

USER MANUAL

BSD-013G

SINGLE-AXIS DRIVER AND CONTROLLER FOR BIPOLAR AND UNIPOLAR STEP MOTORS

INTERINAR ELECTRONICS, LLC.

<http://www.interinar.com>

Copyright Information

© 2006-2009 Interinar Electronics, LLC. All rights reserved.

This document is furnished exclusively for the customers of Interinar Electronics.

Other uses are unauthorized without written permission of Interinar Electronics.

Information contained in this document may be updated from time to time due to product improvements and may not conform in every respect to former issues.

Disclaimer of Liability

Interinar Electronics is not responsible for special, incidental, or consequential damages resulting from any breach of warranty, or under any legal theory, including lost profits, downtime, goodwill, damage to or replacement of equipment or property, or any costs of recovering, reprogramming, or reproducing any data stored in or used with Interinar products.

Interinar Electronics is also not responsible for any personal damage, including that to life and health, resulting from use of any of our products. Customer takes full responsibility for any application where Interinar products are implemented.

Interinar Electronics Technical Support

Email: support@interinar.com

Website: <http://www.interinar.com>

USER MANUAL.....i

1 INTRODUCTION.....1-1

1.1.1 BSD-013G Overview.....1-1

1.1.2 FLEXIBILITY.....1-1

1.1.3 SAFETY SUMMARY.....1-1

1.1.4 TECHNICAL SUPPORT.....1-1

2 HARDWARE REFERENCE.....2-1

2.1 OVERVIEW.....2-1

2.2 HARDWARE DESCRIPTION.....2-1

2.2.1 CONTROLLER FEATURES.....2-2

2.2.2 DRIVER FEATURES.....2-2

2.3 CONNECTORS.....2-3

2.3.1 AVAILABLE CONNECTORS.....2-3

2.3.2 POWER CONNECTOR – J1.....2-4

2.3.3 MOTOR CONNECTOR – J3.....2-4

2.3.4 SIGNAL INPUT CONNECTOR – J4.....2-5

2.3.5 J6 AUXILIARY CONNECTOR.....2-6

2.3.6 JP1 JUMPER.....2-7

2.3.7 R1 TRIM POTENTIOMETER.....2-7

2.3.8 SW1 DIP-SWITCH.....2-7

2.4 CONNECTING TO BSD-013G.....2-9

2.4.1 POWER SUPPLY.....2-9

2.4.2 STEP MOTOR.....2-9

2.4.3 EXTERNAL CONTROLLER.....2-9

2.4.4 START/STOP SWITCH.....2-10

2.4.5 EXTERNAL POTENTIOMETER.....2-10

3 OPERATION MODES.....3-1

3.1.1 OVERVIEW.....3-1

3.2 SETUP MODE.....3-1

3.2.1 S1 – MOTOR CURRENT SETUP MODE.....3-1

3.2.2 S2 - FREQUENCY RANGE SELECTION MODE.....3-3

3.2.3 S3 – FIXED FREQUENCY SETUP MODE.....3-4

3.3 NORMAL MODE.....3-5

3.3.1 N1 – NORMAL OPERATION AS STEP/DIRECTION DRIVER.....3-5

3.3.2 N2 – NORMAL OPERATION AS ADJUSTABLE STEP FREQUENCY CONTROLLER.....3-5

3.3.3 N3 – NORMAL OPERATION AS FIXED STEP FREQUENCY CONTROLLER.....3-6

3.4 AUTOMATIC IDLE CURRENT REDUCTION (AICR).....3-7

4 APPLICATION.....4-8

4.1 POWER SUPPLY.....4-8

4.1.1 VOLTAGE.....4-8

4.1.2 CURRENT.....4-8

4.2 STEPPER MOTOR.....4-8

4.2.1 4-WIRE MOTORS.....4-9

4.2.2 6-WIRE MOTORS.....4-9

4.2.3 8-WIRE MOTORS.....4-10

4.3 TROUBLESHOOTING.....4-12

5 ELECTRICAL AND MECHANICAL SPECIFICATION.....5-13

5.1 ABSOLUTE MAXIMUM RATINGS.....5-13

5.2 ELECTRICAL CHARACTERISTICS.....5-13

5.3 EXTERNAL STEP PULSE TIMING PARAMETERS ON STP INPUT.....5-13

5.4 STEP PULSE GENERATOR.....5-14

5.5 MOUNTING.....5-14

1 INTRODUCTION

1.1.1 BSD-013G Overview

This manual discusses operations of the BSD-013G Single-Axis Step Motor Driver and Controller. The BSD-013G comes in two versions, which differ only in maximum resolution of microstepping:
 - BSD-013G-8 with maximum resolution of 1/8th of the full step
 - BSD-013G-16 with maximum resolution of 1/16th of the full step
 The BSD-013G is designed to work with most step motors, both Unipolar and Bipolar, as long as the switching sequence and power requirements for the motor complies with driver’s specification. The driver comes with standard phase current range from 95mA to 1500mA but it can be delivered as a special version with phase current in range from 12mA to 185mA.
 Through the power of specialized components, BSD-013G offers price/performance ratio for Single Axis Stepper Control that was not previously available.
 The BSD-013G is intended to replace a sophisticated and costly controllers in applications where only basic features are required and precise motion profile is not needed.

1.1.2 FLEXIBILITY

BSD-013G may operate as a common Step-Direction driver or as a Stand-Alone controller-driver. The advanced design allows easy connection to variety of step motors available on the market and supports both Unipolar and Bipolar step motors. Tuning the driver to a specific step motor is an easy process and does not require any special knowledge or skills.

1.1.3 SAFETY SUMMARY

Always remove power and discharge the circuit before touching it.
 This module contains parts susceptible to damage by ESD (Electrostatic Discharge). The BSD-013G must be handled in accordance to procedures specified for ESD devices.
 Do not make any modification to the board or components.
DO NOT PLUG/UNPLUG ANY WIRES AND CONNECTORS TO/FROM THE MODULE WHILE POWER IS ON.

1.1.4 TECHNICAL SUPPORT

Interinar Electronics is happy to respond to any question or concern regarding the BSD-013G or any other product it manufactures or sells. Contact Technical Support Staff by sending email to support@interinar.com

2 HARDWARE REFERENCE

2.1.1 OVERVIEW

The BSD-013G is designed to control and drive Unipolar and Bipolar Step Motors either directly, by outputting step pulses from internal Step Pulse Generator (SPG) or indirectly, by accepting Step and Direction signals from the external microcontroller or PC. Any source of TTL level signals (5V logic) can be used as a controlling device for BSD-013G driver. The operation of the standard version with CMOS 3.3V external devices is possible but not guaranteed. However, we can deliver the special CMOS 3.3V version if requested.

By utilizing features of the on-board microcontroller, the BSD-013 becomes stand-alone controller-driver with minimal number of external components needed.

2.2 HARDWARE DESCRIPTION

The BSD-013G is based on powerful DMOS microstepping driver and together with fast microcontroller allows for easy building of an ideal step motor system.

The simplicity of the design has another advantage in lower number of components making this driver a very rigid and reliable. Once configured correctly the driver does not require any further adjustments or maintenance.

Single voltage supply simplifies power requirements and lowers overall system cost.

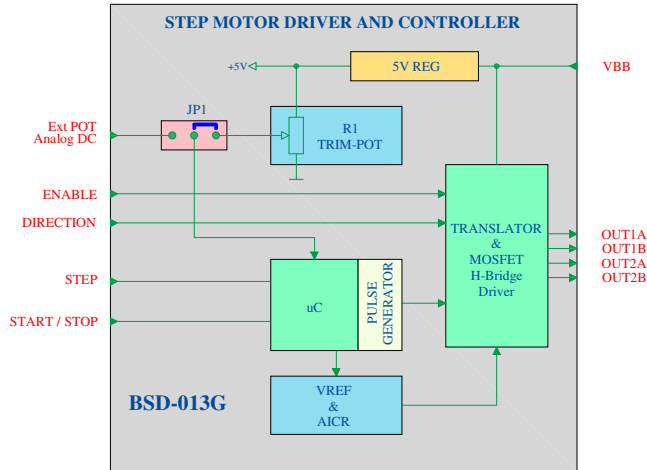


Figure 1. BSD-013G Simplified Block Diagram

2.2.1 CONTROLLER FEATURES

- Constant-Speed Operation at Fixed Step Frequency rate
- Varied-Speed Operation at Frequency rate adjustable by potentiometer or analog voltage
- Step Pulse rate settings in three Frequency Ranges
- External Start and Stop control
- Continuous Operation until Stop signal is received
- Automatic Idle Current Reduction (AICR) in all Normal modes
- Immediate Stop

2.2.2 DRIVER FEATURES

- Unipolar or Bipolar Step Motor operation
- Built-in Translator
- Phase Current from 95mA to 1500mA (default)
- Phase Current from 12mA to 185mA (special order)
- Four Stepping Modes: Full, Half, 1/4th, 1/8th (BSD-013G-8) or 1/16th (BSD-013G-16)
- Automatic current decay mode detection/selection
- Mixed and Slow current decay modes
- Synchronous rectification for low power dissipation
- Fixed Off-Time current regulator for Constant Current operation
- Internal Under-Voltage-Lock-Out protection
- Thermal Shutdown protection
- Crossover Current protection
- Single Power Supply

2.3 CONNECTORS

2.3.1 AVAILABLE CONNECTORS

The BSD-013G features following connectors:

- **POWER CONNECTOR (J1)** – power for step motor and all electronics on board
- **MOTOR CONNECTOR (J3)** – step motor
- **SIGNAL INPUT CONNECTOR (J4)** – Enable, Step and Direction signals
- **AUXILIARY CONNECTOR (J6)** – Start/Stop switch and potentiometer connector

The location of the connectors on the board is shown below:

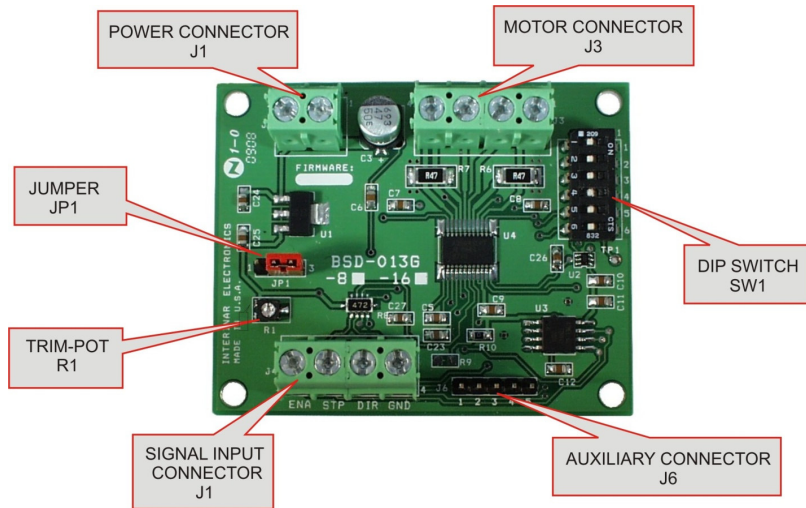


Figure 2. Connectors and Major Components

2.3.2 POWER CONNECTOR – J1

Connector type: Standard 5mm, 2-pole terminal block, acceptable wires size 26 to 12 AWG.

Table 1 – POWER CONNECTOR – J1

Terminal #	PIN DESCRIPTION	LABEL
1	Negative or Common Voltage Supply	GND
2	Positive Voltage Supply	+VBB

Polarity reversal is **NOT ALLOWED** and will cause permanent damage to the driver. Exceeding Max Allowed Voltage will result in permanent damage to the driver.

When using a non-stabilized power supply, specifically rectifier/capacitor type, please derate the Max Allowed Voltage to 70% in order to prevent overvoltage and damage to the driver. This type of power supply can produce about 1.4 times the rated voltage when the load is not present or very low. This type of overvoltage condition may occur when the driver is disabled.

2.3.3 MOTOR CONNECTOR – J3

Connector type: Standard 5mm, 4-pole terminal block, acceptable wires size 26 to 12 AWG.

The pairs of terminals belonging to the same phase are located next to each other and labeled on the board as PH1 and PH2.

Mixing wires of two phases together is prohibited and will result in permanent damage to the driver.

In case the initial rotation of the motor has to be reversed and the DIR input cannot be used, swap the wires of one phase only. Do not swap the wires of two phases at the same time, as this will not reverse the direction.

Table 2 – MOTOR CONNECTOR – J3

Terminal #	PIN DESCRIPTION	LABEL
1	OUT2B	PH2
2	OUT2A	
3	OUT1A	PH1
4	OUT1B	

2.3.4 SIGNAL INPUT CONNECTOR – J4

Connector type: Standard 5mm, 4-pole terminal block, acceptable wires size 26 to 12 AWG.

This connector is used only when the driver operates in Step-Direction (N1) mode with signals provided from external microcontroller or PC. All three inputs feature 4.7kohm pull-up resistors to +5V. This way controlling the input is as simple as shorting it to the Ground. Any sinking device may be used for that purpose. Specifically, this can be done with jumper, switch, open-collector, open-drain, direct TTL gate output. In all other cases, it is important to make sure there will be no voltage exceeding +5V present on any input at any time.

Table 3 – SIGNAL INPUT CONNECTOR – J4

Terminal #	PIN DESCRIPTION	LABEL
1	Enable	ENA
2	Step	STP
3	Direction	DIR
4	Ground	GND

2.3.4.1 ENA – Enable.

Input – active LOW.
Internally pulled up to +5V trough 4.7kohm resistor.
When LOW, all motor outputs are ENABLED.
When HIGH, all motor outputs are DISABLED, but translator is still processing Step and Direction signals. This condition may result in initial position error when using ENABLE to start and stop the motor. The driver must be ENABLED in advance before Step and Direction changes.
Regardless of operation mode, the BSD-013G always stops powering the motor when ENABLE signal is HIGH, absent or not connected.

2.3.4.2 STP - Step.

Input – active LOW.
Internally pulled up to +5V trough 4.7kohm resistor.
A Low-to-High transition (rising edge) advances the motor one increment. The size of the increment is determined by MS1 and MS2 (see Table 9). Minimum Step pulse High Time (width) is 1.0us. Minimum Step pulse Low Time is 1.0us.

2.3.4.3 DIR - Direction.

Input – active LOW.
Internally pulled up to +5V trough 4.7kohm resistor.
Determines the direction of the rotation of the motor.
Any changes to this input do not take effect until the next Step rising edge.
If the motor connections follow correct phase order then when this input is Low, the direction will be Clockwise and when High, Counterclockwise. If the direction of the rotation in reference to DIR signal level is not what is desired, then swapping wires of just one phase of the motor will reverse direction order.

2.3.4.4 GND - Ground.

Signal Ground – return path for all three inputs.
Should not be used as power ground or for any other purpose.

2.3.5 J6 AUXILIARY CONNECTOR

Connector type: single-row 5-pin male header (0.100” pitch).

This header provides connection to potentiometer (or Analog Voltage - ANA) and optional Start/Stop switch.

Table 4 – AUXILIARY CONNECTOR – J6

Pin #	PIN DESCRIPTION	LABEL
1	Internally connected to +5V	1
2	Wiper or Analog Positive DC Voltage (ANA)	2
3	Ground	3
4	Ground	4
5	Start/Stop switch (STA)	5

2.3.5.1 PIN#1.

Positive, +5V from driver’s internal voltage regulator.
Used when external potentiometer connected.
Should not be used as a source of voltage/current for any other purpose if the current drained from this pin exceeds 10mA.
Not protected.
Shorting this pin to ground for prolonged time will damage the driver.

2.3.5.2 PIN#2.

Input – the wiper of the external potentiometer or positive Analog DC voltage (ANA).
Any potentiometer of value from 5kohm to 1Mohm may be used.
A DC voltage in range from 0 to +5V may be used in place of the potentiometer.
The function of this pin depends on the operating mode.

Table 5 – Function of PIN#2

MODE	FUNCTION DESCRIPTION	JP1
S1	V _{REF} Adjustment	2-3
S3	Setup of Fixed Step Pulse Frequency	2-3
N2	Adjustment of Step Pulse Frequency	2-3

Not protected.
Applying voltage higher than +5.5V or lower than -0.5V to this pin will damage the driver.
Reversing polarity is not allowed and will result in permanent damage to the driver.

2.3.5.3 PIN#3.

Signal Ground – return path for potentiometer or DC voltage (ANA).
Should not be used as power ground or for any other purpose.

2.3.5.4 PIN#4.

Signal Ground – return path for Start/Stop switch.
Should not be used as power ground or for any other purpose.

2.3.5.5 PIN#5.

Input – external Start/Stop switch (STA). Use Normal-Open (NO) switch for most applications. The Start/Stop switch is necessary if operating the driver as a stand-alone controller in modes N2 and N3. Instead of switch, the open-collector, open-drain or direct TTL gate output may be used. If Enable input is used as start/stop condition, then the STA input can be used as an End Limit switch. Not protected.
Applying voltage higher than +5.5V or lower than -0.5V to this pin will damage the driver. Reversing polarity is not allowed and will result in permanent damage to the driver.

2.3.6 JP1 JUMPER

The BSD-013G has built-in a small trim-potentiometer (trim-pot) R1 for adjusting motor current and setting the fixed frequency of Step Pulse Generator (SPG). To use this trim-pot JP1 jumper has to be set in 1-2 position. Move jumper to 2-3 position if external potentiometer or analog voltage (ANA) connected to J6 header will be used.

Table 6 – JUMPER JP1

POSITION	DESCRIPTION
1-2	Use trim-pot R1 (default)
2-3	Use external potentiometer connected to J6 (pin# 2)

2.3.7 R1 TRIM POTENTIOMETER

The trim potentiometer (trim-pot) installed on board is all it is needed to set up the motor current and driver configuration. To use this trim-pot the JP1 jumper needs to be in 1-2 position (see Table 6). Caution needs to be taken when using this trim-pot. Use only special trimming tool or small-flat screwdriver. This component has limited duty cycle and easily is damaged when improper tool is used.

2.3.8 SW1 DIP-SWITCH

The 6-position dip-switch is used in process of setting motor parameters and configuring the driver. Each individual switch is numbered from 1 to 6. The driver is shipped with all switches in OFF state as default.

Table 7 – Power-Up Mode Condition Truth Table

MODE	SW1.x				MODE DESCRIPTION
	.1	.2	.3	.4	
S1	OFF	OFF	OFF	ON	SETUP – V_{REF} , N1 or N2
S2	ON	OFF	OFF	ON	SETUP – FREQUENCY RANGE, N2 or N3
S3	ON	OFF	OFF	OFF	SETUP – FIXED FREQUENCY
N1,N2,N3	OFF	OFF	OFF	OFF	NORMAL OPERATION

2.3.8.1 SW1.1 – Fixed Frequency Setup.

Default: OFF
Allowed position during boot up: ON, OFF
Allowed position in normal operation: OFF
Used in modes: S1, S2, S3.
Function during boot up: see Table 7.

2.3.8.2 SW1.2 – Frequency Range Setup.

Default: OFF
Allowed position during boot up: OFF
Allowed position in normal operation: OFF
Used in modes: S1, S2, S3.
Function during boot up: none
Function in S2 mode: see Table 8.

2.3.8.3 SW1.3 – Frequency Range Setup.

Default: OFF
Allowed position during boot up: OFF
Allowed position in normal operation: OFF
Used in modes: S1, S2, S3.
Function during boot up: none
Function in S2 mode: see Table 8.

Table 8 – FREQUENCY RANGE SELECTION – SW1.2 AND SW1.3

MODE	SW1.x		FREQUENCY RANGE	
	.2	.3		
S2	OFF	OFF	RESERVED	-
S2	ON	OFF	2Hz to 80Hz	F1
S2	OFF	ON	62.5Hz to 3.125kHz	F2
S2	ON	ON	500Hz to 26kHz	F3

2.3.8.4 SW1.4 – Motor Current Setup.

Default: OFF
Allowed position during boot up: ON, OFF
Allowed position in normal operation: OFF
Used in modes: S1, S2, S3.
Function during boot up: see Table 7.

2.3.8.5 SW1.5 – Microstepping MS1.

Default: OFF
Allowed position during boot up: ON or OFF
Allowed position in normal operation: ON or OFF
Used in modes: S1, S2, S3, N1, N2, N3.
Function during boot up: has no effect.
Function during normal operation: see Table 9.

2.3.8.6 SW1.6 – Microstepping MS2.

Default: OFF
Allowed position during boot up: ON or OFF
Allowed position in normal operation: ON or OFF
Used in modes: S1, S2, S3, N1, N2, N3.
Function during boot up: has no effect.
Function during normal operation: see Table 9.

Table 9 – Microstepping Resolution Truth Table

SW1.5 (MS1)	SW1.6 (MS2)	RESOLUTION-STEP		EXCITATION MODE	
		BSD-013G-8	BSD-013G-16	BSD-013G-8	BSD-013G-16
ON	ON	FULL	FULL	2 PHASE	2 PHASE
OFF	ON	HALF	HALF	1-2 PHASE	1-2 PHASE
ON	OFF	QUARTER	QUARTER	W1-2 PHASE	W1-2 PHASE
OFF	OFF	EIGHTH	SIXTEENTH	2W1-2 PHASE	4W1-2 PHASE

2.4 CONNECTING TO BSD-013G

2.4.1 POWER SUPPLY

The power supply selection should be based on step motor specification and maximum allowable voltage for the driver. There is no need for stabilized power supply, however it is recommended to use it. When using a non-stabilized power supply, specifically rectifier/capacitor type, please derate the Max Allowed Voltage to 70% in order to prevent overvoltage and damage to the driver. This type of power supply can produce about 1.4 times the rated voltage when the load is not present or very low. This type of overvoltage condition may occur when the driver is disabled.

NEVER CONNECT OR DISCONNECT ANY PORT FROM BSD-013G WHILE POWER IS ON.

2.4.2 STEP MOTOR.

The step motor should be connected to the J3 terminal block. Labels are placed next to the terminals in two groups, clearly marking each phase. There is no reference to the beginning and end of each phase. Make sure that all four motor wires are tightly connected and there is no possibility of accidental disconnection. For 6- and 8-wire motors, make sure all unused wires are separately insulated. This is especially important when additional connectors are used between the driver and the motor.

DISCONNECTING MOTOR WHILE POWER IS ON WILL CAUSE PERMANENT DAMAGE TO THE DRIVER.

2.4.3 EXTERNAL CONTROLLER

In case the BSD-013G will work in mode N1, as a driver with externally provided Step and Direction signals it is important to connect appropriate signals to corresponding poles of J4 terminal block. This terminal block allows controlling three main inputs of the driver: Step, Direction and Enable. The fourth pole is used for signal ground and should not be used as power ground. All three inputs are pulled-up internally to +5V through 4.7kohm resistors. The TTL (5V level) interface, open-collector, opto-coupler, relay and switch can be used directly in connection with this port (see Figure 3). The CMOS 3.3V operation is possible but not guaranteed.

If not used, the Step and Direction inputs may be left disconnected. The Enable input will be always used regardless of the operation mode of the driver.

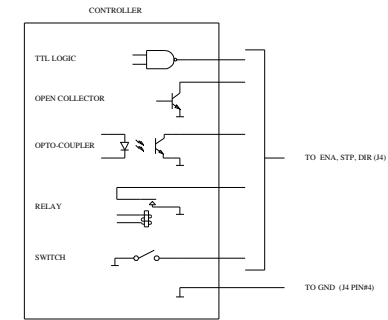


Figure 3. Controlling methods

2.4.4 START/STOP SWITCH

The BSD-013G working in modes N2 or N3, as stand-alone controller, requires START/STOP switch or TTL (5V level) signal. The switch or signal must be connected directly to pins 4 and 5 of the J6 single-row header.

Open-collector (open-drain), relay or opto-coupler may be also used if properly connected (see Figure 3).

2.4.5 EXTERNAL POTENTIOMETER

The BSD-013G features a small trim-pot and does not require external potentiometer for setting up motion parameters. This small trim-pot has limited duty cycle and should not be used during normal operation. For that reason, using external potentiometer is strongly recommended and convenient. When controller works in mode N2 with adjustable step frequency, the use of the external potentiometer is necessary. The potentiometer must be connected directly to pins 1,2 and 3 of the J6 single-row header (see Figure 6).

3 OPERATION MODES

3.1.1 OVERVIEW

The BSD-013G is capable of driving and controlling step motors in several different modes. The two types of Operation Mode are listed below.

- Setup Mode
 - **S1** – Motor Current Setup and selection of Normal Mode N1 or N2
 - **S2** – Selection of Frequency Range and Normal Mode N2 or N3
 - **S3** – Fixed Frequency Setup
- Normal Mode
 - **N1** – Normal Operation as STEP/DIRECTION driver
 - **N2** – Normal Operation as controller with Adjustable Step Pulse Frequency Generator
 - **N3** – Normal Operation as controller with Fixed Step Pulse Frequency Generator

All other modes are subsets of these two basic modes.

Regardless of operation mode, the BSD-013G always stops powering the motor when ENABLE signal is HIGH, absent or not connected.

3.2 SETUP MODE

In Setup modes the BSD-013G will set and store:

- Motor current
- Default mode of the driver
- Frequency range of the Step Pulse Generator (SPG)
- Fixed frequency of the Step Pulse Generator (SPG)

3.2.1 S1 – MOTOR CURRENT SETUP MODE

The BSD-013G cannot correctly control the step motor if the motor’s phase current is not set prior to any mode of operation. The phase current can be obtained directly from the label of the motor, data sheet or by calling manufacturer. The BSD-013G is a CONSTANT CURRENT type driver. It means that the phase current is all you need to know to make it work with your motor. Other motor’s parameters like rated voltage, resistance and impedance do not play any role at this initial setup. However, these parameters cannot be ignored as they will affect the system performance later on.

The BSD-013G uses reference voltage V_{REF} always present on TP1 (test point located right below dip-switch SW1) to adjust and keep the motor current at correct level. The relation between V_{REF} and phase current I can be described as follows:

$$V_{REF} [V] = k \times I [A]$$

Where:

- V_{REF} in Volts
- I in Amps
- k – coefficient, based on value of the sensing resistors R6, R7
 $k=2.64$ for 0.33ohm resistors marked as R33 for standard version 95mA to 1500mA
 $k=21.6$ for 2.7ohm resistors marked as 2R7 for special version 12mA to 185mA

Example:

- Motor is labeled 0.91A, BSD-013G driver with 0.33ohm sensing resistors

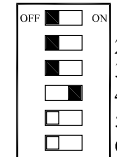
$$V_{REF} = 2.64 \times 0.91A = 2.4V$$

This resulting V_{REF} value must be used during motor current setup procedure.

The S1 mode can be entered only during boot up (power up) process, while the SW1.4 dip-switch in ON and SW1.1 to SW1.3 in OFF position (see Table 7).

Enter mode S1:

- Turn OFF the power
- Turn ON switch SW1.4
- Turn OFF switch SW1.1, SW1.2 and SW1.3
- Switches SW1.5 and SW1.6 are irrelevant in this mode

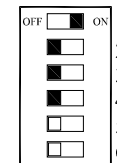
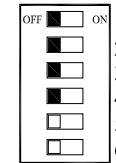


- Place JP1 in 1-2 position to use R1 trim-pot or place JP1 in 2-3 position for external potentiometer connected to J6 pins #1, 2 and 3
- Turn ON the power
- Connect Volt Meter between TP1 and GND
- Rotate trim-pot (or external potentiometer) until the Volt Meter shows value equal to the V_{REF} value calculated for that particular motor
- If intended operation of the driver is mode N1, then leave SW1.1 in OFF position
- If intended operation of the driver is mode N2, then move SW1.1 to ON position

Exit from mode S1:

- Move SW1.4 to OFF position

- OR -



- Turn OFF the power

Actual storing of the V_{REF} value and the mode selection to the EEPROM occurs while the SW1.4 is moved from the ON to the OFF position. However, storing can be performed only once per each cycle. That means, if any mistake was made, the whole procedure must be repeated, starting from turning OFF the power first and then reentering the S1 mode again.

The driver will not be functional until the next power OFF to ON transition.

3.2.2 S2 - FREQUENCY RANGE SELECTION MODE

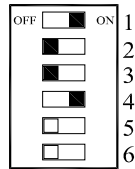
This setup mode needs to be entered only in case when user intends to use BSD-013G as a stand-alone controller/driver with on board Step Pulse Generator. In such case, the selection of the Step Frequencies Range must be done prior to using Step Pulse Generator. The BSD-013G can output Step pulses in three separate frequency ranges but only one at the time. Switching from one range to another is not possible during normal operation. User needs to determine the value of the step pulse frequency based on motor parameters, step mode of the driver and desired speed of the motor.

The R3 trim-pot or external potentiometer may be used to adjust to any frequency available within particular range. If the required frequency is not available within current range, then S2 mode setup needs to be performed again.

The S2 mode can be entered only during boot up (power up) process while the SW1.4 and SW1.1 dip-switches are ON and SW1.2 and SW1.3 are in OFF position (see table 7).

Enter mode S2:

- Turn OFF the power
- Turn ON switches SW1.4 and SW1.1
- Turn OFF switch SW1.2 and SW1.3
- Switches SW1.5 and SW1.6 are irrelevant for this mode

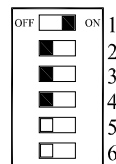
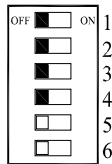


- Turn ON the power
- Set both switches SW1.2 and SW1.3 to desired position (see table)
- If the intended operation of the driver is mode N3, then move the SW1.1 to OFF position
- If the intended operation of the driver is mode N2, then leave SW1.1 in ON position

Exit mode S2:

- Move SW1.4 to OFF position

- OR -



- Turn OFF the power

Actual storing of the frequency range value and the mode selection to the EEPROM occurs while the SW1.4 is moved from the ON to the OFF position. However, storing can be performed only once per each cycle. That means, if any mistake was made, the whole procedure must be repeated, starting from turning OFF the power first and then reentering the S2 mode again.

The driver will not be functional until the next power OFF to ON transition.

3.2.3 S3 – FIXED FREQUENCY SETUP MODE

This setup mode needs to be entered only in case when user intends to use BSD-013G as stand-alone controller/driver with on board Step Pulse Generator operating at Fixed Step Frequency. In such case, the selection of the Step Frequencies Range (S2 mode) must be done prior to entering S3 mode and using Step Pulse Generator.

Once S3 mode is entered the Step Pulse Generator will output immediately Step pulse at the frequency determined by previous S2 setup and the actual position of the trim-pot (or external potentiometer). Precaution must be taken while entering this mode as the motor will start immediately if the ENABLE input is LOW or shorted to GND. It is recommended to perform this setup very first time without any load attached to the motor's shaft. Once approximate frequency is established, user may repeat this setup again with load attached. It is also recommended to use ENABLE and DIRECTION switches connected to the driver in case the motor reaches mechanical limits of the assembly.

The S3 mode can be entered only during boot up (power up) process while the SW1.1 dip-switch is ON and SW1.2, SW1.3 and SW1.4 are in OFF position (see table 7).

Enter mode S3:

- Turn OFF the power
- Turn ON switch SW1.1
- Turn OFF switch SW1.2, SW1.3 and SW1.4
- Switches SW1.5 and SW1.6 in position selecting desired step mode according to table 9
- Connect ENABLE switch between ENA and GND and leave it in OFF position
- Connect DIRECTION switch between DIR and GND and leave it in OFF position
- Rotate the trim-pot or external pot to the middle position
- Turn ON the power
- Turn ON the ENABLE switch – MOTOR SHOULD START ROTATING
- Rotate the trim-pot or external pot to increase or decrease the speed of the motor
- Change positions of SW1.5 and SW1.6 to select other step modes
- Use ENABLE and DIRECTION switches if motor moves to mechanical limits of your assembly
- Once the motor operates at desired frequency you may store it and exit this setup mode

Exit mode S3:

- Move SW1.1 to OFF position
- Turn OFF the power

Actual storing of the fixed frequency range value and the mode selection to the EEPROM occurs while the SW1.1 is moved from the ON to the OFF position. However, storing can be performed only once per each cycle. That means, if the mistake was made, the whole procedure must be repeated, starting from turning OFF the power first and then reentering the S3 mode again.

The driver will not be functional until the next power OFF to ON transition

3.3 NORMAL MODE

The BSD-013G will function properly only in Normal Mode. To access it the SW1.1 to SW1.4 have to be in OFF position and after power up the driver will enter Normal Mode based on stored parameters. The position of the SW1.5 and SW1.6 is irrelevant for mode selection and can be changed at any time.

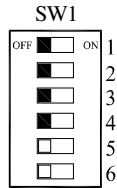


Figure 4. Switch SW1 during boot up to Normal Mode

3.3.1 N1 – NORMAL OPERATION AS STEP/DIRECTION DRIVER

The BSD-013G energizes the motor only when ENABLE signal is low and motor will start rotating when the STEP pulse is present on STP input. The direction of the rotation depends on signal level on DIR input.

- Parameters necessary for N1 Operation Mode:
- Perform S1 setup with N1 selection
 - Cycle the power OFF/ON

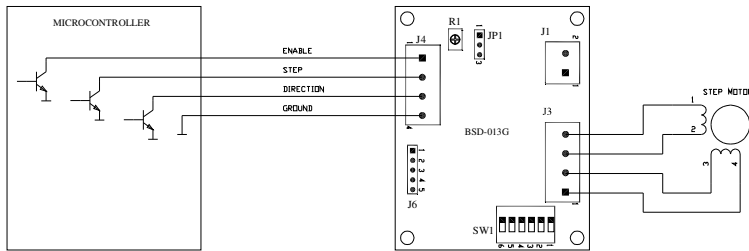


Figure 5. Normal N1 operation as Step/Direction driver

3.3.2 N2 – NORMAL OPERATION AS ADJUSTABLE STEP FREQUENCY CONTROLLER

This mode takes advantage of the on-board Step Pulse Generator (SPG), which outputs step pulses with frequency adjustable by potentiometer. The BSD-013G energizes the motor only when ENABLE signal is low. The SPG starts outputting pulses when STA input becomes LOW and stops outputting pulses when

the STA input goes HIGH. The direction of the rotation depends on voltage level on DIR input. The JP1 jumper needs to be set in position 2-3 if external potentiometer will be used.

- Parameters necessary for N2 Operation Mode:
- Perform S1 setup with N2 selection
 - Perform S2 setup with N2 selection
 - Cycle the power OFF/ON

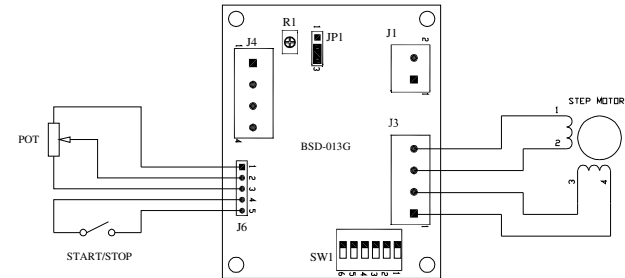


Figure 6. Normal N2 operation as adjustable step frequency controller

3.3.3 N3 – NORMAL OPERATION AS FIXED STEP FREQUENCY CONTROLLER

This mode takes advantage of the on-board Step Pulse Generator (SPG), which outputs step pulses at fixed frequency. The BSD-013G energizes the motor only when ENABLE signal is low. The SPG starts outputting pulses when STA input becomes LOW and stops outputting pulses when the STA input goes HIGH. The direction of the rotation depends on voltage level on DIR input.

- Parameters necessary for N3 Operation Mode:
- Perform S1 setup with N2 selection
 - Perform S2 setup with N3 selection
 - Perform S3 setup
 - Cycle the power OFF/ON

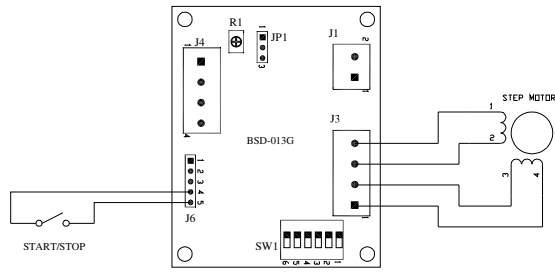


Figure 7. Normal N3 operation as fixed step frequency controller

3.4 AUTOMATIC IDLE CURRENT REDUCTION (AICR)

The BSD-013G driver is equipped with Automatic Idle Current Reduction (AICR) circuitry. The main purpose of using this feature is the reduction of the heat dissipated in the motor and the driver during the time when the motor stays idle in one position (without moving), for prolonged time. Driving the motor at 100% its rated current while still standing will not only produce the heat in the motor, which may lead to overheating, but it is a waste of energy. In majority of applications, the torque needed to keep the load in the position is minimal compared to the torque needed to move the load from one location to another. Only a handful of applications require producing the holding torque at the same level during both rotation and stand still periods.

Automatic Idle Current Reduction is active in all Normal Operation Modes:

- N1 – the AICR is activated 4 seconds after last step pulse present on STP input and deactivated immediately when a new step pulse arrives on STP input
- N2 – the AICR is activated 4 seconds after the STA input goes HIGH and deactivated immediately when the STA input becomes LOW
- N3 – the AICR is activated 4 seconds after the STA input goes HIGH and deactivated immediately when the STA input becomes LOW

Automatic Idle Current Reduction IS NOT AVAILABLE IN SETUP MODES.

4 APPLICATION

4.1 POWER SUPPLY

The BSD-013G is a constant-current driver, which means that it will maintain correct phase current regardless of the voltage applied to it. However, this statement implies certain limitations described below.

4.1.1 VOLTAGE

The BSD-013G works mostly in Constant-Current Mode by switching the voltage on motor terminals (chopping), while monitoring and maintaining correct level of the phase current. For that reason the BSD-013G is called a Constant-Current Driver. The driver will stay in Constant-Current Mode as long as the voltage applied to the power terminal is higher than the rated voltage of the motor. For example: motor label shows 12V. The BSD-013G will work in Constant-Current Mode only if the power supply voltage is above 12V and lower than max allowed for the driver 30V. If the power supply delivers 12V or less. The driver will work in Voltage Mode. In such case, the driver will no longer maintain the phase-current. Here the phase-current will be limited directly by the resistance of the motor's windings.

Both regulated and unregulated power supplies may be used. A regulated power supply can be rated up to max allowed voltage for the BSD-013G which is 30Vdc. However, unregulated power supply cannot exceed 21Vdc because it is 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 higher, which will exceed the maximum voltage allowed for the driver.

4.1.2 CURRENT

The BSD-013G requires no more current than the twice of the phase-current ($2 \times I_{ph}$) of the motor. There is a common misconception, based on wrong measurements, that in real application only fraction of that current is being utilized. However, these measurements are performed using RMS values, which lead to mistakes in selecting the power supply. If the power supply is not capable of supplying enough current, then the driver will not be able to deliver it to the motor. As a result, the motor will not produce the torque specified in data sheet.

The current needed for logic on the board is marginal and may be ignored in this calculation.

4.2 STEPPER MOTOR

The BSD-013G is based on DMOS technology and despite the fact it features output protection it will be damaged if not properly connected to the motor. Common mistakes include phase wire mixing and connecting motor directly to Vbb or Gnd. Only two-phase stepper motors may be used. That includes both bipolar and unipolar motors. Bipolar motors are always 4-wire type. Unipolar motors come in 6- or 8-wire version, which gives more flexibility in selecting performance. Most of "thin-can" 2-phase motors have different switching sequence and will not work with BSD-013G (please compare switching sequence in motor data sheet). The 5-phase motors cannot be used with BSD-013G.

**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.**

4.2.1 4-WIRE MOTORS

This type of motor can be connected only one way. See drawing below. If default direction of the rotation is opposite to desired, then swapping two wires of only one phase will cause motor to rotate in opposite direction.

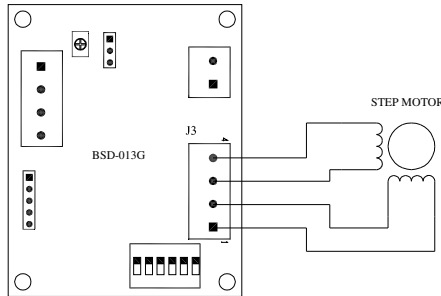


Figure 8. Bipolar 4-wire motor connection.

Table 10 – Parameters for bipolar 4-wire motor.

MODE	POWER	CURRENT	VOLTAGE	TORQUE
Bipolar	100%	100%	100%	100%

4.2.2 6-WIRE MOTORS

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.

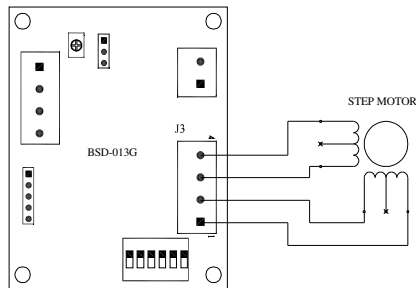


Figure 9. Bipolar-series connection of 6-wire motor.

The BSD-013G 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, center tap connection must be used.

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

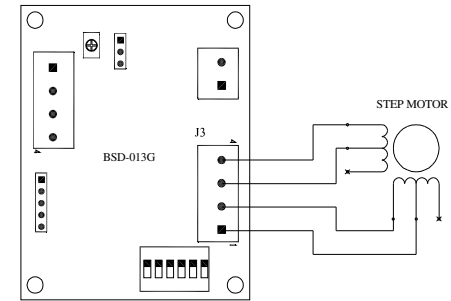


Figure 10. Unipolar connection of 6-wire motor.

Table 11 – Parameters for 6-wire motor

MODE	POWER	CURRENT	VOLTAGE	TORQUE
Bipolar-Series	100%	70%	140%	140%
Unipolar	100%	100%	100%	100%

4.2.3 8-WIRE MOTORS

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.

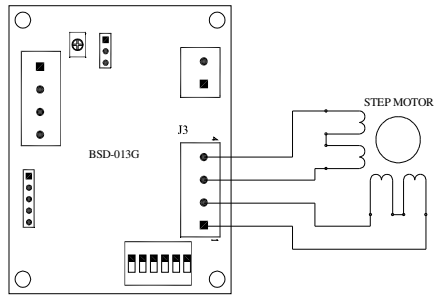


Figure 11. Bipolar-series connection of 8-wire motor.

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

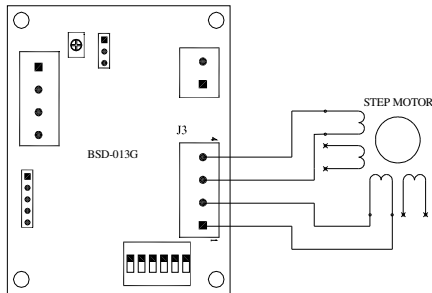


Figure 12. Unipolar connection of 8-wire motor.

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

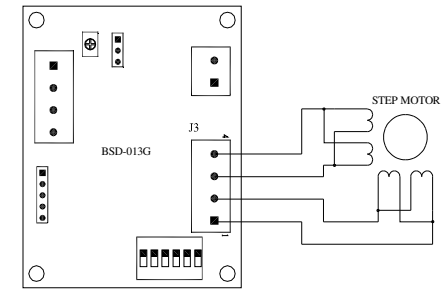


Figure 13. Bipolar-parallel connection of 8-wire motor.

Table 12 – Parameters for 8-wire motor.

MODE	POWER	CURRENT	VOLTAGE	TORQUE
Bipolar-Series	100%	70%	140%	140%
Bipolar-Parallel	100%	140%	70%	140%
Unipolar	100%	100%	100%	100%

4.3 TROUBLESHOOTING

If after power on the driver does not function according to previously set mode, turn it off and make sure that the SW1.1 to SW1.4 are left in OFF position. Turn ON the power again and observe presence of +5V (min 4.5V, max 5.2V) on pin #1 of J6 (AUX) in reference to GND pin #3, 4 of J6. If min of +4.5V is not present, then disconnect all ports but J1 (POWER) and check the voltage again. Presence of correct voltage in this condition suggests that problems are associated with shorts on other ports. Look for damaged connectors and wires.

In cases the BSD-013G shows no presence of +5V, contact our Technical Support by sending email to support@interinar.com

5 ELECTRICAL AND MECHANICAL SPECIFICATION

5.1 ABSOLUTE MAXIMUM RATINGS

Table 13 – Absolute maximum ratings for BSD-013G driver-controller.

CHARACTERISTIC	SYMBOL	RATING	UNITS
Motor Supply Voltage	VB	30	V
Motor Current	Iout	+/- 1.5	A
Logic Input Voltage	Vin	-0.3 to +5.5	V
Operating Ambient Temperature	Ta	-20 to 85	°C

5.2 ELECTRICAL CHARACTERISTICS

Table 14 – Electrical characteristics for BSD-013G driver-controller.

CHARACTERISTIC	SYMBOL	Condition	Min	Typ	Max	UNITS
Motor Outputs						
Motor Supply Voltage	VB	Operating	8		30	V
Motor Current	Iout	Standard	95		1500	mA
		Special	12		185	mA
Control Logic – Enable, Step, Direction, STA						
Logic Input Voltage	VIH (1)		3.5	-	-	V
	VIL (0)		-	-	1.5	V
Control Analog Input – ANA						
Analog DC Voltage	Vana		0	-	5	V
Protection						
Crossover Dead Time	tDT		100	475	800	ns
Thermal Shutdown Temperature	Tj		-	165	-	°C
Thermal Shutdown Hysteresis	TjHYS		-	15	-	°C
AICR delay time	tAICR		-	4	-	s
Idle current reduction	IAICR			25		%

5.3 EXTERNAL STEP PULSE TIMING PARAMETERS ON STP INPUT

Table 15 – Step pulse timing parameters.

CHARACTERISTIC	SYMBOL	TYP	UNITS
STEP – Minimum HIGH pulse width	tA	1	µs
STEP – Minimum LOW pulse width	tB	1	µs
Setup time	tC	200	ns
Hold time	tD	200	ns
Maximum frequency	fSTP	51600	Hz

5.4 STEP PULSE GENERATOR

Table 16 – Frequency of Step Pulse Generator.

RANGE	FREQUENCY
F1	2Hz to 100Hz
F2	62.5Hz to 3.125kHz
F3	500Hz to 26kHz

Table 17 – Frequency of Step Pulse Generator vs. Analog Voltage on ADA input.

ADA	FREQUENCY RANGE		
	F1	F2	F3
0V	2Hz	62.5Hz	500Hz
5V	100Hz	3.125kHz	26kHz

5.5 MOUNTING

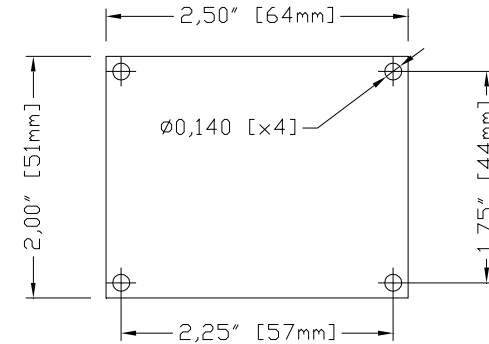


Figure 14. Mechanical dimensions.