

# **SYSTEM 3+**

**C R H Electronics Design**

# SYSTEM 3+

## All in one 3 Axis Stepper drive board with Charge Pump Parallel Buffered inputs/outputs By C R Harding

### Specifications

- 3 Axis XYZ outputs, ideal for milling machines.
- Compact design, no interconnecting boards.
- Right angle Unpluggable motor connectors
- Step increment and current settings for each motor
- Two phase PWM operation.
- Uses internal synchronous rectification to reduce board size and heat dissipation.
- Includes thermal shutdown, UVLO and crossover current protection.
- 1/8, 1/4, 1/2 or full Step selectable.
- Standard 25 way PC Parallel port connection
- 1, 1.5, 2 & 2.5Amp switch selectable max stepper current.
- On board 5V & 12V regulators with spare output connection.
- Uses single power supply line (24V -30V DC regulated supply recommended)
- Maximum 35V @ 2.5A per phase motor outputs.
- LED indicator display of Step & Direction for each axis plus Enable and Power.
- Board size 105 X 165 mm. FR4, silk screen legend, immersion gold, 2oz copper, RoHS compliant.
- Buffered inputs and output connections with pull-ups (up to 30mA drive).
- 12V Fan connector.
- Built in charge pump circuit connected to all output drivers and pins.
- Kit comes with ready soldered surface mount driver chips

**Manual**      **V1.1 July 08**  
**Hardware**    **V1.0 May 08**

### **Dip switch settings for each Axis**

MS2 & MS1 Adjust Step rate.  
(MS2 on MS1 on) Full Step  
(MS2 on MS1 off) ½ Step  
(MS2 off MS1 on) ¼ Step  
(MS2 off MS1 off) 1/8 Step

C1 & C2 Control maximum stepper current

(C1 on C2 off)	1A
(C1 on C2 on)	1.5A
(C1 off C2 off)	2A
(C1 off C2 on)	2.5A

### **Power Input**

Maximum input voltage 35V, recommended regulated voltage 24-30V.

If using an unregulated power supply, check peak voltage across output before connecting the System3 board. A 25V unregulated supply can have 35V peak unloaded output. It may be necessary to place a load resistor permanently across the output to reduce the peak voltage as when the board is not enabled the power consumption is quite low.

Power is supplied to the board via a separate 20A terminal block.

These connections are also available by a smaller connector along with a 5V regulated supply that can be used to power further circuit boards.

### **Signal Inputs**

The board has five inputs that are buffered before connecting to the PC via the parallel port. Each signal has its own pull-up resistor so that a simple switching circuit can be formed by simply ground the input pin. These five inputs together with ground terminals are located at the top of the board next to the 74HC04 buffer chip. The input buffers are signal invertors so that if a input pin is unconnected it will create a low on the relevant parallel port pin. Grounding the input will thus create a high signal level.

### **Signal Outputs**

The board has five spare output connections which are buffered and capable of driving up to 30mA drive current. These outputs are only enabled with the charge pump signal and are all located at the bottom of the board. These pins can also be used for a fourth axis and driving relay boards for spindle motor control or variable speed control boards.

### **Stepper motor connections**

The following diagrams show typical connections for a range of different motors.

If your motor rating is in excess of the 2.5A maximum current limit then you should use the windings in serial connection for maximum efficiency.

### **Outputs**

**5V+:** Power output from the onboard regulator. This can be used to work other circuit boards, sensors, relays etc. **Maximum external load must not exceed 100mA.**

**12V+:** Power output from the onboard regulator used to drive fans and relays. **Maximum external load must not exceed 250mA**

### **Charge Pump Circuit**

The System3 board uses a 12 KHz charge pump signal from the controlling software to operate the enable line on all three driver circuits. This signal uses pin1 from the parallel port for its input and must be setup in your software configuration. When the signal is present the red enable light will illuminate shown that the board is active. If your software does not support this function you may override this signal with the J3 jumper link making the board permanently enabled.

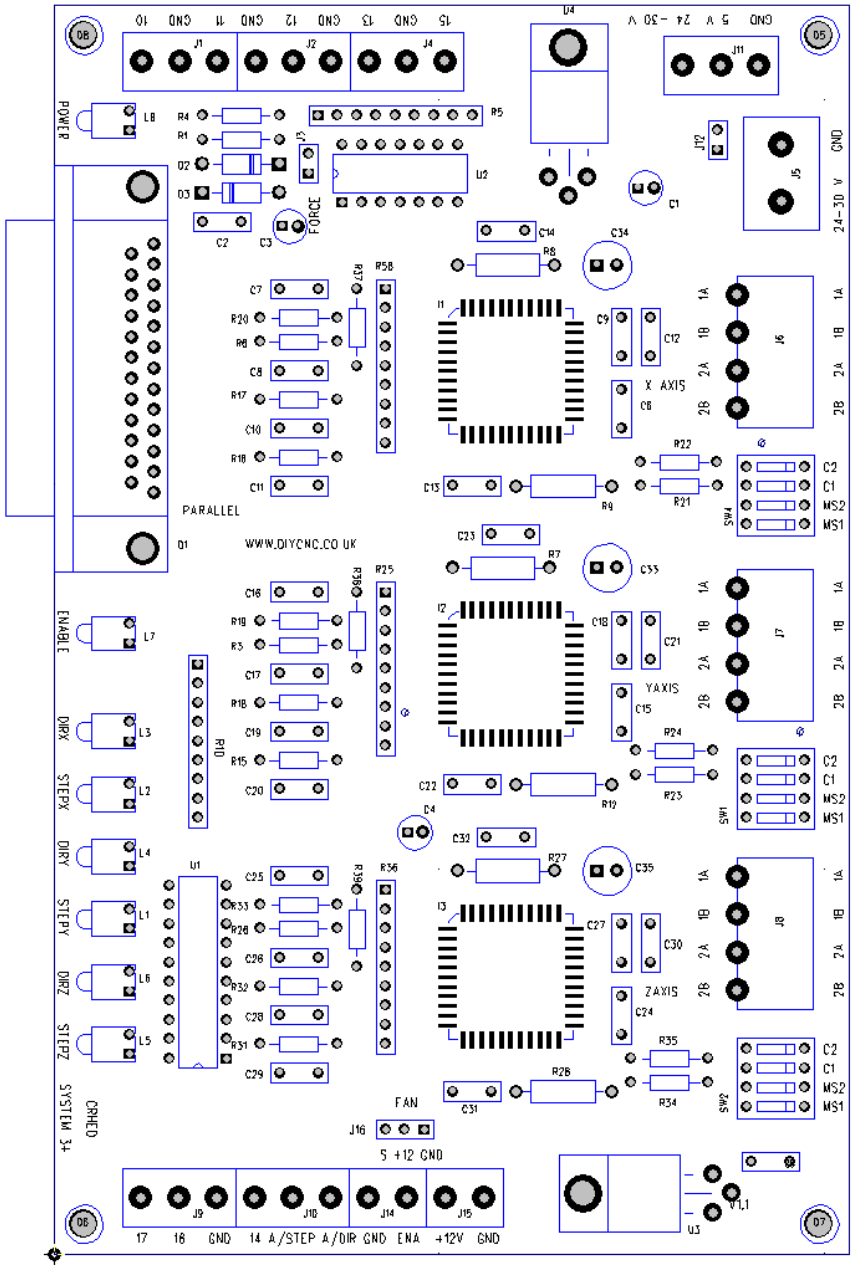
**The following table shows a typical parallel software set-up**

<b>Parallel Port Pin</b>	<b>System 3 + signal</b>	<b>Input / Output</b>
<b>1</b>	<b>Charge pump signal</b>	<b>Enable</b>
<b>2</b>	<b>X Direction</b>	<b>X Axis</b>
<b>3</b>	<b>X Step</b>	<b>X Axis</b>
<b>4</b>	<b>Y Direction</b>	<b>Y Axis</b>
<b>5</b>	<b>Y Step</b>	<b>Y Axis</b>
<b>6</b>	<b>Z Direction</b>	<b>Z Axis</b>
<b>7</b>	<b>Z Step</b>	<b>Z Axis</b>
<b>8</b>	<b>A Direction (4<sup>th</sup> Axis)</b>	<b>Output pin</b>
<b>9</b>	<b>A Step (4<sup>th</sup> Axis)</b>	<b>Output pin</b>
<b>10</b>	<b>Input 1</b>	<b>Input pin</b>
<b>11</b>	<b>Input 2</b>	<b>Input pin</b>
<b>12</b>	<b>Input 3</b>	<b>Input pin</b>
<b>14</b>	<b>Output signal</b>	<b>Output pin</b>
<b>13</b>	<b>Input 4</b>	<b>Input pin</b>
<b>15</b>	<b>Input 5</b>	<b>Input pin</b>
<b>16</b>	<b>Output signal</b>	<b>Output pin</b>
<b>17</b>	<b>Output signal</b>	<b>Output pin</b>
<b>18-25</b>	<b>Ground</b>	<b>GND</b>

Pins 8 & 9 are normally used for the fourth axis but can also be used for spindle control. The step signal becomes the speed signal and the direction becomes on/off or backwards/forwards.

If you are using Mach2/3 software, set up each axis as shown above and leave the, low/step box unchecked. You can check or uncheck the direction box to reverse the stepper motor direction as required.

**Fig1 System 3 Component layout**

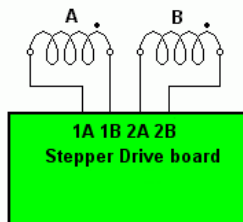


## 4 leads - Bipolar Drive

### 4 Leads

The standard connection for a four lead motor.

This is the standard connection for a bipolar drive. There are still four windings and, depending on motor type, they are in series or parallel. Most manufacturers makes two models with the same winding, but one time connected is series and one time in parallel.



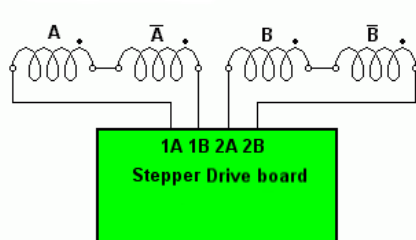
## Bipolar Drive - Serial Connection

### 6 Leads

The windings are connected in serial. Since most 6 lead motors are wound bifilar - link -, so the inductance will be quadruple of the single winding value.

### 8 Leads

The windings are connected in serial. Since most 8 lead motors are wound monofilar - link -, then the inductance will be double. If the motor was wound bifilar - link -, the inductance will be quadruple .

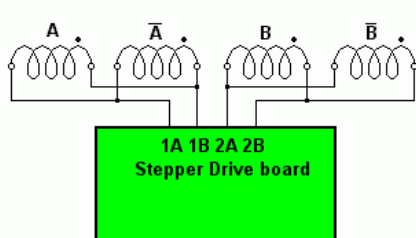


## Bipolar Drive- 8 leads - Windings Parallel

### 8 Leads

This is the standard high speed connection for an eight lead motor.

With the windings in parallel, the motor current can be higher whilt the inductance is lower. This is a typical connection for a motor that need to run at a high speed..



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## IMPORTANT:

Double check that connections are correct before applying power to the board, windings connected out of phase may cause damage to the board. Do not connect or disconnect wires with the power on. It is a good idea to adjust the current switch settings to the minimum setting if you are in any doubt of the connections. It should be noted that some six wire motors are three phase operation and are unsuitable for this board.

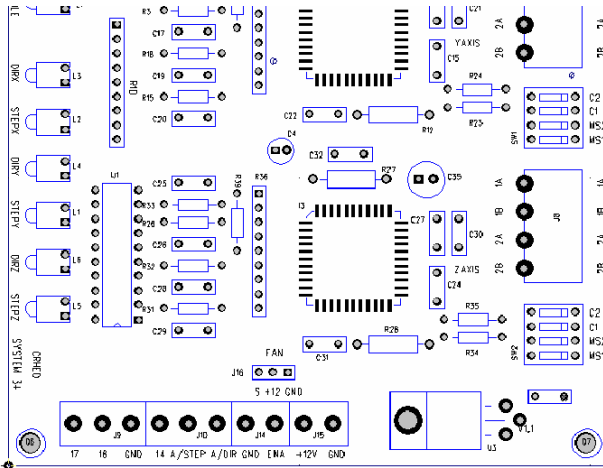
**The PCB Stepper outputs on the System3 board are marked 1A & 1B this represents one winding. Outputs 2A & 2B are the other winding.**



heating of chips and motors. This will also stop the usual whistling and humming noises associated with stepper motors.

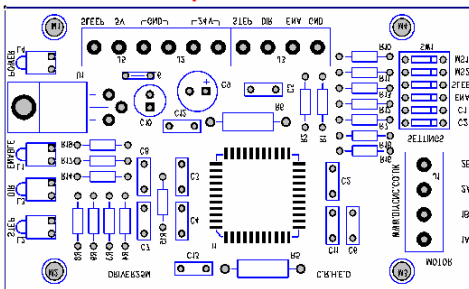
### Adding a fourth or A Axis

The following diagram shows how to connect a further axis to the System 3+ board. Although we have shown our own DRV25M board any other driver board can be used including Opto isolated versions as the board buffers can supply up to 30mA of drive current.



Adding a 4th Axis

24-30V



DRV25M

## KIT CONSTRUCTION

Building the System 3 board kit should take about two hours to build. You will need a good soldering iron; preferably temperature controlled and set to 400-450 degrees. The solder provided is lead free with a mild active flux. This helps it to flow easily but you need an extra 50 degrees higher temperature compared to lead solders. As the driver chips are surface mount devices the PCB is supplied with them ready mounted into position. With reference to the board layout diagram, start by placing the components with the longest leads that will need cropping after soldering. I find that the best way is to push the component through the holes until it is in contact with the board and then bending the leads at 45 degrees on the underside to stop the component moving while soldering. Using this technique you can place several components before soldering. The 0.18 ohm resistors will need their leads bent close to the body and positioned a couple of millimetres away from the board, see Fig2 for details. After soldering and cropping the long leaded components next place the small capacitors which have fairly short leads. The board has LED's that are mounted at right angles with the plastic housings provided. Slide the LED legs through the housing before bending the legs at 90 degrees. The longer of the two leads on the LED's is the anode or positive and goes to the square pad. Solder one leg first and then position square with the board before soldering the other leg. The 7805 & 7812 regulators need the centre leg bending slightly forward before bending all the legs back and fitting a bolt through the metal tag to secure. There are two IC's and two diodes to fit and a jumper for charge pump override or testing. Fit the DIP Switches and the sets of connector blocks. The blocks are manufactured in either a three or two terminals but there is an interlocking system built into their sides for multiplying the amount of terminals needed. Make sure that they are slid together before fitting to the PCB. The stepper motor output connector needs to be orientated correctly so that the terminals plug in and away from the edge of the board, check this before soldering. If available you could clean up the flux residue with a proprietary flux cleaner when complete. I have found the **SERVISOL DE-FLUX 160** flux remover / PCB cleaner is very effective.

### Notes:

- Position power resistors 2 Watt 0.18 ohm so they are a couple of millimetres away from the PCB see Fig 2.
- L6 is a wire link used to couple the analogue and digital ground planes, use a chopped resistor lead.
- Long lead on LED is anode (goes to square pad)
- Check dot on resistor arrays (common, goes to square pad).
- Long lead on electrolytic caps is positive (goes to square pad)

## Component parts list for SYSTEM 3.

### Capacitors

C1, C4	100uF 16V
C2, C5, C7, C8, C13, C14, C16, C17	CAP 0.1uF 100V
C3	1uF 50V
C6, C9, C12, C15, C18, C21, C24, C27, C30	CAP 0.22uF 100V
C10, C11, C19, C20, C28, C29	CAP 1nF 100V
C22, C23, C25, C26, C31, C32	CAP 0.1uF 100V
C33, C43, C35	CAP 100uF 50V

### Semiconductors

D2, D3	DIODE	1N4148
I1, I2, I3	A3977	PLCC44
U2	74HC04	buffer
U4	7805	TO-220
U1	74HC541	Buffer
L1, L2, L5	LEDRA	GREEN
L3, L4, L6	LEDRA	ORANGE
L7	LEDRA	RED
L8	LEDRA	BLUE

### Resistors All 1/4watt unless specified

R1	RES	100k	5%
R3, R6, R26	RES	15k	5%
R5	RES-SIP9R	47K	
R10	RES-SIP9R	470	
R7, R8, R9, R12, R27, R28	RES	2W	0.18 5%
R4	RES	470	5%
R15, R16, R17, R18, R31, R32	RES	22k	5%
R19, R20, R33	RES	1k	5%
R21, R23, R34	RES	5.6k	5%
R22, R24, R35	RES	12k	5%
R25, R36, R56	RES-SIP8R	10K	
R37, R38, R39 (not fitted)			

### Connectors

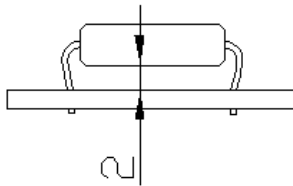
D1	DB25-HM
J1, J2, J4, J9, J10, J11	TERM3 5mm
J3 JUMPER	SIP\2P
J5	TERM20-2 7.5mm
J6, J7, J8	4 way male Connectors
(supplied with matching 4 way right angle terminal connectors)	
J14, J15	TERM2 5mm

**J12**  
**SW1, SW2, SW3**  
**J16**

**wire-link**  
**DIPSW4**  
**SIP\3P (Fan)**

**System 3+ PCB, FR4, 2 layer, 2 oz copper, silk screen legend.**  
**3 mm Nuts & Bolts for regulators**  
**Lead free solder**

Fig2



Contact Details

J Harding  
12 Herm Close  
Seabridge  
Newcastle-under-Lyme.  
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