Silencer™ Series Brushless Controllers

BDA-Q4-70-10

4-quadrant speed controller for brushless motors

Instruction Manual

GENERAL

- Powerful 4-quadrant PWM speed controller for electronically commutating three-phase brushless motors with Hall sensor spacing of either 60 or 120 degrees
- Integral short-circuit and overheat protection
- Three jumper-selectable modes of operation:
  - Torque Control
  - Velocity Control using digital encoder feedback
  - Velocity Control using Hall sensor feedback
- Maximum constant current can be adjusted via an on-board potentiometer
- Wide operating voltage range (11 to 70 volts)
- Robust aluminum case with mounting holes
- Removable screw terminal connectors allow fast installation and removal
- Compact design allows optimum utilization of real estate
- Controller output stage has been constructed using POWER-MOS-FET technology, resulting in very high efficiency (up to 95%)

NORTHROP GRUMMAN
Component Technologies

Woosung Hitech Co., Ltd.

Poly-Scientific

82-51-783-8300 FAX. 82-51-783-9413
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BDA-Q4-70-10 SPECIFICATIONS

ELECTRICAL DATA		BDA-Q4-70-10
Operating voltage (+Input, Power Gnd)		11-70 VDC
Current Ratings	- Peak (Impulse)	20 A
	- Continuous	10 A
Frequency of Power Output Stage		49 kHz
Efficiency		95%
Bandwidth of Current Controller		2.5 kHz

INPUTS	
Set value (+ Set value, - Set value)	+/- 10 VDC
Encoder Input Signals (Encoder A, Encoder B)	Channel A, B-TTL-max. 100kHz
Enable (Enable)	8-30 VDC (active high)

OUTPUTS		
Current Monitor (Monitor I)		0.5 volts/amp
Speed Monitor (Monitor n)		10 VDC full scale of nMax
Supervision Output Signal (Ready/Error)		Open Collector - 30 VDC max.
Auxiliary Voltage Sources	(-15V, 10 mA)	-15 VDC - 10 mA max.
	(+15V, 10 mA)	+15 VDC - 10 mA max.
	(+5V, 200 mA)	+5 VDC - 200 mA max.

DISPLAY
2-color LED - Green-Ready, Red - Error

TEMPERATURE RANGE
Storage -104 to 176ºF (-40 to +80°C)
Operation -50 to 113ºF (-10 to +45°C)

MOISTURE RANGE
20 to 80% non-condensed

MECHANICAL DATA	
Weight (including terminal connectors)	22.9 oz. (650.0 grams)
Dimensions (L x W x H)	7.09 in. x 3.94 in. x 1.57 in. (180mm x 100mm x 40mm)
Mounting	4 x M4 with a distance between holes of 4.78 in. x 3.54 in. (121.5mm x 90mm)

SAFETY NOTES

- Installation to be performed by skilled personnel only.
- Operating voltages exceeding the specified values, or improper connections will destroy the controller and will void the product warranty.
- Unauthorized opening and attempted repair will put the user in danger and will void the product warranty.
- Device contains **ESD** sensitive components. **Do not touch any of the terminal connector pins**.
- For initial commissioning, the motor shaft should be free to turn (no load applied to the motor).

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BDA-Q4-70-10 SPECIFICATIONS

TERMINATION TABLE - CONNECTOR A		
Terminal #	***Nomenclature***	***Description***
1	ϕB	Motor Phase B
2	ϕC	Motor Phase C
3	ϕA	Motor Phase A
4	+ Input	Positive Power Supply Connection
5	Power Gnd	Negative Power Supply Connection

TERMINATION TABLE - CONNECTOR B		
Terminal #	***Nomenclature***	***Description***
6	+5V, 200mA	+5 volt supply for Hall switches and/or Incremental Encoder
7	Encoder A	Channel A Encoder Input
8	Encoder B	Channel B Encoder Input
9	Signal Gnd	Ground for Hall Switches and/or Incremental Encoder
10	S1	Hall Switch #1
11	S2	Hall Switch #2
12	S3	Hall Switch #3
13	Enable	Enable Input (active high)

TERMINATION TABLE - CONNECTOR C		
Terminal #	***Nomenclature***	***Description***
14	+15V, 10mA	Auxiliary Voltage Source — +15 VDC
15	Signal Gnd	Signal Ground
16	-15V, 10mA	Auxiliary Voltage Source — -15 VDC
17	+ Set Value	Positive Voltage for Velocity Control
18	- Set Value	Negative Voltage for Velocity Control
19	Monitor I	Current Monitor Output
20	Monitor n	Speed Monitor Output
21	Ready/Error	Ready Signal Output

BDA-Q4-70-10 SPECIFICATIONS

INPUTS

- **Set Value (17,18)** – These inputs are used to control the velocity of the motor. They have a range of –10 to +10 VDC, and are connected internally to a differential amplifier. The input impedance is 20 kilohms. An input of 0 volts to +10 volts will result in a motor speed of 0 rpm to maximum motor rpm, with the motor rotating **CWVSE (clockwise viewing shaft end)**. An input of 0 volts to –10 VDC will result in a motor speed of 0 rpm to maximum motor rpm, with the motor rotating **CCWVSE (counter-clockwise viewing shaft end)**.
- **Encoder A (7) – Encoder B (8)** – Inputs from digital encoder (channels A and B). These inputs are used when the **velocity mode using encoder feedback** is selected. (jumpers 5,6,and 7 set)
- **ϕA (3), ϕB (1),ϕC (2)** – These are the motor phase lead inputs. Connect motor phase A to input A, motor phase B to input B, and motor phase C to input C.
- **S1 (10), S2 (11), S3 (12)** – These are the motor Hall sensor inputs. Connect motor Hall sensor S1 to input S1, motor Hall sensor S2 to input S2, and motor Hall sensor S3 to input S3.
- **Enable (13)** – Enables or disables the controller. Pulling this input high (**connecting to terminal 14**) will **enable** the controller, and voltage will be applied to the motor windings. Leaving this input with no connection or connecting it to ground (**terminal 15**) will **disable** the controller, and no voltage will be applied to the motor windings.
- **+ Input (4), Power Gnd (5)** – These inputs are for the supply voltage (11-70 volts). **Please Observe Polarity!** + Input connects to the **positive supply lead**, while the Power Gnd connects to the **negative supply lead**.

OUTPUTS

- **+5V, 200 mA (6)** – This output is an auxiliary voltage source for the supply of Hall switches and/or an incremental encoder. Use in conjunction with **Signal Gnd (terminal 9)**.
- **+15V, 10 mA (14), -15V, 10 mA (16)** – These outputs are auxiliary voltage sources for use as reference voltages for velocity control when using an external potentiometer.
- **Monitor I (19)** – This output is for supervisional purposes when it is necessary to monitor motor current. This analog signal (voltage) is directly proportional to **motor current**, and is output at the rate of 0.5 volts per amp of motor current. The output range is –10 VDC to +10 VDC.
- **Monitor n (20)** – This output is for supervisional purposes when it is necessary to monitor motor speed. This analog signal (voltage) is directly proportional to **motor speed**. The output range is –10 VDC to +10 VDC. The output impedance is 10 kilohms. The output proportionality is 10 VDC = Maximum Speed.
- **Ready/Error (21)** – This output signal is to show the status of the drive, and can be used to provide a feedback signal to other devices and controls. The open-collector output is normally turned on, which means the output is pulled to GND (low logic state) if there is no fault within the drive system. In the case of a fault (faults include: **under-voltage, over-voltage, overheat or overcurrent)**, the output goes high (high logic state). Maximum input range is 30 VDC @ 20 mA. **A FAULT CAN BE RESET BY TOGGLING THE ENABLE (TURNING THE ENABLE OFF THEN ON**).

PUTTING THE CONTROLLER INTO OPERATION

Prior to putting the controller into operation, the following parameters must be decided upon and programmed by installing the jumpers on the left side of the control.

- Operating Mode (torque, velocity using Hall feedback, velocity using encoder feedback)
- Method of Velocity Control (select whether the on-board potentiometer, or an external potentiometer is used)
- Timing (timing determined by the number of motor poles)
- Phasing (60 or 120 degree Hall sensor spacing)
- Speed Range (speed range of the motor used with the controller)

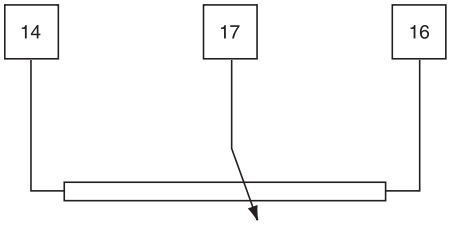
OPERATING MODE		
Desired Mode of Operation	*Install Jumper(s)*	*Active Potentiometers*
Torque	J4	Gain, nmax, Imax, Offset
Velocity Using Hall Feedback	J7, J8, J9	Gain, nmax, Imax, Offset
Velocity Using Encoder Feedback	J5, J6, J7	Imax, Offset

METHOD OF VELOCITY CONTROL

Motor velocity may be controlled by using either the **on-board potentiometer**, or an **external potentiometer** *(recommend 10 kilohm, 10 turn potentiometer)*.

EXTERNAL POTENTIOMETER
- Install Jumper between terminals 15 and 18
- Remove Jumper J3
- Wiper connected to terminal 17, ends connected to terminals 14 and 16 (see Fig. A)

Fig. A



INTERNAL POTENTIOMETER
- Remove Jumper from terminal 15 and 18
- Set Jumper J3

BDA-Q4-70-10 SPECIFICATIONS

TIMING

Jumper J2 sets the timing of the Hall sensor logic to match the type of motor being controlled. The setting is related to the number of motor poles. For the majority of motor installations, and **most Northrop Grumman PolyScientific motors, J2 SHOULD BE SET**. For all installations, initially install J2. If you find you have no speed control, remove J2.

PHASING

Jumper J1 sets the phase shift of the signals of the Hall sensors. This setting will correspond to either **60 or 120 degree Hall spacing (if you are not sure of this setting, see the motor manufacturer's literature; all PolyScientific motors utilize 120 degree Hall spacing)**.

- 60 Degree Hall Spacing – Set Jumper J1
- 120 Degree Hall Spacing – Remove Jumper J1

SPEED RANGE

Jumpers J10 and J11 set the speed range. One of four speed ranges are available for setting. For best speed control results, set the jumpers to the **lowest acceptable speed range of the motor**.

2-Pole Motor	*8-Pole Motor*	*Set Jumper(s)*
2500rpm	625 rpm	J10, J11
5000rpm	1250rpm	J10
10,000rpm	2500rpm	J11
40,000rpm	10,000rpm	None

CURRENT LIMITING

Current-limiting is available via the on-board current potentiometer. The settings are as follows:
Fully CCW - minimum setting
Fully CW - maximum setting

FUSING

Proper overcurrent protection (fusing) is required for the protection of this controller. We recommend a maximum of **10 amp – 120 volt – non-time delay** fuse. This fuse should be connected in series with the + **Input** line and the **Positive power supply terminal**.

Note: Considerations regarding the power supply
Output voltage: > 11 V and < 70V with a residual voltage of < 5%

Output Current: 10 A nominal, 20 A peak

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Note: Procedure for calculating the necessary minimum supply voltage

Default:
- torque M_B [mNm]
- Operating speed n_B [min^{-1}]
- Rated voltage of the motor U_N [V]
- Idling speed with UN n0 [min^{-1}]
- Characteristic curve slope $\frac{\Delta n}{\Delta M}$ [min^{-1}mNm]

Result:

$$Vcc = \frac{U_N}{n_0} * \left(n_B + \frac{\Delta n}{\Delta M} * M_B \right) + 4V$$

FUNCTION OF POTENTIONMETERS			
Potentiometer	***Function***	***Action Turning CCW***	***Action Turning CW***
Gain Coarse	Gain Adjustment	Decrease Gain	Increase Gain
Gain Fine	Gain Adjustment	Decrease Gain	Increase Gain
nMax	Velocity Adjustment	Decrease Velocity	Increase Velocity
IMax	Current Limit Adjustment	Decrease Current Limit	Increase Current Limit
Offset	Adj. n=0 at set Value=0	Motor turns CW	Motors turns CCW

NOTE: The minimum setting of IMax potentiometer is 0.3 amps; the maximum setting is 10 amps.

ADJUSTMENT OF POTENTIOMETERS

VELOCITY CONTROL USING EITHER HALL SENSOR OR ENCODER FEEDBACK

- Turn **nMax** potentiometer fully **ccw**. Turn **external potentiometer** or **offset potentiometer** (depending upon which potentiometer is the chosen method of speed control) fully **cw**. Apply power to the controller. Turn **nMax** potentiometer **cw** until desired maximum motor speed is obtained. The speed may now be varied by use of either the **external potentiometer** or the **offset potentiometer**.
- Adjust **IMax** to correspond with the required value of current limitation (see motor manufacturer's literature for maximum allowable motor current.
- Turn **Gain Coarse** potentiometer slowly clockwise until the required gain is reached. If motor runs rough, is vibrating, or noisy, turn potentiometer slowly counterclockwise until the instability is eliminated. **Gain Fine** may be used in the same manner if better resolution is desired (***fine tune***).

TORQUE CONTROL

Adjust **IMax** to correspond with the required value of current limitation (see motor manufacturer's literature for maximum allowable motor current.

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TROUBLESHOOTING

Symptom	*Operating Mode*	*Possible Causes*	*Corrections*
Motor Does Not Turn	All	1. Power supply voltage less than 11.0 volts	Check power supply voltage
		2. Enable not active	Check for High Level at terminal #14
		3. Speed potentiometer set to 0 volts	Check speed potentiometer setting
		4. Current limitation adjusted too low	Check IMax potentiometer setting
		5. Wrong operation mode selected	Check jumper settings
		6. Loose connection	Check connections
		7. Improper connection	Check connections
No Speed Control	Velocity Mode using Hall or Encoder Feedback	1. Jumper J2 set	Remove Jumper J2
		2. Improper Encoder Signal	Check Encoder Signals

NOTE: This device contains no user-servicable parts; also dangerous voltages are present inside. Opening device will not only void the product warranty, but may put personnel in danger!

OUTLINE DRAWING

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APPENDIX A

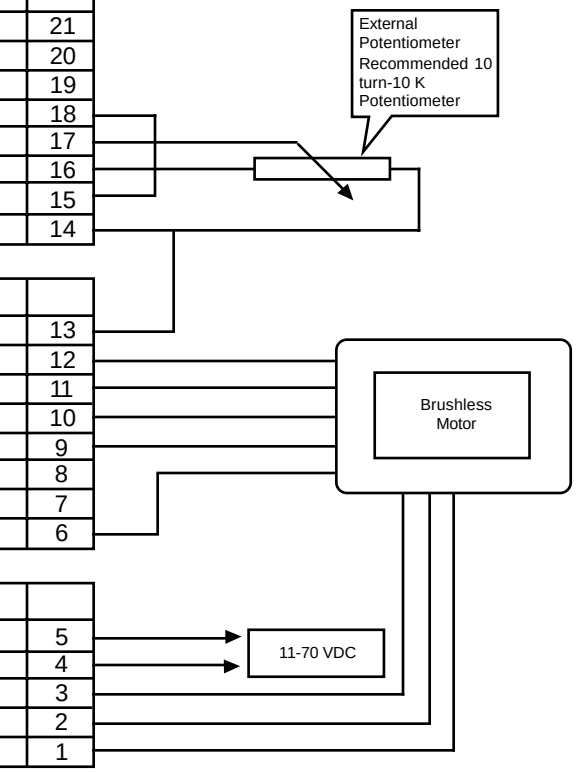
CONNECTION DIAGRAMS

Connection Diagram for
VELOCITY MODE USING HALL SENSOR FEEDBACK AND EXTERNAL POTENTIOMETER

Connector C	
READY/ERROR	21
MONITOR n	20
MONITOR I	19
- SET VALUE	18
+ SET VALUE	17
-15V, 10mA	16
SIGNAL GND	15
+15V, 10mA	14

Connector B	
ENABLE	13
S3	12
S2	11
S1	10
SIGNAL GND	9
ENCODER B	8
ENCODER A	7
+5V, 200mA	6

Connector A	
POWER GND	5
+INPUT	4
ϕ A	3
ϕ C	2
ϕ B	1



- **Install Jumper(s) - J7, J8, J9**
- **Active Potentiometers - Gain nMax, IMax, Offset**

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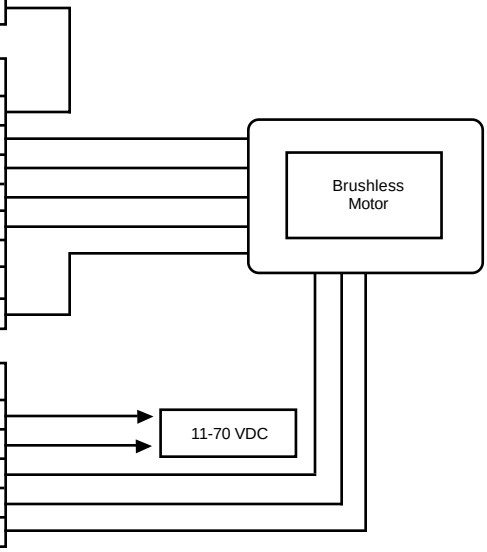
CONNECTION DIAGRAMS

Connection Diagram for
TORQUE MODE

Connector C	
READY/ERROR	21
MONITOR n	20
MONITOR I	19
- SET VALUE	18
+ SET VALUE	17
-15V, 10mA	16
SIGNAL GND	15
+15V, 10mA	14

Connector B	
ENABLE	13
S3	12
S2	11
S1	10
SIGNAL GND	9
ENCODER B	8
ENCODER A	7
+5V, 200mA	6

Connector A	
POWER GND	5
+INPUT	4
ϕ A	3
ϕ C	2
ϕ B	1



- **Install Jumper(s) - J14**
- **Active Potentiometers - Gain nMax, IMax, Offset**

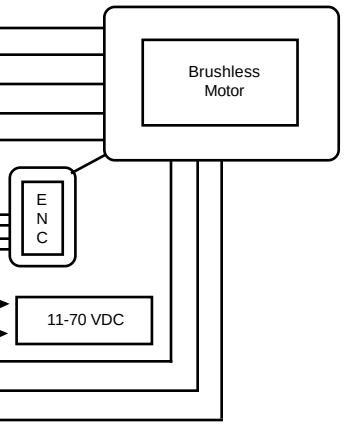
CONNECTION DIAGRAMS

Connection Diagram for
VELOCITY MODE USING ENCODER FEEDBACK

Connector C	
READY/ERROR	21
MONITOR n	20
MONITOR I	19
- SET VALUE	18
+ SET VALUE	17
-15V, 10mA	16
SIGNAL GND	15
+15V, 10mA	14

Connector B	
ENABLE	13
S3	12
S2	11
S1	10
SIGNAL GND	9
ENCODER B	8
ENCODER A	7
+5V, 200mA	6

Connector A	
POWER GND	5
+INPUT	4
ϕ A	3
ϕ C	2
ϕ B	1



- **Install Jumper(s) - J5, J6, J7**
- **Active Potentiometers - IMax, Offset**

ALSO AVAILABLE FROM POLY-SCIENTIFIC

Commercial Brushless & Brush DC Motors and Military/Aerospace DC Motors and Resolvers

Silencer™ Brushless DC Motors

- *Sizes 12, 23, 34 and 42*
- *Standard NEMA frames in 1.2" to 4.15" diameter*
- *Speeds up to 20,000 rpm*
- *Continuous torques range from 2.4 to 519 oz-in*
- *Compact size - lengths range from 1.3" to 5.5"*
- *Standard options include gearheads, resolvers, encoders & electronic drivers*

Permanent Magnet DC Brush Motors Series - C23, C34 and C42

- *Sizes 23, 34, and 42*
- *Standard NEMA frames in 1.31 to 4.0" diameter*
- *Long-life, replaceable brushes*
- *Gearmotors available in most frame sizes*
- *Up to 560 oz-in continuous torque*
- *Up to 3,500 oz-in peak starting torque*

Miniature C13 Series

- *Long-life, replaceable metal graphite brushes*
- *Stainless steel shafts*
- *.125" and .187" inch diameters*
- *Continuous torques from 7.5 to 13 oz-in*
- *Encoder and tachometer packages*
- *Up to 1274 oz-in peak starting torque*
- *Weighs only 6.8 oz*

Brushless DC Motors BOF, BON and BI Series

- *Lengths from 1.3" to 2.8"*
- *Continuous torques from 12.6 to 41 oz-in*
- *Speeds up to 20,000 rpm*
- *High torque per dollar ratio*
- *Standard options include electronic drivers, encoders, and gearheads. Hall effect, resolver and sensorless feedback are also available*

Servo Torque Motors

- *Torques from 6 oz-in to 14 lb-ft.*
- *1.1" to 5.25" O.D. standard*
- *Gold commutators available*
- *Tachometer and potentiometer options available*
- *Housed motors or as separate rotor/stator sets*

DC Cube Torque Brush Motors

- *Up to 24 oz-in peak torque*
- *Options include gearheads, brakes, resolvers and potentiometers*
- *Available with rare earth magnets*
- *Available in sizes:*
  - ❑ 1" x 1" x 1"
  - ❑ 1" x 1" x .75"
  - ❑ 1" x 1" x 1.35"
  - ❑ .75" x .75" x .75"

Brush and Brushless, Single and Multispeed, Pancake and Housed Resolvers

- *Coupled to R/D converters, they provide a digital interface to computerized motion control systems.*
- *±7' accuracy standard, ±3' available for single speed*
- *400-10,000 Hz frequency range standard*
- *Arc second accuracies are standard for multispeed resolvers*

We also offer:
- ❑ Custom engineering services
- ❑ Limited angle rotation (LAR) (toroidally wound) DC brushless motors

Resolvers and Synchros

Our brushless resolvers are economical, highly accurate motion feedback sensors that can be used to provide position and velocity information for closed-loop electronic control, as well as brushless DC motor commut ation. They contain no internal electronics or optics and are unaffected by heat, electrical noise, shock and vibration.

NORTHROP GRUMMAN
Component Technologies

Poly-Scientific

Woosung-Hitech is an innovative motion technology products company with design and manufacturing capabilities for slip rings, brush & brushless DC motors and drives, fiber optics, actuators and integrated rotary assemblies.

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