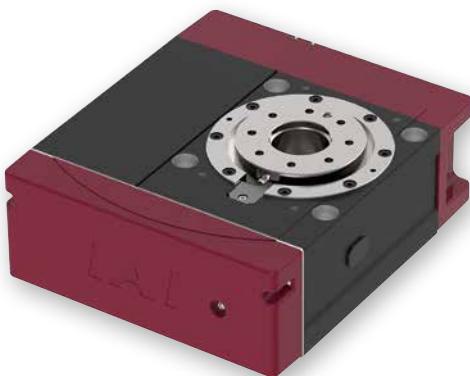


# EC-RTC18

Body width  
190 mm  
24v stepper motor

## ■ Model specification items

<b>EC</b>	<b>RTC18</b>	<b>M</b>	<b>330</b>		
Series	Type	Reduction ratio	Swaying angle	Power • I/O cable length	Option
		M Reduction ratio 1/40	330 330° rotation	Refer to the table of power • I/O cable below	Refer to the table of options below



CE RoHS 10

Horizontal Vertical Side Ceiling

## ■ Product

Oscillation angle (degree)
330

## ■ Table of options

Name	Option code	Reference page
RCON-EC connection specification (Note 1)	ACR	2-477
Brake	B	2-477
External stopper	ES	2-480
Non-motor end specification	NM	2-490
PNP specification	PN	2-490
Shaft adaptor	SA	2-492
Table adapter	TA	2-493
Twin power supply specification	TMD2	2-493
Battery-less absolute encoder specification	WA	2-494
Wireless communication specification	WL	2-494
Wireless axis operation specification	WL2	2-495

(Note 1) When RCON-EC connection specification (ACR) is selected, PNP specification (PN) and twin power supply specification (TMD2) cannot be selected.

## ■ Table of Power • I/O cable length

### ■ Standard connector cable

Cable code	Cable length	User wiring specification (flying leads)	RCON-EC connection specification (Note 3) (with connectors on both ends)
		CB-EC-PWBIO□□□-RB supplied	CB-REC-PWBIO□□□-RB supplied
0	No cable	○ (Note 2)	○
1 ~ 3	1 ~ 3m	○	○
4 ~ 5	4 ~ 5m	○	○
6 ~ 7	6 ~ 7m	○	○
8 ~ 10	8 ~ 10m	○	○

(Note 2) Only the terminal block connector is included. Refer to P2-503 for details.

(Note 3) If RCON-EC connection specification (ACR) is selected as an option.

(Note) The robot cable is standard.

### ■ 4-way connector cable

Cable code	Cable length	User wiring specification (flying leads)	RCON-EC connection specification (Note 4) (with connectors on both ends)
		CB-EC2-PWBIO□□□-RB supplied	CB-REC2-PWBIO□□□-RB supplied
S1 ~ S3	1 ~ 3m	○	○
S4 ~ S5	4 ~ 5m	○	○
S6 ~ S7	6 ~ 7m	○	○
S8 ~ S10	8 ~ 10m	○	○

(Note 4) If RCON-EC connection specification (ACR) is selected as an option.

(Note) The robot cable is standard.

Selection Notes

- (1) Output torque decreases as rotational speed increases. Refer to the "Correlation between Rotational Speed and Output Torque" for details.
- (2) The allowable moment of inertia of the rotating workpiece varies according to rotational speed. Refer to the "Correlation between Rotational Speed and Allowable moment of inertia" for details.
- (3) The brake is for holding only. Do not use it for braking and emergency stop purposes.
- (4) When selecting, perform a calculation based on the "Selection Method (P2-83)" and confirm the operating conditions.
- (5) When performing the push motion, refer to the "Correlation between the Push Force and Current Limit" for confirmation. The push force is only for a reference value.
- (6) The maximum acceleration/deceleration is 0.7G for horizontal/ceiling mounting and 0.5G for side and vertical mounting.

## Main specifications

Item	Description
Reduction ratio	1/40
Maximum torque (N·m)	25.2
Speed/acceleration/ deceleration (Note 5)	Max. speed (degree/s) 450 Min. speed (degree/s) 20 Rated acceleration/deceleration (G) 0.3 Max. acceleration/deceleration (G) (Note 6) 0.7
Brake	Brake specification Non-excitation actuating solenoid brake Brake holding torque (N·m) (Note 7) 16
Motion range (degree)	330

(Note 5)  $1G=9807/\text{s}^2$

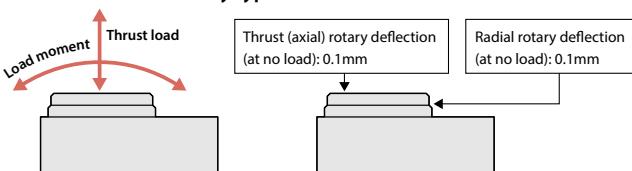
(Note 6) Horizontal only. The maximum acceleration/deceleration will be 0.5G when side or vertical mounted.

(Note 7) Both the allowable moment of inertia and brake retaining torque will not necessarily be established. Confirm that the load torque does not exceed the retaining torque.

Item	Description
Driving system	Hypoid gear + timing belt
Positioning repeatability	$\pm 0.02$ degrees
Homing method	Mechanical stopper method
Homing precision	$\pm 0.02$ degrees
Backlash	0.2 degree or less
Allowable thrust load	1000N
Dynamic allowable load moment (Note 8)	25 N·m
Allowable moment of inertia	$0.49\text{kg}\cdot\text{m}^2$
Radial rotary deflection	0.1mm or less
Thrust rotary deflection	0.1mm or less
Ambient operating temperature, humidity	0 - 40°C, 85%RH or less (Non-condensing)
Degree of protection	IP20
Vibration/shock resistance	$4.9\text{m}/\text{s}^2$
Overseas standards	CE marking, RoHS directive
Motor type	Stepper motor (□56)
Encoder type	Incremental
Number of encoder pulses	800 pulse/rev

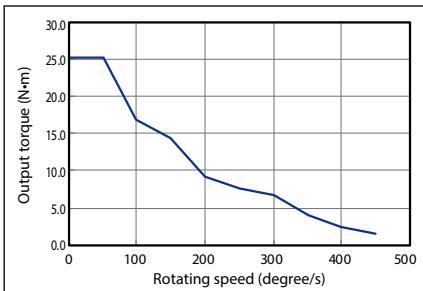
(Note 8) 16 N·m for side mount and vertical mount.

## Direction of the rotary type moment

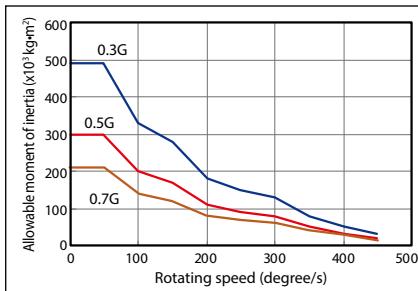


## Correlation between Speed and Output Torque, Allowable moment of Inertia

### Rotating speed and output torque



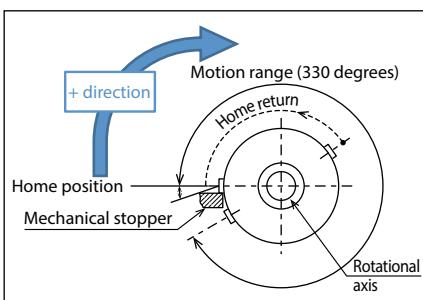
### Rotating speed and allowable moment of inertia



(Note) 0.7G can be used only for vertical and ceiling mount.

## Method of home return and direction of positive rotation

## 330-degree rotary specification

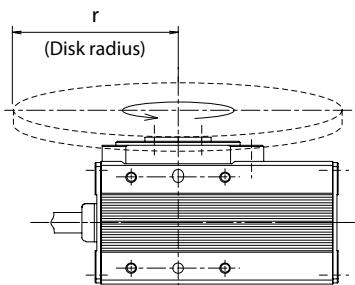


The + direction is the clock-wise direction, viewing from the top.  
Home return motion rotates in the counter clock-wise direction.  
It detects the mechanical stopper position and stops after a reverse rotation movement.

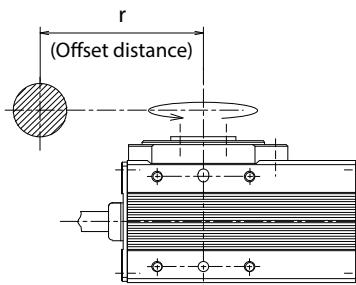
The home return movement cannot be in the clock-wise direction.  
(Note) In the non-motor specification, all the movements are reversed.

### ■ Guideline for the loaded object and mass

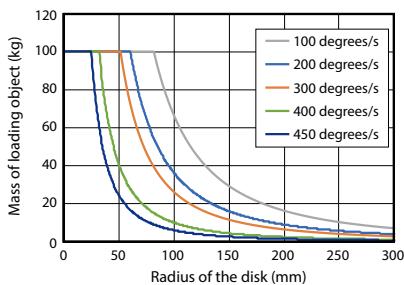
- When the center of gravity of a circular plate load is the same as the rotational center of the output shaft



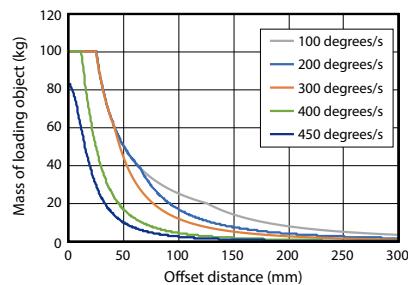
- When the center of gravity of the load is offset from the rotational center of the output shaft



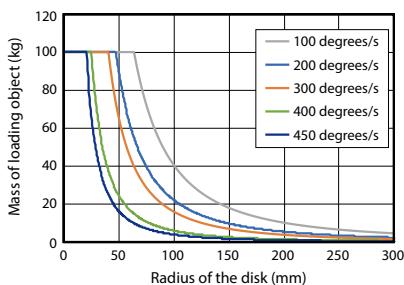
### Acceleration 0.3G



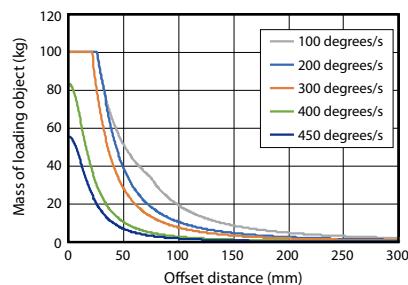
### Acceleration 0.3G



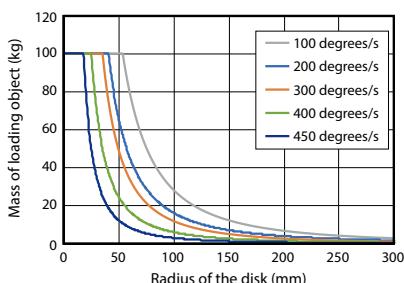
### Acceleration 0.5G



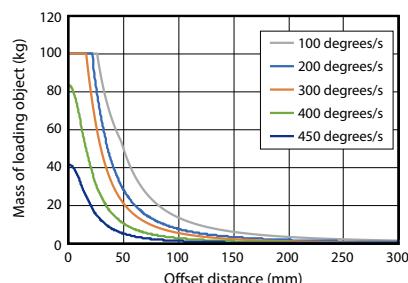
### Acceleration 0.5G



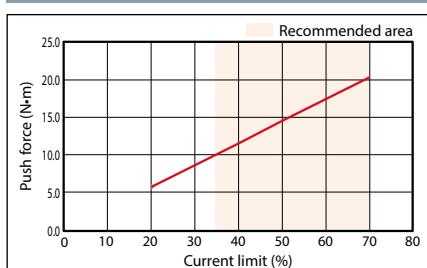
### Acceleration 0.7G



### Acceleration 0.7G



### ■ Correlation between Push force and Current limit



## Dimensions

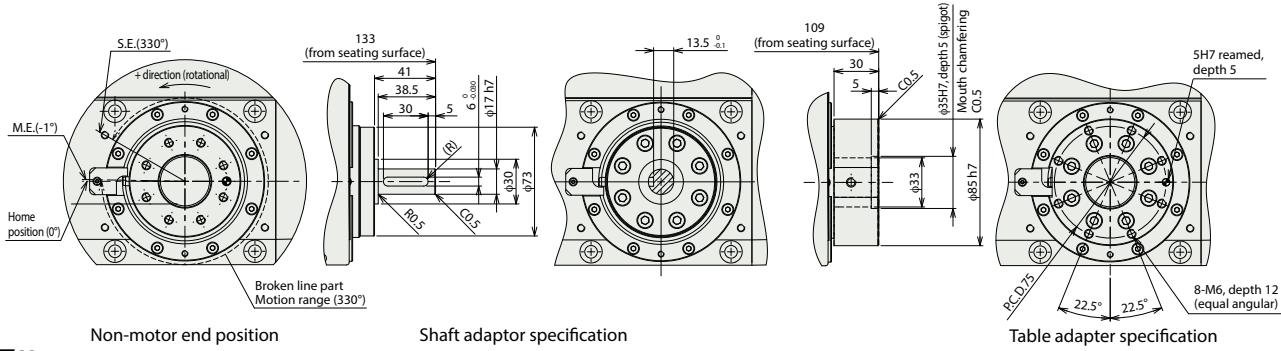
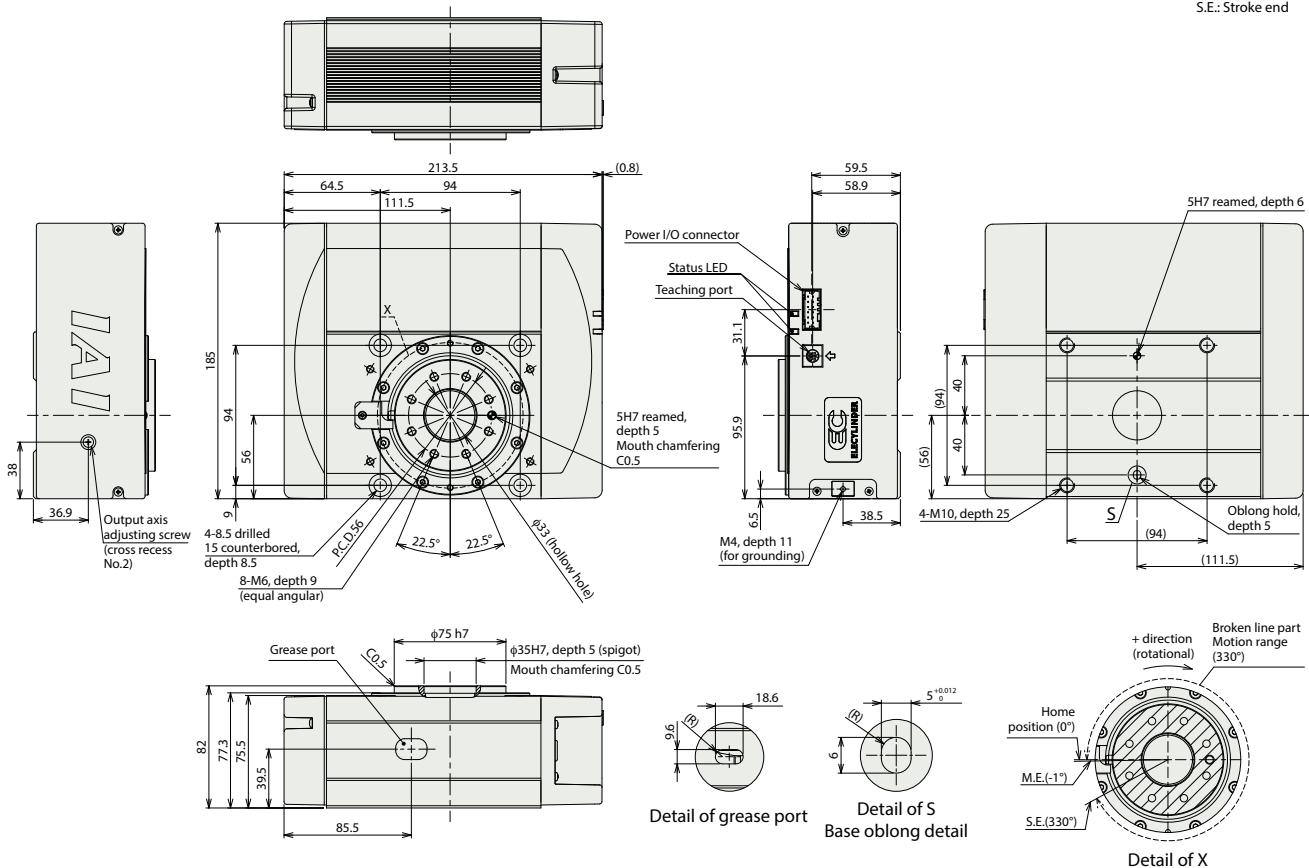
CAD drawings can be downloaded from our website.  
[www.intelligentactuator.com](http://www.intelligentactuator.com)

2D  
CAD

3D  
CAD

(Note) The hatched area in the Detail of X is the rotary part.

M.E.: Mechanical end  
 S.E.: Stroke end



## Mass

	Item	Description
Mass	Without brake	6.16kg
	With brake	6.54kg

## Applicable controllers

(Note) The EC series is equipped with a built-in controller. Refer to P2-499 for the details of the built-in controller.

# EC-SRG11

Side-mounted motor  
Body width 110 mm  
24v stepper motor

## ■ Model specification items

<b>EC</b>	<b>SRG11</b>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Series	Type	Lead	Stroke	Cable length	Option
		H 10mm M 5mm L 2.5mm	50 100 150 200 250 300	50mm l 300mm (Every 50mm)	Refer to the table of power · I/O cable below Refer to the table of options below



**CE** **RoHS 10**

Horizontal Vertical Side Ceiling

## ■ Stroke

Stroke (mm)
50
100
150
200
250
300

## Selection Notes

- (1) Payload in the "Main Specifications" displays the maximum value.
- (2) The horizontal payload represents a value when a guide is used so that radial load and moment load are not applied on the rod. If a guide is not installed, refer to the "Front Bracket Tip Load and Operational Life."
- (3) When performing the push motion, refer to the "Correlation between the Push Force and Current Limit" for confirmation. The push force is only for a reference value.
- (4) When a φ7.8 through hole is used, it is necessary to remove the motor cover.

## ■ Table of options

Name	Option code	Reference page
RCON-EC connection specification (Note 1)	<b>ACR</b>	2-477
Brake	<b>B</b>	2-477
Front spacer	<b>FS</b>	2-482
Specified grease specification	<b>G5</b>	2-487
Non-motor end specification	<b>NM</b>	2-490
PNP specification (Note 1)	<b>PN</b>	2-490
Twin power supply specification	<b>TMD2</b>	2-493
Battery-less absolute encoder specification	<b>WA</b>	2-494
Wireless communication specification	<b>WL</b>	2-494
Wireless axis operation specification	<b>WL2</b>	2-495

(Note 1) When RCON-EC connection specification (ACR) is selected, PNP specification (PN) and twin power supply specification (TMD2) cannot be selected.

## ■ Table of Power · I/O cable length

### ■ Standard connector cable

Cable code	Cable length	User wiring specification (flying leads)	RCON-EC connection specification (Note 3) (with connectors on both ends)
		CB-EC-PWBIO□□□-RB supplied	CB-REC-PWBIO□□□-RB supplied
<b>0</b>	No cable	○ (Note 2)	○
<b>1 ~ 3</b>	1 ~ 3m	○	○
<b>4 ~ 5</b>	4 ~ 5m	○	○
<b>6 ~ 7</b>	6 ~ 7m	○	○
<b>8 ~ 10</b>	8 ~ 10m	○	○

(Note 2) Only the terminal block connector is included. Refer to P2-503 for details.

(Note 3) If RCON-EC connection specification (ACR) is selected as an option.

(Note) The robot cable is standard.

### ■ 4-way connector cable

Cable code	Cable length	User wiring specification (flying leads)	RCON-EC connection specification (Note 4) (with connectors on both ends)
		CB-EC2-PWBIO□□□-RB supplied	CB-REC2-PWBIO□□□-RB supplied
<b>S1 ~ S3</b>	1 ~ 3m	○	○
<b>S4 ~ S5</b>	4 ~ 5m	○	○
<b>S6 ~ S7</b>	6 ~ 7m	○	○
<b>S8 ~ S10</b>	8 ~ 10m	○	○

(Note 4) If RCON-EC connection specification (ACR) is selected as an option.

(Note) The robot cable is standard.

## Main specifications

Item		Description			
Lead		Ball screw lead (mm)	10	5	
Horizontal	Payload	Max. payload (kg) (energy-saving disabled)	16	25	
		Max. payload (kg) (energy-saving enabled)	9	22	
	Speed/ acceleration/ deceleration	Max. speed (mm/s)	700	350	
		Min. speed (mm/s)	13	7	
Vertical	Payload	Rated acceleration/deceleration (G)	0.3	0.3	
		Max. acceleration/deceleration (G)	1	0.5	
	Speed/ acceleration/ deceleration	Max. payload (kg) (energy-saving disabled)	2.5	5	
		Max. payload (kg) (energy-saving enabled)	2	4.5	
Push		Max. speed (mm/s)	600	350	
Brake		Min. speed (mm/s)	13	7	
Stroke	Brake specification	Rated acceleration/deceleration (G)	0.3	0.3	
		Max. acceleration/deceleration (G)	0.5	0.5	
		Max. push force (N)	77	150	
Max. push speed (mm/s)		Max. push speed (mm/s)	20	20	
Brake holding force (kgf)		Non-excitation actuating solenoid brake	2.5	5	
Min. stroke (mm)		50	50	50	
Max. stroke (mm)		300	300	300	
Stroke pitch (mm)		50	50	50	

Item	Description
Driving system	Ball screw, φ8mm, rolled C10
Positioning repeatability	±0.05mm
Lost motion	- (two-point positioning function; cannot be represented)
Rod	φ25mm, Material: Aluminum Hard alumite treated
Guide shaft	SUJ2
Front bracket	Material: Aluminum white alumite treated
Rod non-rotational precision	±0.01 degree
Ambient operating temperature, humidity	0 - 40°C, 85%RH or less (Non-condensing)
Degree of protection	IP20
Vibration/shock resistance	4.9m/s <sup>2</sup>
Overseas standards	CE marking, RoHS directive
Motor type	Stepper motor (□35)
Encoder type	Incremental/battery-less absolute
Number of encoder pulses	800 pulse/rev

■ Payload by speed and acceleration. \* The energy-saving setting is disabled at shipping. Refer to P1-25 for details.

■ Energy-saving setting disabled (power mode) The unit for payload is kg. If blank, operation is not possible.

### Lead 10

Orientation	Horizontal		Vertical	
	Acceleration (G)		Speed (mm/s)	
0	16	10	10	8.5 2.5 2
175	16	10	10	8.5 2.5 2
350	16	9	8	6 2.5 2
435	11	7	5.5	4.5 2.5 2
525	7	4.5	3	3 1.5 1.5
600	5	2.5	2.5	2.5 1
700	2	1.5		

### Lead 5

Orientation	Horizontal		Vertical	
	Acceleration (G)		Speed (mm/s)	
0	25	22	5	4.5
85	25	22	5	4.5
130	25	22	5	4.5
215	25	19	5	4.5
260	22	12	5	4
300	18	12	3	3
350	10	7	1	1

### Lead 2.5

Orientation	Horizontal		Vertical	
	Acceleration (G)		Speed (mm/s)	
0	35		10	
40	35		10	
80	35		10	
105	35		10	
135	32		6	
150	13.5		2	
175	11		1	

■ Energy-saving setting enabled (energy-saving mode) The unit for payload is kg. If blank, operation is not possible.

### Lead 10

Orientation	Horizontal		Vertical	
	Acceleration (G)		Speed (mm/s)	
0	9	6	2	
175	9	6	2	
350	9	6	1.5	
435	4	1	0.5	
525	1			

### Lead 5

Orientation	Horizontal		Vertical	
	Acceleration (G)		Speed (mm/s)	
0	22		4.5	
85	22		4.5	
130	22		4.5	
215	18		3	
260	8		1	

### Lead 2.5

Orientation	Horizontal		Vertical	
	Acceleration (G)		Speed (mm/s)	
0	35		6.5	
40	35		6.5	
80	35		6.5	
105	22		4	
135	10		1	

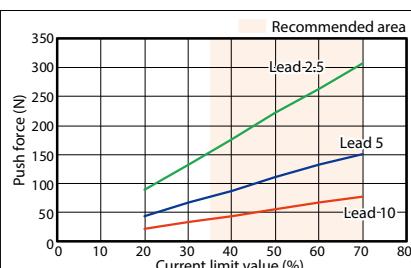
## Stroke and maximum speed

Lead (mm)	Energy-saving setting	50 ~ 200 (every 50mm)		250 (mm)	300 (mm)
		0.3	0.5		
10	Disabled	700<600>		520	370
	Enabled	525<435>		520<435>	370
5	Disabled			350	185
	Enabled			260	185
2.5	Disabled	175		130	90
	Enabled	135		130	90

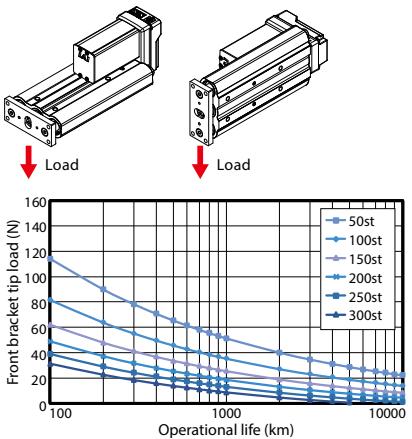
(The unit is mm/s)

(Note) Values in brackets <> are for vertical use.

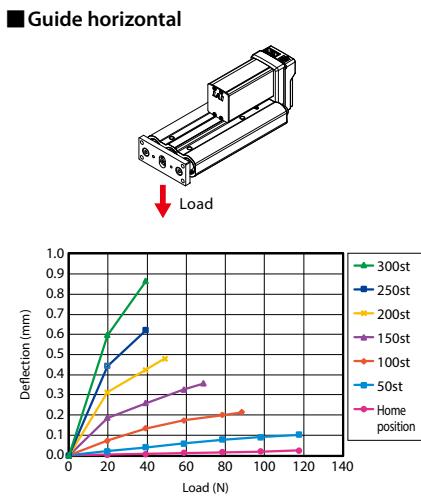
## Correlation between Push force and Current Limit



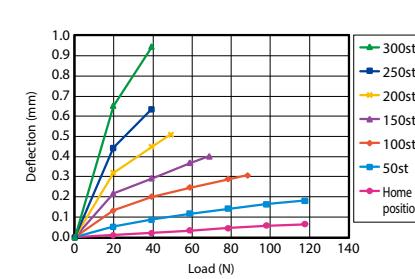
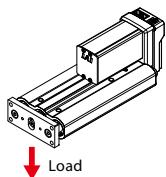
### Front bracket tip load and operational life



### Front bracket tip deflection

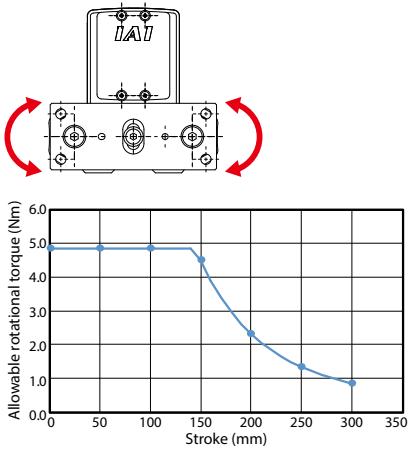


### Guide horizontal



(Note) Front bracket tip deflection is a reference value.

### Front bracket allowable rotational torque



(Note) The rotational torque should be within the allowable range in the graph.

## Dimensions

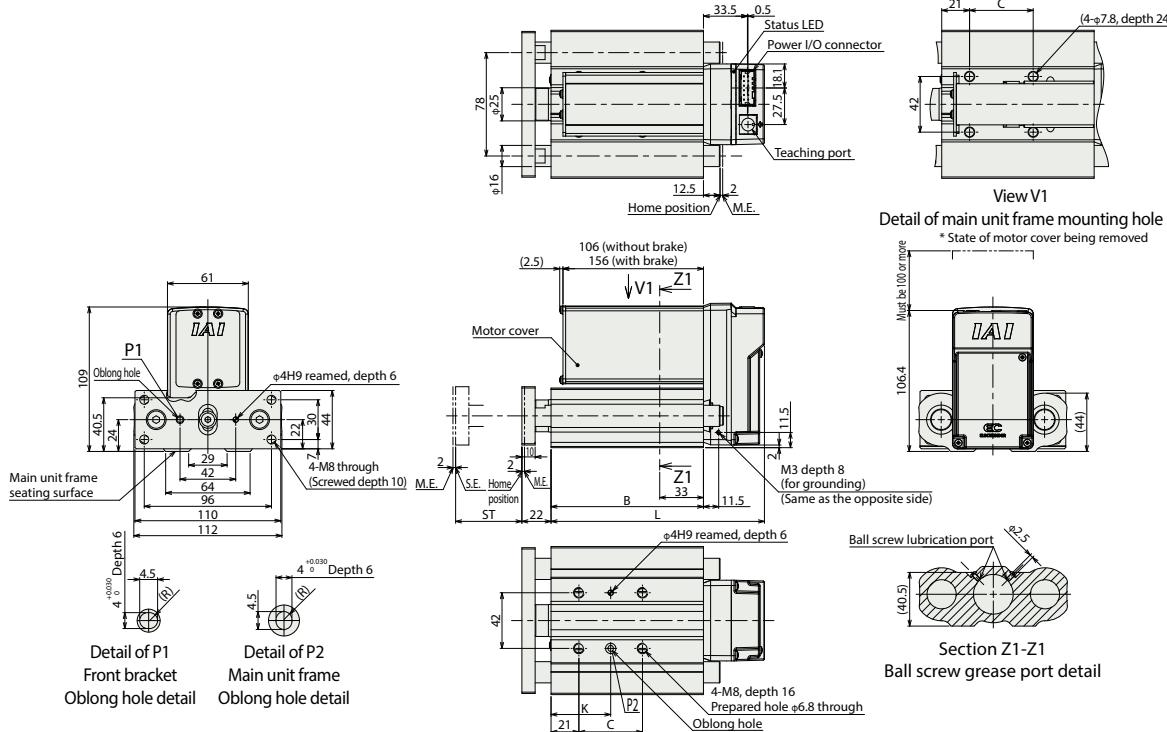
CAD drawings can be downloaded from our website.  
[www.intelligentactuator.com](http://www.intelligentactuator.com)

2D  
CAD

3D  
CAD

(Note) When the slider is returning to its home position, be careful of interference from surrounding objects, as it will travel until it reaches the M.E.

ST: Stroke  
 M.E.: Mechanical end  
 S.E.: Stroke end



## Dimensions by stroke

Stroke	50	100	150	200	250	300
L	161	211	261	311	361	411
B	115	165	215	265	315	365
C	48	48	124	124	200	200
K	45	45	83	83	121	121

## Mass by stroke

Mass (kg)	Stroke	50	100	150	200	250	300
	Without brake	2.7	3.3	3.9	4.5	5.1	5.7
	With brake	3.0	3.6	4.2	4.8	5.4	6.0

## Applicable controllers

(Note) The EC series is equipped with a built-in controller. Refer to P2-499 for the details of the built-in controller.

# EC-SRG15

Side-mounted motor  
Body width 150 mm  
24v stepper motor

## ■ Model specification items

EC	SRG15				
Series	Type	Lead	Stroke	Cable length	Option
		H 20mm M 6mm L 3mm	50 100 150 200 250 300	50mm 100mm 150mm 200mm 250mm 300mm (Every 50mm)	Refer to the table of power • I/O cable below
					Refer to the table of options below



CE RoHS 10

Horizontal Vertical Side Ceiling

## ■ Stroke

Stroke (mm)
50
100
150
200
250
300

## Selection Notes



- (1) Payload in the "Main Specifications" displays the maximum value.
- (2) The horizontal payload represents a value when a guide is used so that radial load and moment load are not applied on the rod. If a guide is not installed, refer to the "Front Bracket Tip Load and Operational Life."
- (3) When performing the push motion, refer to the "Correlation between the Push Force and Current Limit" for confirmation. The push force is only for a reference value.

## ■ Table of options

Name	Option code	Reference page
RCON-EC connection specification (Note 1)	ACR	2-477
Brake	B	2-477
Specified grease specification	G5	2-487
Non-motor end specification	NM	2-490
PNP specification (Note 1)	PN	2-490
Twin power supply specification (Note 1)	TMD2	2-493
Battery-less absolute encoder specification	WA	2-494
Wireless communication specification	WL	2-494
Wireless axis operation specification	WL2	2-495

(Note 1) When RCON-EC connection specification (ACR) is selected, PNP specification (PN) and twin power supply specification (TMD2) cannot be selected.

## ■ Table of Power • I/O cable length

### ■ Standard connector cable

Cable code	Cable length	User wiring specification (flying leads)	RCON-EC connection specification (Note 3) (with connectors on both ends)
		CB-EC-PWBIO□□□-RB supplied	CB-REC-PWBIO□□□-RB supplied
0	No cable	○ (Note 2)	○
1 ~ 3	1 ~ 3m	○	○
4 ~ 5	4 ~ 5m	○	○
6 ~ 7	6 ~ 7m	○	○
8 ~ 10	8 ~ 10m	○	○

(Note 2) Only the terminal block connector is included. Refer to P2-503 for details.

(Note 3) If RCON-EC connection specification (ACR) is selected as an option.

(Note) The robot cable is standard.

## ■ 4-way connector cable

Cable code	Cable length	User wiring specification (flying leads)	RCON-EC connection specification (Note 4) (with connectors on both ends)
		CB-EC2-PWBIO□□□-RB supplied	CB-REC2-PWBIO□□□-RB supplied
S1 ~ S3	1 ~ 3m	○	○
S4 ~ S5	4 ~ 5m	○	○
S6 ~ S7	6 ~ 7m	○	○
S8 ~ S10	8 ~ 10m	○	○

(Note 4) If RCON-EC connection specification (ACR) is selected as an option.

(Note) The robot cable is standard.

## Main specifications

Item		Description		
Lead		Ball screw lead (mm)	20	6
Horizontal	Payload	Max. payload (kg) (energy-saving disabled)	6	40
		Max. payload (kg) (energy-saving enabled)	6	40
	Speed/ acceleration/ deceleration	Max. speed (mm/s)	800	450
		Min. speed (mm/s)	25	8
Vertical	Payload	Rated acceleration/deceleration (G)	0.3	0.3
		Max. acceleration/deceleration (G)	1	1
	Speed/ acceleration/ deceleration	Max. payload (kg) (energy-saving disabled)	0.5	7
		Max. payload (kg) (energy-saving enabled)	0.5	7
Push	Payload	Max. speed (mm/s)	640	400
		Min. speed (mm/s)	25	8
	Speed/ acceleration/ deceleration	Rated acceleration/deceleration (G)	0.3	0.3
		Max. acceleration/deceleration (G)	0.5	0.5
Brake	Max. push force (N)		67	224
	Max. push speed (mm/s)		25	20
	Brake specification		Non-excitation actuating solenoid brake	
	Brake holding force (kgf)		0.5	7
Stroke	Min. stroke (mm)		50	50
	Max. stroke (mm)		300	300
	Stroke pitch (mm)		50	50
			50	

Item	Description
Driving system	Ball screw, φ10mm, rolled C10
Positioning repeatability	±0.05mm
Lost motion	- (two-point positioning function; cannot be represented)
Rod	φ25mm, Material: Aluminum Hard alumite treated
Guide shaft	SUJ2
Front bracket	Material: Aluminum white alumite treated
Rod non-rotational precision	±0.03 degree
Ambient operating temperature, humidity	0 - 40°C, 85%RH or less (Non-condensing)
Degree of protection	IP20
Vibration/shock resistance	4.9m/s <sup>2</sup>
Overseas standards	CE marking, RoHS directive
Motor type	Stepper motor ( 42)
Encoder type	Incremental/battery-less absolute
Number of encoder pulses	800 pulse/rev

**Payload by speed and acceleration.** \* The energy-saving setting is disabled at shipping. Refer to P1-25 for details.

**Energy-saving setting disabled (power mode)** The unit for payload is kg. If blank, operation is not possible.

### Lead 20

Orientation	Horizontal		Vertical	
	Speed (mm/s)	Acceleration (G)	Speed (mm/s)	Acceleration (G)
0	6	0.3	5	0.5
160	6	0.5	5	0.5
320	6	0.7	3	0.5
480	6	1	3	0.5
640	6	4	3	2
800	4	3		0.5

### Lead 6

Orientation	Horizontal		Vertical	
	Speed (mm/s)	Acceleration (G)	Speed (mm/s)	Acceleration (G)
0	40	0.3	35	0.7
50	40	0.5	35	1
90	40	0.7	30	2.5
160	40	1	30	20
250	40	2.5	22.5	18
350	20	10	8	5
400	10	3	3	0.5
450	3			

### Lead 3

Orientation	Horizontal		Vertical	
	Speed (mm/s)	Acceleration (G)	Speed (mm/s)	Acceleration (G)
0	60	0.3	50	0.5
45	60	0.5	50	0.7
80	60	0.7	50	1
125	60	1	45	2.5
175	40	3.5	25	15
200	30	20	10	3
225	5			3.5

**Energy-saving setting enabled (energy-saving mode)** The unit for payload is kg. If blank, operation is not possible.

### Lead 20

Orientation	Horizontal		Vertical	
	Speed (mm/s)	Acceleration (G)	Speed (mm/s)	Acceleration (G)
0	6	0.3	5	0.5
160	6	0.5	5	0.5
310	6	0.7	5	0.5
480	4	1	3	0.5
640	1	1		

### Lead 6

Orientation	Horizontal		Vertical	
	Speed (mm/s)	Acceleration (G)	Speed (mm/s)	Acceleration (G)
0	40	0.3	20	7
50	40	0.5	20	7
90	40	0.7	20	7
160	40	1	20	7
200	35	18	5	
250	10	5	2.5	

### Lead 3

Orientation	Horizontal		Vertical	
	Speed (mm/s)	Acceleration (G)	Speed (mm/s)	Acceleration (G)
0	40	0.3	25	12.5
25	40	0.5	25	12.5
45	40	0.7	25	12.5
80	40	1	25	12
95	40	20	9	
125	40	10	5	

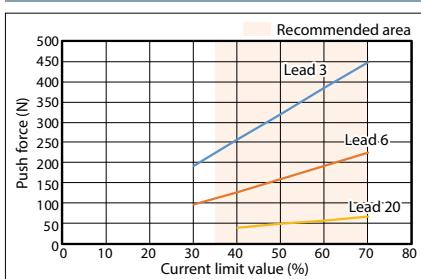
## Stroke and maximum speed

Lead (mm)	Energy-saving setting	50 ~ 200 (every 50mm)	250 (mm)	300 (mm)
20	Disabled		800<640>	
	Enabled		640<480>	
6	Disabled	450<400>	370<350>	265
	Enabled		250	
3	Disabled	225<200>	185	130
	Enabled		125	

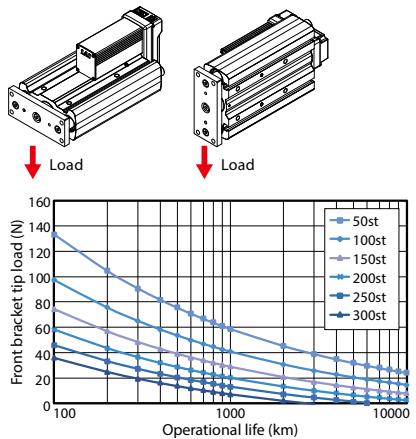
(The unit is mm/s)

(Note) Values in brackets < > are for vertical use.

## Correlation between Push force and Current Limit

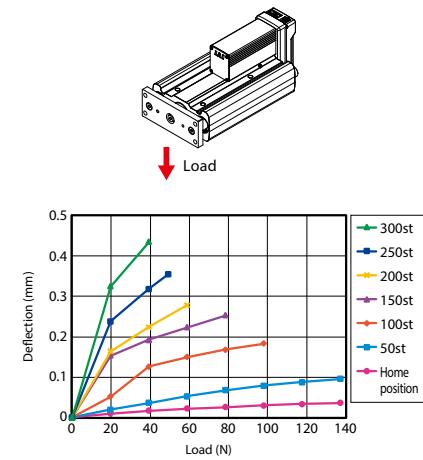


### Front bracket tip load and operational life

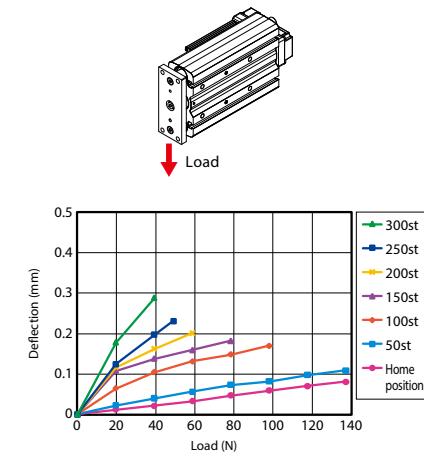


### Front bracket tip deflection

#### Guide horizontal

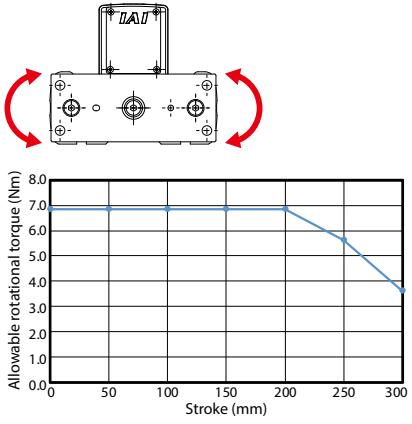


#### Guide vertical



(Note) Front bracket tip deflection is a reference value.

### Front bracket allowable rotational torque



(Note) The rotational torque should be within the allowable range in the graph.

## Dimensions

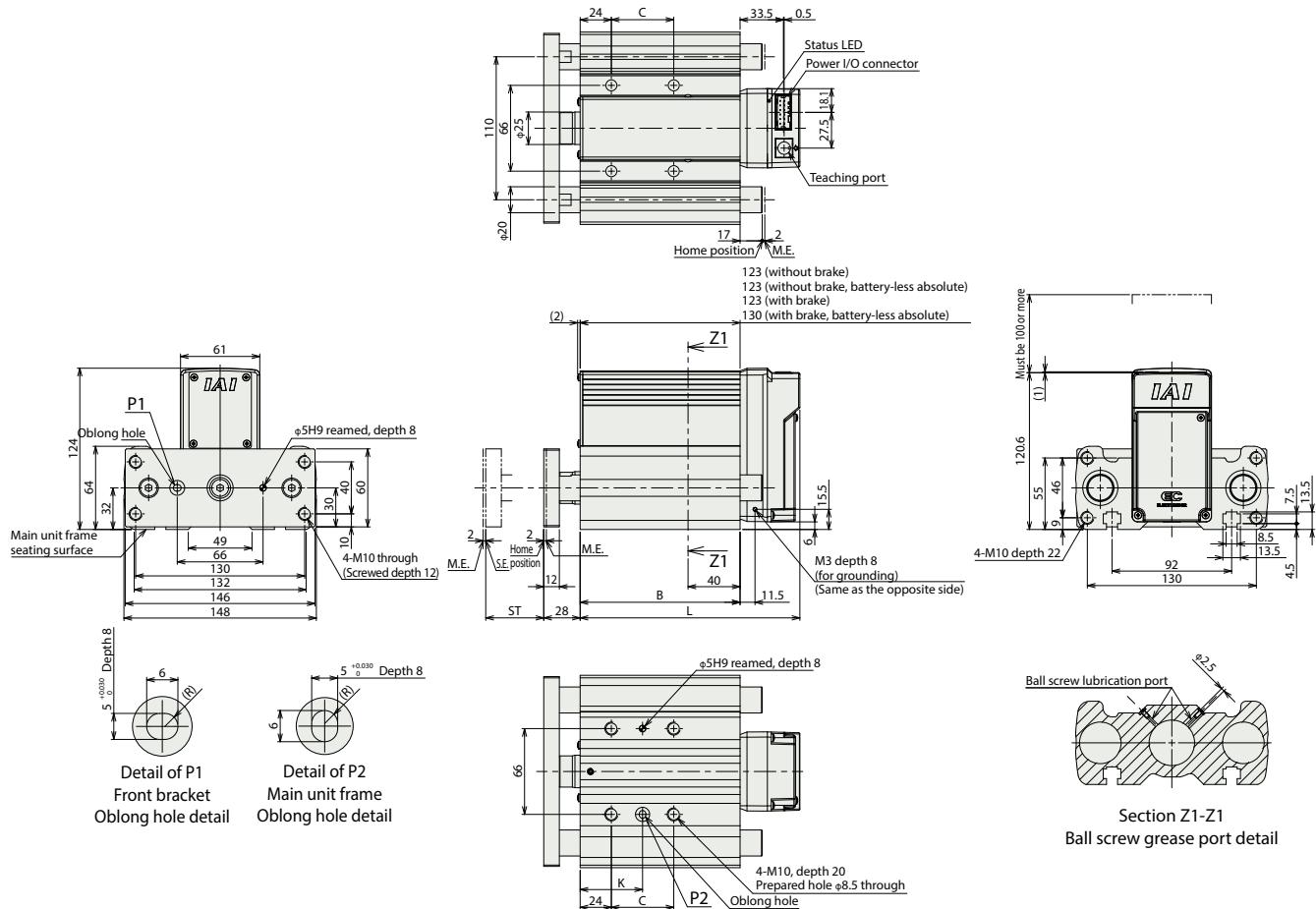
CAD drawings can be downloaded from our website.  
[www.intelligentactuator.com](http://www.intelligentactuator.com)

2D  
CAD

3D  
CAD

(Note) When the slider is returning to its home position, be careful of interference from surrounding objects, as it will travel until it reaches the M.E.

ST: Stroke  
 M.E.: Mechanical end  
 S.E.: Stroke end



## Dimensions by stroke

Stroke	50	100	150	200	250	300
L	169	219	269	319	369	419
B	123	173	223	273	323	373
C	48	48	124	124	200	200
K	48	48	86	86	124	124

## Mass by stroke

Mass (kg)	Stroke	50	100	150	200	250	300
		Without brake	With brake	Without brake	With brake	Without brake	With brake
4.3	5.4	6.5	7.6	8.7	9.8		
4.5	5.6	6.7	7.8	8.9	10		

## Applicable controllers

(Note) The EC series is equipped with a built-in controller. Refer to P2-499 for the details of the built-in controller.