SANMOTION K Series DC Servo Motor

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1. Introduction

With over sixty years of history, SANYO DENKI's DC servo motors have contributed to the advancement of industry in Japan.[1] Recently, they have even been adopted in precision measuring equipment such as coordinate measuring machines and medical equipments. These applications require low motor speed fluctuation and temperature rise to improve measurement accuracy. Also, low voltage and noise are necessary because such machinery operates near people.

Our new *SANMOTION K* series DC servo motors significantly reduce cogging torque, which causes speed fluctuation, and have low temperature rise and reduced loss. Moreover, we have devised the brushes and body structure to lower noise.

As with our current model, the lineup includes four flange sizes (42, 54, 76, and 88 mm). We have added a low-voltage model to the standard lineup in flange sizes of 42 × 42 and 54 × 54 mm.

This article will introduce the lineup of the new model, as well as its specifications and features. While developing this new model we devised manufacturing technologies to ensure stable performance.

2. Specifications

2.1 Appearance and dimensions

Figure 1 depicts one example of the new model, a 54 × 54 mm 110 W motor with an encoder. Figure 2 and Table 1 provide the main dimensions of the new model. The new model has the same mounting dimensions as our current T series. As such, replacement is possible without needing to change equipment-side mounting specifications.

Fig. 1 Appearance
(54 × 54 mm 110 W motor with encoder)

2.2 Lineup and main specifications

Table 2 shows the standard lineup and options. As with the current model, incremental encoders, tachogenerators, and brakes can be mounted to the new model. Options can be combined, so we can flexibly respond to the requirements of individual customers. The standard lineup models also conform to the UL, cUL, and IEC safety standards.

Table 3 lists the main specifications of the low-voltage model, while Table 4 lists the main specifications of the standard voltage model. By adding 42 × 42 mm and 54 × 54 mm low-voltage motors to the standard lineup, even machines operating close to people can be used safely. For this reason, the new model can be used for a wider range of applications while having optimal specifications for precision measurement equipment and medical equipment.

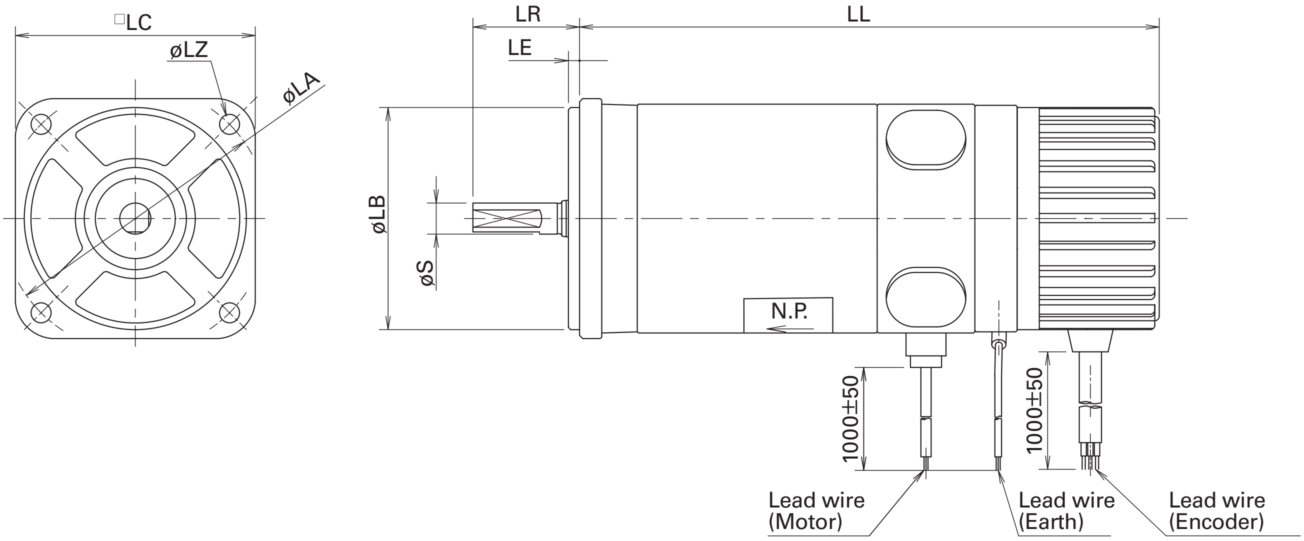


Fig. 2 Main specifications (with encoder)

Table 1 List of main specifications (with encoder)

Dimensions (mm)	Model								
	KB402XS0	KB404XS0 KA404XS0	KB406XS0 KA406XS0	KB506XS0 KA506XS0	KB511XS0 KA511XS0	KA720XS0	KA730XS0	KA840XS0	KA850XS0
LL	83±1	96±1	109±2	110.5±2	130.5±2	134.5±2	158.5±2	166±2	181±2
LA	48±0.2			60±0.3		90±0.3		100±0.3	
LB	$34^{\ 0}_{-0.025}$			$50^{\ 0}_{-0.025}$		$70^{\ 0}_{-0.030}$		$80^{\ 0}_{-0.030}$	
LE	2±0.3			2.5±0.3		3±0.4			
LC	42±0.5			54±0.5		76±0.8		88±0.8	
LZ	4−ø3.5			4−ø4.5		4−ø5.5		4−ø6.6	
LR	24±0.8					30±0.8		35±0.8	
S	$7^{\ 0}_{-0.009}$					$14^{\ 0}_{-0.011}$		$16^{\ 0}_{-0.011}$	

Table 2 List of standard lineup and options

Flange size (mm)	Rated output (W)	Rated armature voltage		Rated speed (min^{-1})	Protection rating	Safety standards	Options		
		Low voltage (KB) 24 V class	Standard voltage (KA) 75 V class				Tachogenerator	Brake	Incremental encoder
42	23	○	–	3000	IP43	UL cUL IEC	3 V/krpm	–	Standard 2000 P/R (A phase, B phase, Z phase)
	40	○	○						
	60	○	○						
54	60	○	○				7 V/krpm	90 VDC	
	80	○	–						
	110	–	○						
76	200	–	○						
	300	–	○	2500					
88	400	–	○						
	500	–	○						

Table 3 List of main specifications (low-voltage model)

Model number	KB402	KB404	KB406	KB506	KB511
Rated armature voltage (V)	20 DC	24 DC			
Rated output (W)	23	40	60	60	80
Rated speed (min^{-1})	3000	3000	3000	3000	3000
Max. speed (min^{-1})	5000	5000	5000	5000	5000
Rated torque (Nm)	0.074	0.13	0.19	0.19	0.26
Peak torque (Nm)	0.42	0.76	1.2	1.8	2.16
Rotor inertia ($\times 10^{-4}$ kg·m^2) (Note)	0.047	0.084	0.108	0.22	0.37
Motor weight (kg) (Note)	0.3	0.4	0.5	0.8	0.85

(Note) Value of motor only

Table 4 List of main specifications (standard voltage model)

Model number	KA404	KA406	KA506	KA511	KA720	KA730	KA840	KA850
Rated voltage (V)	72 DC	70 DC	75 DC	75 DC	80 DC	75 DC	85 DC	80 DC
Rated output (W)	40	60	60	110	200	300	400	500
Rated speed (min^{-1})	3000	3000	3000	3000	3000	2500	2500	2500
Max. speed (min^{-1})	5000	5000	5000	5000	5000	4000	4000	3000
Rated torque (Nm)	0.13	0.19	0.19	0.35	0.64	1.15	1.53	1.91
Peak torque (Nm)	0.76	1.2	1.8	3.4	5.4	9.8	12	16.7
Rotor inertia ($\times 10^{-4}$ kg·m^2) (Note)	0.084	0.108	0.22	0.37	1.47	2.7	5	6
Motor weight (kg) (Note)	0.4	0.5	0.8	0.85	1.8	2.5	3.4	4.1

(Note) Value of motor only

3. Features

3.1 Reduction of cogging torque

Cogging torque causes speed to fluctuate when motors rotate, and vibration and noise in machinery. Cogging torque has been significantly reduced on the new model to help improve performance of customers' equipment.

Figure 3 shows a comparison of cogging torque waveforms. With the new model, cogging torque for both sizes has been reduced by more than half compared to our current model.

For the new model, from the initial development phase, product design and production line design were advanced simultaneously, and we devised manufacturing technologies to ensure stable performance.

The magnet and armature core shapes were designed to minimize cogging torque while maintaining torque characteristics. Specifically, we determined the pole arc angle that optimizes the magnet's inner and outer radii and minimizes cogging torque, as shown in Figure 4. In addition to devising a method for laminating electromagnetic steel plates, we introduced a technique for automating magnet attachment. We applied our knowledge of manual assembly to automated assembly, and developed manufacturing technologies to stably minimize cogging torque.

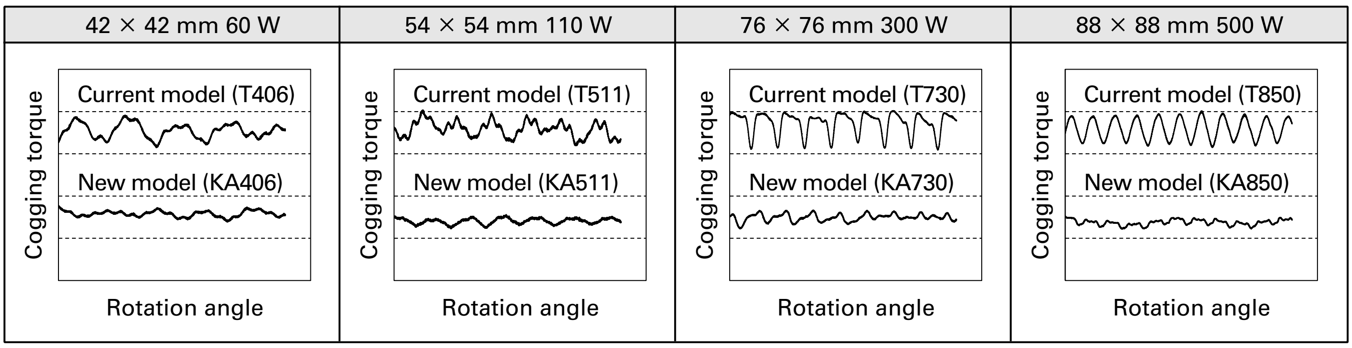


Fig. 3 Comparison of cogging torque waveforms

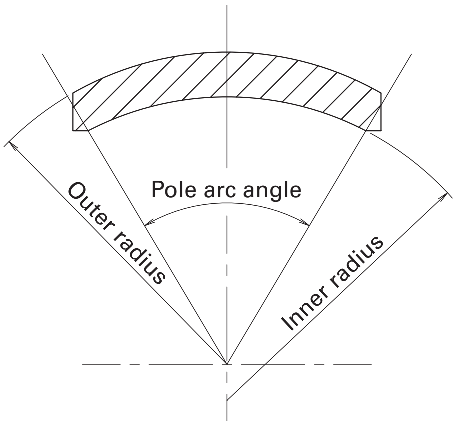
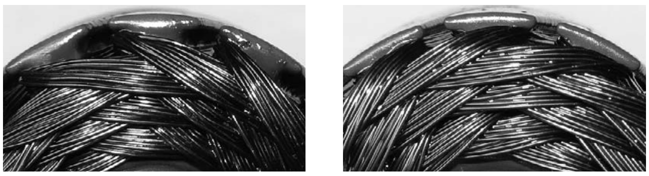


Fig. 4 Magnet shape

3.2 Improved efficiency and low heat generation due to reduced loss

Generally, increasing the winding space factor within a slot can reduce copper loss. Moreover, in DC motors there is mechanical loss that occurs with the mechanical sliding of the brushes and commutators. For the new model, we have increased the winding space factor to reduce copper loss, and optimized the material and number of brushes, consequently reducing mechanical loss.

As one example, Figure 5 shows a comparison of the armature windings for the 54 × 54 mm 110 W model. For the new model, innovations include using a nozzle-type coil winding machine and the control method thereof, and we reduced copper loss by using thick windings with a high space factor.



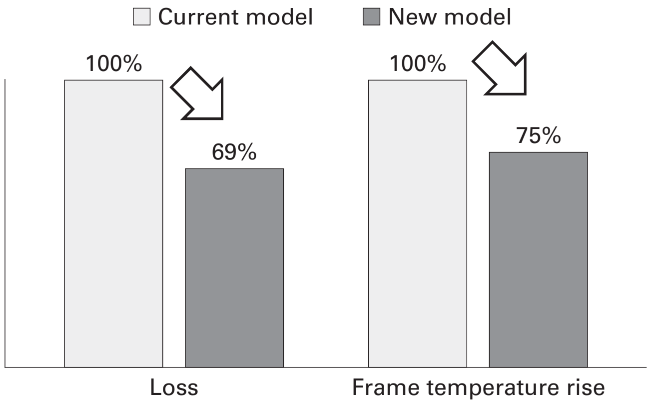
(a) Current model (b) New model

Fig. 5 Comparison of armature windings (54 × 54 mm 110 W motors)

Moreover, by optimizing the number and material of brushes, we have reduced mechanical loss from friction between brushes and commutators while maintaining equivalent brush life to the current model.

Figure 6 shows a comparison of loss and frame temperature rise between the new and current 42 × 42 mm 60 W models. In line with a 31% reduction in loss compared to the current model, frame temperature rise has been reduced by 25%. Also, motor efficiency has been improved by around 10%.

This high efficiency limits temperature rise, so it has little impact on the temperature of customers' equipment, and contributes to energy-saving in equipments.



Note: Test conditions: Rated output
(according to in-house heat dissipation conditions)

Fig. 6 Comparison of loss and temperature rise values (42 × 42 mm 60 W motors, at rated output)

3.3 Low noise

A structural feature of DC servo motors is that they have a mechanical sliding portion consisting of brushes and commutators. The vibrations from the brush and commutator contact is one of the main causes of noise during motor rotation.

For the new model, vibrations and noise caused by brush and commutator contact have been suppressed and noise levels have been reduced by optimizing the number of brushes and improving the rigidity of the bracket portion that supports the brushes.

Figure 7 is a comparison of noise levels for 54 × 54 mm 110 W models. For the new model noise is lower across a wide rotational speed range. Compared to the current model, noise has been reduced by up to around 8 dB.

The low noise levels of the new model allow it to be used comfortably near people, such as in medical equipment.

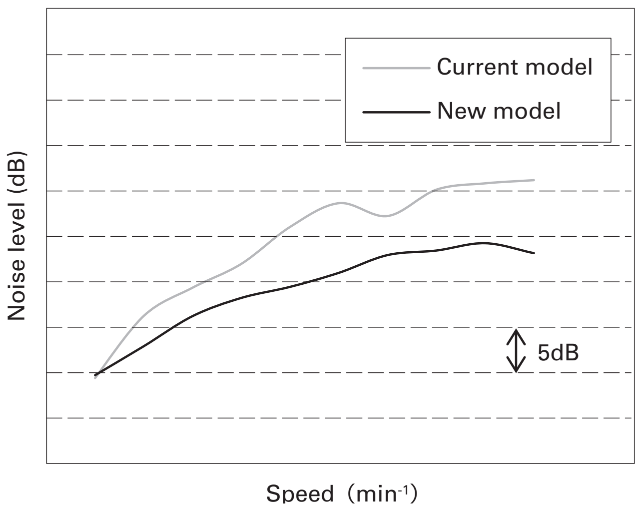


Fig. 7 Noise level comparison (54 × 54 mm 110 W motors, no-load)

4. Conclusion

This article has introduced the lineup, specifications, and features of the *SANMOTION K* series DC servo motor.

The new model features high efficiency, low torque fluctuation, and low motor temperature rise. Moreover, a low-voltage model has been added to the standard lineup. This product can help improve the performance of customers' equipment and create new value. Because the mounting size of the new model is the same as our current model, they can easily replace the current model customers have been using .

We will continue to pursue the ease-of-use unique to DC servo motors, and meet the needs of current and new applications and markets by combining product design and manufacturing technologies.

Reference

(1) SANYO DENKI: Integrated Report 2019
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