330µH/.5A	09P	Choke RM 5,08	L2
1	KB L-934EW GE LED yellow	LED block		LED6
5	KB L-934EW GN LED green	LED block		LED1..LED5
2	KB L-934EW RT LED red	LED block		LED7, LED8
6	BC547B	TO92	Transistor	Q1, Q2, Q3, Q4, Q5, Q6
1	BD675A	BD677	Transistor	Q7
	Bag 2:			
6	0,47R/2W	L<=18mm	RESISTOR	R1, R2, R6, R7, R11, R12
24	BYV27/200	D-15	DIODE	D[1..24]
2	DISTANCE HOLDER 8mm for M3 screws			
4	METRIC SCREWS M3x6			
2	METRIC SCREWS M3x16			
7	KLEMM2	RM 5.08	CAGE CLAMP	X1..X7
3	L298	MTIWATT	STEP-IC	IC2, IC4, IC6
3	L297	DIL-20	STEP-IC	IC1, IC3, IC5
1	LM2574N-5	DIL8	Voltage Regulator	IC8
1	LM324N	DIL14	OP-AMP	IC11
1	74HC04	DIL14	74XX	IC7
1	74HC08	DIL14	74XX	IC10
1	74573	DIL20	74XX	IC9 (74HC, 74HCT, 74LS, … as available)
	Bag 3:			
3	IC-SOCKET	DIL14		
4	IC-SOCKET	DIL20P		
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
11	Jumper blue			
2	ML10	PINHD-2X5	PINHEAD	C-axis, SWITCHES
1	ML26	PINHD-2X13	PINHEAD	LPT
3	BSL20	SOCKETS, 8-8,5mm high, 20 pins (for L298)		
1	D-Sub ST 25 FB	25pin D-SUB plug, male, for ribbon cable		
2	PFL26	26pin ribbon cable connector		
	without bag:			
1	Heatsink			
0,5m	ribbon cable AWG28, 26 wires.			

Z2 Z1 Y2 Y1 GND Vmot X2 X1

X6 X5 X4 X3 X7 X2 X1

Z-Achse Y-Achse X-=<45V GND X-Achse

3D-Stepdriver

JP1

Z-Achse Y-Achse

IC6 IC4 IC2

R11 R7 R1
R12 R6 R2

C10 C19 C15

ICS IC3 IC1
MODE_Y MODE_X

C13 C8 C3
chop step phase inh. half full
step chop step chop

R13 R14 R8 R10 R3 R16
R15 R9 R4
MODE_Z
chop
step

Q5 Q6 Q4 R20 IC7 C18 IC10 SWITCHES C-ACHSE LPT
low current
1 2 = on HIGH
JP4 R21 JP3 JP2
R22 Notaus
3D-Stepdriver V2.83 (C) 8/2012 T. Ostermann
R24 active disabled
IC11 R19 R23 C17 C24 C25 IC9 RN4 RN3 RN2 RN1
C20 R30 R29 R28 www.mechapro.de RN2

LED1 LED2 LED3 LED4 LED5 LED6 LED7 LED8

EndC EndZ EndY EndX SLEEP NORMAL BOOST DISABLE

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