

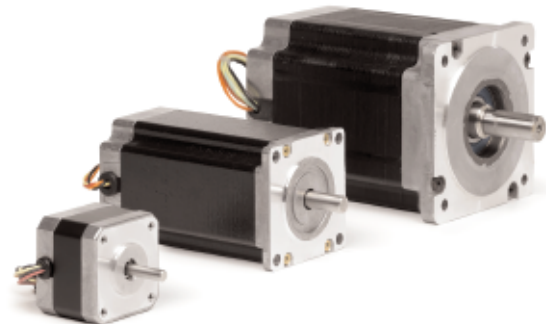
# Stepper Motors and Encoders

## Stepper Motors

- NEMA 17, 23, and 34 sizes
- Up to 1710 oz-in. (12.1 N · m) holding torque
- 3000 rpm max speed
- 1.8 deg step angle
- Matched with P7000 drives for high performance

## Encoders

- 1000 counts/revolution resolution
- NEMA 23 and 34 motor compatibility
- Low profile 1 in. (25.4 mm) height design and easy mounting
- Industrial construction



## Overview

National Instruments offers a complete stepper motion control solution – including stepper motors, drives, controllers, and software – that is easy to set up, configure, and program. Stepper motors available from NI offer high torque, precision, and easy connectivity to stepper motor drives. Due to their ease of use, simplified control needs, and freedom from expensive feedback requirements, stepper motors are an excellent solution for applications such as machine control, manufacturing test, semiconductor positioning, biomedical machines, and lab automation.

## Hardware

Stepper motors provide very precise, extremely cost-effective motion control. The 2-phase motors inherently move in small, precise, 1.8 degree increments at 200 steps/revolution and are brushless and maintenance-free. Stepping action is simple to control and does not require complicated, expensive feedback devices. National Instruments also offers encoders matched to the motors for applications where position verification is required. Stepper motors are available from NI in three different NEMA sizes and with either a single or a dual shaft. The motors provide optimum performance and easy connectivity when matched with the P7000 series stepper drives available from NI.

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# Stepper Motors and Encoders

## Specifications

### NEMA 17 Motor

#### Electrical

Step angle .....	1.8 deg
Steps per revolution .....	200
Angular accuracy .....	±3%
Phases .....	2

#### Industry Standards

Industrial standards .....	CE, UR
Sealing standard .....	IP40
RoHS compliance .....	Yes

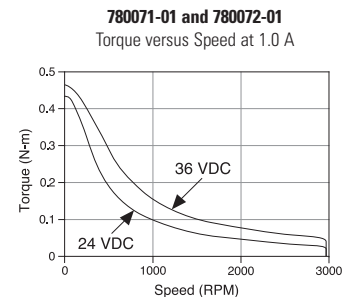
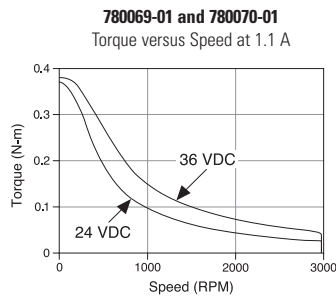
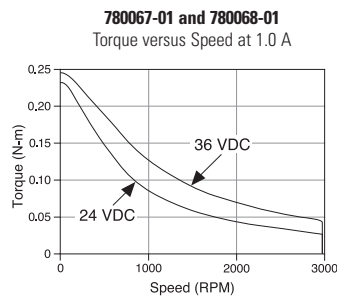
#### Physical

Operating temperature .....	-20 to 40 °C
Shaft load (20,000 hours at 1,500 rpm)	
Radial .....	15 lb (6.8 kg) at shaft center
Axial push .....	6 lb (2.7 kg)
Axial pull .....	15 lb (6.8 kg)

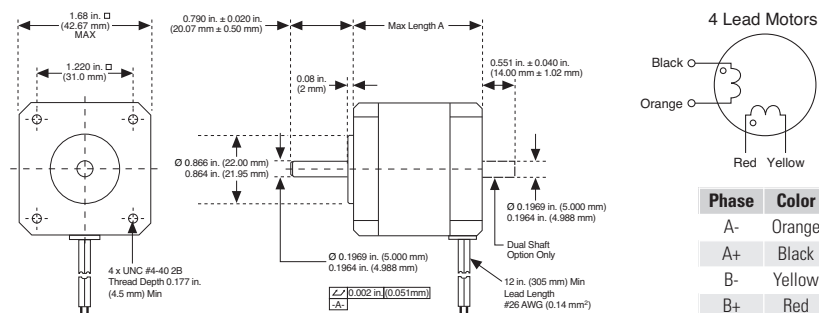
NI Part Number	Manufacturer Part Number	Dual Shaft	Drive	Amps/Phase	Holding Torque oz-in. (N · m)	Rotor Inertia oz-in.-s <sup>2</sup> (kg-m <sup>2</sup> x 10 <sup>-3</sup> )	Phase Inductance mH	Phase Resistance Ω ±10%	Detent Torque oz-in. (N · m)	Thermal Resistance °C/watt	Max Speed rpm
780067-01	CTP10ELF10MAA00	—	P70530	1.0	43 (0.30)	0.0005 (0.0040)	7.7	5.25	1.98 (0.014)	6.21	3000
780068-01	CTP10ELF10MMA00	✓									
780069-01	CTP11ELF11MAA00	—		1.1	63 (0.44)	0.0008 (0.0050)	11	5.19	2.55 (0.018)	5.44	3000
780070-01	CTP11ELF11MMA00	✓									
780071-01	CTP12ELF10MAA00	—		1.0	80 (0.56)	0.0011 (0.0070)	12	6.51	2.97 (0.021)	4.71	3000
780072-01	CTP12ELF10MAA00	✓									

Rated current is per phase, with the motor mounted, and winding temperature rise  $\Delta T = 90^\circ\text{C}$ .  
Resistance is with winding at  $20^\circ\text{C}$ .

### Torque versus Speed



### Dimensions and Wiring



NI Part Number	Manufacturer Part Number	Dual Shaft	Max Length A in. (mm)	Net Weight lb (kg)
780067-01	CTP10ELF10MAA00	—	1.37 (34.7)	0.441 (0.200)
780068-01	CTP10ELF10MMA00	✓		
780069-01	CTP11ELF11MAA00	—	1.61 (40.9)	0.573 (0.260)
780070-01	CTP11ELF11MMA00	✓		
780071-01	CTP12ELF10MAA00	—	1.92 (48.8)	0.750 (0.340)
780072-01	CTP12ELF10MAA00	✓		

# Stepper Motors and Encoders

## NEMA 23 Motor

### Electrical

Step angle .....	1.8 deg
Steps per revolution.....	200
Angular accuracy .....	±3%
Phases .....	2

### Industry Standards

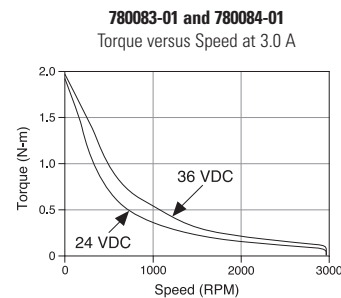
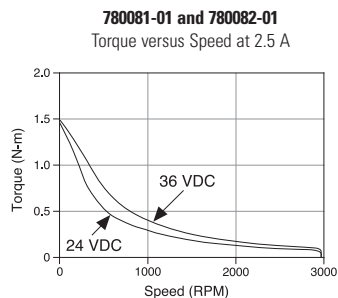
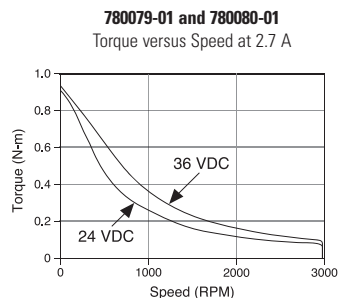
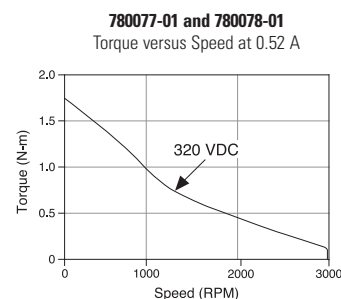
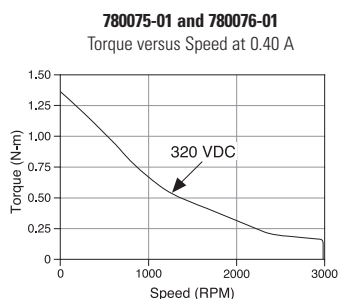
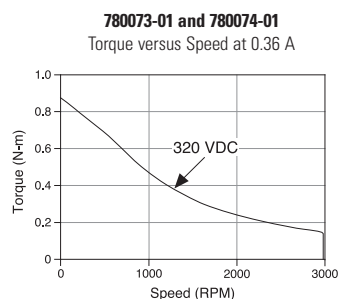
Industrial standards .....	CE, cUR, UR
RoHS compliance .....	Yes

### Physical

Operating temperature .....	-20 to 40 °C
Rated ambient temperature.....	40 °C
Shaft load (20,000 hours at 1,500 rpm)	
Radial .....	20 lb (9.1 kg) at shaft center
Axial push .....	6 lb (2.7 kg)
Axial pull .....	50 lb (22.7 kg)
Recommended encoder .....	780251-01

NI Part Number	Manufacturer Part Number	Dual Shaft	Drive	Amps/Phase	Holding Torque oz-in. (N · m)	Rotor Inertia oz-in.-s <sup>2</sup> (kg-m <sup>2</sup> x10 <sup>-3</sup> )	Phase Inductance mH	Phase Resistance Ω ±10%	Detent Torque oz-in. (N · m)	Thermal Resistance °C/watt	Max Speed rpm	
780073-01	T21NRLC-LNN-NS-00	—	P70360	0.40	180	0.0034	209	42.9	2.97	4.64	3000	
780074-01	T21NRLC-LDN-NS-00	✓			(1.27)	(0.0248)			(0.021)			
780075-01	T22NRLC-LNN-NS-00	—			280	0.0056			5.95			
780076-01	T22NRLC-LDN-NS-00	✓		(1.98)	(0.0408)	(0.042)		3.69				
780077-01	T23NRLC-LNN-NS-00	—		0.67	380	0.0084	136	23.5	6.94	3.04	3000	
780078-01	T23NRLC-LDN-NS-00	✓			(2.68)	(0.0612)			(0.049)			
780079-01	T21NRLH-LNN-NS-00	—	P70530		2.7	180			0.0034			4.6
780080-01	T21NRLH-LDN-NS-00	✓		(1.27)		(0.0248)		(0.021)				
780081-01	T22NRLG-LNN-NS-00	—		280		0.0056	5.95					
780082-01	T22NRLG-LDN-NS00	✓		(1.98)	(0.0408)	(0.042)	3.69					
780083-01	T23NRLH-LNN-NS00	—		3.0	380	0.0084	6.2	1.00	6.94	3.04	3000	
780084-01	T23NRLH-LDN-NS00	✓			(2.68)	(0.0612)			(0.049)			

## Torque versus Speed





# Stepper Motors and Encoders

## NEMA 34 Motor

### Electrical

Step angle .....	1.8 deg
Steps per revolution.....	200
Angular accuracy .....	±3%
Phases .....	2

### Industry Standards

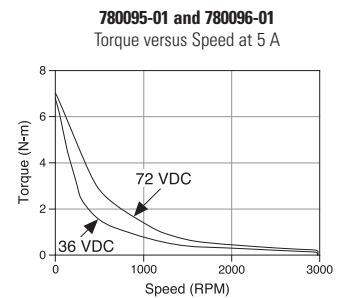
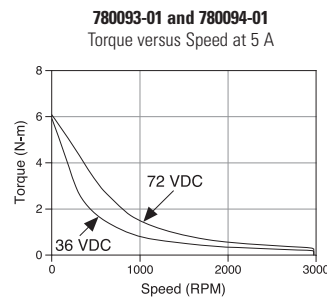
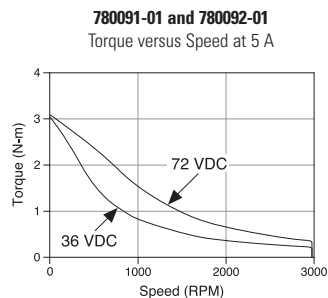
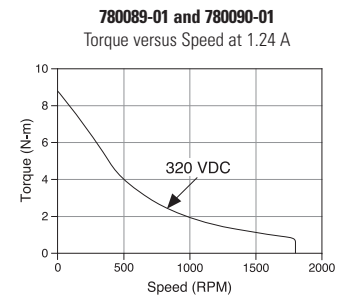
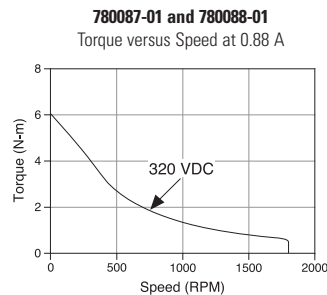
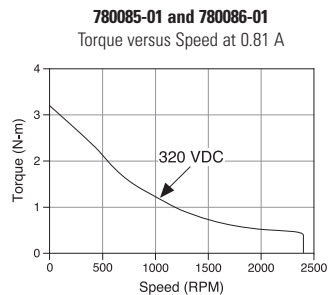
Industrial standards .....	CE, cUR, UR
RoHS compliance .....	Yes

### Physical

Operating temperature .....	-20 to 40 °C
Rated ambient temperature.....	40 °C
Shaft load (20,000 hours at 1,500 rpm)	
Radial	
N31, N32 .....	65 lb (29.5 kg)
N33 .....	110 lb (49.9 kg)
Axial	
N31, N32, N33 .....	305 lb (138.3 kg)
Recommended encoder .....	780252-02

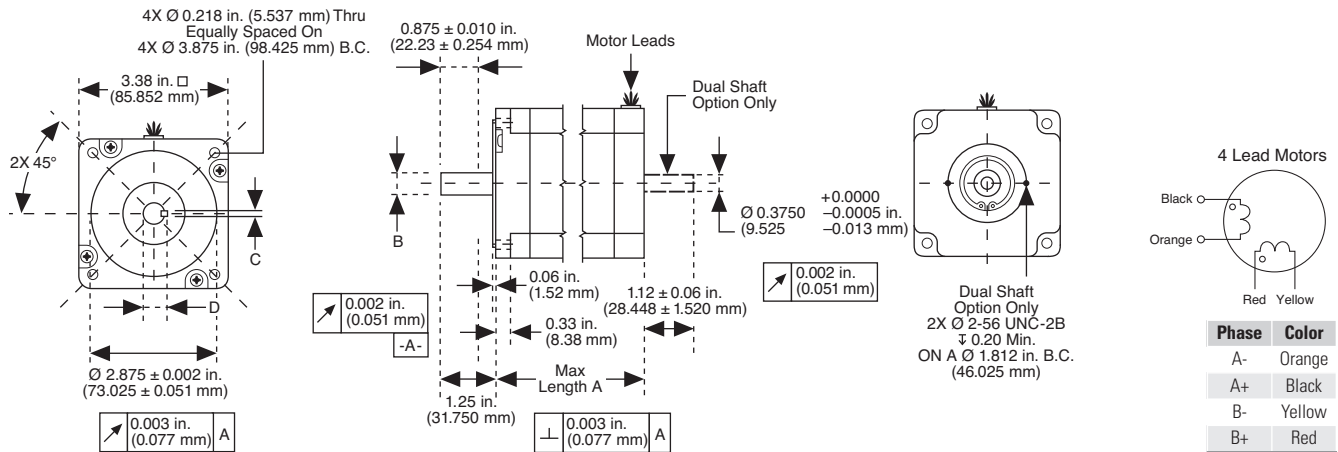
NI Part Number	Manufacturer Part Number	Dual Shaft	Drive	Amps/Phase	Holding Torque oz-in. (N · m)	Rotor Inertia oz-in.-s <sup>2</sup> (kg-m <sup>2</sup> x10 <sup>-3</sup> )	Phase Inductance mH	Phase Resistance Ω ±10%	Detent Torque oz-in. (N · m)	Thermal Resistance °C/watt	Max Speed rpm
780085-01	N31HRLG-LNK-NS-00	—	P70360	0.86	641 (4.52)	0.0202 (0.1430)	138	16.2	18.0 (0.127)	2.65	2400
780086-01	N31HRLG-LEK-M2-00	✓									
780087-01	N32HRLG-LNK-NS-00	—		0.95	1240 (8.76)	0.0380 (0.2680)	206	17.6	36.0 (0.254)	2.00	1800
780088-01	N32HRLG-LEK-M2-00	✓									
780089-01	N33HRLG-LNK-NS-00	—		1.24	1710 (12.08)	0.0567 (0.4000)	144	13.0	54.0 (0.381)	1.61	1800
780090-01	N33HRLG-LEK-M2-00	✓									
780091-01	N31HRHJ-LNK-NS-00	—	P70530	5.5	645 (4.55)	0.0202 (0.1430)	3.5	0.42	18.0 (0.127)	2.65	3000
780092-01	N31HRHJ-LEK-M2-00	✓									
780093-01	N32HRHJ-LNK-NS-00	—		5.1	1195 (8.43)	0.0380 (0.2700)	6.5	0.63	36.0 (0.254)	2.00	3000
780094-01	N32HRHJ-LEK-M2-00	✓									
780095-01	N33HRHJ-LNK-NS-00	—		5.0	1710 (12.07)	0.0567 (0.4000)	9.0	0.83	54.0 (0.381)	1.61	3000
780096-01	N33HRHJ-LEK-M2-00	✓									

## Torque versus Speed



# Stepper Motors and Encoders

## Dimensions and Wiring



**Note:** Motor leads are 12.0 in. (304.8 mm) minimum.

NI Part Number	Manufacturer Part Number	Dual Shaft	Max Length A in. (mm)	B in. (mm)	C in. (mm)	D in. (mm)	Net Weight lb (kg)
780085-01	N31HRLG-LNK-NS-00	—	3.13 (79.502)	0.5000 (12.700)	0.1250 (3.175)	0.555 (14.097)	5.0 (2.27)
780086-01	N31HRLG-LEK-M2-00	✓		0.4995 (12.687)	0.1230 (3.124)	0.538 (13.665)	
780087-01	N32HRLG-LNK-NS-00	—	4.65 (118.11)	0.5000 (12.700)	0.1250 (3.175)	0.555 (14.097)	8.4 (2.27)
780088-01	N32HRLG-LEK-M2-00	✓		0.4995 (12.687)	0.1230 (3.124)	0.538 (13.665)	
780089-01	N33HRLG-LNK-NS-00	—	6.13 (155.70)	0.6250 (15.875)	0.1875 (4.763)	0.705 (17.907)	11.9 (5.39)
780090-01	N33HRLG-LEK-M2-00	✓		0.6245 (15.862)	0.1855 (4.712)	0.688 (17.475)	
780091-01	N31HRHJ-LNK-NS-00	—	3.13 (79.502)	0.5000 (12.700)	0.1250 (3.175)	0.555 (14.097)	5.0 (2.27)
780092-01	N31HRHJ-LEK-M2-00	✓		0.4995 (12.687)	0.1230 (3.124)	0.538 (13.665)	
780093-01	N32HRHJ-LNK-NS-00	—	4.65 (118.11)	0.5000 (12.700)	0.1250 (3.175)	0.555 (14.097)	8.4 (2.27)
780094-01	N32HRHJ-LEK-M2-00	✓		0.4995 (12.687)	0.1230 (3.124)	0.538 (13.665)	
780095-01	N33HRHJ-LNK-NS-00	—	6.13 (155.70)	0.6250 (15.875)	0.1875 (4.763)	0.705 (17.907)	11.9 (5.39)
780096-01	N33HRHJ-LEK-M2-00	✓		0.6245 (15.862)	0.1855 (4.712)	0.688 (17.475)	

# Stepper Motors and Encoders

## Encoders for NEMA 23 and NEMA 34 Motors

### Electrical

Resolution .....	1000 counts/revolution
Input voltage .....	5 V $\pm$ 10%
Input current .....	100 mA max (65 mA typical) with no output load
Channel configuration .....	Quadrature A, B, and Index
Output type .....	Differential line driver
Noise immunity .....	Tested to BS EN61000-6-2; BS EN50081-02; BS EN61000-4-2; BS EN61000-4-3; BS EN61000-4-6; BS EN500811
Symmetry .....	180 deg ( $\pm$ 18 deg) electrical
Quadrature phasing .....	90 deg ( $\pm$ 22.5 deg) electrical
Minimum edge separation .....	67.5 deg electrical
Accuracy .....	Within 0.017 deg mechanical or 1 arc-minute from true position

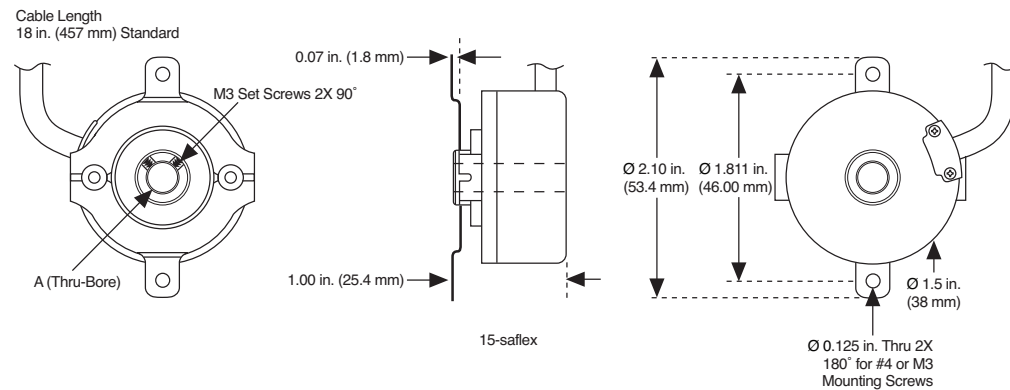
### Industry Standards

Industrial standards .....	CE
Sealing standard .....	IP50
RoHS compliance .....	Yes

### Physical

Operating temperature .....	-20 to 85 °C
Model type .....	Thru-bore
Bore size .....	1/4 in. (780251-01), 8 mm (780252-01)
Mounting .....	1.812 in. (46 mm) two-hole flex mount
Maximum frequency .....	200 kHz
Operating temperature .....	20 to 85 °C
Max shaft speed .....	8000 rpm
Bore tolerance .....	-0.0000 in./+0.0006 in.
User shaft tolerances	
Radial runout .....	0.008 in. max
Axial endplay .....	$\pm$ 0.030 in. max
Starting torque .....	0.300 oz-in. (0.212 N · m)
Moment of inertia .....	$6.7 \times 10^{-5}$ oz-in.-sec <sup>2</sup> (4.8 gm-cm <sup>2</sup> )
Max acceleration .....	$1 \times 10^5$ rad/sec <sup>2</sup>
Weight .....	3 oz typical
Storage temperature .....	-25 to 85 °C
Humidity .....	98% RH noncondensing
Vibration .....	10 g @ 58 to 500 Hz
Shock .....	80 g @ 11 ms duration

## Dimensions, Wiring, and Timing Diagrams



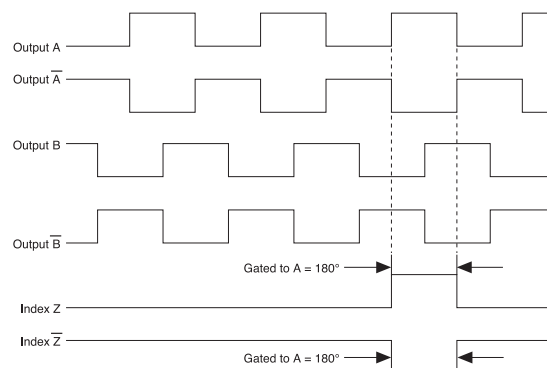
**Note:** All dimensions have a tolerance of  $\pm$ 0.005 in. or  $\pm$ 0.01 in. unless otherwise specified.

NI Part Number	Manufacturer Part Number	A (Thru-Bore Diameter)
780251-01	15T-01SA-1000-N5RHV-F00-CE	1/4 in., 0.250 in.
780252-02	15T-14SA-1000-N5RHV-F00-CE	8 mm

### Wire Description

Pin #	Wire Color	Function
1	Brown	A
2	White	+VDC
3	Yellow	$\bar{A}$
4	Red	B
5	Green	$\bar{B}$
6	Orange	Z
7	Black	COM
8	Blue	$\bar{Z}$

### Quadrature Waveform



## Stepper Motors and Encoders

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### Glossary

**amps/phase** – The maximum amount of current allowed through a phase of the stepper motor. Holding torque, the speed versus torque curve, and so on are determined when the motor is excited by this value. The specifications listed in this data sheet are adjusted for the winding configuration.

**angular accuracy** – A percentage of the step angle that defines the accuracy of each full step.

**detent torque (cogging torque)** – The amount of torque necessary to rotate the stepper motor one full step when the motor is deenergized.

**differential line driver** – A type of electrical digital output that can transmit digital data over a long distance. It consists of a complementary pair of digital lines.

**electrical symmetry** – How close each quadrature channel is to a 50 percent duty cycle when at a constant speed.

**holding torque** – The amount of torque necessary to rotate the stepper motor one full step (microstepping turned off) when the motor is energized at the rated amps/phase of that motor.

**minimum edge separation** – Defines in degrees how close (electrically) an edge on channel A can be to an edge on channel B.

**NEMA** – National Electrical Manufacturers Association (NEMA). NEMA is a U.S.-based association that creates standards for mountings. The NEMA size of a motor defines its shaft size and mounting configuration.

**phase inductance** – The inductance of each phase of the stepper motor. The specifications listed in this data sheet are already adjusted for the winding configuration.

**phases** – A wound wire in the stepper motor that is excited with current to produce electromagnetic force. Two or more phases work together by alternating between positively energized, deenergized, and negatively energized states to rotate the stepper motor.

**quadrature phasing** – The electrical phase shift between channels A and B in a quadrature encoder.

**step angle** – The distance the motor rotates each full step of the stepper motor. Also defined as 360 degrees divided by the steps per revolution.



# NI Services and Support



NI has the services and support to meet your needs around the globe and through the application life cycle – from planning and development through deployment and ongoing maintenance. We offer services and service levels to meet customer requirements in research, design, validation, and manufacturing. Visit [ni.com/services](http://ni.com/services).

## Training and Certification

NI training is the fastest, most certain route to productivity with our products. NI training can shorten your learning curve, save development time, and reduce maintenance costs over the application life cycle. We schedule instructor-led courses in cities worldwide, or we can hold a course at your facility. We also offer a professional certification program that identifies individuals who have high levels of skill and knowledge on using NI products. Visit [ni.com/training](http://ni.com/training).

## Professional Services

Our NI Professional Services team is composed of NI applications and systems engineers and a worldwide National Instruments Alliance Partner program of more than 600 independent consultants and integrators. Services



range from start-up assistance to turnkey system integration. Visit [ni.com/alliance](http://ni.com/alliance).

## OEM Support

We offer design-in consulting and product integration assistance if you want to use our products for OEM applications. For information about special pricing and services for OEM customers, visit [ni.com/oem](http://ni.com/oem).



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We also offer service programs that provide automatic upgrades to your application development environment and higher levels of technical support. Visit [ni.com/ssp](http://ni.com/ssp).

## Hardware Services

### System Assurance Programs

NI system assurance programs are designed to make it even easier for you to own an NI system. These programs include configuration and deployment services for your NI PXI, CompactRIO, or Compact FieldPoint system. The NI Basic System Assurance Program provides a simple integration test and ensures that your system is delivered completely assembled in one box. When you configure your system with the NI Standard System Assurance Program, you can select from available NI system driver sets and application development environments to create customized, reorderable software configurations. Your system arrives fully assembled and tested in one box with your software preinstalled. When you order your system with the standard program, you also receive system-specific documentation including a bill of materials, an integration test report, a recommended maintenance plan, and frequently asked question documents. Finally, the standard program reduces the total cost of owning an NI system by providing three years of warranty coverage and calibration service. Use the online product advisors at [ni.com/advisor](http://ni.com/advisor) to find a system assurance program to meet your needs.

### Calibration Services

NI recognizes the need to maintain properly calibrated devices for high-accuracy measurements. We provide manual calibration procedures, services to recalibrate your products, and automated calibration software specifically designed for use by metrology laboratories. Visit [ni.com/calibration](http://ni.com/calibration).

### Repair and Extended Warranty

NI provides complete repair services for our products. Express repair and advance replacement services are also available. We offer extended warranties to help you meet project life-cycle requirements. Visit [ni.com/services](http://ni.com/services).