Functional description of BSD-02LH Module

The BSD-02LH module is the part of the BSD-02 family of drivers. The main difference is higher microstepping resolution. The BSD-02LH is suitable for driving bipolar and unipolar step motors from 50mA to 2.5A and up to 30V.

Driver can operate in one of the 4 stepping modes: Full-, Half-, Quarter- or Sixteenth- Step without requiring any phase-sequence tables, high frequency control lines or complex interfaces to program. Ideal for applications where a complex microcontroller is unavailable or over-burdened.

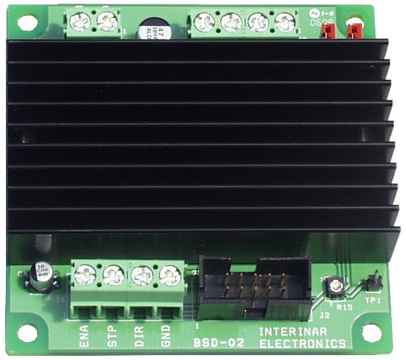

Figure 1 Step Motor Driver BSD-02

Features

- +/- 2.5A, 30V Output Rating
- Synchronous rectification
- Crossover-Current Circuit Protection
- Under-Voltage Lockout Protection
- Thermal Shutdown Protection
- Automatic Current-Decay Mode
- Enable and Sleep Inputs
- Built-in Translator
- Translator Home State Output
- Reduced audible motor noise
- Increased step accuracy
- Low Quiescent Current (10mA MAX)

Table 1: 2-pin Terminal Block J1

Pin #	Pin Description
1	GND - power ground.
2	$+V_B$ - motor supply voltage. Min 8.0V , Max 30V.

Table 2: 10-pin Header J2 (see Figure 2)

Pin #	Pin Description
1	ENABLE - input, active-low. When logic-low all outputs are enabled. When logic-high all outputs are disabled but Step and Direction signals are still processed in translator. Board has built in pull-up resistor so if this input is left disconnected the driver will be disabled. This input is also available on pin 1 of J4.
2	+5V DC - output. Up to 100mA can be drained from this pin to supply power to the external logic. May be left disconnected if not used.
3	SLEEP – input, active-low. When logic-low all outputs and most of the internal circuitry are disabled. When logic-high, normal operation resumed and translator set to home state. Board has built in pull-up resistor assuring normal operation if this input is left disconnected. This input may be left disconnected when not used.
4	RESET - input, active-low. When logic-low all outputs are off and translator is set to predefined home state. STEP input is ignored until RESET goes high. Board has built in pull-up resistor. This input may be left disconnected when not used.
5	DIRECTION - input. Determines the direction of the rotation of the motor. Depends on how motor was connected if low was Counter Clockwise then high will be Clockwise and vice-versa. Board has built in pull-up resistor. Also available on pin 3 of J4.
6	STEP - input. A low-to-high transition advances the motor one increment. The size of the increment is determined by MS1 and MS2 (*see Table65 and Table 7*). Minimum Step Pulse Width is 1.0us. Minimum Step Low Time is 1.0us. Board has built in pull-up resistor. Also available on pin 2 of J4.
7	MS2 - input. Together with MS1 determines the size of the increment of the rotation (*see Table6 and Table 7*). Board has built in pull-up resistor and jumper JP6 for convenience. Shipped with JP6 OFF (default).
8	MS1 - input. Together with MS2 determines the size of the increment of the rotation (*see Table6 and Table 7*). Board has built in pull-up resistor and jumper JP5 for convenience. Shipped with JP5 OFF (default).
9	HOME- output. Logic indicator of the initial state of the translator. At power up the translator is reset to the home state (*see Table10 for home state conditions*).
10	GND - signal ground.

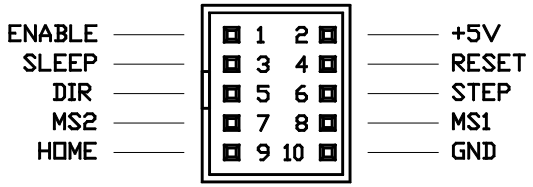

Figure 2. 10-Pin Header J2

Table 3: 4-pin Terminal Block J3

Pin #	Pin Description
1	O1B - output. Phase 1 output B.
2	O1A - output. Phase 1 output A.
3	O2A - output. Phase 2 output A.
4	O2B - output. Phase 2 output B.

DO NOT CONNECT OR DISCONNECT MOTOR WIRES WHILE DRIVER IS POWERED OR DRIVER WILL BE PERMANENTLY DAMAGED!

Table 4: 4-pin Terminal Block J4

Pin #	Pin Description
1	ENABLE - input, active-low. When logic-low all outputs are enabled. When logic-high all outputs are disabled but Step and Direction signals are still processed in translator. Board has built in pull-up resistor so if this input is left disconnected the driver will be disabled. This input is also available on pin 1 of J2.
2	STEP - input. A low-to-high transition advances the motor one increment. The size of the increment is determined by MS1 and MS2 (*see Table5 and Table 6*). Minimum Step Pulse Width is 1.0us. Minimum Step Low Time is 1.0us. Board has built in pull-up resistor. Available also on pin 6 of J4.
3	DIRECTION - input. Determines the direction of the rotation of the motor. Depends on how motor was connected if low was Counter Clockwise then high will be Clockwise and vice-versa. Board has built in pull-up resistor. Available also on pin 5 of J4.
4	GND - signal ground.

Setting the Max Current Limit.

To guarantee proper operation of the motor it is important to adjust Max Current Limit by adjusting V_{REF} to appropriate level. Calculation of V_{REF} for Half-, Quarter- and Sixteenth-Step Mode is based on the following formula:

$$V_{REF}\,[V] = \mathbf{1.6} * I_{max}\,[A]$$

for example: if motor is rated 1.68A then V_{REF} should be approx. 2.69V
(V_{REF} = 1.6 * 1.68A = 2.69V).
Use Voltmeter connected as per Table 5 and Figure 3.

Table 5: Max current adjustment

Voltmeter	Adjust
Between TP1 and GND	R15

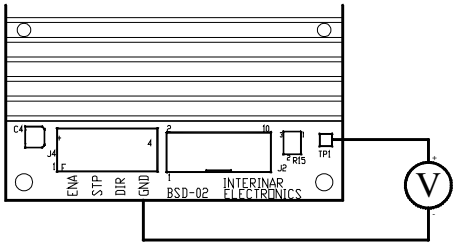

Figure 3 Adjustment of Voltage Reference Vref

DO NOT ADJUST Vref ABOVE 4.0V IF OPERATING IN HALF-, QUARTER- OR SIXTEENTH-STEP MODES.

For FULL-STEP mode, VREF can be applied up to the maximum of +5V, because the peak current in FULL-STEP mode reaches only 70.7% of the maximum value.
To calculate Vref in Full-Step mode use following formula:

$$V_{REF}\,[V] = \mathbf{2.26} * I_{max}\,[A]$$

The max current available in Full-Step mode is +/- 2.2A
DO NOT FORGET TO ADJUST THE CURRENT WHEN SWITCHED BACK TO HALF-, QUARTER- OR SIXTEENTH-STEP MODES.
If driver will be operated with step mode changing from Full to Microstep during operation, then Vref should be calculated using formula for Microstep mode.

Table 6: Jumpers Description

JP #	Jumper Position	Description
5	OFF ON	MS2 – input. Microstep resolution. - see Table 7**(default)** - see Table 7
6	OFF ON	MS1 – input. Microstep resolution. - see Table 7**(default)** - see Table 7

Table 7: Microstep Resolution

JP 6	JP 5	Jumper Position	Resolution	Excitation
ON	ON		Full Step	2 Phase
ON	OFF		Half Step	1-2 Phase
OFF	ON		Quarter Step	W1-2 Phase
OFF	OFF		Sixteenth Step **(default)**	4W1-2 Phase

Controlling Mixed Decay Mode.

The driver is shipped with active Mixed Decay mode. First, the driver operates in fast-decay as the trip point is reached. After this fast-decay portion the driver will switch to slow-decay for the remainder of the fixed off-time period. Fixed off-time is set at 30usec during manufacturing process and can't be adjusted.

Choosing the Power Supply.

VOLTAGE **–** The BSD-02LH driver works by switching the voltage to the motor terminals ON and OFF while monitoring phase current to maintain its level. Depending on how fast the motor should run you will need a power supply with voltage rating at least twice that of the motor. You may use both regulated and unregulated power supplies. A regulated power supply can be rated up to max allowed voltage for the BSD-02LH which is 30Vdc. If you choose an unregulated power supply do not exceed 21Vdc as they are rated at full load current. At lesser loads, like when the driver is disabled, the actual voltage of the power supply may be up to 1.4 times the rated voltage.

CURRENT – The BSD-02LH driver requires no more supply current than the sum of the two phase currents of the motor. The current needed for logic on the board is marginal and can be ignored in this calculation. In reality you will need a lot less than that, depending on the motor, speed, load and voltage. The more the power supply voltage exceeds the rated motor voltage, the less current you will need from the power supply. For example: a driver powered from 24V power supply will draw approximately only half of the current that it would if powered from 12V. For that reason we recommend to use power supply with at least twice the rated phase current of the motor.

Mounting the BSD-02LH.

The BSD-02LH can be mounted in two ways:
1. Using SnapTrack rail attached to your panel with double-stick foam tape or screws. Driver boards seats firmly in the rail without screws.
(The Snap-Track is available from www.Interinar.com).
2. Using four holes located in the corners of the circuit board. In this case use plastic standoffs or spacers at least ¼" high to support the board. To fasten the board use #4 screws.

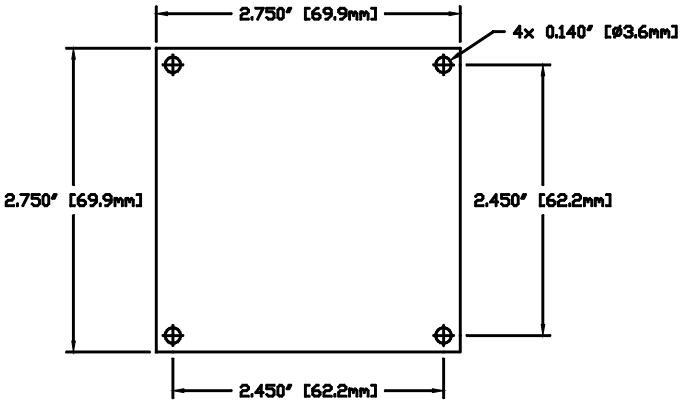

Figure 4 Dimensions and Mounting Holes.

NEVER use heat sink as a support and never attach any objects to it.
DO NOT REMOVE HEAT SINK FROM THE BOARD as it is assembled with non-reworkable heat transfer material which needs to be replaced once removed.
Heat sink is electronically connected to Ground but it should not be used as Ground connection.

The BSD-02LH features large heat sink which is sufficient for most applications. Heat dissipated in IC is transferred through thermal vias and pad directly to the heat sink. During extensive use of the driver at the maximum current the temperature of the heat sink may easily rise 40°C above ambient. For that reason it is necessary to use external fan providing forced air flow in direction parallel to the fins of the heat sink. Significant improvement can be achieved with air flow rates above 400 LFM (2m/s). Figure 5 shows direction of airflow.

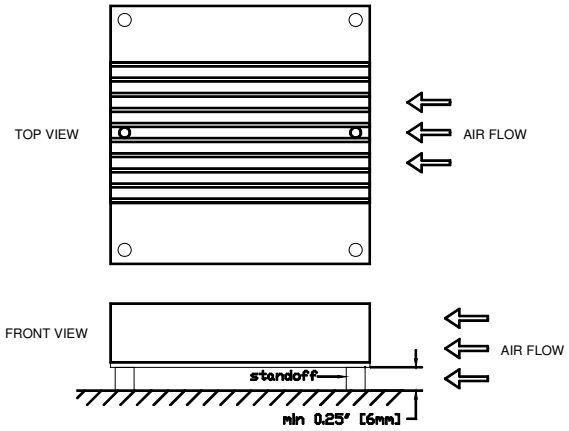

Figure 5 Air Flow direction.

Use external fan if operating under following conditions:
- current up to 1.4A - no fan needed
- current 1.4 to 2.0A - fan recommended
- current 2.1 to 2.5A - fan necessary

In some cases when the motor works with extremely low rpm or standstill (idle) for long time waiting for the next step with outputs enabled (Enable signal low) the temperature of the driver IC may exceed max Junction Temperature of +150 °C. In this case internal Thermal Shut Down circuitry will be activated at +165 °C, all outputs will be disabled and motor will stop working. When Junction Temperature falls back below +150°C driver will resume normal operation. *This thermal protection is intended only to protect the driver from failure when junction temperature exceeds specified limit and should not imply that output short circuits are permitted. Do not short outputs. Do not connect any output to Ground or Power Supply. Do not disconnect or connect motor while driver is powered.*
To keep the temperature down it is recommended to disable outputs (ENABLE= HIGH) when motor standstill (idle phase).
Working at highest temperature range should be avoided also due to step accuracy. When Thermal Shut Down temperature is reached motor will stop rotating skipping steps. Since most step motors are used in open loop your controller will not be able to recognize missing steps and position accuracy will be affected.

Connecting the Motor.

The BSD-02LH driver is based on DMOS technology and despite the fact it features output protection it will be damaged if not properly connected to the motor.

NEVER CONNECT OR DISCONNECT THE MOTOR WHILE THE POWER IS ON.
INSULATE UNUSED MOTOR LEADS SEPARATELY.
DO NOT CONNECT ANY MOTOR LEADS TO GROUND OR POWER SUPPLY.

4-LEAD MOTOR
This kind of motor can be connected only one way. See drawing below. If default direction of the rotation is opposite to the desired then swapping the wires of just one phase will cause motor to rotate in opposite direction.

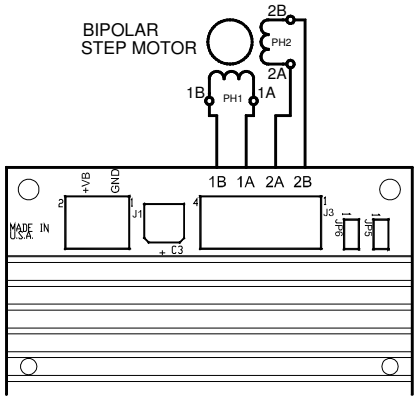

Figure 6 Bipolar motor connection.

6-LEAD MOTOR
Motors with 6 leads can be connected in two different ways:
1. Bipolar-Series connection- center tap is not used. Both ends of each phase are connected to the driver. In series connection motor should be operated at 70% of the rated current. Running motor at full rated current will saturate and overheat the motor. The series connection is preferred method because it produces less heat in the driver and produces higher torque.

The BSD-02LH may not be able to drive some motors in series connection. Specifically, construction of 7.5 degree tin-can motors requires different switching sequence. In such case unipolar connection must be used.

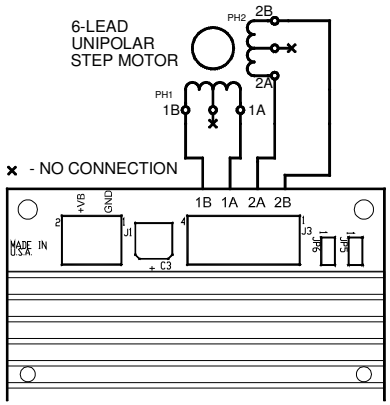

Figure 7. Unipolar motor - serial connection.

2. Unipolar connection – one end of each phase is insulated. The other end and center tap are connected to the driver. Motor should be run at full rated current. This connection works better at higher speeds.

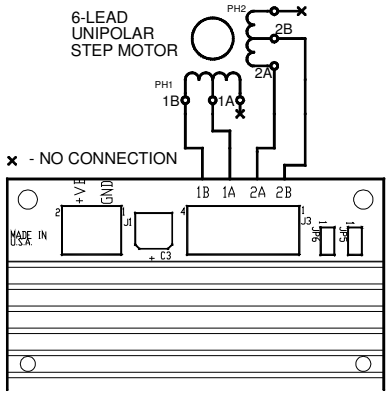

Figure 8. Unipolar motor - unipolar connection.

Table 8 shows difference between both configurations in reference to Unipolar.

Table 8: Ratings for 6-lead motor.

Mode	Power	Current	Voltage	Torque
Bipolar-Series	1.0	0.7	1.4	1.4
Unipolar	1.0	1.0	1.0	1.0

8-LEAD MOTOR
This motor can be connected in three ways.
1. Bipolar-Series connection which gives more torque at lower speeds and less torque at higher speeds. In series connection motor should be operated at only 70% of the rated current because using twice as large winding of each phase produces rated torque at lower current. Running motor at full rated current will saturate and overheat the motor.

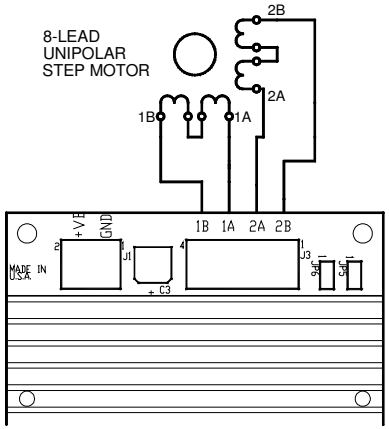

Figure 9. Unipolar motor - bipolar-serial connection.

2. Bipolar-Parallel connection. Motor should be run at 1.4l rated current. This connection is not recommended as higher current generates more heat in the driver and motor.

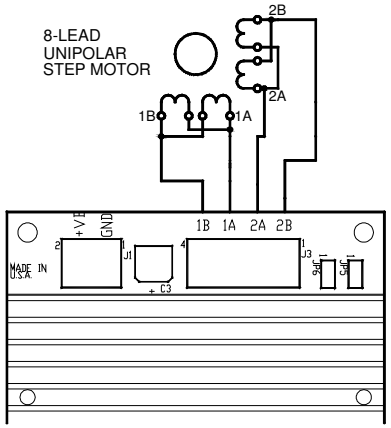

Figure 10. Unipolar motor – bipolar-parallel connection.

3. Unipolar connection – only one pair of each phase is used. This connection works better at higher speeds.

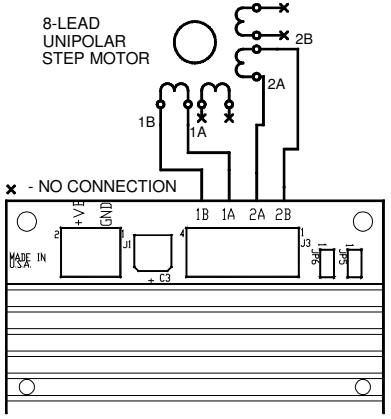

Figure 11. Unipolar motor – unipolar connection.

Table 8 shows difference between all three configurations in reference to Unipolar.

Table 9: Ratings for 8-lead motor.

Mode	Power	Current	Voltage	Torque
Bipolar-Series	1.0	0.7	1.4	1.4
Bipolar-Parallel	1.0	1.4	0.7	1.4
Unipolar	1.0	1.0	1.0	1.0

Connecting Control Signals.

All signal inputs of the BSD-02LH are at TTL-level and have internal pull-up resistors of 4.7k connected to +5V . Inputs don't require any source of power. All inputs are sourcing type and active LOW in reference to GND. This allows direct connection to any TTL circuitry as well as mechanical switches and relays. Simply shorting any input to GND will change its status. Unused inputs may be left not connected and will remain HIGH. The only control output – HOME is also at TTL-level and indicates initial state of the translator. It may be used in a program when step mode has to be changed while motor is running. Home State is the position to which the translator is reset at power up. It is also the state when the current for both phases in equal to 70.71% regardless of selected step mode allowing smooth and error-free transition from one step mode to another. Home State is defined at 45deg step angle and with DIR signal High.

The Table 10 shows Step Sequencing.
Home State is highlighted.
To understand this table, try to imagine bipolar motor with just 4 Full steps per revolution.
Only first two full steps are shown. Follow the same pattern for remaining steps.

Table 10: Step Sequencing

Full Step	Half Step	1/4 Step	1/16 Step	Phase 1 Current (%Itripmax) (%)	Phase 2 Current (%Itripmax) (%)	Step Angle (°)
	1	1	1	100.00	0.00	0.0
			2	99.52	9.80	5.6
			3	98.08	19.51	11.3
			4	95.69	29.03	16.9
		2	5	92.39	38.27	22.5
			6	88.19	47.14	28.1
			7	83.15	55.56	33.8
			8	77.30	63.44	39.4
1	**2**	**3**	**9**	**70.71**	**70.71**	**45.0**
			10	63.44	77.30	50.6
			11	55.56	83.15	56.3
			12	47.14	88.19	61.9
		4	13	38.27	92.39	67.5
			14	29.03	95.69	73.1
			15	19.51	98.08	78.8
			16	9.80	99.52	84.4
	3	5	17	0.00	100.00	90.0
			18	-9.80	99.52	95.6
			19	-19.51	98.08	101.3
			20	-29.03	95.69	106.9
		6	21	-38.27	92.39	112.5
			22	-47.14	88.19	118.1
			23	-55.56	83.15	123.8
			24	-63.44	77.30	129.4
2	4	7	25	-70.71	70.71	135.0
			26	-77.30	63.44	140.6
			27	-83.15	55.56	146.3
			28	-88.19	47.14	151.9
		8	29	-92.39	38.27	157.5
			30	-95.69	29.03	163.1
			31	-98.08	19.51	168.8
			32	-99.52	9.80	174.4

Table 11: Electrical Characteristics at Ta=+25°C

Characteristic	Symbol	Test Condition	Limit			Unit
			Min	Typ	Max	
Motor Supply Voltage	V_B	Operating	8.0	-	30	V
Motor Output Current	I_0	½-, ½-, ½-Step Mode	Continuous		±2.5	A*
			Peak		±2.5	A*
		Full-Step Mode	Continuous		±2.5	A*
			Peak		±2.5	A*
Logic Input Voltage	$V_{IN}(1)$		3.5	-	-	V
	$V_{IN}(0)$		-	-	1.5	V
Logic Input Current	$I_{IN}(1)$		-20	<1.0	20	µA
	$I_{IN}(0)$		-20	<1.0	20	µA
Step Frequency	f_{STEP}		-	-	500	kHz
Step Pulse Width (High Time)	T_H		1.0	-	-	us
Step Pulse Low Time	T_L		1.0	-	-	us
Comparator Blank Time	t_{BLANK}		1.1	1.4	1.7	µs
Fixed Off Time	t_{OFF}		24	30	36	µs
Operating Temperature Range	-		-20	-	+85	°C
Heat sink Thermal Resistance	-			5.65		°C/W

* Motor Output Current is limited by duty cycle, ambient temperature and heat sinking.

Table 12: Ratings

Feature	Symbol	Description
Load Supply Voltage	$+V_B$	8.0 to 30.0 V DC Max. Current based on used motors.
Output Current	I_{ODC}	Continuous: from 50mA to 2.5A per each output. Output Current Rating will be limited by duty cycle, ambient temperature and heat sinking. Do not exceed the specified current rating or a junction temperature of 150C.
Step Modes	-	Full Step Half Step Quarter Step Sixteenth Step
Current Decay Modes	-	Mixed Current-Decay Automatic Current-Decay Mode Detection and Selection
Protection	-	Under-Voltage Lockout Protection Crossover-Current Protection Thermal Shutdown Circuitry with hysteresis No special power-up sequencing required
Physical dimensions	inch	2.75” x 2.75” x 0.88" (WxLxH)

Quick Setup Guide.

- Connect the motor to the driver.
- Connect power supply.
- Disable the driver by disconnecting any signal from Enable pin.
- Connect Voltmeter between GND and TP1.
- Calculate Vref based on the phase current of the motor.
- Adjust R15 to achieve desired Vref.
- Connect Enable, Step and Direction signals

Help.

For technical support send email to: support@interinar.com