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# Stepper Motors

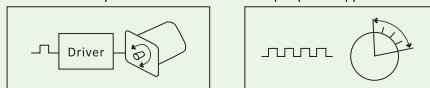




### Stepper Motor Basic

A stepper motor is an electromechanical device which converts electrical pulses into discrete mechanical movements. The shaft of a stepper motor rotates in discrete step increments when electrical command pulses are applied to it in a proper sequence. The motor rotation has several direct relationships to these applied input pulses. The sequence of the applied pulses is directly related to the direction of motor shafts rotation. The speed of the motor shafts rotation is directly related to the frequency of the input pulses and the length of rotation is directly related to the number of input pulses applied.

A stepper motor can be a good choice whenever controlled movement is required. They can be used in applications where you need to control rotation angle, speed, position and synchronism. Because of the inherent advantages, stepper motors have found their places in many different applications, such as CNC routers, laser machines, and so on.



The length of rotation is directly related to the number of input pulses applied.

### Stepper Motor Types

There are three basic stepper motor types. They are variable-reluctance, permanent-magnet and hybrid.

#### Variable-reluctance (VR)

This type of motor consists of a soft iron multi-toothed rotor and a wound stator. When the stator windings are energized with DC current the poles become magnetized. Rotation occurs when the rotor teeth are attracted to the energized stator poles.

#### Permanent Magnet (PM)

Often referred to as a "tin can" or "canstock" motor, the permanent magnet step motor is a low cost and low resolution type motor. PM motors as the name implies have permanent magnets added to the motor structure. The magnetized rotor poles provide an increased magnetic flux intensity and because of this the PM motor exhibits improved torque characteristics when compared with the VR type.

#### Hybrid (HB)

The hybrid stepper motor provides better performance with respect to step resolution, torque and speed. The hybrid stepper motor combines the best features of both the PM and VR type stepper motors. The rotor is multi-toothed like the VR motor and contains an axially magnetized concentric magnet around its shaft. This further increases the detent, holding and dynamic torque characteristics of the motor when compared with both the VR and PM types. Generally speaking, the hybrid motor may be the better choice along with reducing cost, for it offers better performance with respect to step resolution, torque and speed.

### Normal Selection Steps

You can follow the following steps to choose a stepper motor.

#### 1. Determining the Drive Mechanism Component

Determine the mechanism and required specifications. First, determine certain features of the design, such as mechanism, rough dimensions, distances moved, and positioning period.

#### 2. Calculate the Required Resolution

Find the resolution the motor requires. From the required resolution, determine whether a motor only or a geared motor is to be used. The resolution and positioning accuracy of a stepper motor system is affected by several factors — the stepper angle, the selected drive mode (full-step, half-step or microstepper), and the gear rate.

#### 3. Determine the Operating Pattern

Determine the operating pattern that fulfills the required specifications. Find the acceleration (deceleration) period and operating pulse speed in order to calculate the acceleration torque.

#### 4. Calculate the Required Torque

Calculate the load torque and acceleration torque and find the required torque demanded by the motor.

#### 5. Select the Motor

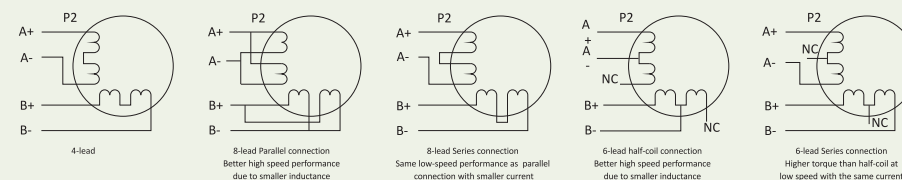
Make a provisional selection of a motor based on required torque. Determine the motor to be used from the speed-torque characteristics.

#### 6. Check the Selected Motor

Confirm the acceleration/deceleration rate and inertia ratio.

### Motor Connections

The M series drives can drive any 2-phase, 4-phase hybrid stepper motors, including 4-lead, 6-lead and 8-lead motors. Step angle of the motors can be 1.8 or 0.9 degree. For 6-lead and 8-lead stepper motors, different connections have different performance shown in the following figures.



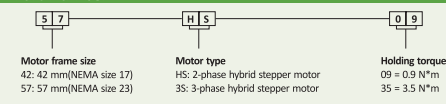
### Leadshine's Stepper Motors

Leadshine offers 2-phase and 3-phase stepper motors from NEMA14 to NEMA51. Made of high quality cold roll sheet copper and anti-high temperature permanent magnet, these stepper motors are highly reliable and generate low motor heating. Because of their nice internal damping characteristics, those stepper motors can run very smoothly and have no obvious resonance area within the whole speed ranges.

### Selection Table

Phase	NEMA Size	Model	Step Angle (°)	# of Leads	Connection	Current/Phase (A)	Holding Torque (Nm)	Length L (mm)	Weight (kg)	Match Drives
2	14	35HS01	1.8	4	-	0.4	0.07	26	0.15	EM402 / DM422C / DM556-CAN
	16	39HS02	1.8	4	-	0.6	0.22	34	0.2	EM402 / DM422C / DM556-CAN
	17	42HS02	1.8	4	-	0.4	0.22	40	0.24	EM402 / DM422C / DM556-CAN
		42HS03	1.8	8	Parallel	1.4	0.47	48	0.34	EM402 / DM422C / DM556-CAN
					Series	0.7	0.47			
					Unipolar	1.0	0.34			
	23	57HS04	1.8	6	Series	2.0	0.4	41	0.45	EM503 / DM556 / DM556-CAN
					Unipolar	2.8	0.28			
					Parallel	4.2	1.3			
		57HS09	1.8	8	Series	2.1	1.3	54	0.6	EM503 / DM556 / DM556-CAN
					Unipolar	2.8	0.9			
					Parallel	4.0	1.8			
		57HS13	1.8	8	Series	2.0	1.8	76	1.0	EM503 / EM705 / DM556 / DM556-CAN
					Unipolar	2.8	1.3			
					Parallel	5.6	2.2			
		57HS22	1.8	8	Series	2.8	2.2	81	1.15	EM503 / EM705 / DM556 / DM556-CAN
					Unipolar	4.0	1.5			
					Parallel	4.0	3.5			
	34	86HS35	1.8	8	Series	2.0	3.5	65	1.7	EM705 / EM806 / DM870
					Unipolar	2.8	2.5			
					Parallel	6.0	4.5			
		86HS45	1.8	8	Series	3.0	4.5	80	2.3	EM806 / DM870 / DM1182
					Unipolar	4.2	3.2			
					Parallel	6.8	8.5			
	42	86HS85	1.8	8	Series	3.4	8.5	118	3.8	EM806 / DM870 / DM1182 / DM2282
					Unipolar	4.9	6.0			
					Parallel	6.8	8.5			
		110HS12	1.8	4	-	5.0	12	99	5.0	DM1182 / DM2282
		110HS20	1.8	4	-	6.5	20	150	8.4	DM1182 / DM2282
		130HS27	1.8	4	-	6.0	27	227	13	DM1182 / DM2282
3	51	130HS45	1.8	4	-	7.0	45	283	19	DM1182 / DM2282
		573S05	1.2	6	Delta	5.2	0.45	42	0.45	3DM683 / 3DM883
		573S09	1.2	6	Delta	3.5	0.9	50	0.75	3DM683 / 3DM883
		573S15	1.2	6	Delta	5.8	1.3	76	1.1	3DM683 / 3DM883
		863S22	1.2	6	Delta	5.0	2.3	71	1.7	3DM683 / 3DM883
		863S42	1.2	6	Delta	5.0	4.3	103	2.9	3DM683 / 3DM883
	34	863S68H	1.2	6	Delta	2.3	6.8	135	4.0	3DM683 / 3DM883

### Part Number



35HSxx  
39HSxx  
42HSxx  
57HSxx  
86HSxx  
110HSxx  
130HSxx  
573Sxx  
863Sxx  
ST curves  
ST curves



## General Specifications

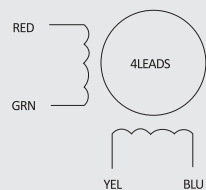
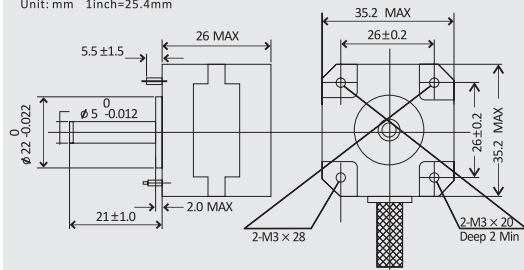
## Selection Table

Phase	NEMA Size	Model	Step Angle (°)	# of Leads	Connection	Current/Phase (A)	Holding Torque (Nm)	Length L (mm)	Weight (kg)	Match Drives
2	14	35HS01	1.8	4	-	0.4	0.07	26	0.15	EM402 / DM422C / DM556-CAN
	16	39HS02	1.8	4	-	0.6	0.22	34	0.20	EM402 / DM422C / DM556-CAN



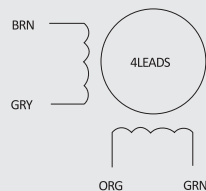
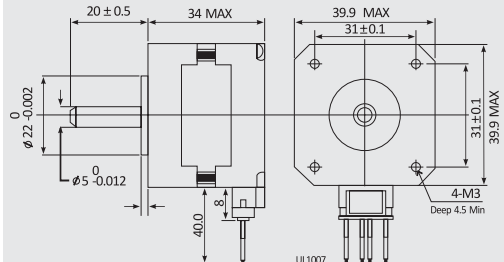
## Mechanical Specifications

Unit: mm 1inch=25.4mm



## Mechanical Specifications

Unit: mm 1inch=25.4mm



## Match Drives

Model	Match Drives
35HSxx / 39HSxx	EM402 / DM422C / DM556-CAN

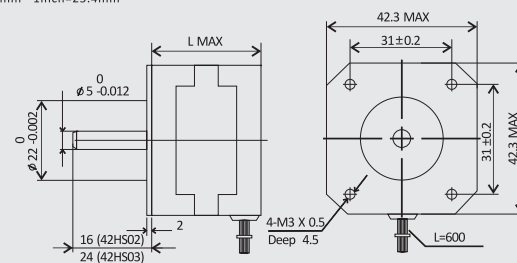
## General Specifications

## Selection Table

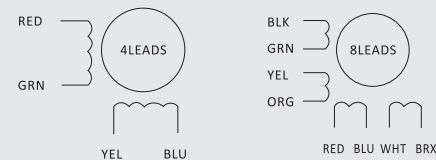
Phase	NEMA Size	Model	Step Angle (°)	# of Leads	Connection	Current/Phase (A)	Holding Torque (Nm)	Length L (mm)	Weight (kg)	Match Drives	
2	17	42HS02	1.8	4	-	0.4	0.22	40	0.24	EM402 / DM422C / DM556-CAN	
					Parallel	1.4	0.47				
		42HS03	1.8	8	Series	0.7	0.47	48	0.34		EM402 / DM422C / DM556-CAN
					Unipolar	1.0	0.34				



Unit: mm 1inch=25.4mm



## Wiring Diagram



## Match Drives

Model	Match Drives
42HSxx	EM402 / DM422C / DM556-CAN





## 57HSxx Series

### General Specifications

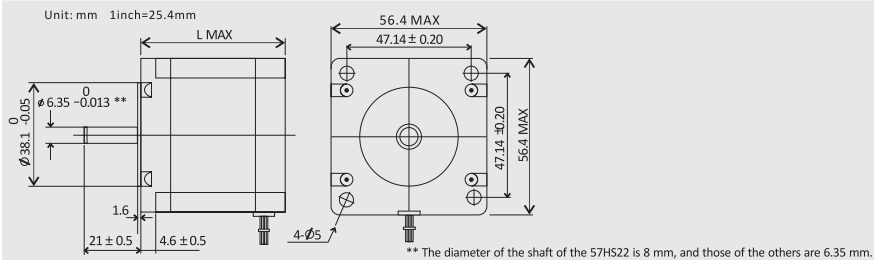
Angle Accuracy	± 5%(full step, no load)
Temperature Rise	80 °C Max
Ambient Temperature	-10 °C — +50 °C
Insulation Resistance	100M Ω min. 500VDC
Dielectric Strength	500VAC for one minute
Shaft Radial Play	0.06 Max. (450g-load)
Shaft Axial Play	0.08 Max. (450g-load)

### Selection Table

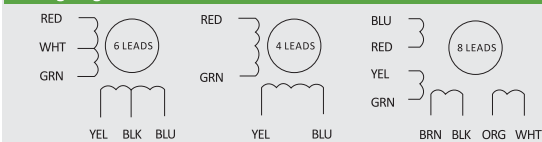
Phase	NEMA Size	Model	Step Angle (°)	# of Leads	Connection	Current/Phase (A)	Holding Torque (Nm)	Length L (mm)	Weight (kg)	Match Drives
2	23	57HS04	1.8	6	Series	2.0	0.4	41	0.45	EM503 / DM556 / DM556-CAN
					Unipolar	2.8	0.28			
		57HS09	1.8	8	Parallel	4.2	1.3	54	0.6	EM503 / EM705 / DM556 / DM556-CAN
					Series	2.1	1.3			
		57HS13	1.8	8	Unipolar	2.8	0.9	76	1.0	EM503 / EM705 / DM556 / DM556-CAN
					Parallel	4.0	1.8			
		57HS22*	1.8	8	Series	2.0	1.8	81	1.15	EM503 / EM705 / DM556 / DM556-CAN
					Unipolar	2.8	1.3			
		57HS22*	1.8	8	Parallel	5.6	2.2	81	1.15	EM503 / EM705 / DM556 / DM556-CAN
					Unipolar	2.8	2.2			

\* The diameter of the shaft of the 57HS22 is 8 mm, and those of the others are 6.35 mm.

### Mechanical Specifications



### Wiring Diagram



### Match Drives

Model	Match Drives	Model	Match Drives
57HS04	EM503 / EM705 / DM556 / DM556-CAN	57HS13	EM503 / EM705 / DM556 / DM556-CAN
57HS09	EM503 / EM705 / DM556 / DM556-CAN	57HS22	EM503 / EM705 / DM556 / DM556-CAN

## 86HSxx Series

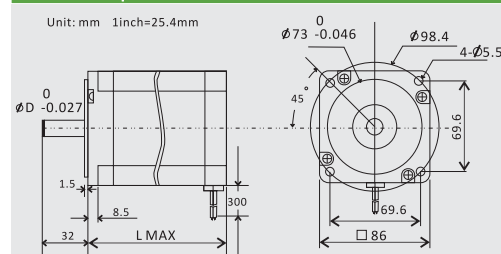
### General Specifications

Angle Accuracy	± 5%(full step, no load)
Temperature Rise	80 °C Max
Ambient Temperature	-10 °C — +50 °C
Insulation Resistance	100M Ω min. 500VDC
Dielectric Strength	500VAC for one minute
Shaft Radial Play	0.06 Max. (450g-load)
Shaft Axial Play	0.08 Max. (450g-load)

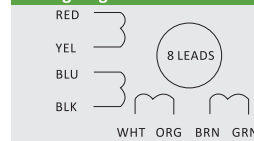
### Selection Table

Phase	NEMA Size	Model	Step Angle (°)	# of Leads	Connection	Current/Phase (A)	Holding Torque (Nm)	Length L (mm)	Weight (kg)	Match Drives
2	34	86HS35	1.8	8	Parallel	4.0	3.5	65	1.7	DM556-CAN / EM705 / EM806 / DM870
					Series	2.0	3.5			
					Unipolar	2.8	2.5			
		86HS45	1.8	8	Parallel	6.0	4.5	80	2.3	EM705 / EM806 / DM870 / DM1182
					Series	3.0	4.5			
					Unipolar	4.2	3.2			
		86HS65	1.8	8	Parallel	6.1	6.5	96	2.3	EM806 / DM870 / DM1182 / DM2282
					Series	3.05	6.5			
					Unipolar	4.3	4.6			
		86HS85	1.8	8	Parallel	6.8	8.5	118	3.8	EM806 / DM870 / DM1182 / DM2282
					Series	3.4	8.5			
					Unipolar	4.9	6.0			
		86HS120	1.8	8	Parallel	6.0	12	156	5.3	EM806 / DM870 / DM1182 / DM2282
					Unipolar	3.0	12			

### Mechanical Specifications

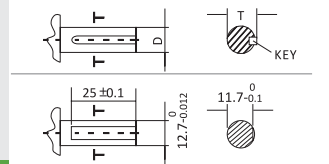


### Wiring Diagram



### Specifications of Motor Shafts

Model	T	KEY	D
86HS35	/	/	9.5
86HS45	/	/	12.7
86HS65, 86HS85	14.7	5*5*25	12.7
86HS120	17.875	5*5*25	15.875



The Shaft of the 86HS45

\* The shaft of the 86HS35 is round, not flat.

### Match Drives

Model	Match Drives
86HS35	EM705 / EM806 / DM1182
86HS45 / 86HS65	EM705 / EM806 / DM1182
86HS85 / 86HS120	EM705 / EM806 / DM1182



## 110HSxx Series

### General Specifications

Angle Accuracy	± 5% (full step, no load)
Temperature Rise	80 °C Max
Ambient Temperature	-10 °C — +50 °C
Insulation Resistance	100M Ω min. 500VDC
Dielectric Strength	500VAC for one minute
Shaft Radial Play	0.06 Max. (450g-load)
Shaft Axial Play	0.08 Max. (450g-load)

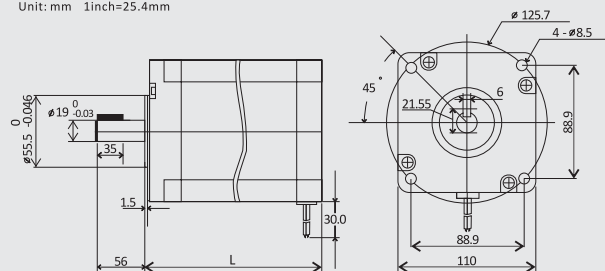


### Selection Table

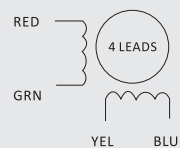
Phase	NEMA Size	Model	Step Angle (°)	# of Leads	Connection	Current/Phase (A)	Holding Torque (Nm)	Length L (mm)	Weight (kg)	Match Drives
2	42	110HS12	1.8	4	-	6.0	12	115	6.0	DM2282 / DM1182
		110HS20	1.8	4	-	6.0	20	150	8.4	DM2282 / DM1182
		110HS28	1.8	4	-	6.5	28	201	11.7	DM2282 / DM1182

### Mechanical Specifications

Unit: mm 1inch=25.4mm



### Wiring Diagram



### Match Drives

Model	Match Drives
110HS12	DM2282 / DM1182
110HS20	
110HS28	

## 130HSxx Series

### General Specifications

Angle Accuracy	± 5% (full step, no load)
Temperature Rise	80 °C Max
Ambient Temperature	-10 °C — +50 °C
Insulation Resistance	100M Ω min. 500VDC
Dielectric Strength	500VAC for one minute
Shaft Radial Play	0.06 Max. (450g-load)
Shaft Axial Play	0.08 Max. (450g-load)

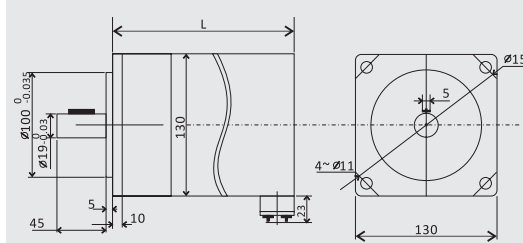


### Selection Table

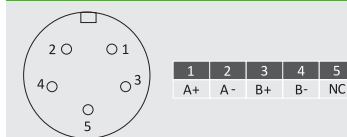
Phase	NEMA Size	Model	Step Angle (°)	# of Leads	Connection	Current/Phase (A)	Holding Torque (Nm)	Length L (mm)	Weight (kg)	Match Drives
2	51	130HS27	1.8	4	-	6.0	27	227	13	DM2282 / DM1182
		130HS33	1.8	4	-	6.0	33	227	13	DM2282 / DM1182
		130HS40	1.8	4	-	7.0	40	283	16	DM2282 / DM1182
		130HS45	1.8	4	-	7.0	45	283	19	DM2282 / DM1182

### Mechanical Specifications

Unit: mm 1inch=25.4mm



### Wiring Diagram



### Match Drives

Model	Match Drives
130HSxx	DM2282 / DM1182

### Specifications of Motor Shafts

T	KEY	D
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T=21  
KEY=5 × 5 × 30



# 573Sxx Series

## General Specifications

Angle Accuracy	± 5%(full step, no load)
Temperature Rise	80 °C Max
Ambient Temperature	-10 °C — +50 °C
Insulation Resistance	100M Ω min. 500VDC
Dielectric Strength	500VAC for one minute
Shaft Radial Play	0.06 Max. (450g-load)
Shaft Axial Play	0.08 Max. (450g-load)



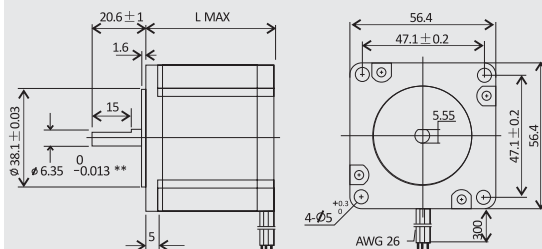
## Selection Table

Phase	NEMA Size	Model	Step Angle (°)	# of Leads	Connection	Current/Phase (A)	Holding Torque (Nm)	Length L (mm)	Weight (kg)	Match Drives
3	23	573S05	1.2	6	Delta	5.2	0.45	42	0.45	3DM683 / 3DM883
		573S09	1.2	6	Delta	3.5	0.9	50	0.75	3DM683 / 3DM883
		573S15	1.2	6	Delta	5.8	1.3	76	1.1	3DM683 / 3DM883

\* The diameter of the shaft of the 573S15 is 8 mm, and those of the others are 6.35 mm.

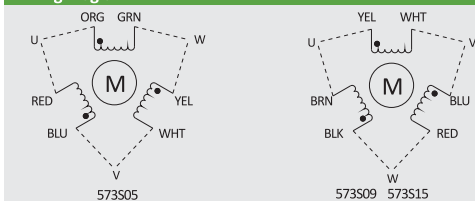
## Mechanical Specifications

Unit: mm 1inch=25.4mm



\*\* The diameter of the shaft of the 573S15 is 8 mm, and those of the others are 6.35 mm.

## Wiring Diagram



## Match Drives

Model	Match Drives
573S05	3DM683 / 3DM883
573S09	3DM683 / 3DM883
573S15	3DM683 / 3DM883

# 863Sxx Series

## General Specifications

Angle Accuracy	± 5%(full step, no load)
Temperature Rise	80 °C Max
Ambient Temperature	-10 °C — +50 °C
Insulation Resistance	100M Ω min. 500VDC
Dielectric Strength	500VAC for one minute
Shaft Radial Play	0.06 Max. (450g-load)
Shaft Axial Play	0.08 Max. (450g-load)

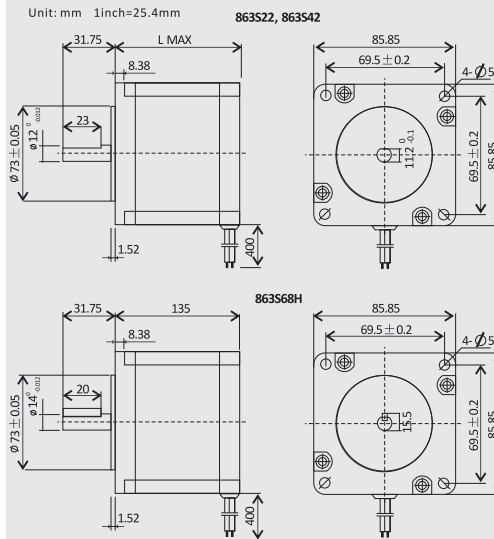


## Selection Table

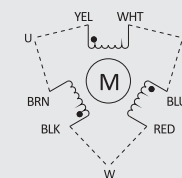
Phase	NEMA Size	Model	Step Angle (°)	# of Leads	Connection	Current/Phase (A)	Holding Torque (Nm)	Length L (mm)	Weight (kg)	Match Drives
3	23	863S22	1.2	6	Delta	5.0	2.3	71	1.7	3DM683 / 3DM883
		863S42	1.2	6	Delta	5.0	4.3	103	2.9	3DM683 / 3DM883
		863S68H	1.2	6	Delta	2.3	6.8	135	4.0	3DM683 / 3DM883

## Mechanical Specifications

Unit: mm 1inch=25.4mm

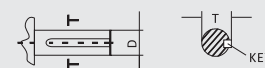


## Wiring Diagram



## Specifications of Motor Shafts

Model	T	KEY	D
863S68H	15.5	4*4*20	14



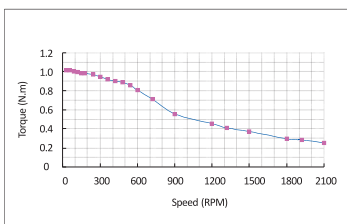
## Match Drives

Model	Match Drives
863S22	3DM683 / 3DM883
863S42	3DM683 / 3DM883
863S68H	3DM683 / 3DM883



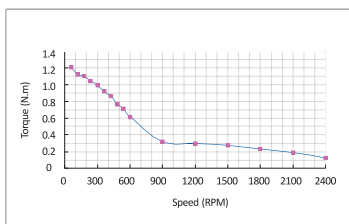
## Speed-Torque Curves of 2-phase Stepper Motors

57HS09



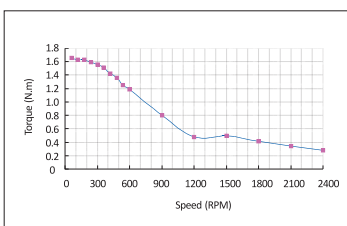
Stepper Motor: 57HS09  
Stepper Drive: MD556  
Input Voltage: 36 VDC  
Output Current: 3.8 A(Peak)  
Microstep: 1600 steps/rev.  
Connection: Parallel

57HS13



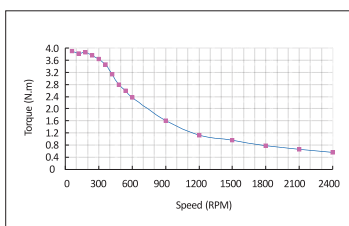
Stepper Motor: 57HS13  
Stepper Drive: MD556  
Input Voltage: 36 VDC  
Output Current: 3.8 A(Peak)  
Microstep: 2000 steps/rev.  
Connection: Parallel

57HS22



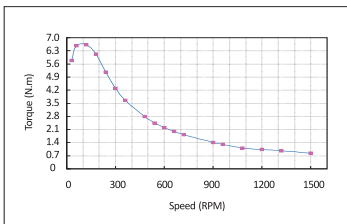
Stepper Motor: 57HS22  
Stepper Drive: MD556  
Input Voltage: 36 VDC  
Output Current: 5.6 A(Peak)  
Microstep: 2000 steps/rev.  
Connection: Parallel

86HS45



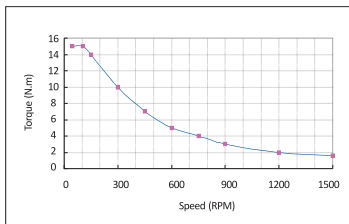
Stepper Motor: 86HS45  
Stepper Drive: MD882  
Input Voltage: 64 VDC  
Output Current: 8.2 A(Peak)  
Microstep: 2000 steps/rev.  
Connection: Parallel

86HS85



Stepper Motor: 86HS85  
Stepper Drive: MD882  
Input Voltage: 68 VDC  
Output Current: 7.3 A (Peak)  
Microstep: 3200 steps/rev.  
Connection: Parallel

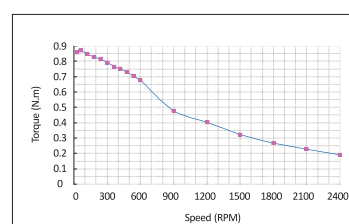
110HS20



Stepper Motor: 110HS20  
Stepper Drive: MD2278  
Input Voltage: 110 VAC  
Output Current: 7.8 A (Peak)  
Microstep: 400 steps/rev.  
Connection: Parallel

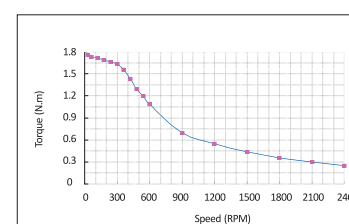
## Speed-Torque Curves of 3-phase Stepper Motors

573S09



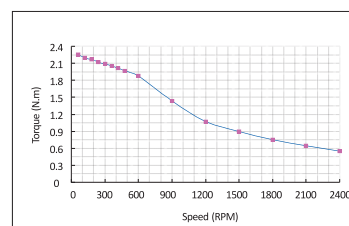
Stepper Motor: 573S09  
Stepper Drive: 3MD560  
Input Voltage: 36 VDC  
Output Current: 4.9 A(Peak)  
Microstep: 2000 steps/rev.  
Connection: Delta

573S15



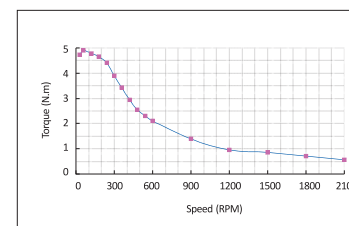
Stepper Motor: 573S15  
Stepper Drive: 3MD560  
Input Voltage: 36 VDC  
Output Current: 7.7 A(Peak)  
Microstep: 2000 steps/rev.  
Connection: Delta

863S22



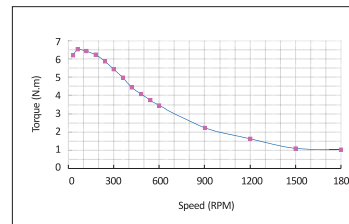
Stepper Motor: 863S22  
Stepper Drive: 3ND883  
Input Voltage: 64 VDC  
Output Current: 6.6 A(Peak)  
Microstep: 2000 steps/rev.  
Connection: Delta

863S42



Stepper Motor: 863S42  
Stepper Drive: 3ND883  
Input Voltage: 64 VDC  
Output Current: 7.4 A(Peak)  
Microstep: 2000 steps/rev.  
Connection: Delta

863S68H



Stepper Motor: 863S68H  
Stepper Drive: 3MD2380  
Input Voltage: 220 VAC  
Output Current: 3.36 A(Peak)  
Microstep: 2000 steps/rev.  
Connection: Delta