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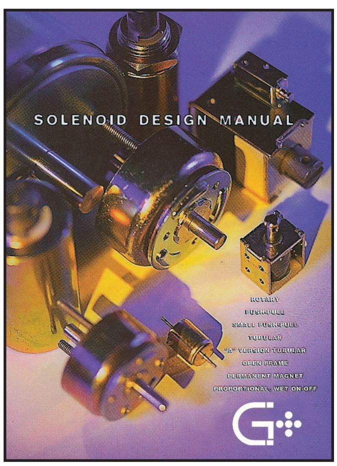
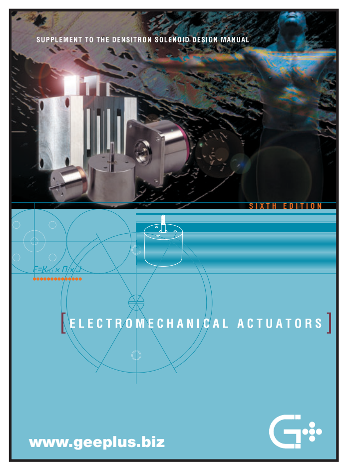
☐ Solenoid Design Manual ☐ Electro Mechanical Actuators

[Solenoid Design Manual]





[Electro Mechanical Actuators]

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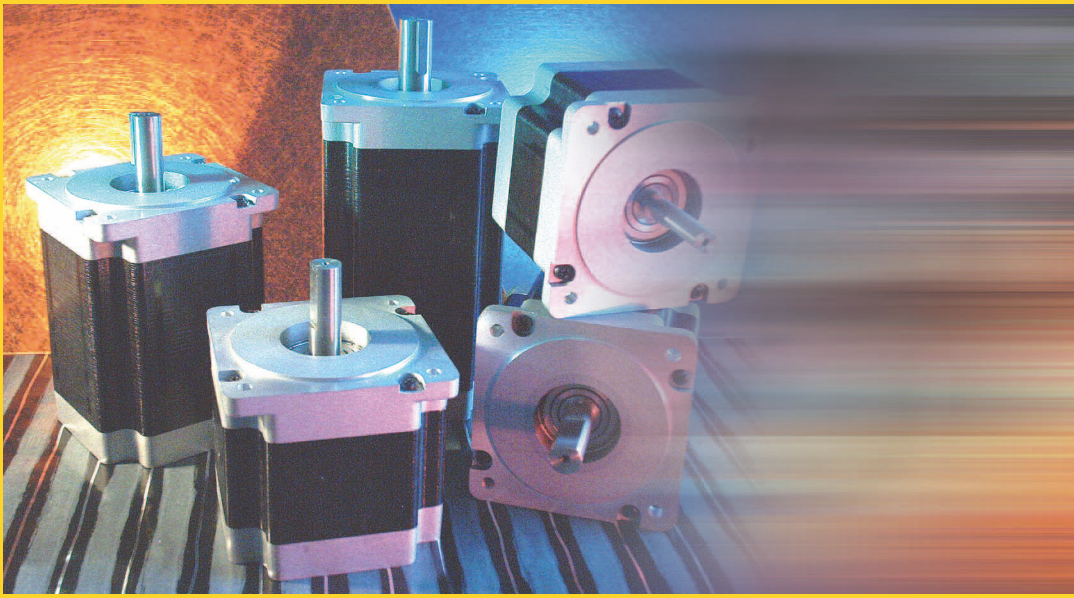

DSMH
series

high torque stepping motors for increased operating speed

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[Contents]

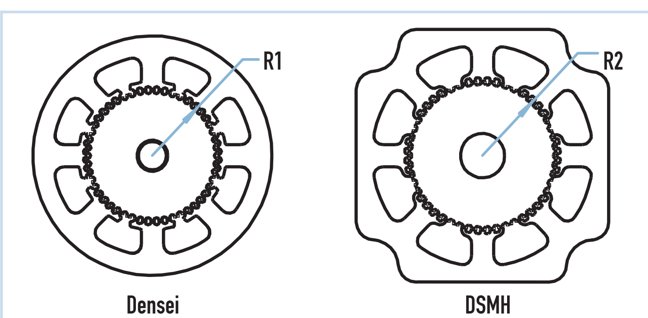
The DSMH series of high speed stepping motors are designed for maximum operating torque. The DSM57H employs a new lamination design which produces torque typically 50 - 100% greater than round bodied designs; high lamination rigidity reduces audible noise and vibration. The motors exhibit high torque and efficiency, and are suited to microstepping operation.

Key Features of DSMH Series Stepping Motors

Feature	Identifying Characteristics of Application	Example
High Torque/Acceleration Maximum benefit where load inertia >> rotor inertia	Heavy machine components Rapid change of speed and direction required	Pick & Place m/c, Engraving/marking m/c, X/Y plotters, Print & Apply label m/c
High Efficiency	Battery power supply, critical systems with back-up power, heat-sensitive products	Portable ticketing m/c, Blood analysis or chemical process equipment
Low Noise	Quiet environment or covert equipment	Medical equipment, Surveillance equipment
Low Vibration	Sensitive to mechanical disturbance	Optical measurement equipment
Microstepping Mode	High resolution required. Reduced noise required. Reduced vibration required	Special effects lighting, Test/measurement systems, Analytical/medical pumps
Heavy-Duty Shaft & Bearing Assy		High side load, Peristaltic pumps, Belt drive systems, Pinch drive systems

DSMH Series Stepping Motor Construction

The most important difference between the DSMH series motor and older stepping motor designs is the form of the rotor and stator laminations. The key differences are illustrated in the drawing below. The comparison is made against the lamination of a Densei motor; one of the best performing examples of the 'round bodied' older design.



The square format makes better use of the available space (dictated by flange dimensions) permitting a larger rotor diameter, some 20% larger than conventional round-bodied designs. This allows 6 teeth to be formed on each stator pole compared to 5 on most stator designs; combined with the large diameter, this increases the cross-sectional area of iron at the interface of rotor and stator teeth, allowing greater magnetic flux and hence attraction force for a given energisation. Because this force acts at a larger radius, mechanical leverage confers further torque advantage.

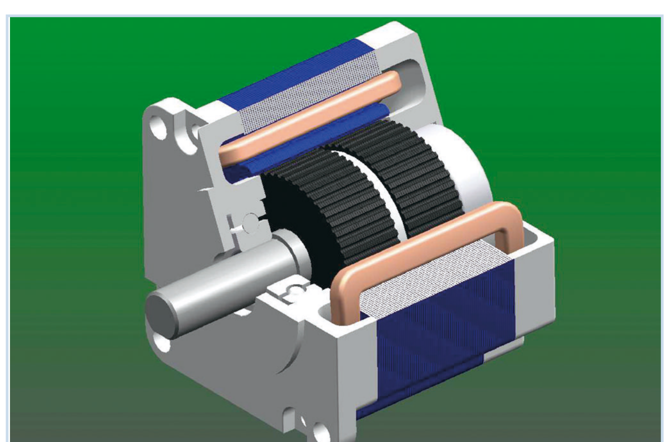
The square lamination form has better mechanical rigidity, and is less prone to excitation into radial mechanical oscillations, the main cause of audible noise produced by stepping motors.

Older designs employ external centring of the end housings on the outside diameter of the stator laminations. Rigidity of the end housings can also contribute to vibration problems. The DSMH series motors employ 'inner centring' where the end housing locates in the stator bore. Improved concentricity, due to inner centring, allows a smaller air gap to be maintained conferring better efficiency.

The use of a light press fit between the end housing and stator bore gives additional support to the stator to prevent radial oscillation, and further reducing mechanical noise - this is particularly beneficial to shorter motor lengths.

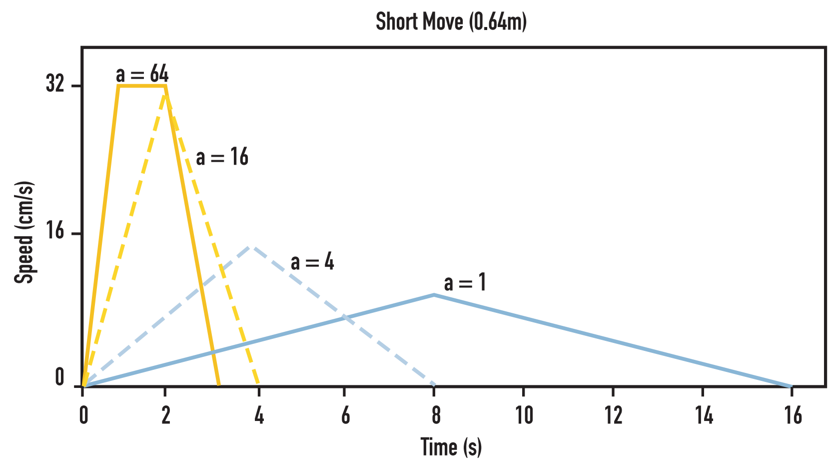
The profile of the rotor and stator teeth is optimised to give smooth operation, and to perform well when driven with microstepping excitation technique.

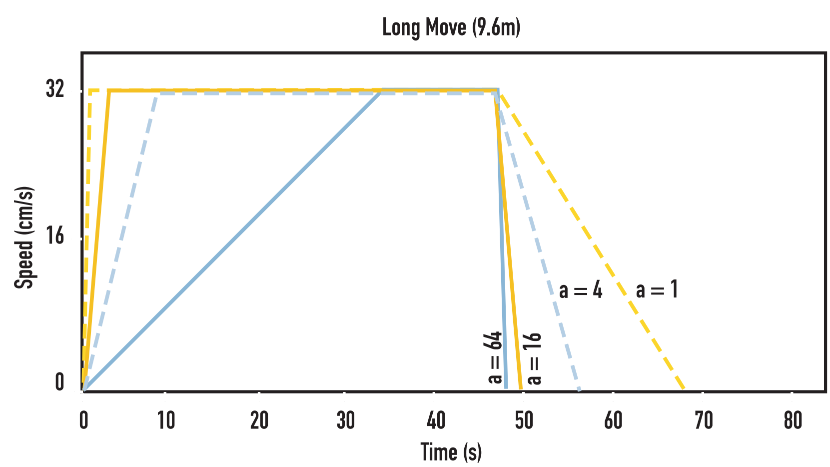
Large diameter shaft and bearings give the DSMH series high load bearing capacity.



[Acceleration and impact on cycle time]

In application where typical moves are short with frequent changes of direction or starts/stops, acceleration has a greater impact on cycle time than maximum speed; this is explained with reference to the graphs below.





In both cases, the maximum speed of the system is 32cm/s. In the case of a short move, the system may never reach this maximum speed, so acceleration is the limiting factor on the cycle time.

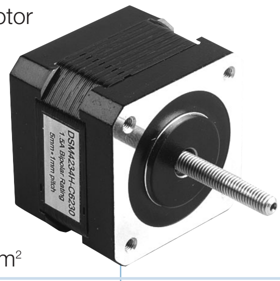
Cycle time of the system is inversely proportional to the square root of the acceleration. For short cycles where maximum speed is never achieved, the motor should be selected on the basis of the best acceleration performance. In order to achieve a reduction to x% of present cycle time, the acceleration must be increased by a factor of $10000/x^2$ (to reduce cycle to 70% of current time, acceleration must be increased by a factor of 10000/(70*70) = 2 approx). The maximum acceleration of a system is determined by the ratio of reserve torque (motor torque-static load torque) / total inertia (rotor inertia + load inertia).

Motors with small rotor diameter generally exhibit superior acceleration to those with large rotors. Some motors are built with hollow rotor lamination design to further reduce inertia - a compromise must be made between motor torque, and a low rotor inertia for fast acceleration capability.

The graph overleaf shows comparative acceleration capability of motors in G+'s DSMH series, with different loads attached. To determine which motor will give best dynamic performance, draw a vertical line corresponding to the moment of inertia of your load.

Leadscrew motor

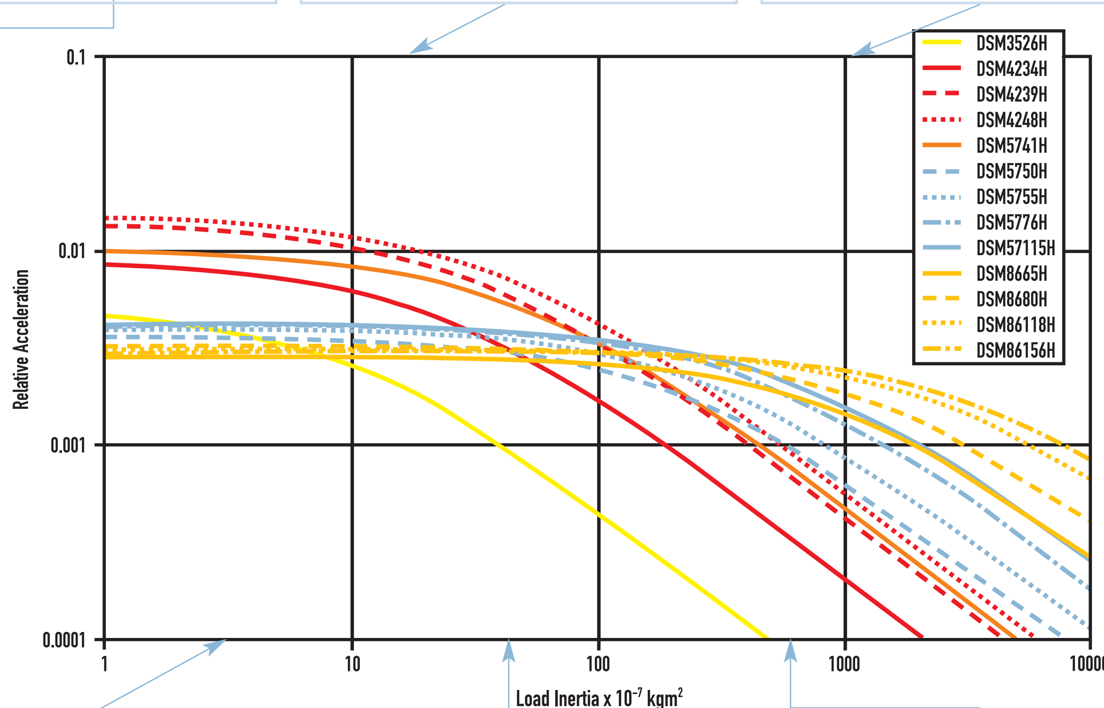
M5 leadscrew
30L



0.15 x 10^{-7} kgm^2

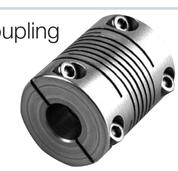
Leadscrew ø10 x 300L
Steel 23 x 10^{-7} kgm^2
(as fitted to hollow shaft motor)

Leadscrew ø25 x 300L
900 x 10^{-7} kgm^2



Shaft coupler
ø13 x 19L steel
4.2 x 10^{-7} kgm^2

Leadscrew and shaft coupling
ø10 x 300L
26 x 32L Aluminium
62 x 10^{-7} kgm^2



Steel Gear
ø40 x 20L
400 x 10^{-7} kgm^2

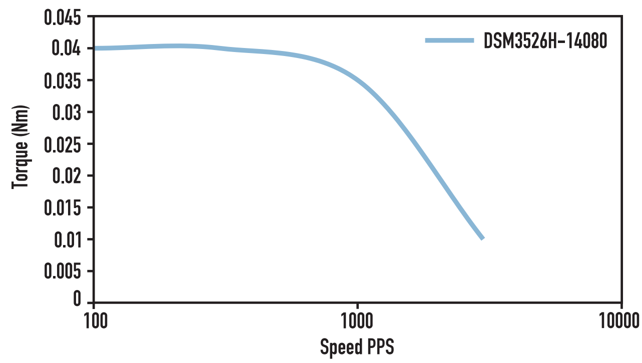
This is an approximate guide only, and is based on holding torque (running torque is generally slightly lower and reduces as speed is increased), and assumes a frictionless system with no static torque.

It is significant that the inertia region 10-100*10^{-7} corresponds closely to the inertia of typical shaft couplers. For leadscrew and other systems, this coupling inertia can be eliminated by the use of hollow shaft motors such as G+'s DSM5755H-08200, or of motors with leadscrew ground into the shaft itself.

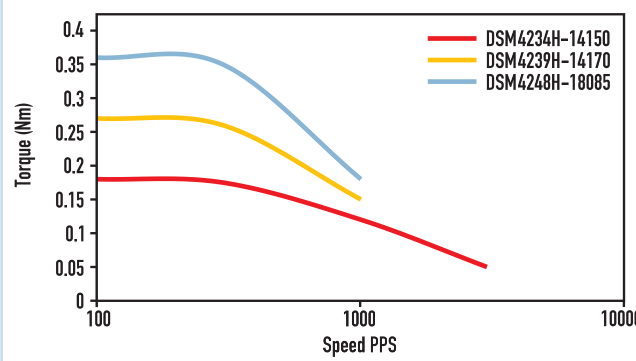
DSMH Series Motor Specifications

Insulation Resistance	**>100MΩ at 500VDC**
Dielectric Strength	**500VAC for 1 minute**
Step Angle	**1.8° +/-5%**

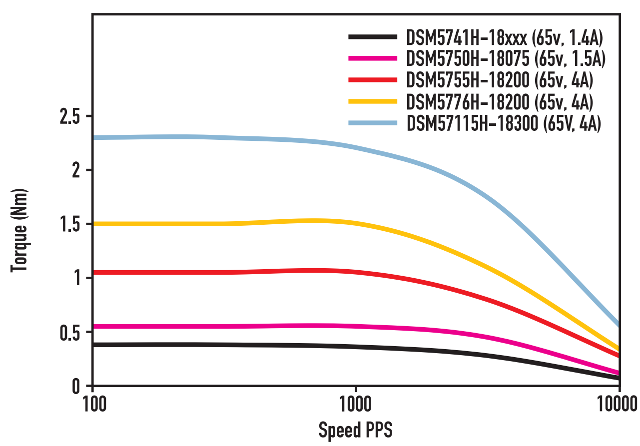
Part Number	Coil Resistance (Ω)	Coil Inductance (mH)	Nominal Current (A)	Holding Torque (Nm)	Detent Torque (Nm)	Rotor Inertia ($x10^{-6}kgm^2$)	Mass (kg)	Leadwires
DSM2030H-14060	6.5	1.7	0.6	0.018			0.06	450mm 28AWG
DSM2033H-14060	6.5	1.7	0.6	0.018			0.06	450mm 28AWG
DSM2832H-16065	2.8	1	0.65	0.058		0.9	0.11	300mm 26AWG
DSM2845H-16065	3.4	1.2	0.65	0.09		1.2	0.14	300mm 26AWG
DSM2851H-16065	4.6	1.4	0.65	0.11		1.8	0.2	300mm 26AWG
DSM3526H-14080	4	2.3	0.8	0.051		1	0.15	300mm 26AWG
DSM3526H-16040	4	2.3	0.4	0.055		1	0.15	300mm 26AWG
DSM4234H-x4040	30	32	0.4	0.25	<0.02	2.4	0.2	400mm 26AWG
DSM4234H-x4150	1.3	1.3	1.5	0.21	0.02	2.4	0.2	400mm 26AWG
DSM4239H-x4170	1.5	3.2	1.7	0.44	0.022	3.2	0.24	400mm 26AWG
DSM4248H-x8085	3	2.3	0.85	0.48	0.028	4.0	0.29	>400mm 26AWG
DSM5741H-x8070	5	35	0.7	0.55	0.025	12	0.5	500mm 22/24AWG
DSM5750H-x8075	5	30	0.75	0.8	0.03	15	0.65	500mm 22/24AWG
DSM5755H-x8200	0.7	3	2	1.15	0.04	28	0.75	500mm 22/24AWG
DSM5776H-x8100	4.0	12	1	1.85	0.08	44	1.15	500mm 22/24AWG
DSM5776H-x8200	1.0	4	2	1.85	0.08	44	1.15	500mm 22/24AWG
DSM57115H-18300	0.7	2	3	2.7	0.15	69	1.75	500mm 22/24AWG
DSM8665H-18220	1.5	4.1	2.2	2.9		100	2.0	300mm 22/24AWG
DSM8680H-18275	0.95	4.0	2.75	4.5		140	2.3	300mm 22/24AWG
DSM86118H-18300	1.4	7.4	3.0	8.5		270	3.8	300mm 22/24AWG
DSM86156H-18310	1.7	9.7	3.1	12		400	5.4	300mm 22/24AWG
DSM11099H-18275								
DSM110150H-18								



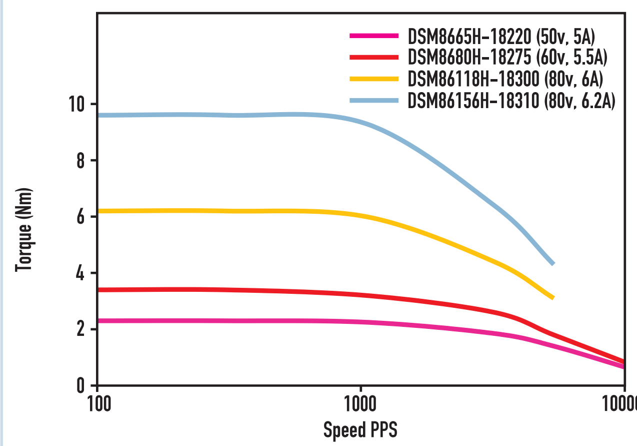
DSM3526H-14080, full step, 12v with Series Resistance



DSM42 characteristics, full step, 12v with series resistance



DSM57H characteristics, 1/2 step, Bipolar chopper



DSM86H characteristics, 1/2 step Bipolar chopper

P/N Construction and Interpretation

Part Numbers for the DSMH Series of stepping motors are composed as follows:

DSM	57	55	H	1	8	042
G+ Stepping Motor	Frame size (mm)	Frame length (mm)	High Torque	Shaft: 0=Noshft ext (hollow sht) 1=Single shaft front end 2=Double shaft 3=Single shaft rear end	Number of Leads	Nominal current

DSM2030H-14060

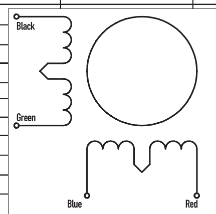
Step Angle	1.8°	
Holding Torque	18mNm	2.5oz-in
Current (RMS)	Bipolar	
	600mA	
Winding Resistance (Ω)	6.5	
Winding Inductance (mH)	1.7	
Detent Torque		
Insulation Class	Class B, 100M Ω	
Mass	60g	
Bearings	Ball Bearings Japan	

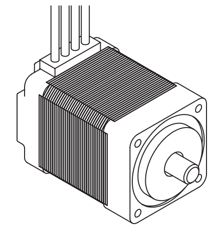
Label Details

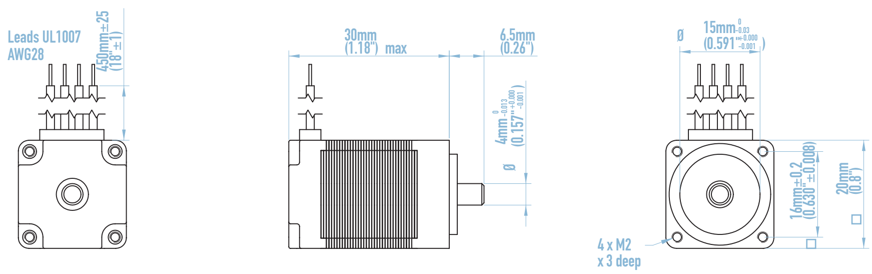
DSM2030H14060
BIPOLAR 600mA
Made in China

Direction of Rotation		Step	Black	Green	Blue	Red
CW ↑	CCW ↓	1	+	-	+	-
		2	+	-	OFF	OFF
		3	+	-	-	+
		4	OFF	OFF	-	+
		5	-	+	-	+
		6	-	+	OFF	OFF
		7	-	+	+	-
		8	OFF	OFF	+	-

Sequence shown is for half-step excitation. For full step excitation energise as steps 1,3,5,7







DSM2033H-14060

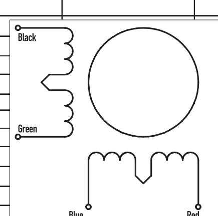
Step Angle	1.8°	
Holding Torque	18mNm	2.5oz-in
Current (RMS)	Bipolar	
	600mA	
Winding Resistance (Ω)	6.5	
Winding Inductance (mH)	1.7	
Detent Torque		
Insulation Class	Class B, 100M Ω	
Mass	60g	
Bearings	Ball Bearings Japan	

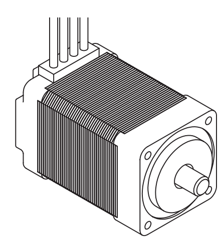
Label Details

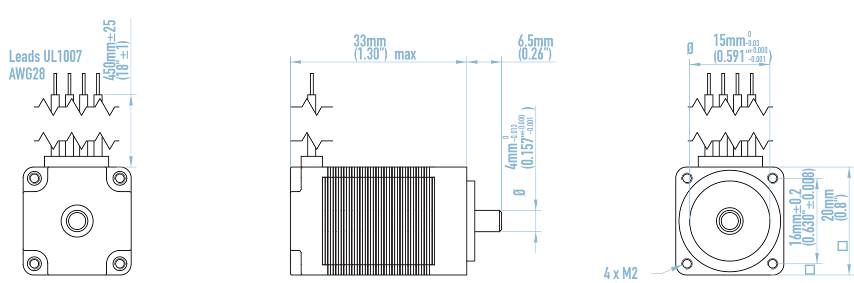
DSM2033H14060
BIPOLAR 600mA
Made in China

Direction of Rotation		Step	Black	Green	Blue	Red
CW ↑	CCW ↓	1	+	-	+	-
		2	+	-	OFF	OFF
		3	+	-	-	+
		4	OFF	OFF	-	+
		5	-	+	-	+
		6	-	+	OFF	OFF
		7	-	+	+	-
		8	OFF	OFF	+	-

Sequence shown is for half-step excitation. For full step excitation energise as steps 1,3,5,7







DSM2832H-16065

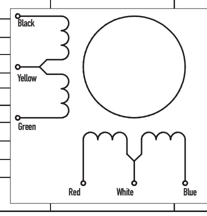
Step Angle Accuracy	±5			
Holding Torque (Bipolar)	58mNm		8oz-in	
Current (RMS)	Bipolar		Unipolar	
	0.9A		0.65A	
Winding Resistance (Ω)	2.8			
Winding Inductance (mH)	1			
Detent Torque				
Rotor Inertia (gcm²)	0.9			
Insulation Class	Class B, 100M			
Mass	110g			
Bearings				

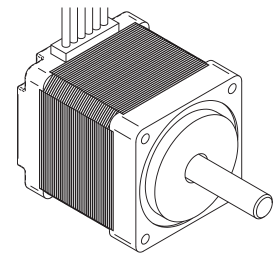
Label Details

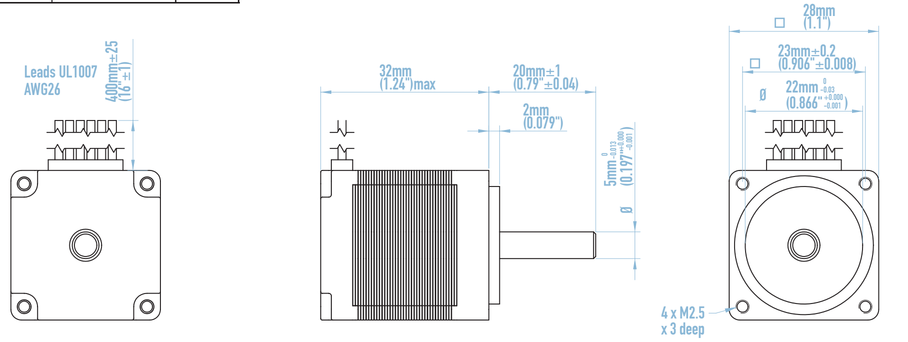
DSM2832H-16065
BIPOLAR 0.9A
UNIPOLAR 0.65A
Made in China

Direction of Rotation		Step	Yellow +VE		White +VE	
			Black	Green	Red	Blue
CW ↑	CCW ↓	1	ON	OFF	ON	OFF
		2	ON	OFF	OFF	OFF
		3	ON	OFF	OFF	ON
		4	OFF	OFF	OFF	ON
		5	OFF	ON	OFF	ON
		6	OFF	ON	OFF	OFF
		7	OFF	ON	ON	OFF
		8	OFF	OFF	ON	OFF

Sequence shown is for half-step excitation. For full step excitation energise as steps 1,3,5,7







DSM2845H-16065

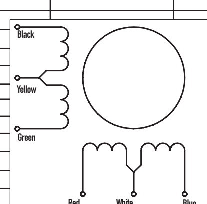
Step Angle Accuracy	±5			
Holding Torque (Bipolar)	58mNm		8oz-in	
Current (RMS)	Bipolar		Unipolar	
	0.9A		0.65A	
Winding Resistance (Ω)	2.8			
Winding Inductance (mH)	1			
Detent Torque				
Rotor Inertia (gcm²)	0.9			
Insulation Class	Class B, 100M			
Mass	140g			
Bearings				

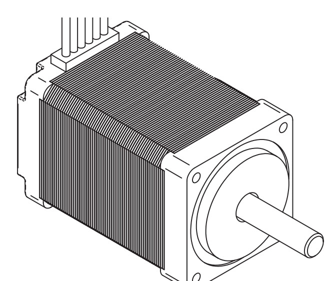
Label Details

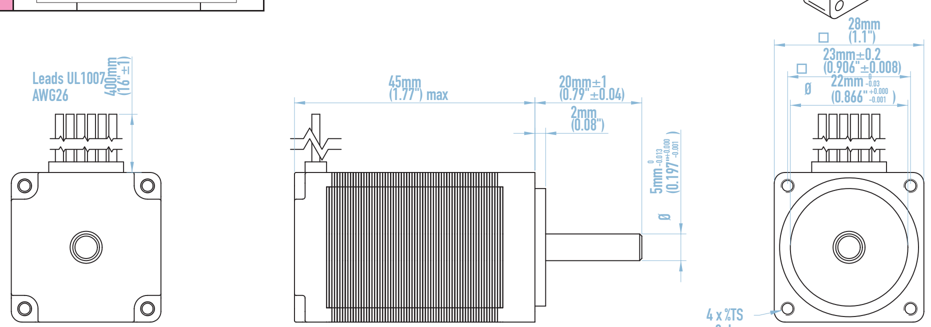
DSM2845H-16065
BIPOLAR 0.9A
UNIPOLAR 0.65A
Made in China

Direction of Rotation		Step	Yellow +VE		White +VE	
			Black	Green	Red	Blue
CW ↑	CCW ↓	1	ON	OFF	ON	OFF
		2	ON	OFF	OFF	OFF
		3	ON	OFF	OFF	ON
		4	OFF	OFF	OFF	ON
		5	OFF	ON	OFF	ON
		6	OFF	ON	OFF	OFF
		7	OFF	ON	ON	OFF
		8	OFF	OFF	ON	OFF

Sequence shown is for half-step excitation. For full step excitation energise as steps 1,3,5,7







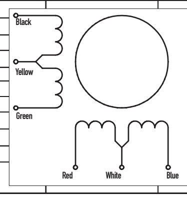
DSM3526H-16040

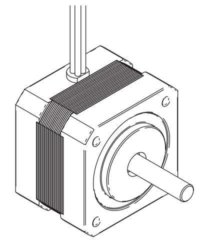
Step Angle	1.8°	
Step Angle Accuracy	±5	
Holding Torque (Bipolar)	55mNm	7.5oz-in
Current (RMS)	Bipolar	Unipolar
	0.9A	0.65A
Winding Resistance (Ω)	15	
Winding Inductance (mH)	7.5	
Detent Torque	10mNm	1.4oz-in
Rotor Inertia (gcm²)	10	
Insulation Class	Class B, 100M Ω	
Mass	150	
Bearings	Ball Bearings 695ZZ	

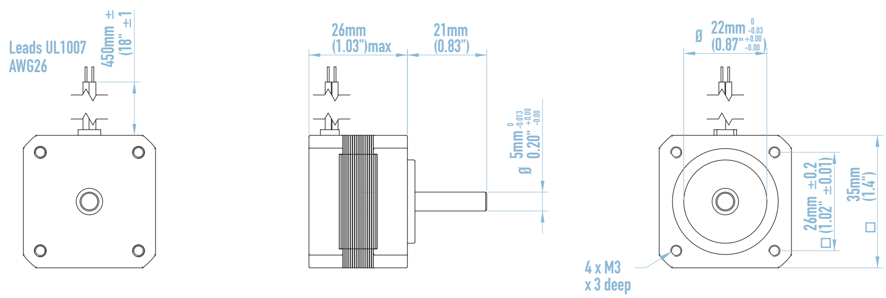
Direction of Rotation		Step	Yellow +VE		White +VE	
			Black	Green	Red	Blue
CW ↑	CCW ↓	1	ON	OFF	ON	OFF
		2	ON	OFF	OFF	OFF
		3	ON	OFF	OFF	ON
		4	OFF	OFF	OFF	ON
		5	OFF	ON	OFF	ON
		6	OFF	ON	OFF	OFF
		7	OFF	ON	ON	OFF
		8	OFF	OFF	ON	OFF

Sequence shown is for half-step excitation. For full step excitation energise as steps 1,3,5,7

Label Details
DSM3526H-16040
BIPOLAR 0.28A
UNIPOLAR 0.4A
Made in China







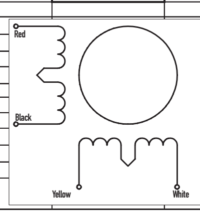
DSM3526H-14080

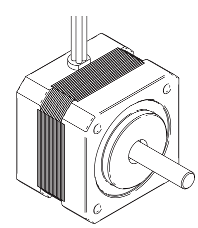
Step Angle	1.8°	
Step Angle Accuracy	±5	
Holding Torque	55mNm	7.5oz-in
Current (RMS)	Bipolar	
	830mA	
Winding Resistance (Ω)	4	
Winding Inductance (mH)	2.3	
Detent Torque	10mNm	1.4oz-in
Rotor Inertia (gcm²)	10	
Insulation	Class B, 100M Ω	
Mass	150g	
Bearings	Ball Bearings 695ZZ (China)	

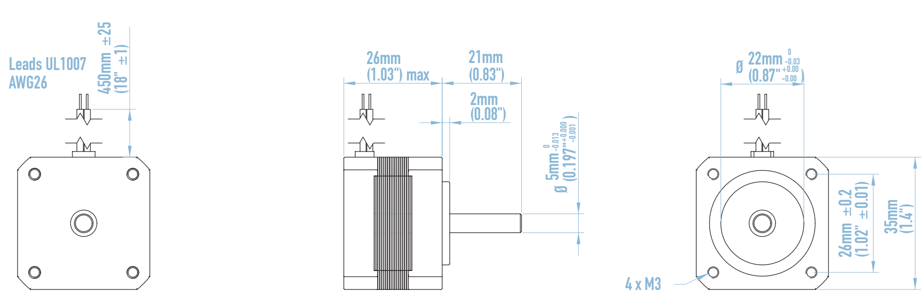
Direction of Rotation		Step	Red	Black	Yellow	White
CW ↑	CCW ↓	1	+	-	+	-
		2	+	-	OFF	OFF
		3	+	-	-	+
		4	OFF	OFF	-	+
		5	-	+	-	+
		6	-	+	OFF	OFF
		7	-	+	+	-
		8	OFF	OFF	+	-

Sequence shown is for half-step excitation. For full step excitation energise as steps 1,3,5,7

Label Details
DSM3526H-14080
BIPOLAR 830mA
Made in China

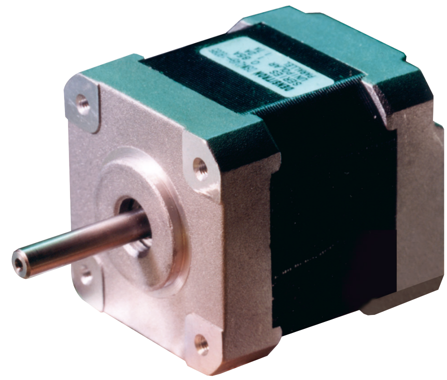






DSM42H

Step Angle	1.8º
Step Angle Accuracy	+/-5%
Operating Ambient Temp	-20/+55
Bearings	NSK 625ZZ



DSM4234H-14040

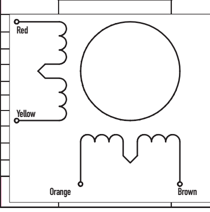
Step Angle	1.8°	
Step Angle Accuracy	±5	
Holding Torque	0.21Nm	1.8lb-in
Current (RMS)	Bipolar	
	400mA	
Winding Resistance (Ω)	30	
Winding Inductance (mH)	32	
Detent Torque	0.02Nm	0.17lb-in
Rotor Inertia (gcm²)	24	
Insulation	Class B, 100M Ω	
Mass	200g	
Bearings	Ball Bearings 625ZZ (Japan)	

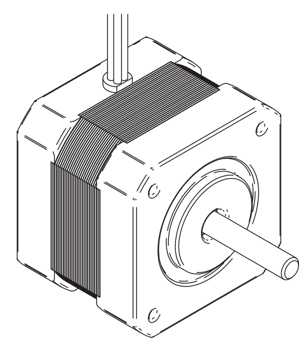
Label Details

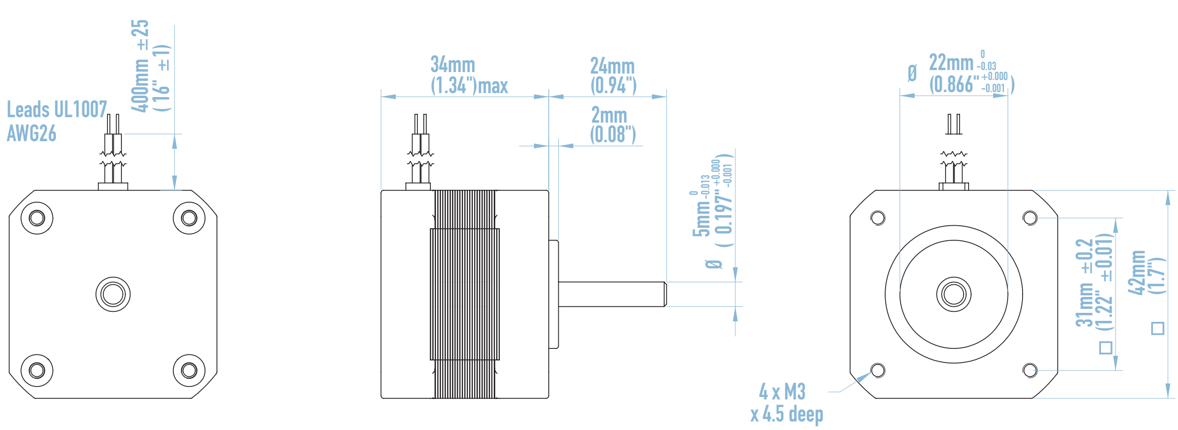
DSM4234H-14040
BIPOLAR 400mA
Made in China

Direction of Rotation		Step	Red	Yellow	Orange	Brown
CW ↑	CCW ↓	1	+	-	+	-
		2	+	-	OFF	OFF
		3	+	-	-	+
		4	OFF	OFF	-	+
		5	-	+	-	+
		6	-	+	OFF	OFF
		7	-	+	+	-
		8	OFF	OFF	+	-

Sequence shown is for half-step excitation. For full step excitation energise as steps 1,3,5,7







DSM4234H-14150

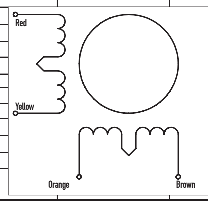
Step Angle	1.8°	
Step Angle Accuracy	±5	
Holding Torque	0.21Nm	1.8lb-in
Current (RMS)	Bipolar	
	1.5A	
Winding Resistance (Ω)	1.3	
Winding Inductance (mH)	1.3	
Detent Torque	0.02Nm	0.17lb-in
Rotor Inertia (gcm²)	24	
Insulation	Class B, 100M Ω	
Mass	200g	
Bearings	Ball Bearings 625ZZ (Japan)	

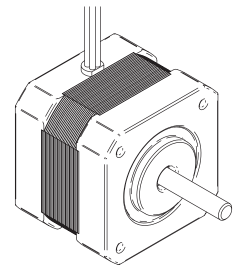
Label Details

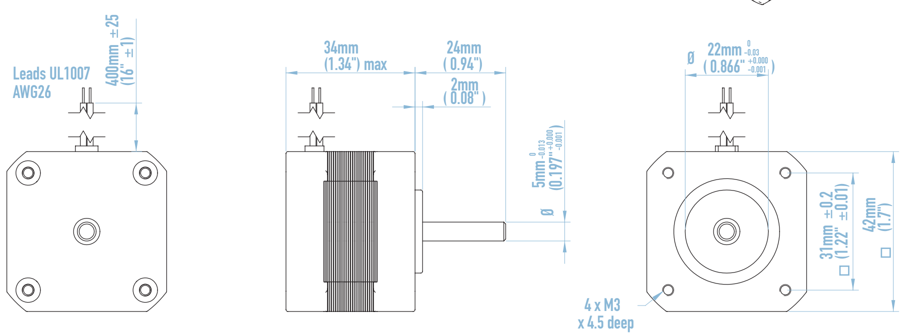
DSM4234H-14150
BIPOLAR 1.5A
Made in China

Direction of Rotation		Step	Red	Yellow	Orange	Brown
CW ↑	CCW ↓	1	+	-	+	-
		2	+	-	OFF	OFF
		3	+	-	-	+
		4	OFF	OFF	-	+
		5	-	+	-	+
		6	-	+	OFF	OFF
		7	-	+	+	-
		8	OFF	OFF	+	-

Sequence shown is for half-step excitation. For full step excitation energise as steps 1,3,5,7







DSM4239H-14170

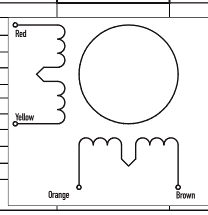
Step Angle	1.8°	
Step Angle Accuracy	±5	
Holding Torque	0.21Nm	1.8lb-in
Current (RMS)	Bipolar	
	1.7A	
Winding Resistance (Ω)	1.5	
Winding Inductance (mH)	3.2	
Detent Torque	0.022	0.19lb-in
Rotor Inertia (gcm²)	24	
Insulation	Class B, 100M Ω	
Mass	2040	
Bearings	Ball Bearings 625ZZ (Japan)	

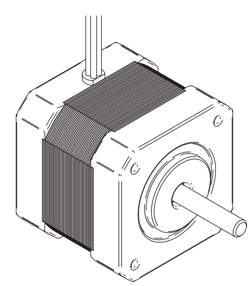
Label Details

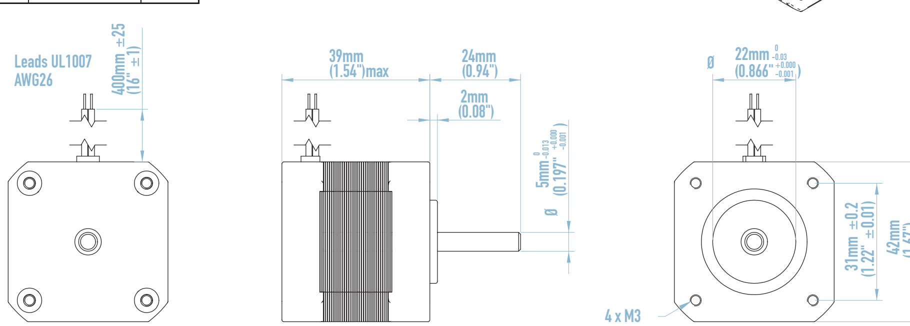
DSM4239H-14170
BIPOLAR 1.7A
Made in China

Direction of Rotation		Step	Black	Green	Blue	Red
CW ↑	CCW ↓	1	+	-	+	-
		2	+	-	OFF	OFF
		3	+	-	-	+
		4	OFF	OFF	-	+
		5	-	+	-	+
		6	-	+	OFF	OFF
		7	-	+	+	-
		8	OFF	OFF	+	-

Sequence shown is for half-step excitation. For full step excitation energise as steps 1,3,5,7







DSM4248H-18085

Step Angle	1.8°			
Step Angle Accuracy	±5			
Holding Torque	0.48Nm		4lb-in	
Current (RMS)	Bipolar Parallel	Bipolar Series	Unipolar	
	1.7A	0.85A	1.2A	
Winding Resistance (Ω)	3			
Winding Inductance (mH)	2.3			
Detent Torque	0.028		0.24lb-in	
Rotor Inertia (gcm^2)	40			
Insulation Class	Class B, 100M Ω			
Mass	290			
Bearings	Ball Bearing 625ZZ (Japan)			

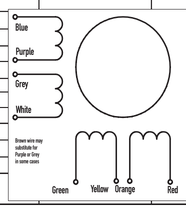
Label Details

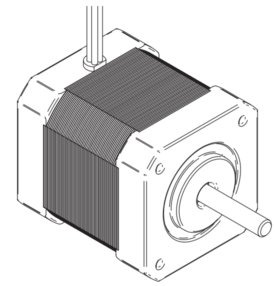
DSM4248H-18085
BIPOLAR PLL 1.7A
BIPOLAR SER 0.85A
UNIPOLAR 1.2A

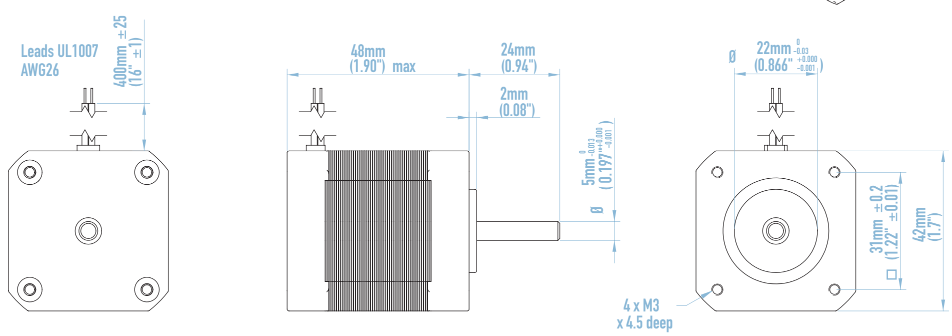
Made in China

Direction of Rotation		Step	Blue / Grey	Purple / White	Green / Orange	Yellow / Red
CW ↑	CCW ↓	1	+	-	+	-
		2	+	-	OFF	OFF
		3	+	-	-	+
		4	OFF	OFF	-	+
		5	-	+	-	+
		6	-	+	OFF	OFF
		7	-	+	+	-
		8	OFF	OFF	+	-

Sequence shown is for half-step excitation. For full step excitation energise as steps 1,3,5,7







DSM57H

Step Angle 1.8º

Step Angle Accuracy +/-5%

Operating Ambient Temp -20/+80

Bearings NSK 6000ZZ

DSM5741H-18070

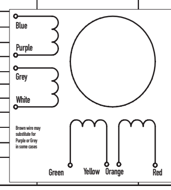
Step Angle	1.8°			
Step Angle Accuracy	±5			
Holding Torque (Bipolar)	0.55Nm		4.7lb-in	
Current (RMS)	Bipolar Parallel	Bipolar Series	Unipolar	
	1.4A	0.7A	1A	
Winding Resistance (Ω)	5			
Winding Inductance (mH)	35			
Detent Torque	0.025		0.21lb-in	
Rotor Inertia (gcm²)	120			
Insulation Class	Class B, 100M Ω			
Mass	0.5kg			
Bearings	Ball Bearings 6000ZZ (Japan)			

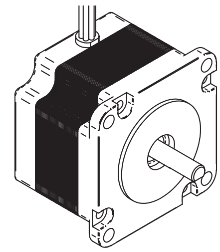
Label Details

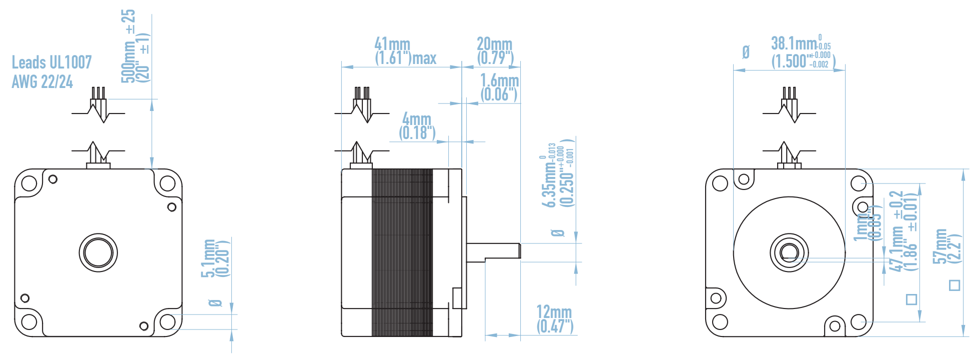
DSM5741H-18070
BIPOLAR PLL 1.4A
BIPOLAR SER 0.7A
UNIPOLAR 1A
Made in China

Direction of Rotation	Step	Blue / Grey	Purple / White	Green / Orange	Yellow / Red
CW ↑ / CCW ↓	1	+	-	+	-
	2	+	-	OFF	OFF
	3	+	-	-	+
	4	OFF	OFF	-	+
	5	-	+	-	+
	6	-	+	OFF	OFF
	7	-	+	+	-
	8	OFF	OFF	+	-

Sequence shown is for half-step excitation. For full step excitation energise as steps 1,3,5,7







DSM5750H-18075

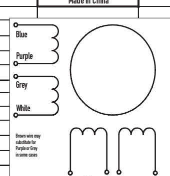
Step Angle	1.8°			
Step Angle Accuracy	±5			
Holding Torque (Bipolar)	0.8Nm		6.5lb-in	
Current (RMS)	Bipolar Parallel	Bipolar Series	Unipolar	
	1.5A	0.75A	1A	
Winding Resistance (Ω)	5			
Winding Inductance (mH)	30			
Detent Torque	0.03		0.26lb-in	
Rotor Inertia (gcm²)	150			
Insulation Class	Class B, 100M Ω			
Mass	0.65kg			
Bearings	Ball Bearings 6000ZZ (Japan)			

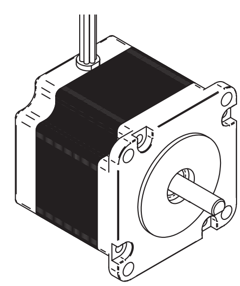
Label Details

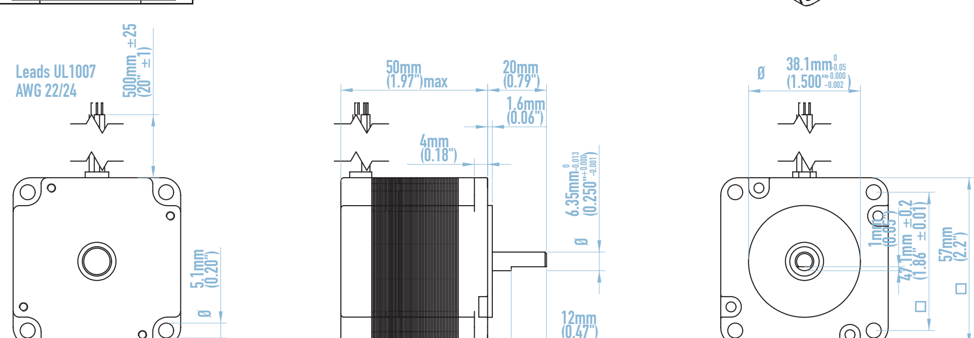
DSM5750H-18075
BIPOLAR PLL 1.5A
BIPOLAR SER 0.75A
UNIPOLAR 1A
Made in China

Direction of Rotation	Step	Blue / Grey	Purple / White	Green / Orange	Yellow / Red
CW ↑ / CCW ↓	1	+	-	+	-
	2	+	-	OFF	OFF
	3	+	-	-	+
	4	OFF	OFF	-	+
	5	-	+	-	+
	6	-	+	OFF	OFF
	7	-	+	+	-
	8	OFF	OFF	+	-

Sequence shown is for half-step excitation. For full step excitation energise as steps 1,3,5,7







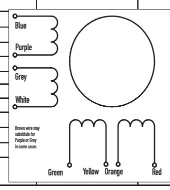
DSM5755H-18200

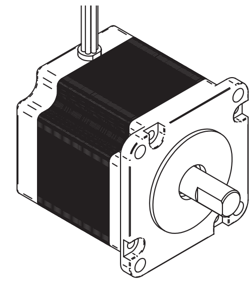
Step Angle	1.8°			
Step Angle Accuracy	±5			
Holding Torque (Bipolar)	1.05Nm		9lb-in	
Current (RMS)	Bipolar Parallel	Bipolar Series	Unipolar	
	4A	2A	2.8A	
Winding Resistance (Ω)	0.7			
Winding Inductance (mH)	3			
Detent Torque	0.04		0.34lb-in	
Rotor Inertia (gcm²)	280			
Insulation Class	Class B, 100M Ω			
Mass	0.75			
Bearings	Ball Bearings 6000ZZ (Japan)			

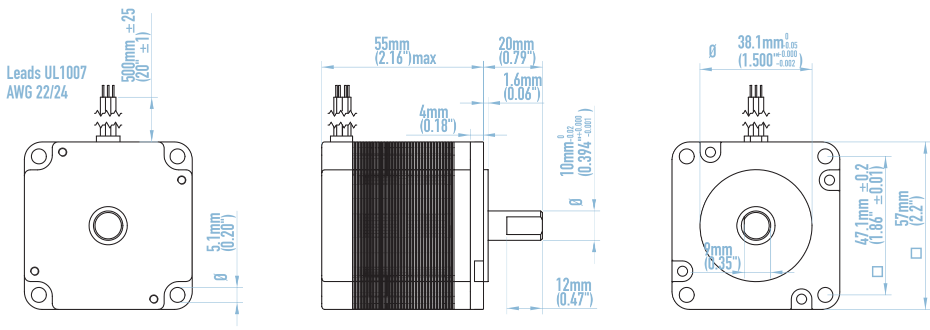
Direction of Rotation		Step	Blue / Grey	Purple / White	Green / Orange	Yellow / Red
CW ↑	CCW ↓	1	+	-	+	-
		2	+	-	OFF	OFF
		3	+	-	-	+
		4	OFF	OFF	-	+
		5	-	+	-	+
		6	-	+	OFF	OFF
		7	-	+	+	-
		8	OFF	OFF	+	-

Sequence shown is for half-step excitation. For full step excitation energise as steps 1,3,5,7

Label Details
DSM5755H-18200
BIPOLAR PLL 4A
BIPOLAR SER 2A
UNIPOLAR 2.8A
Made in China







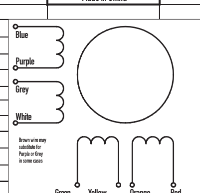
DSM5755H-28200

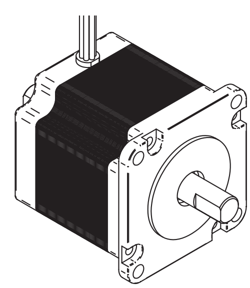
Step Angle	1.8°			
Step Angle Accuracy	±5			
Holding Torque (Bipolar)	1.05Nm		9lb-in	
Current (RMS)	Bipolar Parallel	Bipolar Series	Unipolar	
	4A	2A	2.8A	
Winding Resistance (Ω)	0.7			
Winding Inductance (mH)	3			
Detent Torque	0.04		0.34lb-in	
Rotor Inertia (gcm²)	280			
Insulation Class	Class B, 100MΩ			
Mass	0.75			
Bearings	Ball Bearings 6000ZZZ (Japan)			

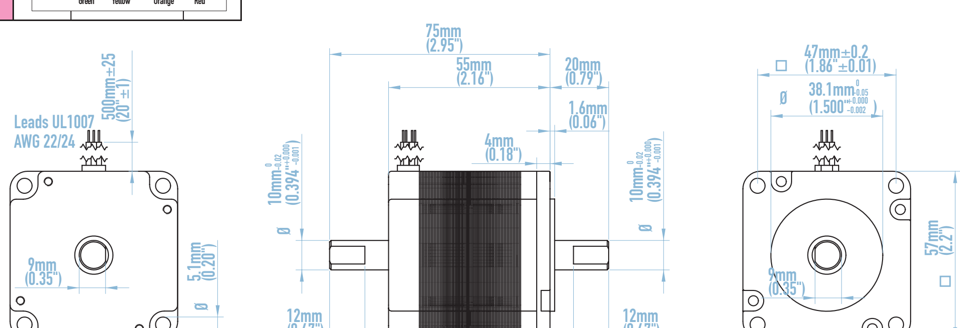
Direction of Rotation		Step	Blue / Grey	Purple / White	Green / Orange	Yellow / Red
CW ↑	CCW ↓	1	+	-	+	-
		2	+	-	OFF	OFF
		3	+	-	-	+
		4	OFF	OFF	-	+
		5	-	+	-	+
		6	-	+	OFF	OFF
		7	-	+	+	-
		8	OFF	OFF	+	-

Sequence shown is for half-step excitation. For full step excitation energise as steps 1,3,5,7

Label Details
DSM5755H-28200
BIPOLAR PLL 4A
BIPOLAR SER 2A
UNIPOLAR 2.8A
Made in China







DSM5776H-18100

Step Angle	1.8°			
Step Angle Accuracy	±5			
Holding Torque (Bipolar)	1.85		16lb-in	
Current (RMS)	Bipolar Parallel	Bipolar Series	Unipolar	
	2A	1A	1.4A	
Winding Resistance (Ω)	4			
Winding Inductance (mH)	12			
Detent Torque	0.08Nm		0.68lb-in	
Rotor Inertia (gcm^2)	440			
Insulation Class	Class B, 100M Ω			
Mass	1.15			
Bearings	Ball Bearings 6000ZZ (Japan)			

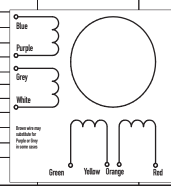
Direction of Rotation	Step	Blue / Grey	Purple / White	Green / Orange	Yellow / Red
CW ↑ / CCW ↓	1	+	-	+	-
	2	+	-	OFF	OFF
	3	+	-	-	+
	4	OFF	OFF	-	+
	5	-	+	-	+
	6	-	+	OFF	OFF
	7	-	+	+	-
	8	OFF	OFF	+	-

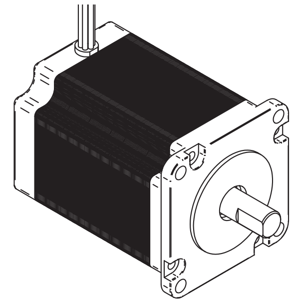
Sequence shown is for half-step excitation. For full step excitation energise as steps 1,3,5,7

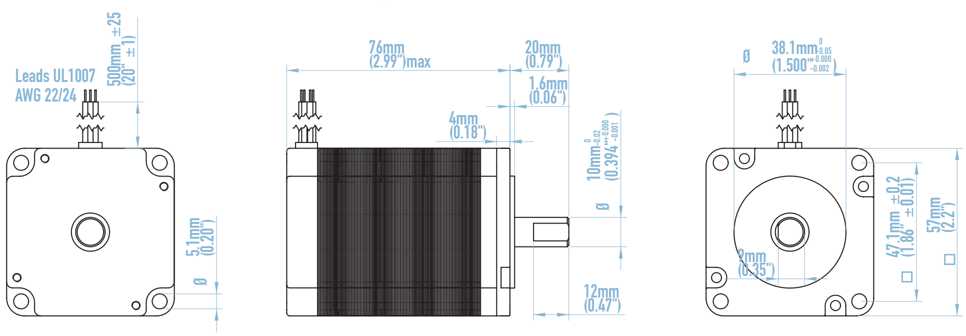
Label Details

DSM5776H-18100
BIPOLAR PLL 2A
BIPOLAR SER 1A
UNIPOLAR 1.4A

Made in China







DSM5776H-18200

Step Angle	1.8°			
Step Angle Accuracy	±5			
Holding Torque (Bipolar)	1.85		16lb-in	
Current (RMS)	Bipolar Parallel	Bipolar Series	Unipolar	
	4A	2A	2.8A	
Winding Resistance (Ω)	1			
Winding Inductance (mH)	4			
Detent Torque	0.08Nm		0.68lb-in	
Rotor Inertia (gcm^2)	440			
Insulation Class	Class B, 100M Ω			
Mass	1.15			
Bearings	Ball Bearings 6000ZZ (Japan)			

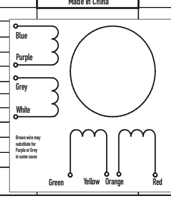
Direction of Rotation	Step	Blue / Grey	Purple / White	Green / Orange	Yellow / Red
CW ↑ / CCW ↓	1	+	-	+	-
	2	+	-	OFF	OFF
	3	+	-	-	+
	4	OFF	OFF	-	+
	5	-	+	-	+
	6	-	+	OFF	OFF
	7	-	+	+	-
	8	OFF	OFF	+	-

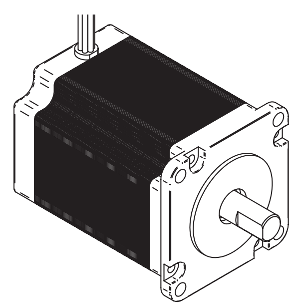
Sequence shown is for half-step excitation. For full step excitation energise as steps 1,3,5,7

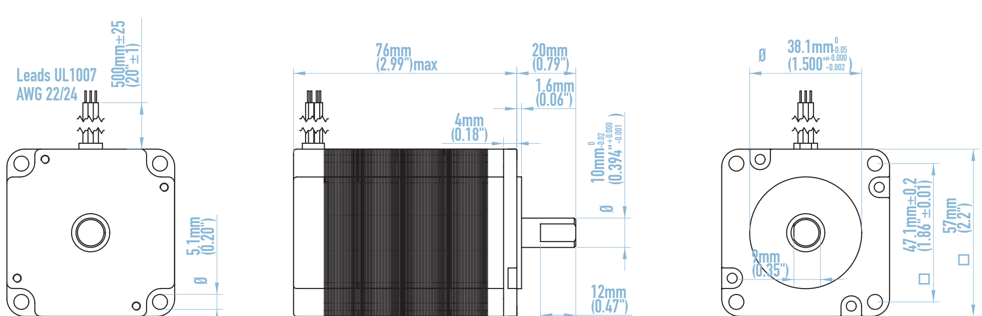
Label Details

DSM5776H-18200
BIPOLAR PLL 4A
BIPOLAR SER 2A
UNIPOLAR 2.8A

Made in China







DSM5776H-28200

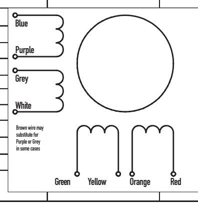
Step Angle	1.8°			
Step Angle Accuracy	±5			
Holding Torque (Bipolar)	1.85		16lb-in	
Current (RMS)	Bipolar Parallel	Bipolar Series	Unipolar	
	4A	2A	2.8A	
Winding Resistance (Ω)	1			
Winding Inductance (mH)	4			
Detent Torque	0.08Nm		0.68lb-in	
Rotor Inertia (gcm2)	440			
Insulation Class	Class B, 100MΩ			
Mass	1.15			
Bearings	Ball Bearings 6000ZZZ (Japan)			

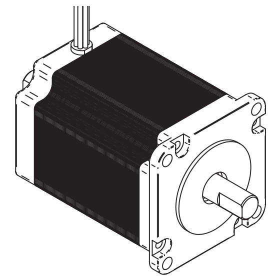
Direction of Rotation	Step	Blue / Grey	Purple / White	Green / Orange	Yellow / Red
CW ↑ / CCW ↓	1	+	-	+	-
	2	+	-	OFF	OFF
	3	+	-	-	+
	4	OFF	OFF	-	+
	5	-	+	-	+
	6	-	+	OFF	OFF
	7	-	+	+	-
	8	OFF	OFF	+	-

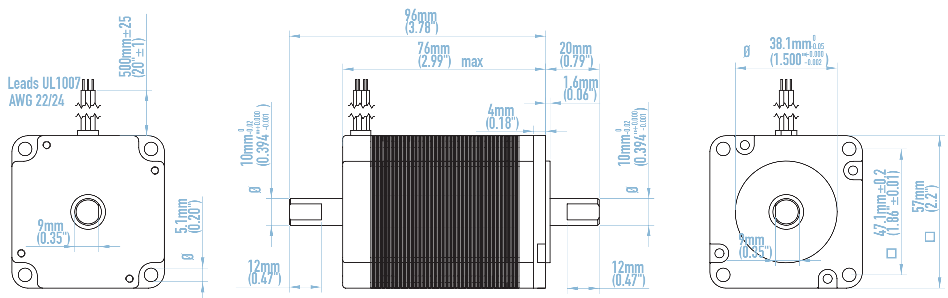
Sequence shown is for half-step excitation. For full step excitation energise as steps 1,3,5,7

Label Details

DSM5776H-28200
BIPOLAR PLL 4A
BIPOLAR SER 2A
UNIPOLAR 2.8A
Made in China







DSM57115H-18300

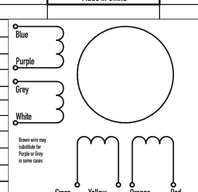
Step Angle	1.8°			
Step Angle Accuracy	±5			
Holding Torque (Bipolar)	2.7Nm		23lb-in	
Current (RMS)	Bipolar Parallel	Bipolar Series	Unipolar	
	6A	3A	4.2A	
Winding Resistance (Ω)	0.7			
Winding Inductance (mH)	2			
Detent Torque	0.15Nm		1.3lb-in	
Rotor Inertia (gcm^2)	690			
Insulation Class	Class B, 100MΩ			
Mass	1.75kg			
Bearings	Ball Bearings 6000ZZZ (Japan)			

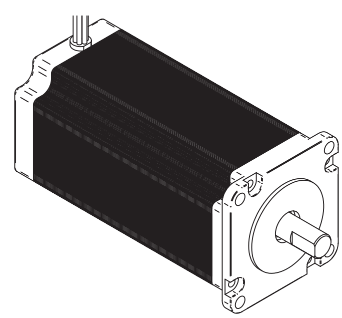
Direction of Rotation	Step	Blue / Grey	Purple / White	Green / Orange	Yellow / Red
CW ↑ / CCW ↓	1	+	-	+	-
	2	+	-	OFF	OFF
	3	+	-	-	+
	4	OFF	OFF	-	+
	5	-	+	-	+
	6	-	+	OFF	OFF
	7	-	+	+	-
	8	OFF	OFF	+	-

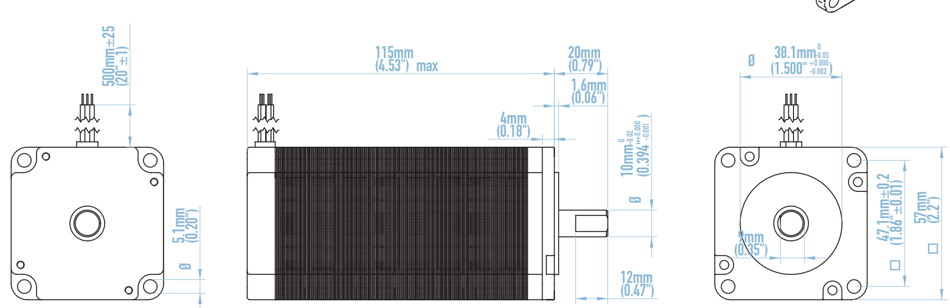
Sequence shown is for half-step excitation. For full step excitation energise as steps 1,3,5,7

Label Details

DSM57115H-18300
BIPOLAR PLL 6A
BIPOLAR SER 3A
UNIPOLAR 4.2A
Made in China







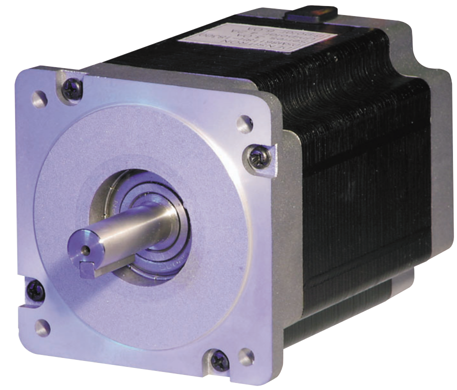
DSM86H

Step Angle 1.8º

Step Angle Accuracy +/-5%

Operating Ambient Temp -20/+80

Bearings NSK 6203ZZ Front
NSK 6002ZZ Rear



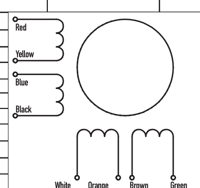
DSM8665H-18220

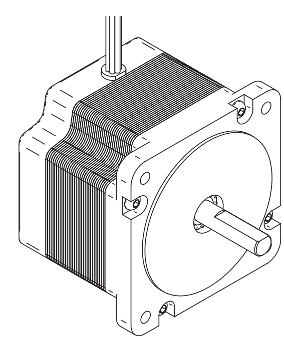
Step Angle	1.8º			
Step Angle Accuracy	±5			
Holding Torque (Bipolar)	2.9Nm		2.1ft-lb	
Current (RMS)	Bipolar Parallel	Bipolar Series	Unipolar	
	4.4A	2.2A	3.1A	
Winding Resistance (Ω)	1.5			
Winding Inductance (mH)	4.1			
Detent Torque				
Rotor Inertia (kgcm²)	1			
Insulation Class	Class B, 100MΩ			
Mass	2.0kg			
Bearings	Front 6203ZZ, Rear 6002ZZ, (Japan)			

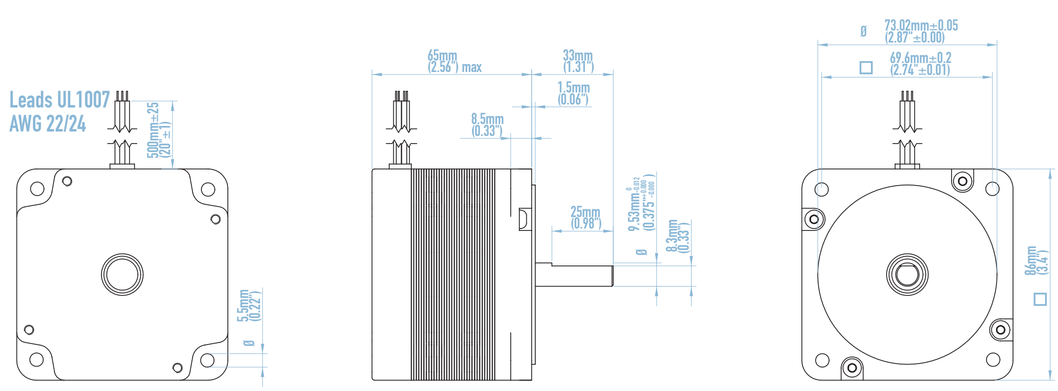
Label Details
DSM86655H-18220
BIPOLAR PLL 4.4A
BIPOLAR SER 2.2A
UNIPOLAR 3.1A
Made in China

Direction of Rotation		Step	Red / Blue	Yellow / Black	White / Brown	Orange / Green
CW ↑	CCW ↓	1	+	-	+	-
		2	+	-	OFF	OFF
		3	+	-	-	+
		4	OFF	OFF	-	+
		5	-	+	-	+
		6	-	+	OFF	OFF
		7	-	+	+	-
		8	OFF	OFF	+	-

Sequence shown is for half-step excitation. For full step excitation energise as steps 1,3,5,7







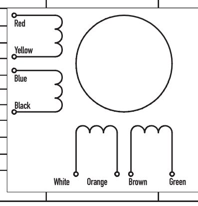
DSM8680H-18275

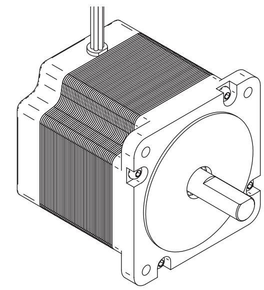
Step Angle	1.8°		
Step Angle Accuracy	±5		
Holding Torque (Bipolar)	4.5Nm		3.2ft-lb
Current (RMS)	Bipolar Parallel	Bipolar Series	Unipolar
	5.5A	2.75A	3.9A
Winding Resistance (Ω)	0.95		
Winding Inductance (mH)	4		
Detent Torque			
Rotor Inertia (kgcm²)	1.4		
Insulation Class	Class B, 100MΩ		
Mass	2.3kg		
Bearings	Front 6203ZZ, Rear 6002ZZ (Japan)		

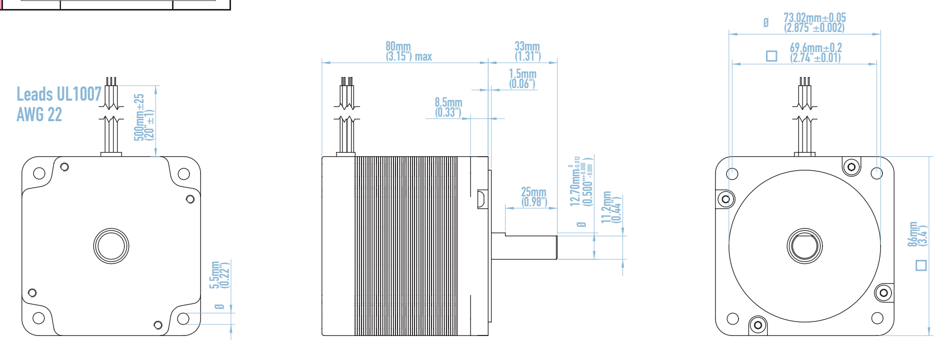
Label Details
DSM8680H-18275
BIPOLAR PLL 5.5A
BIPOLAR SER 2.75A
UNIPOLAR 3.9A
Made in China

Direction of Rotation		Step	Red / Blue	Yellow / Black	White / Brown	Orange / Green
CW ↑	CCW ↓	1	+	-	+	-
		2	+	-	OFF	OFF
		3	+	-	-	+
		4	OFF	OFF	-	+
		5	-	+	-	+
		6	-	+	OFF	OFF
		7	-	+	+	-
		8	OFF	OFF	+	-

Sequence shown is for half-step excitation. For full step excitation energise as steps 1,3,5,7







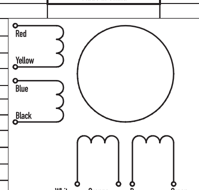
DSM86118H-18300

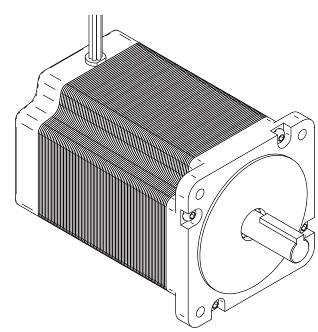
Step Angle	1.8°		
Step Angle Accuracy	±5		
Holding Torque (Bipolar)	8.5Nm		6.1ft-lb
Current (RMS)	Bipolar Parallel	Bipolar Series	Unipolar
	6A	3A	4.2A
Winding Resistance (Ω)	1.4		
Winding Inductance (mH)	7.4		
Detent Torque			
Rotor Inertia (kgcm²)	2.7		
Insulation Class	Class B, 100MΩ		
Mass	3.8kg		
Bearings	Front 6203ZZ, Rear 6002ZZ (Japan)		

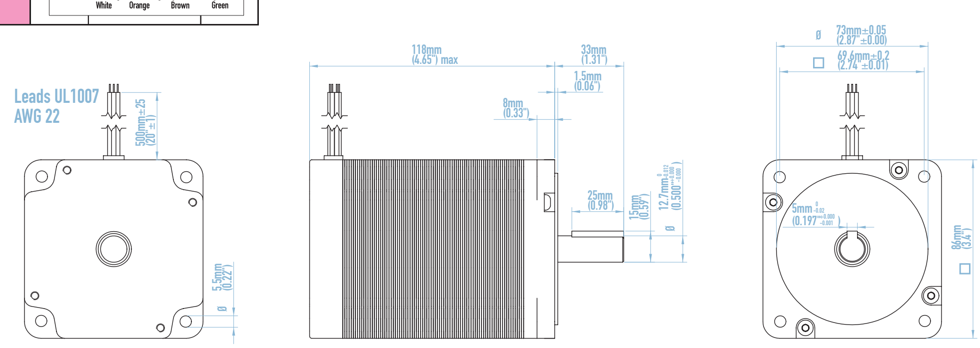
Label Details
DSM86118H-18300
BIPOLAR PLL 6A
BIPOLAR SER 3A
UNIPOLAR 4.2A
Made in China

Direction of Rotation		Step	Red / Blue	Yellow / Black	White / Brown	Orange / Green
CW ↑	CCW ↓	1	+	-	+	-
		2	+	-	OFF	OFF
		3	+	-	-	+
		4	OFF	OFF	-	+
		5	-	+	-	+
		6	-	+	OFF	OFF
		7	-	+	+	-
		8	OFF	OFF	+	-

Sequence shown is for half-step excitation. For full step excitation energise as steps 1,3,5,7







DSM86156H-18310

Step Angle	1.8°			
Step Angle Accuracy	±5			
Holding Torque (Bipolar)	8.5Nm		6.1ft-lb	
Current (RMS)	Bipolar Parallel	Bipolar Series	Unipolar	
	6.2A	3.1A	4.3A	
Winding Resistance (Ω)	1.7			
Winding Inductance (mH)	9.7			
Detent Torque				
Rotor Inertia (kgcm²)	4			
Insulation Class	Class B, 100MΩ			
Mass	5.4kg			
Bearings	Front 6203ZZ, Rear 6002ZZ, (Japan)			

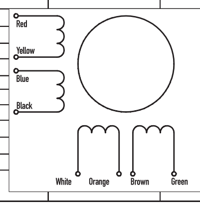
Label Details

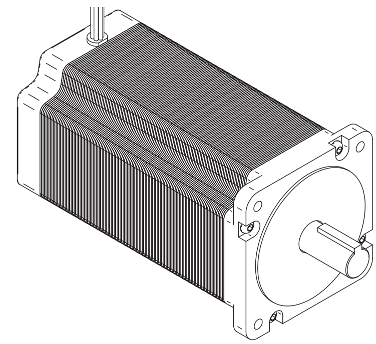
DSM86156H-18310
BIPOLAR PLL 6.2A
BIPOLAR SER 3.1A
UNIPOLAR 4.3A

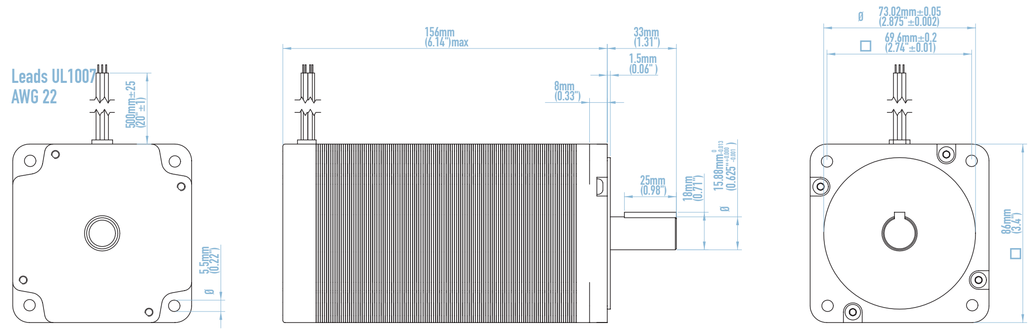
Made in China

Direction of Rotation	Step	Red / Blue	Yellow / Black	White / Brown	Orange / Green
CW ↑ / CCW ↓	1	+	-	+	-
	2	+	-	OFF	OFF
	3	+	-	-	+
	4	OFF	OFF	-	+
	5	-	+	-	+
	6	-	+	OFF	OFF
	7	-	+	+	-
	8	OFF	OFF	+	-

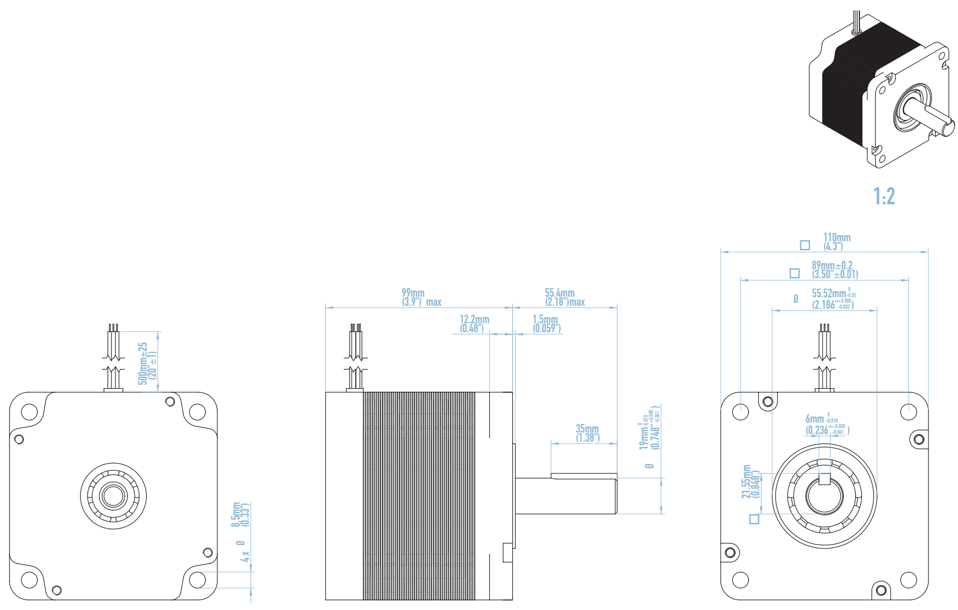
Sequence shown is for half-step excitation. For full step excitation energise as steps 1,3,5,7



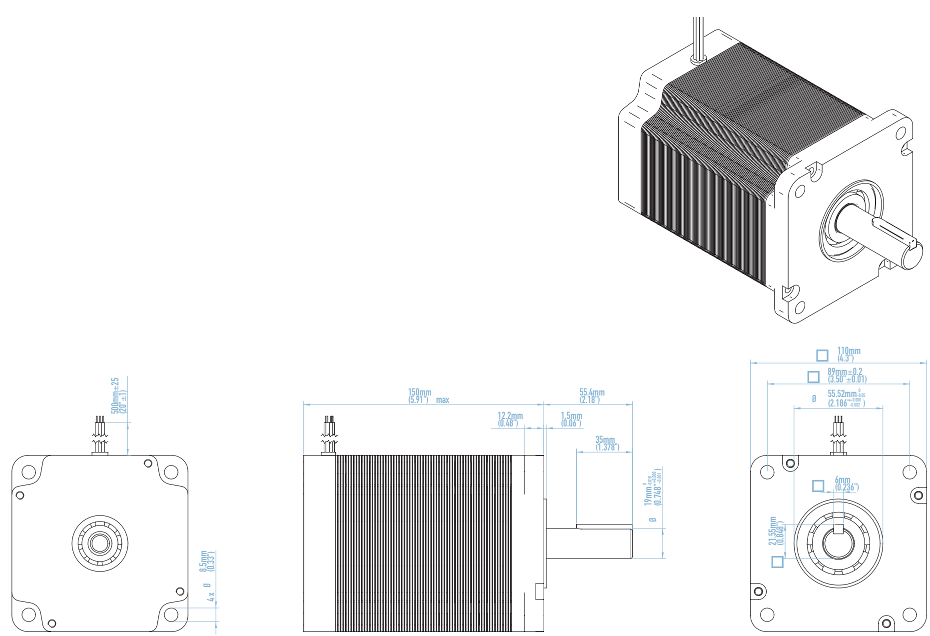




DSM11099H-18275



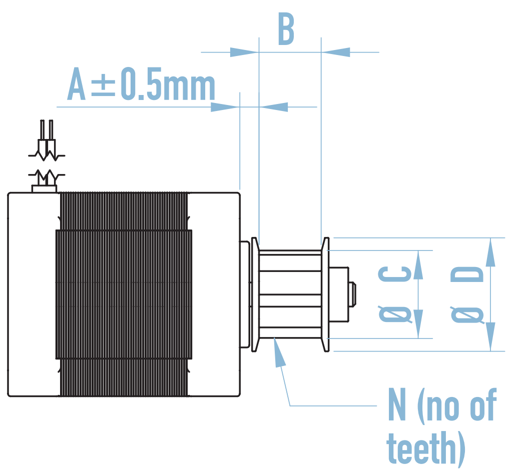
DSM110150



Gears and Timing Pulleys

Motors can be supplied with gears or timing pulleys fitted subject to availability of suitable components to implement such modification.

In order to quote for inclusion of a fitted gear or pulley, the following information should be supplied:



Pulley Type	Flange	Belt Width (B)	Teeth (N)
Classic 0.08"	Double	3/16" (4.8mm)	
Classic 0.08"	Double	1/4" (6.35mm)	10, 11, 12, 14, 16
HTD 3mm	Double	9mm	10, 12, 14, 15, 16
HTD 5mm	Double	9mm	12, 14, 15, 16, 18
HTD 5mm	Double	15mm	12, 14, 15, 16, 18, 20, 21
Classic 1/5"	Double	1/4"	
Classic 1/5"	Double	3/8"	10, 12, 14, 15, 16, 18
Classic 3/8"	Double	1/2"	
Classic 3/8"	Double	3/4"	

- Model of motor on which the modified part is to be based
- Type, pitch, size (no of teeth), width, material of fitted component (eg Classic timing pulley, 1/5" pitch, double flanged, 12 teeth, _" width, Moulded plastic)
- Position of fitted component in relation to mounting face of the motor (eg as defined by 'A' dimension in the drawing to the left)
- Lot Quantity

DSM5755H-08200

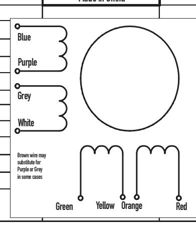
Step Angle	1.8°			
Step Angle Accuracy	±5			
Holding Torque (Bipolar)	1.05Nm		9lb-in	
Current (RMS)	Bipolar Parallel	Bipolar Series	Unipolar	
	4A	2A	2.8A	
Winding Resistance (Ω)	0.7			
Winding Inductance (mH)	3			
Detent Torque	0.04		0.34lb-in	
Rotor Inertia (gcm²)	280			
Insulation Class	Class B, 100M Ω			
Mass	0.75kg			
Bearings	Ball Bearings 6000ZZ (Japan)			

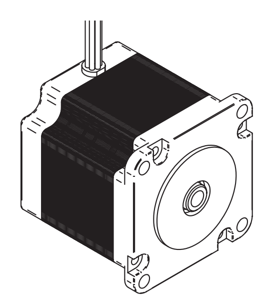
Label Details

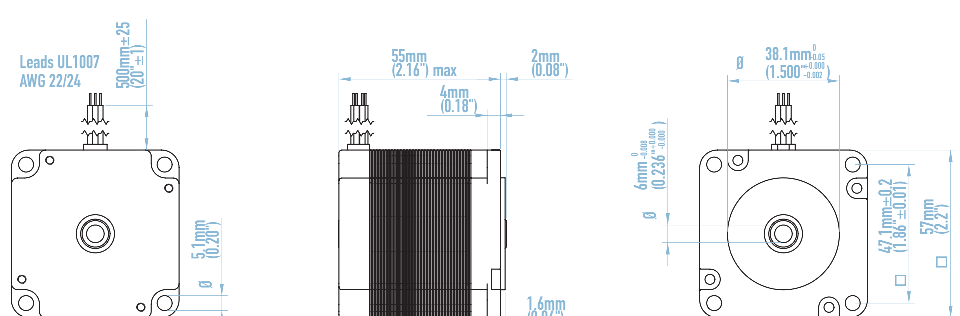
DSM5755H-08200
BIPOLAR PLL 4A
BIPOLAR SER 2A
UNIPOLAR 2.8A
Made in China

Direction of Rotation	Step	Blue / Grey	Purple / White	Green / Orange	Yellow / Red
CW ↑ / CCW ↓	1	+	-	+	-
	2	+	-	OFF	OFF
	3	+	-	-	+
	4	OFF	OFF	-	+
	5	-	+	-	+
	6	-	+	OFF	OFF
	7	-	+	+	-
	8	OFF	OFF	+	-

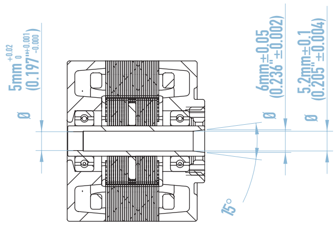
Sequence shown is for half-step excitation. For full step excitation energise as steps 1,3,5,7



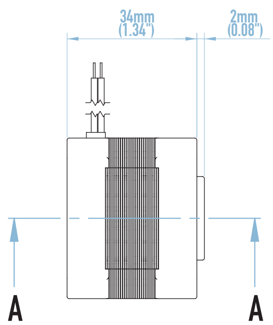


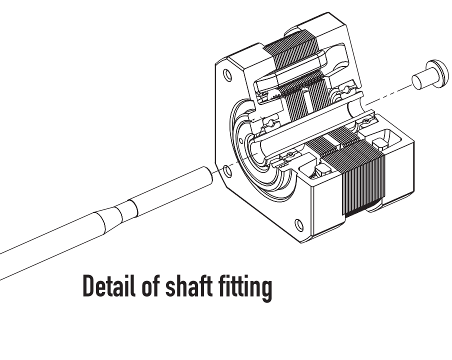


DSM4234-04150



SECTION A-A

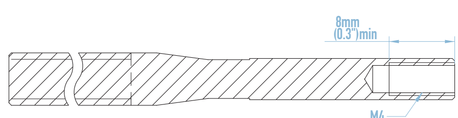




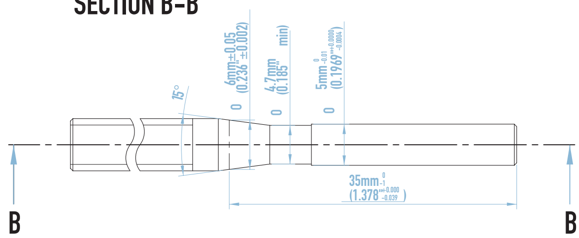
Detail of shaft fitting

Modified Shafts

Geeplus can supply motors with modified shaft where quantities merit this in any motor type. In some cases modified shaft designs can be supplied in limited quantity based on hollow shaft motor designs. Alternatively, we can supply the hollow shaft motor alone for you to fit your own design of shaft.



SECTION B-B



Connectors

Motors can be supplied with connectors fitted, subject to economic lot quantity, and to availability of specified connectors, and tooling.

For applications where connector is required, but is not yet specified we recommend Molex Micro-Fit 3.0 series, this is a latching type connector with high current-carrying capability suited to these products, and with a range of plating options available. We normally hold cable-mounting receptacles in stock for 4, 6, & 8-way termination, mating connectors for PCB or for cable mounting are readily available from several stocking distributors.

Linear Stepping Actuators produce linear movement as a series of discrete linear steps. Each increment of the excitation pulse sequence moves the actuator forward by a fixed linear displacement. The displacement can be accurately controlled by applying a measured number of steps. The basic resolution can be subdivided by driving in microstep mode in the same way as a rotary stepping motor.

Actuators provide basic (full step) resolution down to 5 microns, or less with microstep drive.

Standard devices comprise a stepping motor with leadscrew or leadscrew nut built into the shaft. For higher quantities, devices incorporating anti-rotation feature and/or linear guides can be developed.

Forming the nut or leadscrew as part of the motor itself reduces inertia and backlash associated with shaft couplings to ensure maximum acceleration with minimum positioning error.

Operation

The construction of the DSM4234LN unit is shown opposite.

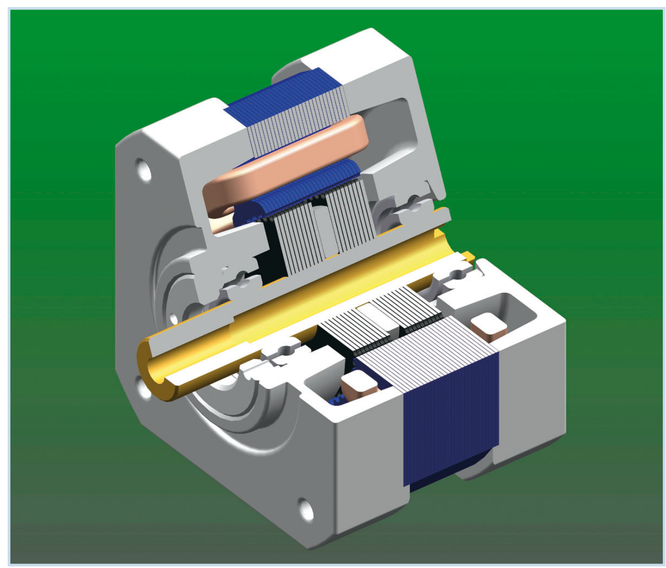
- The front bearing is supported by a threaded nut to adjust for minimum backlash. This solid support minimises backlash in either direction irrespective of loading (backlash between the leadscrew and nut will still exist in this device).
- The shaft is large in diameter compared to a standard motor, and incorporates a threaded portion in the front end. This is made of brass for good lubricity.
- In other respects the unit is similar to a standard hybrid stepping motor sharing the same inherent robustness, and simple control characteristics.

G+ offers standard devices for linear stepping actuators in three forms:

The DSM4234LN device incorporates a leadscrew nut, a threaded shaft of unlimited length can be fitted to this. This device incorporates rigidly preloaded bearings to withstand end loads in either direction.

The DSM42234H-C6230 and DSM4234H-C6231 devices incorporate a leadscrew cut directly into the shaft of the motor. The front bearing is spring preloaded to ensure zero backlash under light loading. Under heavier loading, the preload spring may compress to give backlash errors in the pulling direction.

For higher power, customer specified leadscrews can be fitted to the hollow shaft motor DSM5755H-08200, to allow larger actuators to be built.

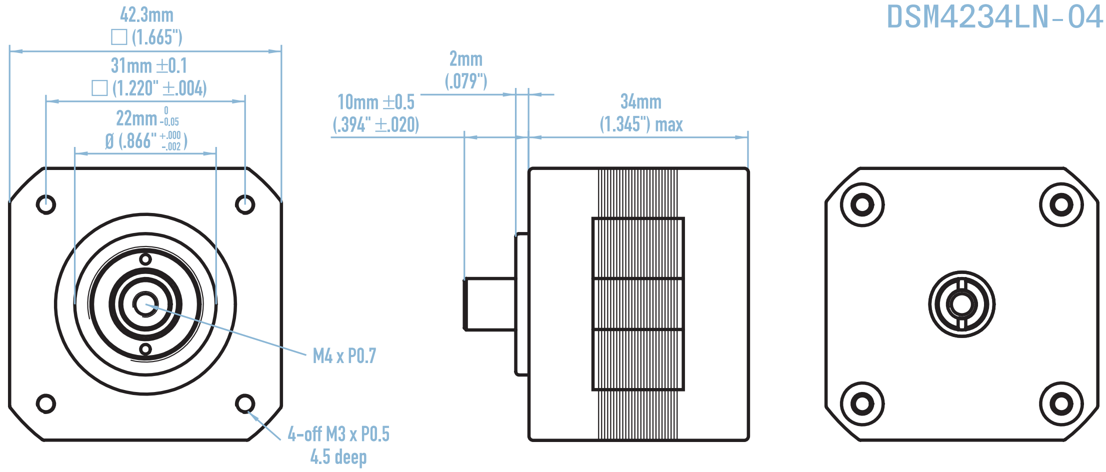


DSMH Series Motor Specifications

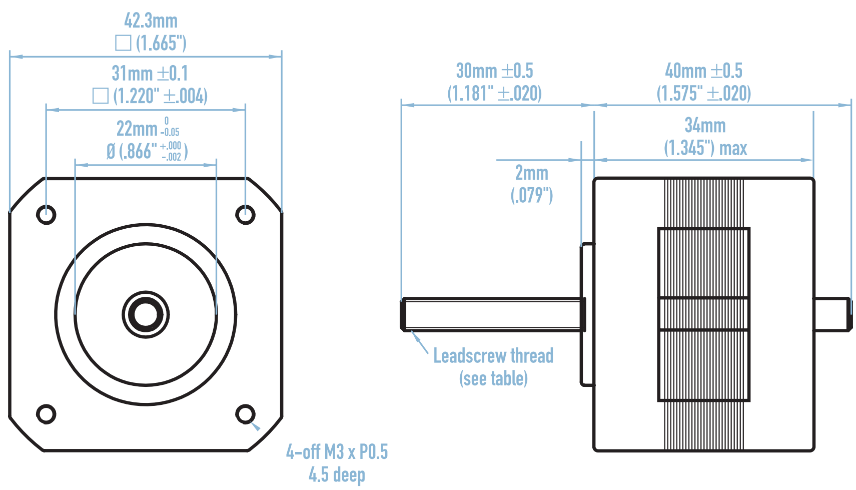
Part Number	Motor Specification	Leadscrew Specification	Step Size	Load Capacity	Bearing Type
DSM4234LN-04150	DSM4234H-14150	M4 x P0.7 Nut	3.5µm	150N	
DSM4234H-C6230	DSM4234H-14150	M5 x 1.0 Lead, g6	5µm	20N/120N	Koyo 625ZZ
DSM4234H-C6231	DSM4234H-14150	M5 x 2.0 Lead, twin start, g6	10µm	20N/60N	Koyo 625ZZ

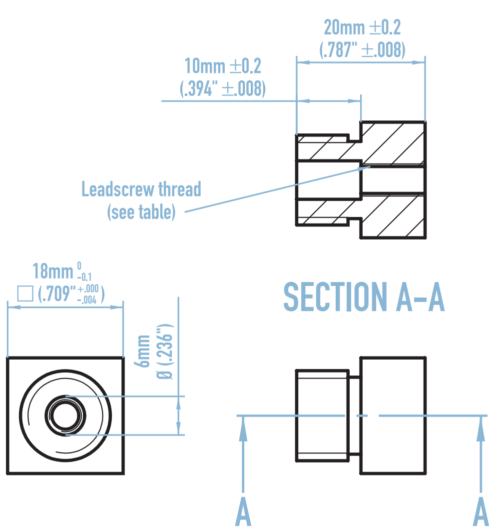
Where 2 figures are given for load capacity, the first figure relates to the force exerted by the preload spring, and the second figure to the drive capacity of the system (the load which can be driven based on motor torque and leadscrew specification).

DSM4234LN-04150



DSM4234H-C6230
DSM4234H-C6231



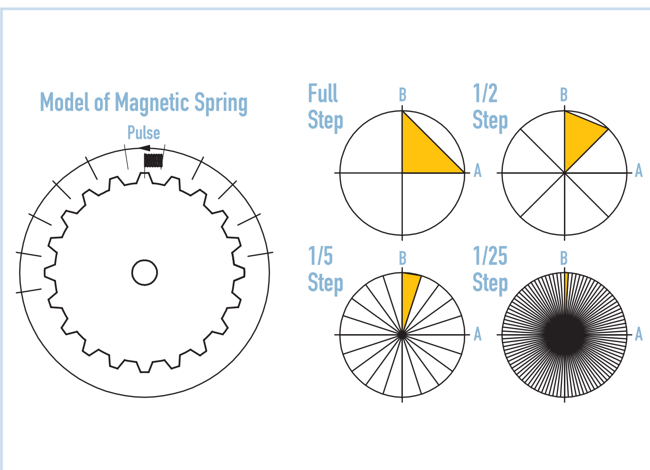


DSM42-LN-1mm	M5, 1mm Lead, g6
DSM42-LN-2mm	Twinstart, M5, 2mm Lead, g6

Back EMF - as the rotor of a stepping motor rotates, a 'back EMF' is generated and reduces the effective source voltage. In a constant voltage drive, this causes current to reduce linearly with increasing speed, and in all drive types results in an increase in the motor time constant. 'Back EMF' is proportional to the number of winding turns and is generally smallest for low-inductance (low-resistance motors). The effects of 'Back EMF' are minimised by use of a drive with high source voltage.

Resonance

The field produced by energising the phase windings in a stepping motor advances in discrete steps. The magnetic attraction between rotor and stator can be considered as a magnetic spring and like any spring-mass system, the motor is susceptible to overshoot and settling time phenomena, and can go into resonance at frequencies where the electrical pulse frequency is close to the natural frequency of the spring-mass system.



In the above diagrams, the yellow shaded area represents the energy input to the spring/mass system in each step with full-step drive, and at fractional step drive for different resolutions. This energy pulse is closely related to the tendency to resonance.

At the resonant frequency, a dramatic reduction in usable torque may be exhibited. Severity of this is usually worse in poorly damped systems using full-step excitation.

The natural frequency can be shifted by altering the mass (load), or the spring rate (related to excitation current) of the system.

The tendency to resonance can be greatly reduced by microstepping a stepping motor-drive system. This reduces the amount of energy imparted in each pulse.

Ferrofluid - ferrofluid is a magnetic liquid comprised of a carrier (normally a synthetic oil) in which small magnetic particles are bound in suspension. The ferrofluid is attracted to the poles of a magnet. If injected into the airgap between rotor and stator of a stepping motor it is held in the airgap by the magnetic field. The ferrofluid can be made in a range of viscosity grades, and confers a number of benefits to stepping motor operation:

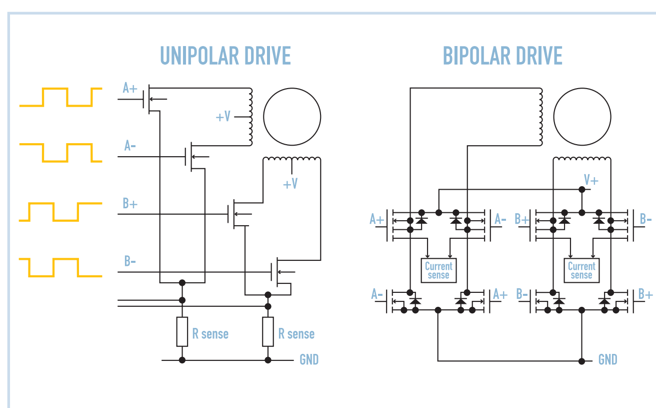
- Reduced audible noise and vibration (up to 20dB in some cases)
- Reduced resonance
- Reduced settling time
- Corrosion resistance of polepiece surfaces

At high operating speed, a loss in usable torque will be seen due to the viscous drag imparted by the ferrofluid.

Drive Technology

Bipolar and Unipolar Drives

The two most basic drive configurations are unipolar and bipolar constant voltage drives. Unipolar drive uses a motor with centre tap winding and has been widely used as it is easily and cheaply implemented using only 4 switching transistors. Unipolar drive has a fundamental performance disadvantage compared to bipolar drive - because only half the winding is energised. The excitation (product of current multiplied by number of coil turns in which it flows) is only 0.7 that of a bipolar drive for a given power dissipation. For low current, the cost benefit of using a smaller and cheaper motor is typically greater than the cost difference between bipolar and unipolar drive configurations.



L/R Drive

L/R drives are similar to the basic bipolar or unipolar configuration, but with resistance added in series with each motor winding. A higher source voltage is required to induce the rated phase current in the motor windings and has the effect of reducing the electrical time constant, permitting higher speed operation, but at the expense of significant power dissipation in the series resistors, hence reduced efficiency.

Motors

Stepping motor design has advanced significantly in the past 5 years with the introduction of high-performance hybrid motors able to deliver up to twice the torque, and to work at much higher speed levels than older designs. This development has been made possible by the use of rare-earth magnet materials, and by the reducing cost and increasing power levels of highly sophisticated drive devices. Modern drive devices make it easy to control current levels to reduce power consumption and heat dissipation when stationary, or boost current (torque) for fast acceleration. The ability to control power levels in a sophisticated manner means a smaller motor can be overdriven to meet peak torque requirements of an application, then run at reduced power to prevent heat dissipation problems. Densitron's DSMH series motors are designed for maximum torque capability, this results in slightly reduced torque at continuous duty, but provides substantial torque reserves when overdriven for maximum torque and acceleration.

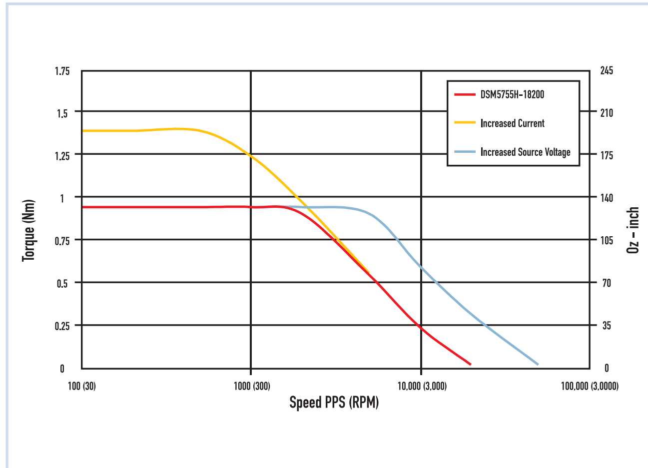
Limitations of Stepping Motor/Drives

Torque limitation

The maximum torque which can be produced by a stepping motor-drive system is ultimately limited by the stepping motor design and construction. Torque is proportional to the tangential portion of magnetic flux flowing across the motor airgap, and to the radius at which forces due to this flux are produced. For a given motor design, flux is ultimately limited by the cross sectional area of rotor teeth (also proportional to rotor radius), and saturation flux density of the lamination steel used. In small size motors, the space needed between stator poles to insert motor windings may limit the number of stator teeth, and reduce the cross-sectional area.

Magnetic flux also depends on the motor excitation, this is the sum of fields due to the permanent magnets, and the winding current. Ideally the excitation current should induce a field approaching saturation when the current is at the maximum level where heat can be dissipated with continuous operation. In some cases, the thermal limit occurs well before saturation commences, in this case higher torque can be produced for short periods by increasing the motor excitation (current) to the point where magnetic saturation of the motor steel occurs.

In order to develop higher torque, either the radius or axial length of the airgap must be increased. Large rotor radius restricts the space available for windings, so is limited by the motor frame size. Increased motor length requires multiple rotor stacks (1 stack is a sandwich of two rotor sections, with a magnet disc sandwiched between). Maximum number of stacks can be limited by capacity of the presses used in motor manufacture, or by straightness / rigidity of the rotor and stator assemblies between which tight tolerances on radial clearance must be maintained. The impact of source voltage and drive current on stepping motor performance are shown in the graph below.



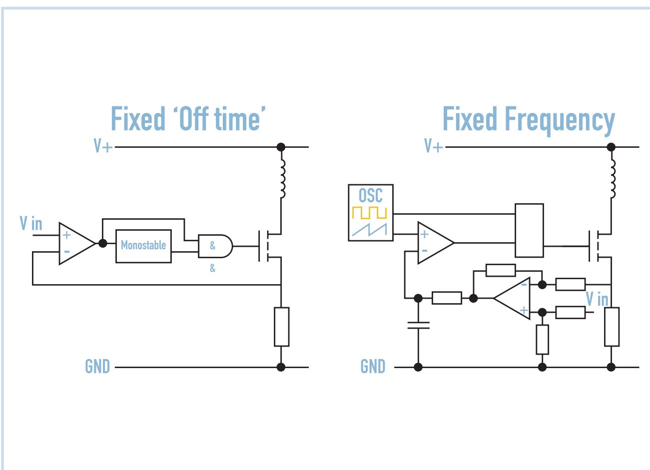
Speed limitation

Iron Losses - each time a stepping motor is driven through one full excitation cycle (50 times per revolution for a 2 phase, 200 steps/rev motor), the flux in stator polepieces is reversed twice. Due to magnetic hysteresis, some energy is lost and dissipated as heat for each such cycle. This 'iron loss' becomes a limiting factor at high operating speed and is a particular problem for hybrid stepping motors with high resolution due to the large number of drive cycles required to produce 1 revolution. Iron losses are minimised by using a material with low hysteresis, and by keeping the flux path in the stator as short as possible (typically the case in motors with large diameter rotor design).

Inductance (time constant) - the inductance of motor windings resists changes in winding current when the applied voltage changes and the current follows an exponential characteristic to reach a stable value. In a simple constant-voltage drive, this final value is determined by the voltage and coil resistance. As speed is increased, a stage will be reached where the winding current is unable to reach the steady-state value before the applied voltage is reversed. As speed increases further, the amplitude of current flowing in the motor windings, and hence developed torque will reduce. For high speed operation, the 'electrical time constant' can be reduced by using a source voltage much higher than the rated motor voltage, steady state current is limited by additional series resistance (see L/R drive), or more efficiently by use of a 'chopper amplifier' PWM control circuit.

PWM Drive

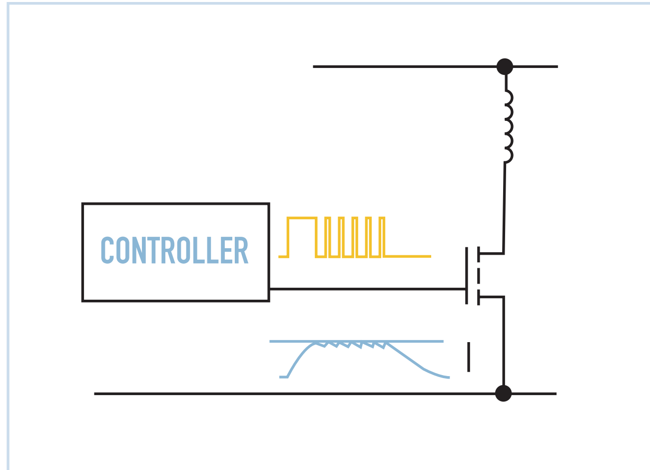
PWM drives use a high source voltage to overcome the 'Back EMF' and inductance characteristics of the motor, and 'chop' the motor supply to control current. Due to the motor inductance, the winding current resists change and becomes approximately constant, with a small ripple superimposed due to the chopping function. PWM drive has all the performance benefits of L/R configuration, but without the associated power loss. There are three main types of PWM drive, the two best known use closed-loop current control and are known as 'fixed off-time' and 'fixed frequency' controls. Both of these configurations use a closed control loop with feedback of the winding current, and are largely tolerant of variation in source voltage, or of motor inductance and back-emf characteristics below the point where these limit system speed.



In the 'fixed off-time' drive, the winding current is measured and compared to a target value. When this exceeds the target, a monostable causes the output to switch off for a short fixed interval. This interval is sufficient for the current to decay below the target value, so when the 'off-time' is finished, current again rises and the cycle repeats. A small ripple is seen in the current waveform about the target value.

In a fixed frequency PWM drive, a 'difference' signal is generated proportional to the difference between target value and actual current. This is compared to a sawtooth waveform from the oscillator. When the difference is larger than the sawtooth the output switches off, switching back on at the start of the next cycle. The 'on' time becomes shorter as the difference signal reduces.

The third type of PWM drive differs from the others in that the current control is open loop. No feedback is used in the current control circuit. This type of drive is inherently cheaper than other PWM drives. It has limitations in that it must be matched to the motor and source voltage to be used and for consistent operation, requires a stable source voltage.



When a phase winding is first energised, the controller initially switches on for a period sufficient to attain the rated phase current, it then switches alternately on and off at a duty cycle which maintains this current level.

Compared to a simple fixed-voltage drive, the only additional cost required to build an open-loop PWM drive is that of the extra processing power required to generate the PWM waveform, and any additional cost required for higher voltage switching devices. With more development time and processing power it is possible for this type of drive to generate a microstep drive waveform. For high speed operation, it may be necessary to modify the initial pulsewidth to compensate for back-emf effects.