GB

IAI
Quality and Innovation

# Wrist Unit WU

www.robocylinder.de

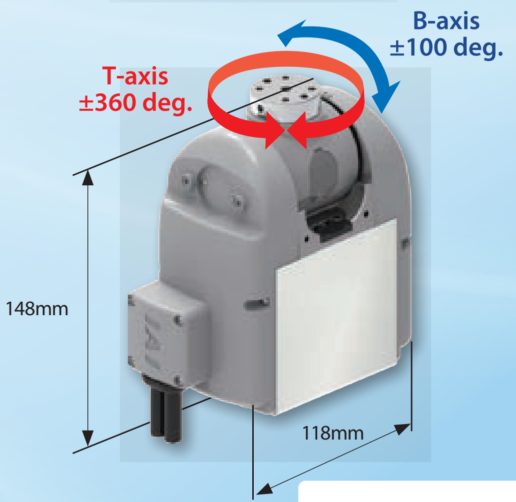
# 2-axis rotary joint unit

# **Wrist Unit** is now available

## 1 IAI's unique design makes the unit light and compact.

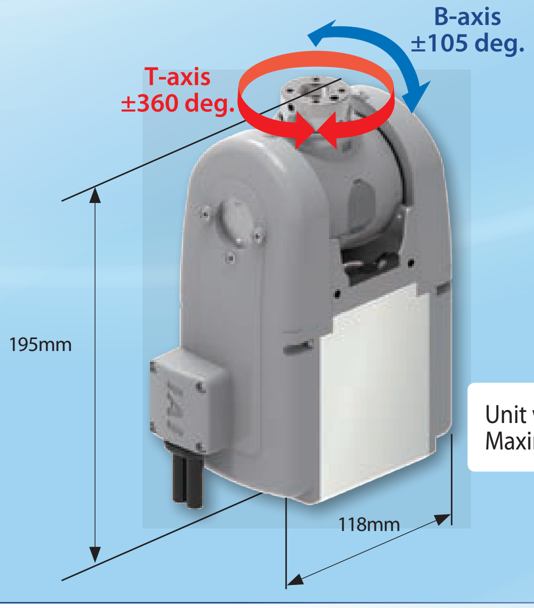
**Equipped with a Battery-less Absolute Encoder as Standard**

### Compact S type



Unit weight: 1.6 kg
Maximum Payload 1.0 kg

### Medium M type



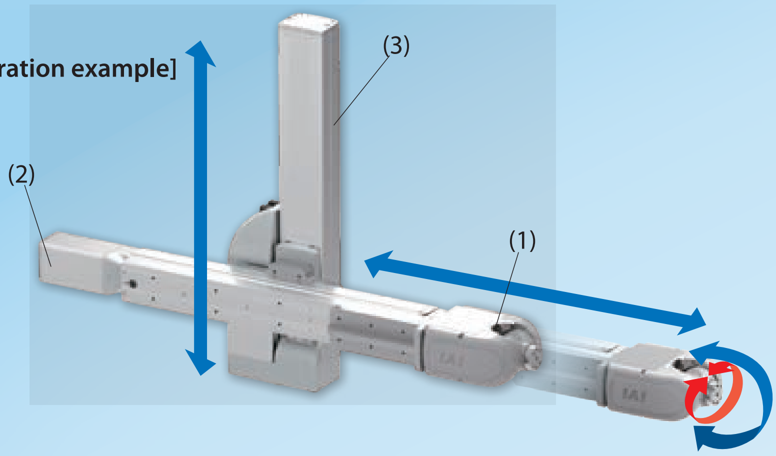
Unit weight: 2.8 kg
Maximum Payload 2.0 kg

## 2 Ideal for cost reduction of equipment. Low cost compared to 6-axis articulated robots.

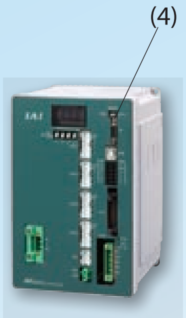
Diagonal approaches and tip swiveling, possible until now only with vertical articulated robots, can now be performed with the minimum required axis configuration.

Ideal for cost reduction of equipment.

**[Configuration example]**



+

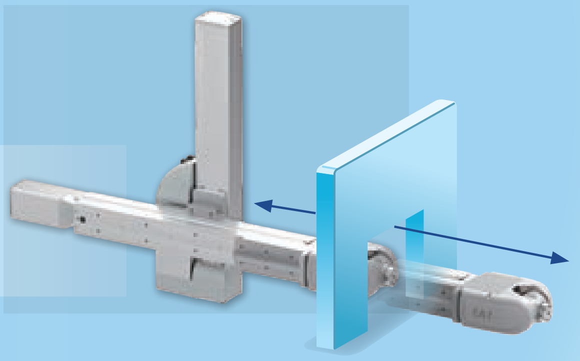


MSEL Controller

| | | |
|---|---|---|
| (1) Wrist Unit: | WU-S | |
| (2) Table Type: | RCP6-TA6C | Stroke: 320 mm |
| (3) Slider Type: | RCP6-SA7R | Stroke: 300 mm |
| (4) Controller: | MSEL | |

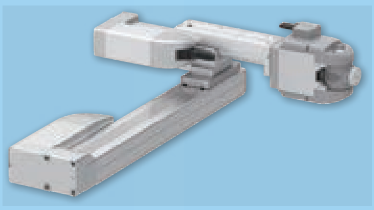
### Work in tight spaces

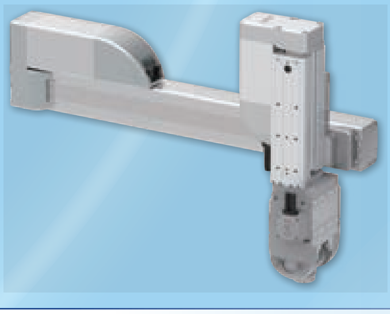
Combination with a cartesian RoboCylinder makes it capable of avoiding obstacles and working in tight spaces.



### Flexible combinations

The combination pattern, number of axes and stroke can be freely selected according to the application.

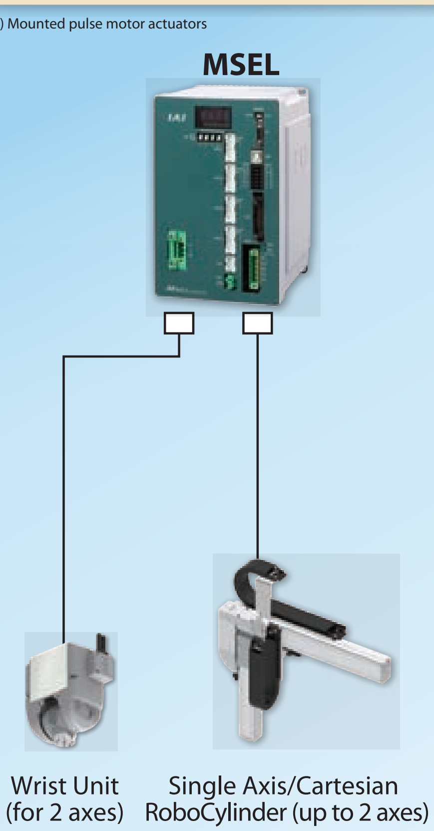




## 3 Interpolation function with orthogonal axes is possible

**When connecting Wrist Unit and 2-axis combination** (*)

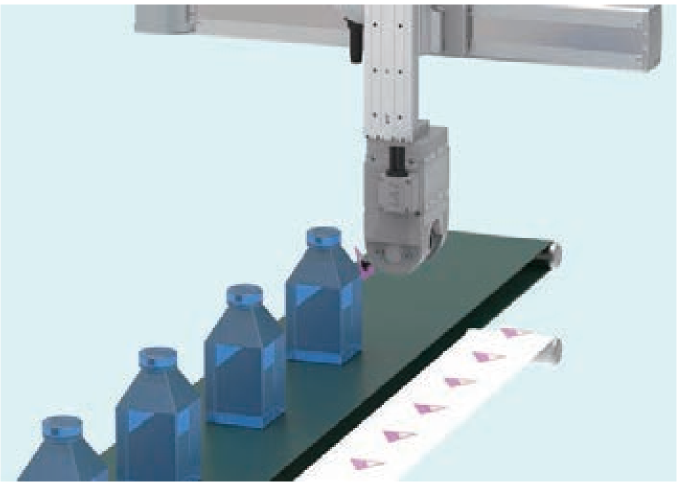
(*) Mounted pulse motor actuators



## Application Examples

### Bottle labeling equipment

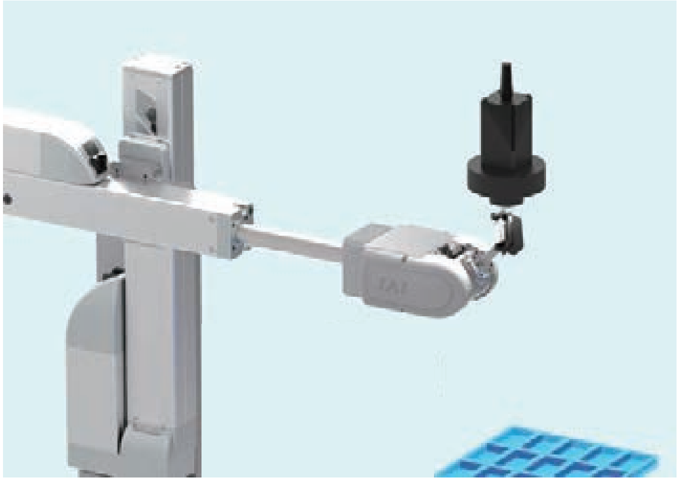
This device affixes labels to bottles. Adjusts the angle to the labeling surface on the B-axis and rotates the label on the T-axis to change the orientation.



### Automotive connector inspection equipment

This device inspects the external view of connectors for automobiles, using a camera.

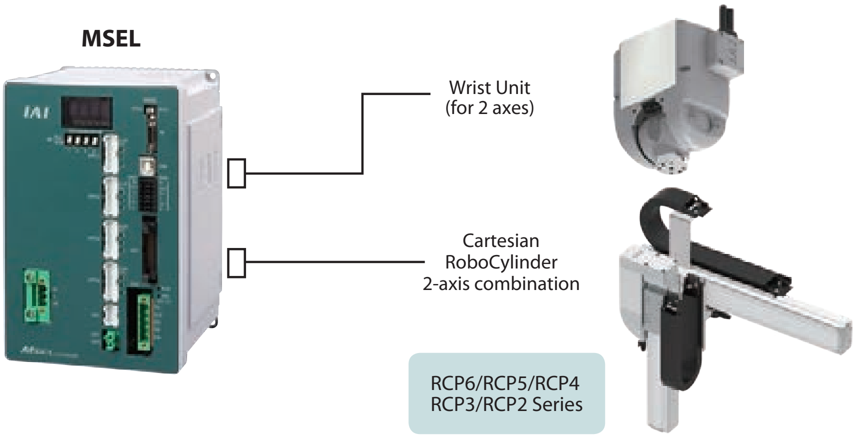
The Wrist Unit rotates the connector for inspection from various angles.



### Controller connection example

"Wrist Unit + RoboCylinder 2-axis combination" can be controlled with a single MSEL controller.

Please refer to P.17 for more information.



## WU Series List

| Type | | Compact type | | Medium type | |
|---|---|---|---|---|---|
| Model | | WU-S | | WU-M | |
| External view | |  | |  | |
| Axis combination | | B-axis (wrist swing) | T-axis (wrist rotation) | B-axis (wrist swing) | T-axis (wrist rotation) |
| Operation range | | ±100 deg. | ±360 deg. | ±105 deg. | ±360 deg. |
| Max. torque *1 | | 0.65N·m | 0.65N·m | 1.65N·m | 1.65N·m |
| Max. allowable moment of inertia *2 | | 0.0085kgm$^2$ | 0.0075kgm$^2$ | 0.015kgm$^2$ | 0.0165kgm$^2$ |
| Max. load weight | | 1kg | | 2kg | |
| Max. speed *3 | Independent operation | 750 deg/s | 1200 deg/s | 900 deg/s | 1200 deg/s |
| | Simultaneous operation of the B- and T-axes | 600 deg/s | 600 deg/s | 600 deg/s | 600 deg/s |
| Max. acceleration/ deceleration | Without load torque *4 | 0.7 G (6865 deg/s$^2$) | 0.7 G (6865 deg/s$^2$) | 0.7 G (6865 deg/s$^2$) | 0.7 G (6865 deg/s$^2$) |
| | With load torque *4 | 0.3 G (2942 deg/s$^2$) | 0.3 G (2942 deg/s$^2$) | 0.3 G (2942 deg/s$^2$) | 0.3 G (2942 deg/s$^2$) |
| Motor type | | 28□ Pulse motor | 28□ Pulse motor | 35□ Pulse motor | 35□ Pulse motor |
| Unit weight | | 1.6kg | | 2.8kg | |
| Reference page | | P.13 | | P.15 | |

*1 Indicates the maximum torque at low speed. The output torque varies with the speed.

*2 Indicates the maximum moment of inertia in rotation. Value when the acceleration is 0.3 G.

*3 Maximum set speed with no load.

*4 When the rotational axes of the B-axis and T-axis are horizontal with respect to the floor surface or when the center of gravity of the transported object is offset from the rotational axis, the unit will be subject to load torque due to the weight of the object. The allowable moment of inertia decreases when load torque is present. Please refer to "Model Selection Process (P.7 on)" for more information.

## Model Specification Items

| WU | — | ☐ | — | WA | — | PM1 | — | ☐ | — | ☐ |
|---|---|---|---|---|---|---|---|---|---|---|
| Series | — | Type | — | Encoder Type | — | Applicable Controllers | — | Cable Length | — | Options |

Type

| | |
|---|---|
| **S** | Compact type |
| **M** | Medium type |

Encoder Type

| | |
|---|---|
| **WA** | Battery-less Absolute |

Applicable Controllers

| | |
|---|---|
| **PM1** | MSEL |

Cable Length

| | |
|---|---|
| **N** | None |
| **P** | 1m |
| **S** | 3m |
| **M** | 5m |
| **X□□** | Specified length |
| **R□□** | Robot cable |

Options

| | |
|---|---|
| **A1** | Cable exit direction (Right) |
| **A2** | Cable exit direction (Bottom) |
| **A3** | Cable exit direction (Left) |
| **AC1.5** | Actuator cable length 1.5 m |
| **VC** | Air fitting |
| **CVR** | Cable (air fitting) in opposite position |
| **WCS** | Wiring collar |

## Options

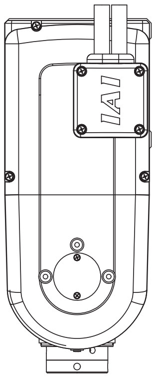
### Cable exit direction

**Model** **A1 / A2 / A3**

**Description** Specify when changing the actuator cable exit direction.

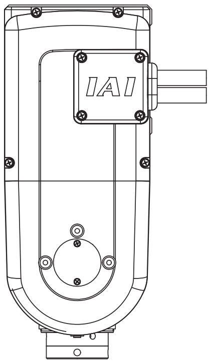
**Top direction exit (standard)**

■ No option specified (blank)



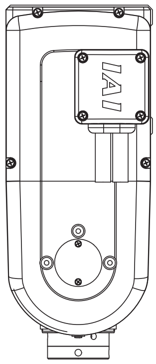
**Exit to right side**

■ Option specified: A1



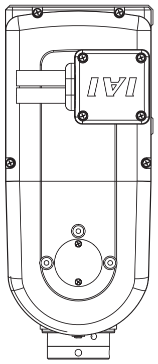
**Exit to bottom**

■ Option specified: A2



**Exit to left side**

■ Option specified: A3



### Actuator cable length 1.5 m

**Model** **AC1.5**

**Description** This option extends the length of the actuator cable exiting the actuator body to 1.5 m. (Standard length is 0.2 m)
When this option is selected, the maximum cable length between the actuator and controller will be 18 m (X18, R18).

### Air fitting

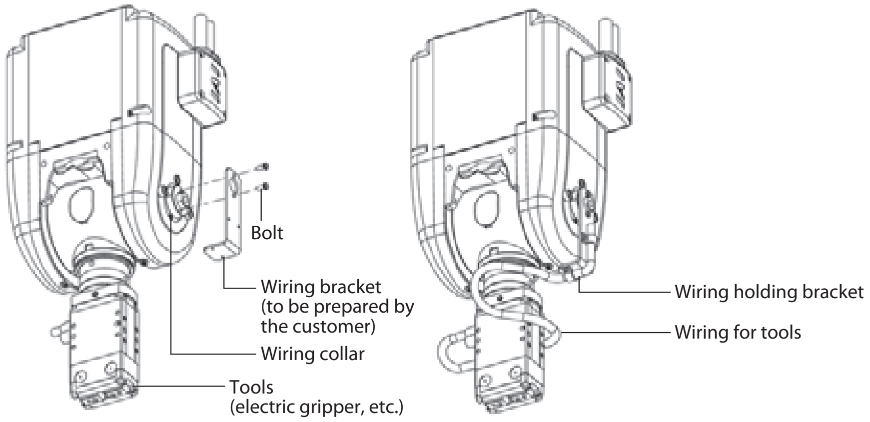
**Model** **VC**

**Description** This option allows attachment of an air fitting (ø6) for connecting pneumatic devices such as vacuum pads to the side of the main body. It is mounted on the same side as the actuator cable outlet. Please refer to the dimensions on the product pages. (WU-S: P.14, WU-M: P.16)

### Wiring collar

**Model** **WCS**

**Description** When using electric grippers or similar wiring is made easy by using the wiring collar.
Use the wiring collar as the base to which the wiring bracket (to be prepared by the customer) is to be attached.
Please refer to the dimensions on the product pages. (WU-S: P.14, WU-M: P.16)



### Cable (air fitting) in opposite position

**Model** **CVR**

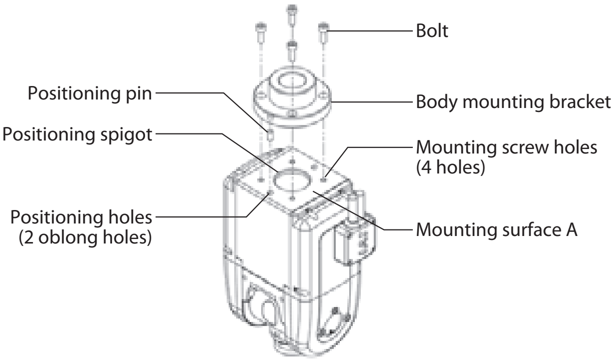
**Description** This option allows the actuator cable outlet, air fitting, and wiring collar (optional) to be mounted on the other side (opposite position). Please refer to the dimensions on the product pages. (WU-S: P.14, WU-M: P.16)

# Mounting Method

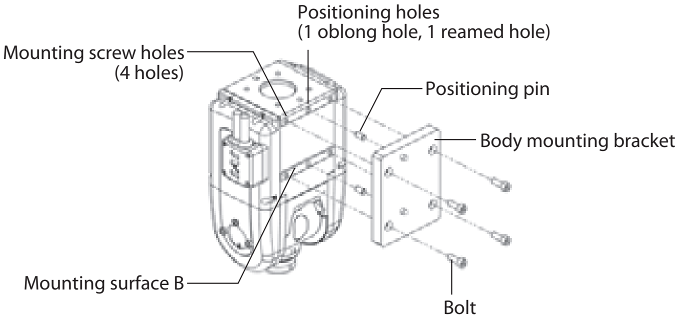
## Body mounting method

The body mounting surface should be a machined surface or a plane with similar accuracy.
The actuator has screw holes and positioning holes for body mounting on the top (mounting surface A) and side (mounting surface B).
For details on positions and dimensions, refer to the product pages.

(1) When using mounting surface A
(Thread depth WU-S: M4 through (screw depth: 6) /
WU-M: M5 through (screw depth: 10)

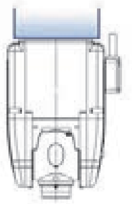


(2) When using mounting surface B
(Thread depth WU-S: M4 depth 8 / WU-M: M5 depth 10)

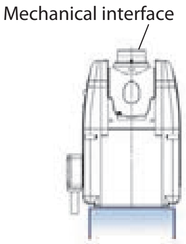


## Body installation orientation

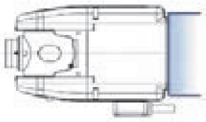
All 6 orientations below are possible.



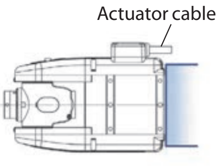
(1) Mechanical interface look down



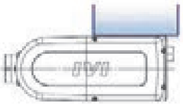
(2) Mechanical interface look up



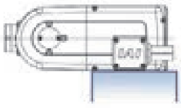
(3) Actuator cable bottom



(4) Actuator cable top



(5) Mounting surface B top



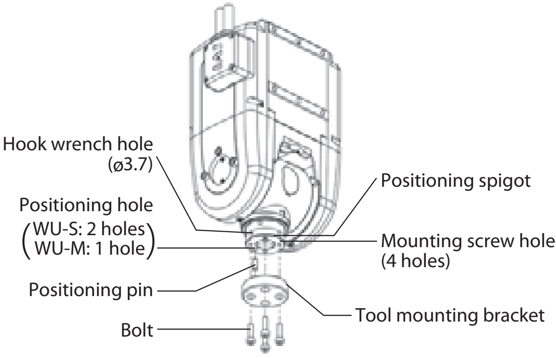
(6) Mounting surface B bottom

## Tool mounting method

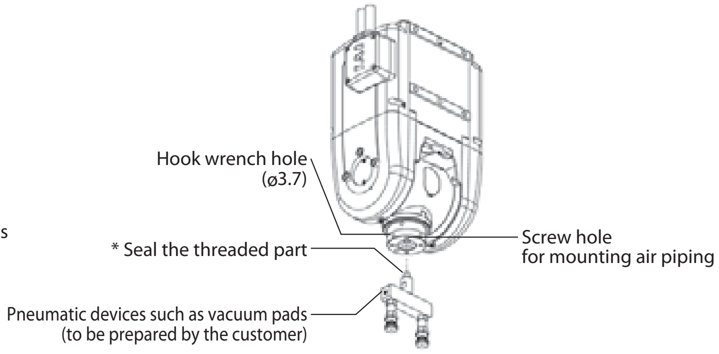
The unit has screw holes for bracket mounting to the body tip (mechanical interface), screw holes for air piping mounting, and positioning holes. Refer to the dimensions (WU-S: P.14, WU-M: P.16) for details regarding the position and dimensions.

Do not apply excessive force to the output shaft when tightening bolts or air piping threads. The mechanical interface has holes for a hook wrench. Use these to fix the output shaft in the rotating direction.

(1) When using bracket mounting screws
(Thread depth WU-S: M4 depth 6 / WU-M: M4 through (screw depth: 6)



(2) When using air piping mounting screws
Seal the threaded part of the air piping with sealing tape, etc.
(Thread depth WU-S: M6 through (screw depth: 4.5) /
WU-M: M6 through (screw depth: 4.5)

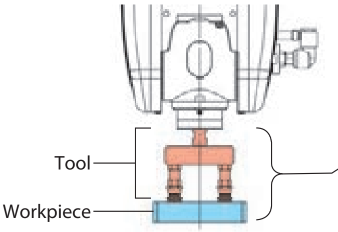


# Model Selection Process

Follow steps 1 through 4. For a selection example, refer to the following pages.

## Step 1

**Check the weight of the transported object**



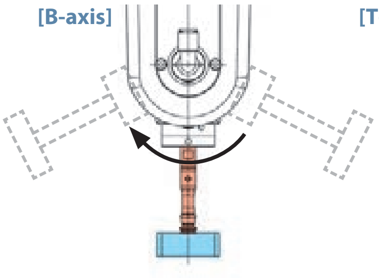
**Weight of transported object** ≤ **Maximum payload**

## Step 2

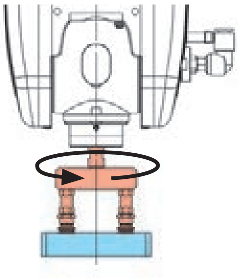
**Check the moment of inertia**

The allowable moment of inertia of the Wrist Unit decreases to the extent that load torque is applied to the B- and T-axes.
First, calculate the load torque and obtain the corrected allowable moment of inertia.

**[B-axis]**



**[T-axis]**



"Formulae for calculating moment of inertia of typical shapes" are on page 12.

Check the presence of load torque on the B- and T-axes

**If "Yes"**

**Moment of inertia applied to B- and T-axes** ≤ **Corrected allowable moment of inertia for compact and medium types***

* It varies with the speed and acceleration/deceleration.

**If "None"**

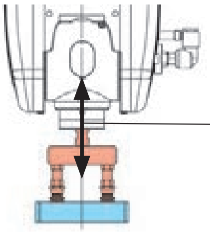
**Moment of inertia applied to B- and T-axes** ≤ **Allowable moment of inertia for compact and medium types***

* It varies with the speed and acceleration/deceleration.

## Step 3

**Check the allowable dynamic thrust load**

Make sure that the thrust load (load perpendicular to the mounting surface) does not exceed the allowable dynamic thrust load.

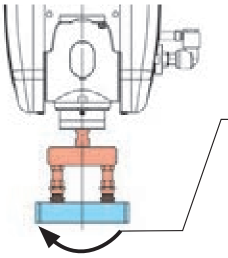


**Dynamic thrust load: F** ≤ **Allowable dynamic thrust load**

## Step 4

**Check the allowable dynamic load moment**

Make sure that the load moment does not exceed the allowable dynamic moment.

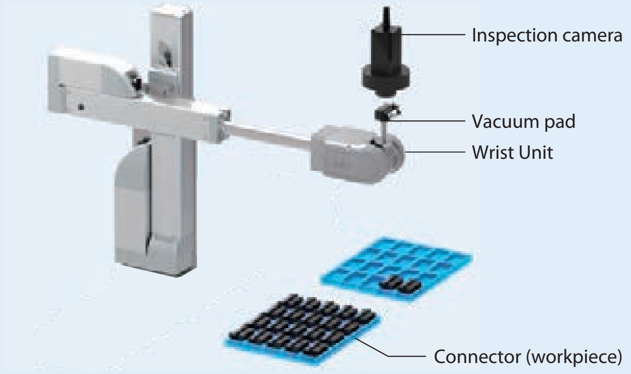


**Dynamic load moment: M** ≤ **Allowable dynamic load moment**

# Model Selection Example: Automotive Connector Inspection Equipment

The model selection example given is based on the application example “Automotive connector inspection equipment” (P. 3).

## Automotive connector inspection equipment



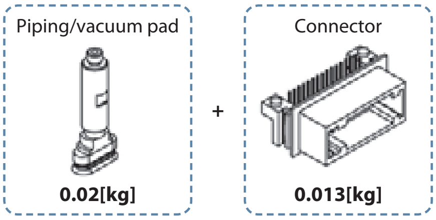
**[Overview]**

This device inspects the external view of connectors for automobiles, using a camera. The Wrist Unit rotates the connector for inspection from various angles.

## Step 1 Check the weight of the transported object

**<Weight of transported object = weight of tool + weight of workpiece>**

| | Maximum load weight |
|---|---|
| **WU-S: Compact type** | 1kg |
| **WU-M: Medium type** | 2kg |



**Transported object** = Piping/vacuum pad **0.02[kg]** + Connector **0.013[kg]** = **0.033[kg]**

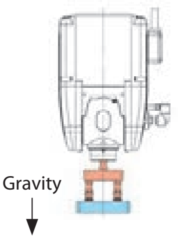
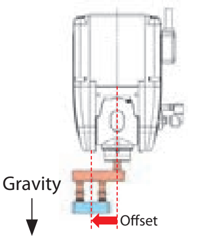
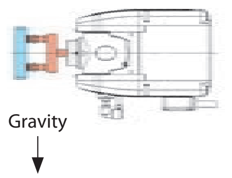
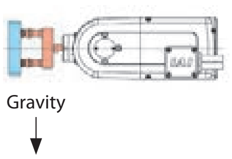
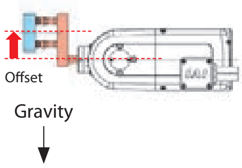
Both WU-S (compact) and WU-M (medium) can be used

## Step 2 Check the moment of inertia

Check the presence of load torque on the B- and T-axes

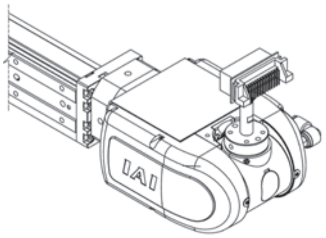
- **If “Yes”** ➡ Calculate the load torque and obtain the corrected allowable moment of inertia. Then calculate the moment of inertia and check that it does not exceed the allowable value.
- **If “None”** ➡ Calculate the moment of inertia and confirm that it is less than the allowable moment of inertia.

### ■ Conditions in which load torque is applied

| | Presence of load torque | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| **Installation orientation** |  |  |  |  |  |
| **B-axis** | Yes | Yes | None | Yes | Yes |
| **T-axis** | None | Yes | None | None | Yes |

As the current example of the “automotive connector inspection equipment” corresponds to these, the B-axis and T-axis are calculated and confirmed as described below.

### Automotive connector inspection equipment [example]

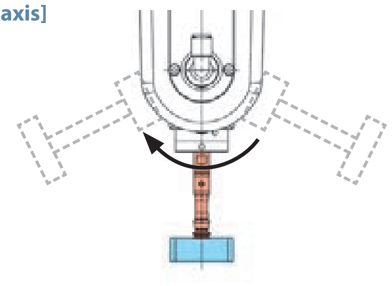


1 [B-axis] Load torque “Yes”

2 [T-axis] Load torque “None”

## 1. Check B-axis

**[B-axis]**

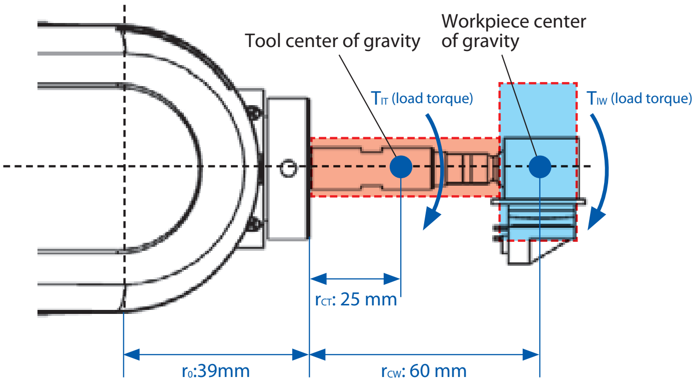


**Load torque "Yes"**

**Moment of inertia applied on B-axis** < **Corrected allowable moment of inertia for compact and medium types***

* It varies with the speed and acceleration/deceleration.

### (1) Calculating load torque $T_l$



$T_{lT}$: Load torque due to tool weight [N·m]
$T_{lW}$: Load torque due to workpiece weight [N·m]
$m_T$: Tool weight [kg]
$m_W$: Workpiece weight [kg]
g: Acceleration of gravity [m/s$^2$]
$r_0$: Mounting surface distance [mm]
$r_{CT}$: Tool center mass location [mm]
$r_{CW}$: Workpiece center mass location [mm]

$$\begin{aligned}T_l&=T_{lT}+T_{lW}\\&=m_T\cdot g(r_0+r_{CT})\times10^{-3}+m_W\cdot g(r_0+r_{CW})\times10^{-3}\\&=0.02\times9.8\times(39+25)\times10^{-3}+0.013\times9.8\times(39+60)\times10^{-3}\\&=0.025[\mathrm{Nm}]\end{aligned}$$

Calculation result

### (2) Calculating the allowable moment of inertia correction factor Cj

$$C_j=\frac{T_{max}-T_l}{T_{max}}$$

$T_{max}$: Output torque (right table) [Nm]
$T_l$: Load torque calculation result (1)

**[Operating conditions of the Wrist Unit]**

**B-axis rotation** Speed: **600** [deg/s]
Acceleration: **0.3** [G]

First, calculate with the value for the compact type (S)

$$C_j=\frac{T_{max}-T_l}{T_{max}}$$

$$=\frac{0.58-0.025}{0.58}$$

$$=0.96$$

Calculation result

**■ Output torque by speed [Nm]**

WU-S: Compact type

| Speed<br>deg./s | B-axis | T-axis |
|---|---|---|
| 0 | 0.65 | 0.65 |
| 150 | 0.65 | 0.65 |
| 300 | 0.62 | 0.62 |
| 450 | 0.6 | 0.6 |
| 600 | 0.58 | 0.58 |
| 750 | 0.52 | 0.52 |
| 900 | 0.45 | 0.45 |
| 1050 | 0.45 | 0.45 |
| 1200 | 0.45 | 0.45 |

WU-M: Medium type

| Speed<br>deg./s | B-axis | T-axis |
|---|---|---|
| 0 | 1.65 | 1.65 |
| 150 | 1.65 | 1.65 |
| 300 | 1.65 | 1.65 |
| 450 | 1.65 | 1.65 |
| 600 | 1.58 | 1.58 |
| 750 | 1.36 | 1.36 |
| 900 | 1.14 | 1.14 |
| 1050 | 0.96 | 0.96 |
| 1200 | 0.79 | 0.79 |

### (3) Calculating the corrected allowable moment of inertia $J_{tl}$

$J_{tl}=J_{max}C_j$ (kgm$^2$)

$J_{max}$: Allowable moment of inertia (right table) [kgm$^2$]
$C_j$: Allowable moment of inertia correction factor calculation result (2)

$J_{tl}=0.008\times0.96$

$=0.0077$ Calculation result

**■ Allowable moment of inertia by speed/acceleration [kgm$^2$]**

WU-S: Compact type

| Speed | B-axis | T-axis |
|---|---|---|
| | Acceleration/deceleration | |
| deg./s | 0.3G | 0.3G |
| 0 | 0.008 | 0.0035 |
| 150 | 0.008 | 0.0035 |
| 300 | 0.008 | 0.0035 |
| 450 | 0.008 | 0.0035 |
| 600 | 0.008 | 0.0035 |
| 750 | | 0.0035 |
| 900 | | 0.0035 |
| 1050 | | 0.0035 |
| 1200 | | 0.0025 |

WU-M: Medium type

| Speed | B-axis | T-axis |
|---|---|---|
| | Acceleration/deceleration | |
| deg./s | 0.3G | 0.3G |
| 0 | 0.0150 | 0.0126 |
| 150 | 0.0150 | 0.0126 |
| 300 | 0.0118 | 0.0072 |
| 450 | 0.0055 | 0.0054 |
| 600 | 0.0055 | 0.0054 |
| 750 | | 0.0054 |
| 900 | | 0.0036 |
| 1050 | | 0.0036 |
| 1200 | | 0.0036 |

### (4) Checking the moment of inertia of the transported object

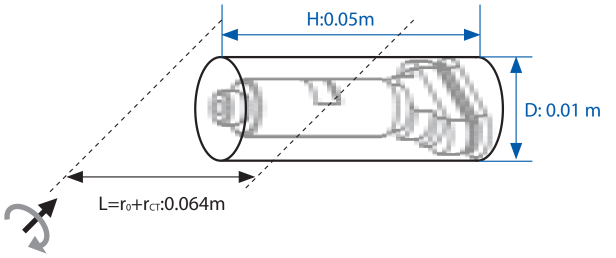
Using the Formulae for calculating moment of inertia of typical shapes (P.12), calculate the moment of inertia of the tool and workpiece to be used and make sure they do not exceed the corrected allowable moment of inertia (4) ≤ (3) obtained in (3).

**Points**

Calculations can be made easier by positing simplified shapes for transported objects such as tools and workpieces.

#### (1) Moment of inertia of piping/vacuum pad: $J_{BT}$

Calculation when simplified to cylinder



**P.12 formula 2.(5) used**

$m_T$: Cylinder weight 0.02 [kg]
D: Cylinder diameter 0.01 [m]
H: Cylinder length 0.05 (m)

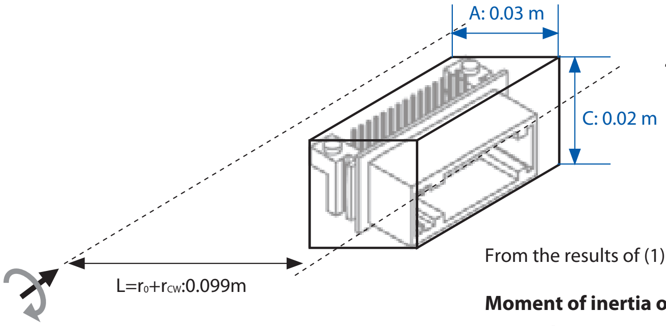
$$J_{BT}=\frac{m_T\left(\frac{D^2}{4}+\frac{H^2}{3}\right)}{4}+m_T(r_0+r_{CT})^2$$

$$=\frac{0.02\times\left(\frac{0.01^2}{4}+\frac{0.05^2}{3}\right)}{4}+0.02\times(0.039+0.025)^2$$

$$=8.62\times10^{-5}$$

#### (2) Moment of inertia of connector: $J_{BW}$

Calculation when simplified to cuboid



**P.12 formula 2.(6) used**

$m_W$: Cuboid weight 0.013 [kg]
A: One side of cuboid 0.03 [m]
C: One side of cuboid 0.02 [m]

$$J_{BW}=\frac{m_W(A^2+C^2)}{12}+m_W(r_0+r_{CW})^2$$

$$=\frac{0.013\times(0.03^2+0.02^2)}{12}+0.13\times(0.039+0.06)^2$$

$$= 1.28 \text{ x } 10^{-4}$$

From the results of (1) and (2)

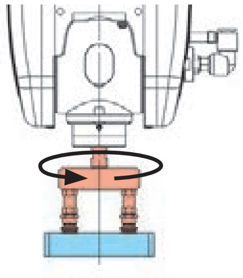
**Moment of inertia of transported object around B-axis**

$$=J_{BT}+J_{BW}$$
$$= 8.62 \text{ x } 10^{-5} + 1.28 \text{ x } 10^{-4}$$
$$=2.1\times10^{-4}$$

Usable, as it is less than the corrective allowable moment of inertia obtained in (3)

## 2. Checking T-axis

**[T-axis]**



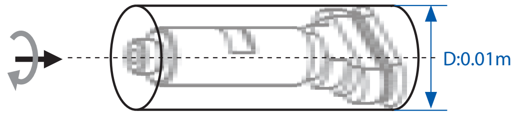
Load torque “None”

Moment of inertia applied on T-axis < Allowable moment of inertia for compact and medium types *

* It varies with the speed and acceleration/deceleration.

If load torque is not applied, using the Formulae for calculating moment of inertia of typical shapes (P.12), calculate the moment of inertia of the tool and workpiece to be used and make sure they do not exceed the corrected allowable moment of inertia.

#### (1) Moment of inertia of piping/vacuum pad: $J_{TT}$



**P.12 formula 1.(1) used**

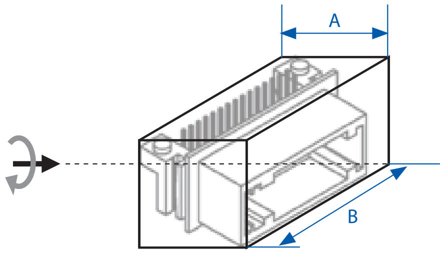
$m_T$: Cylinder weight 0.02 [kg]
D: Cylinder diameter 0.01 [m]

$$J_{TT}=\frac{m_T\times D^2}{8}$$

$$=\frac{0.02\times0.01^2}{8}$$

$$=2.50\times10^{-7}$$

### (2) Moment of inertia of the connector: $J_{TW}$



**P.12 formula 1.(3) used**

$m_W$: Cuboid weight 0.013 [kg]
A: One side of cuboid 0.03 [m]
B: One side of cuboid 0.05 [m]

$$J_{TW}=\frac{m_W(A^2+B^2)}{12}$$

$$=\frac{0.013\times(0.03^2+0.05^2)}{12}$$

$$= 3.68 \times 10^{-6}$$

From the results of (1) and (2)

**Moment of inertia of transported object around T-axis**

$=J_{TT}+J_{TW}$

$=2.50\times10^{-7}+3.68\times10^{-6}$

$=3.9\times10^{-6}[\text{kgm}^2]$

From the allowable moment of inertia (table below), we see that WU-S (compact) can be used

### [Operating conditions of the Wrist Unit]

**T-axis rotation** speed: **600** [deg/s]
Acceleration: **0.3** [G]

**■ Allowable moment of inertia by speed/acceleration [kgm$^2$]**

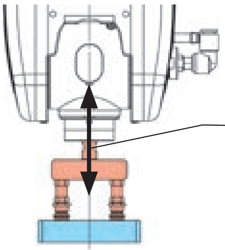
WU-S: Compact type

| Speed | B-axis | | T-axis | |
|---|---|---|---|---|
| | Acceleration/deceleration | | | |
| deg./s | 0.3G | 0.7G | 0.3G | 0.7G |
| 0 | 0.0085 | 0.0065 | 0.0075 | 0.0035 |
| 150 | 0.0085 | 0.0065 | 0.0075 | 0.0035 |
| 300 | 0.0085 | 0.005 | 0.0065 | 0.0035 |
| 450 | 0.0085 | 0.005 | 0.0065 | 0.0025 |
| 600 | 0.0085 | 0.005 | 0.0065 | 0.0025 |
| 750 | | 0.005 | 0.0065 | 0.0025 |
| 900 | | | 0.0065 | 0.0025 |
| 1050 | | | 0.0065 | 0.0025 |
| 1200 | | | 0.0065 | 0.0025 |

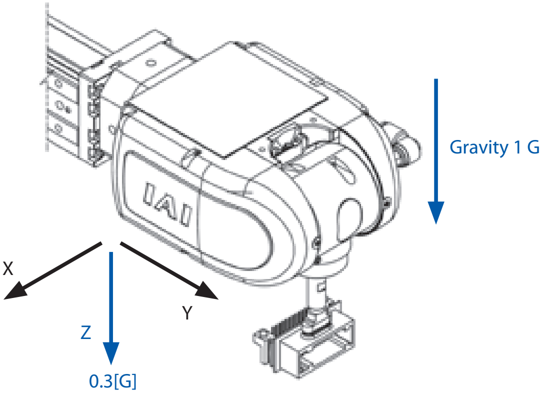
WU-M: Medium type

| Speed | B-axis | | T-axis | |
|---|---|---|---|---|
| | Acceleration/deceleration | | | |
| deg./s | 0.3G | 0.7G | 0.3G | 0.7G |
| 0 | 0.0150 | 0.0145 | 0.0165 | 0.0126 |
| 150 | 0.0150 | 0.0145 | 0.0165 | 0.0126 |
| 300 | 0.0150 | 0.0127 | 0.0165 | 0.0090 |
| 450 | 0.0099 | 0.0045 | 0.0126 | 0.0063 |
| 600 | 0.0090 | 0.0036 | 0.0108 | 0.0054 |
| 750 | | 0.0036 | 0.0099 | 0.0054 |
| 900 | | 0.0036 | 0.0099 | 0.0045 |
| 1050 | | | 0.0081 | 0.0045 |
| 1200 | | | 0.0081 | 0.0045 |

## Step 3 Check the allowable dynamic thrust load



Dynamic thrust load: F ≤ Allowable dynamic thrust load



**$F=(m_T+m_W)\cdot(a+g)\cdot 9.8[N]$**

$m_T$: Tool weight 0.02 [kg]
$m_W$: Workpiece weight 0.013 [kg]
g: Acceleration of gravity 1.0 [G]
a: Travel acceleration of Z-axis 0.3 [G]

$F=(0.02+0.013)\times(0.3+1.0)\times9.8$

$=0.033\times1.3\times9.8$

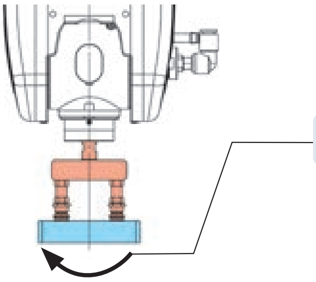
$=0.42[N]$

From the allowable dynamic thrust load (table below), we see that WU-S (compact) can be used

**■ Allowable dynamic thrust load**

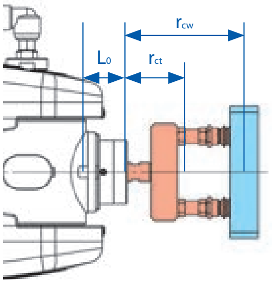
| | Allowable thrust load |
|---|---|
| **WU-S: Compact type** | 330N |
| **WU-M: Medium type** | 450N |

## Step 4 Check the allowable dynamic load moment



**Dynamic load moment: M** ≤ **Allowable dynamic load moment**

$$M=m_T \cdot a \cdot 9.8(L_0+r_{CT})\times 10^{-3}+m_W \cdot a \cdot 9.8(L_0+r_{CW})\times 10^{-3} \text{ [Nm]}$$



$m_T$: Tool weight 0.02 [kg]
$m_W$: Workpiece weight 0.013 [kg]
a: Travel acceleration of X-axis 0.3 [G]
$L_0$: Load center of mass position
WU-S (Compact) 17.5 [mm]
WU-M (Medium) 21.5 [mm]
$r_{CT}$: Tool center mass location 25 [mm]
$r_{CW}$: Workpiece center mass location
60 [mm]

$$\begin{aligned} M&=0.02\times 0.3\times 9.8\times(17.5+25)\times 10^{-3}\\ &\quad+0.013\times 0.3\times 9.8\times(17.5+60)\times 10^{-3}\\ &=0.025+0.030\\ &=0.055 \text{ [Nm]}\end{aligned}$$

From the allowable dynamic moment (table below), we see that WU-S (compact) can be used

**■ Allowable dynamic load moment**

| | Allowable dynamic load moment |
|---|---|
| **WU-S: Compact type** | 1.4Nm |
| **WU-M: Medium type** | 4.2Nm |

WU-S (compact) can be used, as seen from the results of steps 1 to 4

# Formulae for calculating moment of inertia of typical geometrical shapes

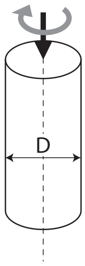
## 1. When the rotational axis passes through the center of the object

### (1) Moment of inertia of cylinder 1

* The same formula can be applied irrespective of the height of the cylinder (also for circular plate)

**<Formula> $I = M \times D^2/8$**

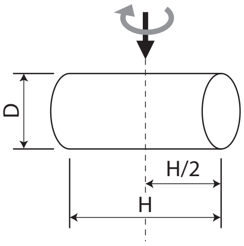
Moment of inertia of cylinder: I (kg·m²)
Cylinder weight: M (unit: kg)
Cylinder diameter: D (m)



### (2) Moment of inertia of cylinder 2

**<Formula> $I = M \times (D^2/4 + H^2/3) / 4$**

Moment of inertia of cylinder: I (kg·m²)
Cylinder weight: M (kg)
Cylinder diameter: D (m)
Cylinder length: H (m)

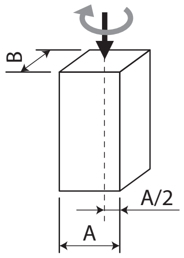


### (3) Moment of inertia of cuboid 1

* The same formula can be applied irrespective of the height of the cuboid (also for rectangular plate)

**<Formula> $I = M \times (A^2 + B^2) / 12$**

Moment of inertia of cuboid: I (kg·m²)
First side of cuboid: A (m)
Second side of cuboid: B (m)



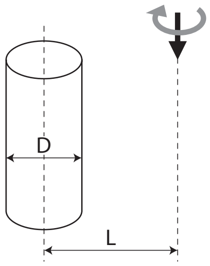
## 2. When the center of the object is offset from the rotational axis

### (4) Moment of inertia of cylinder 3

* The same formula can be applied irrespective of the height of the cylinder (also for circular plate)

**<Formula> $I = M \times D^2/8 + M \times L^2$**

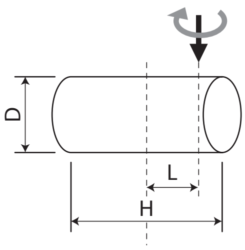
Moment of inertia of cylinder: I (kg·m²)
Cylinder weight: M (kg)
Cylinder diameter: D (m)
Distance from rotational axis to center: L (m)



### (5) Moment of inertia of cylinder 4

**<Formula> $I = M \times (D^2/4 + H^2/3) / 4 + M \times L^2$**

Moment of inertia of cylinder: I (kg·m²)
Cylinder weight: M (kg)
Cylinder diameter: D (m)
Cylinder length: H (m)
Distance from rotational axis to center: L (m)

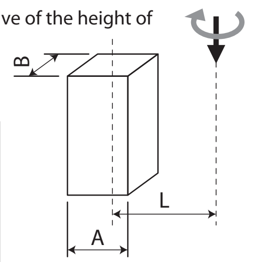


### (6) Moment of inertia of cuboid 2

* The same formula can be applied irrespective of the height of the cuboid (also for rectangular plate)

**<Formula> $I = M \times (A^2 + B^2) / 12 + M \times L^2$**

Moment of inertia of cuboid: I (kg·m²)
Cuboid weight: M (kg)
First side of cuboid: A (m)
Second side of cuboid: B (m)
Distance from rotational axis to center: L (m)



# WU-S

Battery-less Absolute

Compact type

24v Pulse Motor

**■ Model Specification Items**

| | | | | | |
|---|---|---|---|---|---|
| **WU** | **S** | **WA** | **PM1** | ☐ | ☐ |
| Series | Type | Encoder Type | Applicable Controllers | Cable Length | Options |
| | S: Compact Type | WA: Battery-less Absolute | PM1: MSEL | N : None<br>P : 1m<br>S : 3m<br>M : 5m<br>X☐☐ : Specified Length<br>R☐☐ : Robot Cable | Refer to Options table below. |

* Does not include a controller

* Please refer to P.4 for more information about the model specification items.

CE RoHS

* Please refer to P.6 for more information on the installation method and orientation.

POINT Selection Notes

When making a selection, it is necessary to calculate the moment of inertia of the operating conditions and to use a model that allows that moment of inertia. Calculate the moment of inertia of the transported object for the B- and T-axes respectively. Please refer to "Model Selection Process (P.7 on)" for more information.

(Note 1) Shows maximum set speed with no load.

(Note 2) When the rotational axes of the B-axis and T-axis are horizontal with respect to the floor surface or when the center of gravity of the transported object is offset from the rotational axis, the unit will be subject to load torque due to the weight of the object. The allowable moment of inertia decreases when load torque is present. Please refer to "Model Selection Process (P.7 on)" for more information.

## Actuator Specifications

| Model | Axis configuration | Operation range (deg.) | Max. speed (Note 1) (deg/s) | | Max. payload (kg) | Max. acceleration/deceleration (G) | |
|---|---|---|---|---|---|---|---|
| | | | Independent operation | Simultaneous operation of the B- and T-axes | | Without load torque (Note 2) | With load torque (Note 2) |
| WU-S-WA-PM1-①-② | B-axis (wrist swing) | ±100 | 750 | 600 | 1 | 0.7 G (6865 deg/s²) | 0.3 G (2942 deg/s²) |
| | T-axis (wrist rotation) | ±360 | 1200 | 600 | | 0.7 G (6865 deg/s²) | 0.3 G (2942 deg/s²) |

Legend: ① Cable length ② Options

*1 G ≈ 9807 deg/s²

## Cable Length <per axis *1>

| Type | Cable code |
|---|---|
| Standard type | **P**(1m) |
| | **S**(3m) |
| | **M**(5m) |
| Specified length | **X06**(6m) to **X10**(10m) |
| | **X11**(11m) to **X15**(15m) |
| | **X16**(16m) to **X20**(20m) *2 |
| Robot cable | **R01**(1m) to **R03**(3m) |
| | **R04**(4m) to **R05**(5m) |
| | **R06**(6m) to **R10**(10m) |
| | **R11**(11m) to **R15**(15m) |
| | **R16**(16m) to **R20**(20m) *2 |

Cable between actuator and controller.

*1 Required for both B- and T-axes. Select the cable length in the model name to have 2 cables attached.

*2 When actuator cable length change "AC1.5" is selected as an option, 18 m (X18, R18) will be the maximum length.

## Actuator Specifications

| Item | Description | |
|---|---|---|
| | B-axis (wrist swing) | T-axis (wrist rotation) |
| Drive system | Pulse motor<br>+ timing belt | Pulse motor<br>+ timing belt<br>+ bevel gear |
| Positioning repeatability | ±0.015 deg. | ±0.15 deg. |
| Lost motion | 0.06 degrees | 0.4 degrees |
| Allowable dynamic thrust load *1 | 330N | |
| Allowable dynamic load moment *1 | 1.4N·m | |
| Unit weight | 1.6kg | |
| Brake retaining torque *2 | 0.96N·m | 0.96N·m |
| Ambient operating temperature, humidity | 0~40°C, 85% RH or less (Non-condensing) | |

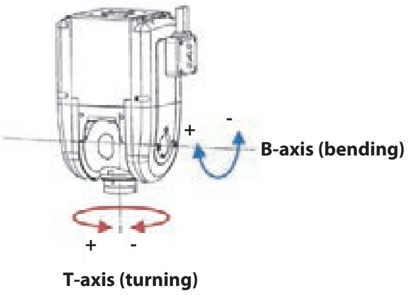
*1 Using the unit with a load exceeding the values above leads to reduced service life and/or damage.

*2 Equipped with brake as standard.

## Options

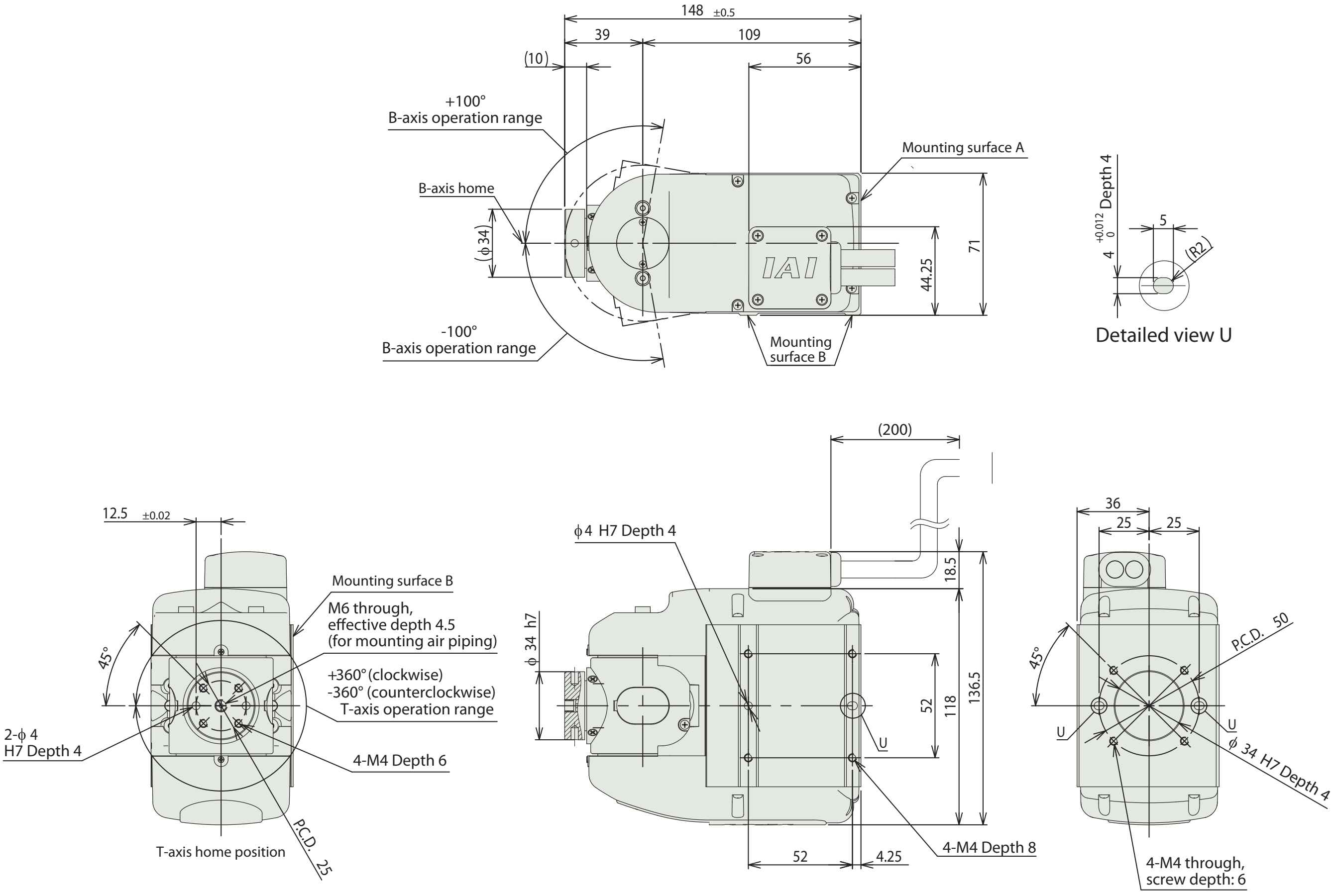
| Name | Option code | Reference page |
|---|---|---|
| Cable exit direction (Right) | **A1** | See P.5, P.14 |
| Cable exit direction (Bottom) | **A2** | See P.5, P.14 |
| Cable exit direction (Left) | **A3** | See P.5, P.14 |
| Actuator cable length 1.5 m | **AC1.5** | See P.5, P.14 |
| Cable (air fitting) in opposite position | **CVR** | See P.5, P.14 |
| Air fitting | **VC** | See P.5, P.14 |
| Wiring collar | **WCS** | See P.5, P.14 |

## Name and Coordinates of Each Axis



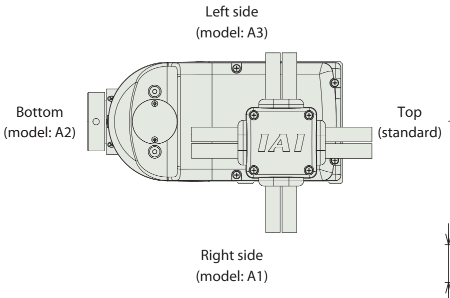
## Dimensions

CAD drawings can be downloaded from our website.
www.robocylinder.de
2D CAD
3D CAD

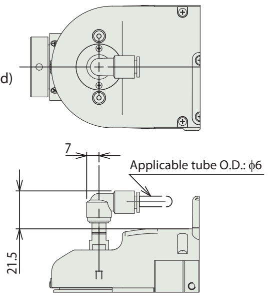


### Options

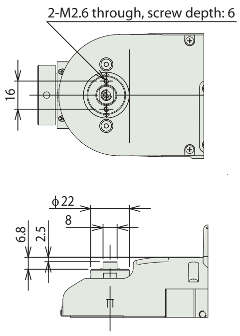
**■ Cable exit direction**



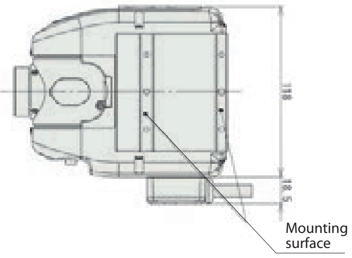
**■ Air fitting (model: VC)**



**■ Wiring collar (model: WCS)**



**■ Cable (air fitting) opposite position (model: CVR)**



## Applicable Controllers

| Name | External view | Max. number of connectable axes | Power supply voltage | Control method | | | | Maximum number of positioning points | Reference page |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Positioner | Pulse-train | Program | Network * selection | | |
| MSEL-PC/PG |  | 4 | Single phase<br>100 to<br>230 V AC | – | – | ● | DeviceNet<br>CC-Link<br>EtherCAT<br>EtherNet/IP<br>PROFIBUS<br>[illegible] | 30000 | See P.17 |

# WU-M

Battery-less Absolute | Medium type | 24v Pulse Motor

**■ Model Specification Items**

| WU | — | M | — | WA | — | PM1 | — | ☐ | — | ☐ |
|---|---|---|---|---|---|---|---|---|---|---|
| Series | — | Type | — | Encoder Type | — | Applicable Controllers | — | Cable Length | — | Options |
| | | M: Medium Type | | WA: Battery-less Absolute | | PM1:MSEL | | N : None<br>P : 1m<br>S : 3m<br>M : 5m<br>X☐☐ : Specified Length<br>R☐☐ : Robot Cable | | Refer to Options table below. |

* Does not include a controller

* Please refer to P.4 for more information about the model specification items.

C€ RoHS

* Please refer to P.6 for more information on the installation method and orientation.

**POINT Selection Notes**

When making a selection, it is necessary to calculate the moment of inertia of the operating conditions and to use a model that allows that moment of inertia. Calculate the moment of inertia of the transported object for the B- and T-axes respectively. Please refer to "Model Selection Process (P.7 on)" for more information.

(Note 1) Shows maximum set speed with no load.

(Note 2) When the rotational axes of the B-axis and T-axis are horizontal with respect to the floor surface or when the center of gravity of the transported object is offset from the rotational axis, the unit will be subject to load torque due to the weight of the object. The allowable moment of inertia decreases when load torque is present. Please refer to "Model Selection Process (P.7 on)" for more information.

## Actuator Specifications

| Model | Axis configuration | Operation range (deg.) | Max. speed (Note 1) (deg/s) | | Max. payload (kg) | Max. acceleration/deceleration (G) | |
|---|---|---|---|---|---|---|---|
| | | | Independent operation | Simultaneous operation of the B- and T-axes | | Without load torque (Note 2) | With load torque (Note 2) |
| WU-M-WA-PM1-①-② | B-axis (wrist swing) | ±105 | 900 | 600 | 2 | 0.7 G (6865 deg/s²) | 0.3 G (2942 deg/s²) |
| | T-axis (wrist rotation) | ±360 | 1200 | 600 | | 0.7 G (6865 deg/s²) | 0.3 G (2942 deg/s²) |

Legend: ① Cable length ② Options

*1 G = 9800 deg/s²

## Cable Length <per axis *1>

| Type | Cable code |
|---|---|
| Standard type | **P**(1m) |
| | **S**(3m) |
| | **M**(5m) |
| Specified length | **X06**(6m) to **X10**(10m) |
| | **X11**(11m) to **X15**(15m) |
| | **X16**(16m) to **X20**(20m) *2 |
| Robot cable | **R01**(1m) to **R03**(3m) |
| | **R04**(4m) to **R05**(5m) |
| | **R06**(6m) to **R10**(10m) |
| | **R11**(11m) to **R15**(15m) |
| | **R16**(16m) to **R20**(20m) *2 |

Cable between actuator and controller.

*1 Required for both B- and T-axes. Select the cable length in the model name to have 2 cables attached.

*2 When actuator cable length change "AC1.5" is selected as an option, 18 m (X18, R18) will be the maximum length.

## Actuator Specifications

| Item | Description | |
|---|---|---|
| | B-axis (wrist swing) | T-axis (wrist rotation) |
| Drive system | Pulse motor<br>+ timing belt | Pulse motor<br>+ timing belt<br>+ bevel gear |
| Positioning repeatability | ±0.015 deg. | ±0.15 deg. |
| Lost motion | 0.06 degrees | 0.4 degrees |
| Allowable dynamic thrust load *1 | 450N | |
| Allowable dynamic load moment *1 | 4.2N·m | |
| Unit weight | 2.8kg | |
| Brake retaining torque *2 | 2.8N·m | 2.8N·m |
| Ambient operating temperature/humidity | 0~40°C, 85% RH or less (Non-condensing) | |

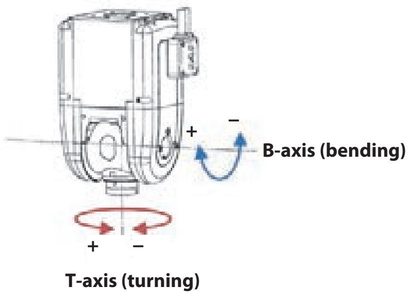
*1 Using the unit with a load exceeding the values above leads to reduced service life and/or damage.

*2 Equipped with brake as standard.

## Options

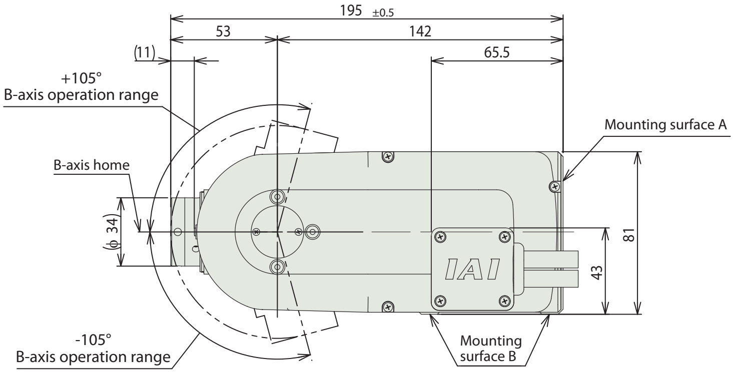
| Name | Option Code | Reference page |
|---|---|---|
| Cable exit direction (Right) | **A1** | See P.5, P.16 |
| Cable exit direction (Bottom) | **A2** | See P.5, P.16 |
| Cable exit direction (Left) | **A3** | See P.5, P.16 |
| Actuator cable length 1.5 m | **AC1.5** | See P.5, P.16 |
| Cable (air fitting) in opposite position | **CVR** | See P.5, P.16 |
| Air fitting | **VC** | See P.5, P.16 |
| Wiring collar | **WCS** | See P.5, P.16 |

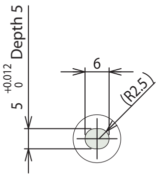
## Name and Coordinates of Each Axis



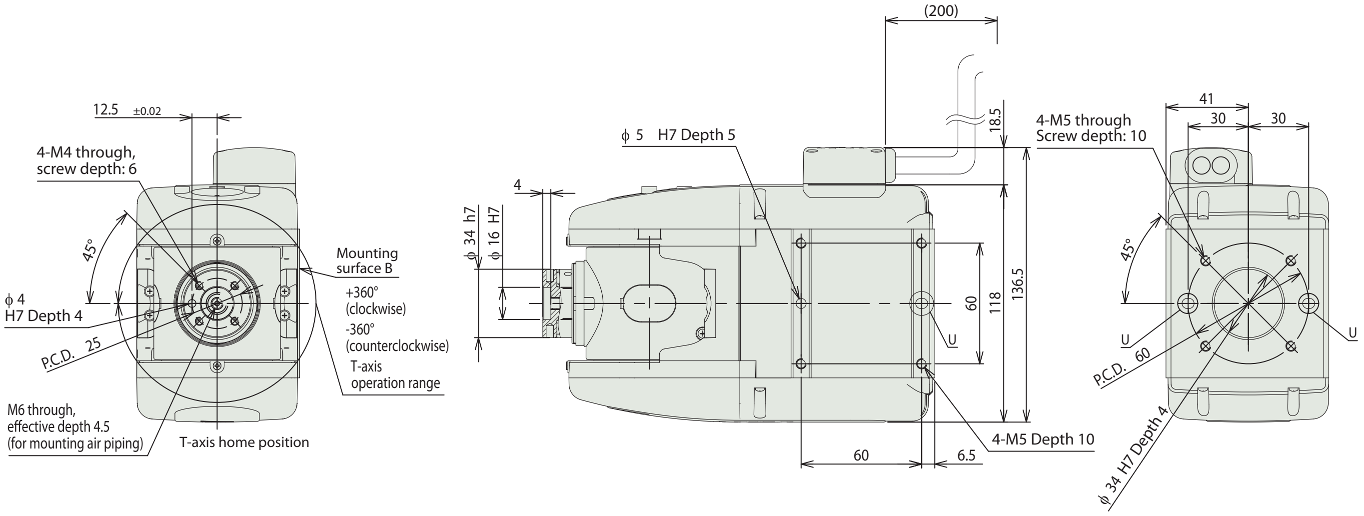
## Dimensions

CAD drawings can be downloaded from our website.
www.robocylinder.de
2D CAD 3D CAD



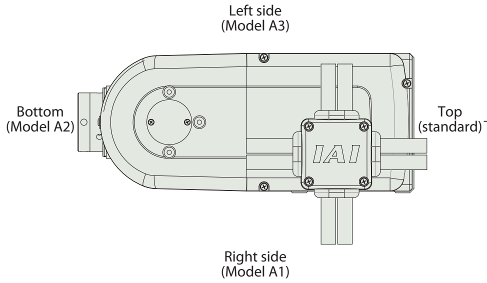


Detailed view U

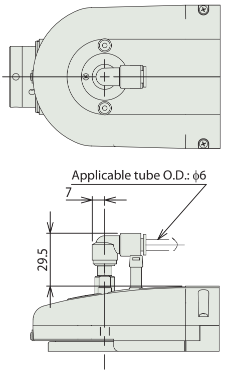


### Options

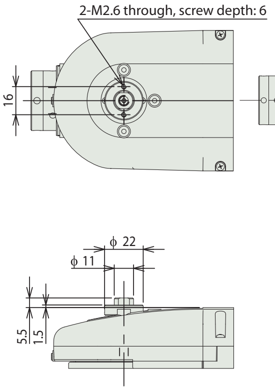
- Cable exit direction



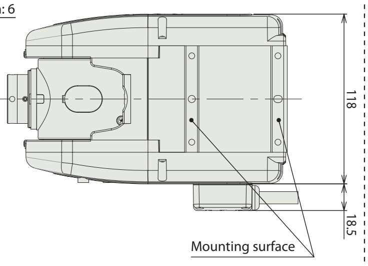
- Air fitting (model: VC)



- Wiring collar (model: WCS)



- Cable (air fitting) in opposite position Model: CVR



## Applicable Controllers

| Name | External view | Max. number of connectable axes | Power supply voltage | Control method | | | | Maximum number of positioning points | Reference page |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Positioner | Pulse-train | Program | Network * selection | | |
| MSEL-PC/PG |  | 4 | Single phase<br>100 to<br>230 V AC | – | – | ● | DeviceNet<br>CC-Link<br>EtherCAT<br>EtherNet/IP<br>PROFIBUS | 30000 | See P.17 |

# MSEL

## RCP6/RCP5/RCP4/RCP3/RCP2
## Program Controller
## for Wrist Unit WU

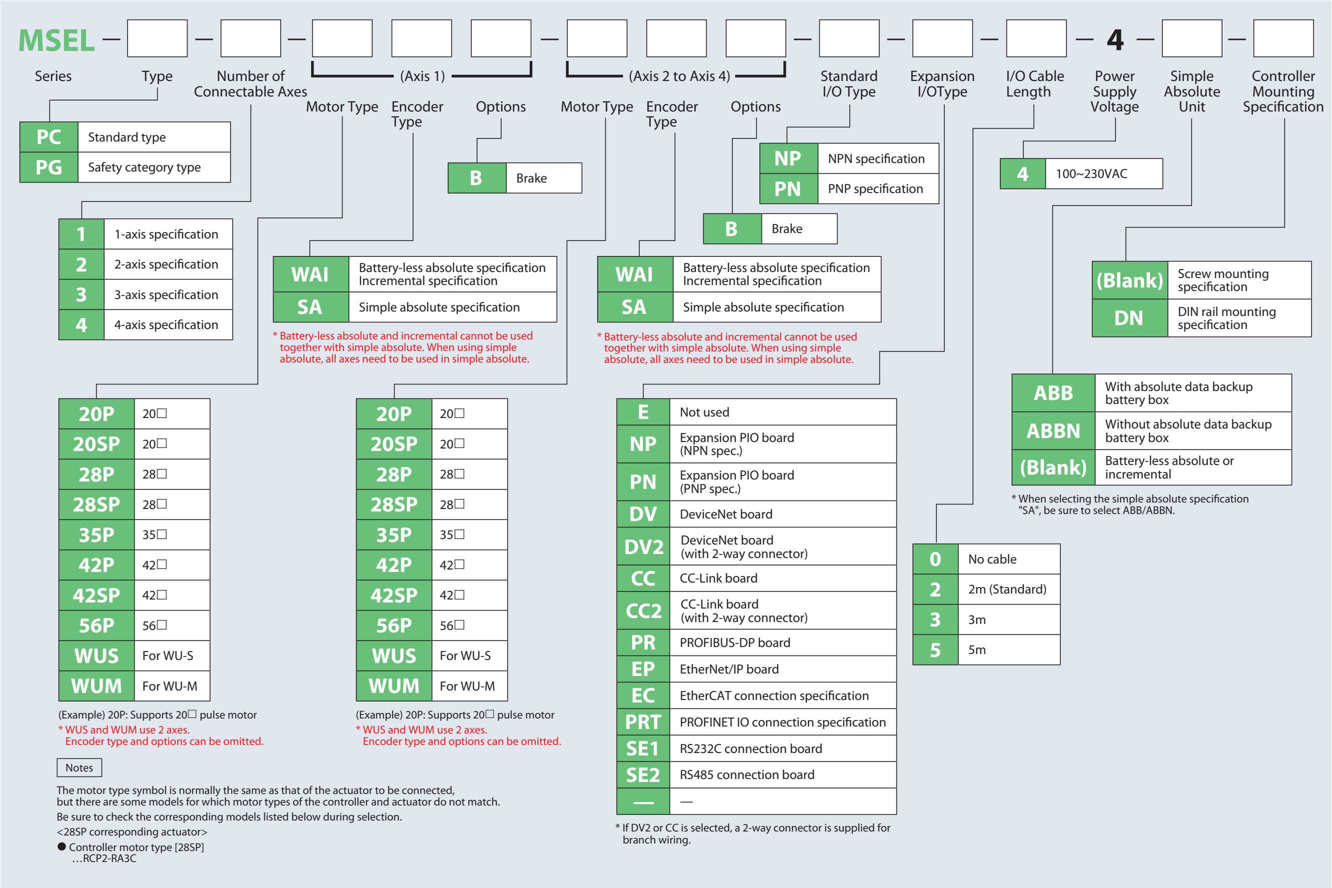
## List of Models

Program controller available for operation of RCP6/RCP5/RCP4/RCP3/RCP2 series actuators. A single unit can handle various forms of control with up to 4 axes.

| Type name | PC | PG |
|---|---|---|
| Type | Standard type | Safety category type |
| Max. number of controlled axes | 4 | |
| No. of positions | 30000 points | |
| Power supply | Single-phase 100~230VAC | |
| Safety category | B | 3 [*1] |

*1: To comply with the safety category, the customer will need to install a safety circuit externally to the controller.

## Model Specification Items



MSEL – ☐ – ☐ – ☐ ☐ ☐ – ☐ ☐ ☐ – ☐ – ☐ – ☐ – 4 – ☐ – ☐

Series – Type – Number of Connectable Axes – (Axis 1) Motor Type, Encoder Type, Options – (Axis 2 to Axis 4) Motor Type, Encoder Type, Options – Standard I/O Type – Expansion I/OType – I/O Cable Length – Power Supply Voltage – Simple Absolute Unit – Controller Mounting Specification

**Type**

| | |
|---|---|
| PC | Standard type |
| PG | Safety category type |

**Number of Connectable Axes**

| | |
|---|---|
| 1 | 1-axis specification |
| 2 | 2-axis specification |
| 3 | 3-axis specification |
| 4 | 4-axis specification |

**Motor Type (Axis 1)**

| | |
|---|---|
| 20P | 20☐ |
| 20SP | 20☐ |
| 28P | 28☐ |
| 28SP | 28☐ |
| 35P | 35☐ |
| 42P | 42☐ |
| 42SP | 42☐ |
| 56P | 56☐ |
| WUS | For WU-S |
| WUM | For WU-M |

(Example) 20P: Supports 20☐ pulse motor

* WUS and WUM use 2 axes.
Encoder type and options can be omitted.

**Encoder Type (Axis 1)**

| | |
|---|---|
| WAI | Battery-less absolute specification<br>Incremental specification |
| SA | Simple absolute specification |

* Battery-less absolute and incremental cannot be used together with simple absolute. When using simple absolute, all axes need to be used in simple absolute.

**Options (Axis 1)**

| | |
|---|---|
| B | Brake |

**Motor Type (Axis 2 to Axis 4)**

| | |
|---|---|
| 20P | 20☐ |
| 20SP | 20☐ |
| 28P | 28☐ |
| 28SP | 28☐ |
| 35P | 35☐ |
| 42P | 42☐ |
| 42SP | 42☐ |
| 56P | 56☐ |
| WUS | For WU-S |
| WUM | For WU-M |

(Example) 20P: Supports 20☐ pulse motor

* WUS and WUM use 2 axes.
Encoder type and options can be omitted.

**Encoder Type (Axis 2 to Axis 4)**

| | |
|---|---|
| WAI | Battery-less absolute specification<br>Incremental specification |
| SA | Simple absolute specification |

* Battery-less absolute and incremental cannot be used together with simple absolute. When using simple absolute, all axes need to be used in simple absolute.

**Options (Axis 2 to Axis 4)**

| | |
|---|---|
| B | Brake |

**Standard I/O Type**

| | |
|---|---|
| NP | NPN specification |
| PN | PNP specification |

**Expansion I/OType**

| | |
|---|---|
| E | Not used |
| NP | Expansion PIO board (NPN spec.) |
| PN | Expansion PIO board (PNP spec.) |
| DV | DeviceNet board |
| DV2 | DeviceNet board (with 2-way connector) |
| CC | CC-Link board |
| CC2 | CC-Link board (with 2-way connector) |
| PR | PROFIBUS-DP board |
| EP | EtherNet/IP board |
| EC | EtherCAT connection specification |
| PRT | PROFINET IO connection specification |
| SE1 | RS232C connection board |
| SE2 | RS485 connection board |
| — | — |

* If DV2 or CC is selected, a 2-way connector is supplied for branch wiring.

**I/O Cable Length**

| | |
|---|---|
| 0 | No cable |
| 2 | 2m (Standard) |
| 3 | 3m |
| 5 | 5m |

**Power Supply Voltage**

| | |
|---|---|
| 4 | 100~230VAC |

**Simple Absolute Unit**

| | |
|---|---|
| ABB | With absolute data backup battery box |
| ABBN | Without absolute data backup battery box |
| (Blank) | Battery-less absolute or incremental |

* When selecting the simple absolute specification "SA", be sure to select ABB/ABBN.

**Controller Mounting Specification**

| | |
|---|---|
| (Blank) | Screw mounting specification |
| DN | DIN rail mounting specification |

Notes

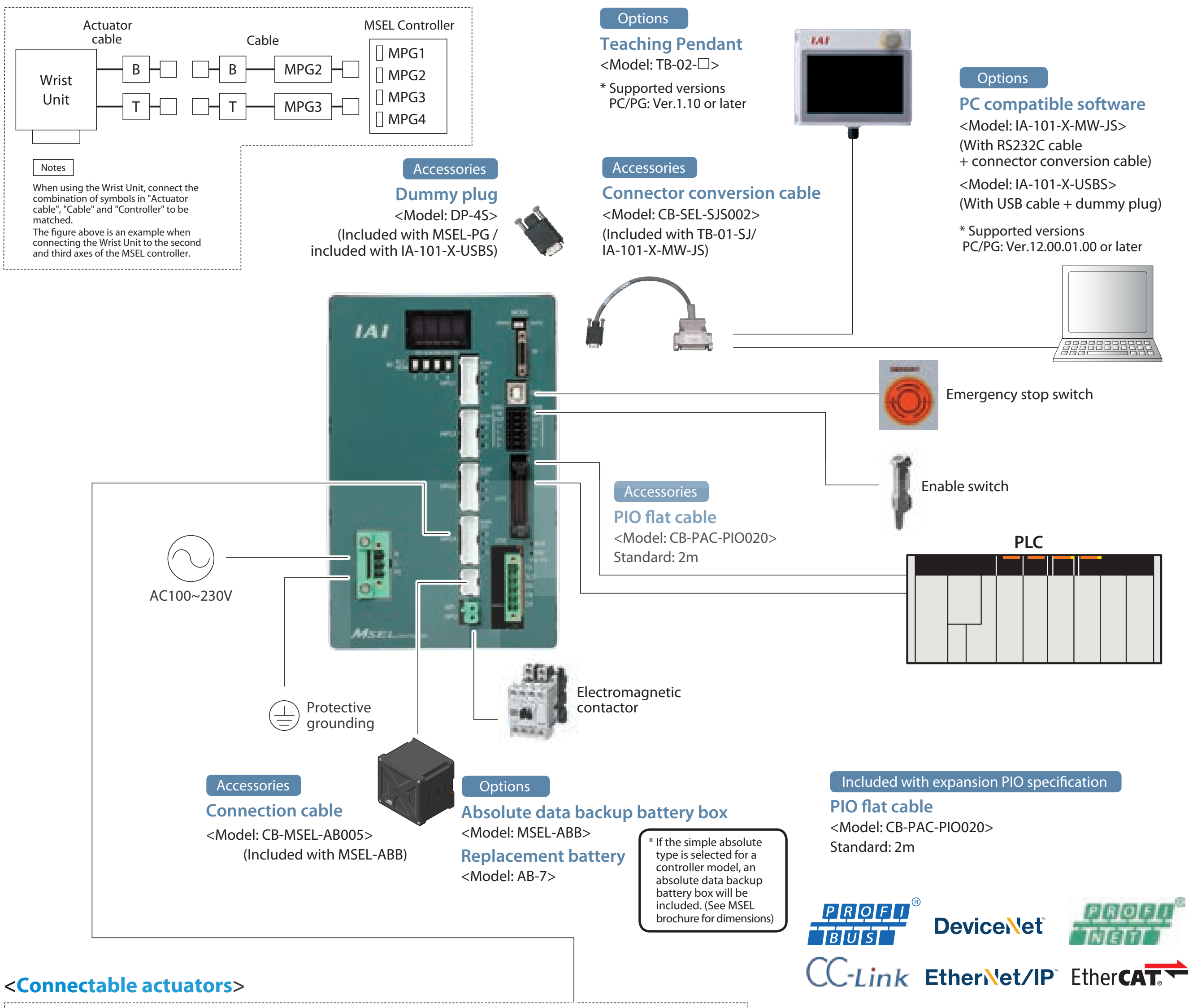
The motor type symbol is normally the same as that of the actuator to be connected, but there are some models for which motor types of the controller and actuator do not match.

Be sure to check the corresponding models listed below during selection.

<28SP corresponding actuator>

- Controller motor type [28SP] …RCP2-RA3C

## System Configuration



Notes

When using the Wrist Unit, connect the combination of symbols in "Actuator cable", "Cable" and "Controller" to be matched.
The figure above is an example when connecting the Wrist Unit to the second and third axes of the MSEL controller.

Options
**Teaching Pendant**
<Model: TB-02-☐>
* Supported versions
PC/PG: Ver.1.10 or later

Options
**PC compatible software**
<Model: IA-101-X-MW-JS>
(With RS232C cable
+ connector conversion cable)
<Model: IA-101-X-USBS>
(With USB cable + dummy plug)
* Supported versions
PC/PG: Ver.12.00.01.00 or later

Accessories
**Dummy plug**
<Model: DP-4S>
(Included with MSEL-PG /
included with IA-101-X-USBS)

Accessories
**Connector conversion cable**
<Model: CB-SEL-SJS002>
(Included with TB-01-SJ/
IA-101-X-MW-JS)

Accessories
**PIO flat cable**
<Model: CB-PAC-PIO020>
Standard: 2m

Accessories
**Connection cable**
<Model: CB-MSEL-AB005>
(Included with MSEL-ABB)

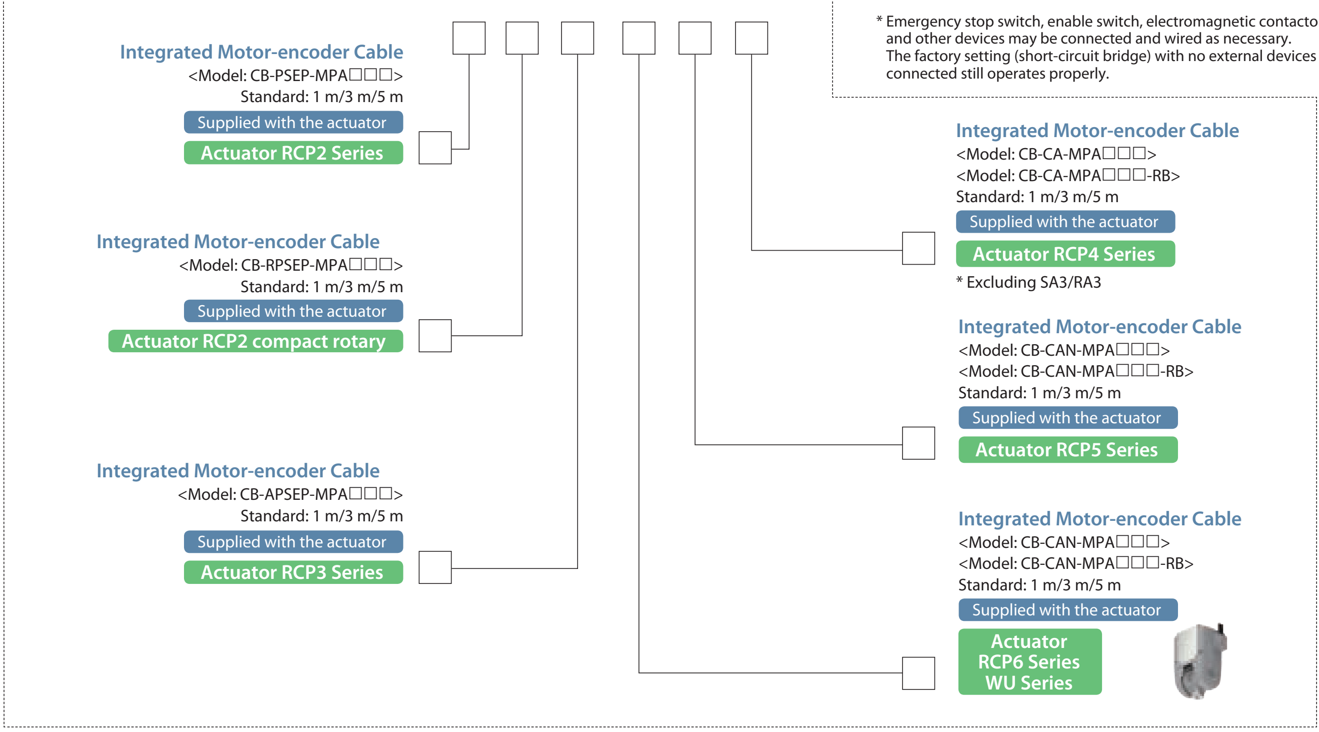
Options
**Absolute data backup battery box**
<Model: MSEL-ABB>
**Replacement battery**
<Model: AB-7>

* If the simple absolute type is selected for a controller model, an absolute data backup battery box will be included. (See MSEL brochure for dimensions)

Included with expansion PIO specification
**PIO flat cable**
<Model: CB-PAC-PIO020>
Standard: 2m

### <Connectable actuators>

* Emergency stop switch, enable switch, electromagnetic contactor, and other devices may be connected and wired as necessary.
The factory setting (short-circuit bridge) with no external devices connected still operates properly.



**Integrated Motor-encoder Cable**
<Model: CB-PSEP-MPA☐☐☐>
Standard: 1 m/3 m/5 m
Supplied with the actuator
**Actuator RCP2 Series**

**Integrated Motor-encoder Cable**
<Model: CB-RPSEP-MPA☐☐☐>
Standard: 1 m/3 m/5 m
Supplied with the actuator
**Actuator RCP2 compact rotary**

**Integrated Motor-encoder Cable**
<Model: CB-APSEP-MPA☐☐☐>
Standard: 1 m/3 m/5 m
Supplied with the actuator
**Actuator RCP3 Series**

**Integrated Motor-encoder Cable**
<Model: CB-CA-MPA☐☐☐>
<Model: CB-CA-MPA☐☐☐-RB>
Standard: 1 m/3 m/5 m
Supplied with the actuator
**Actuator RCP4 Series**
* Excluding SA3/RA3

**Integrated Motor-encoder Cable**
<Model: CB-CAN-MPA☐☐☐>
<Model: CB-CAN-MPA☐☐☐-RB>
Standard: 1 m/3 m/5 m
Supplied with the actuator
**Actuator RCP5 Series**

**Integrated Motor-encoder Cable**
<Model: CB-CAN-MPA☐☐☐>
<Model: CB-CAN-MPA☐☐☐-RB>
Standard: 1 m/3 m/5 m
Supplied with the actuator
**Actuator RCP6 Series WU Series**

**WU Wrist Unit**
**Catalogue No. 0717-E**

Quality and Innovation

**IAI Industrieroboter GmbH**
Ober der Röth 4
D-65824 Schwalbach / Frankfurt
Germany
Phone: +49-6196-8895-0
Fax: +49-6196-8895-24
E-Mail: info@IAI-GmbH.de
Internet: http://www.eu.IAI-GmbH.de

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**IAI America, Inc.**
2690 W. 237th Street, Torrance, CA 90505, U.S.A
Phone: +1-310-891-6015, Fax: +1-310-891-0815

**IAI (Shanghai) Co., Ltd**
Shanghai Jiahua Business Center A8-303, 808,
Hongqiao Rd., Shanghai 200030, China
Phone: +86-21-6448-4753, Fax: +86-21-6448-3992

**IAI CORPORATION**
577-1 Obane, Shimizu-Ku, Shizuoka, 424-0103 Japan
Phone: +81-543-64-5105, Fax: +81-543-64-5192

**IAI Robot (Thailand) Co., Ltd**
825 PhairojKijja Tower 12th Floor, Bangna-Trad RD.,
Bangna, Bangna, Bangkok 10260, Thailand
Phone: +66-2-361-4457, Fax: +66-2-361-4456