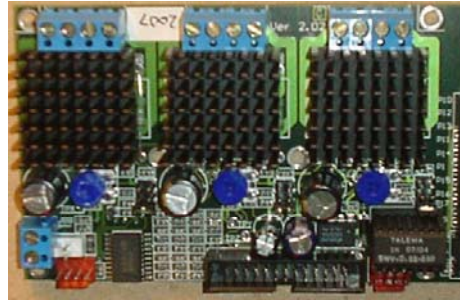# XS-3525/8S-3

Preliminary DataSheet Version 2.02

The XS-3525/8S-3 microstepping stepper motor driver is the perfect choice for CNC retrofitting of desktop and small benchtop milling machines. Connect bipolar wired stepper motors, power, and a parallel port signal source

- Small Size 4.64 X 2.84 inches.
- Drives up to 35Volts @ 2.5 A/phase
- 4 different microstepping step levels from Full-Step(FS) to 1/8 step
- Filtered & Buffered Step & Dir lines
- Built in DC-DC converter for +5V
- Break-out screw terminals for I/O

Microstepping Truth Table

MS2	MS1	Output
0	0	Full Step
0	1	Half Step
1	0	Quarter Step
1	1	Eighth Step

1 means jumper **NOT** installed

The XS-3525/8S-3 Stepper Driver is a 3 axis pulse-width-modulated (PWM) current controlled bipolar micro-stepping controller.
Each axis drive has a ±2.5 Amp/phase @ 35Volt maximum continuous Output Rating. The drive circuitry has thermal shutdown protection and crossover-current protection. Synchronous rectification circuitry eliminates the need for external clamp diodes in most applications.
Each axis accepts Step & Direction signals, along with 2 jumper inputs to define microsteps per full step.

The board is of 4-Layer construction with Isolated Power and Logic supply planes. The drive circuitry has a heat sink attached to allow cooler operation.

Power

Each axis can be separately setup to deliver different maximum current levels by adjusting an on-board potentiometer. The potentiometer creates a voltage which is input to the drivers Vref (Voltage Reference) pin. The Vref voltage is referenced to ground (GND) and can be monitored at the test points TPX,TPY and TPZ. The reference voltage at the test points is related to the motor drive current by the following formula:

$$Vref = Motor\ Current * 1.44$$

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2.5 Amp = Vref 3.60V
2.0 Amp = Vref 2.88V
1.5 Amp = Vref 2.16V
1.0 Amp = Vref 1.44V
0.5 Amp = Vref 0.72V
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The Vref circuitry is based on the +5V generated with the on-board DC-DC converter. The Vref's allow for a wide selection range, which can be set to exceed the maximum (3.60V) Exceeding the 3.60V will cause the drive circuitry to attempt to deliver more current than it is rated for, which can cause overheating of the device. Overheating the device lowers life expectancy of the circuitry as well as introducing the possibility of a thermal shutdown cycle (which can lead to motor/system position losses). You should never drive the motor at a current higher than specified by the motor manufacturer. Generally, very little extra torque will be achieved, and the motor will probably overheat.

The Vref voltage is compared to on-board Sense Resistors which have a ±5% accuracy rating. Full current can be achieved with voltages as low as 3.42V on Vref. When attempting to deliver 2.5A/phase, start with a Vref voltage of 3.42V.

The system motor drive circuitry can handle up to 35 volts **which includes Back EMF** (BEMF)**.** The recommended maximum running voltage is 30VDC. **The absolute maximum voltage is 35VDC.** Exceeding the maximum voltage (35V) will destroy the circuitry!

Because stepper motors are current driven, rather than voltage driven devices, it is generally acceptable, and most often necessary, to drive the motor at a voltage higher than the motor's rated (nameplate) voltage. The on-board drive circuitry limits the source/sink current to the motor without the need for external power resistors.

12 Volt and 24 volt power supplies are the most common power sources with voltage outputs under the maximum 35V. Of the two, 24V will provide much better performance. 24V will charge the motor coils to the proper level twice as fast as 12V. This means reaching the proper torque quicker, and means getting a more torque at a higher step rate. Because 24V will allow the motor coils to charge quicker, the internal switches will remain ON for a shorter amount of time. This allows the board to run cooler. 12VDC may be used for initial setup and testing however it does not provide any level of protection over using a higher voltage like 24VDC.

The minimum motor supply voltage is 8.0 volts.

ABSOLUTE MAXIMUM RATINGS

T_A=+25°C

which should not be exceeded

Load Supply Voltage(V_{BB}) (including Back EMF) **35V**
Output Current(I_{OUT}) **±2.5A**
Operating Temperature Range(T_A) **–20°C to +85°C**
Junction Temperature(T_J) **+150°C**

Logic Input Voltage
    Logic HIGH min. voltage 2.9V (MAX. +5.0 VDC)
    Logic LOW max. voltage 1.5V

Recommended Maximum Running Voltage: 30VDC

Restrictions

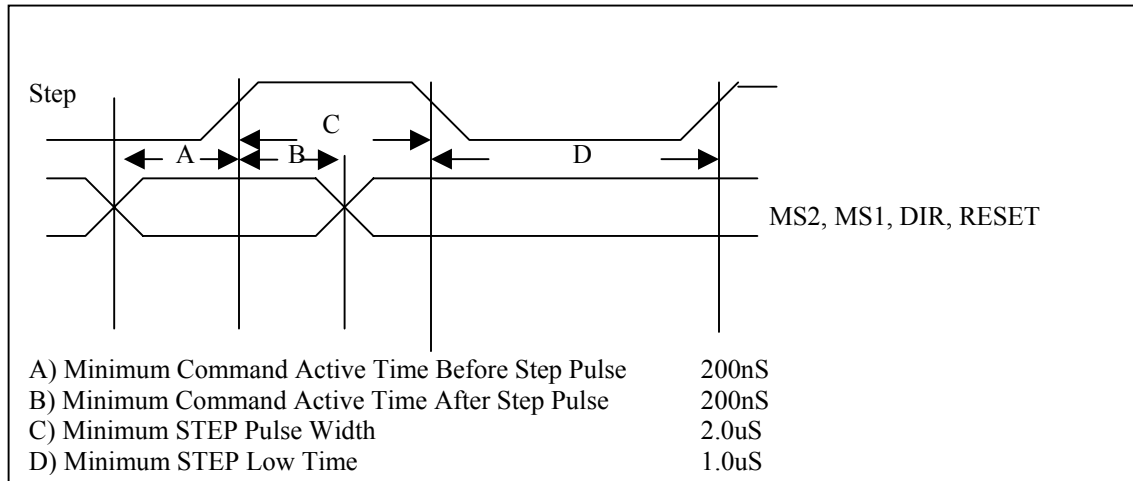Do **NOT** adjust the Vref voltages with motors attached
Do **NOT** adjust the Vref voltages to more than 3.60V
Do **NOT** connect **or** disconnect motors, fans, etc when the drive is powered.
Do **NOT** place a fuse between the motors and the drive.
Do **NOT** allow V_{BB} to exceed 35VDC, STEP & DIR lines to exceed +5.0 VDC
Do **NOT** connect scopes or any other test devices to the motor leads (A, A#, B, B#)

A) Minimum Command Active Time Before Step Pulse 200nS
B) Minimum Command Active Time After Step Pulse 200nS
C) Minimum STEP Pulse Width 2.0uS
D) Minimum STEP Low Time 1.0uS

Step Sequencing

Table 1.

FULL	HALF	QUARTER	EIGHTH	ANGLE	NOTE:
	1	1	1	0	
			2	11.25	
		2	3	22.50	
			4	33.75	
1	2	3	5	45	HOME#
			6	56.25	
		4	7	67.50	
			8	78.75	
	3	5	9	90	
			10	101.25	
		6	11	112.50	
			12	123.75	
2	4	7	13	135	
			14	146.25	
		8	15	157.50	
			16	168.75	
	5	9	17	180	
			18	191.25	
		10	19	202.50	
			20	213.75	
3	6	11	21	225	
			22	236.25	
		12	23	247.50	
			24	258.75	
	7	13	25	270	
			26	281.25	
		14	27	292.50	
			28	303.75	
4	8	15	29	315	
			30	326.25	
		16	31	337.50	
			32	348.75	
	9 or 1	17 or 1	33 or 1	360 or 0	restart cycle

360 is 4 FULL Steps

Connectors

See the last page for a drawing with pin-out signal location

The 4-pin Molex header on the Lower Left of the board has ENA# for all three axes as well as GND

The 4-pin header on the lower right has the A Axis STEP, DIR as well as, Vcc and GND. The A axis STEP & DIR lines are filtered and buffered (like the X, Y, and Z lines) before being transferred over to the 4-pin header.

The 2-pos screw terminal on the lower left is used for Motor Power Supply (VBB) (Min 8.0 Volts, Max 35.0 Volts)

The 2-pin Molex header on the lower left side of the is tied to the system ground (**GND**) and motor power supply planes (**VBB**). In systems using 12 or 24 volts, this connector can be used to supply power to a cooling fan rated for the appropriate voltage. **Use of a cooling fan is recommended for systems operating at or near the maximum current rating** (see below). Lower voltage system (12V) may also require fan cooling since the internal drivers will be ON for longer periods during coil charging.

The 26-pin IDC header is used as a source for the axes' STEP and DIRECTION signals. With the IDC26-DB25 cable supplied with the board, use the following pin information:

Board Usage	Parallel Port	DB25 Pin Number
STEP X	PD0	2
DIR X	PD1	3
STEP Y	PD2	4
DIR Y	PD3	5
STEP Z	PD4	6
DIR Z	PD5	7
GND	GND	18,19,20,21, 22,23,24,25

On the IDC26 header, Pin 26 is connected to system VCC. In most configurations, the pin will not be connected since typical IDC – DB25 adapters do not use this pin. Special designs may use this pin as a voltage source for signal power (i.e. 10K resistor pullup for I/O lines). It is not intended to power external devices.

Other I/O Screw Terminals:
  The break-out screw terminals on the right hand side of the board provide the user with access to all unused Parallel Port I/O (except A axis STEP and DIR). The I/O may be used for software driven functions such as limit switches, home switches, E-STOP switches, spindle motor enable, coolant pump enable, etc. The stepper driver board plays NO role in the processing of these signals other than to provide a place to access them. Refer to your software package to properly setup and use function similar to the ones listed above. The Numbers on the board next to the screw terminals (i.e. P10, P12…) represent the **P**arallel **P**ort **P**in number (DB25 **p**in number).

The GND & Vcc (+5VDC) available on the right hand side of the board can be used to pull limit inputs high through a 10K resistor. It is not intended to drive other devices. This GND can be used for Vref set reference.

Setup & Operation

Almost all board failures occur during initial setup, while moving the board to a new location or adding connectors because of **miswiring and shorts**. It is imperative that the wiring to the board be double checked, that the motor phase information is correct.

  You should be familiar with, and ready to use your signal generator (i.e. software such as TurboCNC or Mach2, or a step generator like a microprocessor)

Take static discharge precautions (ground yourself before handling the board).

- ❑ With Power Supply (PS) off, Attach Vbb & Gnd to screw terminals. Note Polarity when connecting!
- ❑ Power ON PS (see red LED light up on stepper driver board)
- ❑ Check/adjust your Vrefs (probe Black to GND, Red to Vref – Make sure Black is not on +5VDC, Vcc)
- ❑ Power OFF PS
- ❑ Hook up 24VDC fan if you are going to be using one (and Vbb is 24VDC)
- ❑ Hook up a stepper motor. **Make sure that the Phases are correct**. Double check connections (no disconnected wires, bare ware or shorted wires)
- ❑ Power ON PS
- ❑ The motor should "lock up" (not turn with simple finger pressure). If NOT then <u>STOP</u> here
- ❑ Power OFF PS
- ❑ Connect the IDC26-DB25 cable. It is generally then connected to a PC parallel port extension cable
- ❑ Power ON PS
- ❑ Try to jog the motor with software (i.e. TurboCNC or Mach2)
- ❑ If motor moves properly -> continue, otherwise <u>STOP</u> here.
- ❑ Turn OFF PS
- ❑ Hook up your other motors
- ❑ Double check connections (again!)
- ❑ Turn ON PS
- ❑ Test jogging for newly attached axes

If the motors run backwards, swap either the A-A#, or B-B# wire pairs (but not both). Generally though, this can (and should be) be achieved through software.

ENA# Inputs

  The drive ships with all three axes enable by use of the ENA# jumper. This is the jumper, in the set of three each axis has, that is closest to the IDC header. By removing these jumpers, enable control can be passed to the ENA# connector (4-pin Molex header on the left hand side of the board). This connector can allow the remote enabling/disabling of any or all of the axes. For a single switch enable of all thee axes, simply make a connector that wires all three axes enables together, and place this on one side of a SPST switch. Wire the GND from the header to the other side of the switch. When the switch is in the "closed" position, the GND will be connected to the ENA# inputs and the drives will be enabled. When the switch is "open", the drives will become disabled. Similarly, three separate switches each with an individual ENA# and GND can be wired up to allow separate enabling/disabling of the drives. As an alternative, the ENA# can be controlled by software through an output port (i.e. one of the parallel port outputs). In this case, when the ENA#(s) are connected to an output, and the output state is LOW, the drive(s) will be enabled. When the output goes HIGH, the drive(s) will be disabled.

The **Heat Sinks** are attached with thermally conductive adhesive pad. The driver board is meant to operate in a Horizontal position. The adhesive pad has not been tested for holding strength when the driver board is operated in a vertical position. In practical application however, the boards may be mounted vertically <u>once the adhesive has cured</u>. This will generally have taken place by the time you receive it. The heatsinks conduct heat away from the driver chips. A

cooling fan can help this process considerably, and given the cost of small fans, they are well worth the expense. If the board is mounted within an enclosure, place the fan so that it will bring in cool outside air and blow it over the heatsinks. Make sure there is adequate ventilation holes so that the warm air in the enclosure can exhaust. Be sure that the fan is situated so that no flying debris, such as coolant, chips or dust can get sucked in by the fan. Dust and dirt blown in and deposited on the heatsink will degrade the heat transfer and the board can fail due to overheating. You may want to periodically blow out any dust accumulated on the heatsinks.

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Unipolar Motor Note: When Setting Vref for a UNIPOLAR rated motor, use a current of 50.0% of the rated unipolar current, when wired for series mode. EX: Unipolar rated at 2.0A, when wired in series mode would be setup for 1.00A, or Vref of 1.44 Volts. Half winding mode would use the full 2.0A rating, Vref = 2.44V.

 The drive will work with three type of stepper motors, 4-wire, 6-wire or 8-wire motors.

4-wire motors are truly bipolar, and can only be run as such.

6-wire motors can be wired two ways to work with the bipolar drive.
   The first is half-winding. In this method, one end wire, and the center-tap wire of the phase is used. The other end is insulated and left unused. This method uses unipolar nameplate current specifications, and will produce nameplate torque.
  The second is series winding. In this configuration, the center-tap is insulated, and unused. This method uses all of the wiring per phase, but has <u>double</u> the number of wire turns as half-winding or unipolar mode. Because of this, the amperage requirement becomes <u>half</u> the nameplate rating. Because the wire in the coil can handle more current than 'half', motor manufacturers will often "boost" the torque rating by specifying currents up to 71% of unipolar rated current while running in series mode. This is fine for FULL step motor drives, but not necessarily so good for microstepping drives. Using this much can smear microstepping smoothness and accuracy. Any extra torque achieved by this method will generally be lost to machine vibrations due to loss of microstepping smoothness.   The best performance will be somewhere between the 50% and 71% current rating.

  The advantage of using series winding is that lower power drives may be used. For example a unipolar motor rated for 4.0A/phase is over the 2.5A/phase maximum of the XS3525/8S-3. Running in series requires only 2.0A/phase to achieve the same torque. The disadvantage of this method is that it raises motor inductance, which in turn, slows motor coil charging time. Since proper torque is reached only when the coil has charged to the required level, the longer it takes to charge, the longer until full torque is achieved. This leads to slower full torque stepping rates. Conversely, a half-winding configuration requires full nameplate rated current, but if the drive is capable of this, the advantage is that rated torque can be achieved twice as fast as series winding (using the same voltage, when comparing half-winding and series).

6-Wire motor Wired Bipolar Series

8-wire motor — Bipolar Parallel

6-Wire motor Wired Bipolar Half-Winding

8-wire motor — Bipolar Series