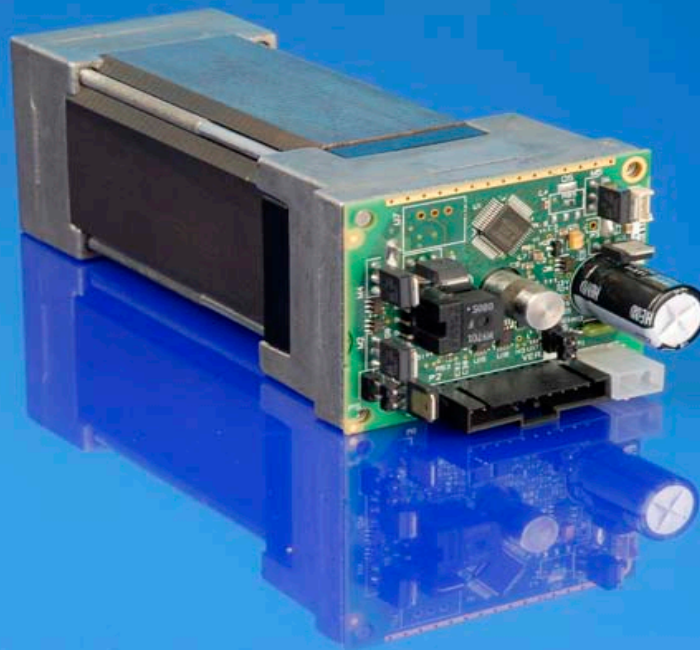


Brushless DC Motor and GreenDrive™ Manual



⚠ WARNING

Read this Operator's Manual carefully before using this device. Failure to understand and follow the contents of this manual may result in electrical shock, fire and/or serious personal injury.

Nidec

NIDEC MOTOR CORPORATION





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NT TM *Dynamo*



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Information furnished by Nidec Motor Corporation is believed to be accurate and reliable. Nidec Motor Corporation reserves the right to change the design or operation of the equipment described herein and any associated motion products without notice.

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Revision: 2
Date: Aug. 24, 2011
Nidec Motor Corporation, 2011

This document has been prepared to conform to the current released version of the product. Because of our extensive development efforts and our desire to further improve and enhance the product, inconsistencies may exist between the product and documentation in some instances. Call your customer support representative if you encounter an inconsistency.



CUSTOMER SUPPORT

Nidec Motor Corporation
1551 East Broadway Street
Princeton, Indiana 47670
U.S.A.
Telephone: (812) 385-2564

It is Nidec Motor Corporations' goal to ensure your greatest possible satisfaction with the operation of our products. We are dedicated to providing fast, friendly, and accurate assistance. We offer you many ways to get the support you need. Our wide range of services include:

FAX	(812) 386-7504
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You can FAX questions and comments to Nidec Motor Corporation. Just send a FAX to the number listed above.

Website	www.hurst-motors.com
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If you have Internet capabilities, you also have access to technical support using our website. The website includes technical notes, frequently asked questions, release notes, and other technical documentation.

Customer Service (Sales)	(812) 385-2564
--------------------------	----------------

Email: hurst@nidec-motor.com

Nidec Motor Corporation has an extensive array of distributors. Contact our customer service department for the distributor nearest to you or refer to our website at www.hurst-motors.com.





Nidec Motor Corporation
Brushless DC Motor and GreenDrive™ Manual

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SAFETY INFORMATION

Safety Symbols

In this operator's manual and on the product, safety symbols and signal words are used to communicate important safety information. This section is provided to improve understanding of these signal words and symbols.



This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

DANGER

DANGER indicates a hazardous situation which, if not avoided, will result in death or serious injury.

WARNING

WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION

CAUTION indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

NOTICE

NOTICE indicates information that relates to the protection of property.



This symbol means read the operator's manual carefully before using the equipment. The operator's manual contains important information on the safe and proper operation of the equipment.



This is the electrical shock symbol.

General Safety Rules

WARNING

Failure to follow safe installation guidelines can cause death or serious injury. The voltages used in motion control systems can cause severe electric shock and/or burns, and could be lethal. Extreme care is necessary at all times when working with or adjacent to this equipment. The installation must comply with all relevant safety regulations and standards in the country of use.

Safety Precautions

This product is intended for professional incorporation into a complete system by qualified persons. If you install the product incorrectly, it may present a safety hazard. The product and system may use high voltages and currents, carry a high level of stored electrical energy, or are used to control mechanical equipment that can cause injury. You must give close attention to the electrical installation and system design to avoid hazards either in normal operation or in the event of equipment malfunction. System design, installation, commissioning, and maintenance must be carried out by personnel who have the necessary training and experience. Read and follow this safety information and this instruction manual carefully.

Qualified Person

For the purpose of this manual and product, a “qualified person” is one who is familiar with the installation, construction, operation, and potential hazards associated with the equipment into which this motor and drive will be installed. In addition, this individual has the following qualifications:

- Is trained and authorized to energize, de-energize, clear and ground and tag circuits and equipment in accordance with established safety practices.
- Is trained in the proper care and use of protective equipment in accordance with established safety practices.
- Is trained in rendering first aid.

Setup, Commissioning and Maintenance

It is essential that you give careful consideration to changes to control settings. Depending on the application, a change could have an impact on safety. You must take appropriate precautions against inadvertent changes or tampering. Restoring default parameters in certain applications may cause unpredictable or hazardous operation.

Safety of Machinery

All machinery in which this product is used must comply with all federal, state, and local safety standards. The level of integrity offered by the product’s control function – for example stop/start, forward/reverse and maximum speed is not sufficient for use in safety-critical applications without additional independent channels of protection. All applications where malfunction could cause injury or loss of life must be subject to a risk assessment, and further protection provided where needed.

NOTICE

Fuses

Fuses or over-current protection must be provided in accordance with the National Electrical Code and any additional local codes.

Specific Safety Information

Users must determine the suitability of the control for their application, including the level of reliability required, and are solely responsible for the function of the end-use product. These controls contain exposed electrical components and are not intended to withstand exposure to water or other environmental contaminants which can compromise insulating components. Such exposure may result in insulation breakdown and accompanying localized electrical heating.

⚠ WARNING

A control may remain permanently closed or open as a result of exposure to excessive mechanical, electrical, thermal or environmental conditions or at normal end-of-life. If failure of the control to operate could result in personal injury or property damage, the user should incorporate supplemental system control features to achieve the desired level of reliability and safety. For example, backup controls have been incorporated in a number of applications for this reason.

INTRODUCTION

Thank you for selecting the Dynamo or HST23 Motor powered by the integrated GreenDrive™ control. This manual contains all basic and necessary information concerning the brushless DC motor(s) and GreenDrive™ control.

If you require any additional information, please contact Nidec Motor Corporation/Hurst Division at 812-385-2564 or hurst@nidec-motor.com.

Features

- NEMA 23 and Size 17 Motor (Dynamo Only)
- Ball Bearing System
- Stainless Steel Shaft
- 12 to 45 Vdc Input Voltage
- Open or Closed Loop Speed and Open Loop Torque Operating Modes
- Analog or Pulse Width Modulated (PWM) Control Methods
- Gear box options for high torque applications
- Enable and Direction Inputs
- Efficiency up to 85%
- Two channel Quadrature Encoder or Tachometer Outputs
- 4-Quadrant Operation
- Current Limit Protection
- Under Voltage Protection
- Industry Standard Connectors

Product Description

The Hurst brushless DC motion control system is an integrated, variable-speed brushless DC motor and control package. This system includes a low voltage customer interface that can be connected to a system controller or connected to an external potentiometer, forward/reverse switch, run/stop switch, or other user I/O. The motor is equipped with a triple-fixed preloaded ball bearing system and multiple mounting arrangements. The system also includes internal current limiting, and under voltage protection for system safeguarding.

Two channel encoder signals are available to close system loop internally or externally. The encoder also permits the user to determine speed and direction of the motor. A Tachometer signal is also accessible for a low cost alternative to the encoder.

The integrated motor control includes a power amplifier designed to operate directly from a DC voltage input of 12 to 45 volts. The power amplifier contains an inverter and an optional low voltage power supply. The inverter converts input DC power into three phase voltages. The optional low voltage power supply can be used to supply an auxiliary 5 Vdc to power additional customer circuitry.

The GreenDrive™ also includes a variety of control methods and operating modes. The integrated motor operating modes are:

- Closed loop speed - Together with the internal two-channel quadrature encoder or tachometer signal, allows the user to close a speed loop internally to the control for applications requiring minimum speed variation with varying loading.
- Open loop speed - Motor speed varies with input command but speed will decrease with increased load.
- Preset speed - Allows the GreenDrive™ to be programmed with one fixed speed.
- Torque control - An open loop operating mode in which motor torque, directly proportional to current, will vary with input command.

The system control methods are:

- Analog - Varies speed or torque based on a 0-5 Vdc input.
- PWM - Varies speed based on PWM duty cycle.
- PWM & Direction - Varies speed and direction based on PWM duty cycle.

GETTING STARTED

Minimum Requirements:

Hurst BLDC Motor

Power Supplies

- Motor Power Supply 12 to 45 Vdc (dependent on motor rating)
- Control Power Supply 0 to 5 Vdc optional internal power supply available

Customer Data Sheet

Cables available upon request

Motor Part Number Identification

Before using the Hurst BLDC motor, it is important to know the characteristics of the motor you have selected. The motor part number identification matrix detailed in the tables below explains the type of motor and control you have, based on the digits within the motor part number located on the nameplate for the brushless DC motor detailed in the figures below.

Standard Part Numbers (15 digit Part Number)

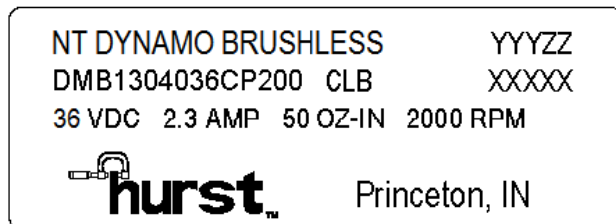


FIGURE 1 – DYNAMO MOTOR NAMEPLATE EXAMPLE

Motor Family	Date Code (DDYY)		
Part Number	Insulation Class	Serial Number	
Voltage	Current	Torque	Speed
Manufacturing Location			

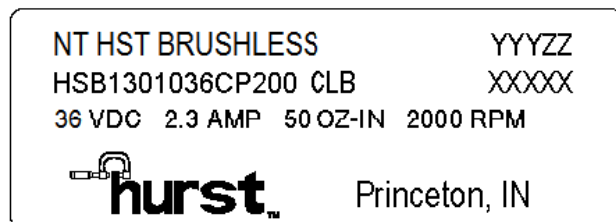


FIGURE 2 – HST23 MOTOR NAMEPLATE EXAMPLE

Motor Family	Date Code (DDYY)		
Part Number	Insulation Class	Serial Number	
Voltage	Current	Torque	Speed
Manufacturing Location			



Refer to the label on the motor to retrieve information about rated speed, torque, voltage, and current.

As an example, if you have a Dynamo motor part number “DMB1304036CP200”

- Product Family - **DM**B1304036CP200 = Dynamo
- Operating Mode - DM**B**1304036CP200 = Open Loop Speed
- Control Method - DMB**1**304036CP200 = Analog Input Signal
- Encoder/Resolver - DMB1**3**04036CP200 = 400 Line Encoder
- Thermal Protection - DMB13**0**4036CP200 = No Thermal Protection
- Rated Torque - DMB130**4**036CP200 = Rated Torque (30 oz. in.)
- Voltage - DMB1304**036**CP200 = 36Vdc Motor
- Winding - DMB1304036**C**P200 = “C” Winding
- Mechanical Features - DMB1304036**P20**0 = Planetary Gear 3:1 NEMA 23
- Preset Speed - DMB1304036CP20**10** = No Preset Speed

As an example, if you have a HST23 motor part number “HSB1301036CP200”

- Product Family - **HS**B1301036CP200 = HST23 Motor
- Operating Mode - HS**B**1301036CP200 = Open Loop Speed
- Control Method - HSB**1**301036CP200 = Analog Input Signal
- Encoder/Resolver - HSB1**3**01036CP200 = 400 Line Encoder
- Thermal Protection - HSB13**0**1036CP200 = No Thermal Protection
- Rated Torque - HSB130**1**036CP200 = Rated Torque (50 oz. in.)
- Voltage - HSB1301**036**CP20 = 36Vdc Motor
- Winding - HSB1301036**C**P200 = “C” Winding
- Mechanical Features - HSB1301036**P20** = Planetary Gear 3:1 NEMA 23
- Preset Speed - HSB1301036CP20**0** = No Preset Speed



Standard Part Numbers are 15 characters in length (Example: DMB1304036CP200 or HSB1301036CP200).

Custom Part Numbers (11 digit Part Number)


Customer Part Number	YYYYZ
DM2012-1000	CLB XXXXX
12 VDC 2.3 AMP 50 OZ-IN 2000 RPM	
	
Princeton, IN	

FIGURE 3 – DYNAMO MOTOR NAMEPLATE
CUSTOM PART NUMBER EXAMPLE

Customer Part Number	Date Code (DDYY)
Part Number	Insulation Class
Voltage	Current
Torque	Speed
Manufacturing Location	


Customer Part Number	YYYYZ
HS2024-1000	CLB XXXXX
24 VDC 2.3 AMP 50 OZ-IN 2000 RPM	
	
Princeton, IN	

FIGURE 4 – HST23 MOTOR NAMEPLATE
CUSTOM PART NUMBER EXAMPLE

Customer Part Number	Date Code (DDYY)
Part Number	Insulation Class
Voltage	Current
Torque	Speed
Manufacturing Location	



Refer to the label on the motor to retrieve information about rated speed, torque, voltage, and current.

As an example, if you have a Dynamo motor part number “DM2012-1000”

- Product Family - **DM**2012-1000 = Dynamo Motor
- Rated Torque - DM**2**012-1000 = Rated Torque (10 oz. in.)
- Voltage - DM2**012**-1000 = 12Vdc Motor
- Motor Number - DM2012-**1000** = Sequential Number (Customer Specific)

As an example, if you have a HST23 motor part number “HS2024-1000”

- Product Family - **HS**2024-1000 = HST23 Motor
- Rated Torque - HS**2**024-1000 = Rated Torque (100 oz. in.)
- Product Family - HS2**024**-1000 = 24Vdc Motor
- Motor Number - HS2024-**1000** = Sequential Number (Customer Specific)



Custom Part Numbers are 11 characters in length (Example: DM2012-1000 or HS2024-1000). Contact Hurst for motor details.

TABLE 1 – DYNAMO PART NUMBER IDENTIFICATION MATRIX

Product Family	Operating Mode	Control Method (Input Signal)	Encoder (ppr)	Thermal Protection	Model - Rated Torque (oz-inch)	Input Voltage (Vdc)	Winding (See Chart)	Mechanical Features	Preset Speed ¹⁰ (RPM)
DM - Dynamo	A – External ¹	0 – None	0 - None	0 - None	0 – See Note ¹¹	012 – 12 V	A	100 - Size 17 – without cables	0 - None
	B - Open Loop Speed	1 – Analog ³	1 - 100 ppr		1 - 5	024 – 24 V	B	101 - Size 17 - with cables	1 – Special ¹³
	C - Closed Loop Speed	2 – Analog ⁴ (w/ 5Vdc supply)	2 - 250 ppr		2 - 10	036 – 36 V	C	200 - NEMA 23 – without cables	A – 250
	D – Preset Speed ²	3 – PWM ^{3,5}	3 - 400 ppr		3 - 20	045 – 45 V	D	201 - NEMA 23 – with cables	B – 300
	E – Torque ¹² (Open Loop)	4 – PWM ⁵ (w/ 5Vdc supply)	4 - 1000 ppr		4 - 30	048 – 48 V ⁸	E	G00-07 ⁹ Spur Gear Ratios with cables P10-P1C ⁹ Planetary Gear Ratios (Size 17) with cables P20-P2C ⁹ Planetary Gear Ratios (NEMA 23) with cables	C – 500
		5 – PWM ^{3,6} & Direction	5 - 256 ppr ⁷ (w/index)		5 - 40				D – 600
		6 - PWM ⁶ & Direction (w/ 5Vdc supply)			6 - See Note ¹¹				E – 750
		7 – ON/OFF ³							F – 900
	8 – ON/OFF ⁴							G – 1000	
								H – 1200	
								J – 1500	
								K – 1800	
								L - 2000	
								M – 2500	
								N – 3000	
								P – 3500	
								Q – 3600	
								R – 4000	
								S - 4500	

¹ Only Motor phase and commutation signal outputs are supplied (User supplies their own motor drive).

² Use only with Control Method **7** – ON/OFF or **8** – ON/OFF.

³ User to supply 5 Vdc control logic signal; Power supply able to supply a typical current of 35 mA.

⁴ Internally supplied 5 Vdc source; max current = 5 ma.

⁵ PWM input signal used in conjunction with direction line (Pin 7).

⁶ PWM input signal (Pin 3) used as command and direction.

⁷ Only available with Operating Mode **A** – External.

⁸ Use only with Operating Mode **A** – External or 45 Vdc for all other operating modes.

⁹ See 'Table 3 – Dynamo Spur Gearing part number Identification Matrix' or 'Table 4 – Dynamo Planetary Gearing part number Identification Matrix' for Gear Options.

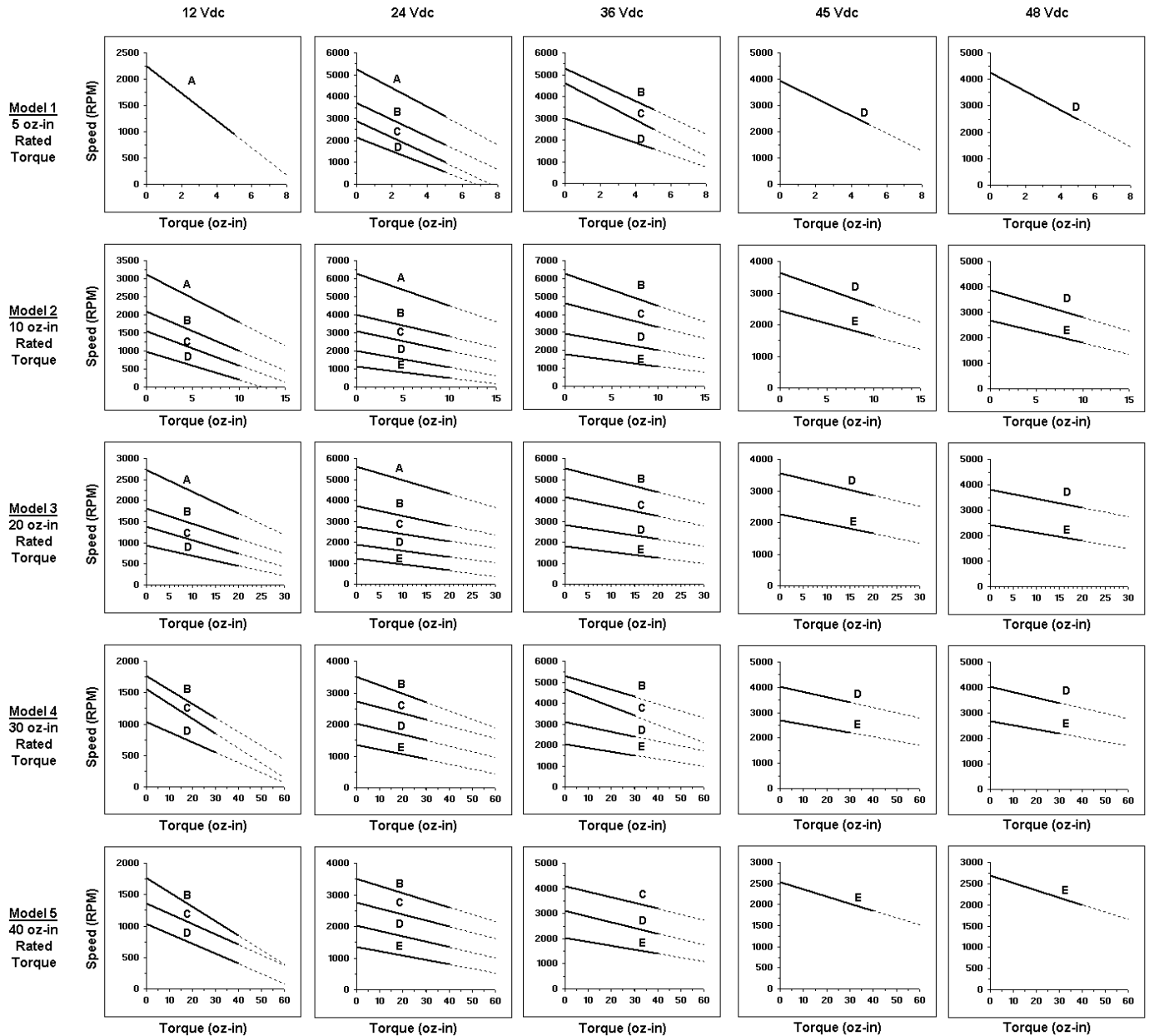
¹⁰ Use only with Operating Mode **D** - Preset Speed. Preset Speed must be below solid portion of the diagonal line of the winding curve selected. The maximum continuous torque is dependent upon the preset speed selected. Other Preset speeds available upon request.

¹¹ Use only with Spur and Planetary Gearing; See 'Table 3 – Dynamo Spur Gearing part number Identification Matrix' or 'Table 4 – Dynamo Planetary Gearing part number Identification Matrix' for Gear Options.

¹² Use only with **1** – Analog or **2** – Analog (w/ 5Vdc supply).

¹³ If standard listed speeds do not meet your needs, contact the factory for your specific requests.

TABLE 2 – DYNAMO SPEED VS. TORQUE CURVES



Performance data shown is typical. More detailed data is available from Nidec Motor Corporation for each of the above ratings. Refer to the Customer Data Sheet supplied with your system. Ambient operating temperature range: 0 - 40°C. The solid portion of the diagonal line is continuous duty and the dotted line represents momentary operation. At 25°C ambient the max motor winding operating temperature rise is 65°C with motor mounted to a 4" x 4" x 0.25" aluminum plate.

TABLE 3 – DYNAMO SPUR GEARING PART NUMBER IDENTIFICATION MATRIX

Rated Speed RPM	Rated Torque @ 24Vdc	Rated Current @ 24Vdc	Gear Ratio	Gear Stages	Max. Radial Load (lb)	Max. Axial Load (lb)	Wt. (lb)	Length "A" inches [mm]	Part Number		
	(oz.in.)	(Amps)							GreenDriver™ M Control	Model #	Winding
93 to 280	15	0.35	2:1	2	7	5	1.6	4.87 [123.7]	0	E	G00
	75	1.4							6	E	G00
37 to 112	38	0.35	5:1	2	7	5	1.6	4.87 [123.7]	0	E	G01
	188	1.4							6	E	G01
18 to 56	75	0.35	10:1	2	7	5	1.6	4.87 [123.7]	0	E	G02
	200 ¹	1.4							6	E	G02
6.2 to 18	200 ¹	0.35	30:1	3	7	5	1.6	4.87 [123.7]	0	E	G03
3.1 to 9.3	200 ¹	0.35	60:1	3	7	5	1.6	4.87 [123.7]	0	E	G04
1.8 to 5.6	200 ¹	0.35	100:1	4	7	5	1.6	4.87 [123.7]	0	E	G05
0.6 to 1.8	200 ¹	0.35	300:1	5	7	5	1.6	4.87 [123.7]	0	E	G06
0.3 to 0.9	200 ¹	0.35	600:1	5	7	5	1.6	4.87 [123.7]	0	E	G07

¹Motor rated torque will exceed the 200 oz.in. maximum geartrain rating. If this service is anticipated, a current limiting device should be used.

- All values are at nominal rated input voltage.
- Ambient operating temperature range: 0 to 40°C.
- **At 25°C ambient the max motor winding operating temperature rise is 65°C with gearmotor mounted to a 4" x 4" x 0.25" aluminum plate.**
- Performance data shown is typical. More detailed data is available from Hurst for each of the above ratings.
- Refer to the Customer Data Sheet supplied with your system or contact Hurst for other gear ratios and voltages (7 to 45 Vdc).

TABLE 4 – DYNAMO PLANETARY GEARING PART NUMBER IDENTIFICATION MATRIX

	Rated Speed	Rated Torque @ 24Vdc	Rated Current @ 24Vdc	Gear Ratio	Gear Stage	Gear Head Inertia	Gear Head Backlash (Std./Low)	Wt.	Length "A" inches [mm]	Part Number		
	RPM	lb.in.	Amps			oz.in.-sec ²	arc-min	lb.	GreenDrive™ M Control	Model #	Winding	Gear #
Size 17	225 to 675	1.7	1	3:1	Single	3.83E-04	6/3	2.1	6.49 [164.8]	2	C	P10
		6.8	3.6	3:1	Single	3.83E-04	6/3	3.4	8.74 [222.0]	4	C	P10
	168 to 506	2.3	1	4:1	Single	2.41E-04	6/3	2.1	6.49 [164.8]	2	C	P11
		9	3.6	4:1	Single	2.41E-04	6/3	3.4	8.74 [222.0]	4	C	P11
	122 to 368	3.1	1	5.5:1	Single	1.76E-04	6/3	2.1	6.49 [164.8]	2	C	P12
		12	3.6	5.5:1	Single	1.76E-04	6/3	3.4	8.74 [222.0]	4	C	P12
	96 to 289	3.9	1	7:1	Single	1.51E-04	6/3	2.1	6.49 [164.8]	2	C	P13
		16	3.6	7:1	Single	1.51E-04	6/3	3.4	8.74 [222.0]	4	C	P13
	67 to 202	5.6	1	10:1	Single	1.54E-04	6/3	2.1	6.49 [164.8]	2	C	P14
		23	3.6	10:1	Single	1.54E-04	6/3	3.4	8.74 [222.0]	4	C	P14
	42 to 127	8.5	1	16:1	Double	2.22E-04	10/5	2.7	6.98 [177.3]	2	C	P15
		34	3.6	16:1	Double	2.22E-04	10/5	4	9.23 [234.4]	4	C	P15
	31 to 92	12	1	22:1	Double	1.73E-04	10/5	2.7	6.98 [177.3]	2	C	P16
		47	3.6	22:1	Double	1.73E-04	10/5	4	9.23 [234.4]	4	C	P16
	24 to 72	15	1	28:1	Double	1.50E-04	10/5	2.7	6.98 [177.3]	2	C	P17
		60	3.6	28:1	Double	1.50E-04	10/5	4	9.23 [234.4]	4	C	P17
	17 to 51	21	1	40:1	Double	1.32E-04	10/5	2.7	6.98 [177.3]	2	C	P18
		85	3.6	40:1	Double	1.32E-04	10/5	4	9.23 [234.4]	4	C	P18
	12 to 37	29	1	55:1	Double	1.31E-04	10/5	2.7	6.98 [177.3]	2	C	P1A
		117 ¹	3.6	55:1	Double	1.31E-04	10/5	4	9.23 [234.4]	4	C	P1A
10 to 29	37	1	70:1	Double	1.30E-04	10/5	2.7	6.98 [177.3]	2	C	P1B	
	149 ¹	3.6	70:1	Double	1.30E-04	10/5	4	9.23 [234.4]	4	C	P1B	
6.7 to 20	52 ¹	1	100:1	Double	1.30E-04	10/5	2.7	6.98 [177.3]	2	C	P1C	
NEMA 23	225 to 675	1.7	1	3:1	Single	1.68E-03	6/3	3.2	6.68 [169.7]	2	C	P20
		6.8	3.6	3:1	Single	1.68E-03	6/3	4.5	8.93 [226.8]	4	C	P20
	168 to 506	2.3	1	4:1	Single	1.27E-03	6/3	3.2	6.68 [169.7]	2	C	P21
		9	3.6	4:1	Single	1.27E-03	6/3	4.5	8.93 [226.8]	4	C	P21
	122 to 368	3.1	1	5.5:1	Single	1.08E-03	6/3	3.2	6.68 [169.7]	2	C	P22
		12	3.6	5.5:1	Single	1.08E-03	6/3	4.5	8.93 [226.8]	4	C	P22
	96 to 289	3.9	1	7:1	Single	1.01E-03	6/3	3.2	6.68 [169.7]	2	C	P23
		16	3.6	7:1	Single	1.01E-03	6/3	4.5	8.93 [226.8]	4	C	P23
	67 to 202	5.6	1	10:1	Single	9.50E-04	6/3	3.2	6.68 [169.7]	2	C	P24
		23	3.6	10:1	Single	9.50E-04	6/3	4.5	8.93 [226.8]	4	C	P24
	42 to 127	8.5	1	16:1	Double	1.28E-03	10/5	4.2	7.50 [190.5]	2	C	P25
		34	3.6	16:1	Double	1.28E-03	10/5	5.5	9.75 [247.7]	4	C	P25
	31 to 92	12	1	22:1	Double	1.09E-03	10/5	4.2	7.50 [190.5]	2	C	P26
		47	3.6	22:1	Double	1.09E-03	10/5	5.5	9.75 [247.7]	4	C	P26
	24 to 72	15	1	28:1	Double	1.01E-03	10/5	4.2	7.50 [190.5]	2	C	P27
		60	3.6	28:1	Double	1.01E-03	10/5	5.5	9.75 [247.7]	4	C	P27
	17 to 51	21	1	40:1	Double	9.53E-04	10/5	4.2	7.50 [190.5]	2	C	P28
		85	3.6	40:1	Double	9.53E-04	10/5	5.5	9.75 [247.7]	4	C	P28
	12 to 37	29	1	55:1	Double	9.51E-04	10/5	4.2	7.50 [190.5]	2	C	P2A
		117 ¹	3.6	55:1	Double	9.51E-04	10/5	5.5	9.75 [247.7]	4	C	P2A
10 to 29	37	1	70:1	Double	9.50E-04	10/5	4.2	7.50 [190.5]	2	C	P2B	
	149 ¹	3.6	70:1	Double	9.50E-04	10/5	5.5	9.75 [247.7]	4	C	P2B	
6.7 to 20	52 ¹	1	100:1	Double	9.49E-04	10/5	4.2	7.50 [190.5]	2	C	P2C	

¹ Motor rated torque can exceed indicated maximum gearhead rating. If this service is anticipated, a current limiting device should be used.

- All values are at nominal rated input voltage.
- Ambient operating temperature range: 0 to 40°C.
- **At 25°C ambient the max motor winding operating temperature rise is 65°C with gearmotor mounted to a 4" x 4" x 0.25" aluminum plate.**
- Performance data shown is typical. More detailed data is available from Hurst for each of the above ratings.
- Refer to the Customer Data Sheet supplied with your system or contact Hurst for other gear ratios and voltages (7 to 45 Vdc).

TABLE 5 – HST23 PART NUMBER IDENTIFICATION MATRIX

Product Family	Operating Mode	Control Method (Input Signal)	Encoder (ppr) / Resolver	Thermal Protection	Model-Rated Torque (oz-inch)	Input Voltage (Vdc)	Winding (see Chart)	Mechanical Features	Preset Speed ¹⁰ (RPM)	
HS - HST	A – External ¹	0 – None	0 - None	0 - None	1 - 50	012 – 12 V	A	100 - NEMA 23 ∅.25" Shaft without cables	0 - None	
	B – Open Loop Speed	1 – Analog ³	1 - 100 ppr		2 - 100	024 – 24 V	B	101 - NEMA 23 ∅.25" Shaft with cables	1 – Special ¹⁴	
	C – Closed Loop Speed	2 – Analog ⁴ (w/ 5Vdc supply)	2 - 250 ppr			036 – 36 V	C	200 - NEMA 23 ∅.375" Shaft without cables	A – 250	
	D – Preset Speed ²	3 – PWM ^{3,5}	3 - 400 ppr			045 – 45 V	D	201 - NEMA 23 ∅.375" Shaft with cables	B – 300	
	E – Torque ¹³ (Open Loop)	4 – PWM ⁵ (w/ 5Vdc supply)	4 - 1000 ppr			048 – 48 V ⁸		P20-P2C ⁹ - Planetary Gear Ratios (NEMA 23) with cables	C – 500	
	F – Motor Phase Leads Only	5 – PWM ^{3,6} & Direction	5 - 256 ppr ⁷ (w/index)			160 - 160 V ¹²			D – 600	
			6 - PWM ⁶ & Direction (w/ 5Vdc supply)	6 – Resolver ¹¹			300 – 300 V ¹²			E – 750
			7 – ON / OFF ³	7 - 1024 ppr ¹¹						F – 900
			8 – ON / OFF ⁴	8 - 2048 ppr ¹¹						G – 1000
										H – 1200
										J – 1500
										K – 1800
										L - 2000
										M – 2500
										N – 3000
									P - 3500	
									Q – 3600	
									R – 4000	
									S - 4500	

¹ Only Motor phase and commutation signal outputs are supplied (User supplies their own motor drive).

² Use only with Control Method **7** – ON/OFF or **8** – ON/OFF.

³ User must supply 5 Vdc supply for control logic; Power supply able to supply a minimum current of 35 mA.

⁴ Internally supplied 5 Vdc source; max current = 5 ma.

⁵ PWM input signal used in conjunction with direction line (Pin 7).

⁶ PWM input signal (Pin 3) used as command and direction.

⁷ Only available with Operating Mode **A** – External.

⁸ Use only with Operating Mode **A** – External or 45 Vdc for all other operating modes.

⁹ See Table 7 – HST23 Planetary Gearing part number Identification Matrix for Gear Options.

¹⁰ Use only with Operating Mode **D** – Preset Speed. Preset Speed must be below solid portion of the diagonal line of the winding curve selected. The maximum continuous torque is dependent upon the preset speed selected. Other Preset speeds available upon request.

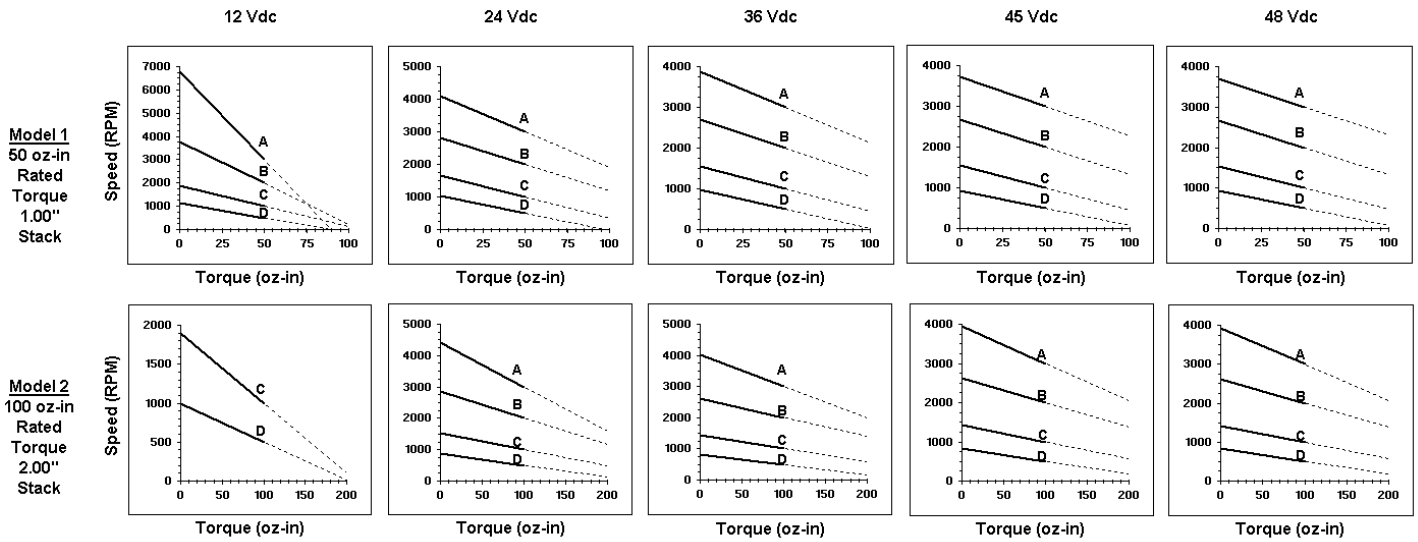
¹¹ Use with Operating Mode **F** – Motor Phase Leads Only and with Control Method **0** – None.

¹² Use with Operating Mode **A** – External or with Operating Mode **F** – Motor Phase Leads Only.

¹³ Use only with **1** – Analog, or **2** – Analog (w/ 5Vdc supply).

¹⁴ If standard listed speeds do not meet your needs, contact the factory for your specific requests.

TABLE 6 – HST23 SPEED VS. TORQUE CURVES



Performance data shown is typical. More detailed data is available from Nidec Motor Corporation for each of the above ratings. Refer to the Customer Data Sheet supplied with your system. Ambient operating temperature range: 0 to 40°C. The solid portion of the diagonal line is continuous duty and the dotted line represents momentary operation. At 25°C ambient the max motor winding operating temperature rise is 65°C with motor mounted to a 4" x 4" x 0.25" aluminum plate.

TABLE 7 – HST23 PLANETARY GEARING PART NUMBER IDENTIFICATION MATRIX

	Rated Speed	Rated Torque @ 24Vdc	Rated Current @ 24Vdc	Gear Ratio	Gear Stage	Gear Head Inertia	Gear Head Backlash (Std./Low)	Wt.	Length "A" inches [mm]	Part Number		
	RPM	lb.in.	Amps			oz.in.-sec ²	arc-min	lb.	GreenDrive™ M Control	Model #	Winding	Gear #
NEMA 23	220 to 660	11	4.6	3:1	Single	1.68E-03	6/3	3.8	7.27 [184.7]	1	B	P20
		23	8.2	3:1	Single	1.68E-03	6/3	4.6	8.27 [210.1]	2	B	P20
	166 to 500	15	4.6	4:1	Single	1.27E-03	6/3	3.8	7.27 [184.7]	1	B	P21
		30	8.2	4:1	Single	1.27E-03	6/3	4.6	8.27 [210.1]	2	B	P21
	121 to 363	21	4.6	5.5:1	Single	1.08E-03	6/3	3.8	7.27 [184.7]	1	B	P22
		41	8.2	5.5:1	Single	1.08E-03	6/3	4.6	8.27 [210.1]	2	B	P22
	95 to 286	26	4.6	7:1	Single	1.01E-03	6/3	3.8	7.27 [184.7]	1	B	P23
		53	8.2	7:1	Single	1.01E-03	6/3	4.6	8.27 [210.1]	2	B	P23
	67 to 200	38	4.6	10:1	Single	9.50E-04	6/3	3.8	7.27 [184.7]	1	B	P24
		75	8.2	10:1	Single	9.50E-04	6/3	4.6	8.27 [210.1]	2	B	P24
	42 to 125	57	4.6	16:1	Double	1.28E-03	10/5	4.8	8.09 [205.5]	1	B	P25
		113	8.2	16:1	Double	1.28E-03	10/5	5.6	9.09 [230.9]	2	B	P25
	30 to 91	78	4.6	22:1	Double	1.09E-03	10/5	4.8	8.09 [205.5]	1	B	P26
		156	8.2	22:1	Double	1.09E-03	10/5	5.6	9.09 [230.9]	2	B	P26
	24 to 71	99	4.6	28:1	Double	1.01E-03	10/5	4.8	8.09 [205.5]	1	B	P27
		198	8.2	28:1	Double	1.01E-03	10/5	5.6	9.09 [230.9]	2	B	P27
	17 to 50	142	4.6	40:1	Double	9.53E-04	10/5	4.8	8.09 [205.5]	1	B	P28
		283	8.2	40:1	Double	9.53E-04	10/5	5.6	9.09 [230.9]	2	B	P28
	12 to 36	195	4.6	55:1	Double	9.51E-04	10/5	4.8	8.09 [205.5]	1	B	P2A
		347 ¹	8.2	55:1	Double	9.51E-04	10/5	5.6	9.09 [230.9]	2	B	P2A
9 to 28	248	4.6	70:1	Double	9.50E-04	10/5	4.8	8.09 [205.5]	1	B	P2B	
	288 ¹	8.2	70:1	Double	9.50E-04	10/5	5.6	9.09 [230.9]	2	B	P2B	
6 to 20	110 ¹	4.6	100:1	Double	9.49E-04	10/5	4.8	8.09 [205.5]	1	B	P2C	

¹Motor rated torque can exceed indicated maximum gearhead rating. If this service is anticipated, a current limiting device should be used.

- All values are at nominal rated input voltage.
- Ambient operating temperature range: 0 to 40°C.
- **At 25°C ambient the max motor winding operating temperature rise is 65°C with gearmotor mounted to a 4" x 4" x 0.25" aluminum plate.** 4"
- Performance data shown is typical. More detailed data is available from Hurst for each of the above ratings.
- Refer to the Customer Data Sheet supplied with your system or contact Hurst for other gear ratios and voltages (7 to 45 Vdc). (7 to 45

MOUNTING RECOMMENDATIONS

Dynamo Motor Size 17

Axial & Radial Loading Recommendations

- Radial - 10lbs max [45N max]
- Axial - 2lbs max [9N max]

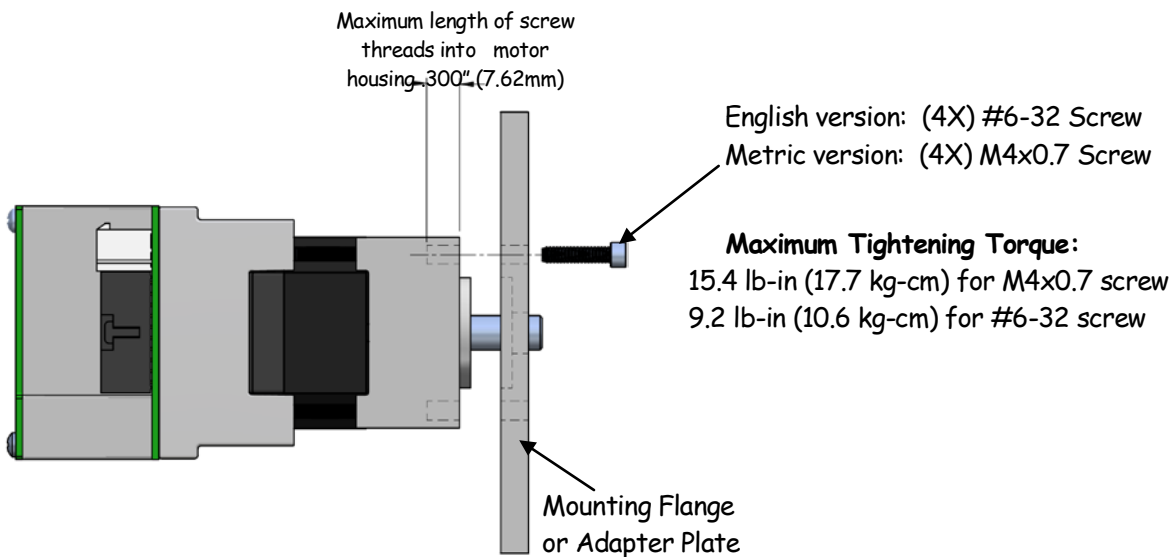
The threaded mounting holes on the motor housing have a depth as shown in the figure below.

NOTICE

Using screws longer than specified will result in the screw bottoming-out in the motor housing and not securing the motor properly.

The figure below illustrates the screw thread sizes, thread engagement length and torque requirements for mounting the Dynamo Size 17 motor.

FIGURE 5 – DYNAMO SIZE 17 MOTOR



At 25°C ambient the max motor winding operating temperature rise is 65°C with motor mounted to a 4" x 4" x 0.25" aluminum plate. See Technical Specifications, Mechanical Outline, Dynamo Size 17 Motor for additional information.

Dynamo NEMA 23 Motor

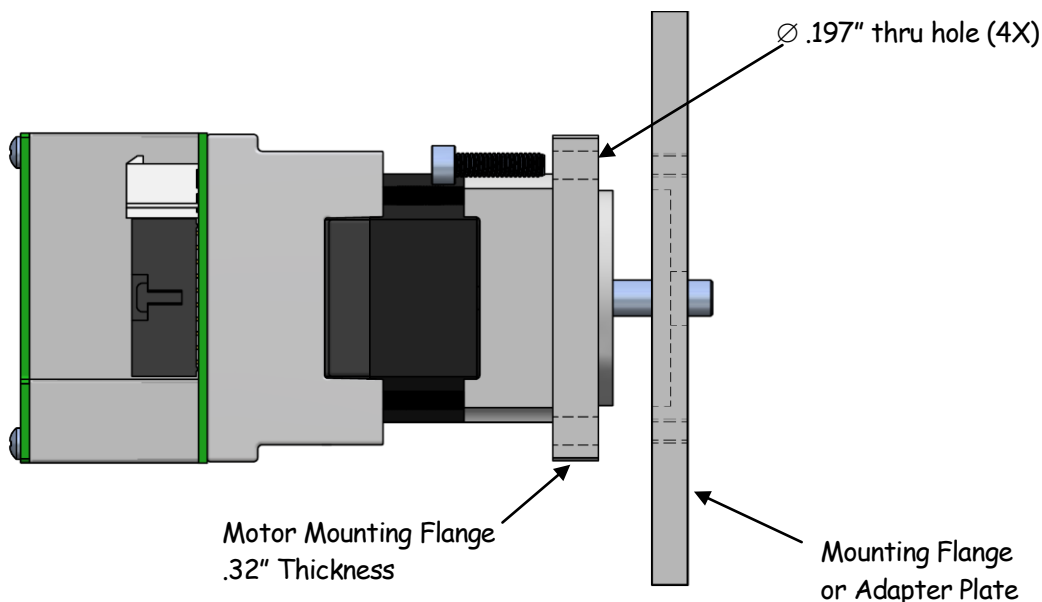
Axial & Radial Loading Recommendations

- Radial - 10lbs max [45N max]
- Axial - 2lbs max [9N max]

The mounting holes on the motor housing are through holes. Mounting screws must be mounted through the motor flange in order to secure the motor properly as shown in figure below.

The figure below illustrates the screw mounting direction for mounting the NEMA 23 Dynamo motor. Be sure to follow the recommended screw torque requirements for your particular mounting flange and screws.

FIGURE 6 – DYNAMO NEMA 23 MOTOR



At 25°C ambient the max motor winding operating temperature rise is 65°C with motor mounted to a 4" x 4" x 0.25" aluminum plate. See Technical Specifications, Mechanical Outline, Dynamo NEMA 23 Motor for additional information.

Dynamo Motor W/ Spur Gearing

Axial & Radial Loading Recommendations

- Radial - 7lbs max [32N max]
- Axial - 5lbs max [23N max]

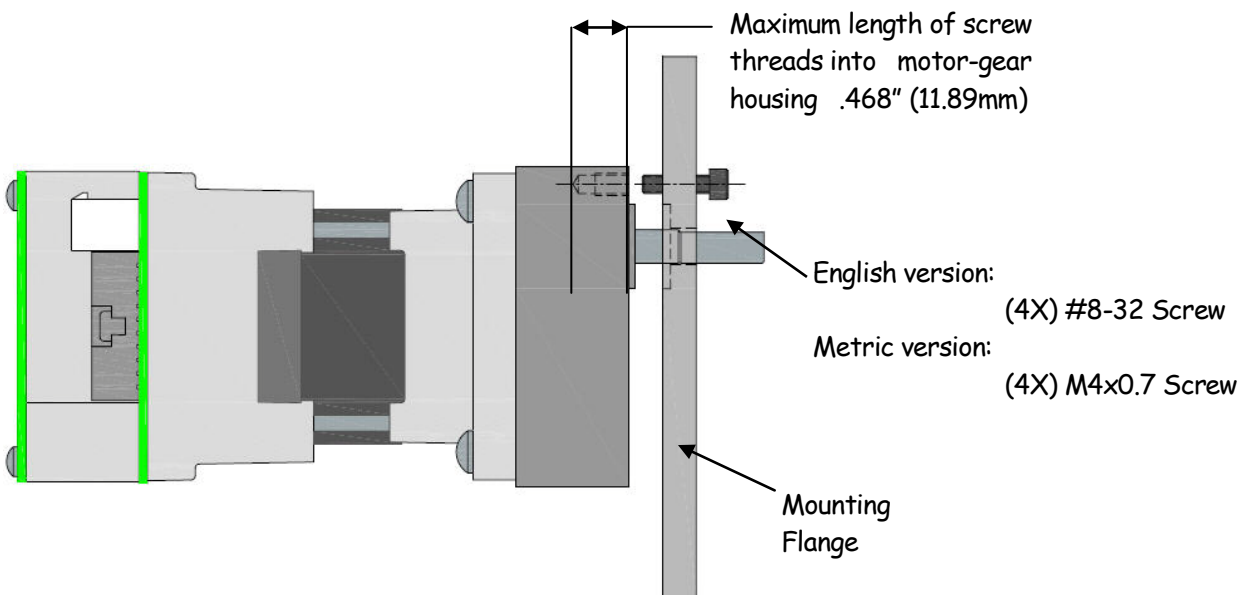
The threaded mounting holes on the motor housing have a depth as shown in the figure below.

NOTICE

Using screws longer than specified will result in the screw bottoming-out in the motor housing and not securing the motor properly.

The figure below illustrates the screw thread sizes, thread engagement length and torque requirements for mounting the Dynamo Size 17 motor.

FIGURE 7 –DYNAMO SIZE 17 MOTOR W/ SPUR GEARING



At 25°C ambient the max motor winding operating temperature rise is 65°C with motor mounted to a 4" x 4" x 0.25" aluminum plate. See Technical Specifications, Mechanical Outline, Dynamo Size 17 Motor w/ Spur Gearing for additional information.

Dynamo Size 17 Motor W/ Planetary Gearing

Axial & Radial Loading Recommendations

- Radial – 19 lbs max [N max] (2000 RPM at 1.2 inches from mounting face)
- Axial - 60lbs max [N max] (2000 RPM)

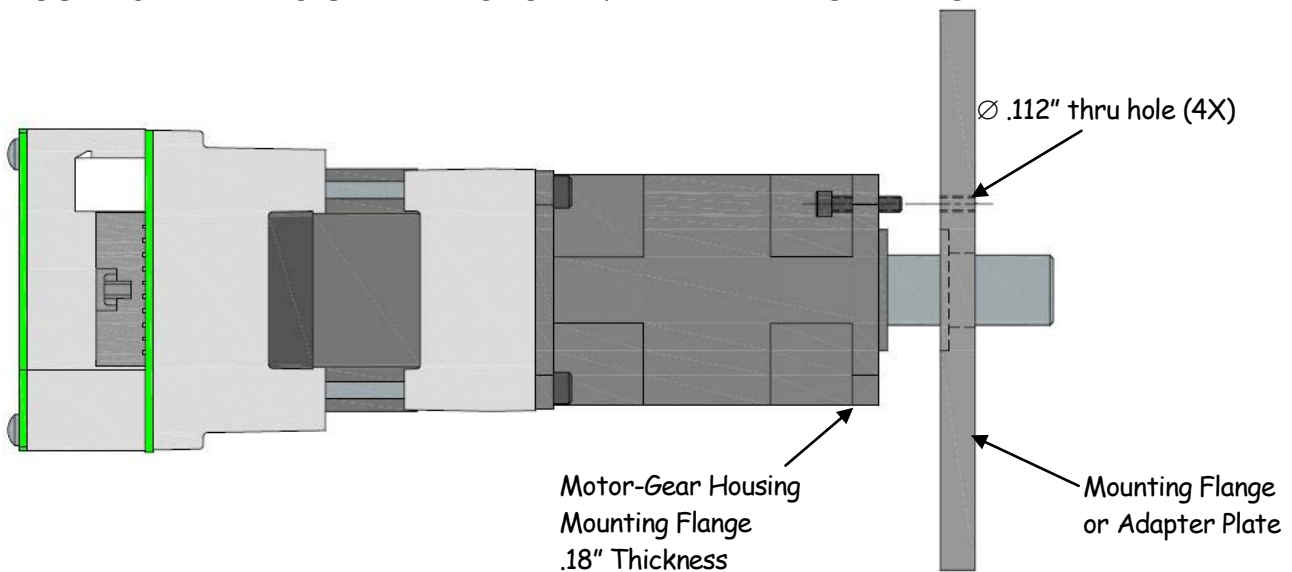


Radial and Axial Loading recommendations are at 2000 rpm and 1.2 inches from mounting face.

The mounting holes on the motor-gear housing are through holes. Mounting screws must be mounted through the motor-gear housing flange in order to secure the motor properly as shown in figure below.

The figure below illustrates the screw mounting direction for mounting the Dynamo Size 17 motor with planetary gear head. Be sure to follow the recommended screw torque requirements for your particular mounting flange and screws.

FIGURE 8 –DYNAMO SIZE 17 MOTOR W/ PLANETARY GEARING



At 25°C ambient the max motor winding operating temperature rise is 65°C with motor mounted to a 4" x 4" x 0.25" aluminum plate. See Technical Specifications, Mechanical Outline, Dynamo Size 17 Motor w/ Planetary Gearing for additional information.

Dynamo NEMA 23 Motor W/ Planetary Gearing

Axial & Radial Loading Recommendations

- Radial – 19 lbs max [N max] (2000 RPM at 1.2 inches from mounting face)
- Axial - 60lbs max [N max] (2000 RPM)

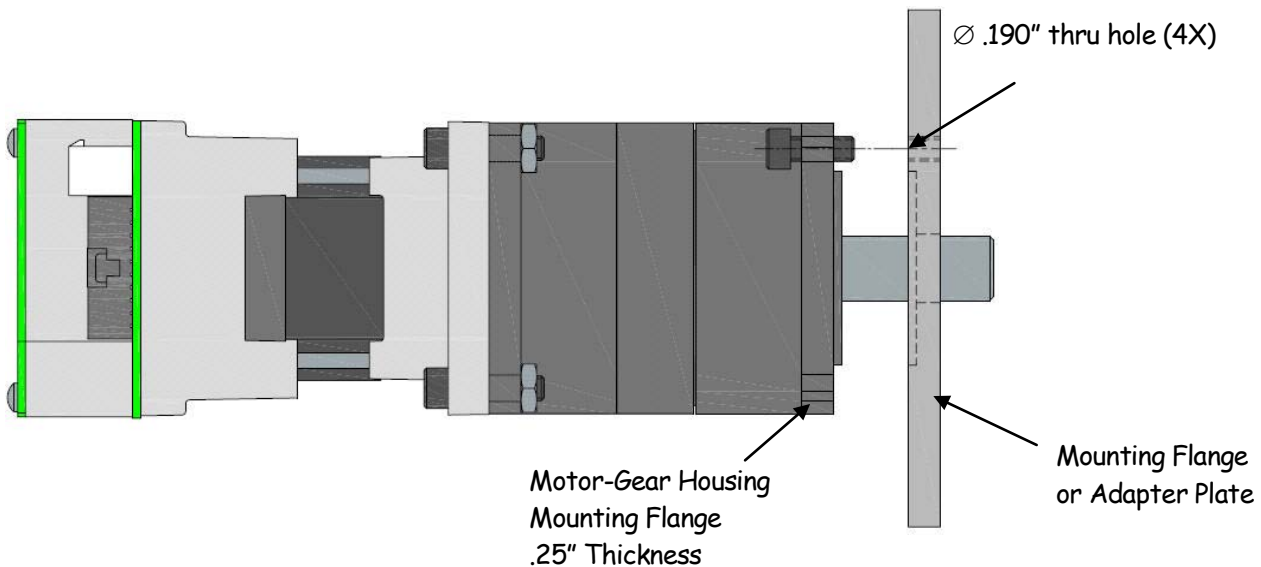


Radial and Axial Loading recommendations are at 2000 rpm and 1.2 inches from mounting face.

The mounting holes on the motor-gear housing are through holes. Mounting screws must be mounted through the motor flange in order to secure the motor properly as shown in figure below.

The figure below illustrates the screw mounting direction for mounting the Dynamo NEMA 23 motor with planetary gear head. Be sure to follow the recommended screw torque requirements for your particular mounting flange and screws.

FIGURE 9 –DYNAMO NEMA 23 MOTOR W/ PLANETARY GEARING



At 25°C ambient the max motor winding operating temperature rise is 65°C with motor mounted to a 4" x 4" x 0.25" aluminum plate. See Technical Specifications, Mechanical Outline, Dynamo NEMA 23 Motor w/ Planetary Gearing for additional information.

HST23 NEMA 23 Motor

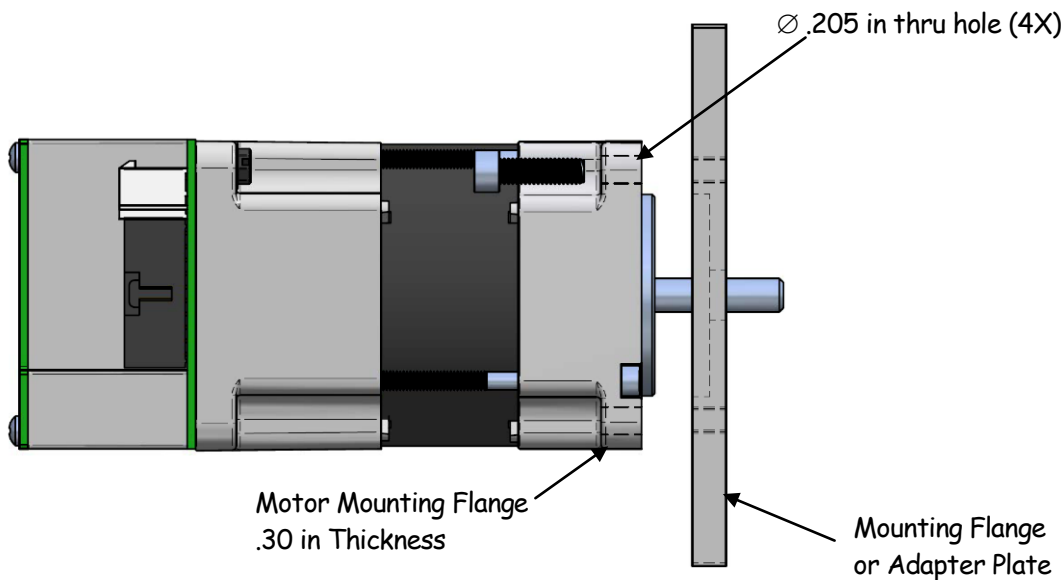
Axial & Radial Loading Recommendations

- Radial - 20lbs max [91N max]
- Axial - 7lbs max [32N max]

The mounting holes on the motor housing are through holes. Mounting screws must be mounted through the motor flange in order to secure the motor properly as shown in figure below.

The figure below illustrates the screw mounting direction and screw thread sizes for mounting the HST23 NEMA 23 motor. Be sure to follow the recommended screw torque requirements for your particular mounting flange and screws.

FIGURE 10 – HST23 NEMA 23 MOTOR



At 25°C ambient the max motor winding operating temperature rise is 65°C with motor mounted to a 4" x 4" x 0.25" aluminum plate. See Technical Specifications, Mechanical Outline, HST23 NEMA 23 Motor for additional information.

HST23 NEMA 23 Motor W/ Planetary Gearing

Axial & Radial Loading Recommendations

- Radial – 19 lbs max [N max] (2000 RPM at 1.2 inches from mounting face)
- Axial - 60lbs max [N max] (2000 RPM)

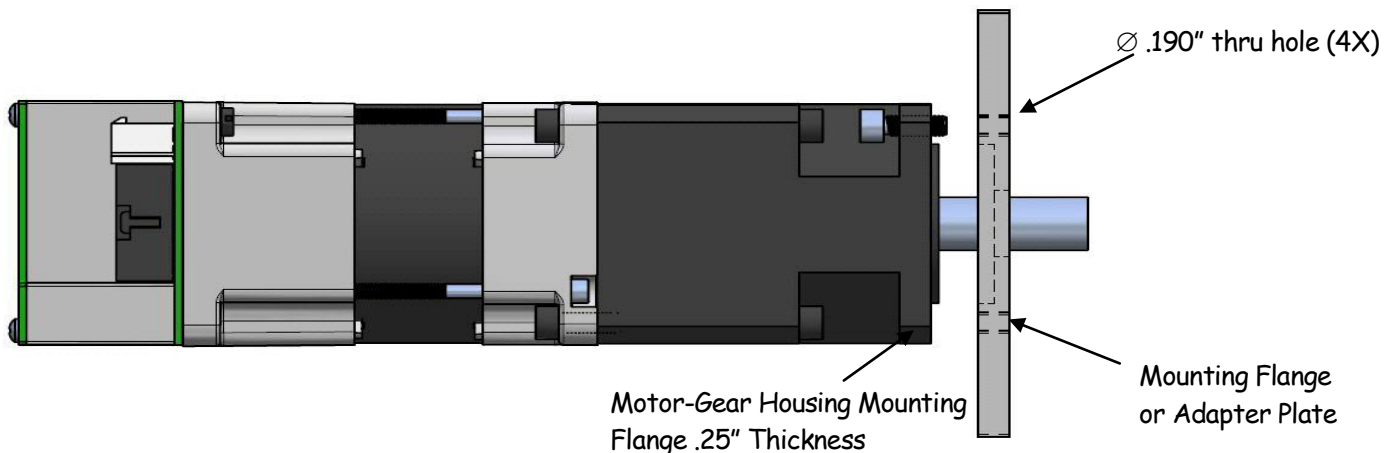


Radial and Axial Loading recommendations are at 2000 rpm and 1.2 inches from mounting face.

The mounting holes on the motor-gear housing are through holes. Mounting screws must be mounted through the motor-gear housing flange in order to secure the motor properly as shown in figure below.

The figure below illustrates the screw mounting direction and screw thread sizes for mounting the HST23 NEMA 23 motor. Be sure to follow the recommended screw torque requirements for your particular mounting flange and screws.

FIGURE 11 – HST23 NEMA 23 MOTOR W/ PLANETARY GEARING



At 25°C ambient the max motor winding operating temperature rise is 65°C with motor mounted to a 4" x 4" x 0.25" aluminum plate. See Technical Specifications, Mechanical Outline, HST23 NEMA 23 Motor w/ Planetary Gearing for additional information.

CHOOSING A POWER SUPPLY

There are two important parameters to consider when choosing a power supply in your application, voltage and current.

Motor Power Supply

- **Voltage Input Range: 12 to 45 Vdc**

Refer to your motor label for rated voltage. The integrated motor control is intended to be operated from a low voltage DC power supply rated between **12 to 45 Vdc**. The maximum voltage of the GreenDrive™ is 45 Vdc, therefore do not exceed this voltage. Filter capacitors are supplied internal to the GreenDrive™ control for increased reliability under typical power conditions. It is recommended that the power supply meet the latest editions of UL60950 and CSA 60950 specifications.

- **Current Input Range: 3x Rated Motor Current (Typical)**

The maximum or rated power supply current needed should typically be at least three times the rated motor current to ensure adequate current headroom for intermittent motor overloading.

Connecting inputs and outputs

Motor Power Supply Connections

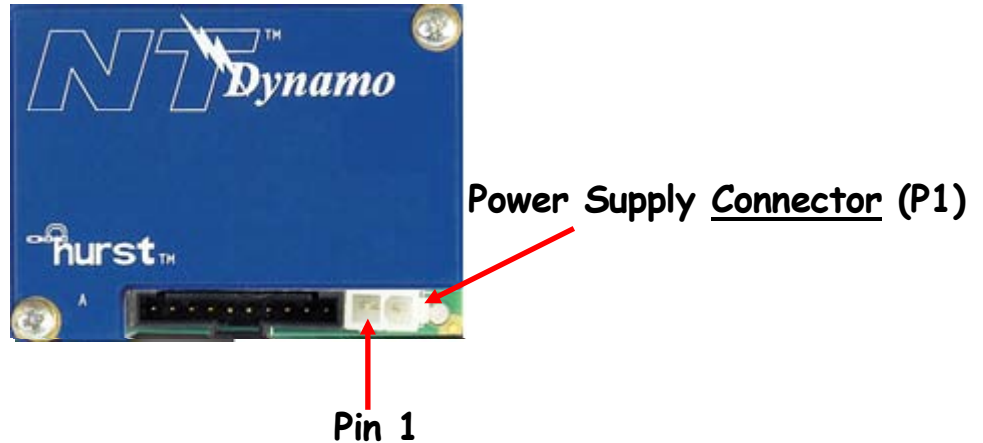
CAUTION

Never connect or disconnect the power supply to a motor or control while the power is turned on. Minor or moderate injury could result if not avoided.



All wire gauge sizes must be in accordance with all federal, state, and local codes.

FIGURE 12 – POWER SUPPLY CONNECTIONS (P1)



Connect the power supply to the GreenDrive™ using a 2-pin connector (Molex P/N 39-01-2020 or equivalent) and terminals (Molex P/N 39-00-0039 or equivalent).

1. Connect the positive lead from the external power supply to pin 1 on the motor's power supply connector labeled as P1 .
2. Connect the negative lead from the external power supply to pin 2 on the motor's power supply connector labeled as P1.

Table 8 – Motor Power Supply Connector Pin functions (P1)

Pin No.	Description	Input/Output	Notes
1	+DC	Input	12-45 Vdc
2	GND	Input	

Control Connections

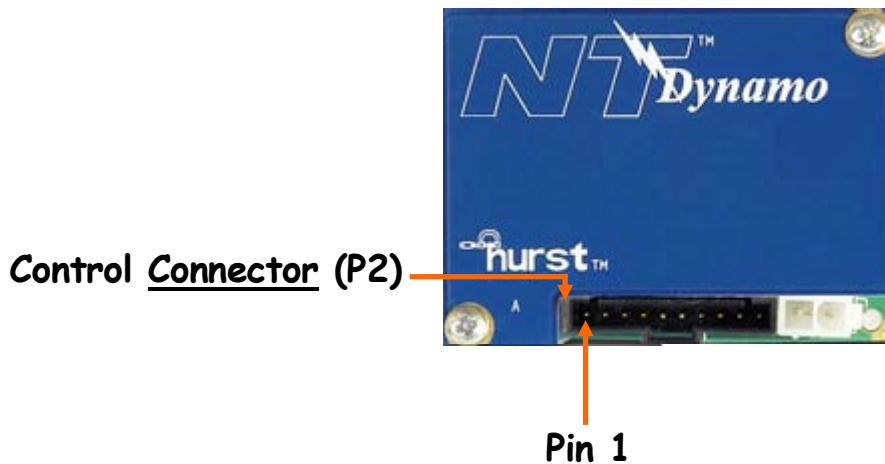
CAUTION

Never connect or disconnect the power supply to a motor or control while the power is turned on. Minor or moderate injury could result if not avoided.



All wire gauge sizes must be in accordance with all federal, state, and local codes.

FIGURE 13 – CONTROL CONNECTIONS (P2)



Connect the control inputs and outputs to the GreenDrive™ using a 10-pin connector (Molex P/N 50-57-9410 or equivalent) and terminals (Molex P/N 16-02-0103 or equivalent).

TABLE 9 - CONTROL CONNECTOR PIN FUNCTIONS (P2)

Pin No.	Description	Input/Output	Notes
1	Tachometer	Output	Speed Output – 15 Pulses/Revolution (PPR) for Dynamo and 9 PPR for HST23 at TTL Level (0 to 5 Vdc) and 50% Duty Cycle
2	Speed / Torque	Input	Only used for Analog Control Method
3	PWM	Input	Input - PWM Control Method <ul style="list-style-type: none"> • 0% duty cycle minimum command • 100% duty cycle maximum command • Used with Direction Input pin (Pin 7)
4	Encoder Channel B	Output	Speed and Direction Output – PPR based on encoder line count at TTL Level (0 to 5 Vdc) and 50% Duty Cycle; No output if encoder not present
5	Encoder Channel A	Output	Speed and Direction Output – PPR based on encoder line count at TTL Level (0 to 5 Vdc) and 50% Duty Cycle; No output if encoder not present
6	Direction	Output	Direction Output – 0 Vdc output = clockwise lead end 5 Vdc output = counter-clockwise lead end Can be used in conjunction with Tachometer output (Pin 1) to determine speed and direction
7	Direction / PWM & Direction	Input	Direction - <ul style="list-style-type: none"> • Clockwise Lead End = Low level (GND) • Counter- Clockwise Lead End = High level (5 Vdc) Used in conjunction with PWM (Pin 3) and Speed/Torque (Pin 2) PWM & Direction - <ul style="list-style-type: none"> • 0% duty cycle maximum command in the counterclockwise direction lead end • 50% duty cycle minimum command • 100% duty cycle maximum command in the clockwise direction lead end
8	Enable	Input	Low level signal (0 Vdc) enables drive
9	GND	--	Return path for + 5 Vdc (Pin 10)
10	+5 Vdc	Input/Output	Input - User supplied 5 Vdc Output - Optional Integral 5 Vdc supply

Inputs/Outputs

Tachometer (Pin 1)

Tachometer outputs are generated from an internal controller by the three hall effect sensors. On the standard Dynamo motor, the output is 15 pulses per revolution and the HST23 is 9 pulses per revolution. The tachometer output provides speed information. At each commutation point, the tachometer output changes state independent of motor direction. The GreenDrive™ can be used in conjunction with the Direction output (Pin 6). See Figure 9 below for additional details.

Speed/Torque (Pin 2)

The Speed/Torque input (Pin 2) can be used in Open Loop Speed, Closed Loop Speed, or Open Loop Torque Operating Modes. The speed/torque input operates in Analog Control Method where the voltage applied relates to a current level in the motor.

Speed

The speed input can have a 0-5 Vdc input or a potentiometer in conjunction with optional integrated power supply. The 0-5 Vdc input consists of a variable command input and a GND input. The potentiometer consists of three pins, a 5-volt input, a GND input and a variable command output. The user can adjust the command output by adjusting the potentiometer with the wiper connected to the command input and the other two potentiometer connections attached to the +5 Vdc and GND pins of the connector pins.

NOTICE

Care must be taken by the user not to exceed the 0-5 volt range of the variable command input. Voltages outside this range could cause permanent damage to the control.

Torque

The torque input must have a 0-4 Vdc input.

Internally Supplied Voltage Command Input

The 0-4 Vdc input consists of a variable command input and a GND input. The potentiometer consists of three pins, a 4-volt input, a GND input and a variable command output. The user can adjust the command output by adjusting the potentiometer with the wiper connected to the command input and the other two potentiometer connections attached to the control connector Pin 10 and control connector Pin 9 pins. The impedance of the control connector Pin 10 output is 22K Ω .

Externally Supplied Voltage Command Input

The user must supply a 0-4 Vdc input into Pin 2 on the control connector. If a 5 Vdc supply is to be used, a 22 K Ω resistor must be placed in series with a 100 K Ω potentiometer. If a 4 Vdc supply is used, a resistor is not needed. The potentiometer consists of three pins, a supply voltage input, a GND input and a variable command output. The user can adjust the command output by adjusting the potentiometer with the wiper connected to the command input and the other two potentiometer connections attached to the control connector Pin 10 and control connector Pin 9 pins.

NOTICE

In torque mode, care must be taken by the user not to exceed the 0-4 volt range of the variable command input (Pin 2). Voltages outside this range could cause permanent damage to the control.

PWM (Pin 3)

The PWM input can be used in Open Loop Speed and Closed Loop Speed Operating Modes. The PWM input operates in PWM Control method, where the PWM command is from 0 to 100%; 0% being no current applied to the windings and 100% full current applied to the windings. The frequency of the PWM signal in the PWM control method operates between 15 kHz and 25 kHz.

Encoder - Channel A and B (Pin 4, 5)

If an encoder is not required in your application, please skip this section. The control contains a shaft mounted optical encoder. The encoder outputs two quadrature signals from which direction and speed can be determined. These outputs can be used by the GreenDrive™ to close the speed loop in Closed Loop Speed and Preset Speed Operating Modes. The signals are also available to the user to close a speed loop external. These signals are also available on output pins for the same functionality externally. There are two output pins that are allocated to the encoder, one for channel A, and one for channel B.

TABLE 10 – ENCODER SPECIFICATIONS

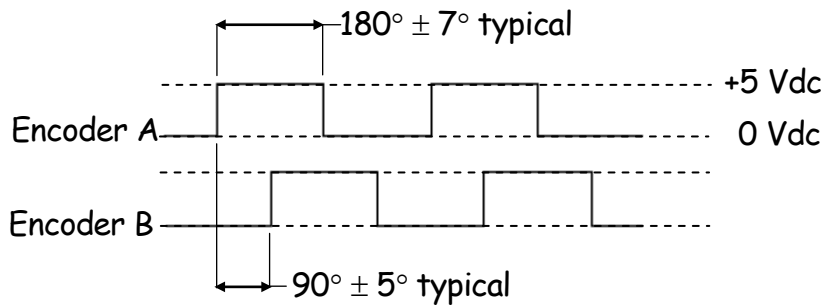


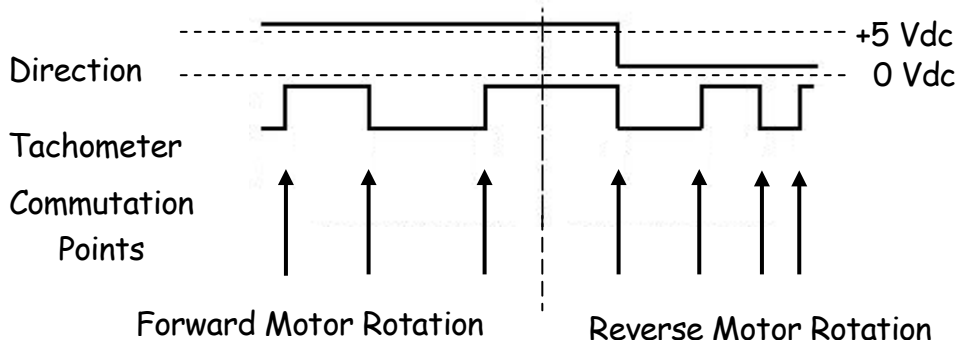
FIGURE 14 – ENCODER OUTPUT – CCW DIRECTION VIEWED FROM LEAD END

Encoder Type	Incremental	Notes
Output Format	Two Channel Quadrature	
Output Type	Square Wave	
Frequency Response	20 kHz	Frequency = (Velocity (rpm) X N)/60 N= Number of Counts per Revolution
Pull-up Resistor for Encoder Output	1 k Ω - 10 k Ω	

Direction (Pin 6)

Direction outputs are generated from an internal controller by the three hall effect sensors. When the motor is rotating clockwise from the lead end, the direction output will be considered a low level (GND). When rotation is counter-clockwise from the lead end, the direction output will give a high level (5 Vdc). The GreenDrive™ can be used in conjunction with the Tachometer output (Pin 1). The figure below displays additional information about the direction and tachometer output.

FIGURE 15 – TACHOMETER AND DIRECTION INDICATION OUTPUTS



Direction/PWM & Direction (Pin 7)

The direction input can be used in Open Loop Speed, Closed Loop Speed, Preset Speed, or Open Loop Torque Operating Modes. The direction input operates in Analog and PWM Control Methods where the input level determines the direction of the motor. The input will be used in conjunction with PWM (Pin 3) and Speed/Torque (Pin 2). A high level (5 Vdc) causes a counter-clockwise direction (viewed from the lead end). A low level (0 Vdc) causes a clockwise direction (viewed from the lead end). This line has an internal 1.5k Ω pull up resistor. The 1.5k Ω pull up resistor requires the pin to be driven by a circuit capable of sinking at least 3.5 mA.

The PWM & Direction input can be used in Open Loop Speed and Closed Loop Speed Operating Modes. The PWM & Direction input operates in PWM & Direction Control Method where 0% duty cycle maximum command in the counterclockwise direction (viewed from the lead end), 50% duty cycle minimum command (0 input), 100% duty cycle maximum command in the clockwise direction (viewed from the lead end). The frequency of the PWM signal in the PWM & Direction control method operates at 2.5kHz.

Enable (Pin 8)

The Enable input is used in all control methods and operating modes. A low level (0 Vdc) on the Enable pin enables the control to start the selected Control Type. A high level (+5 Vdc) on the Enable input causes the GreenDrive™ to stop controlling the motor, thus allowing the motor to coast. This line has an internal 2.15k Ω pull up resistor. The 2.15k Ω pull up resistor requires the pin to be driven by a circuit capable of sourcing at least 2.33 mA.

GND (Pin 9)

The GND pin (Pin 9) is the return path for + 5 Vdc (Pin 10) input/output pin. It is also common connection for External, Analog or PWM Control Methods. Pin 9 (Gnd), is common to the (Gnd) terminal of the power supply connector. Use isolated input signals as required to avoid ground loop issues.

+5 Vdc (Pin 10) (Input)



In this section, pin 10 is described as an externally supplied input. If you selected the internally generated output, see the section below.

- **Voltage Input Range: 4.75 to 5.25 Vdc**
- **Current Input: power supply must provide a minimum of 56 mA**

The +5 Vdc input is externally supplied by the end user depending on the GreenDrive™ option selected.

The +5 Vdc input provides power for internal electronics. The user supplied +5 Vdc input is critical to the performance of the motor control. Care and attention must be taken not to deviate away from voltage specifications to prevent potential harm to the motor control system.

+5 Vdc (Pin 10) (Output)

This is an internally generated supply. It is a low current supply of up to 5 mA. This supply will power internal electronics as well as an external potentiometer in the Analog Control Method or other low current peripherals.

NOTICE

The +5 Vdc internal supply is generated by the motor control and therefore is critical to the performance of the motor control. Care and attention must be taken not to deviate away from the specified use of this supply unless specified by Nidec Motor Corporation.

CONTROL TYPES

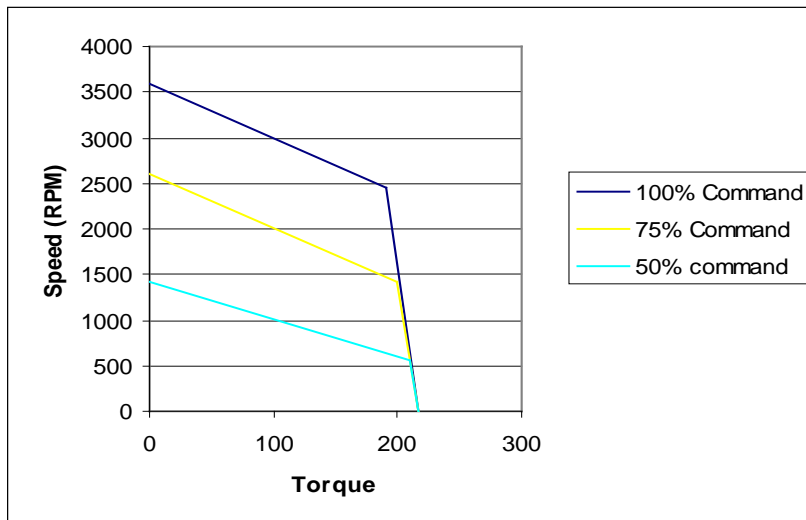
The GreenDrive™ can operate in one of four operating modes: Open Loop Speed, Closed Loop Speed, Pre-Set Speed, or Torque. The control method can come from three possible sources on the user control connector (Analog, PWM, or PWM & Direction). All control methods provide four-quadrant control for the brushless DC motor. The following describes each operating mode and possible control method:

Operating Modes

Open Loop Speed

When your GreenDrive™ control is configured for Open Loop Speed, the speed of the motor varies with the input command. The motor speed is not measured thus there is no feedback from the control to correlate input command speed to actual speed. For a given input command the speed will vary with the applied load.

FIGURE 16 – SPEED VARYING WITH LOAD WITH GIVEN INPUT COMMAND



Closed Loop Speed

The motor control can implement an internal closed loop speed control using either the tachometer signal or the encoder. Steady state speed is maintained within $\pm 3\%$ from 1% to 100% of rated torque.

Preset Speed

The GreenDrive™ can be configured to a predetermined fixed speed when power is applied. Steady state speed is maintained within $\pm 3\%$ from 1% to 100% of rated torque.

Torque (Open Loop)

Torque mode is an open loop operating mode in which motor torque (current) will vary with input command. It is implemented by applying a signal appropriate to the torque level to the Analog Speed/Torque pin.

Control Methods

Analog (Torque)

- Torque - Pin 2
- Direction - Pin 7
- Enable - Pin 8

The Analog mode allows the user to control torque with a 0-4 Vdc signal. The user interface includes speed/torque input, direction, and enable. The impedance to the 5 Vdc supply is a 22k Ω resistor. A 0 volt input will be interpreted as zero command. A 4 volt input will be interpreted as maximum command. If the user chooses to use a potentiometer for the Speed/Torque input in Torque control, the user must select a 100k Ω potentiometer.

The enable pin is used to enable the drive and direction input is used to determine direction. A high level signal on the enable pin causes the drive to start. A low level signal on the enable pin causes the drive to stop controlling the motor, thus allowing the motor to coast.

The Direction input is used in conjunction with the analog input to determine the direction in which the command input should be applied. A high level signal commands the clockwise direction from the lead end.

FIGURE 17 – ANALOG TORQUE CONTROL METHOD W/O INTERNAL 5 VDC SUPPLY
(TYPICAL CONNECTIONS FOR A 5 VDC POWER SUPPLY)

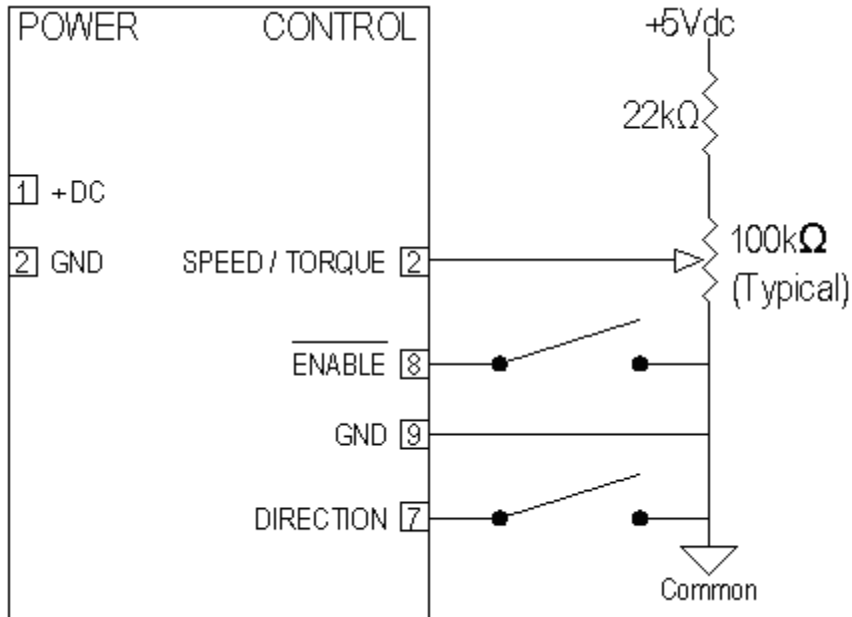


FIGURE 18 – ANALOG TORQUE CONTROL METHOD W/O INTERNAL 5 VDC SUPPLY
(TYPICAL CONNECTIONS FOR A 4 VDC POWER SUPPLY)

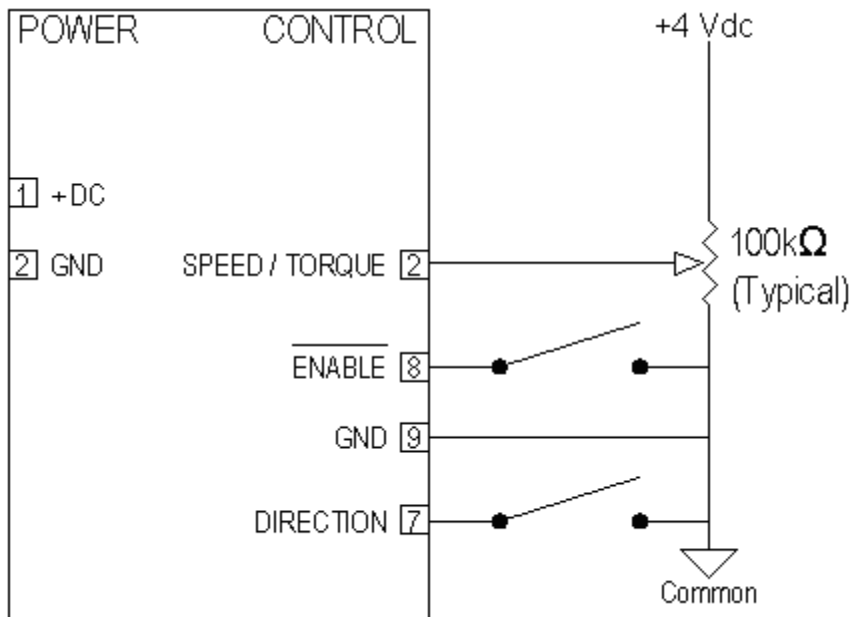
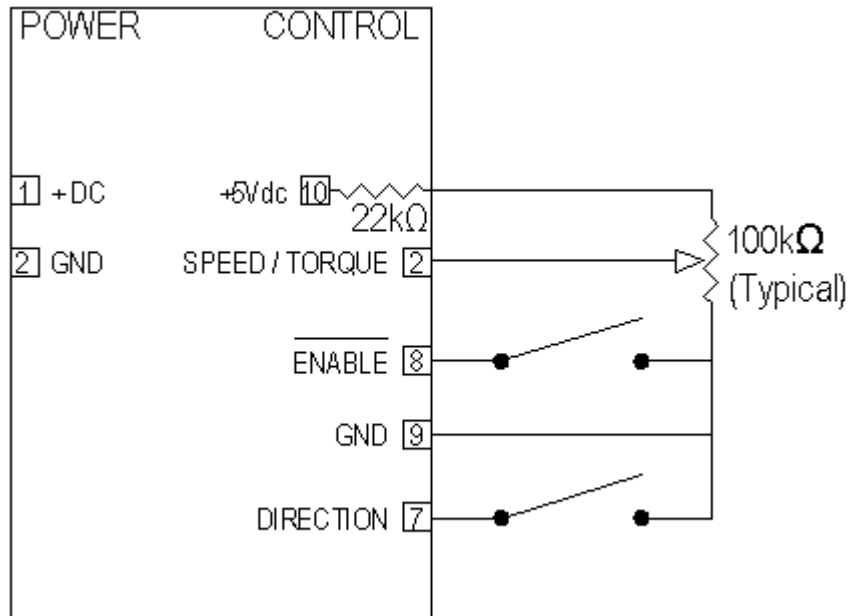


FIGURE 19 – ANALOG TORQUE CONTROL METHOD W/ INTERNAL 5 VDC SUPPLY
(TYPICAL CONNECTIONS)



Analog (Speed)

- **Speed** - **Pin 2**
- **Direction** - **Pin 7**
- **Enable** - **Pin 8**

The Analog mode allows the user to control speed with a 0-5 Vdc signal. The user interface includes speed/torque input, direction, and enable. A 0 volt input will be interpreted as zero command. A 5 volt input will be interpreted as maximum command.

The enable pin is used to enable the drive and direction input is used to determine direction. A high level signal on the enable pin causes the drive to start. A low level signal on the enable pin causes the drive to stop controlling the motor, thus allowing the motor to coast.

The direction input is used in conjunction with the analog input to determine the direction of rotation. A high level signal commands the clockwise direction from the lead end.

FIGURE 20 – ANALOG SPEED CONTROL METHOD W/O INTERNAL 5 VDC SUPPLY (TYPICAL CONNECTIONS)

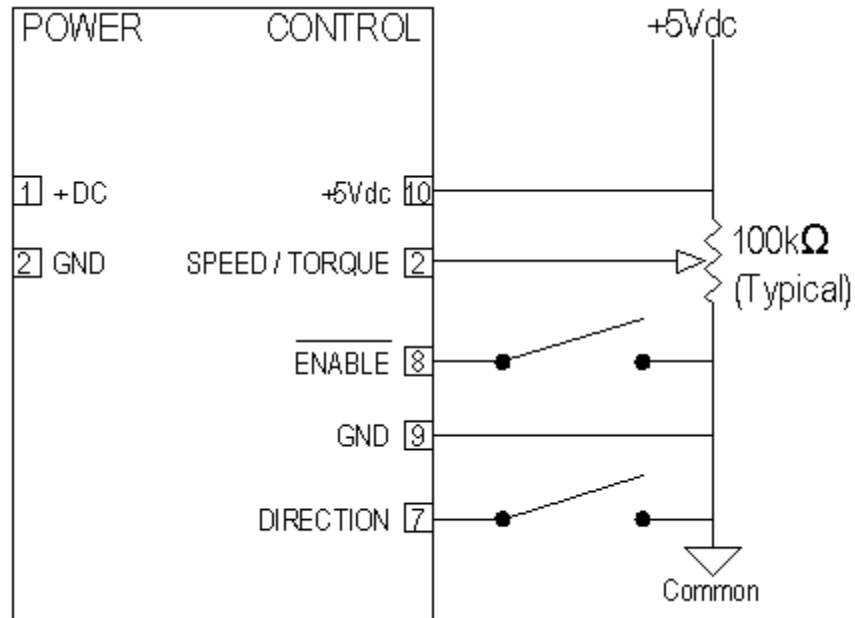
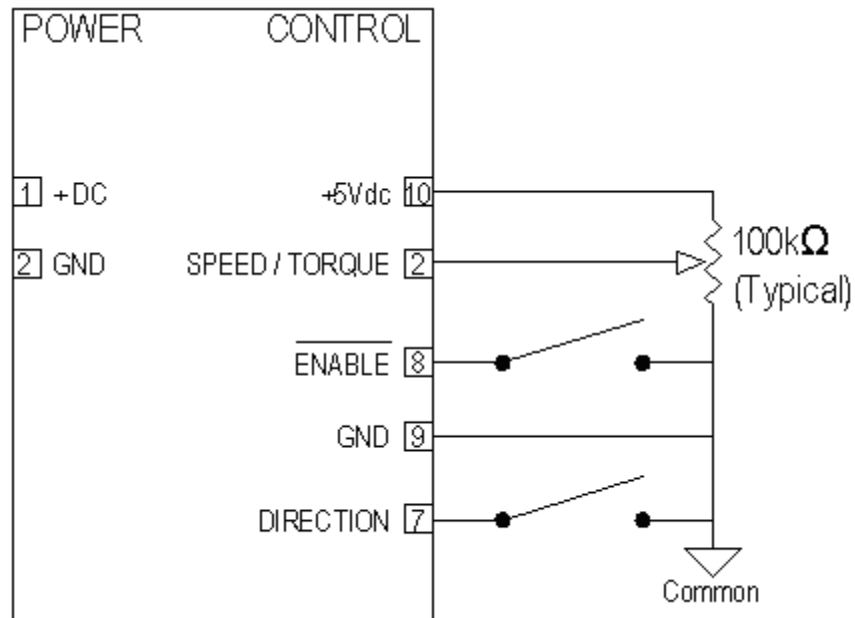


FIGURE 21 – ANALOG SPEED CONTROL METHOD W/ INTERNAL 5 VDC SUPPLY (TYPICAL CONNECTIONS)



PWM

- **PWM** - Pin 3
- **Direction** - Pin 7
- **Enable** - Pin 8

The PWM mode accepts a PWM signal on the PWM input pin (Pin 3) on the control connector to control speed. PWM control method allows the user to vary input command with PWM signal based on duty cycle. The PWM signal should be a fixed frequency, variable input where the duty cycle represents the voltage applied to the motor. The PWM signal should be an active high PWM signal at 2.5 kHz. A 0% duty cycle input indicates minimum command. A 100% duty cycle input indicates maximum command.

FIGURE 22 – PWM CONTROL METHOD W/O INTERNAL 5 VDC SUPPLY
(TYPICAL CONNECTIONS)

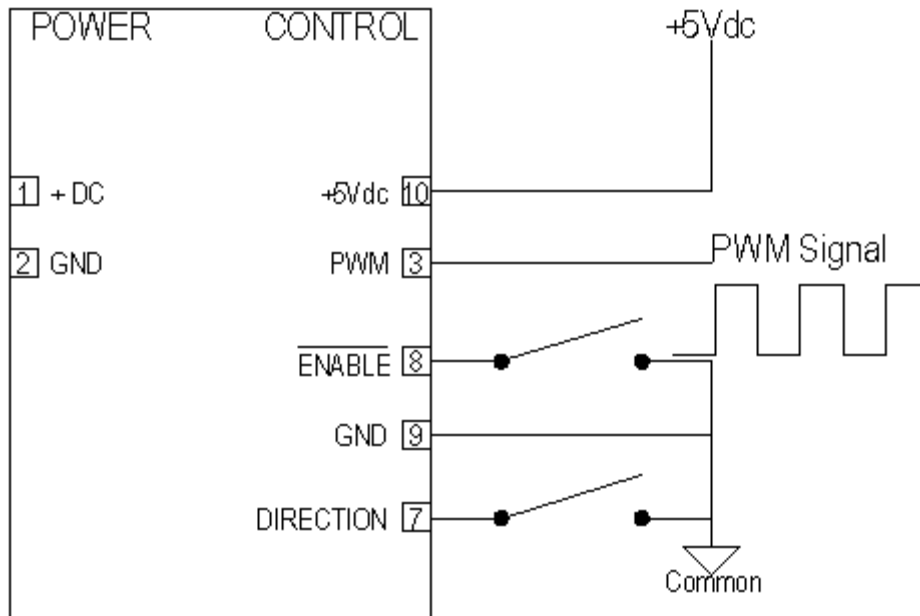
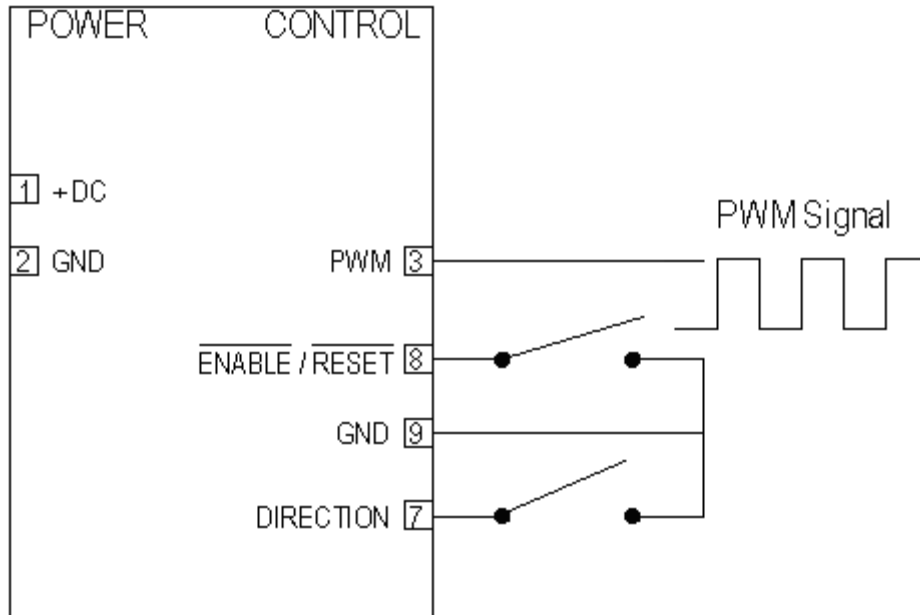


FIGURE 23 – PWM CONTROL METHOD W/ INTERNAL 5 VDC SUPPLY
(TYPICAL CONNECTIONS)



PWM & Direction

- **PWM & Direction** - Pin 7
- **Enable** – Pin 8

The PWM & Direction mode accepts a PWM signal on the Direction input pin (Pin 7) on the control connector to control speed and direction. PWM & Direction permits the user to vary input command and direction with change in duty cycle input. The PWM signal should be an active high PWM signal at 2.5 kHz to the PWM input pin. A 0% duty cycle input indicates maximum command in the counterclockwise direction when viewing the motor from the lead end. A 50% duty cycle input indicates minimum command. A 100% duty cycle input indicates maximum command in the clockwise direction when viewing the motor from the lead end. A high level on the Enable pin enables the drive.

FIGURE 24 – PWM & DIRECTION CONTROL METHOD W/O INTERNAL 5 VDC SUPPLY (TYPICAL CONNECTIONS)

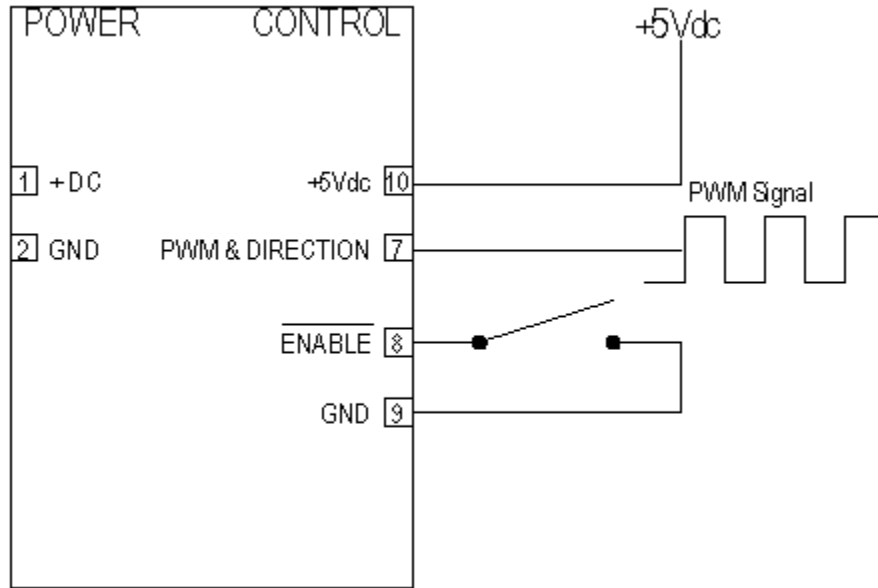
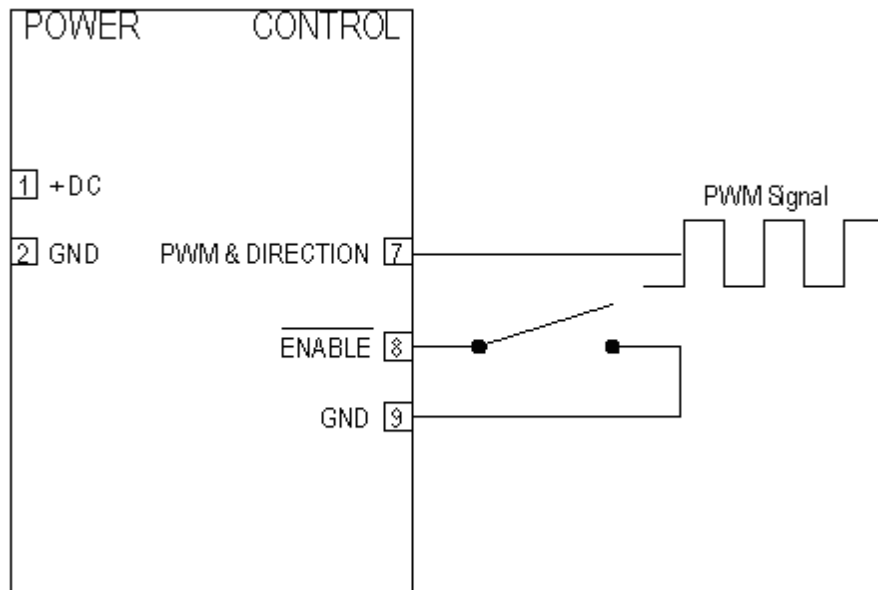


FIGURE 25 – PWM & DIRECTION CONTROL METHOD W/ INTERNAL 5 VDC SUPPLY (TYPICAL CONNECTIONS)



ON/OFF

- **Enable** – Pin 8

The ON/OFF mode will only be used with Preset Speed operating mode to enable or disable the motor.

FIGURE 26 – ON/OFF CONTROL METHOD W/O INTERNAL 5 VDC SUPPLY (TYPICAL CONNECTIONS)

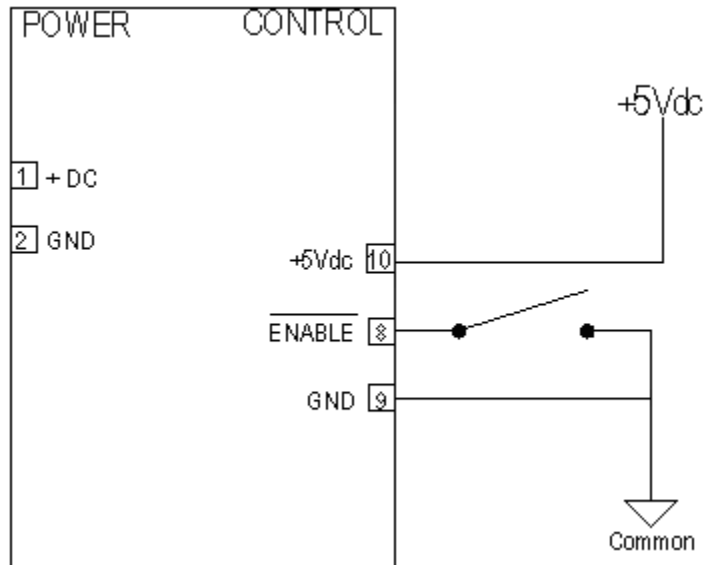
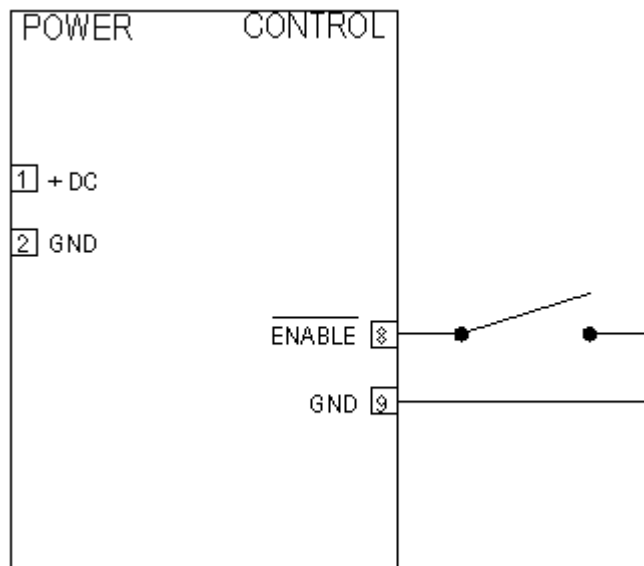


FIGURE 27 – ON/OFF CONTROL METHOD W/ INTERNAL 5 VDC SUPPLY (TYPICAL CONNECTIONS)

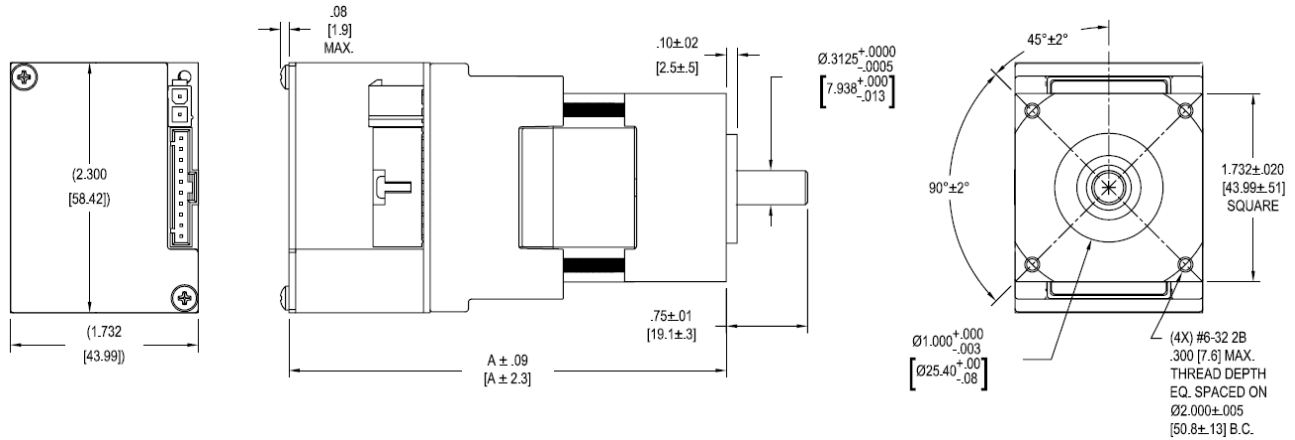


MECHANICAL SPECIFICATIONS

Dimensional Outline Drawings

Dynamo Size 17 Motor

FIGURE 28 – DYNAMO SIZE 17 MOTOR



Dynamo NEMA 23 Motor

FIGURE 29 – DYNAMO NEMA 23 MOTOR

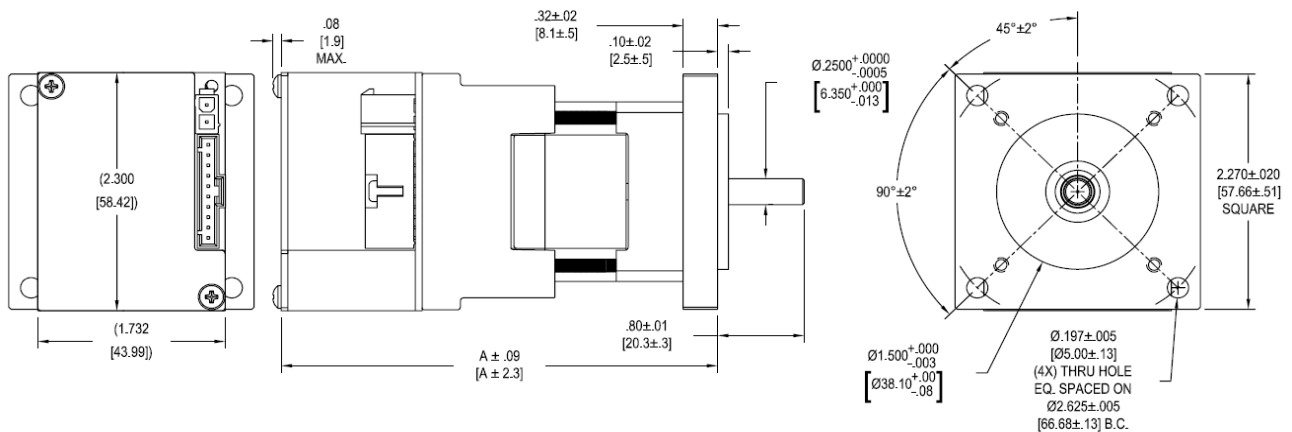


TABLE 11 – DYNAMO OVERALL LENGTH

Model	Overall Length (A)
1	3.79 [96.3]
2	4.04 [102.6]

Model	Overall Length (A)
3	4.79 [121.7]
4,5,6	6.29 [159.7]

Dynamo Size 17 Motor W/ Planetary Gearing

FIGURE 30 – DYNAMO SIZE 17 MOTOR W/ PLANETARY GEARING

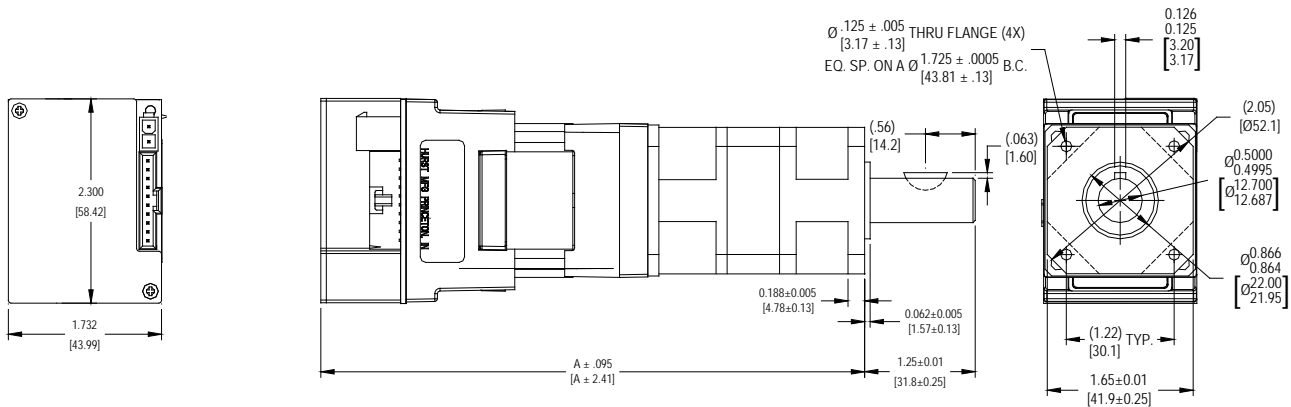


TABLE 12 – SIZE 17 DYNAMO PLANETARY GEARING OVERALL LENGTH

Model	Overall Length (A)	Model	Overall Length (A)
0	6.49 [164.8]	4	8.74 [222.0]
0*	6.98 [177.3]	4*	9.23 [234.4]

* Gear Reductions 16:1 and higher

NEMA 23 Dynamo Motor W/ Planetary Gearing

FIGURE 31 – NEMA 23 DYNAMO MOTOR W/ PLANETARY GEARING

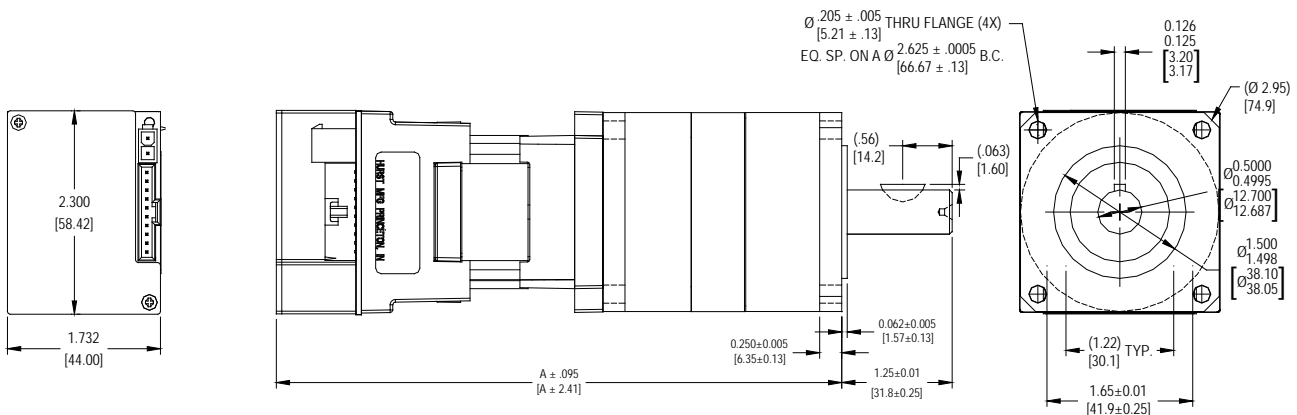


TABLE 13 – NEMA 23 DYNAMO PLANETARY GEARING OVERALL LENGTH

Model	Overall Length (A)	Model	Overall Length (A)
0	6.68 [169.7]	4	8.93 [226.8]
0*	7.50 [190.5]	4*	9.75 [247.7]

* Gear Reductions 16:1 and higher

Dynamo Size 17 Motor W/ Spur Gearing

FIGURE 32 – DYNAMO SIZE 17 MOTOR W/ SPUR GEARING

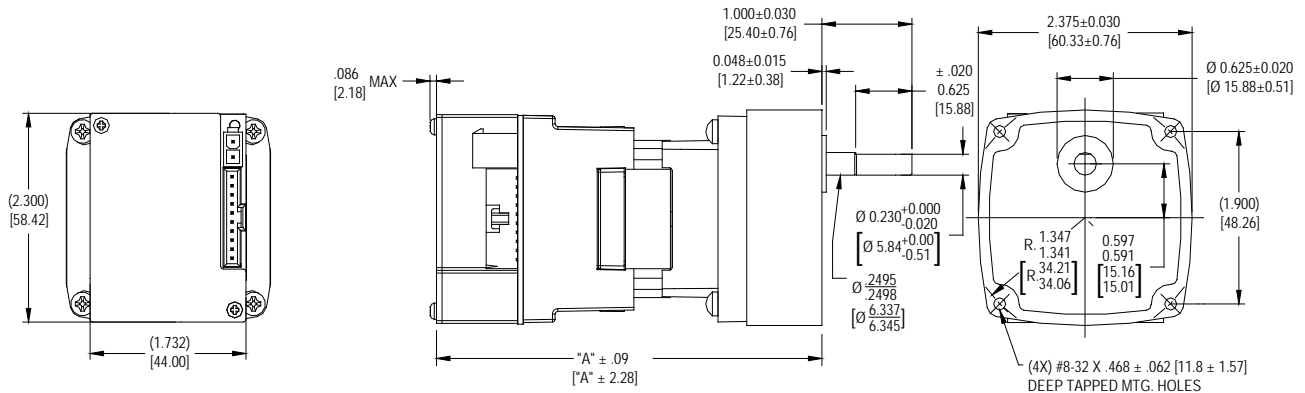


TABLE 14 – DYNAMO SIZE 17 MOTOR W/ SPUR GEARING OVERALL LENGTH

Model	Overall Length (A)
0	4.87 [123.7]
6	7.12 [180.8]

HST23 NEMA 23 Motor W/ Planetary Gearing

FIGURE 35 – HST23 NEMA 23 MOTOR W/ PLANETARY GEARING

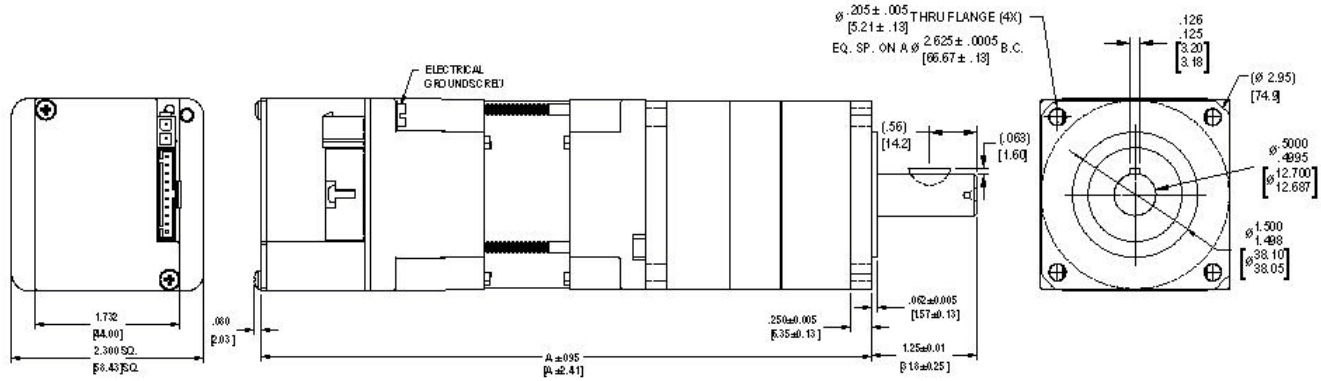


TABLE 16 – HST23 NEMA 23 OVERALL LENGTH

Model	Overall Length (A)	Model	Overall Length (A)
1	7.27 [184.7]	2	8.27 [210.1]
1*	8.09 [205.5]	2*	9.09 [230.9]

* Gear Reductions 16:1 and higher

CABLES & MATING CONNECTORS

FIGURE 36 – MOTOR POWER SUPPLY CABLE (HURST PART NUMBER: 120016)

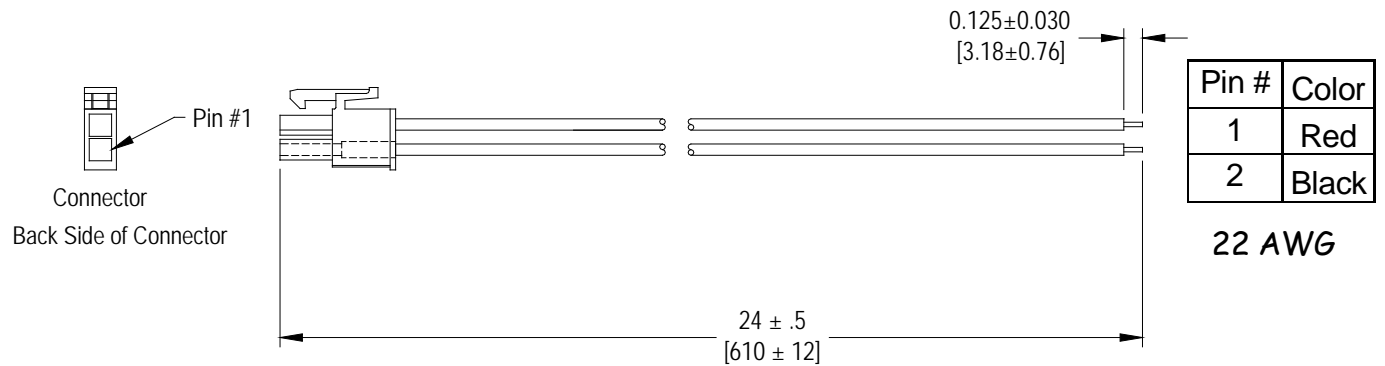


FIGURE 37 – MOTOR POWER SUPPLY MATING CONNECTOR (P1)

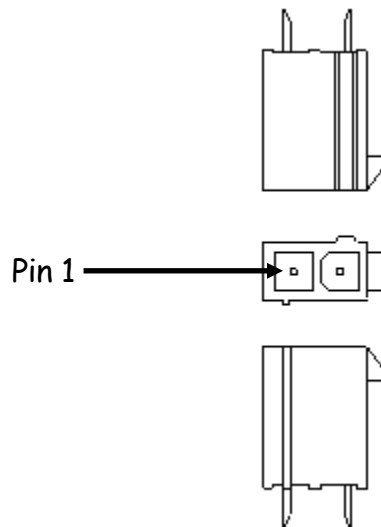


TABLE 17 – MOTOR POWER SUPPLY CABLE REFERENCE

Description	Manufacturer	Manufacturer Part #
Connector	Molex	39-01-2020
Terminal	Molex	39-00-0038 (chain)
	Molex	39-00-0039 (loose)
Control Mating Connector (P1)	Molex	39-28-1023

NOTICE

Minimum Gauge Size is recommended to be 22 AWG or greater.

FIGURE 38 – CONTROL CABLE (HURST PART NUMBER: 120067)

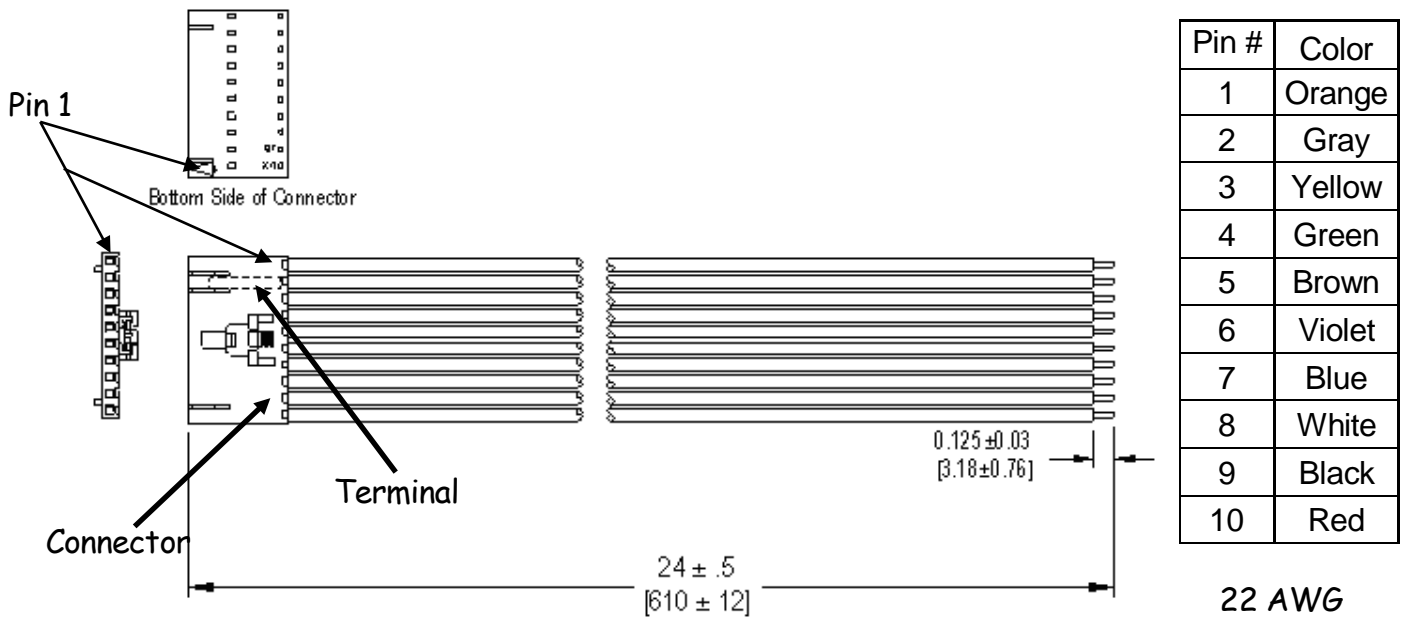


FIGURE 39 – CONTROL MATING CONNECTOR (P2)

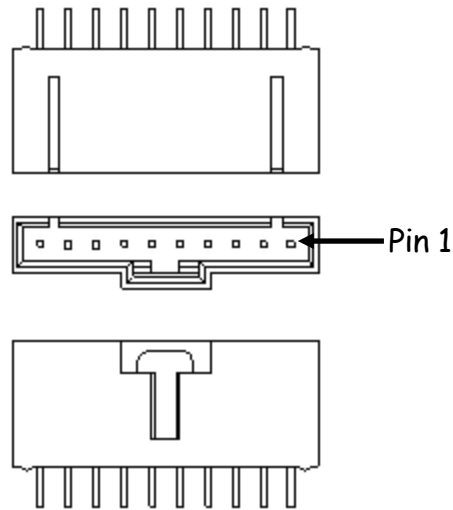


TABLE 18 – CONTROL CABLE REFERENCE

Description	Manufacturer	Manufacturer Part #
Connector	Molex	50-57-9410
Terminal	Molex	16-02-0087 (chain)
	Molex	16-02-0103 (loose)
Control Mating Connector (P2)	Molex	70543-0009

NOTICE

Minimum Gauge Size is recommended to be 22 AWG or greater.

WARRANTY

NIDEC MOTOR CORPORATION

TERMS AND CONDITIONS OF SALE



NIDEC MOTOR CORPORATION

Nidec Motor Corporation is herein referred to as the "Seller" and the customer or person or entity purchasing goods ("Goods") from Seller is referred to as the "Buyer." These Terms and Conditions, any price list or schedule, quotation, acknowledgment or invoice from Seller relevant to the sale of the Goods and all documents incorporated by specific reference herein or therein, constitute the complete and exclusive statement of the terms of the agreement governing the sale of Goods by Seller to Buyer. Seller's acceptance of Buyer's purchase order is expressly conditional on Buyer's assent to all of Seller's terms and conditions of sale, including terms and conditions that are different from or additional to the terms and conditions of Buyer's purchase order. Buyer's acceptance of or payment for the Goods will manifest Buyer's assent to these Terms and Conditions. Seller reserves the right in its sole discretion to refuse orders.

1. **PRICES:** Unless otherwise specified in writing by Seller, the price quoted or specified by Seller for the Goods shall remain in effect for thirty (30) days after the date of Seller's quotation or acknowledgment of Buyer's order for the Goods, whichever occurs first, provided an unconditional authorization from Buyer for the shipment of the Goods is received and accepted by Seller within such time period. If such authorization is not received by Seller within such thirty (30) day period, Seller shall have the right to change the price for the Goods to Seller's price for the Goods at the time of shipment. All prices are exclusive of taxes, transportation and insurance, which are to be borne by Buyer.

2. **TAXES:** Any current or future tax or governmental charge (or increase in same) affecting Seller's costs of production, sale, or delivery or shipment, or which Seller is otherwise required to pay or collect in connection with the sale, purchase, delivery, storage, processing, use or consumption of Goods, shall be for Buyer's account and shall be added to the price or billed to Buyer separately, at Seller's election.

3. **TERMS OF PAYMENT:** Unless otherwise specified by Seller, terms are net thirty (30) days from date of Seller's invoice in U.S. currency. Seller shall have the right, among other remedies, either to terminate this agreement or to suspend further performance under this and/or other agreements with Buyer in the event Buyer fails to make any payment when due, which other agreements Buyer and Seller hereby amend accordingly. Buyer shall be liable for all expenses, including attorneys' fees, relating to the collection of past due amounts. If any payment owed to Seller is not paid when due, it shall bear interest, at a rate to be determined by Seller, which shall not exceed the maximum rate permitted by law, from the date on which it is due until it is paid. Should Buyer's financial responsibility become unsatisfactory to Seller, cash payments or security satisfactory to Seller may be required by Seller for future deliveries and for the Goods theretofore delivered. If such cash payment or security is not provided, in addition to Seller's other rights and remedies, Seller may discontinue deliveries.

4. **SHIPMENT AND DELIVERY:** While Seller will use all reasonable commercial efforts to maintain the delivery date(s) acknowledged or quoted by Seller, all shipping dates are approximate and not guaranteed. Seller reserves the right to make partial shipments. Seller, at its option, shall not be bound to tender delivery of any Goods for which Buyer has not provided shipping instructions and other required information. If the shipment of the Goods is postponed or delayed by Buyer for any reason, Buyer agrees to reimburse Seller for any and all storage costs and other additional expenses resulting therefrom. Risk of loss and legal title to the Goods shall transfer to Buyer for sales in which the end destination of the Goods is outside of the United States immediately after the Goods have passed beyond the territorial limits of the United States. For all other shipments, risk of loss for damage and responsibility shall pass from Seller to Buyer upon delivery to and receipt by carrier at Seller's shipping point. All shipments are F.O.B. Seller's shipping point. Any claims for shortages or damages suffered in transit are the responsibility of Buyer and shall be submitted by Buyer directly to the carrier. Shortages or damages must be identified and signed for at the time of delivery.

5. **LIMITED WARRANTY:** Subject to the limitations of Section 6, Seller warrants that the Goods manufactured by Seller will be free from defects in material and workmanship and meet Seller's published specifications at the time of shipment under normal use and regular service and maintenance for a period of one year from the date of shipment of the Goods by Seller, unless otherwise specified by Seller in writing. Products purchased by Seller from a third party for resale to Buyer ("Resale Products") shall carry only the warranty extended by the original manufacturer. **THE WARRANTY SET FORTH IN THIS SECTION 5 AND THE WARRANTY SET FORTH IN SECTION 7, ARE THE SOLE AND EXCLUSIVE WARRANTIES GIVEN BY SELLER WITH RESPECT TO THE GOODS AND ARE IN LIEU OF AND EXCLUDE ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, ARISING BY OPERATION OF LAW OR OTHERWISE, INCLUDING WITHOUT LIMITATION, MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE WHETHER OR NOT THE PURPOSE OR USE HAS BEEN DISCLOSED TO SELLER IN SPECIFICATIONS, DRAWINGS OR OTHERWISE, AND WHETHER OR NOT SELLER'S PRODUCTS ARE SPECIFICALLY DESIGNED AND/OR MANUFACTURED BY SELLER FOR BUYER'S USE OR PURPOSE.**

This warranty does not extend to any losses or damages due to misuse, accident, abuse, neglect, normal wear and tear, negligence (other than Seller's), unauthorized modification or alteration, use beyond rated capacity, unsuitable power sources or environmental conditions, improper installation, repair, handling, maintenance or application or any other cause not the fault of Seller. To the extent that Buyer or its agents has supplied specifications, information, representation of operating conditions or other data to Seller in the selection or design of the Goods and the preparation of Seller's quotation, and in the event that actual operating conditions or other conditions differ from those represented by Buyer, any warranties or other provisions contained herein which are affected by such conditions shall be null and void. If within thirty (30) days after Buyer's discovery of any warranty defects within the warranty period, Buyer notifies Seller thereof in writing, Seller shall, at its option and as Buyer's exclusive remedy, repair, correct or replace F.O.B. point of manufacture, or refund the purchase price for, that portion of the Goods found by Seller to be defective. Failure by Buyer to give such written notice within the applicable time

period shall be deemed an absolute and unconditional waiver of Buyer's claim for such defects. Goods repaired or replaced during the warranty period shall be covered by the foregoing warranty for the remainder of the original warranty period or ninety (90) days from the date of shipment, whichever is longer. Buyer assumes all other responsibility for any loss, damage, or injury to persons or property arising out of, connected with, or resulting from the use of Goods, either alone or in combination with other products/components. Section 5 applies to any entity or person who may buy, acquire or use the Goods, including any entity or person who obtains the Goods from Buyer, and shall be bound by the limitations therein, including Section 6. Buyer agrees to provide such subsequent transferee conspicuous, written notice of the provisions of Sections 5 and 6.

6. **LIMITATION OF REMEDY AND LIABILITY: THE SOLE AND EXCLUSIVE REMEDY FOR BREACH OF ANY WARRANTY HEREUNDER (OTHER THAN THE WARRANTY PROVIDED UNDER SECTION 7) SHALL BE LIMITED TO REPAIR, CORRECTION OR REPLACEMENT, OR REFUND OF THE PURCHASE PRICE UNDER SECTION 5. SELLER SHALL NOT BE LIABLE FOR DAMAGES CAUSED BY DELAY IN PERFORMANCE AND THE REMEDIES OF BUYER SET FORTH IN THIS AGREEMENT ARE EXCLUSIVE. IN NO EVENT, REGARDLESS OF THE FORM OF THE CLAIM OR CAUSE OF ACTION (WHETHER BASED IN CONTRACT, INFRINGEMENT, NEGLIGENCE, STRICT LIABILITY, OTHER TORT OR OTHERWISE), SHALL SELLER'S LIABILITY TO BUYER AND/OR ITS CUSTOMERS EXCEED THE PRICE PAID BY BUYER FOR THE SPECIFIC GOODS PROVIDED BY SELLER GIVING RISE TO THE CLAIM OR CAUSE OF ACTION. BUYER AGREES THAT IN NO EVENT SHALL SELLER'S LIABILITY TO BUYER AND/OR ITS CUSTOMERS EXTEND TO INCLUDE INCIDENTAL, CONSEQUENTIAL OR PUNITIVE DAMAGES.** The term "consequential damages" shall include, but not be limited to, loss of anticipated profits, business interruption, loss of use, revenue, reputation and data, costs incurred, including without limitation, for capital, fuel, power and loss or damage to property or equipment. It is expressly understood that any technical advice furnished by Seller with respect to the use of the Goods is given without charge, and Seller assumes no obligation or liability for the advice given, or results obtained, all such advice being given and accepted at Buyer's risk. To the extent that Seller has been provided by or on behalf of Buyer any specifications, description of operating conditions or other data and information in connection with the selection or design of the Goods and/or the provision of

Services, and the actual operating conditions or other circumstances differ from those provided by Buyer and relied upon by Seller, any warranties or other provisions contained herein which are affected by such conditions shall be null and void.

7. **PATENTS AND COPYRIGHTS:** Subject to the limitations of the second paragraph of Section 6, Seller warrants that the Goods sold, except as are made specifically for Buyer according to Buyer's specifications, do not infringe any valid U.S. patent or copyright in existence as of the date of shipment. This warranty is given upon the condition that Buyer promptly notify Seller of any claim or suit involving Buyer in which such infringement is alleged and cooperate fully with Seller and permit Seller to control completely the defense, settlement or compromise of any such allegation of infringement. Seller's warranty as to use patents only applies to infringement arising solely out of the inherent operation according to Seller's specifications and instructions (i) of such Goods, or (ii) of any combination of Goods acquired from Seller in a system designed by Seller. In the event such Goods are held to infringe such a U.S. patent or copyright in such suit, and the use of such Goods is enjoined, or in the case of a compromise or settlement by Seller, Seller shall have the right, at its option and expense, to procure for Buyer the right to continue using such Goods, or replace them with non-infringing Goods, or modify same to become non-infringing, or grant Buyer a credit for the depreciated value of such Goods and accept return of them. In the event of the foregoing, Seller may also, at its option, cancel the agreement as to future deliveries of such Goods, without liability.

8. **EXCUSE OF PERFORMANCE:** Seller shall not be liable for delays in performance or for non-performance due to acts of God; acts of Buyer; war; fire; flood; weather; sabotage; strikes or labor disputes; civil disturbances or riots; governmental requests, restrictions, allocations, laws, regulations, orders or actions; unavailability of or delays in transportation; default of suppliers; or unforeseen circumstances or any events or causes beyond Seller's reasonable control. Deliveries or other performance may be suspended for an appropriate period of time or canceled by Seller upon notice to Buyer in the event of any of the foregoing, but the balance of the agreement shall otherwise remain unaffected as a result of the foregoing. If Seller determines that its ability to supply the total demand for the Goods, or to obtain material used directly or indirectly in the manufacture of the Goods, is hindered, limited or made impracticable due to causes set forth in the preceding paragraph, Seller may allocate its available supply of the Goods or such material (without obligation to acquire other supplies of any such Goods or material) among itself and its purchasers on such basis as Seller determines to be equitable without liability for any failure of performance which may result therefrom.

9. **CANCELLATION:** Buyer may cancel orders only upon reasonable advance written notice and upon payment to Seller of Seller's cancellation charges which include, among

other things, all costs and expenses incurred, and, to cover commitments made, by the Seller and a reasonable profit thereon. Seller's determination of such termination charges shall be conclusive.

10. CHANGES: Buyer may request changes or additions to the Goods consistent with Seller's specifications and criteria. In the event such changes or additions are accepted by Seller, Seller may revise the price and dates of delivery. Seller reserves the right to change designs and specifications for the Goods without prior notice to Buyer, except with respect to Goods being made-to-order for Buyer.

11. NUCLEAR/MEDICAL: GOODS AND SERVICES SOLD HEREUNDER ARE NOT FOR USE IN CONNECTION WITH ANY NUCLEAR, MEDICAL, LIFE-SUPPORT AND RELATED APPLICATIONS. Buyer accepts goods and services with the foregoing understanding, agrees to communicate the same in writing to any subsequent purchasers or users and to defend, indemnify and hold harmless Seller from any claims, losses, suits, judgments and damages, including incidental and consequential damages, arising from such use, whether the cause of action be based in tort, contract or otherwise, including allegations that the Seller's liability is based on negligence or strict liability.

12. ASSIGNMENT: Buyer shall not assign its rights or delegate its duties hereunder or any interest herein without the prior written consent of Seller, and any such assignment, without such consent, shall be void.

13. QUANTITY: Buyer agrees to accept overruns of up to ten percent (10%) of the order on "made-to-order" goods, including parts. Any such additional items shall be priced at the price per item charged for the specific quantity ordered.

14. TOOLING: Tool, die, and pattern charges, if any, are in addition to the price of the Goods and are due and payable upon completion of the tooling. All such tools, dies and patterns shall be and remain the property of Seller. Charges for tools, dies, and patterns do not convey to Buyer, title, ownership interest in, or rights to possession or removal, or prevent their use by Seller for other purchasers, except as otherwise expressly provided by Seller and Buyer in writing with reference to this provision.

15. INSPECTION/TESTING: Buyer, at its option and expense, may inspect and observe the testing by Seller of the Goods for compliance with Seller's standard test procedures prior to shipment, which inspection and testing shall be conducted at Seller's plant at such reasonable time as is specified by Seller. Any rejection of the Goods must be made promptly by Buyer before shipment. Tests shall be deemed to be satisfactorily completed and the test fully met when the Goods meet Seller's criteria for such procedures.

16. DRAWINGS: Seller's prints and drawings (including without limitation, the underlying technology) furnished by Seller to Buyer in connection with this agreement are the property of Seller and Seller retains all rights, including without limitation, exclusive rights of use, licensing and sale. Possession of such prints or drawings does not convey to Buyer any rights or license, and Buyer shall return all copies (in whatever medium) of such prints or drawings to Seller immediately upon request therefore.

17. GENERAL PROVISIONS: These terms and conditions supersede all other communications, negotiations and prior oral or written statements regarding the subject matter of these terms and conditions. No change, modification, rescission, discharge, abandonment, or waiver of these terms and conditions shall be binding upon the Seller unless made in writing and signed on its behalf by a duly authorized representative of Seller. No conditions, usage of trade, course of dealing or performance, understanding or agreement purporting to modify, vary, explain, or supplement these terms and conditions shall be binding unless hereafter made in writing and signed by the party to be bound, and no modification or additional terms shall be applicable to this agreement by Seller's receipt, acknowledgment, or acceptance of purchase orders, shipping instruction forms, or other documentation containing terms at variance with or in addition to those set forth herein. Any such modifications or additional terms are specifically rejected and deemed a material alteration hereof. If this document shall be deemed an acceptance of a prior offer by Buyer, such acceptance is expressly conditional upon Buyer's assent to any additional or different terms set forth herein. No waiver by either party with respect to any breach or default or of any right or remedy, and no course of dealing, shall be deemed to constitute a continuing waiver of any other breach or default or of any other right or remedy, unless such waiver be expressed in writing and signed by the party to be bound. All typographical or clerical errors made by Seller in any quotation, acknowledgment or publication are subject to correction. The validity, performance, and all other matters relating to the interpretation and effect of this agreement shall be governed by the law of the state of Missouri without regard to its conflicts of laws principles. Buyer and Seller agree that the proper venue for all actions arising in connection herewith shall be only in Missouri and the parties agree to submit to such jurisdiction. No action, regardless of form, arising out of transactions relating to this contract, may be brought by either party more than two (2) years after the cause of action has accrued. The U.N. Convention on Contracts for the International Sales of Goods shall not apply to this agreement.

MC-TC-1000 Revised 9/06

GLOSSARY OF TERMS

Ambient Temperature - The temperature of the surrounding environment.

BLDC (Brushless DC)/Brushless Permanent Magnet (BPM) Motor - A synchronous electric motor which is powered by direct current (DC) electricity and which has an electronically controlled commutation system, instead of a mechanical commutation system based on brushes. In such motors, current and torque, and voltage and rpm are linearly related.

Commutation - The action of applying currents or voltages to the proper electrical motor phases so as to produce optimum motor torque at a motor's shaft.

Duty Cycle – The relationship between the on-time and off-time of a device.

Encoder - An electro-mechanical device used to convert the angular position of a shaft or axle to an analog or digital code. *See also Resolver.*

HST23 - Hurst Segmented Technology NEMA 23 (2.3 inch frame)

IP (International Protection) Ratings – Defined in International Standard IEC 60529. This system classifies the degrees of protection provided against the intrusion of solid objects (including body parts like hands and fingers), dust, accidental contact, and water in electrical enclosures. It uses a two digit code to specify the degree of particle and water resistance of an enclosed object. The first digit indicates the degree of protection of the interior from the ingress of solid foreign objects. The second digit indicates the degree of protection of the interior from the ingress of water. The table below describes the two digits that describe the level of protection of the enclosure.

TABLE 19 – DESCRIPTION OF IP STANDARD

First Digit	Description	Second Digit	Description
X	Not tested (no protection specified)	X	Not tested (no protection specified)
0	No protection provided	0	No protection provided

1	Protection against entry of objects larger than 50 square mm	1	Protection against drops of water falling vertically
2	Protection against entry of objects larger than 12 square mm	2	Protection against drops of water falling vertically when the object is tilted up to 15 degrees from its normal position
3	Protection against entry of objects larger than 2.5 square mm	3	Protection from entry of water spray from angle of up to 60 degrees from vertical
4	Protection against entry of objects larger than 1.0 square mm	4	Protection from entry of water splashes or spray from any direction
5	Protection against entry of dust in sufficient quantity to prevent satisfactory operation	5	Protection from a low pressure jet of water in any direction
6	Complete protection against entry of dust	6	Protection against heavy seas or a strong jet of water in any direction
		7	Protection against immersion up to 1 meter
		8	Protection against submersion over 1 meter

IP50 – Subset of the IP Rating; The “5” in the description indicates complete protection, (limited ingress permitted) dust protected; dust deposits are permitted, but their volume must not affect the function of the unit. The “0” indicates no special protection against water or liquids. See also *International Protection (IP) Ratings*.

NEMA (National Electrical Manufacturers Association) – Sets many common standards used in electrical products.

Planetary Gear Train - An assembly of meshed gears consisting of a central gear, a coaxial internal or ring gear, and one or more intermediate pinions supported on a revolving carrier.

PPR - Pulses per Revolution

PWM (Pulse Width Modulation) – A type of signal that varies the duty cycle, to either convey information over a communications channel or control the amount of power sent to a load; uses a square wave where the width of its pulse is varied periodically, resulting in the variation of the average value of the waveform.

Resolver - A type of rotary electrical transformer used for measuring degrees of rotation. It is considered an analog device, and has a digital counterpart, the encoder.

Spur Gear - A toothed wheel with radial teeth parallel to the axis.

Tachometer - An instrument or circuit that measures the rotation speed of a shaft or disk.

TTL (Transistor-Transistor Logic) - a class of digital circuits built from bipolar junction transistors (BJT), and resistors. It is called *transistor-transistor logic* because both the logic gating function (e.g., AND, NOR) and the amplifying function are performed by transistors.

APPENDIX

Reference and Agency Documents

The following reference/agency documents apply in part or entirely as indicated in the body of this document.

Reference Documents

UL 60950, CSA 60950, UL 60730, and National Electric Code (NFPA 70)

Safety Agency Approvals

The Motor control is designed to meet the relevant requirements of UL60730. To be determined if Agency certification is completed.

RoHS Regulation

Construction and parts conform to European Union (EU) compliance of RoHS Directive 2002/95/EC.



NIDEC MOTOR CORPORATION

Part Number: TDE1006

Revision: 2

Date: Aug. 24, 2011

Nidec Motor Corporation, 2011

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