Development of the *SANMOTION F* Series 56 mm sq. 2-Phase 1.8° Stepping Motors

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1. Introduction

Stepping motors help simplify systems because they feature open loop control that can perform highly accurate positioning and speed control even without any position or speed sensors. They are used in a wide variety of fields, including office automation equipment and general industrial machinery. Demand for these products has been growing in recent years, and especially for use in semiconductor manufacturing equipment and medical devices. Products in these fields are required to have high torque, low noise, and low energy consumption. We released the *SANMOTION F* 42 mm sq. 2-Phase 1.8° stepping motors[(1)] in 2017 to great acclaim.

Against such a backdrop, we expanded the lineup with a newly developed *SANMOTION F* 56 mm sq. 2-Phase 1.8° stepping motors.

Our goal was to increase torque approximately 40% compared to our current model, as well as reduce noise and increase efficiency. We also enriched the lineup of options.

This article begins by showing the new models' appearance, lineup, and specifications. We then discuss the design concept we applied for the new models to increase torque, reduce noise, and reduce power consumption. This is followed by an explanation of how this was accomplished, along with a comparison with the current model. Finally, we discuss customizability and the lineup of options.

2. Specifications

2.1 Appearance

Figure 1 shows the appearance of the new model. Regarding the connection, although all of the current models (103H712 series) were lead types, the new models are connector types as standard. The advantage of a connector type is that you can connect a harness after mounting the motor to equipment. This makes handling of leads and mounting the motor to equipment easier. Also, harness customization had resulted in a number of different models for the current model, and it was difficult for customers to manage parts. For the new model, harness customization is handled using a relay harness, and the standardized motor makes it easier to manage parts.

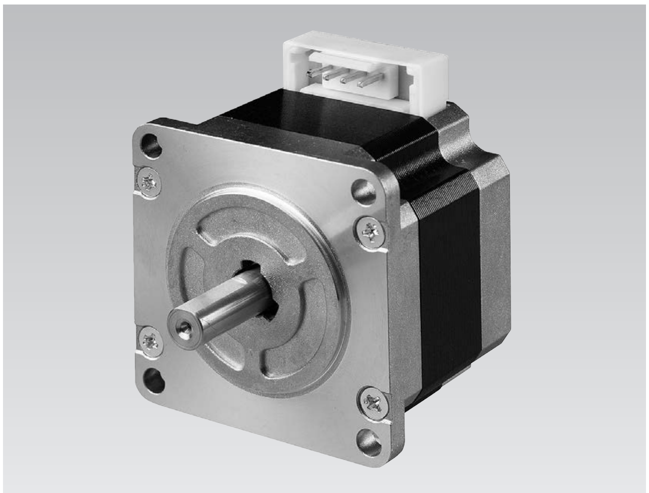

Fig. 1 Appearance of the new model (SM2562 type, bipolar)

2.2 External dimensions

Figure 2 provides the major dimensions of the new model. For mounting compatibility with the current models, the new models' flange size is 56 mm sq., with the same mounting pitch and fitting part dimensions as the current models. With this, replacement of the current models with new models is easy without requiring customers to change their equipment mounting specifications. We also used a standard shaft diameter of ø8 mm with increased shaft strength to handle the increased torque.

As with the current models, shaft specifications can be customized tailor to customer requests.

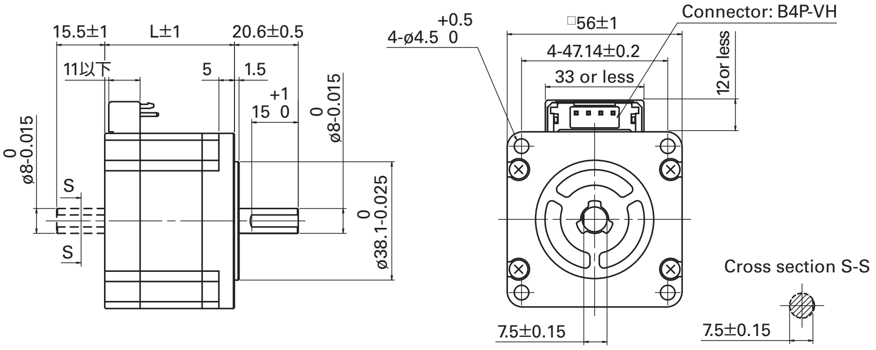

Fig. 2 Dimensions of the new model

Table 1 Unipolar motor lineup and main specifications

Model no.		Holding torque at 2-phase excitation	Rated current	Winding inductance	Rotor inertia	Mass	Motor length (L)
Single shaft	Dual shaft	N m or more	A/phase	mH	$\times 10^{-4}$kg m^2	kg	mm
SM2561C10U41	**SM2561C10U11**	0.53	1	6.8	0.14	0.49	41.8
SM2561C20U41	**SM2561C20U11**	0.53	2	1.8	0.14	0.49	41.8
SM2561C30U41	**SM2561C30U11**	0.53	3	0.77	0.14	0.49	41.8
SM2562C10U41	**SM2562C10U11**	1.1	1	12.6	0.28	0.69	53.8
SM2562C20U41	**SM2562C20U11**	1.1	2	3.3	0.28	0.69	53.8
SM2562C30U41	**SM2562C30U11**	1.1	3	1.37	0.28	0.69	53.8
SM2563C10U41	**SM2563C10U11**	1.7	1	17	0.5	1.1	75.8
SM2563C20U41	**SM2563C20U11**	1.7	2	4.2	0.5	1.1	75.8
SM2563C30U41	**SM2563C30U11**	1.7	3	1.75	0.5	1.1	75.8
SM2564C10U41	**SM2564C10U11**	1.75	1	22	0.6	1.27	85.8
SM2564C20U41	**SM2564C20U11**	1.75	2	5.4	0.6	1.27	85.8
SM2564C30U41	**SM2564C30U11**	1.75	3	2.2	0.6	1.27	85.8

Table 2 Bipolar motor lineup and main specifications

Model no.		Holding torque at 2-phase excitation	Rated current	Winding inductance	Rotor inertia	Mass	Motor length (L)
Single shaft	Dual shaft	N m or more	A/phase	mH	$\times 10^{-4}$kg m^2	kg	mm
SM2561C10B41	**SM2561C10B11**	0.75	1	13.5	0.14	0.49	41.8
SM2561C20B41	**SM2561C20B11**	0.75	2	3.5	0.14	0.49	41.8
SM2561C30B41	**SM2561C30B11**	0.75	3	1.5	0.14	0.49	41.8
SM2561C40B41	**SM2561C40B11**	0.75	4	0.85	0.14	0.49	41.8
SM2561C60B41	**SM2561C60B11**	0.75	6	0.38	0.14	0.49	41.8
SM2562C10B41	**SM2562C10B11**	1.4	1	25.5	0.28	0.69	53.8
SM2562C20B41	**SM2562C20B11**	1.4	2	6.5	0.28	0.69	53.8
SM2562C30B41	**SM2562C30B11**	1.4	3	2.9	0.28	0.69	53.8
SM2562C40B41	**SM2562C40B11**	1.4	4	1.5	0.28	0.69	53.8
SM2562C60B41	**SM2562C60B11**	1.4	6	0.72	0.28	0.69	53.8
SM2563C10B41	**SM2563C10B11**	2.35	1	36	0.5	1.1	75.8
SM2563C20B41	**SM2563C20B11**	2.35	2	9.5	0.5	1.1	75.8
SM2563C30B41	**SM2563C30B11**	2.35	3	4.2	0.5	1.1	75.8
SM2563C40B41	**SM2563C40B11**	2.35	4	2.4	0.5	1.1	75.8
SM2563C60B41	**SM2563C60B11**	2.35	6	1.05	0.5	1.1	75.8
SM2564C10B41	**SM2564C10B11**	2.5	1	41	0.6	1.27	85.8
SM2564C20B41	**SM2564C20B11**	2.5	2	11	0.6	1.27	85.8
SM2564C30B41	**SM2564C30B11**	2.5	3	4.9	0.6	1.27	85.8
SM2564C40B41	**SM2564C40B11**	2.5	4	2.8	0.6	1.27	85.8
SM2564C60B41	**SM2564C60B11**	2.5	6	1.15	0.6	1.27	85.8

2.3 Lineup and main specifications

Table 1 and Table 2 show the lineup and main specifications for unipolar and bipolar type stepping motors, respectively. The new models are available in four motor lengths—41.8 mm, 53.8 mm, 75.8 mm, and 85.8 mm. 12 unipolar models and 20 bipolar models are available with single shaft and dual shaft models, for a total of 64 standard models. The motor length of the new models is the same as or shorter than the current models, making replacement with the same size easy and even downsizing is possible.

The new models also conform to the UL and cUL safety standards as standard.

3. Product Features

3.1 High torque

The new models provide approximately 40% higher torque in the operating speed range compared with the current models. Figure 3 shows a comparison of the rotational speed vs. torque characteristics of the new and current models. Stepping motors have an extremely narrow gap between the stator and rotor, and the amount of magnetic flux in the gap has a significant effect on torque. We decided to use a magnet with high residual magnetic flux density for the new models. We also improved the machining accuracy of parts such as the stator and rotor, and carefully designed our assembly processes and facilities. We increased both machining accuracy and assembly accuracy, and were able to reduce the gap length by 28% while maintaining the same productivity and quality. We used a design with a higher amount of magnetic flux in the gap and increased torque even at high speeds, helping customer equipment operate faster.

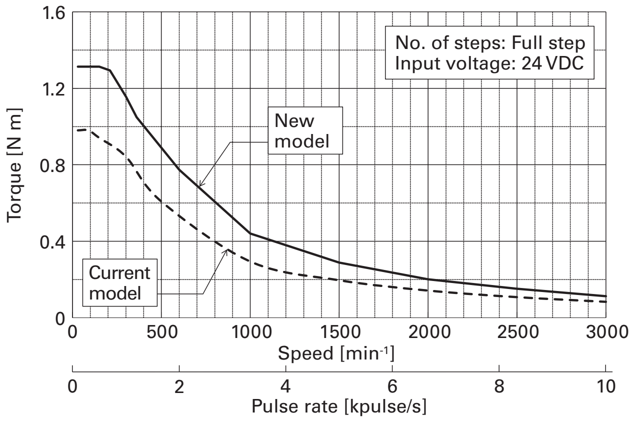

Fig. 3 Rotational speed vs. torque characteristics (SM2562C30B41)

3.2 Low noise

Compared with the current models, the noise level of the new models in their operating speed range has been reduced by 3 dB. This is equivalent to reducing acoustic energy by half. Stepping motors are often used in medical devices, and equipment is often used near medical personnel and patients. So, this equipment is required to operate quietly. To achieve low noise, we incorporated the following innovative ideas.

(1) High-rigidity stator core

We analyzed the structure of the stator core, and determined the back yoke and pole shapes to increase the rigidity of the stator structure.

(2) High-rigidity motor

We designed the new models so that the bracket and stator fitting parts would be easier to assemble while maintaining high motor rigidity. We optimized the tightening allowance and engagement length.

By designing the stator structure and motor with higher rigidity, we were able to optimally distribute the fixed vibration value and reduce noise.

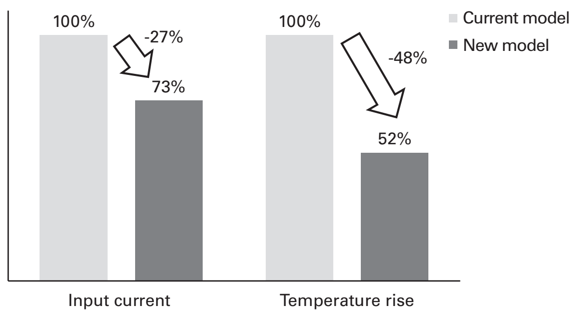

Fig. 4 Comparison of input current and temperature rise (SM2562C30B41)

3.3 Reduced power consumption through increased motor efficiency

Compared to the current model, the new model is approximately 3% more efficient. We increased the winding fill factor in the slot, reduced copper loss, and made use of the optimal core design to reduce iron loss. This allowed us to reduce overall loss. The reduction of these losses together with the increased torque discussed above made it possible to achieve equivalent torque to the current models with less input current.

Figure 4 shows an example comparing the input current and motor temperature increase for SM2562C30B41. When the torque is the same as the current models, the input current of the new models can be reduced 27%. This results in a 48% reduction in the temperature increase of the motor.

This reduces heat generation in equipment and contributes to energy savings.

3.4 Customizability and a wide lineup of options

As with the current models, we designed the new models so that it can be easily customized. It can be customized as required by the customer. For example, the axial shape could be changed, or a tap hole on a bracket could be added. We also added more options and designed a lineup of standard options, including models with gears and models with encoders. Table 3 shows the lineup of options. We prepared a lineup of models with gears, consisting of six low-backlash gear models with different speed-reduction rates, and two harmonic gear models. We prepared a lineup of models with encoders, consisting of three models with different step numbers. We also offer a lineup of models with electromagnetic brakes. With this, customers can easily customize products to suit their equipment, and can select from a wide lineup of options for greater flexibility in designing equipment.

Table 3 Lineup of options

Low-backlash gear	Gear ratio	1:3.6, 1:7.2, 1:10, 1:20, 1:30, 1:36
	Backlash	0.55° or less
Harmonic gear	Gear ratio	1:50, 1:100
Encoder	Microsteps	1000, 2000, 4000 P/R
	Number of channels	3
	Output circuit	Line driver
	Input voltage	5 VDC ±5%
Electromagnetic brake	Input voltage	24 VDC ±5%
	Static friction torque	0.8 N m or more

4. Conclusion

In this article, we introduced the lineup, specifications, and features of the *SANMOTION F* 56 mm sq. 2-Phase 1.8° stepping motor.

For the new models, we increased torque approximately 40%, reduced noise 3 dB, and increased efficiency approximately 3% compared with the current models. We switched to using a connector type so we could use the same motor for harness customization. The new models can easily replace the current models thanks to the mounting and size compatibility. We also enhanced the lineup of options.

The new stepping motors are easy to use and can contribute toward creating new value when used in customer equipment. We will continue our efforts to further improve stepping motor performance and functionality, and to develop products that will satisfy even more customers.

References

(1) Koji Nakatake and 6 others: Development of the *SANMOTION F* Series 42 mm sq. 2-Phase 1.8° Stepping Motor
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