Stepping Motor Knowlege

Stepping motors are highly precise, digitally controlled motors that are able to provide reliable operation without using detectors to sense or indicate position. The operation of the motor is controlled through electrical pulses. The direction of current flowing through the windings of the motor is switched with each pulse. The electrical pulse is converted into shaft rotation in steps of a fixed angle. Together with the driver, it constitutes an open loop controlling system, which is of low cost and simple to construct.

Characteristics

Precise Position Control

The specified number of pulses determines the output degree(s) generated.

Linear Speed Selection

The running speed is linearly variable and determined by the frequency of the pulses.

Forward & Reverse, Pause and Holding Function

The forward & reverse rotation is controlled by the polarity. There is still holding torque even while the motor rotor is being locked. There is still current flowing through the motor winding, but no pulse signal creating rotation from the outside controller.

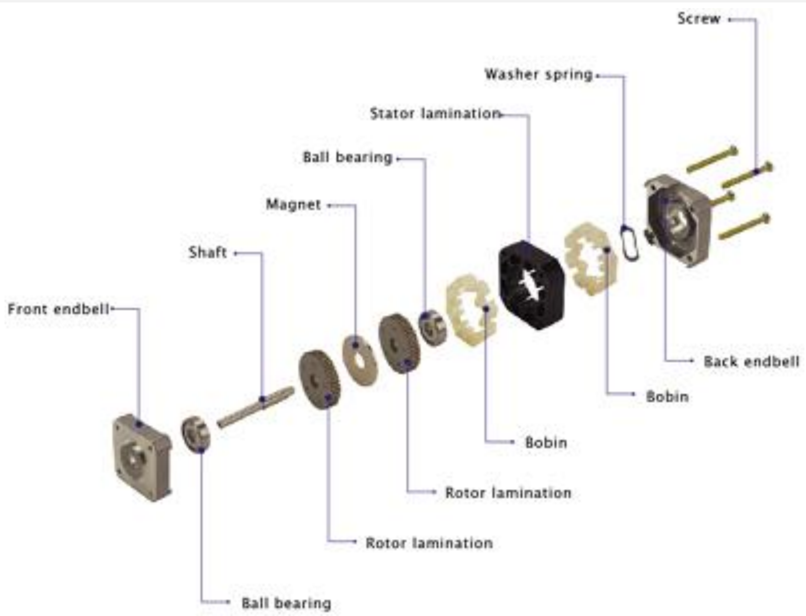
Low Speed Feature

Low frequency pulses being input, a stepping motor can operate at very low rotating speeds. This can be done without a speed reduction gearbox and thereby save power and maintain precision.

Long Life

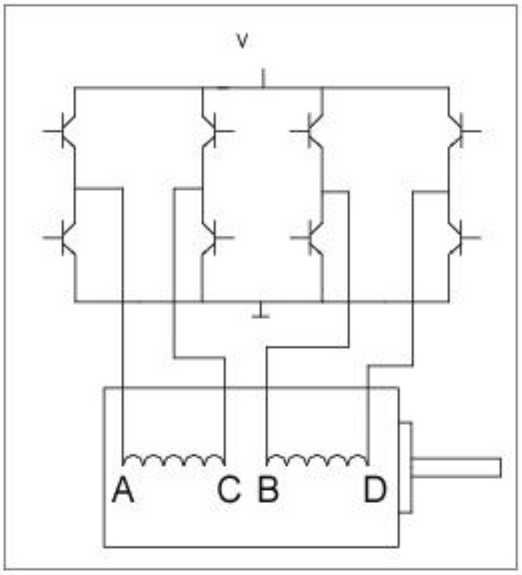
The brushless design provides stepping motors with a very long life. In fact, the stepping motor life is determined by the life of the bearings. Stepping motors are widely being used in many types of digitally controlled motion control applications, such as printers, intelligent (performance) stage lighting, office, bank and industrial equipment, medical, packaging, textile, aerospace, robotics and automotive.

Basic Structure



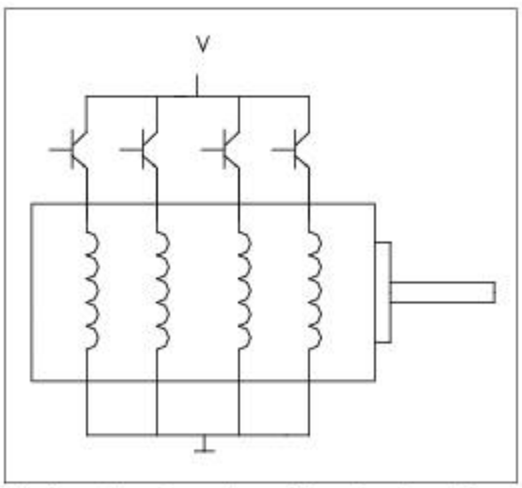
Operating Principles

The driver's internal logic circuit generates a series of pulses in a specified order that drive the stepping motor windings, causing the rotor to rotate forward, reverse, or lock in position. For example: a 2 phase 1.8 degree stepping motor normally is designed with two types of windings, i.e. 4-wire (bipolar) or 6-wire (unipolar).



4-wire stepping motor with bipolar driver

When energizing its coils by special sequence (see item 3 in page 9) , this motor will rotate 1.8 degree per step. On average, a 4-wire stepping motor provides, 40% more holding torque than a 6-wire stepping motor, because 100% of the winding is used in a bipolar drive.



6-wire stepping motor with unipolar driver

This is brief introduction to stepping motor operating principles. Various conditions and applications may need customized designs which we can provide.

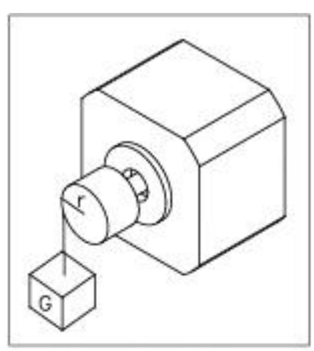
Accelerate

Type of Load

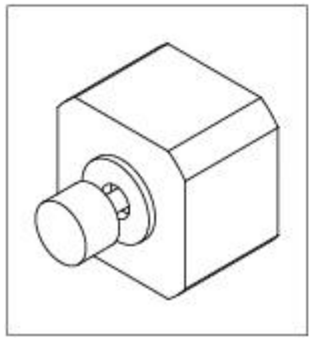
Generally speaking, motor load consists of torque and inertia load

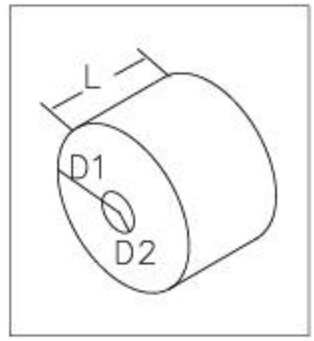
A.Torque load (Tf)

Tf=G*r
G: weight
r: radius



B.Inertia load (TJ)

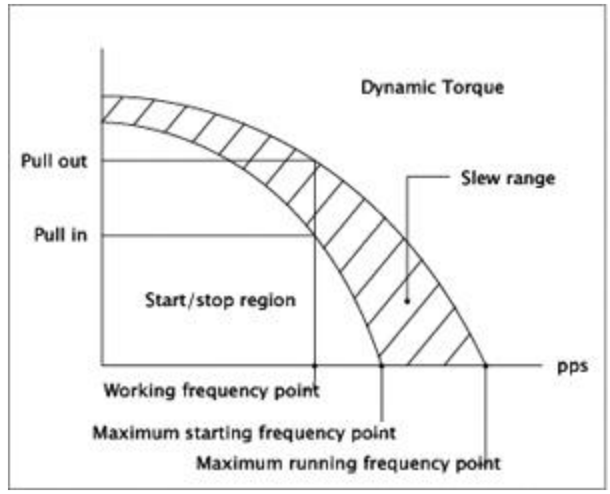




TJ:=J*dw/dt
J=M*(D12+D22)/8*(Kg* cm)
M:mass
D1:outside radius
D2:inside radius
dw/dt:angle acceleration

Explanation of the Dynamic Torque Curve

The dynamic torque curve is an important aspect of stepping motor's output performance.
The followings are some keyword explanations.



Keyword Explanation

1.Working Frequency Point: express the stepping motor's rotational speed value at this point. Units: Hz
n=0*Hz/(360*D)
n:rev/sec
Hz:the frequency value at this point
D:the subdividing value of motor driver
0:the step angle of stepping motor
E.g.: 1.8° stepping motor, in the condition of 1/2 subdividing (each step 0.9°) runs at 500Hz, its speed is 1.25r/s.

2.Start/Stop Region: the region in which a stepping motor can be directly started or stopped.

3.Slew Range: the motor cannot be started directly in this area. It must be started in the start/stop region first, and then accelerated to this area. In this area, the motor cannot be directly stopped, either. Otherwise this will lead to losing-step. The motor must be decelerated back to the start/stop region before it can be stopped.

4.Maximum starting frequency point: at this point, the stepping motor can reach its maximum starting speed under unloaded condition.

5.Maximum running frequency point: at this point, the stepping motor can reach its maximum running speed under an unloaded condition.

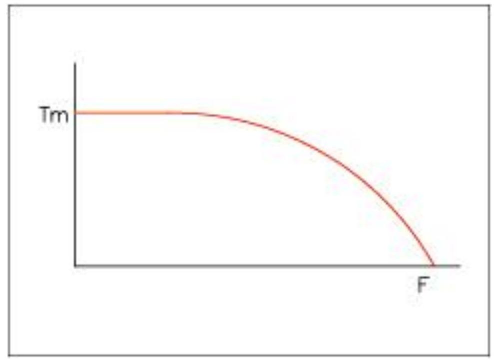
6.Pull-in Torque: the maximum dynamic torque value that a stepping motor can load directly at the particular operating frequency point.

7.Pull-out Torque: the maximum dynamic torque value that a stepping motor can load at the particular operating frequency point when the motor has been started. Because of the inertia of rotation, the Pull-Out Torque is always larger than the Pull-In Torque.

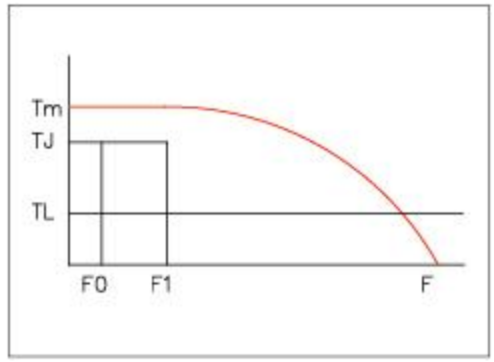
Control of Acceleration and Deceleration

How to accelerate or decelerate in the shortest time is most important when the system's operating frequency point is in the slew range of the dynamic torque curve graph.

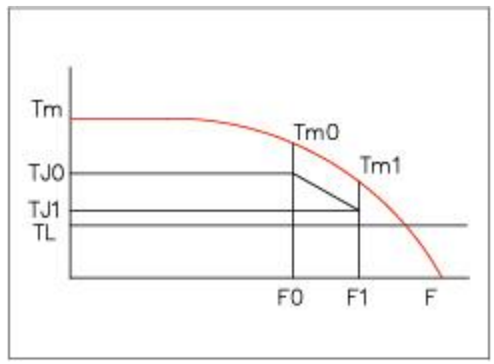
It is shown by the following graph: the dynamic torque's performance of stepping motor will always keep a horizontal straight line in low speed. But in high speed, the curve will slope down quickly influenced by the inductance.



(1)Accelerated Motion of Straight Line
Motor's load value is known as TL, it has to be accelerated from F0 to F1 in the shortest time(tr), what is the value of tr? What is the value of pulse frequency of the acceleration F(t)?
A. Generally TJ=70% Tm
B. tr=1.8*10-5*J*0* (F1-F0)/(TJ-TL)
C. F (t)=(F1-F0)*t/tr+F0, 0<t<tr



(2)Exponential Acceleration
A. Generally TJ0=10%Tm0, TJ1=70%Tm1,
TL = 60%Tm1
B. tr=F4*ln[(TJ0-TL)/(TJ1-TL)]
C. F(t)=F2*[1-e^(-t/F4)]+F0, 0<t<tr
F2=(TL-TJ0)* F1-F0)/(FJ1-TJ0)
F4=1.8*105*J*0*F2/(TJ0-TL)



Note: J is the torque inertia of motor rotor plus its load.
0 is the angle of each step, it equals to the step angle of stepping motor when motor runs in full step. As for the control of deceleration, it can be realized by turning the accelerate pulse frequency above-mentioned.

Reduction of Vibration and Noise

In a non-loading condition, stepping motors may appear to have vibration or even lose steps when the motor is running at or close to resonant frequency.

Solutions for These Conditions

A. Having the motor operate outside of this range.
B. By adopting the micro-step driving method, you can divide one step into multiple steps thereby reducing the vibration. Micro-step is used for increasing a motor's step resolution. This is accomplished by controlling the motor's phase current ratio. Micro-step does not increase step accuracy. However, it will allow a motor to run more smoothly and with less noise. When the motor runs in half step mode, the motor torque will be 15% less than running in full step mode. If the motor is controlled by sine wave current, the motor torque will be reduced by 30%.

How to order

1. Hybrid Stepping Motor

(1).Size

Motor outside dimension in tenths of an inch (EX: Size 17=1.7" Dia)

(2).Type of Stepping Motor

HA: High Torque 0.9°
HE: Standard Torque 3.6°
HD: High Torque1.8° (for Type 17)
HC: High Torque 1.2°
HY: Standard Torque1.8°
HS: High Torque1.8° (for Type 23)

(3).Motor Length (mm)

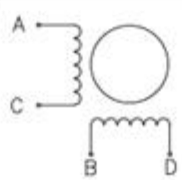
Type \ Length	0	1	2	3	4	5	6	7
11HS				39.5		50.3		
14HY					34	26		20
16HY	34	38						20
16HYXXN					34			
17HAXXN	28				34			
17HD	34	40		48		25		
17HDXXN		40		34		50		
17HE					34			
23HY	40	51	55					
23HS	41	50	54	76	45			
24HC			55.5	79.5				
34HY	63	91	130					
34HS	60.4	93	125.5					

(4).Number of lead wires: 4 wires, 5 wires, 6 wires, 0 indicates connector only
(5).Electric Variation: Variety of resistance and inductance
(6).Mechanical Variation: Variety of shaft and lead wires.

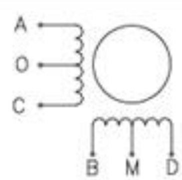
2. General Specifications

Step Accuracy	+/-5%
Temperature Rise	80°C MAX
Insulation Resistance	100M ohm MIN. 500V DC
Dielectric Strength	500V AC 1 min
Radial PlayMAX(450g)	0.02mm MAX(450g)
End PlayMAX(450g)	0.08mm MAX(450g)
Insulation Class	B

3. Winding Diagram and Switching Sequence



STEP	A	B	C	D
1	+	+	–	–
2	–	+	+	–
3	–	–	+	+
4	+	–	–	+



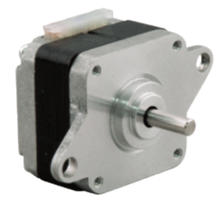
STEP	A	B	C	D	O	M
1	–	–			+	+
2		–	–		+	+
3			–	–	+	+
4	–			–	+	+

4. Outline Drawing and Data Sheet

1.11HS	
2.14HY	
3.16HY	NEW
4.16HY7	20mm super low profile design
5.16HYXXN	Superior in efficiency and precision.
6.16HY7001-11	Linear actuator,
7.17HA	0.9 degree step angle NEMA 17 hybrid stepping motor series
8.17HD	1.8 degree NEMA 17, high torque designed hybrid stepping motor series,Worm shaft motor 25mm super low profile design
9.17HD4001N	Superior in efficiency and precision
10.17HD5	NEW
11.17HDXXN	
12.17HE	
13.23HY	NEW
14.23HS	
15.24HC	NEW
16.34HY	
17.34HS	
18.43HS	

10HF 2-PHASE 3.75°

Key Features



- Low Inertia
- Low Noise
- Small Size

General Specifications

Bi-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
10HF7402-02	84	18	0.143	12	1.70	3	0.42	2	0.01

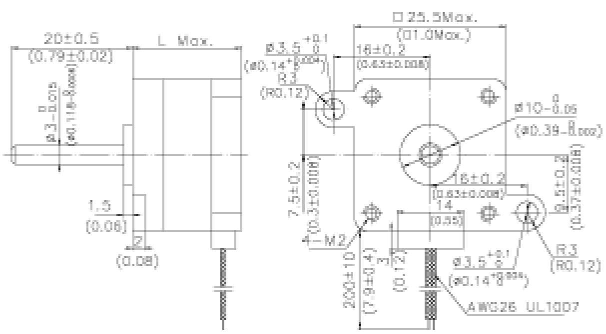
Uni-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
10HF7602-03	42	4.5	0.2	8	1.13	3	0.42	2	0.01

Wiring Diagram

Mechanical Dimensions

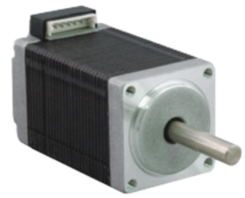
Model Number	L	Mass
	mm(in.)	kg(lb.)
10HF7**	18.5(0.72)	0.045(0.10)



11HS 2-PHASE 1.8°

Key Features

- High Accuracy
- Low Intertia
- Small Size



General Specifications

Bi-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
11HS1005	40	27.8	0.3	69	9.77	5	0.71	9	0.05
11HS1006	5.6	4.3	0.67	60	8.50	5	0.71	9	0.05
11HS1007	10.4	7.6	0.5	50	7.08	5	0.71	9	0.05
11HS1008	2.5	2.2	1	50	7.08	5	0.71	9	0.05
11HS3005	6.8	6.0	0.67	90	12.75	6	0.85	12	0.07
11HS5005	12	12	0.5	100	14.16	8	1.13	18	0.10
11HS5007	51.8	30.7	0.25	95	13.46	8	1.13	18	0.10
11HS5008	3.5	2.3	1	100	14.16	8	1.13	18	0.10
11HS5009	9.2	5.4	0.67	110	15.58	8	1.13	18	0.10

Uni-Polar

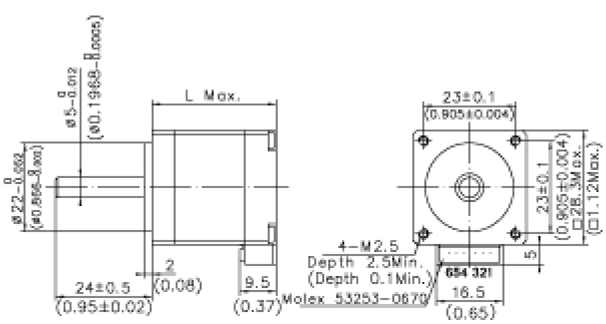
Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
11HS1003	2.8	1.3	0.95	48	6.80	5	0.71	9	0.05
11HS1009	40	12	0.25	32	4.53	5	0.71	9	0.05

11HS1010	9.4	3	0.5	32	4.53	5	0.71	9	0.05
11HS3002-01	3.4	1.6	0.95	65	9.21	6	0.85	12	0.07
11HS5002-01	4.6	2.3	0.95	90	12.75	8	1.13	18	0.10
11HS5003	12	6.3	0.5	80	11.33	8	1.13	18	0.10
11HS5010	2.6	0.9	1	70	9.92	8	1.13	18	0.10

Wiring Diagram

Mechanical Dimensions

Model Number	L	Mass
	mm(in.)	kg(lb.)
11HS1**	31(1.21)	0.10(0.22)
11HS3**	40(1.56)	0.15(0.33)
11HS5**	51(2.01)	0.20(0.44)



14HA 2-PHASE 0.9°

Key Features

- High Accuracy
- Low Intertia
- Small Size

General Specifications

Bi-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
14HA0001N	23	18	0.4	100	14.16	10	1.42	14	0.08
14HA0004N	6.6	6	0.6	85	12.04	10	1.42	14	0.08

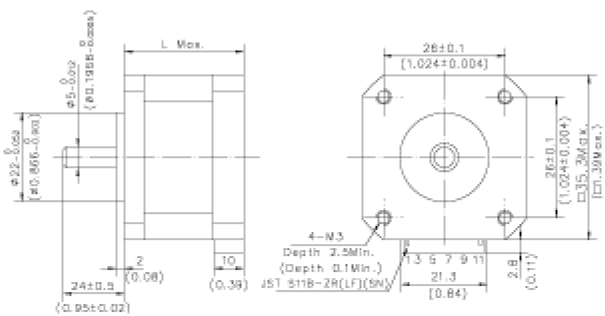
Uni-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
14HA0005N	6.6	2.7	0.6	70	9.92	10	1.42	14	0.08
14HA0006N	23	9	0.4	70	9.92	10	1.42	14	0.08

Wiring Diagram

Mechanical Dimensions

Model Number	L	Mass
	mm(in.)	kg(lb.)
14HA0**N	28(1.10)	0.16(0.35)



14HY 2-PHASE 1.8°

Key Features

■Low Intertia

■Small Size

■High Acceleration

General Specifications

Bi-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
14HY5010	9	8	0.4	60	8.50	10	1.42	12	0.07
14HY8002	5.5	5	0.85	100	14.16	15	2.12	20	0.11

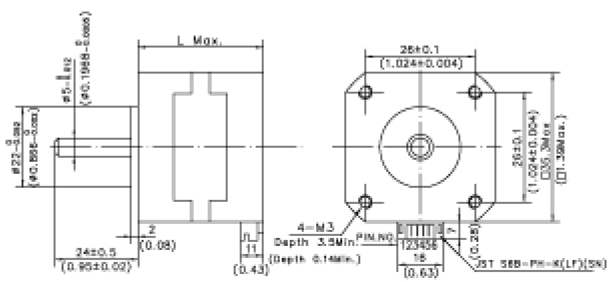
Uni-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
14HY5011	9	4.2	0.4	45	6.37	10	1.42	12	0.07
14HY8001	2.7	1.4	1.2	80	11.33	15	2.12	20	0.11

Wiring Diagram

Mechanical Dimensions

Model Number	L	Mass
	mm(in.)	kg(lb.)
14HY5**	26(1.01)	0.15(0.33)
14HY8**	37(1.44)	0.21(0.46)



16HS 2-PHASE 1.8°

Key Features

- ■High Torque
- ■High Accuracy
- ■Smooth Movement

General Specifications

Bi-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
16HS4401N	7	9.6	0.65	200	28.33	15	2.12	30	0.17

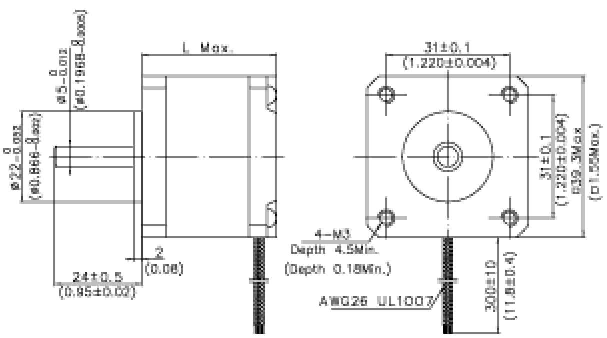
Uni-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
16HS4601N	7	5.6	0.65	150	21.25	15	2.12	30	0.17

Wiring Diagram

Mechanical Dimensions

Model Number	L	Mass
	mm(in.)	kg(lb.)
16HS4**N	36(1.40)	0.21(0.46)



16HY 2-PHASE 1.8°

Key Features

- High Accuracy
- Low Inertia
- High Acceleration

General Specifications

Bi-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
16HY0016	39	50	0.3	150	21.25	12	1.70	20	0.11
16HY1005-04	9.8	18	0.5	200	28.33	18	2.55	24	0.13
16HY7010	14	12.2	0.5	80	11.33	5	0.71	11	0.06

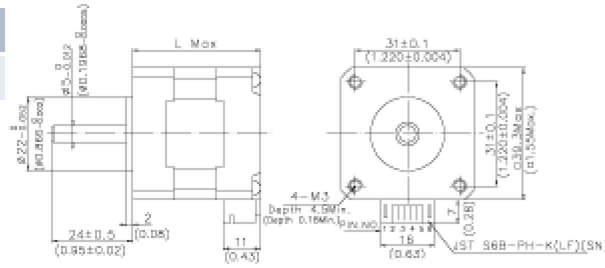
Uni-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
16HY0017	39	23.5	0.3	100	14.16	12	1.70	20	0.11
16HY1006	10.2	10.7	0.5	160	22.66	18	2.55	24	0.13
16HY7006-06	13.3	6.4	0.5	60	8.50	5	0.71	11	0.06

Wiring Diagram

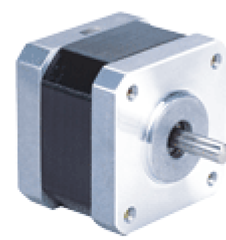
Mechanical Dimensions

Model Number	L	Mass
	mm(in.)	kg(lb.)
16HY0**	33.3(1.30)	0.18(0.40)
16HY1**	38.0(1.48)	0.20(0.44)
16HY7**	20.0(0.78)	0.12(0.26)



17HA 2-PHASE 0.9°

Key Features



- High Accuracy
- Low Noise
- Smooth Movement

General Specifications

Bi-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
17HA0403-44N	8	11	0.43	90	12.75	8	1.13	20	0.11
17HA4401-05N	3.1	3.6	0.87	180	25.50	12	1.70	38	0.21
17HA4402-16N	20	23	0.5	220	31.16	12	1.70	38	0.21
17HA7402-06	6.6	7	0.65	70	9.92	5	0.71	15	0.08

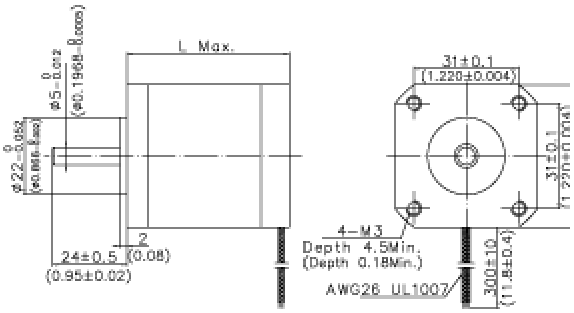
Uni-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
17HA0601N	8	4	0.43	50	7.08	8	1.13	20	0.11
17HA4605N	3.1	2.3	0.87	160	22.66	12	1.70	38	0.21
17HA4606N	20	13	0.5	200	28.33	12	1.70	38	0.21
17HA7602	6.6	2.9	0.65	30	4.25	5	0.71	15	0.08

Wiring Diagram

Mechanical Dimensions

Model Number	L	Mass
	mm(in.)	kg(lb.)
17HA0**N	28(1.10)	0.19(0.42)
17HA4**N	34.3(1.35)	0.23(0.51)
17HA7**	20(0.79)	0.12(0.26)



17HD 2-PHASE 1.8°

Key Features

- ■High Torque
- ■Low Noise
- ■Small Size

General Specifications

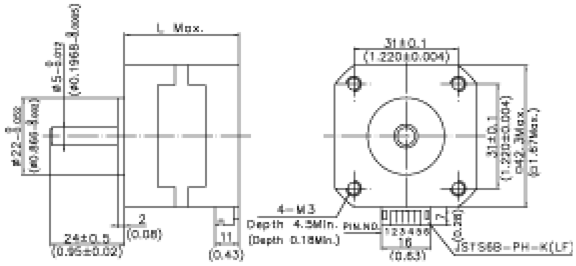
Bi-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
17HD0013	30	27	0.4	260	36.83	12	1.70	38	0.21
17HD1004-01	25	50	0.5	400	56.66	15	2.12	57	0.31
17HD3005-10	30	45	0.4	460	65.16	25	3.54	82	0.45
17HD5003-10	24	36	0.4	180	25.50	5	0.71	20	0.11

Wiring Diagram

Mechanical Dimensions

Model Number	L	Mass
	mm(in.)	kg(lb.)
17HD0**	33.3(1.30)	0.21(0.46)
17HD1**	39.3(1.53)	0.28(0.62)
17HD3**	47.3(1.84)	0.36(0.79)
17HD5**	25.3(0.99)	0.15(0.33)



17HDN 2-PHASE 1.8°

Key Features

- ■High Torque
- ■High Accuracy
- ■Smooth Movement

General Specifications

Bi-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
17HD2011N	1.9	4	1.50	360	50.99	15	2.12	57	0.31
17HD2015N	18	35	0.60	420	59.49	15	2.12	57	0.31
17HD2018N	6	14	0.85	400	56.66	15	2.12	57	0.31
17HD2022N	16	32	0.50	330	46.74	15	2.12	57	0.31
17HD2023N	3.5	5	1	280	39.66	15	2.12	57	0.31
17HD2024N	4.1	8.5	1	365	51.70	15	2.12	57	0.31
17HD2025N	66	116	0.25	350	49.58	15	2.12	57	0.31
17HD2026N	4.4	10	1	400	56.65	15	2.12	57	0.31
17HD2027N	71.4	140	0.25	380	53.82	15	2.12	57	0.31
17HD2028N	60	120	0.28	330	46.74	15	2.12	57	0.31
17HD4005-01N	7.4	11	0.40	160	22.66	12	1.70	38	0.21
17HD4022-01N	3.0	4.2	1.10	210	29.75	12	1.70	38	0.21
17HD4024N	15	20	0.50	198	28.05	12	1.70	38	0.21
17HD4025N	54	78	0.25	230	32.58	12	1.70	38	0.21
17HD4026N	80	89	0.22	200	28.33	12	1.70	38	0.21
17HD4027N	48	30	0.28	200	28.33	12	1.70	38	0.21
17HD6012N	2.4	4	1.50	490	69.41	25	3.54	82	0.45
17HD6016N	5.3	8.4	1	410	58.07	25	3.54	82	0.45
17HD6017N	7.5	14	0.85	430	60.91	25	3.54	82	0.45
17HD6018N	14	23	0.57	420	59.49	25	3.54	82	0.45
17HD6019N	80	130	0.25	450	63.74	25	3.54	82	0.45

17HD6020N	20	35	0.50	490	69.41	25	3.54	82	0.45
17HD6021N	60	90	0.28	430	60.91	25	3.54	82	0.45
17HDB001N	2.3	4.6	1.50	630	89.24	30	4.25	123	0.68
17HDB002N	1.6	3	2	650	92.07	30	4.25	123	0.68

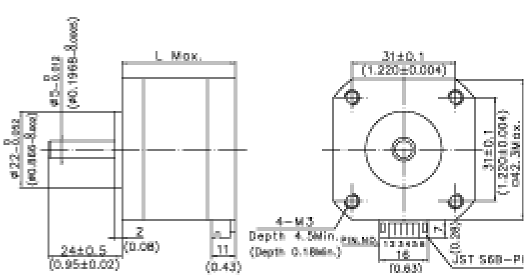
Uni-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cm^	oz-in^
17HD2032N	1.8	1.7	1.4	230	32.58	15	2.12	57	0.31
17HD2033N	7.5	6.9	0.8	260	36.83	15	2.12	57	0.31
17HD4028N	8.3	5.8	0.6	155	21.95	12	1.70	38	0.21
17HD4029N	3	2.1	1	160	22.66	12	1.70	38	0.21
17HD4030N	2.4	2	1.2	200	28.33	12	1.70	38	0.21
17HD4031N	4.2	2.2	0.95	160	22.66	12	1.70	38	0.21
17HD4032N	24	13	0.4	160	22.66	12	1.70	38	0.21
17HD4033N	38.5	21	0.31	160	22.66	12	1.70	38	0.21
17HD6022N	3.3	2.8	1.2	320	45.33	25	3.54	82	0.45
17HD6023N	4.6	4	1	320	45.33	25	3.54	82	0.45
17HD6024N	30	21.6	0.4	300	42.49	25	3.54	82	0.45
17HD6025N	7.5	7.3	0.8	360	50.99	25	3.54	82	0.45
17HD6026N	2.4	2.2	1.4	330	46.74	25	3.54	82	0.45
17HDB003N	2.3	2.4	1.5	420	59.49	30	4.25	123	0.68
17HDB004N	1.6	1.6	2	450	63.74	30	4.25	123	0.68

Wiring Diagram

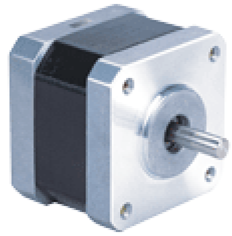
Mechanical Dimensions

Model Number	L	Mass
	mm(in.)	kg(lb.)
17HD2**N	39.8(1.57)	0.28(0.62)
17HD4**N	34.3(1.35)	0.21(0.46)
17HD6**N	48.3(1.90)	0.36(0.79)
17HDB**N	62.8(2.47)	0.60(1.32)



17HE 2-PHASE 3.6°

Key Features



- ■Low Inertia
- ■Low Noise
- ■High Acceleration

General Specifications

Bi-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
17HE1401-01	12	9.4	0.58	80	11.33	15	2.12	20	0.11
17HE1402-01	150	100	0.16	80	11.33	15	2.12	20	0.11
17HE1403-01	0.85	0.7	2.5	90	12.74	15	2.12	20	0.11

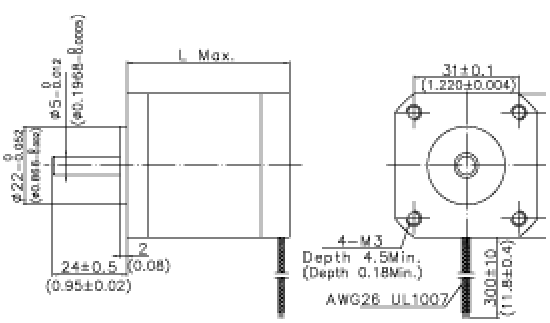
Uni-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
17HE1603-02	75	35	0.2	60	8.50	15	2.12	20	0.11
17HE1604-02	50	25	0.25	60	8.50	15	2.12	20	0.11
17HE1606-02	12	5.5	0.58	60	8.50	15	2.12	20	0.11

Wiring Diagram

Mechanical Dimensions

Model Number	L	Mass
	mm(in.)	kg(lb.)
17HE**	34.3(1.35)	0.2(0.44)



23HM 2-PHASE 1.8°

Key Features

■Low Noise

■Low Inertia

■High Acceleration

General Specifications

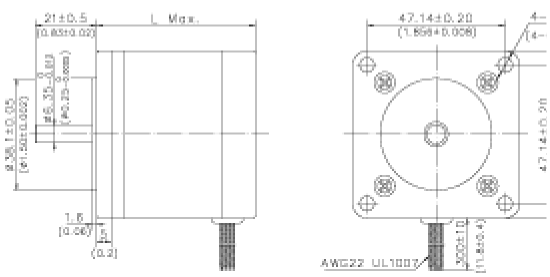
Bi-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
23HM0401-01	1.8	3.2	1.5	420	59.49	25	3.54	100	0.55
23HM0402-01	0.85	1.5	2.2	420	59.49	25	3.54	100	0.55
23HM1402-01	2.6	5.6	1.5	650	92.07	45	6.37	175	0.96
23HM1403-01	1.2	2.6	2.2	650	92.07	45	6.37	175	0.96
23HM2403-01	1.4	3.1	2.2	900	127.48	52	7.37	210	1.16
23HM2404-01	0.7	1.65	3.1	900	127.48	52	7.37	210	1.16
23HM4401-01	1.7	4.7	2.2	1250	177.05	88	12.46	360	1.98
23HM4402-01	0.85	2.4	3.1	1250	177.05	88	12.46	360	1.98

Wiring Diagram

Mechanical Dimensions

Model Number	L	Mass
	mm(in.)	kg(lb.)
23HM0**	40(1.56)	0.36(0.79)
23HM1**	51(1.99)	0.52(1.14)
23HM2**	55(2.15)	0.60(1.32)
23HM4**	76(2.96)	0.90(1.98)



23HS 2-PHASE 1.8°

Key Features

- High Torque
- High Accuracy
- Smooth Movement

General Specifications

Bi-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
23HS0402-02	1.2	2.3	2.1	500	70.82	22	3.12	135	0.74
23HS0403-02	2.8	7	1.3	500	70.82	22	3.12	135	0.74
23HS0404-01	0.75	1.75	2.5	500	70.82	22	3.12	135	0.74
23HS0406	1.6	4.3	1.5	500	70.82	22	3.12	135	0.74
23HS0411	0.65	1.3	2	390	55.22	22	3.12	135	0.74
23HS0412	11.4	22.4	0.71	480	67.97	22	3.12	135	0.74
23HS0413	4.3	10	1	500	70.82	22	3.12	135	0.74
23HS1407	2.7	7	1.5	850	120.40	32	4.53	220	1.21
23HS1408	1.5	3.7	2	850	120.40	32	4.53	220	1.21
23HS2403	2	6.4	2	1100	155.81	40	5.66	260	1.43
23HS2409-01	0.85	2.7	3	810	114.73	40	5.66	260	1.43
23HS2416-03	1.0	3.1	2.6	1000	141.64	40	5.66	260	1.43
23HS2420-01	1.54	4.6	1.8	900	127.48	40	5.66	260	1.43
23HS2428	0.62	2	2.8	900	127.48	40	5.66	260	1.43
23HS2434	14	43	0.7	1000	141.64	40	5.66	260	1.43
23HS2438	5.6	20.4	1.15	1100	155.81	40	5.66	260	1.43
23HS2443	3.4	9.2	1.5	1000	141.64	40	5.66	260	1.43
23HS3409	1	3.36	3	1650	233.71	70	9.91	460	2.53
23HS3431-02	1.2	4	2.8	1650	233.71	70	9.91	460	2.53
23HS3432-02	2	7.5	2.1	1650	233.71	70	9.91	460	2.53
23HS3434	4.2	17	1.4	1650	233.71	70	9.91	460	2.53
23HS3442	7.9	27	1	1500	212.46	70	9.91	460	2.53
23HS3443	17.2	62	0.71	1650	233.71	70	9.91	460	2.53
23HS4401-09	1.0	2.4	2.4	700	99.15	28	3.96	180	0.99
23HS4402	0.65	1.6	3	700	99.15	28	3.96	180	0.99
23HS4404	1.7	4.2	2.1	750	106.23	28	3.96	180	0.99
23HS5402-08	0.5	2.2	6	2500	354.11	120	17.00	750	4.13
23HS5408	2	7.2	3	2700	382.44	120	17.00	750	4.13

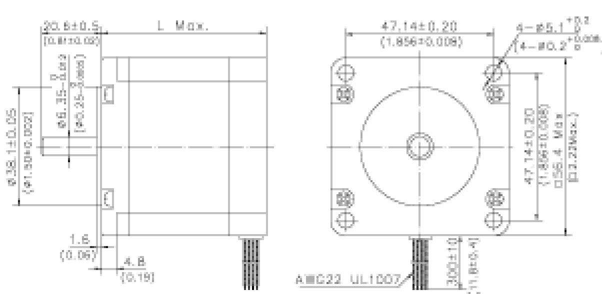
Uni-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
23HS0603	1.4	1.4	2	400	56.66	22	3.12	135	0.74
23HS0605	4.9	5.6	1	420	59.49	22	3.12	135	0.74
23HS0609	0.6	0.5	3	400	56.66	22	3.12	135	0.74
23HS0611	2.2	2.1	1.5	420	59.49	22	3.12	135	0.74
23HS1602	1.65	2.47	2.1	700	99.12	32	4.53	260	1.43
23HS1604	6.3	12	0.8	680	96.29	32	4.53	220	1.21
23HS1605	2.75	4	1.2	560	79.32	32	4.53	220	1.21
23HS1606	1	1.4	3	700	99.12	32	4.53	260	1.43
23HS2602-03	0.75	1.12	3	900	127.48	40	5.66	260	1.43
23HS2603-06	1.8	2.7	2	900	127.48	40	5.66	260	1.43
23HS2611-03	7.4	11.5	1	900	127.48	40	5.66	260	1.43
23HS2619	3.4	5.5	1.5	900	127.48	40	5.66	260	1.43
23HS3604-02	4.1	6.7	1.5	1300	184.14	70	9.91	460	2.53
23HS3605-06	2.25	4.8	2	1350	191.22	70	9.91	460	2.53
23HS3606-04	1	2.1	3	1200	169.97	70	9.91	460	2.53
23HS3607-01	8.6	15	1	1200	169.97	70	9.91	460	2.53
23HS5604	1	2	4.3	2000	283.29	120	17.00	760	4.13

Wiring Diagram

Mechanical Dimensions

Model Number	L	Mass
	mm(in.)	kg(lb.)
23HS0**	41(1.61)	0.42(0.93)
23HS1**	50(1.97)	0.55(1.21)
23HS2**	54(2.13)	0.60(1.32)
23HS3**	76(2.99)	1.00(2.20)
23HS4**	45(1.77)	0.48(1.06)
23HS5**	111(4.37)	1.50(3.30)



23HY 2-PHASE 1.8°

Key Features

- High Accuracy
- Low Inertia
- High Acceleration

General Specifications

Bi-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
23HY0407-01	1.5	2.5	1.5	310	43.91	18	2.55	55	0.30
23HY0414	3.5	6.4	1	320	45.33	18	2.55	55	0.30
23HY1411	4.5	12.2	1	630	89.24	35	4.96	120	0.66
23HY1403-01	2.4	5.6	1.4	540	76.49	35	4.96	120	0.66
23HY2416	7	14.5	1	730	103.40	42	5.95	145	0.80
23HY2417	3	6.4	1.5	700	99.15	42	5.95	145	0.80

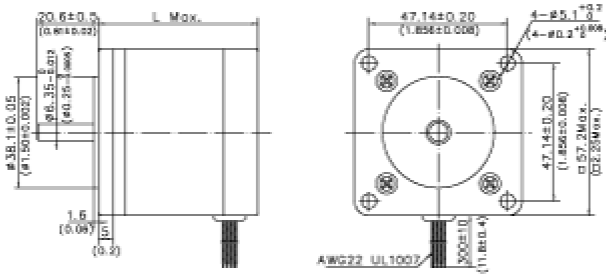
Uni-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
23HY0601	1.5	1.5	1.5	300	42.49	18	2.55	55	0.30
23HY0602	3.6	3.6	1	300	42.49	18	2.55	55	0.30
23HY1602	2.4	3.5	1.4	500	70.82	35	4.96	120	0.66
23HY1615-08	5	7.5	1	500	70.82	35	4.96	120	0.66
23HY2602	2.5	3	1.6	600	84.99	42	5.95	145	0.80
23HY2609	7	9.5	0.84	550	77.90	42	5.95	145	0.80

Wiring Diagram

Mechanical Dimensions

Model Number	L	Mass
	mm(in.)	kg(lb.)
23HY0**	40(1.56)	0.36(0.79)
23HY1**	51(1.99)	0.52(1.14)
23HY2**	55(2.15)	0.60(1.32)



23HS 2-PHASE 1.8°

Key Features

- High Torque
- High Accuracy
- Smooth Movement

General Specifications

Bi-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
23HS0402-02	1.2	2.3	2.1	500	70.82	22	3.12	135	0.74
23HS0403-02	2.8	7	1.3	500	70.82	22	3.12	135	0.74
23HS0404-01	0.75	1.75	2.5	500	70.82	22	3.12	135	0.74
23HS0406	1.6	4.3	1.5	500	70.82	22	3.12	135	0.74
23HS0411	0.65	1.3	2	390	55.22	22	3.12	135	0.74
23HS0412	11.4	22.4	0.71	480	67.97	22	3.12	135	0.74
23HS0413	4.3	10	1	500	70.82	22	3.12	135	0.74
23HS1407	2.7	7	1.5	850	120.40	32	4.53	220	1.21
23HS1408	1.5	3.7	2	850	120.40	32	4.53	220	1.21
23HS2403	2	6.4	2	1100	155.81	40	5.66	260	1.43
23HS2409-01	0.85	2.7	3	810	114.73	40	5.66	260	1.43
23HS2416-03	1.0	3.1	2.6	1000	141.64	40	5.66	260	1.43
23HS2420-01	1.54	4.6	1.8	900	127.48	40	5.66	260	1.43
23HS2428	0.62	2	2.8	900	127.48	40	5.66	260	1.43
23HS2434	14	43	0.7	1000	141.64	40	5.66	260	1.43
23HS2438	5.6	20.4	1.15	1100	155.81	40	5.66	260	1.43
23HS2443	3.4	9.2	1.5	1000	141.64	40	5.66	260	1.43
23HS3409	1	3.36	3	1650	233.71	70	9.91	460	2.53

23HS3431-02	1.2	4	2.8	1650	233.71	70	9.91	460	2.53
23HS3432-02	2	7.5	2.1	1650	233.71	70	9.91	460	2.53
23HS3434	4.2	17	1.4	1650	233.71	70	9.91	460	2.53
23HS3442	7.9	27	1	1500	212.46	70	9.91	460	2.53
23HS3443	17.2	62	0.71	1650	233.71	70	9.91	460	2.53
23HS4401-09	1.0	2.4	2.4	700	99.15	28	3.96	180	0.99
23HS4402	0.65	1.6	3	700	99.15	28	3.96	180	0.99
23HS4404	1.7	4.2	2.1	750	106.23	28	3.96	180	0.99
23HS5402-08	0.5	2.2	6	2500	354.11	120	17.00	750	4.13
23HS5408	2	7.2	3	2700	382.44	120	17.00	750	4.13

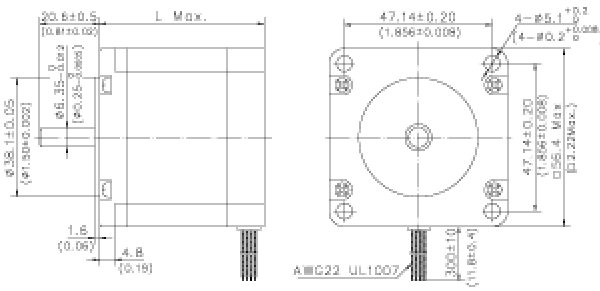
Uni-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
23HS0603	1.4	1.4	2	400	56.66	22	3.12	135	0.74
23HS0605	4.9	5.6	1	420	59.49	22	3.12	135	0.74
23HS0609	0.6	0.5	3	400	56.66	22	3.12	135	0.74
23HS0611	2.2	2.1	1.5	420	59.49	22	3.12	135	0.74
23HS1602	1.65	2.47	2.1	700	99.12	32	4.53	260	1.43
23HS1604	6.3	12	0.8	680	96.29	32	4.53	220	1.21
23HS1605	2.75	4	1.2	560	79.32	32	4.53	220	1.21
23HS1606	1	1.4	3	700	99.12	32	4.53	260	1.43
23HS2602-03	0.75	1.12	3	900	127.48	40	5.66	260	1.43
23HS2603-06	1.8	2.7	2	900	127.48	40	5.66	260	1.43
23HS2611-03	7.4	11.5	1	900	127.48	40	5.66	260	1.43
23HS2619	3.4	5.5	1.5	900	127.48	40	5.66	260	1.43
23HS3604-02	4.1	6.7	1.5	1300	184.14	70	9.91	460	2.53
23HS3605-06	2.25	4.8	2	1350	191.22	70	9.91	460	2.53
23HS3606-04	1	2.1	3	1200	169.97	70	9.91	460	2.53
23HS3607-01	8.6	15	1	1200	169.97	70	9.91	460	2.53
23HS5604	1	2	4.3	2000	283.29	120	17.00	760	4.13

Wiring Diagram

Mechanical Dimensions

Model Number	L	Mass
	mm(in.)	kg(lb.)
23HS0**	41(1.61)	0.42(0.93)
23HS1**	50(1.97)	0.55(1.21)
23HS2**	54(2.13)	0.60(1.32)
23HS3**	76(2.99)	1.00(2.20)
23HS4**	45(1.77)	0.48(1.06)
23HS5**	111(4.37)	1.50(3.30)



24HS 2-PHASE 1.8°

Key Features

■High Torque

■High Accuracy

■Smooth Movement

General Specifications

Bi-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
24HS1402N	0.73	1.6	2.8	870	123.23	40	5.66	280	1.54
24HS1403N	2.92	6.4	1.4	1060	150.14	40	5.66	280	1.54
24HS1404N	0.35	0.8	4	850	120.40	40	5.66	280	1.54
24HS2401-03N	1.1	3.4	2.8	1600	226.63	90	12.75	450	2.48
24HS2402N	0.43	1.1	4	1250	177.05	90	12.75	450	2.48
24HS2404N	4	13	1.4	1600	226.63	90	12.75	450	2.48
24HS3401N	1.1	3.1	2.8	1800	254.96	95	13.46	560	3.08
24HS3403N	4.4	14	1.4	1950	276.20	95	13.46	560	3.08
24HS5401N	0.65	2.4	4	2500	354.11	100	14.16	900	4.95
24HS5402N	1.49	6.5	2.8	2700	382.44	100	14.16	900	4.95
24HS5403N	5.96	25	1.4	2700	382.44	100	14.16	900	4.95

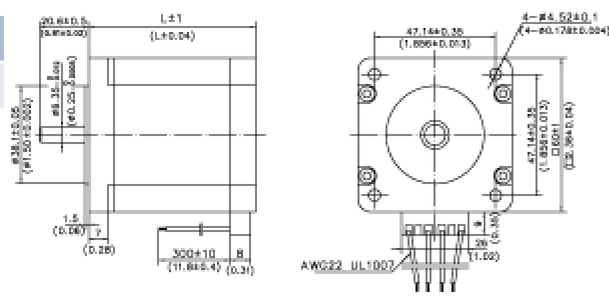
Uni-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
24HS1601N	5.7	6.8	1	740	104.82	40	5.66	280	1.54
24HS1603N	0.74	0.8	2.8	740	104.82	40	5.66	280	1.54
24HS1604N	1.46	1.8	2	740	104.82	40	5.66	280	1.54
24HS2601N	0.9	1.32	3	1130	160.06	90	12.75	450	2.48
24HS2602N	1.9	3	2	1130	160.06	90	12.75	450	2.48
24HS2607N	6.9	10.7	1	1100	155.81	90	12.75	450	2.48
24HS3601N	2.2	3.5	2	1500	212.46	95	13.46	560	3.08
24HS5601N	1.3	2.4	3	2100	297.45	100	14.16	900	4.95
24HS5602N	2.8	5.9	2	2100	297.45	100	14.16	900	4.95
24HS5604N	10	19.5	1	2100	297.45	100	14.16	900	4.95

Wiring Diagram

Mechanical Dimensions

Model Number	L	Mass
	mm(in.)	kg(lb.)
24HS1**	44(1.73)	0.60(1.32)
24HS2**	54(2.13)	0.83(1.83)
24HS3**	65(2.56)	1.05(2.31)
24HS5**	85(3.35)	1.40(3.09)



34HD 2-PHASE 1.8°

Key Features

- ■High Torque
- ■High Accuracy
- ■Smooth Movement

General Specifications

Bi-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
34HD0401	4.4	29.6	1.4	2800	396.60	150	21.25	1100	6.05
34HD0402	2	13.2	2.1	2800	396.60	150	21.25	1100	6.05
34HD0403	0.94	5.8	3.18	2800	396.60	150	21.25	1100	6.05
34HD0404	0.24	1.45	6.3	2800	396.60	150	21.25	1100	6.05
34HD1401	6.6	56	1.4	5600	793.20	250	35.41	1850	10.18
34HD1402	3	27	2.1	6200	878.19	250	35.41	1850	10.18
34HD1403	1.32	10.8	3.18	5600	793.20	250	35.41	1850	10.18
34HD1404	0.33	2.7	6.3	5600	793.20	250	35.41	1850	10.18
34HD2401	7.6	70.4	1.4	8400	1189.80	350	49.58	2750	15.13
34HD2402	1.94	17.6	2.8	8400	1189.80	350	49.58	2750	15.13
34HD2403	0.49	4.4	5.6	8400	1189.80	350	49.58	2750	15.13

Uni-Polar

Model Number	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
	ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
34HD0601	2.2	7.4	2	2100	297.45	150	21.25	1100	6.05
34HD0602	1	3.3	3	2100	297.45	150	21.25	1100	6.05
34HD0603	0.48	1.45	4.5	2100	297.45	150	21.25	1100	6.05
34HD1601	3.3	14	2	4300	609.07	250	35.41	1850	10.18
34HD1602	1.5	6	3	4300	609.07	250	35.41	1850	10.18
34HD1603	0.66	2.7	4.5	4300	609.07	250	35.41	1850	10.18
34HD2601	3.8	17.6	2	6400	906.52	350	49.58	2750	15.13
34HD2602	0.97	4.4	4	6400	906.52	350	49.58	2750	15.13

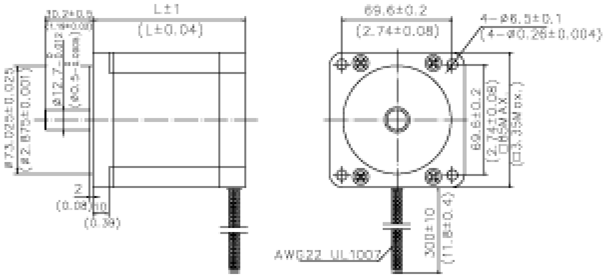
8-Leadwire

Model Number	Type of Connection	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
		ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
	Bi-polar Parallel	0.24	1.4	6.3	2800	396.60	150	21.25	1100	6.05
34HD0601	Bi-polar Series	0.96	5.6	3.18	2800	396.60	150	21.25	1100	6.05
	Uni-polar	0.48	1.4	4.5	2100	297.45	150	21.25	1100	6.05
	Bi-polar Parallel	0.33	2.7	6.3	5600	793.20	250	35.41	1850	10.18
34HD1601	Bi-polar Series	1.32	10.8	3.18	5600	793.20	250	35.41	1850	10.18
	Uni-polar	0.66	2.7	4.5	4300	609.07	250	35.41	1850	10.18
	Bi-polar Parallel	0.49	4.4	5.6	8400	1189.8	350	49.58	2750	15.13
34HD2601	Bi-polar Series	1.94	17.6	2.8	8400	1189.8	350	49.58	2750	15.13
	Uni-polar	0.97	4.4	4	6400	906.52	350	49.58	2750	15.13

Wiring Diagram

Mechanical Dimensions

Model Number	L	Mass
	mm(in.)	kg(lb.)
34HD0**	66.5(2.59)	1.6(3.52)
34HD1**	96(3.74)	2.7(5.94)
34HD2**	125.5(4.89)	3.8(8.36)



34HY 2-PHASE 1.8°

Key Features

- Low Noise
- Low Inertia
- High Acceleration

General Specifications

8-Leadwire

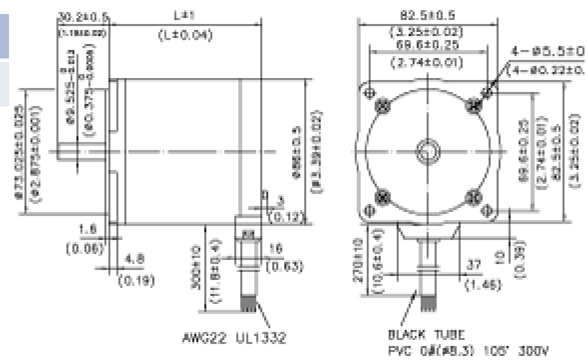
Model Number	Type of Connection	Resistance per Phase	Inductance per Phase	Rated Current	Holding Torque		Detent Torque		Rotor Intertia	
		ohm	mH	A	mNm	oz-in	mNm	oz-in	g.cmˆ	oz-inˆ
	Bi-polar Parallel	2.3	18	1.8	2300	326	120	16.99	560	3.08
34HY0809	Bi-polar Series	9.2	72	0.9	2300	326	120	16.99	560	3.08
	Uni-polar	4.6	18	1.3	1800	255	120	16.99	560	3.08
	Bi-polar Parallel	0.6	3.6	4.2	2300	326	120	16.99	560	3.08
34HY0810	Bi-polar Series	2.4	14.4	2.1	2300	326	120	16.99	560	3.08
	Uni-polar	1.2	3.6	3.0	1800	255	120	16.99	560	3.08
	Bi-polar Parallel	0.3	2.4	5.6	4000	566	210	29.74	1200	6.60
34HY1801-10	Bi-polar Series	1.2	9.6	2.8	4000	566	210	29.74	1200	6.60
	Uni-polar	0.6	2.4	4.0	3100	439	210	29.74	1200	6.60

	Bi-polar Parallel	0.8	6.7	3.9	4600	651	210	29.74	1200	6.60
34HY1803	Bi-polar Series	3.2	26.8	1.9	4600	651	210	29.74	1200	6.60
	Uni-polar	1.6	6.7	2.8	3500	496	210	29.74	1200	6.60
	Bi-polar Parallel	0.47	4.0	8.4	7800	1104	180	25.49	2100	11.55
34HY2801	Bi-polar Series	1.88	16	4.2	7800	1104	180	25.49	2100	11.55
	Uni-polar	0.94	4.0	6	6000	850	180	25.49	2100	11.55
	Bi-polar Parallel	0.19	1.6	9.4	5600	793	180	25.49	2100	11.55
34HY2802	Bi-polar Series	0.76	6.0	4.7	5600	793	180	25.49	2100	11.55
	Uni-polar	0.38	1.5	6.7	4300	609	180	25.49	2100	11.55

Wiring Diagram

Mechanical Dimensions

Model Number	L	Mass
	mm(in.)	kg(lb.)
34HY0**	63(2.48)	1.5(3.31)
34HY1**	91(3.58)	2.6(5.73)
34HY2**	130(5.12)	3.6(7.94)



34HD 2-PHASE 1.8°

Key Features

- High Torque
- High Accuracy
- Smooth Movement

General Specifications

Bi-Polar

Model	Length L(mm)	Step Angle (°)	Holding Torque (N.m)	Current (A/Phase)	Resistance (Ω)	Inductance (mH)	Rotor inertia ($g.cm^2$)	Weight (Kg)
HS43HB99-05	99	1.8	10	5	0.72	9.8	5500	5
HS43HB115-06	115		12	6	0.44	4.9	7200	6
HS43HB150-06	150		20	6	0.8	9.4	10900	8.4
HS43HB201-08	201		27	8	0.6	11	16200	11