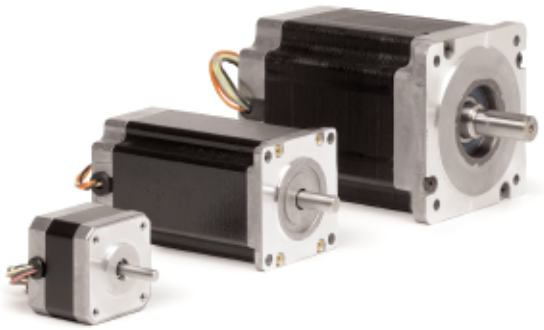
Stepper Motors and Encoders

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.

Specifications Contents

NATIONAL INSTRUMENTS™

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

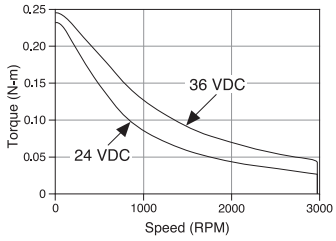
Operating temperature	-20 to 40 °C
Shaft load (20,000 hours at 1,500 rpm)	
Radial	15 lb (6.8 kg) at shaft center
Axial push	6 lb (2.7 kg)
Axial pull	15 lb (6.8 kg)

NI Part Number	Manufacturer Part Number	Dual Shaft	Drive	Amps/Phase	Holding Torque oz-in. (N · m)	Rotor Inertia oz-in.-s² (kg-m² x10⁻³)	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	✓									

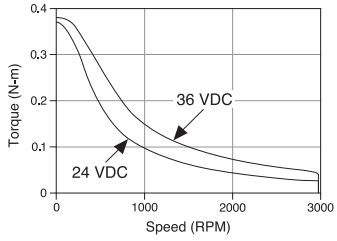
Rated current is per phase, with the motor mounted, and winding temperature rise ΔT = 90 °C.
Resistance is with winding at 20 °C.

Torque versus Speed

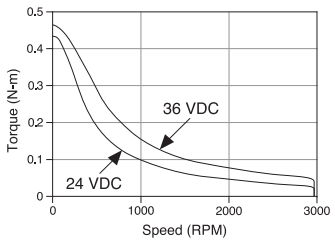
780067-01 and 780068-01
Torque versus Speed at 1.0 A



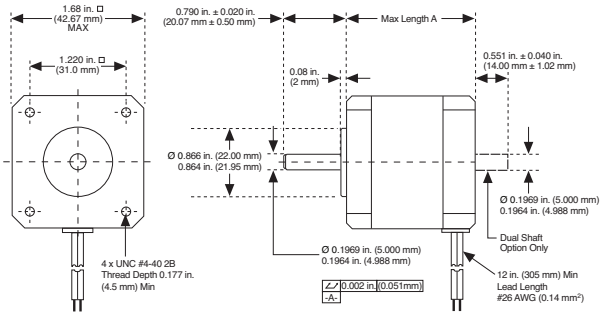
780069-01 and 780070-01
Torque versus Speed at 1.1 A

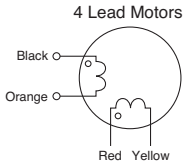


780071-01 and 780072-01
Torque versus Speed at 1.0 A



Dimensions and Wiring





Phase	Color
A-	Orange
A+	Black
B-	Yellow
B+	Red

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	✓		

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

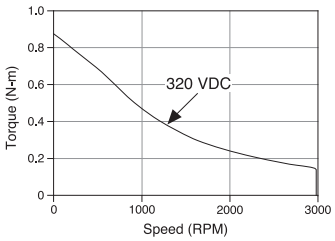
Physical

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

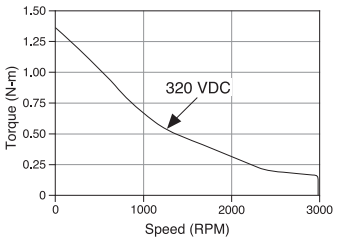
NI Part Number	Manufacturer Part Number	Dual Shaft	Drive	Amps/Phase	Holding Torque oz-in. (N · m)	Rotor Inertia oz-in.-s² (kg-m² x10⁻³)	Phase Inductance mH	Phase Resistance Ω ±10%	Detent Torque oz-in. (N · m)	Thermal Resistance °C/watt	Max Speed rpm
780073-01	T21NRLC-LNN-NS-00	–	P70360	0.40	180 (1.27)	0.0034 (0.0248)	209	42.9	2.97 (0.021)	4.64	3000
780074-01	T21NRLC-LDN-NS-00	✓									
780075-01	T22NRLC-LNN-NS-00	–		0.46	280 (1.98)	0.0056 (0.0408)	209	41.4	5.95 (0.042)	3.69	3000
780076-01	T22NRLC-LDN-NS-00	✓									
780077-01	T23NRLC-LNN-NS-00	–		0.67	380 (2.68)	0.0084 (0.0612)	136	23.5	6.94 (0.049)	3.04	3000
780078-01	T23NRLC-LDN-NS-00	✓									
780079-01	T21NRLH-LNN-NS-00	–	P70530	2.7	180 (1.27)	0.0034 (0.0248)	4.6	0.85	2.97 (0.021)	4.64	3000
780080-01	T21NRLH-LDN-NS-00	✓									
780081-01	T22NRLG-LNN-NS-00	–		2.5	280 (1.98)	0.0056 (0.0408)	7.1	1.23	5.95 (0.042)	3.69	3000
780082-01	T22NRLG-LDN-NS00	✓									
780083-01	T23NRLH-LNN-NS00	–		3.0	380 (2.68)	0.0084 (0.0612)	6.2	1.00	6.94 (0.049)	3.04	3000
780084-01	T23NRLH-LDN-NS00	✓									

Torque versus Speed

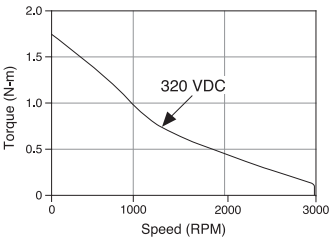
780073-01 and 780074-01
Torque versus Speed at 0.36 A



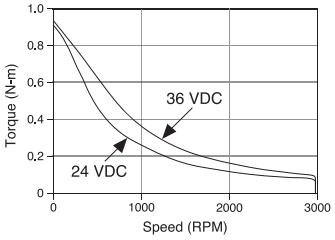
780075-01 and 780076-01
Torque versus Speed at 0.40 A



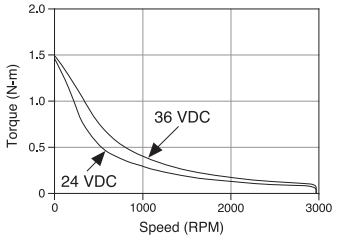
780077-01 and 780078-01
Torque versus Speed at 0.52 A



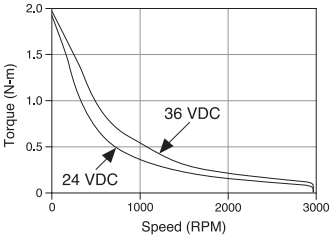
780079-01 and 780080-01
Torque versus Speed at 2.7 A



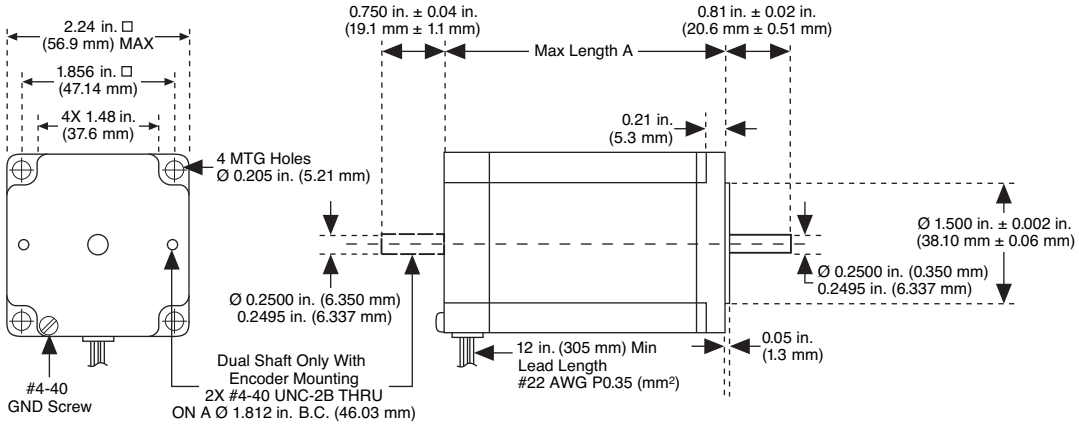
780081-01 and 780082-01
Torque versus Speed at 2.5 A

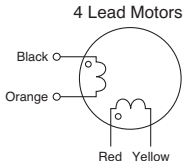


780083-01 and 780084-01
Torque versus Speed at 3.0 A



Dimensions and Wiring





Phase	Color
A-	Orange
A+	Black
B-	Yellow
B+	Red

NI Part Number	Manufacturer Part Number	Dual Shaft	Max Length A in. (mm)	Net Weight lb (kg)
780073-01	T21NRLC-LNN-NS-00	–	2.21 (56.1)	1.6 (0.7)
780074-01	T21NRLC-LDN-NS-00	✓		
780075-01	T22NRLC-LNN-NS-00	–	3.06 (77.7)	2.3 (1.0)
780076-01	T22NRLC-LDN-NS-00	✓		
780077-01	T23NRLC-LNN-NS-00	–	4.06 (103.1)	3.2 (1.5)
780078-01	T23NRLC-LDN-NS-00	✓		
780079-01	T21NRLH-LNN-NS-00	–	2.21 (56.1)	1.6 (0.7)
780080-01	T21NRLH-LDN-NS-00	✓		
780081-01	T22NRLG-LNN-NS-00	–	3.06 (77.7)	2.3 (1.0)
780082-01	T22NRLG-LDN-NS00	✓		
780083-01	T23NRLH-LNN-NS00	–	4.06 (103.1)	3.2 (1.5)
780084-01	T23NRLH-LDN-NS00	✓		

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

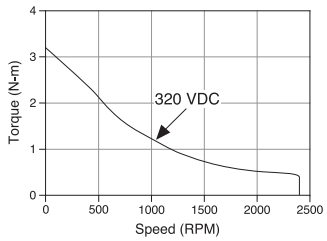
Physical

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

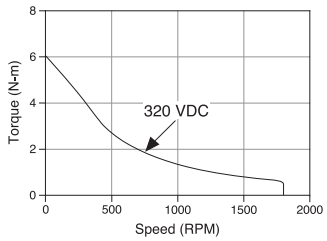
NI Part Number	Manufacturer Part Number	Dual Shaft	Drive	Amps/Phase	Holding Torque oz-in. (N · m)	Rotor Inertia oz-in.-s² (kg-m² x10⁻³)	Phase Inductance mH	Phase Resistance Ω ±10%	Detent Torque oz-in. (N · m)	Thermal Resistance °C/watt	Max Speed rpm
780085-01	N31HRLG-LNK-NS-00	–	P70360	0.86	641 (4.52)	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

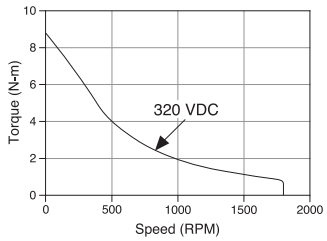
780085-01 and 780086-01
Torque versus Speed at 0.81 A



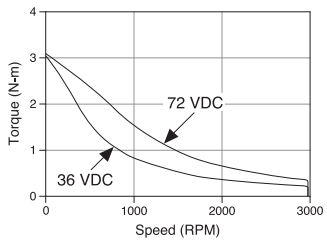
780087-01 and 780088-01
Torque versus Speed at 0.88 A



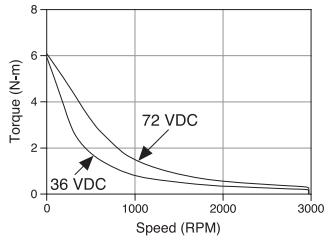
780089-01 and 780090-01
Torque versus Speed at 1.24 A



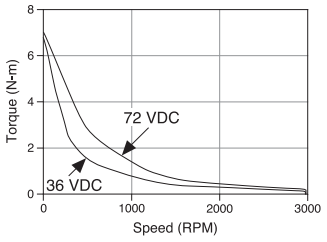
780091-01 and 780092-01
Torque versus Speed at 5 A



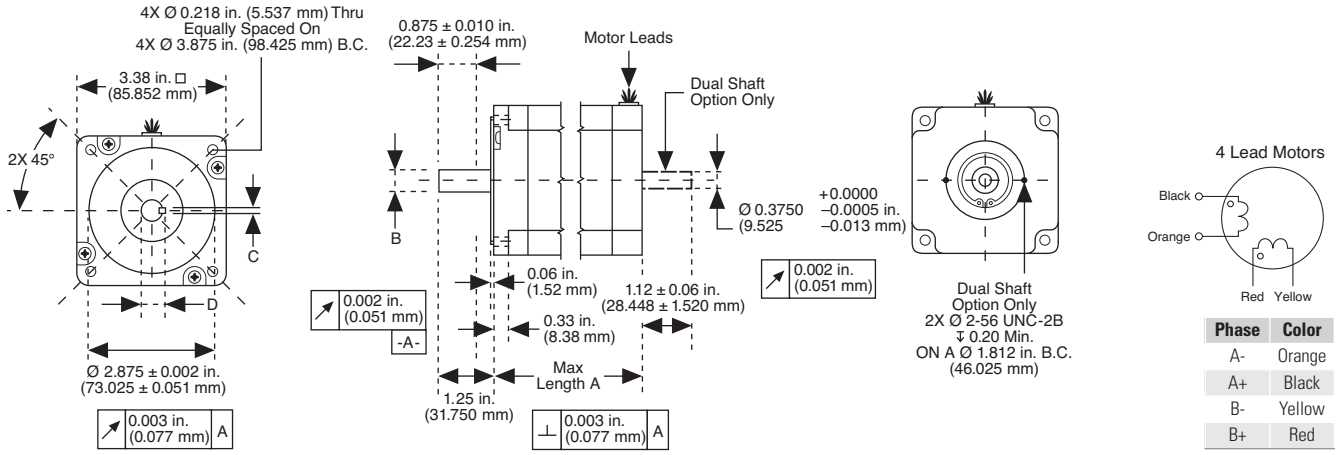
780093-01 and 780094-01
Torque versus Speed at 5 A



780095-01 and 780096-01
Torque versus Speed at 5 A



Dimensions and Wiring



Phase	Color
A-	Orange
A+	Black
B-	Yellow
B+	Red

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) 0.4995 (12.687)	0.1250 (3.175) 0.1230 (3.124)	0.555 (14.097) 0.538 (13.665)	5.0 (2.27)
780086-01	N31HRLG-LEK-M2-00	✓					
780087-01	N32HRLG-LNK-NS-00	–	4.65 (118.11)	0.5000 (12.700) 0.4995 (12.687)	0.1250 (3.175) 0.1230 (3.124)	0.555 (14.097) 0.538 (13.665)	8.4 (2.27)
780088-01	N32HRLG-LEK-M2-00	✓					
780089-01	N33HRLG-LNK-NS-00	–	6.13 (155.70)	0.6250 (15.875) 0.6245 (15.862)	0.1875 (4.763) 0.1855 (4.712)	0.705 (17.907) 0.688 (17.475)	11.9 (5.39)
780090-01	N33HRLG-LEK-M2-00	✓					
780091-01	N31HRHJ-LNK-NS-00	–	3.13 (79.502)	0.5000 (12.700) 0.4995 (12.687)	0.1250 (3.175) 0.1230 (3.124)	0.555 (14.097) 0.538 (13.665)	5.0 (2.27)
780092-01	N31HRHJ-LEK-M2-00	✓					
780093-01	N32HRHJ-LNK-NS-00	–	4.65 (118.11)	0.5000 (12.700) 0.4995 (12.687)	0.1250 (3.175) 0.1230 (3.124)	0.555 (14.097) 0.538 (13.665)	8.4 (2.27)
780094-01	N32HRHJ-LEK-M2-00	✓					
780095-01	N33HRHJ-LNK-NS-00	–	6.13 (155.70)	0.6250 (15.875) 0.6245 (15.862)	0.1875 (4.763) 0.1855 (4.712)	0.705 (17.907) 0.688 (17.475)	11.9 (5.39)
780096-01	N33HRHJ-LEK-M2-00	✓					

Encoders for NEMA 23 and NEMA 34 Motors

Electrical

Resolution	1000 counts/revolution
Input voltage	5 V ±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 (±18 deg) electrical
Quadrature phasing	90 deg (±22.5 deg) electrical
Minimum edge separation	67.5 deg electrical
Accuracy	Within 0.017 deg mechanical or 1 arc-minute from true position

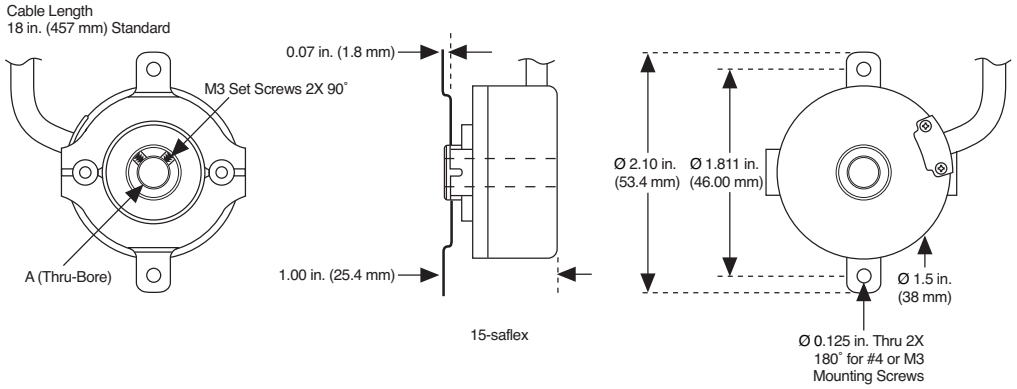
Industry Standards

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	±0.030 in. max
Starting torque	0.300 oz-in. (0.212 N · m)
Moment of inertia	6.7 x 10^{-5} oz-in.-sec^2 (4.8 gm-cm^2)
Max acceleration	1 x 10^5 rad/sec^2
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



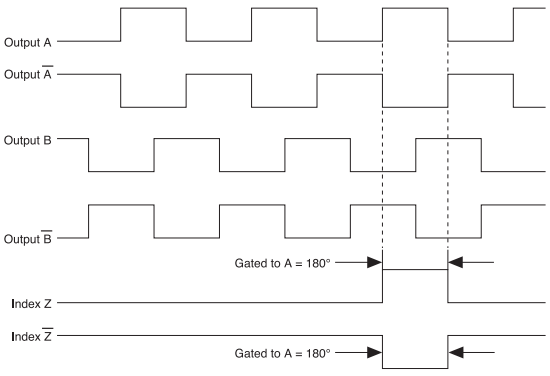
Note: All dimensions have a tolerance of ±0.005 in. or ±0.01 in. unless otherwise specified.

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	$\overline{A}$
4	Red	B
5	Green	$\overline{B}$
6	Orange	Z
7	Black	COM
8	Blue	$\overline{Z}$

Quadrature Waveform



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.

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