

DENSO ROBOT

Horizontal articulated

HS-G SERIES

GENERAL INFORMATION ABOUT ROBOT

Copyright © DENSO WAVE INCORPORATED, 2005-2013

All rights reserved. No part of this publication may be reproduced in any form or by any means without permission in writing from the publisher.

Specifications are subject to change without prior notice.

All products and company names mentioned are trademarks or registered trademarks of their respective holders.

Preface

Thank you for purchasing this high-speed, high-accuracy assembly robot.

Before operating your robot, read this manual carefully to safely get the maximum benefit from your robot in your assembling operations.

Robot series and/or models covered by this manual

Series	Model (Note 1)		Overall arm length
	Floor-mount	Overhead-mount	
HS-G (Small-sized, horizontal articulated)	HS-4535*G	—	350 mm
	HS-4545*G	HSS-4545*G	450 mm
	HS-4555*G	HSS-4555*G	550 mm

NOTE 1: Model names listed above apply to the models of robot systems. The model names of robot units are followed by M. If the robot system model is HS4535*G, for example, the robot unit model is HS4535*E/GM.

Important

To ensure operator safety, be sure to read the precautions and instructions in "SAFETY PRECAUTIONS."

NOTE:

Robots and controllers that will be exported to South Korea after March 1st 2013 need to have KCs mark for each equipment.

How this book is organized

This book is just one part of the robot documentation set. This book consists of SAFETY PRECAUTIONS, chapters one through five, and appendix.

Chapter 1 Packing List of the Robot

Lists the standard components contained in the product package and optional components.

Chapter 2 Configuration of the Robot System

Illustrates the configuration of the robot system and describes the component names of the robot unit and controller.

Chapter 3 Specifications of the Robot Unit

Describes the specifications, motion space, robot positioning time, air piping and signal wiring, and engineering-design notes for robot hands.

Chapter 4 Specifications of the Robot Controller

Lists the specifications of the robot controller and controller setting table (SETPRM LIST).

Chapter 5 Warranty

Describes the warranty period and coverage.

Appendix How to Use the Manual Pack CD

Contents

Chapter 1 Packing List of the Robot	1
1.1 Standard Components	1
1.2 Optional Components.....	2
Chapter 2 Configuration of the Robot System	4
2.1 Configurators	4
2.2 Names of Robot Unit Components	5
2.2.1 Robot Unit Components and Rotation Direction	5
2.2.2 Name Plate	6
2.2.3 Warning and Caution Labels	7
2.3 Names of the Robot Controller Components	8
Chapter 3 Specifications of the Robot Unit	9
3.1 Robot Specifications (HS/HSS-G).....	9
3.2 Outer Dimensions and Workable Space of the Robot Unit (HS/HSS-G).....	11
3.3 Robot Positioning Time (HS/HSS-G)	18
3.4 Notes for Setting the Positioning Speed (HS/HSS-G).....	28
3.5 Air Piping and Signal Wiring	30
3.5.1 Instructions for Using Splash-proof Connector Sets	33
3.6 Engineering-design Notes for Robot Hands (HS/HSS-G)	34
3.7 Stopping Time and Distance (Angle) at an Emergency Stop	37
Chapter 4 Specifications of the Robot Controller	42
4.1 Specifications	42
4.2 Outer Dimensions.....	44
4.3 Controller Setting Table	45
Chapter 5 Warranty	46
Chapter 6 Appendix	47
6.1 Conformity with Standards by Robot Model	47

Chapter 1 Packing List of the Robot

1.1 Standard Components

The components listed below are contained in the product package.

Standard Components

No.	Item	Q'ty
(1)	Robot unit	1
(2)	Robot controller	1
(3)	Power cable (5 m)	1
(4)	Motor & encoder cable (Note 1) (Option)	1
(5)	Manuals ("Manual Pack CD" and "Safety Precautions")	1 set
(6)	WINCAPSIII Install CD (Trial version)	1
(7)	Spare fuses for robot controller	3
(8)	Pendantless connector (Dummy connector) (not contained in UL-Listed robot systems)	1
(9)	Connector set for hand control signals (for CN20 and CN21)	1 set
(10)	Direction indicator label (Note 2)	1
(11)	Warning label (Note 3)	1
(12)	Spare output IC for robot controller	1
(13)	Dowel pins (internally threaded positioning pin and diamond-shaped pin)	1 set
(14)	Short sockets for robot controller	2

Note 1: Choose and order a motor & encoder cable from the table below. The 20-m motor & encoder cable (standard/splash-proof) is not available for controllers equipped with extended-joint options or UL-Listed robot units. The internal cable bending radius shall at least be 200 mm. Excessively bending will result in broken lead wires.

Item	Part No.
Standard cable 2 m	410141-4400
Standard cable 4 m	410141-3611
Standard cable 6 m	410141-3621
Standard cable 12 m	410141-3631
Standard cable 20 m	410141-4440
Splash-proof cable 2 m	410141-4420
Splash-proof cable 4 m	410141-3681
Splash-proof cable 6 m	410141-3691
Splash-proof cable 12 m	410141-3701
Splash-proof cable 20 m	410141-4460

Note 2: After installation, attach the direction indicator label in a position on the robot unit that can be easily seen.

Note 3: Attach the warning label on the robot safety fence or other location where workers will easily notice it. If necessary, prepare a plate for attaching the seal.

When placing an order for UL-Listed robot systems, be sure to order the optional teach pendant or mini-pendant also which is essential to UL-Listed ones.

1.2 Optional Components

The table below lists the optional components.

Optional Components (1)

Classification	No.	Item	Remarks	Part No.	
I/O cables	1	Standard I/O cable set	(8 m) Incl. Nos. 1-1 and 1-2.	410149-0940	
			(15 m) Incl. Nos. 1-1 and 1-2.	410149-0950	
	1-1	I/O cable for "Mini I/O" (68pins)	(8 m)	410141-2700	
			(15 m)	410141-2710	
	1-2	I/O cable for "HAND I/O"	(8 m)	410141-1740	
			(15 m)	410141-1750	
2	I/O cable for "Parallel I/O board" (96 pins)	(8 m)	410141-3050		
		(15 m)	410141-3060		
3	I/O cable for "SAFETY I/O" (36 pins) (Only for global type)	(8 m)	410141-3580		
		(15 m)	410141-3590		
Operation devices	4	Teach pendant	(4 m) With cable	410100-1572	
			(8 m) With cable	410100-1582	
			(12 m) With cable	410100-1592	
	5	Mini-pendant kit (Incl. cable and WINCAPSIII Light)	(4 m) Japanese indication	410109-0392	
			English indication	410109-0402	
			(8 m) Japanese indication	410109-0412	
	6	Pendant extension cable	English indication	410109-0422	
			(12 m) Japanese indication	410109-0432	
7	WINCAPSIII	English indication	410109-0442		
		(4 m) For TP, MP	410141-3711		
8	Parallel I/O board	(8 m) For TP, MP	410141-3721		
		CD-ROM (common to the languages--Japanese, English, German, Korean, and Chinese)	410090-0980		
Optional boards for the robot controller	8	Parallel I/O board	Shipped as installed on the controller	NPN	410010-3320
			Shipped as individual boards (supply part)	PNP	410010-3330
				NPN	410010-3340
			PNP	410010-3350	
	9	DeviceNet board	Shipped as installed on the controller	For Slave station	410010-3370
				For Master station	410010-3380
			Shipped as individual boards (supply part)	For Master & slave station	410010-3390
				For Slave station	410010-3400
	10	CC-Link board	For Master station	410010-3410	
			For Master & slave station	410010-3480	
	11	Conveyor tracking board	Shipped as installed on the controller	410010-3430	
Shipped as individual boards (supply part)			410010-3440		
11	Conveyor tracking board	Shipped as installed on the controller	410010-3460		
		Shipped as individual boards (supply part)	410010-3470		

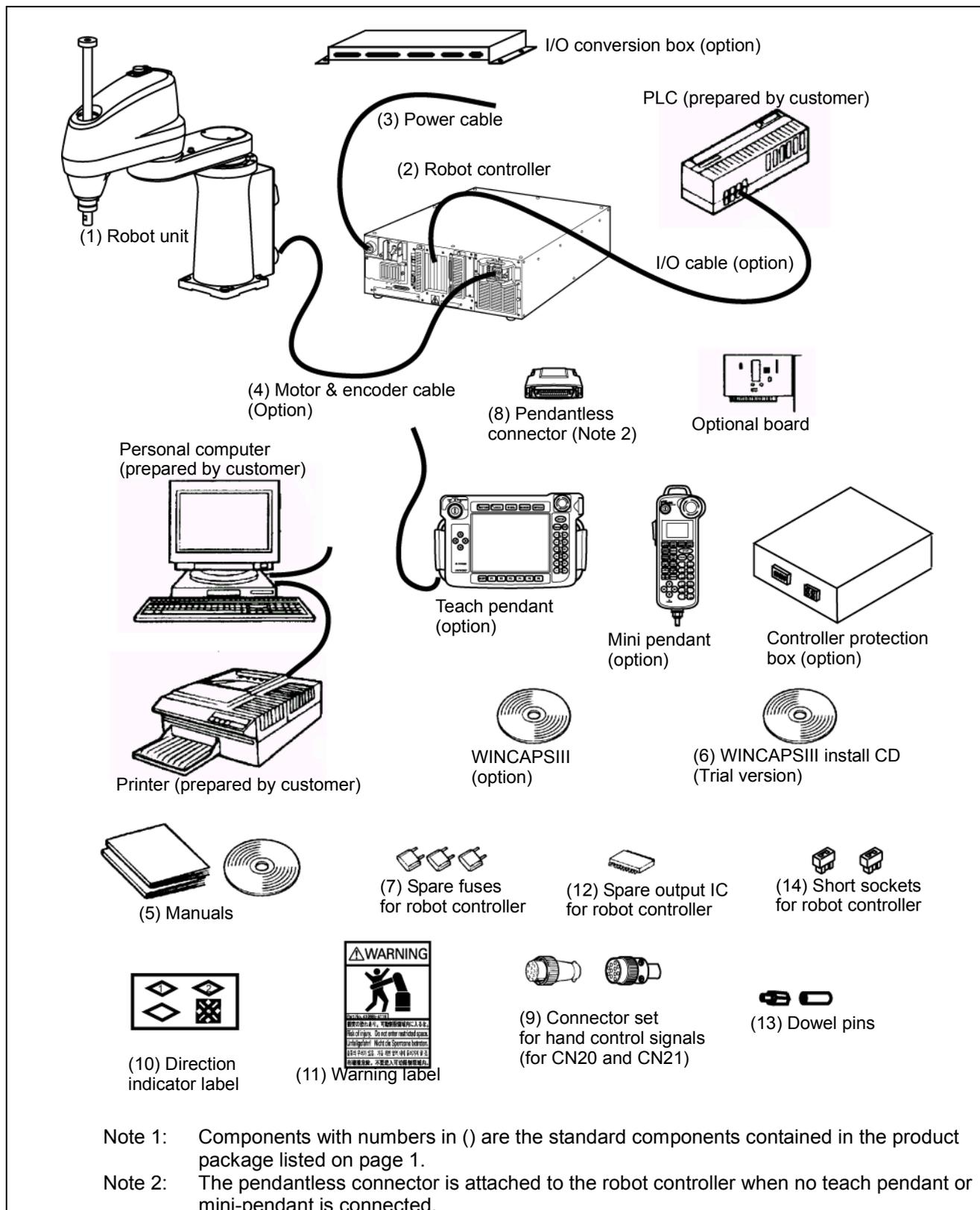
Optional Components (2)

Classification	No.	Item	Remarks	Part No.
Optional functions (For own optional board etc.)	12	Optional function for RS232C board Board manufacturer: CONTEC CO., LTD. Model: COM-2P(PCI)H	Shipped after integrated in the controller	410006-0260
			Added when the board is purchased as a spare part	410006-0270
	13	Optional function for S-LINK V board Board manufacturer: SUNX CO., LTD. Model: SL-VPCI	Shipped after integrated in the controller	410006-0280
			Added when the board is purchased as a spare part	410006-0290
	14	Optional function for PROFIBUS-DP slave board Board manufacturer: Hilscher GmbH Model: CIF50-DPS\DENSO	Shipped after integrated in the controller	410006-0300
			Added when the board is purchased as a spare part	410006-0310
15	EtherNet/IP function Board manufacturer: Hilscher GmbH Model: CIFX 50-RE\DENSO	Shipped after integrated in the controller	410006-0800	
		Added when the board is purchased as a spare part	410006-0810	
16	Optional function for memory extension	Extension only upon controller shipment (3.25MB to 5.5MB)	410006-0320	
Optional box	17	Controller protection box		410181-0091
	18	I/O conversion box	For interchangeability with RC5 type controller	410181-0100
CD Manuals	19	Manual Pack CD	Contained in the robot package.	410002-2661
Optional manuals (Printed materials, English edition)	20	Instruction manual for HS-G, full set	Includes No. C and No. D	410009-0360
	C	Instruction manual for HS-G, basic set	Includes No. C-1 to No. C-3	410009-0260
	C-1	GENERAL INFORMATION ABOUT ROBOT	For HS-G	410002-2610
	C-2	RC7M CONTROLLER MANUAL	For RC7M controller	410002-2430
	C-3	ERROR CODE TABLES		410002-3370
	D	Instruction manual for HS-G, extension set	Includes No. D-1 to No. D-7	410009-0140
	D-1	INSTALLATION & MAINTENANCE GUIDE	For HS-G	410002-2630
	D-2	STARTUP HANDBOOK		410002-2750
	D-3	SETTING-UP MANUAL		410002-3310
	D-4	PROGRAMMER'S MANUAL (I)		410002-3330
D-5	PROGRAMMER'S MANUAL (II)		410002-3350	
D-6	Panel Designer USER'S MANUAL		410002-6480	
D-7	OPTIONS MANUAL	For RC7M controller	410002-2650	
For robot unit	21	Flange kit		410329-0060

Chapter 2 Configuration of the Robot System

2.1 Configurators

The figure below shows configurators of the typical robot system.



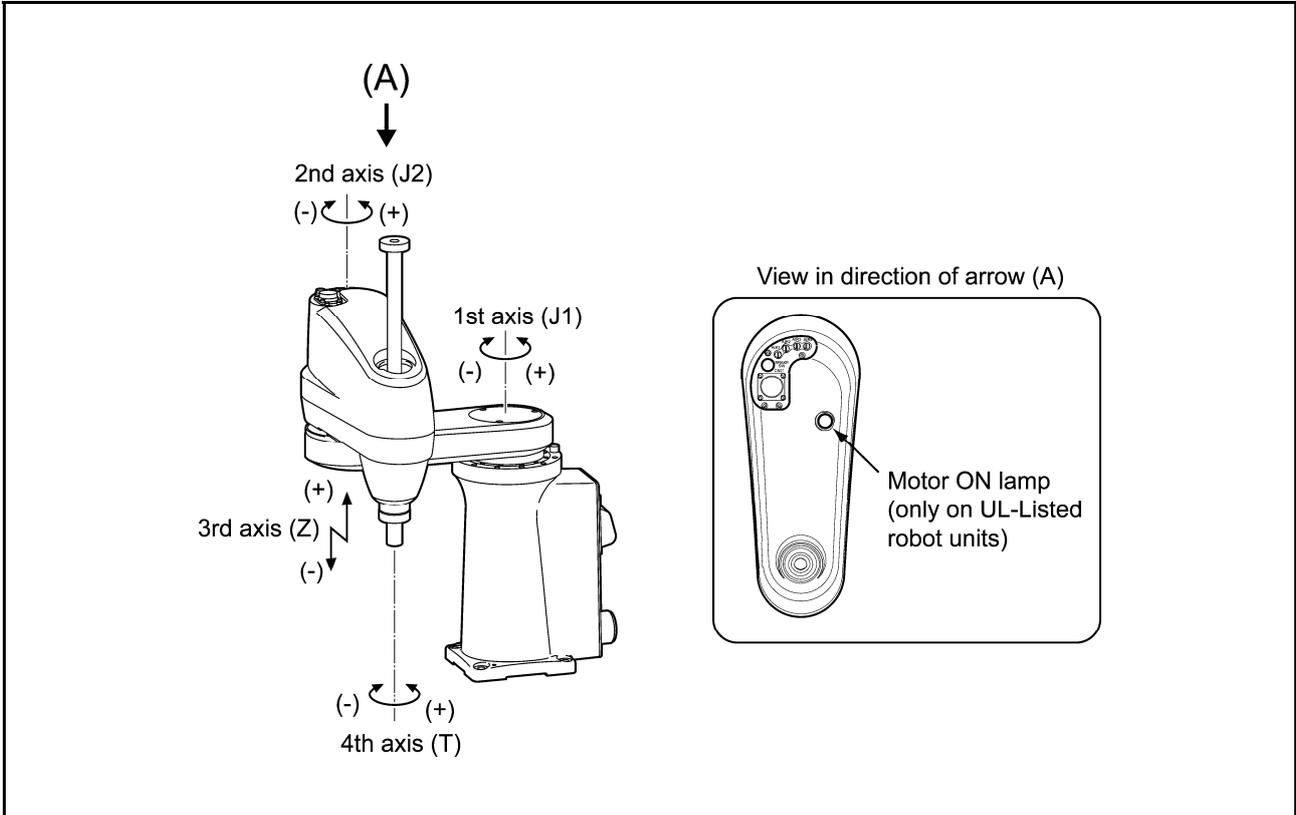
Configurators of the Robot System (HS-G series)

2.2 Names of Robot Unit Components

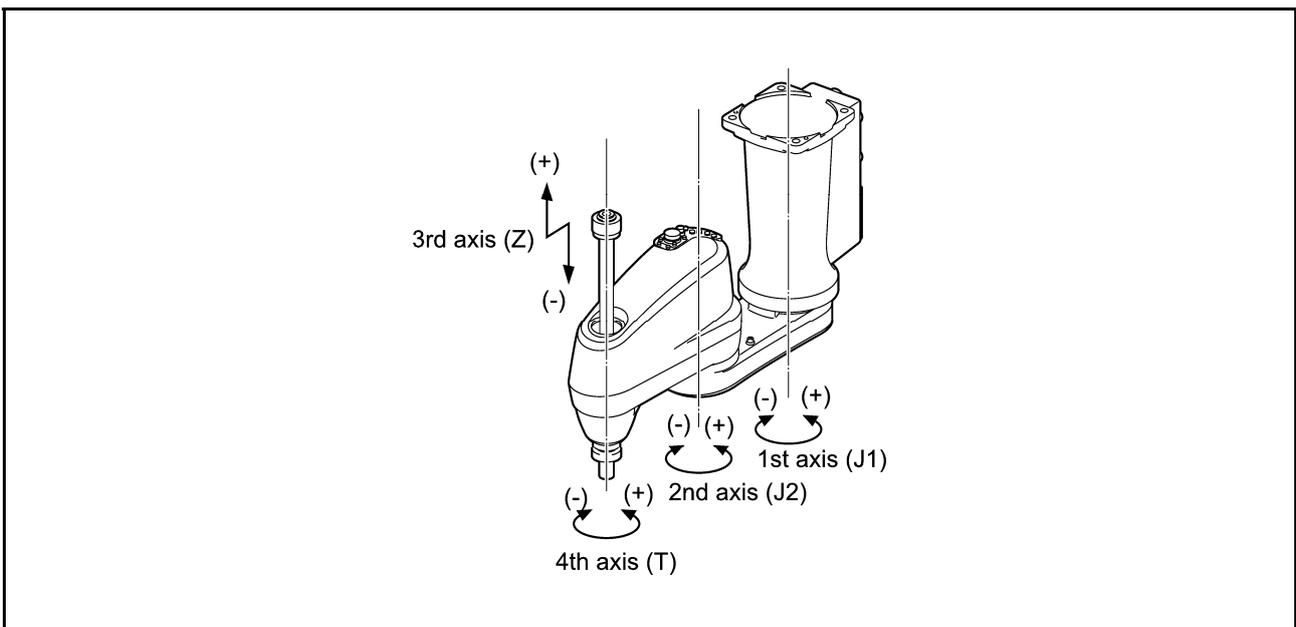
2.2.1 Robot Unit Components and Rotation Direction

The figure below shows the names of the components of the robot unit and the rotation direction of each axis.

Note: The UL-Listed robot unit has the motor ON lamp on the 2nd arm.



Robot Unit Components and Rotation Direction (HS-G series)



Robot Unit Components and Rotation Direction (HSS-G series)

2.2.2 Name Plate

The name plate is affixed in the base part, which includes serial number of the robot, robot model, and day of manufacturer, etc.

The serial number is the figure which identifies the robot of each customer and it is paired with the figure of the controller.

2.2.3 Warning and Caution Labels

The robot unit has warning and caution labels pasted as shown below. They alert the user to the dangers of the areas on which they are pasted. Be sure to observe the instructions printed on those labels.

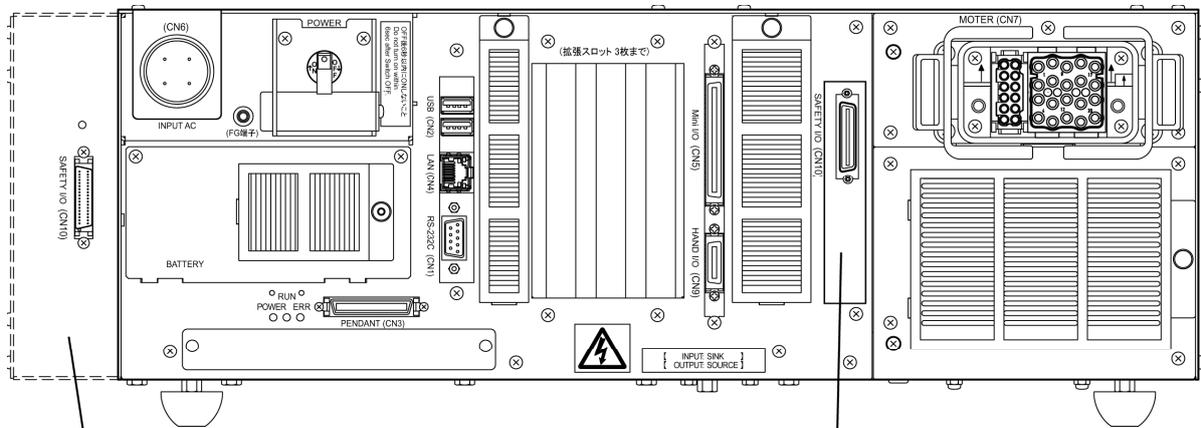
Warning and Caution Labels on the Robot Unit

Location of labels	
<p>Label 2 Brake release switch</p> <p>Label 1 Only on UL-Listed robot units Motor ON lamp (Lights when the motor power is ON)</p> <p>Label 3</p> <p>Label 4</p> <p>Name plate</p>	
Warning and caution labels on the robot unit	Additional description
<p>Label 1</p>	<p>Contact with the robot unit which is in motion can cause serious injuries. Observe the following:</p> <ol style="list-style-type: none"> (1) Never enter the robot's restricted space when the robot is in motion or the motor power is on. (2) When you need to enter the robot's restricted space for recovery from robot failures, be sure to cut the power to the robot motors by activating an emergency stop device or the like.
<p>Label 2 (on UL-Listed robot units only)</p>	<p>When the controller power is on, pressing the brake release switch causes the Z axis to fall. It is DANGEROUS. Observe the following:</p> <ol style="list-style-type: none"> (1) Never press the brake release switch except in an emergency. (2) Before pressing the brake release switch, be sure to check that there is no danger of injuries or damages on equipment.
<p>Label 3</p>	<p>There is a high voltage part. This label alerts the user to the dangers of electrical shocks.</p>
<p>Label 4</p>	<p>Instructions on how to hold the robot unit for transport.</p>

2.3 Names of the Robot Controller Components

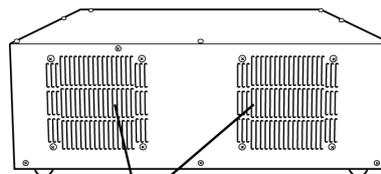
The figure below shows the names of the robot controller components.

Note: For warning and caution labels pasted on the controller, refer to the RC7M CONTROLLER MANUAL.

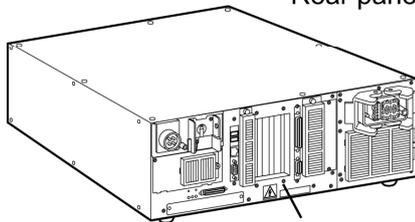


SAFETY BOX
(Only for global type with safety box)

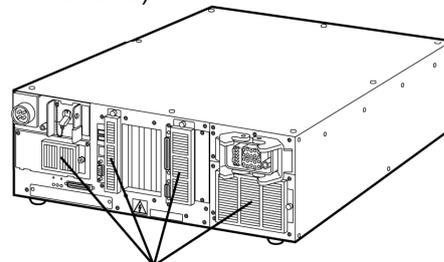
SAFETY BOARD
(Only for global type with safety board)



Rear panel (Air exhaust side)



Front panel



Air intake filters

Connectors for the HS-G series (Encoders connected via bus)

Connector No.	Marking	Name
CN1	RS-232C	Serial interface connector
CN2	USB	USB connector (2 lines)
CN3	PENDANT	Teach pendant connector
CN4	LAN	Ethernet connector
CN5	Mini I/O	I/O connector
CN6	INPUT AC	Power supply connector
CN7	MOTOR	Motor/encoder connector
CN9	HAND I/O	HAND I/O connector
CN10	SAFETY I/O	SAFETY I/O connector (Only for global type)

Names of Robot Controller Components

Chapter 3 Specifications of the Robot Unit

3.1 Robot Specifications (HS/HSS-G)

The table below lists the specifications of the HS-/HSS-G series of robot units.

(1) HS-G Series (Floor-mount type)

Item		Specifications		
Model name of robot system (Note 1)		HS-4535*G (Standard) HS-4535*G-W (Dust- & splash-proof) HS-4535*G-P (Cleanroom) HS-4535*G-UL (UL-Listed)	HS-4545*G (Standard) HS-4545*G-W (Dust- & splash-proof) HS-4545*G-P (Cleanroom) HS-4545*G-UL (UL-Listed)	HS-4555*G (Standard) HS-4555*G-W (Dust- & splash-proof) HS-4555*G-P (Cleanroom) HS-4555*G-UL (UL-Listed)
Model name of robot unit		HS-4535*E/GM (Standard) HS-4535*E/GM-W (Dust- & splash-proof) HS-4535*E/GM-P (Cleanroom) HS-4535*GM-UL (UL-Listed)	HS-4545*E/GM (Standard) HS-4545*E/GM-W (Dust- & splash-proof) HS-4545*E/GM-P (Cleanroom) HS-4545*GM-UL (UL-Listed)	HS-4555*E/GM (Standard) HS-4555*E/GM-W (Dust- & splash-proof) HS-4555*E/GM-P (Cleanroom) HS-4555*GM-UL (UL-Listed)
Overall arm length		125 (J1: 1st axis) + 225 (J2: 2nd axis) = 350 mm	225 (J1: 1st axis) + 225 (J2: 2nd axis) = 450 mm	325 (J1: 1st axis) + 225 (J2: 2nd axis) = 550 mm
Motion angle and stroke		J1 (1st axis): $\pm 155^\circ$, Z (3rd axis): 200 mm if * = 2, 320 mm if * = 3, J2 (2nd axis): $\pm 145^\circ$, T (4th axis): $\pm 360^\circ$		
Axis combination		J1 (1st axis) + J2 (2nd axis) + Z (3rd axis) + T (4th axis)		
Maximum payload		5 kg		
Composite speed	At the center of the hand mounting flange	7,200 mm/s	6,300 mm/s	7,100 mm/s
	Z and T	Z (3rd axis): 2,000 mm/s, T (4th axis): 2400°/s		
Position repeatability (Note 2)	J1 + J2	± 0.015 mm	± 0.02 mm	± 0.02 mm
	Z	± 0.01 mm		
	T	$\pm 0.005^\circ$		
Maximum force-fit		98N (one second or less)		
Maximum allowable moment of inertia around T axis		0.1 kgm ² (with 5 kg payload)		
Position detection		Absolute encoder		
Drive motor and brake		AC servomotors for all axes Brakes for Z axis (3rd axis) and T axis (4th axis)		
Brake releasing	Models except UL-Listed ones	(1) Press the brake release switch in the direct teaching mode. (2) Enter a brake release command with the teach pendant or mini-pendant.		
	UL-Listed models	(1) Press the brake release switch when the controller power is ON. (2) The teach pendant or mini-pendant cannot release the brakes.		
User air piping		4 systems ($\phi 4 \times 2$, $\phi 6 \times 2$)		
User signal lines		19 (for proximity sensor signals, etc.)		
Air source	Operating pressure	0.05 to 0.35 MPa		
	Max. allowable pressure	0.59 MPa		
Degree of protection for dust- & splash-proof type		IP65		

(Continued on the following page)

(Note 1) The model name of robot set refers to the model of a complete set including a robot unit and robot controller. An asterisk (*) in model names denotes the Z-axis stroke.

(Note 2) Value at the constant ambient temperature.

Item	Specifications
Clean class for cleanroom type (FED-STD-209D)	Class 10 (0.1 μ) at point-of-use
Airborne noise (A-weighted equivalent continuous sound pressure level)	80 dB or less
Weight	Approx. 25 kg (55 lbs) (See the name plate on each model.)

(2) HSS-G Series Robot Unit (Overhead-mount type)

Item	Specifications
Model name of robot set (Note 1)	HSS-4545*G (Standard) HSS-4545*G-W (Dust- & splash-proof)
Model name of robot unit	HSS-4545*E/GM (Standard) HSS-4545*E/GM-W (Dust- & splash-proof)
Overall arm length	225 (J1: 1st axis) + 225 (J2: 2nd axis) = 450 mm
Motion angle and stroke	J1 (1st axis): ±152°, J2 (2nd axis): ±141°, Z (3rd axis): 150 mm if * = 1, 200 mm if * = 2, 320 mm if * = 3, T (4th axis): ±360°
Axis combination	J1 (1st axis) + J2 (2nd axis) + Z (3rd axis) + T (4th axis)
Maximum payload	5 kg
Composite speed	At the center of the hand mounting flange
	Z and T
Position repeatability (Note 2)	J1 + J2
	Z
	T
Maximum force-fit	98N (one second or less)
Maximum allowable moment of inertia around T axis	0.1 kgm ² (with 5 kg payload)
Position detection	Absolute encoder
Drive motor and brake	AC servomotors for all axes Brakes for Z axis (3rd axis) and T axis (4th axis)
Brake releasing	Models except UL-Listed ones
User air piping	4 systems (φ4x2, φ6x2)
User signal lines	19 (for proximity sensor signals, etc.)
Air source	Operating pressure
	Maximum allowable pressure
Degree of protection for dust- & splash-proof type	IP65
Airborne noise (A-weighted equivalent continuous sound pressure level)	80 dB or less
Weight	Approx. 25 kg (55 lbs) (See the name plate on each model.)

Note: Overhead-mount type robots cannot be installed on the floor to work facing upward.

(Note 1) The model name of robot set refers to the model of a complete set including a robot unit and robot controller. An asterisk (*) in model names denotes the Z-axis stroke.

(Note 2) Value at the constant ambient temperature.

3.2 Outer Dimensions and Workable Space of the Robot Unit (HS/HSS-G)

The outer dimensions and workable space of the HS/HSS-G series are shown on the following pages.

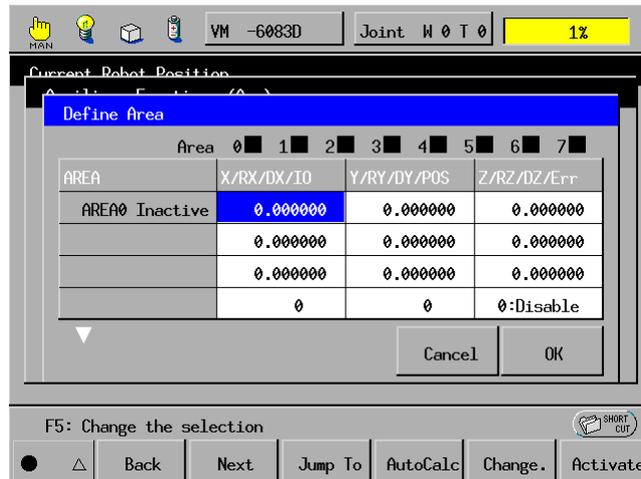
NOTE: The overhead-mount type of robots is designed with a preset motion-prohibited area where the robot cannot work.

The motion-prohibited area of the overhead-mount type is set to AREA7 that is specified in the defined interference check area setting. Therefore, you may define only up to 31 interference check areas excluding AREA7 for the overhead-mount type while you may usually define up to 32 (AREA0 through AREA31).

Refer to the SETTING-UP MANUAL, Chapter 4, Section 4.1.2, "[5] Making the defined interference check areas active or inactive."

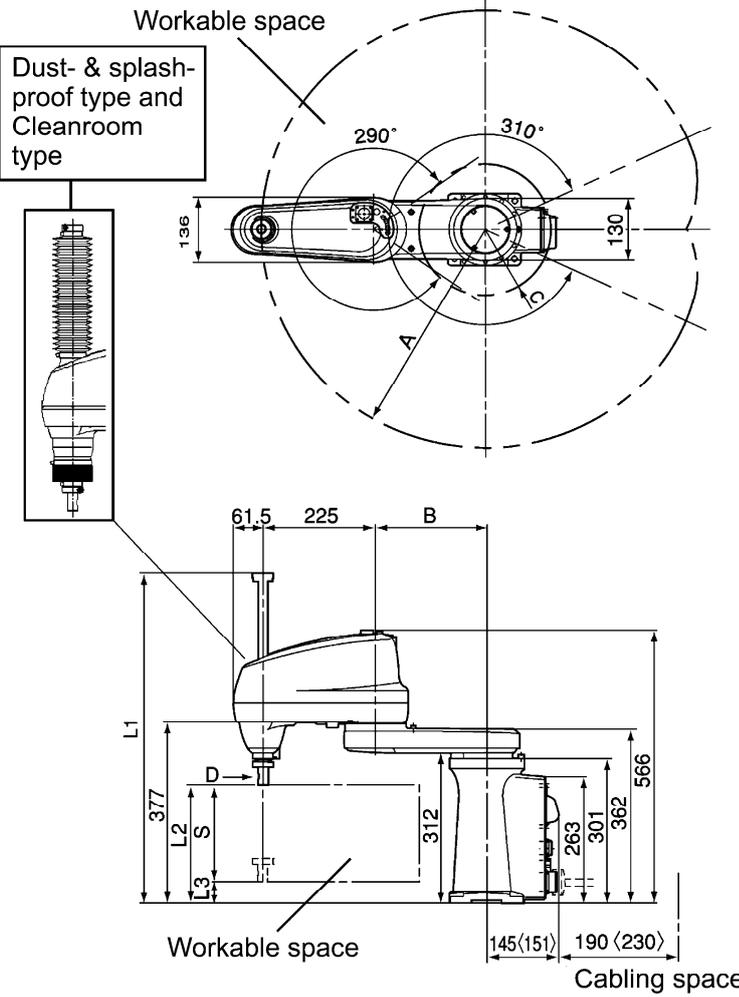
Operating procedure with the teach pendant

Access: [F2 Arm]—[F6 Aux.]—[F6 Area.]

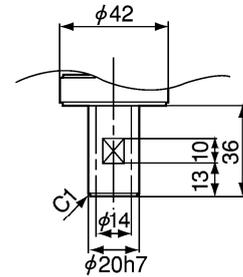


(1) Outer dimensions and workable space (HS-G series; Floor-mount)

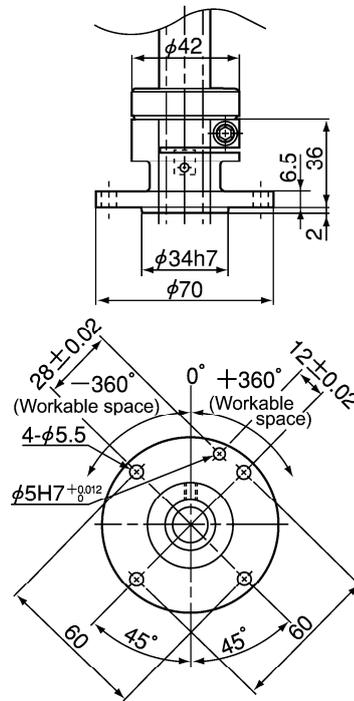
<HS-G>



Detailed drawing of hand mounting face (Viewed from D)

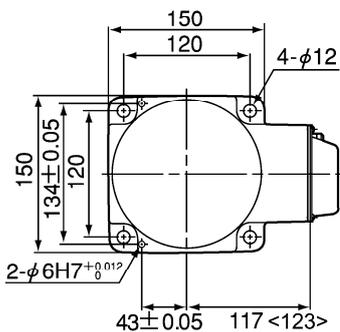


Flange (option) mounting face



Unit: mm

Base mounting dimensions



Model	A	B	C
HS-4535*G	350	125	143
HS-4545*G	450	225	136
HS-4555*G	550	325	191

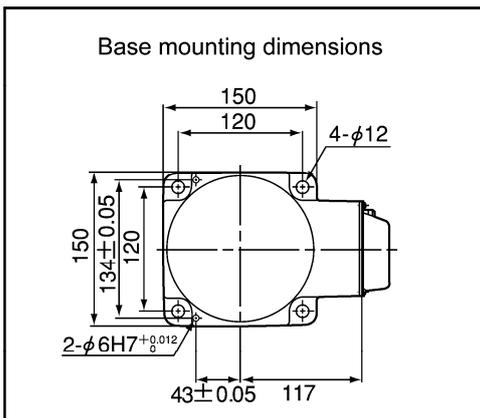
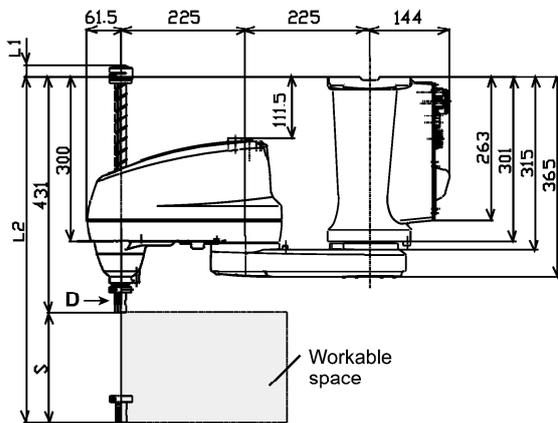
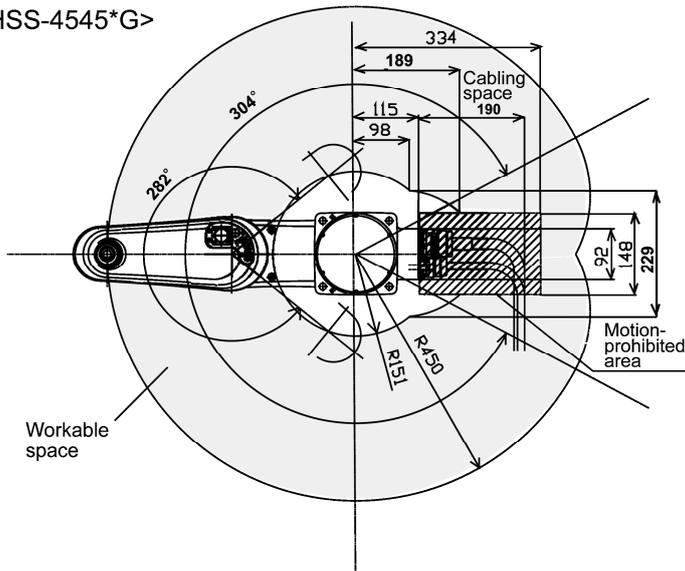
Note: Values enclosed in < > denote dimensions for the dust- & splash-proof type or cleanroom type.

S(mm)	Type	L1	L2	L3
*=2:200	Standard	697	246	46
	Dust- & splash-proof	790	206	6
	Cleanroom	798		
=3:320	Standard	817	246	-74 ¹
	Dust- & splash-proof	910	206	-114* ¹
	Cleanroom	918		

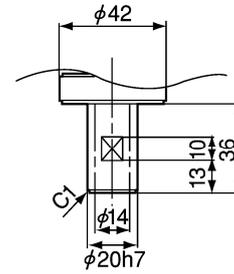
*¹ If the Z-axis stroke is 320mm, the Z axis in the lowermost position may reach below the base mounting face.

(3) Outer dimensions and workable space
(HSS-4545*G; Arm length 450 mm, Overhead-mount, Standard type)

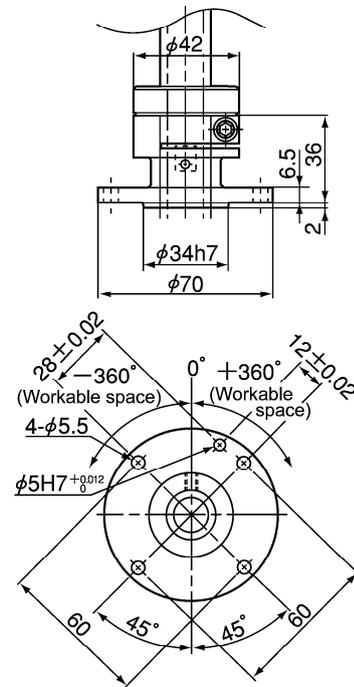
<HSS-4545*G>



Detailed drawing of hand mounting face (Viewed from D)



Flange (option) mounting face



Unit: mm

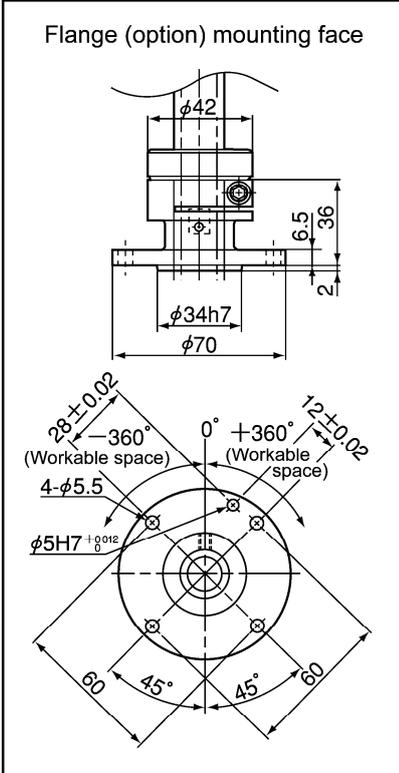
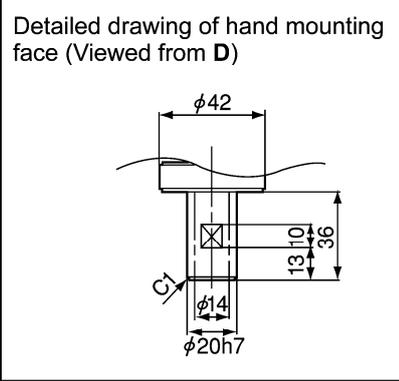
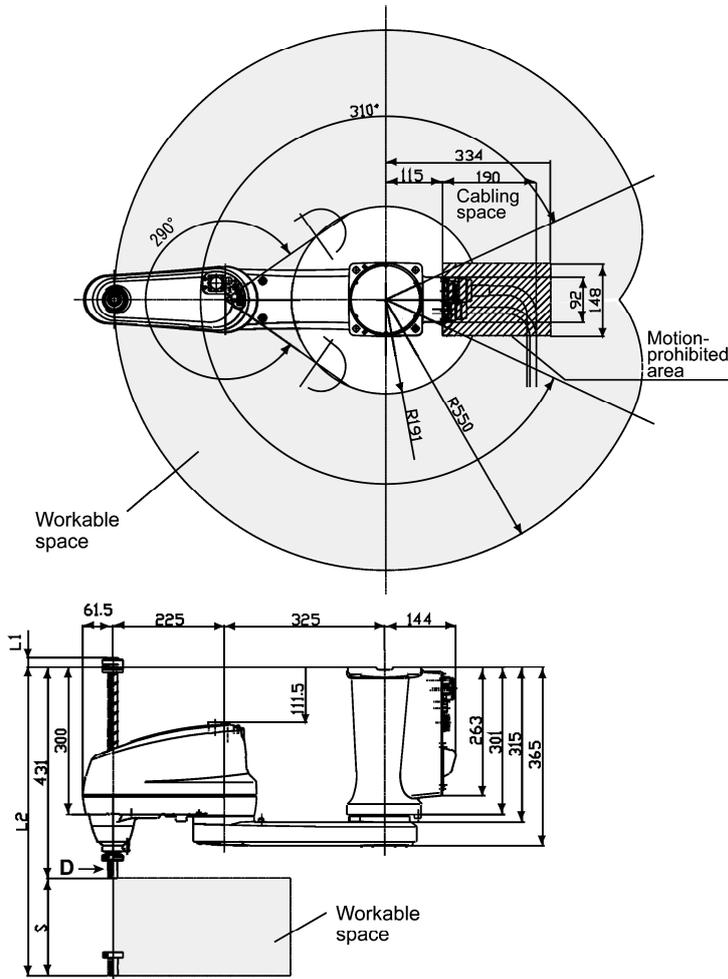
NOTE: Dimensions that differ according to Z-axis stroke (S)

Model	S	L1	L2
HSS-45451G	150	-30	581
HSS-45452G	200	20	631
HSS-45453G	320	140	751

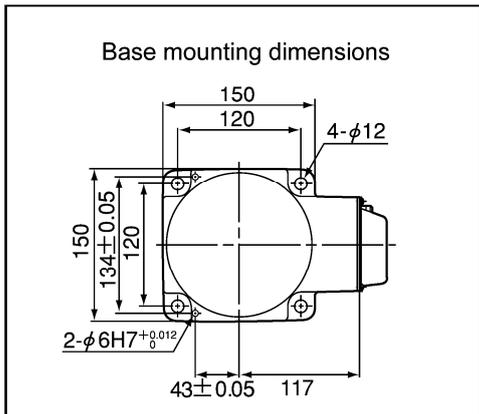
NOTE: In the case of the overhead-mount type, the Z axis in the uppermost position may reach higher than the base mounting face. Be careful with the interference with surrounding facilities.

(4) Outer dimensions and workable space
(HSS-4555*G; Arm length 550 mm, Overhead-mount, Standard type)

<HSS-4555*G>



Unit: mm

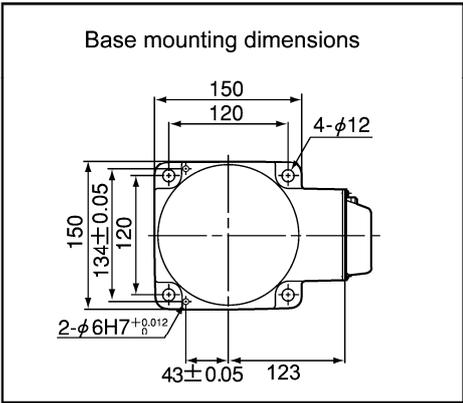
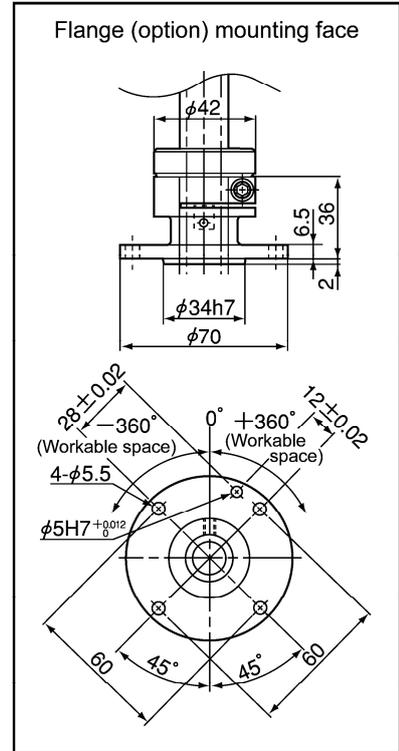
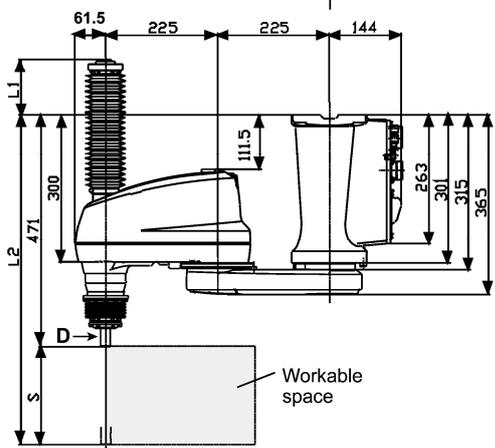
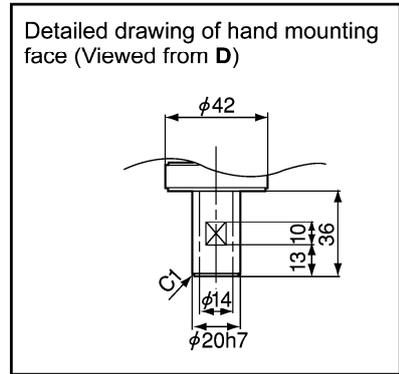
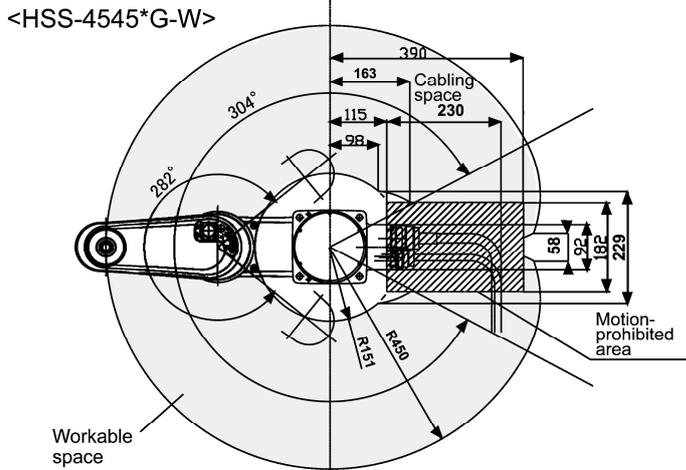


NOTE: Dimensions that differ according to Z-axis stroke (S)

Model	S	L1	L2
HSS-45551G	150	-30	581
HSS-45552G	200	20	631
HSS-45553G	320	140	751

NOTE: In the case of the overhead-mount type, the Z axis in the uppermost position may reach higher than the base mounting face. Be careful with the interference with surrounding facilities.

(5) Outer dimensions and workable space
 (HSS-4545*G-W; Arm length 450 mm, Overhead-mount, Dust- & splash-proof type)



Unit: mm

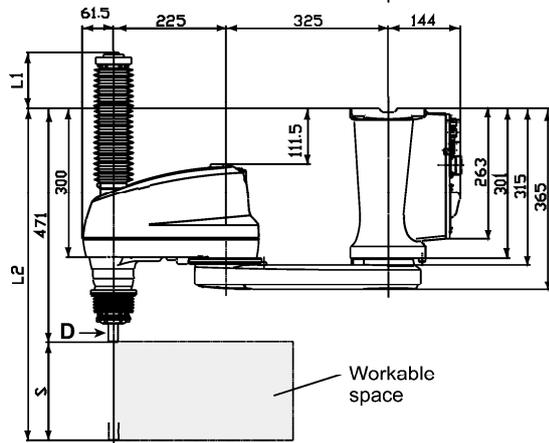
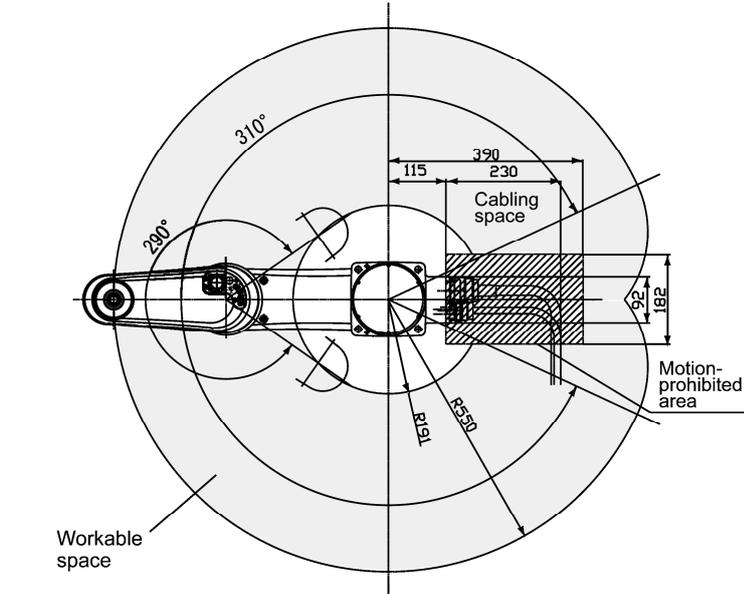
NOTE: Dimensions that differ according to Z-axis stroke (S)

Model	S	L1	L2
HSS-45451G-W	150	64	621
HSS-45452G-W	200	114	671
HSS-45453G-W	320	234	791

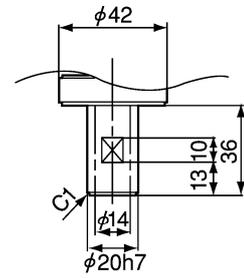
NOTE: In the case of the overhead-mount type, the Z axis in the uppermost position may reach higher than the base mounting face. Be careful with the interference with surrounding facilities.

(6) Outer dimensions and workable space
(HSS-4555*G-W; Arm length 550 mm, Overhead-mount, Dust- & splash-proof type)

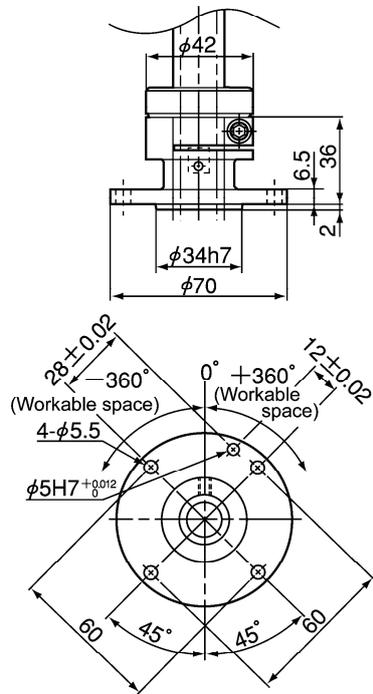
<HSS-4555*G-W>



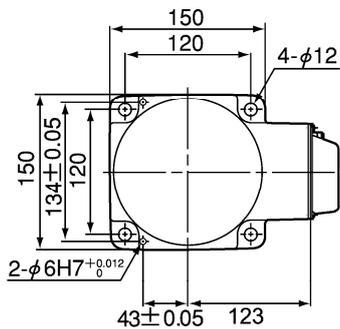
Detailed drawing of hand mounting face (Viewed from D)



Flange (option) mounting face



Base mounting dimensions



Unit: mm

NOTE: Dimensions that differ according to Z-axis stroke (S)

Model	S	L1	L2
HSS-45551G-W	150	64	621
HSS-45552G-W	200	114	671
HSS-45553G-W	320	234	791

NOTE: In the case of the overhead-mount type, the Z axis in the uppermost position may reach higher than the base mounting face. Be careful with the interference with surrounding facilities.

3.3 Robot Positioning Time (HS/HSS-G)

1. The graphs given on the following pages show the positioning times used to calculate the cycle time.
2. Positioning time refers to the time length required from the start of robot operation to the arrival at the target positioning point.
3. After the robot moves to and passes the target positioning point, vibration will be dampened and the robot will be positioned at the target positioning point as shown in the figure below. This vibration dampening time is not considered in those graphs.

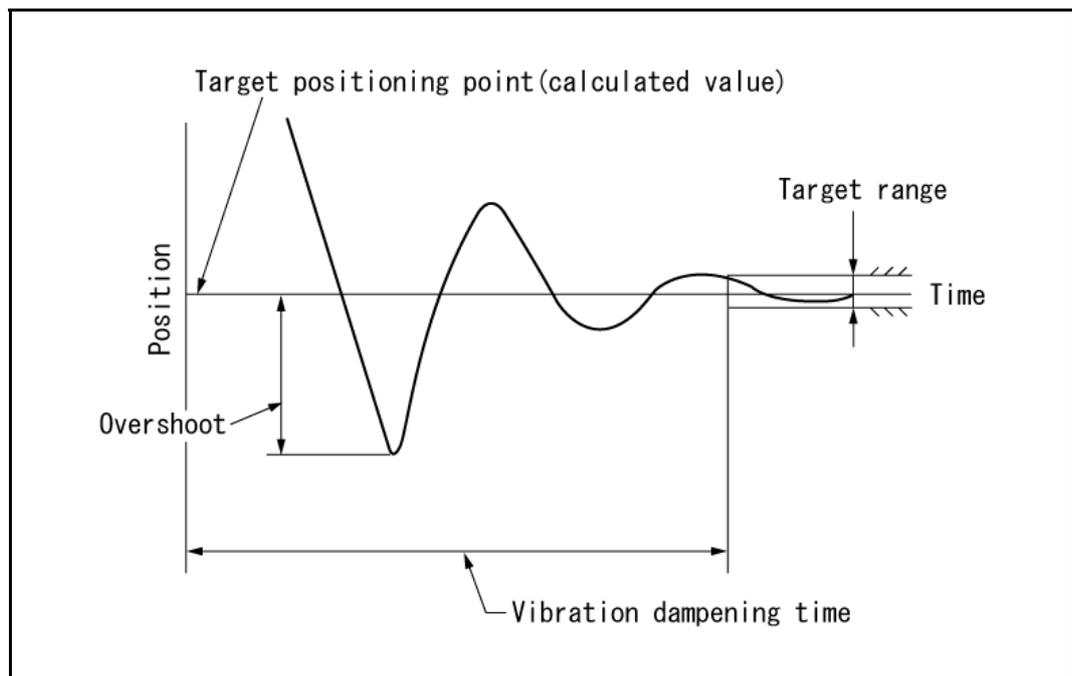
Caution (1) The vibration dampening time depends on factors such as the weight of the hand. If the robot is to be used in such a way that it overshoots or if the vibration dampening time is of great concern, then test the robot carefully beforehand.

(2) If acceleration begins before residual vibration of the robot stops, an overcurrent error (code starts from ERROR6120 where the first digit represents the axis number) may be displayed. In this case, take one of the following measures:

- Lower the deceleration of the preceding operation with a DECEL command to reduce residual vibration.
- Keep the robot in stand-by with a DELAY command until residual vibration stops.
- Lower acceleration with an ACCEL command.

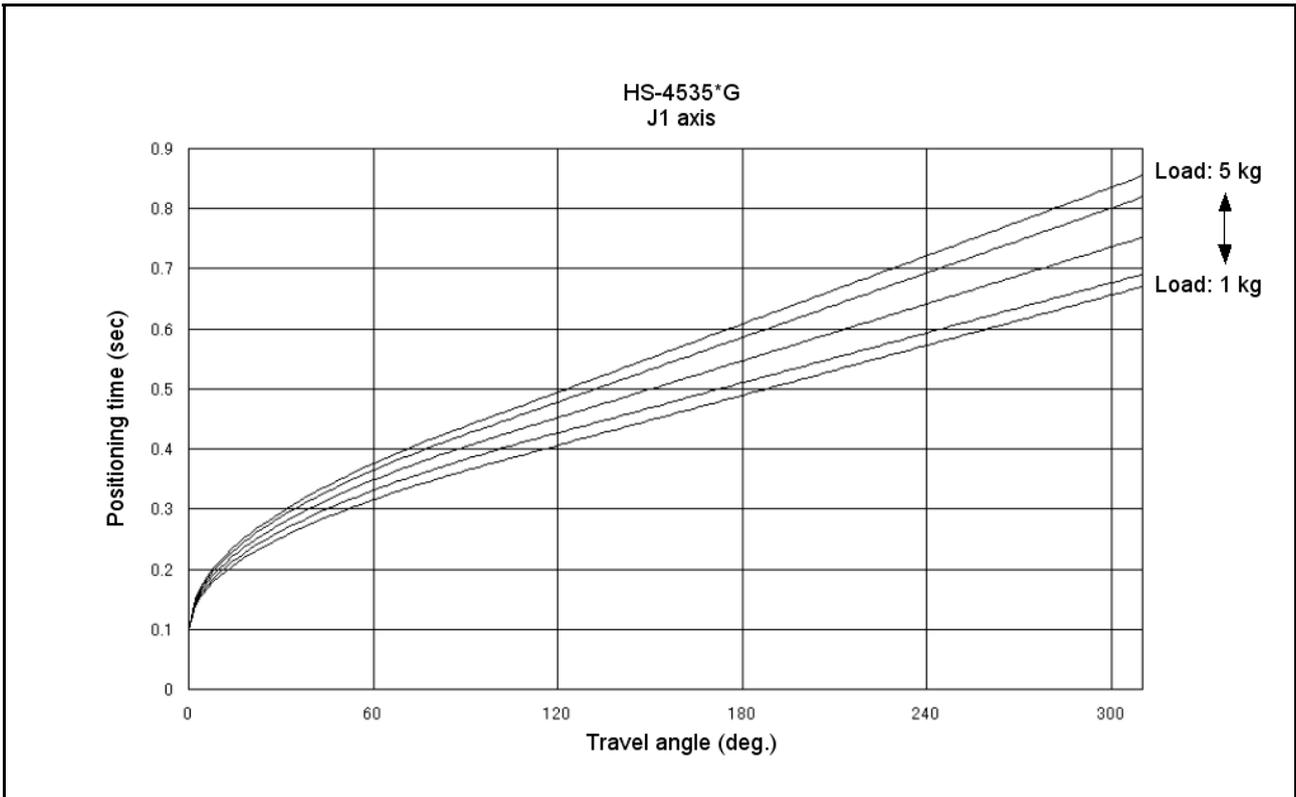
(3) Run the robot with the optimum payload setting in accordance with weight of the hand and workpiece. If not, a robot failure may result.

(4) In the positioning time graphs, the Z-axis stroke is represented near the upper end. Near the lower end, the horizontal movement time along the J1/J2 axis increases. (Refer to "Notes for setting the positioning speed .")

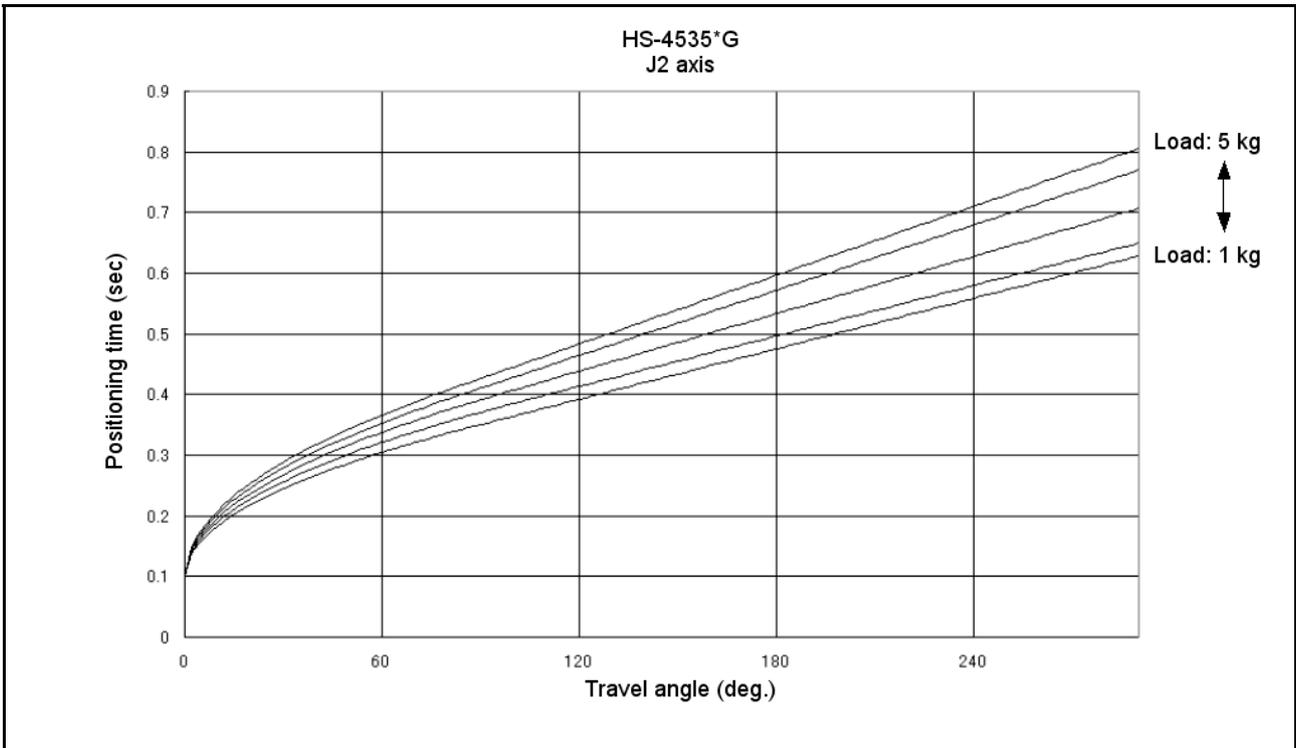


Vibration Dampening Time

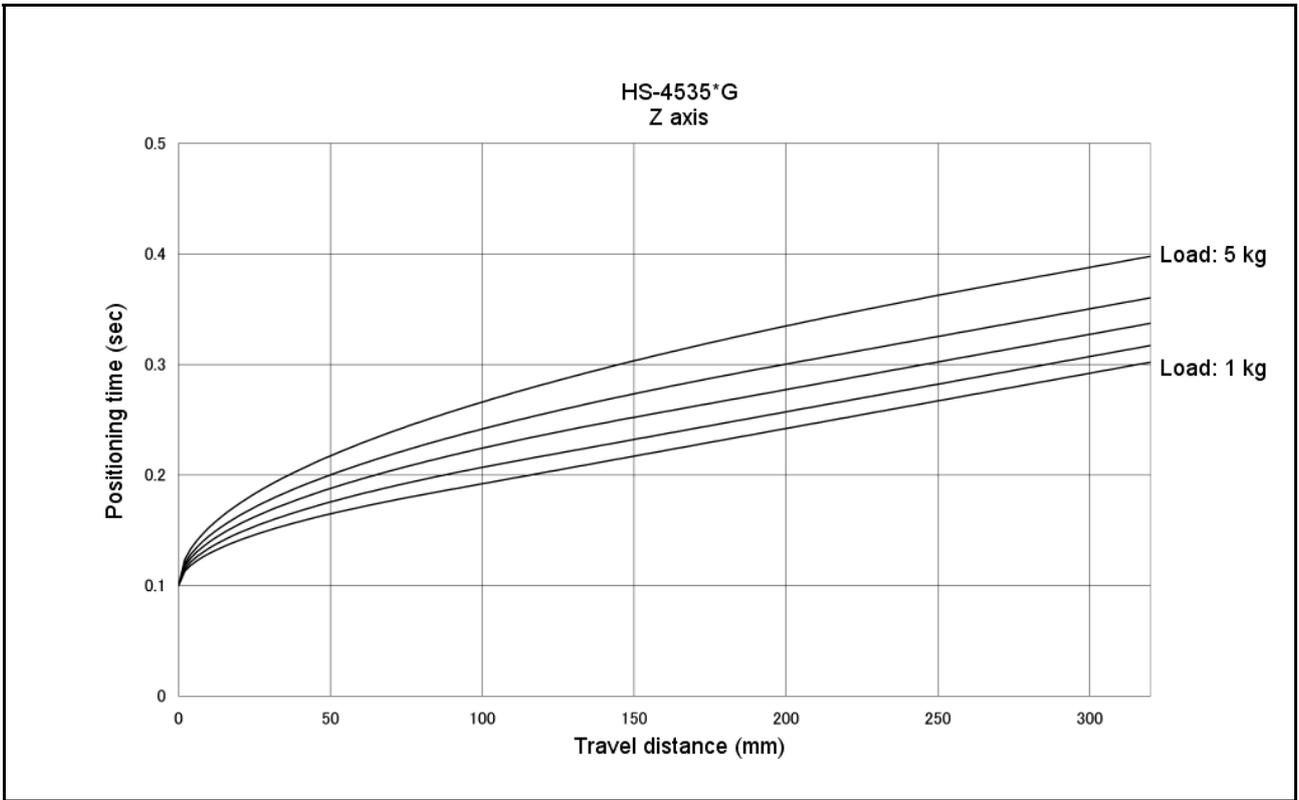
(1) HS-4535*G



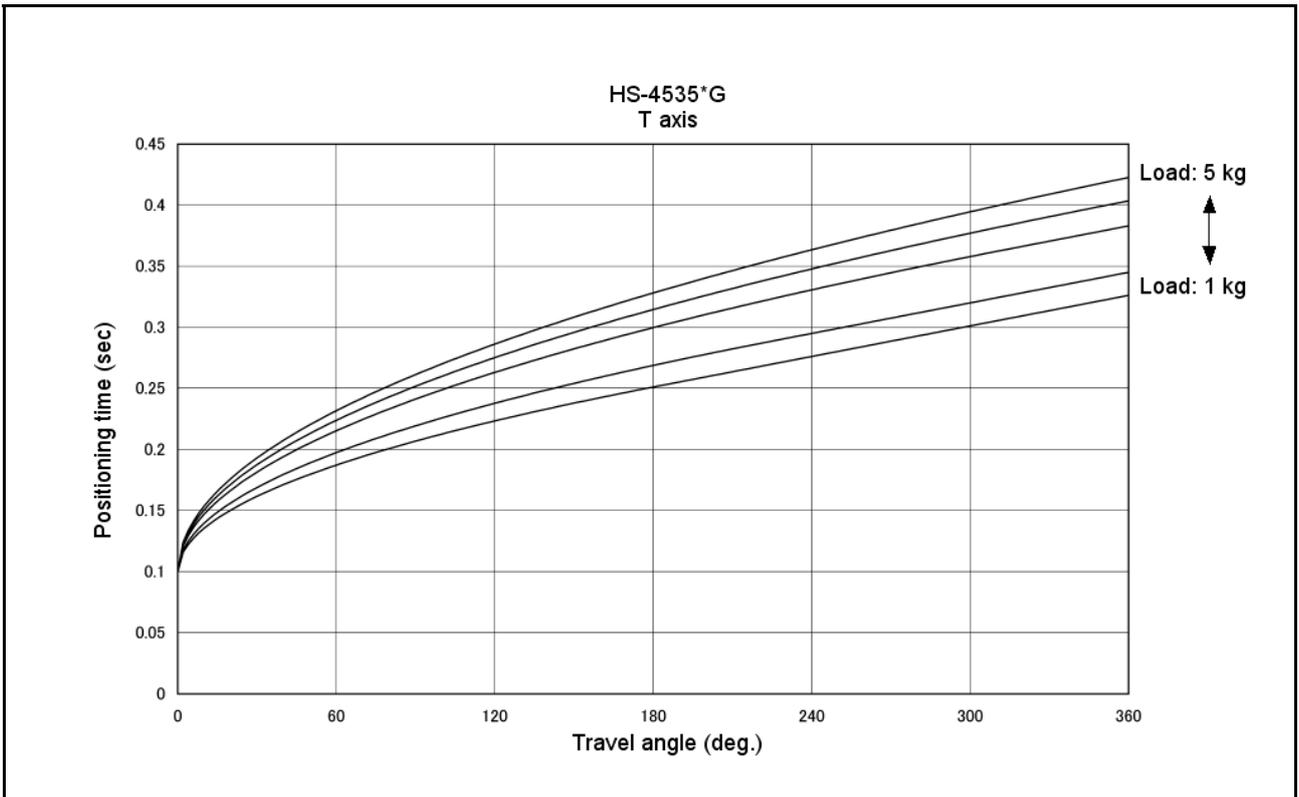
J1 axis (PTP control) on the HS-4535*G



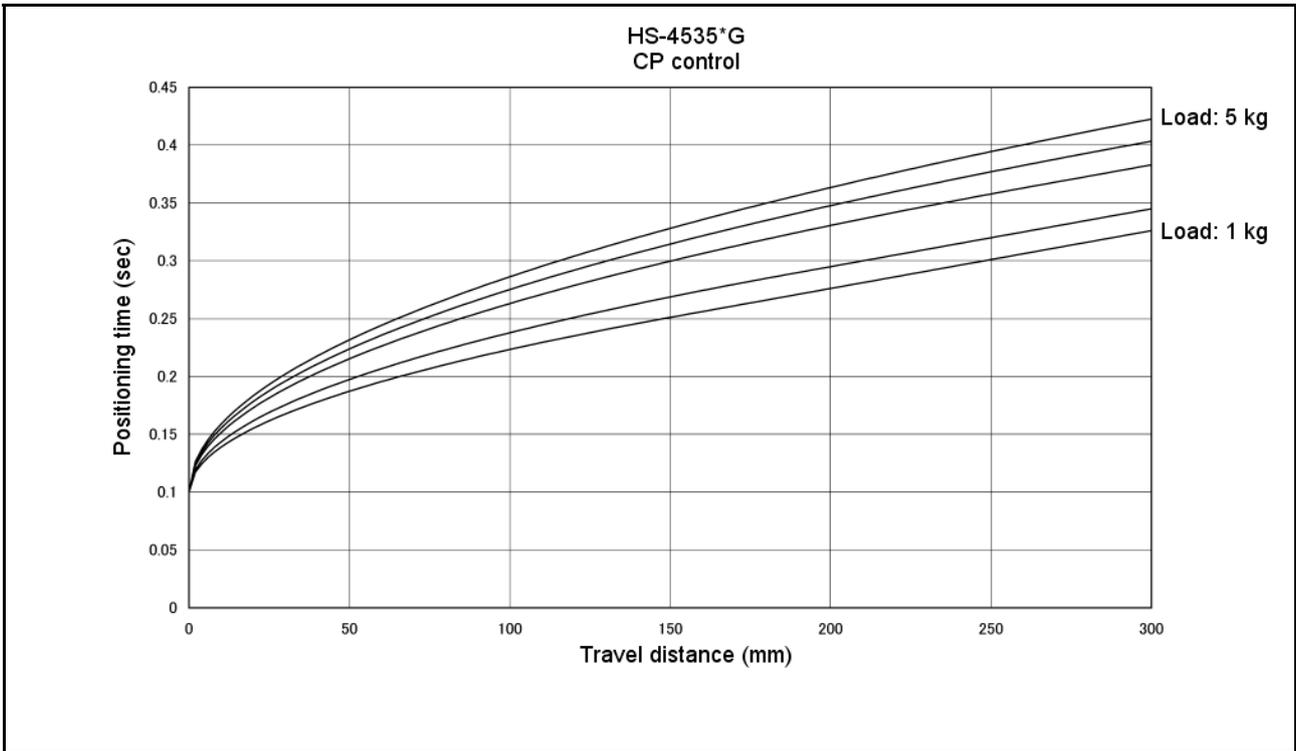
J2 axis (PTP control) on the HS-4535*G



Z axis (PTP control) on the HS-4535*G

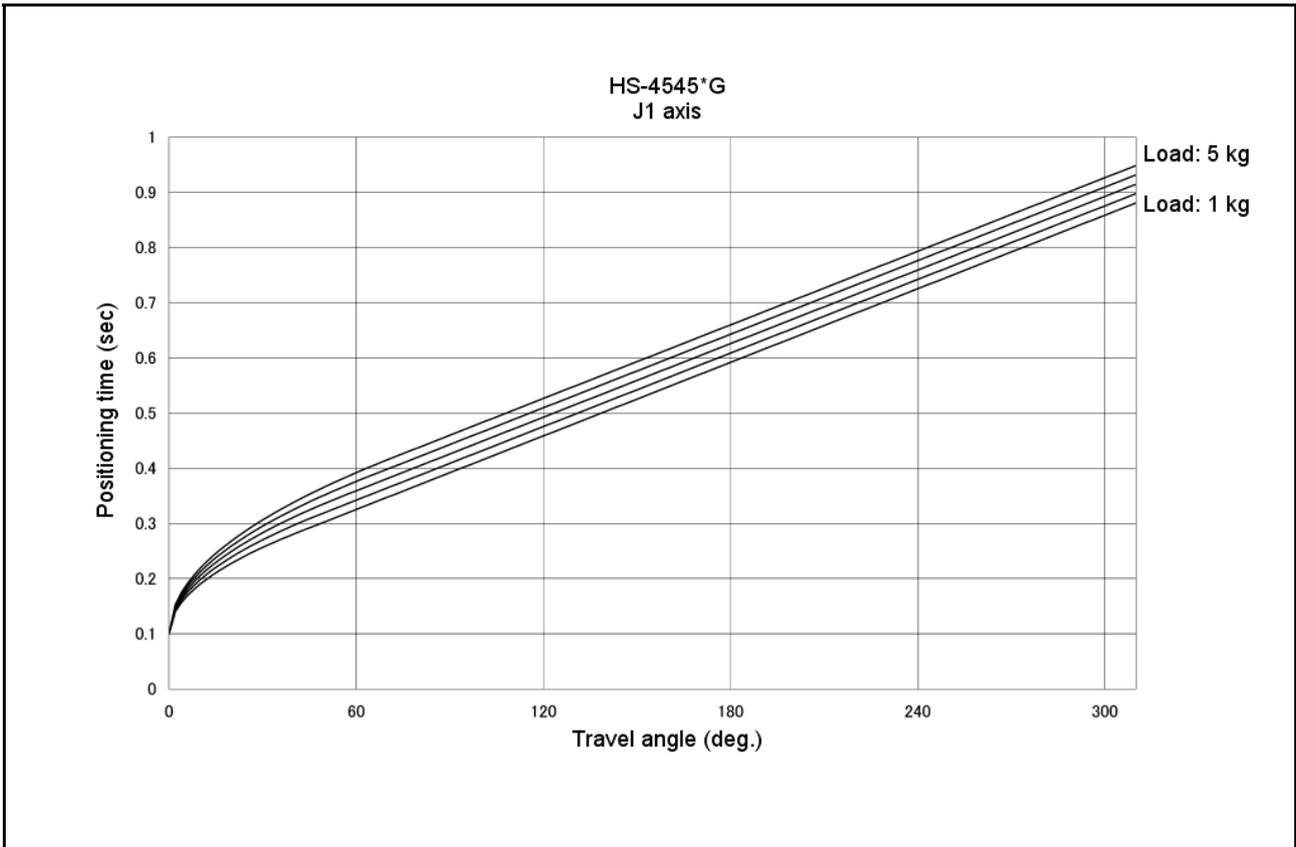


T axis (PTP control) on the HS-4535*G

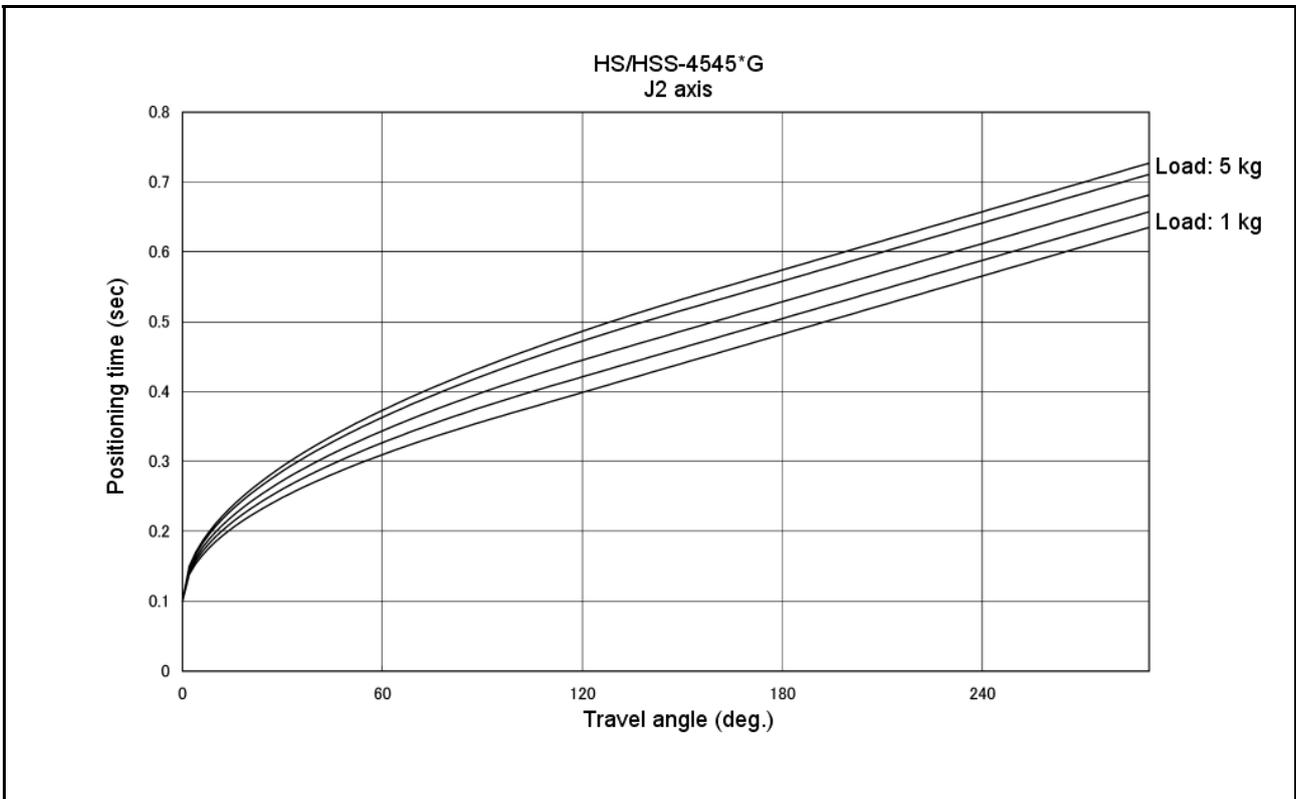


All axes (CP control) on the HS-4535*G

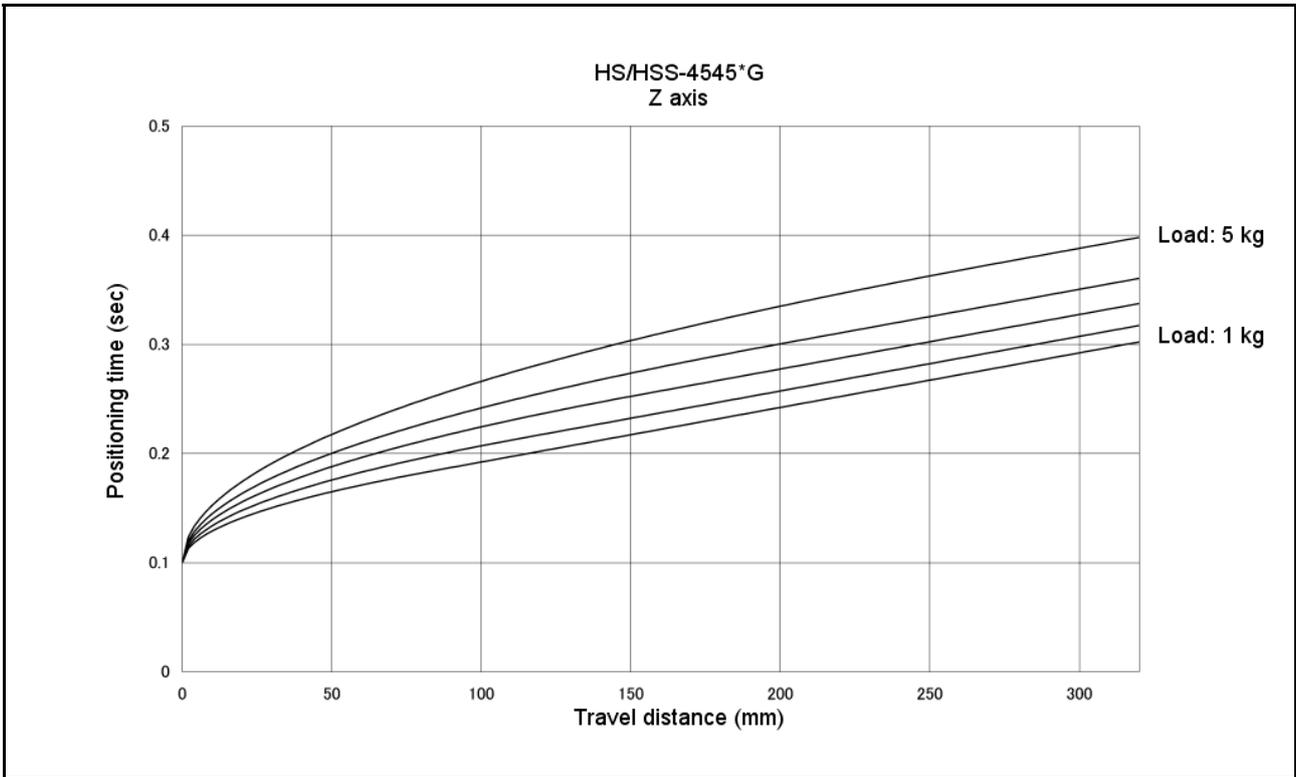
(2) HS/HSS-4545*G



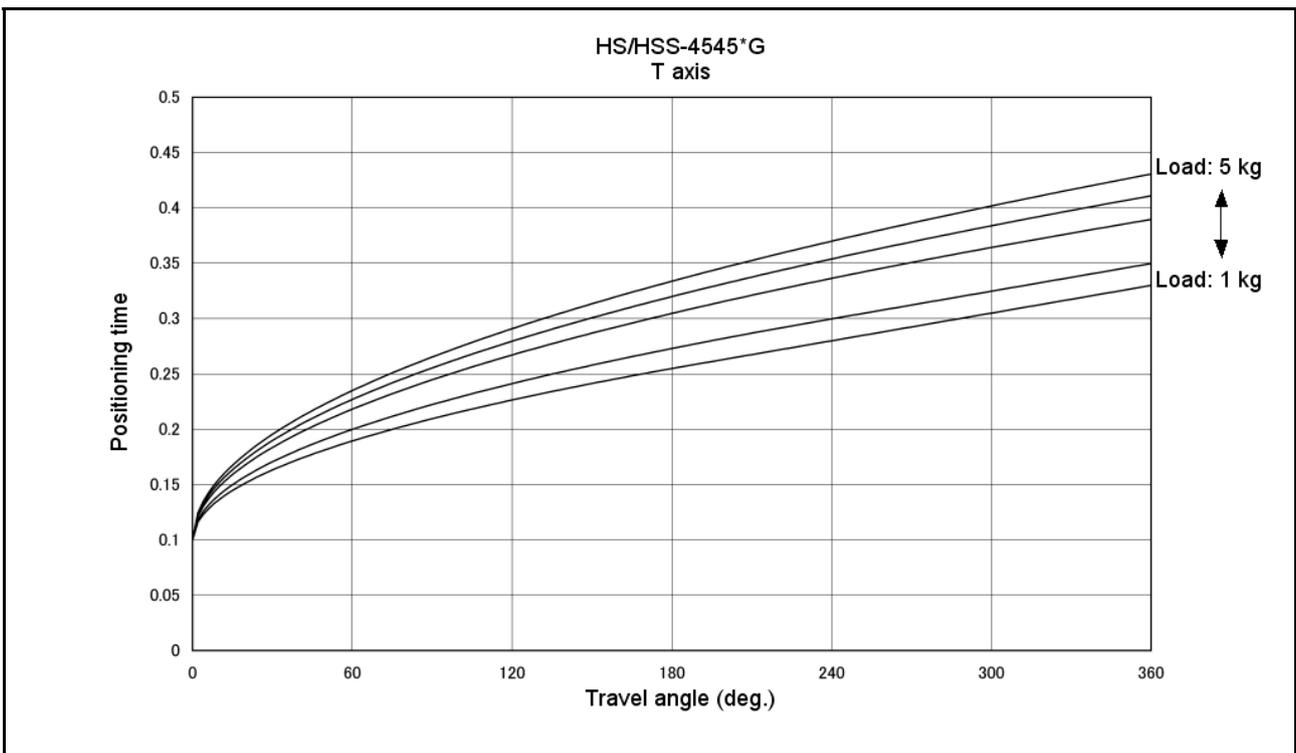
J1 axis (PTP control) on the HS/HSS-4545*G



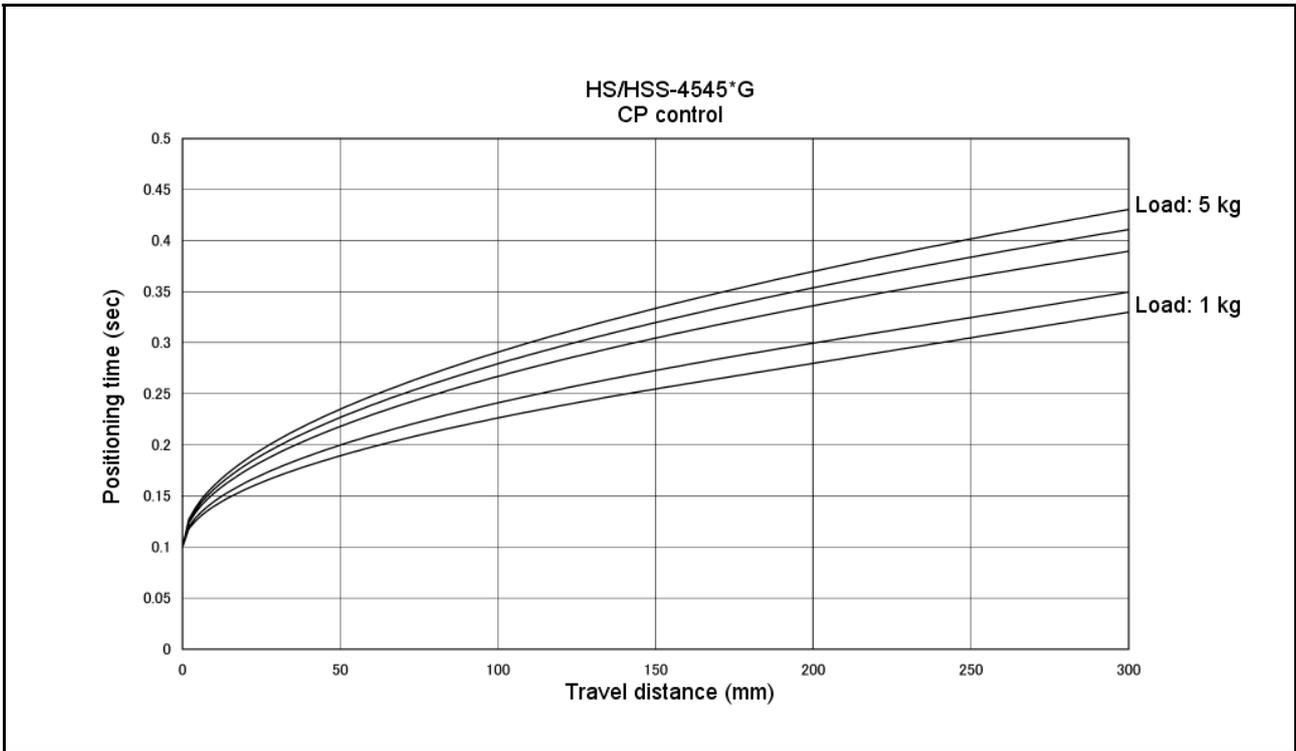
J2 axis (PTP control) on the HS/HSS-4545*G



Z axis (PTP control) on the HS/HSS-4545*G

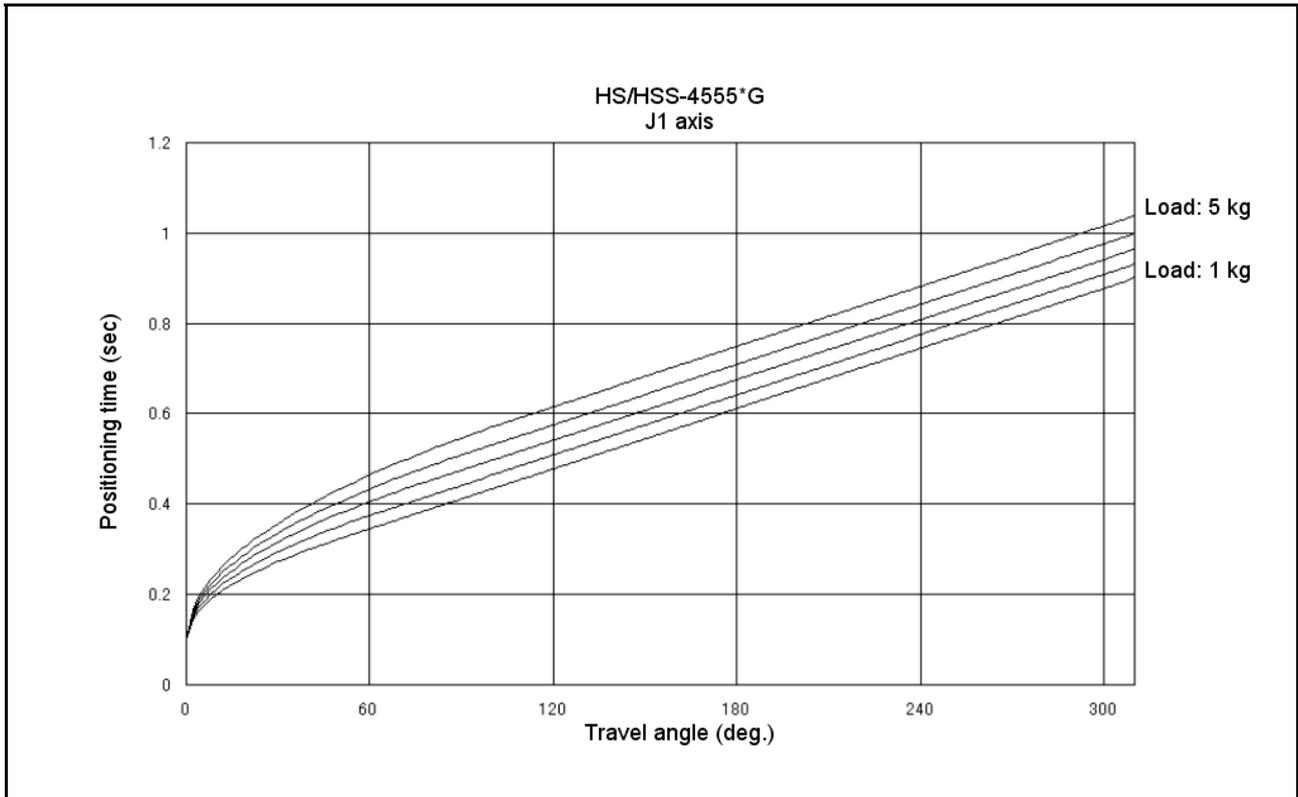


T axis (PTP control) on the HS/HSS-4545*G

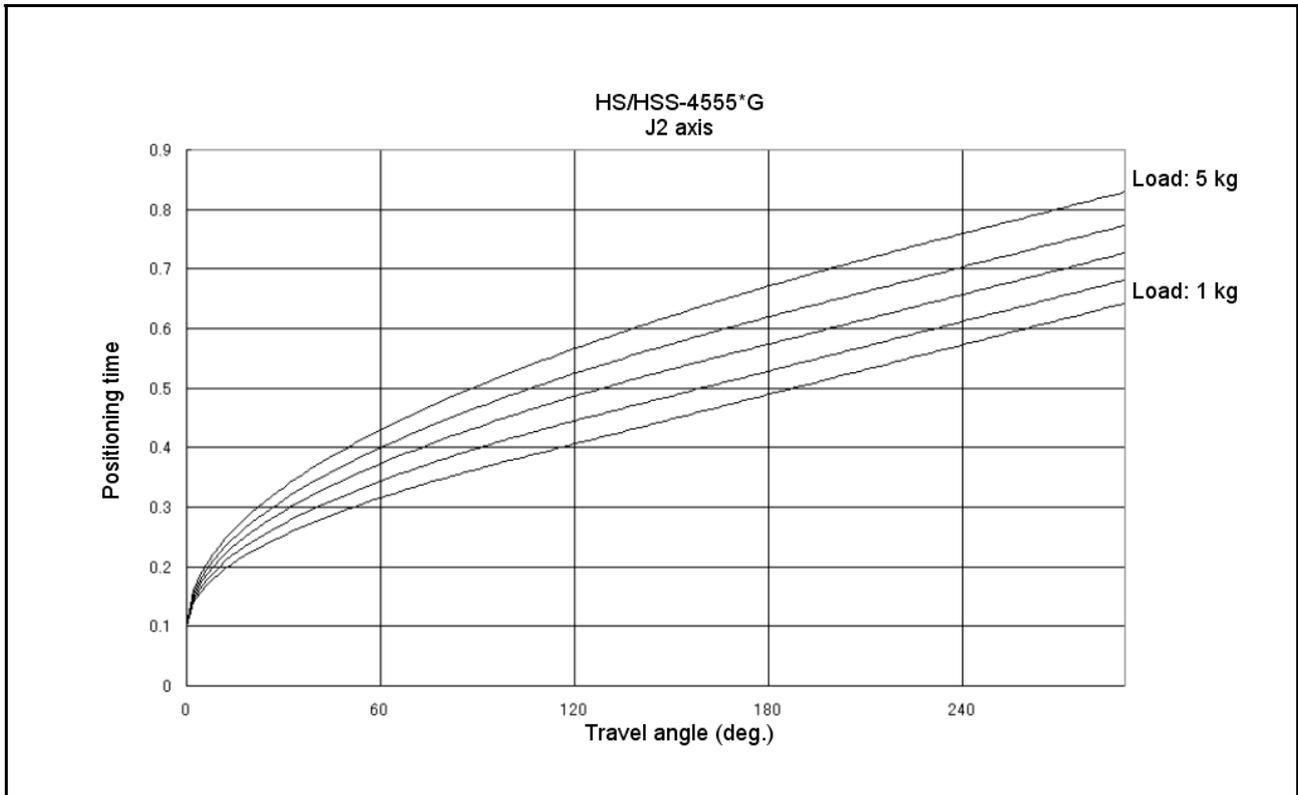


All axes (CP control) on the HS/HSS-4545*G

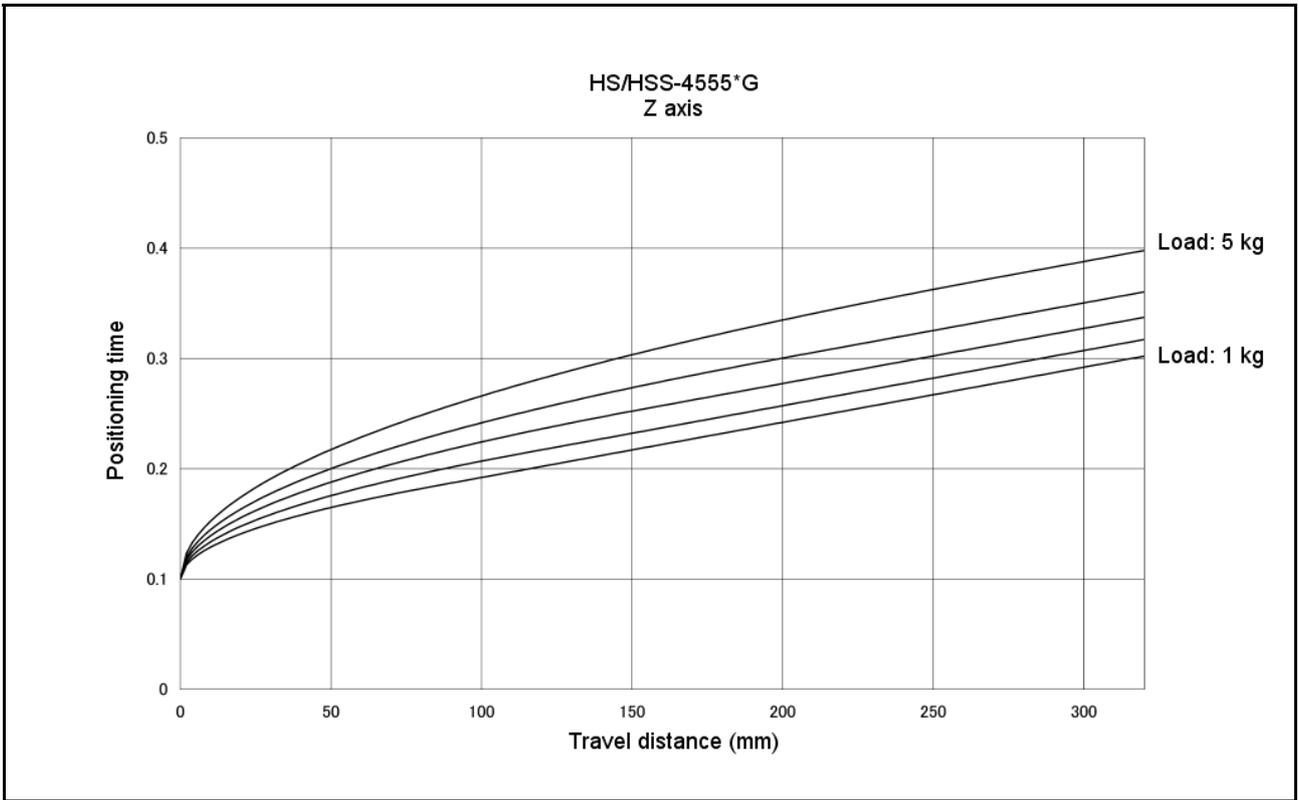
(3) HS/HSS-4555*G



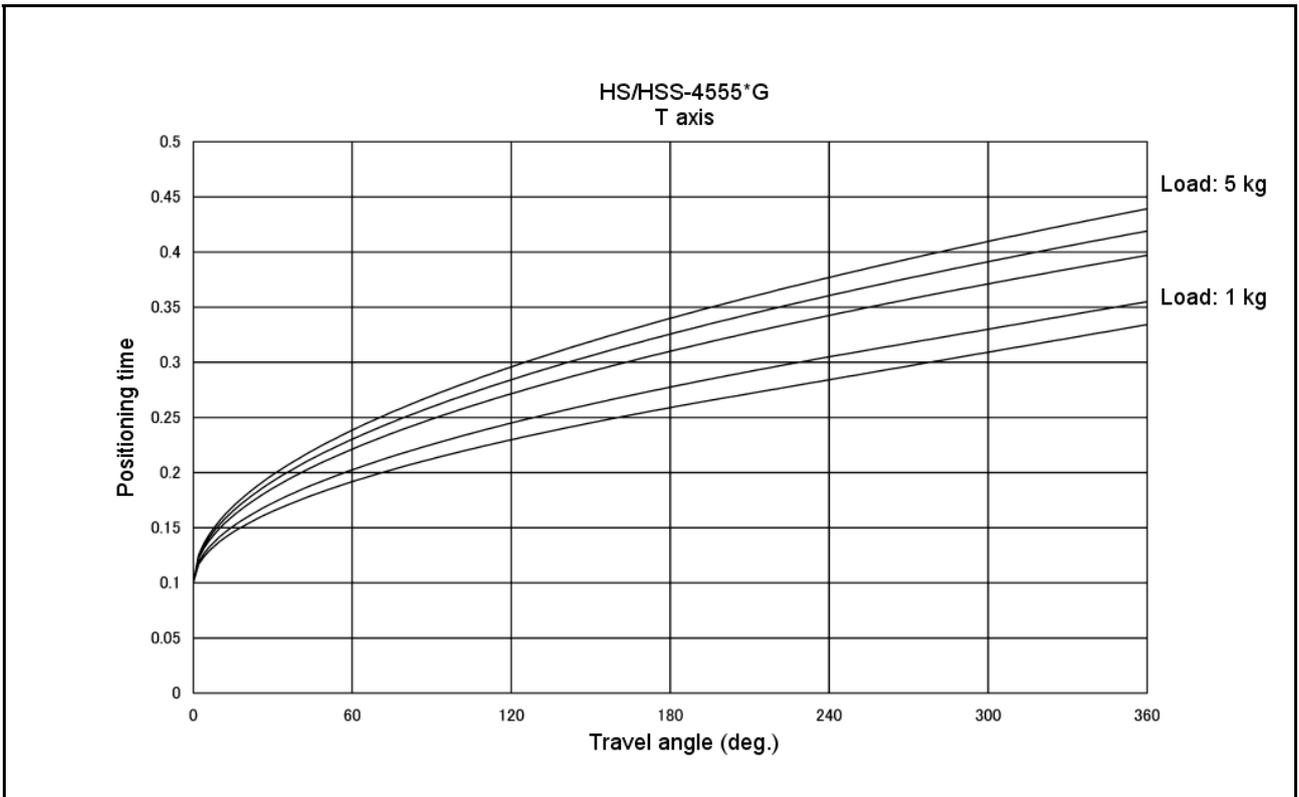
J1 axis (PTP control) on the HS/HSS-4555*G



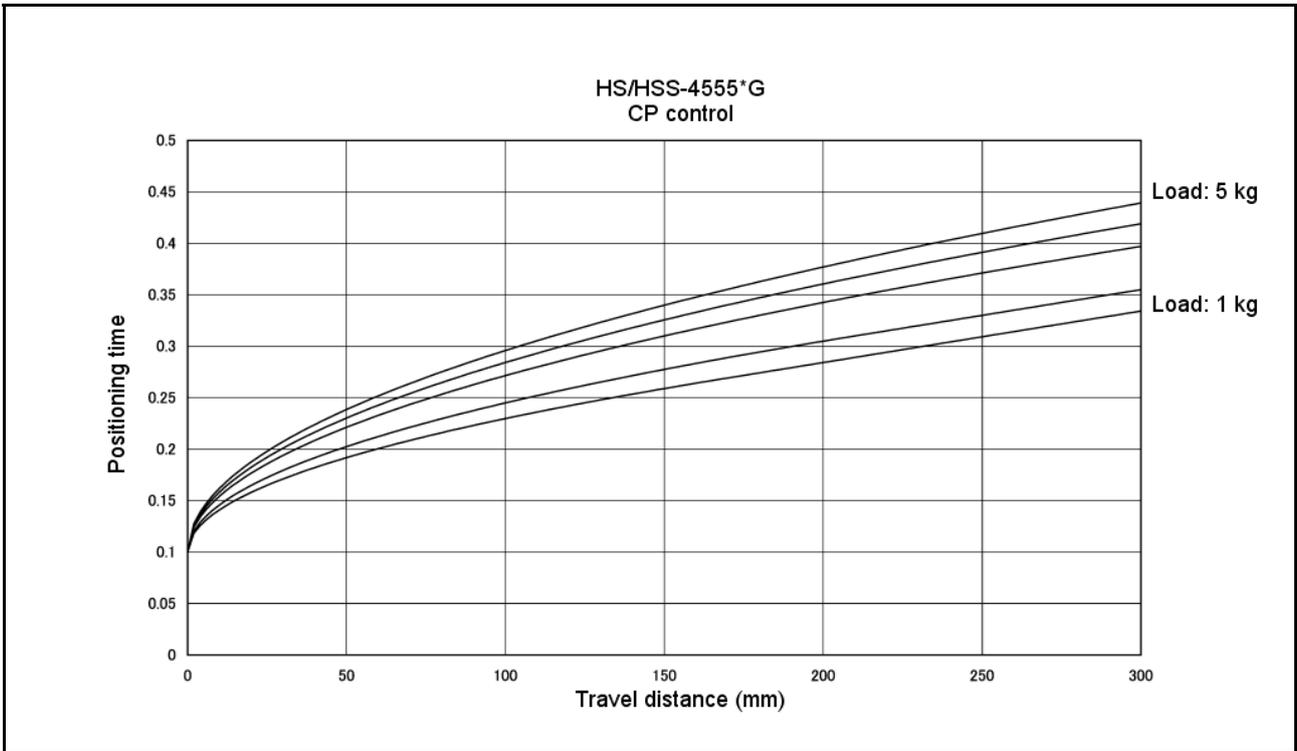
J2 axis (PTP control) on the HS/HSS-4555*G



Z axis (PTP control) on the HS/HSS-4555*G



T axis (PTP control) on the HS/HSS-4555*G



All axes (CP control) on the HS/HSS-4555*G

3.4 Notes for Setting the Positioning Speed (HS/HSS-G)

■ To be applied to all models of the HS-G series (Floor-mount type)

- (1) To horizontally traverse the robot arm at high speeds, teach the robot so that Z axis comes to be as close as possible to its upper end.
- (2) To stabilize positioning of Z axis near its lower end, the following maximum speed limiting control is automatically provided for J1 and J2 axes depending on the Z-axis coordinate value, only when the robot is moved under PTP control.

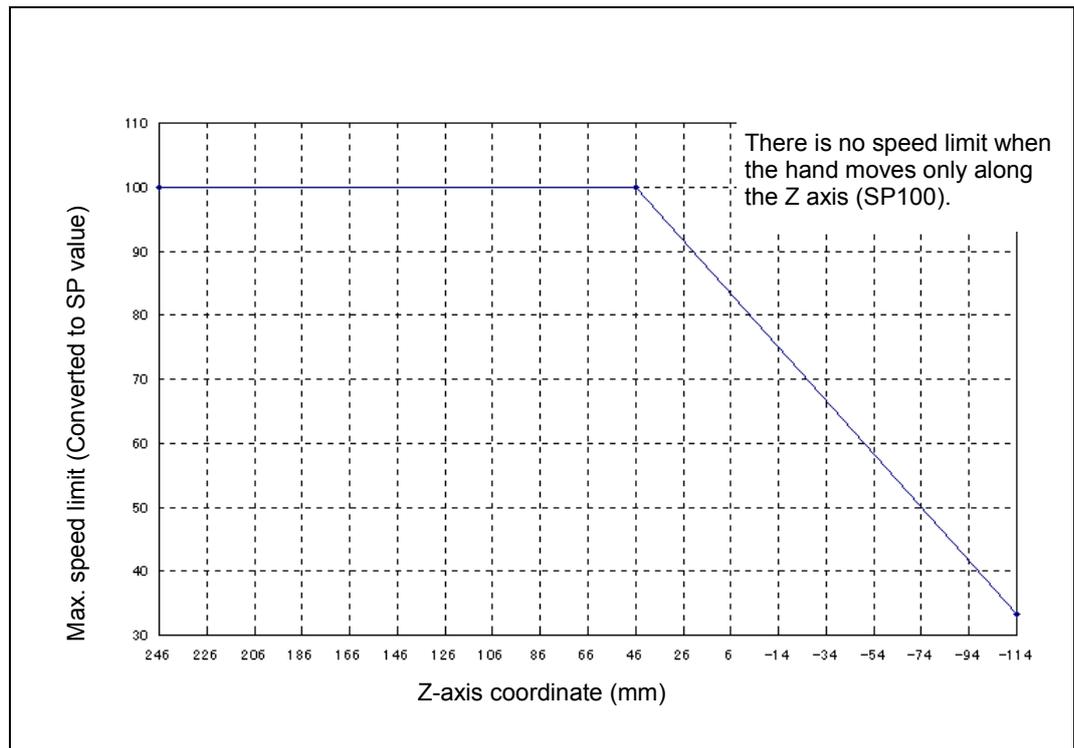
The positioning time of J1 and J2 axes becomes longer according to the maximum speed limit shown below.

$$\frac{\text{[Movement time in J1/J2 positioning time graphs (sec.)]}}{\text{Max. speed limit}} \times 100 \text{ (sec.)}$$

For example, when the robot arm moves by SP100 from the start point (Z-axis coordinate 26 mm) to the target point (Z-axis coordinated -74 mm), the maximum speed limits are as follows:

- 91 when Z-axis coordinate is 26 mm
- 50 when Z-axis coordinate is -74 mm

At this time, the maximum speed is the smaller value (at the lowest end) of 50.



HS-G Series: Maximum Speed Limit on the J1 and J2 (PTP control)

■ To be applied to all models of the HSS-G series (Overhead-mount type)

- (1) To horizontally traverse the robot arm at high speeds, teach the robot so that Z axis comes to be as close as possible to its upper end.
- (2) To stabilize positioning of Z axis near its lower end, the following maximum speed limiting control is automatically provided for J1 and J2 axes depending on the Z-axis coordinate value, only when the robot is moved under PTP control.

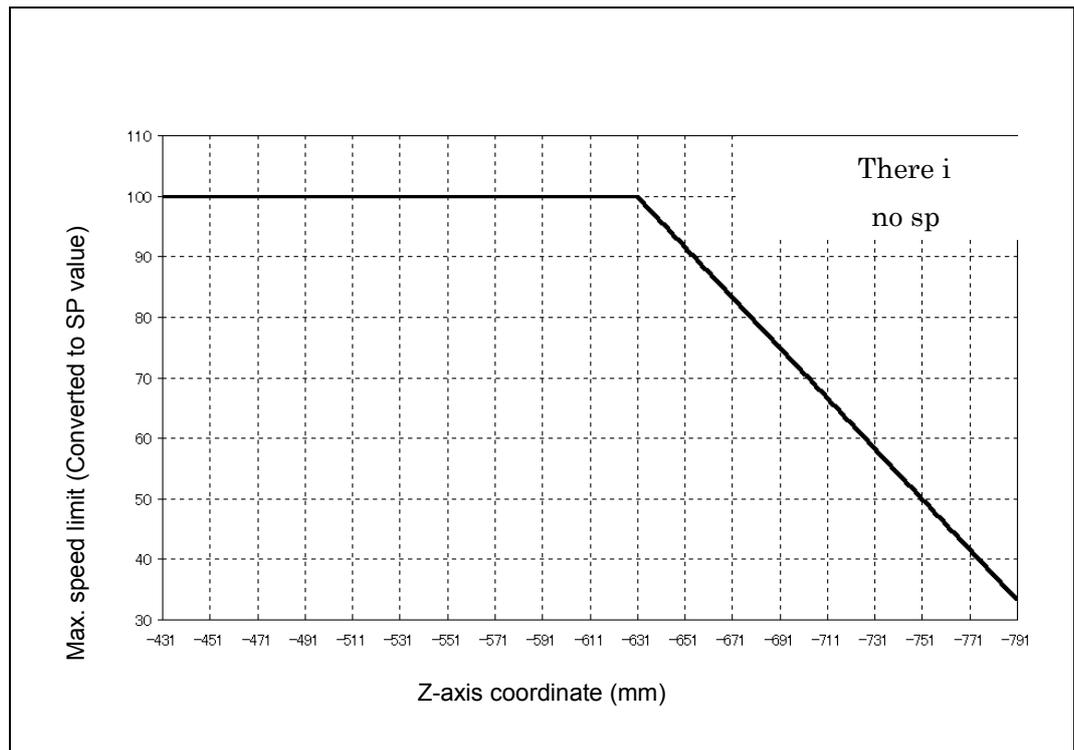
The positioning time of J1 and J2 axes becomes longer according to the maximum speed limit shown below.

$$\frac{\text{[Movement time in J1/J2 positioning time graphs (sec.)]}}{\text{Max. speed limit}} \times 100 \text{ (sec.)}$$

For example, when the robot arm moves by SP100 from the start point (Z-axis coordinate -651 mm) to the target point (Z-axis coordinated -751 mm), the maximum speed limits are as follows:

- 91 when Z-axis coordinate is -651 mm
- 50 when Z-axis coordinate is -751 mm

At this time, the maximum speed is the smaller value (at the lowest end) of 50.



HSS-G: Series Maximum Speed Limit on the J1 and J2 (PTP control)

3.5 Air Piping and Signal Wiring

The HS/HSS-G series is equipped with 4 air pipes ($\phi 4 \times 2$ and $\phi 6 \times 2$) for air chuck and 19 signal lines in the robot unit.

(1) HS/HSS-G (Standard type)

View in direction of arrow (A)

Brake release switch

AIR1 AIR2 AIR3 AIR4

AIR1

BRAKE SW

CN21

Air piping joints (M5)

Connector (CN21) for hand control signal wires

CN21 pin layout

View in direction of arrow (B)

Connector (CN20) for hand control signal wires

CN20 pin layout

Grounding terminal (M5) (Functional ground)

Air No.	Air piping joint	Maximum allowable pressure
AIR 1, 2	$\phi 4$, PT1/8	0.59 MPa
AIR 3, 4	$\phi 6$, PT1/4	

Note 1: Pins #1 to #19 on CN21 and those on CN20 are connected with each other. The maximum rated current per line is 1A.

Note 2: Use the attached connector set for CN20 and CN21.

Connector set part No.	Part No.	Model and name	Appearance
410889-0070	410877-0170 (for CN20)	SRCN6A25-24S (Round connector) (Japan Aviation Electronics Industry Ltd.)	
	410877-0420 (for CN21)	JMSP2119M (Straight plug) (DDK Electronics, Inc.)	

Air Piping and Signal Wiring (HS-G series; Standard type)

(2) HS/HSS-G-W, HS-G-P (Dust- & splash-proof type or Cleanroom type)

View in direction of arrow (A)

Brake release switch

AIR1 AIR2 AIR3 AIR4

BRAKE SW

CN21

Air piping joints (M5)

Connector (CN21) for hand control signal wires

CN21 pin layout

Air vent (*1) (provided in the cleanroom type only)
Outside dia.: $\phi 16$
Inside dia.: $\phi 12$

View in direction of arrow (B)

Connector (CN20) for hand control signal wires

CN20 pin layout

Grounding terminal (M5)

Cleanroom type Point of use (*2) (Y=0)

100

D

Notes for cleanroom type

*1 Recommended suction air flow rate: 25 to 40 liters/min.
Recommended blower: VFC068P (manufactured by Fuji Electric Motor Co., Ltd.)
The cleanroom type requires ventilation inside the robot. Exhaust air from the air vent provided in the back of the robot base.

*2 Dimension D at point of use
HS-4535*G-P: 250 mm
HS-4545*G-P: 350 mm
HS-4555*G-P: 400 mm

Air No.	Air piping joint	Maximum allowable pressure
AIR 1, 2	$\phi 4$, PT1/8	0.59 MPa
AIR 3, 4	$\phi 6$, PT1/4	

Note 1: Pins A to V on CN20 and pins #1 to #19 on CN21 are connected with each other as shown below. The maximum rated current per line is 1A.

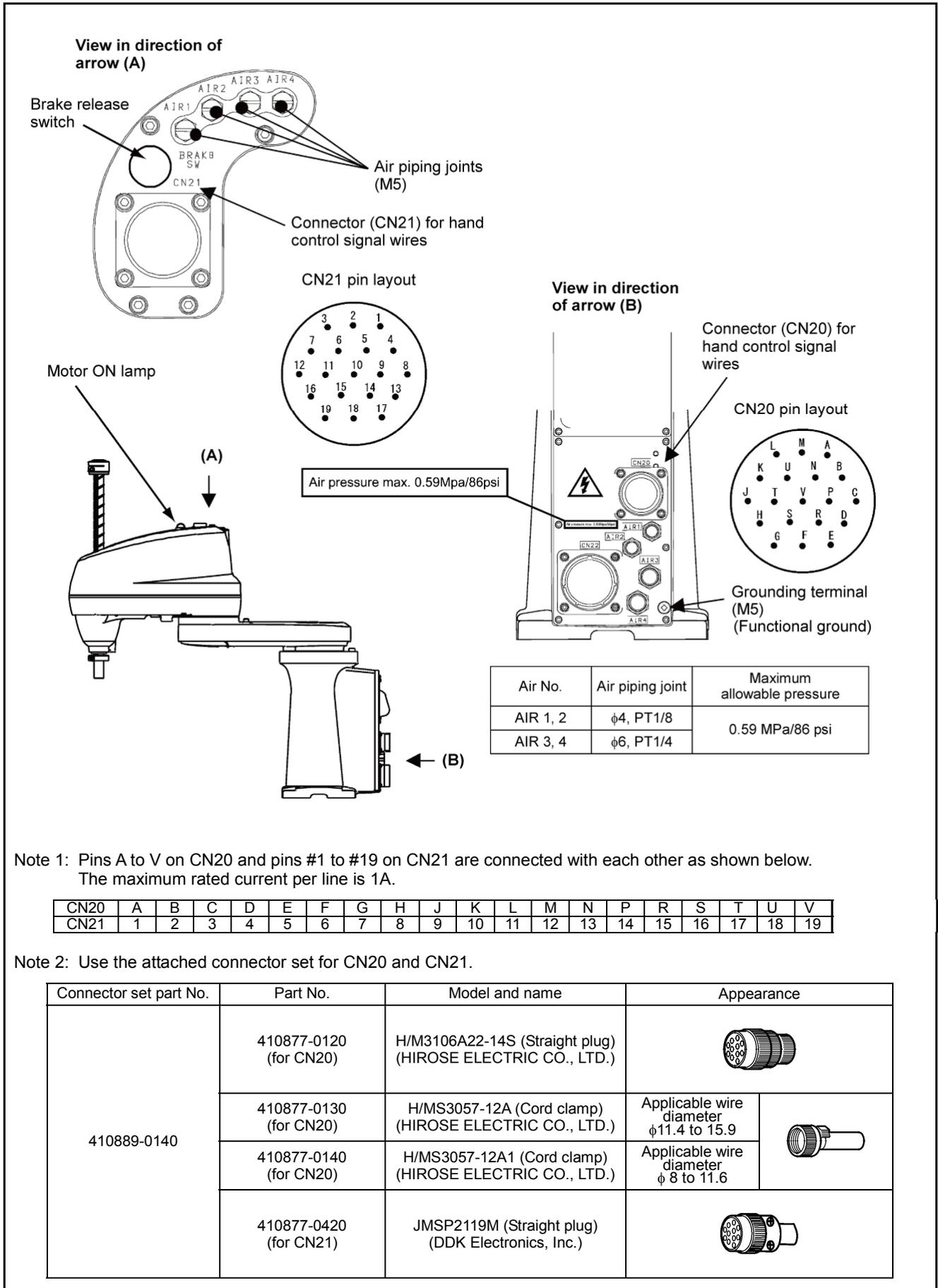
CN20	A	B	C	D	E	F	G	H	J	K	L	M	N	P	R	S	T	U	V
CN21	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

Note 2: Use the attached connector set for CN20 and CN21.

Connector set part No.	Part No.	Model and name	Appearance
410889-0080	410877-0120 (for CN20)	H/M3106A22-14S (Straight plug) (HIROSE ELECTRIC CO., LTD.)	
	410877-0130 (for CN20)	H/MS3057-12A (Cord clamp) (HIROSE ELECTRIC CO., LTD.)	Applicable wire diameter $\phi 11.4$ to 15.9
	410877-0140 (for CN20)	H/MS3057-12A1 (Cord clamp) (HIROSE ELECTRIC CO., LTD.)	Applicable wire diameter $\phi 8$ to 11.6
	410877-0440 (for CN21)	EBSP2119M (Straight plug) (DDK Electronics, Inc.)	

Air Piping and Signal Wiring (HS-G series; Dust- & splash-proof type or Cleanroom type)

(3) HS-G-UL (UL-Listed)



Air Piping and Signal Wiring (HS-G series; UL-Listed)

3.5.1 Instructions for Using Splash-proof Connector Sets

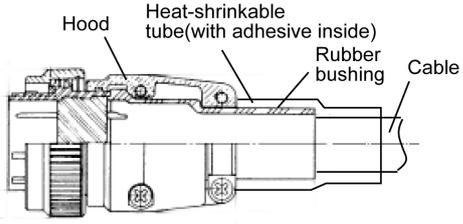
The splash-proof connector sets for CN20 and CN21 assure the splash-proofness as long as they are properly assembled and connected.

When using those connector sets, be sure to observe the following notes.

- (1) The degree of protection of the splash-proof robot unit, which is specified in Section 3.1 "Robot Specifications," is assured as long as the splash-proof connectors are joined with connectors CN20 and CN21 on the robot unit. If there is no connection on CN20 and CN21, the splash-proof rating is not assured.
- (2) Use a sheathed cable for a splash-proof connector. Using an unsheathed cable cannot assure the splash-proof rating.
- (3) Each connector set contains two types of cord clamps for CN20. Use the one that matches the cable diameter.
- (4) Each connector set should be assembled according to the instructions specified by the connector manufacturer.

The table below shows an assembly procedure example of a connector set for CN20, 21. The actual assembly procedure should be in accordance with the instructions specified by the connector manufacturer.

Overview of assembly procedure example of connector set for CN20, 21

Components of connector set for CN20,21	Assembly procedure example
 <p style="text-align: center;">(For straight plug)</p>	<p>(1) Treatment of wire ends: Strip the wire ends of the cable (prepared by the customer). The cable diameter and the lengths "A" and "B" should be in accordance with the instructions given by the connector manufacturer.</p>  <p>(2) Tinning: Tin both the core wires and the connector contacts.</p> <p>(3) Pass the cable through the heat-shrinkable tube for splash-proof purpose (with adhesive inside, prepared by the customer) and the rubber bushing.</p> <p>(4) Solder the core wires onto the connector contacts to connect them each other.</p> <p>(5) Press the rubber bushing against the shell to fit the hood. Then cover the rubber bushing with the heat-shrinkable tube and apply heat to shrink the tube.</p>  

3.6 Engineering-design Notes for Robot Hands (HS/HSS-G)

Design a hand (end-effector) so that it will satisfy conditions (1) and (2) described below.

⚠ Caution: Strictly observe these engineering-design notes. Otherwise, the clamped sections of the robot unit will become loose, rattle or be out of position. In the worst case, the mechanical parts of the robot unit and the robot controller may be damaged.

(1) Mass of hand

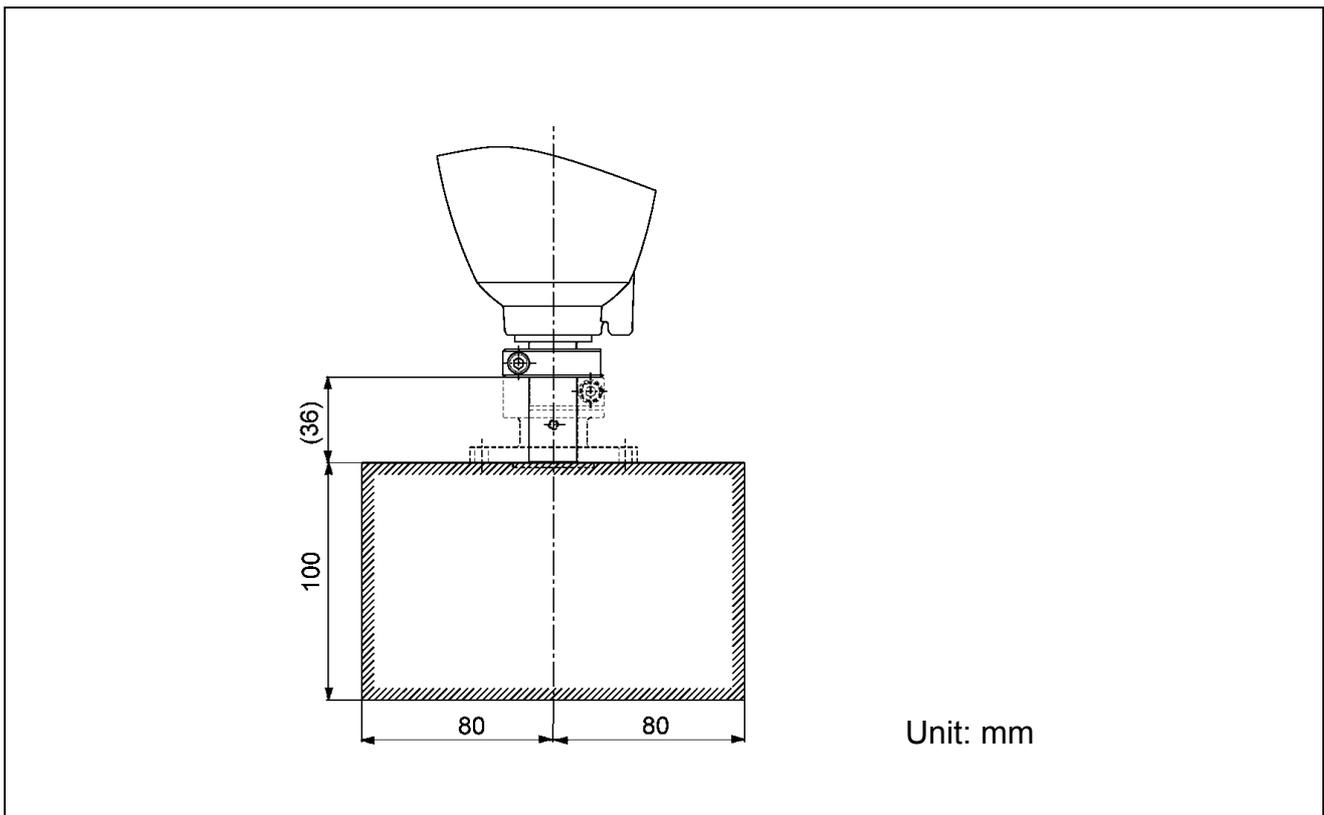
The total mass of a hand or tool (including work-piece) should be less than the maximum allowable payload of the robot. Be sure to include the mass of wirings and piping used for a hand or tool.

Total mass of hand or tool (incl. Work-piece) ≤ Max. allowable payload

NOTE: The maximum allowable payload refers to a mass of payload that you have preset.

(2) Hand center of gravity

The center of gravity of a hand or tool (including work-piece) should be located within the range specified in Figure below.



Hand center of gravity (HS/HSS-G)

(3) Moment of inertia around the T axis

The moment of inertia of a hand or tool (including work-piece) around the T axis should be less than the maximum allowable moment of inertia around the T axis of the robot.

Hand's moment of inertia (incl. Work-piece) around the T axis \leq Max. allowable moment of inertia

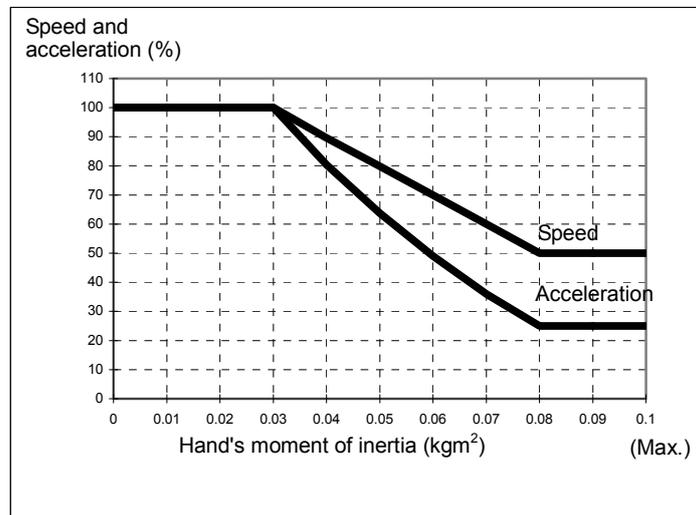
Calculate the moment of inertia around the T axis according to the graph given below.

NOTE: You may program the reduced ratio of the speed and acceleration individually within the range specified below. If you set the reduced ratio of the programmed speed only, the controller automatically calculates that of the acceleration according to the formula below.

$$\text{Acceleration (\%)} = (\text{Speed}/100)^2 \times 100$$

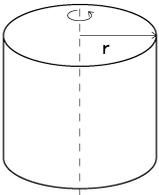
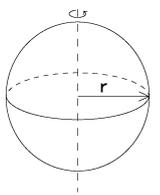
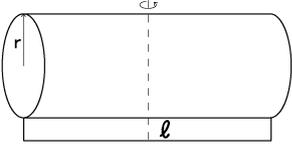
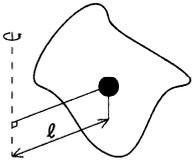
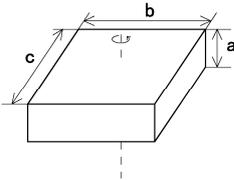
Application sample of hand's moment of inertia

- To run the robot at 100% of the programmed speed and acceleration: The moment of inertia around the T axis should be 0.03 kgm² or less.
- If the moment of inertia around the T axis is 0.04 kgm²: Run the robot at 90% or less of the programmed speed and at 81% or less of the programmed acceleration.



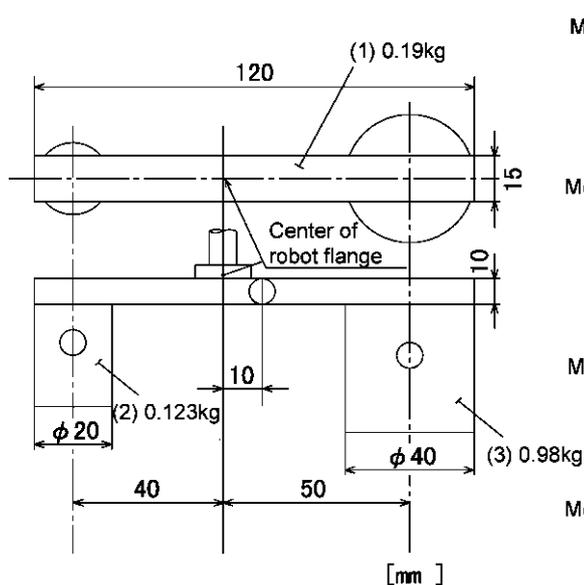
When calculating the hand's or tool's moment of inertia around the T axis, refer to the moment-of-inertia formulas on the next page.

Moment-of-inertia Formulas

<p>1. Cylinder (1) (Axis of rotation = Center axis)</p> <div style="text-align: center;">  $I = \frac{mr^2}{2}$ </div>	<p>4. Sphere (Axis of rotation = Center axis)</p> <div style="text-align: center;">  $I = \frac{2mr^2}{5}$ </div>
<p>2. Cylinder (2) (The axis of rotation passes through the center of gravity.)</p> <div style="text-align: center;">  $I = \frac{m}{4} \left(r^2 + \frac{l^2}{3} \right)$ </div>	<p>5. Center of gravity not on the axis of rotation. I_g: Moment of inertia around center of gravity</p> <div style="text-align: center;">  $I = I_g + m l^2$ <p style="text-align: right;">[kgm²]</p> </div>
<p>3. Rectangular parallelepiped (The axis of rotation passes through the center of gravity.)</p> <div style="text-align: center;">  $I = \frac{m}{12} (b^2 + c^2)$ </div>	<p>I: Moment of inertia [kgm²] m: Mass [kg] r: Radius [m] a, b, c, l: Length [m]</p>

Calculation example : When calculating the moment of inertia of a complicated shape, divide it into simple parts as much as possible for easier calculations.

As shown in the figure below, divide the hand into three parts ((1), (2), (3)).



Moment of inertia around T-axis of (1): I₁ (from 3 and 5 in the above table)

$$I_1 = \frac{0.19}{12} (0.12^2 + 0.015^2) + 0.19 \times 0.01^2 = 2.51 \times 10^{-4} \text{ [kgm}^2 \text{]}$$

Moment of inertia around T-axis of (2): I₂ (from 1 and 5 in the above table)

$$I_2 = \frac{0.123 \times 0.01^2}{2} + 0.123 \times 0.04^2 = 2.03 \times 10^{-4} \text{ [kgm}^2 \text{]}$$

Moment of inertia around T-axis of (3): I₃ (from 1 and 5 in the above table)

$$I_3 = \frac{0.98 \times 0.02^2}{2} + 0.98 \times 0.05^2 = 2.65 \times 10^{-3} \text{ [kgm}^2 \text{]}$$

Moment of inertia around T-axis of entire hand: I

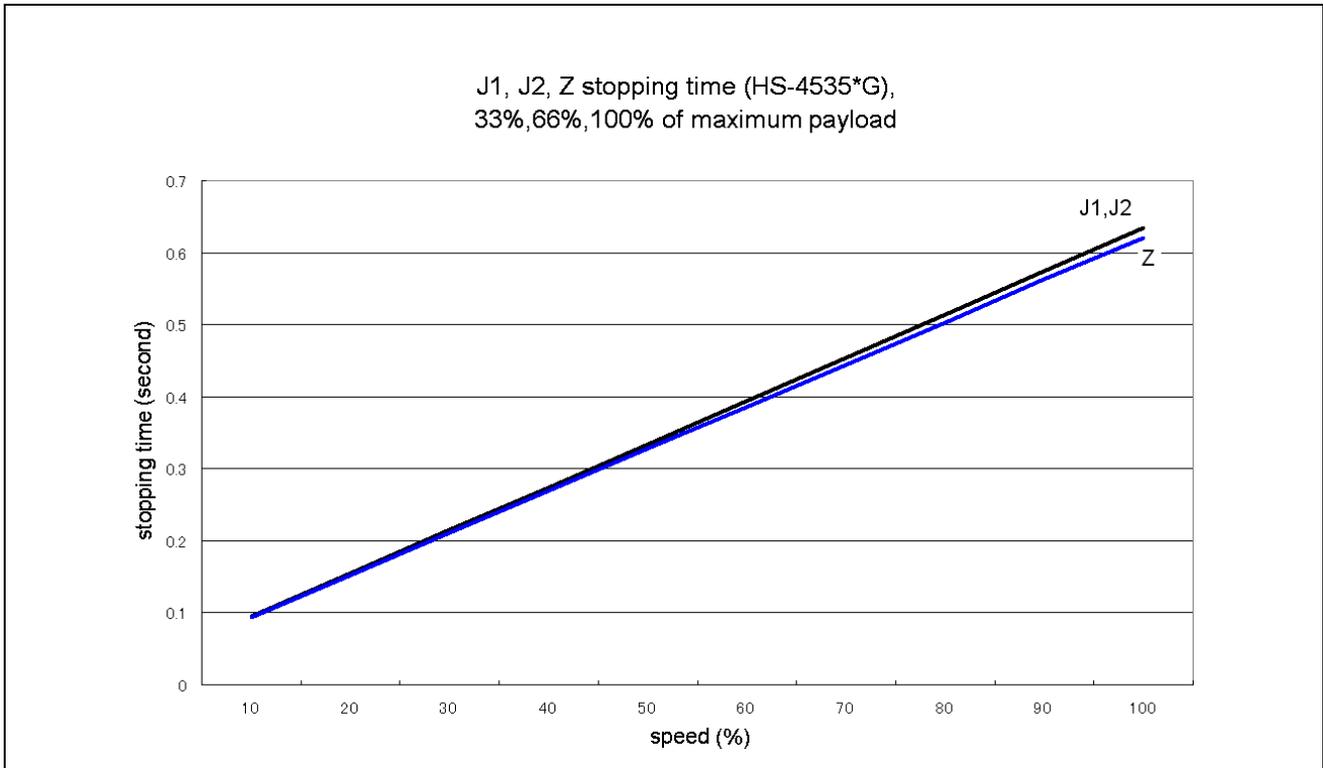
$$I = I_1 + I_2 + I_3 = 0.003 \text{ [kgm}^2 \text{]}$$

Calculation Example of Hand's Moment of Inertia Around the T Axis

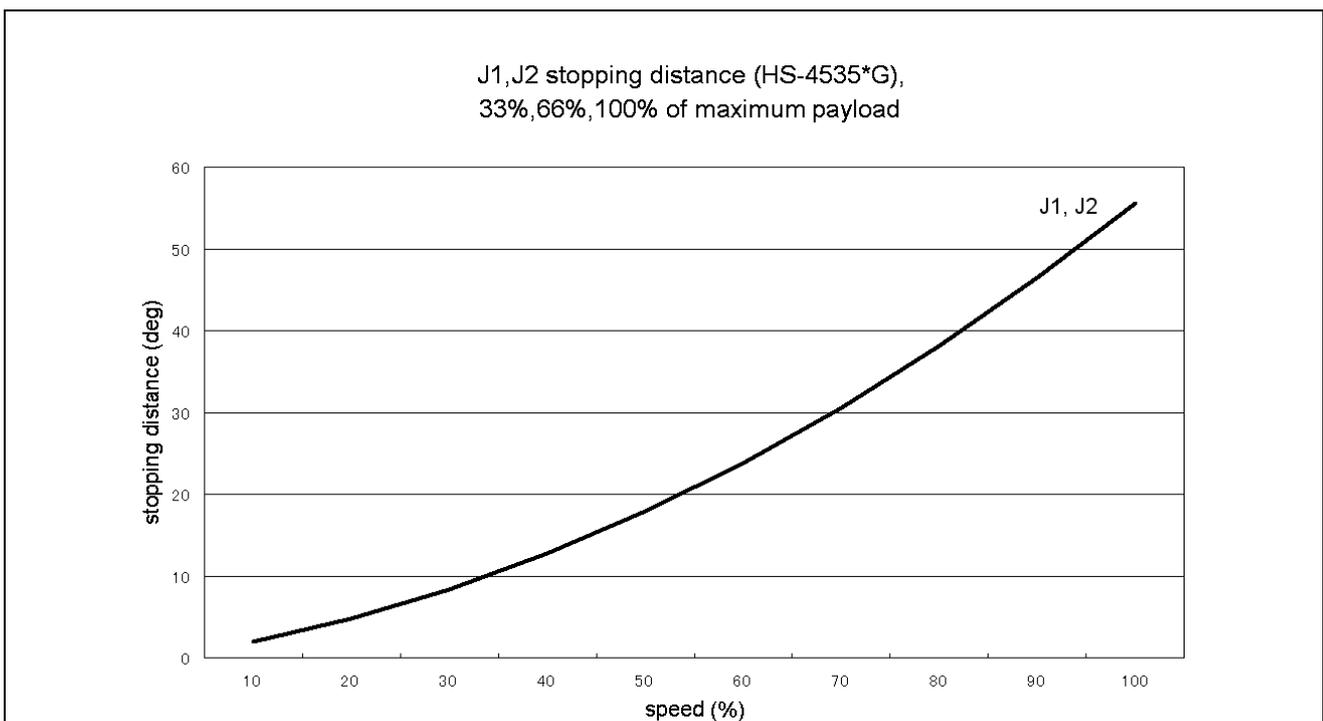
3.7 Stopping Time and Distance (Angle) at an Emergency Stop

Pressing the emergency stop button when the robot is in motion stops the robot. The stopping time required from activation of a stop signal and the distance (angle) for major three joints vary with the robot speed as shown in the graphs below. The measuring conditions are: Robot arm extended, 33%, 66% and 100% of the maximum payload.

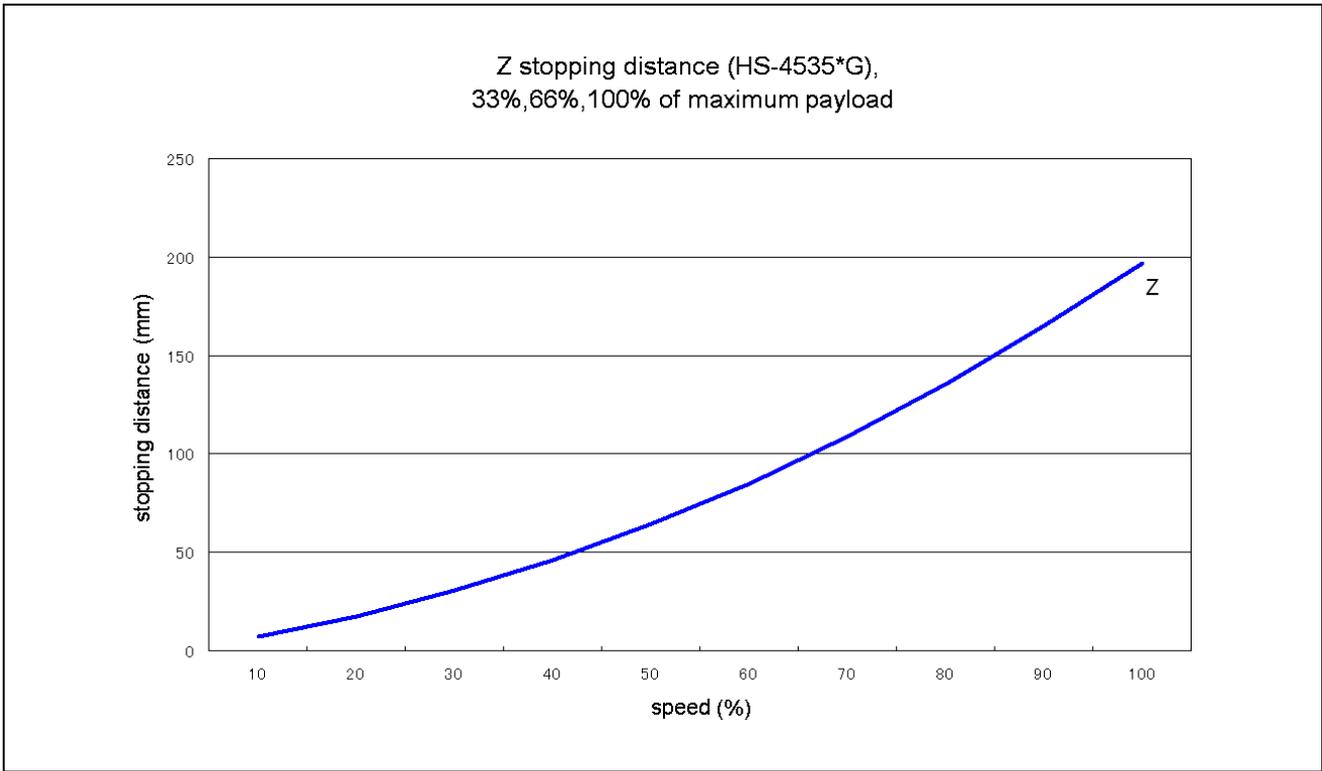
(1) HS-4535*G series (HS-4535*G / HSS-4535*G)



J1, J2, Z stopping time vs. speed at an emergency stop (HS-4535*G series)

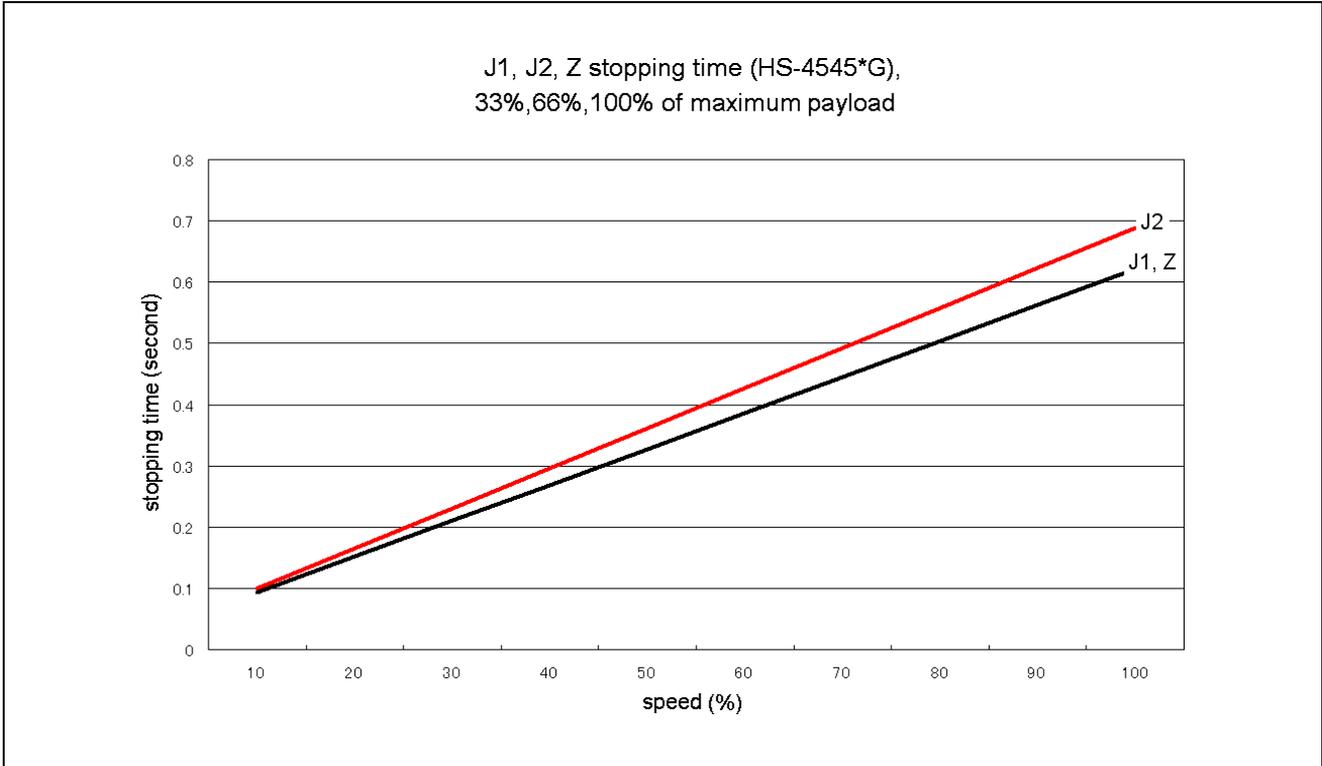


J1, J2 stopping distance vs. speed at an emergency stop (HS-4535*G series)

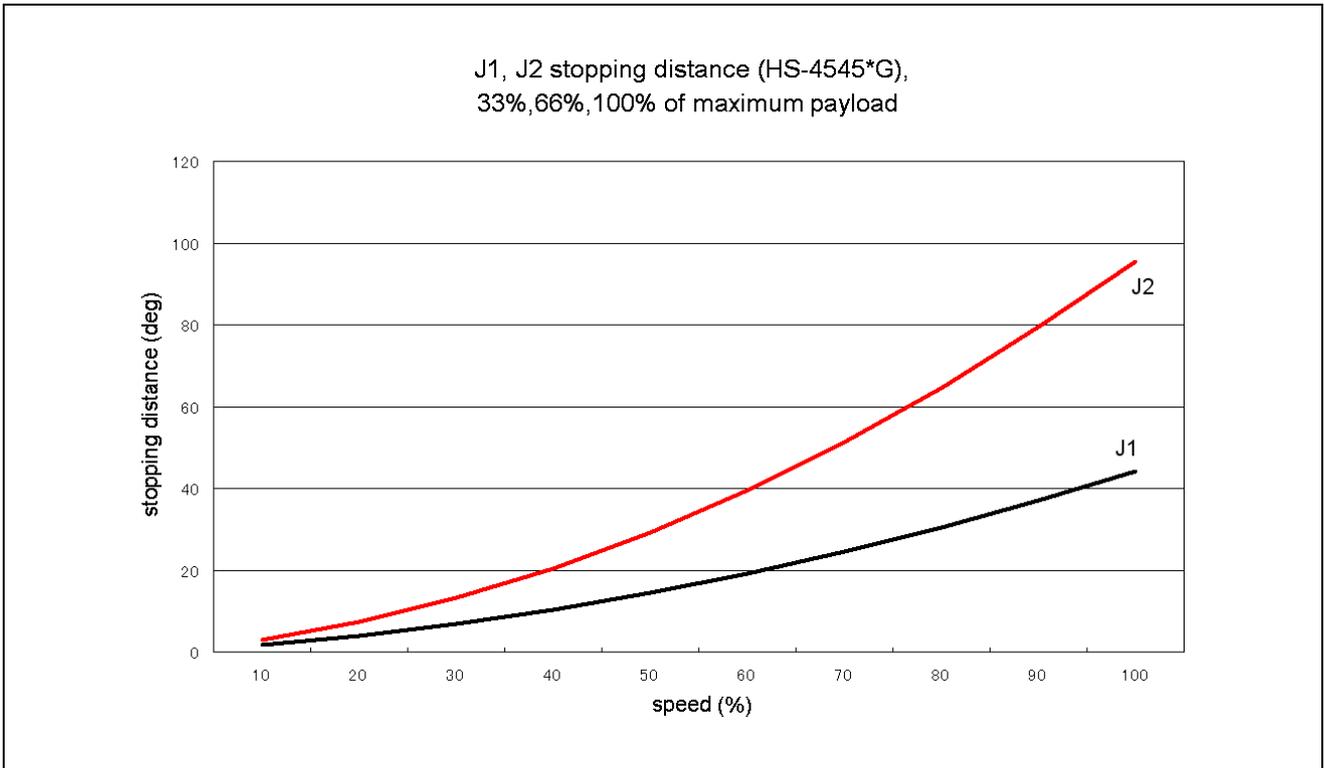


Z stopping distance vs. speed at an emergency stop (HS-4535*G series)

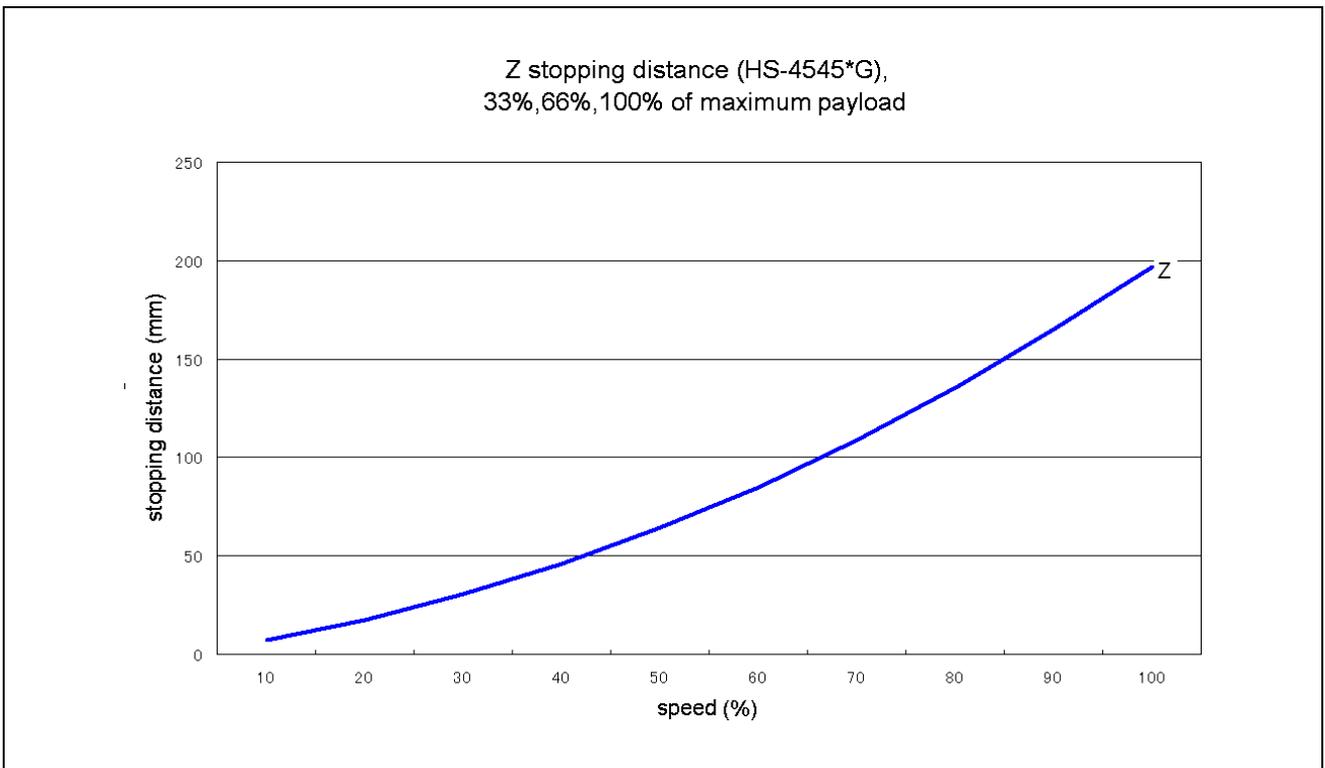
(2) HS-4545*G series (HS-4545*G / HSS-4545*G)



J1, J2, Z stopping time vs. speed at an emergency stop (HS-4545*G series)

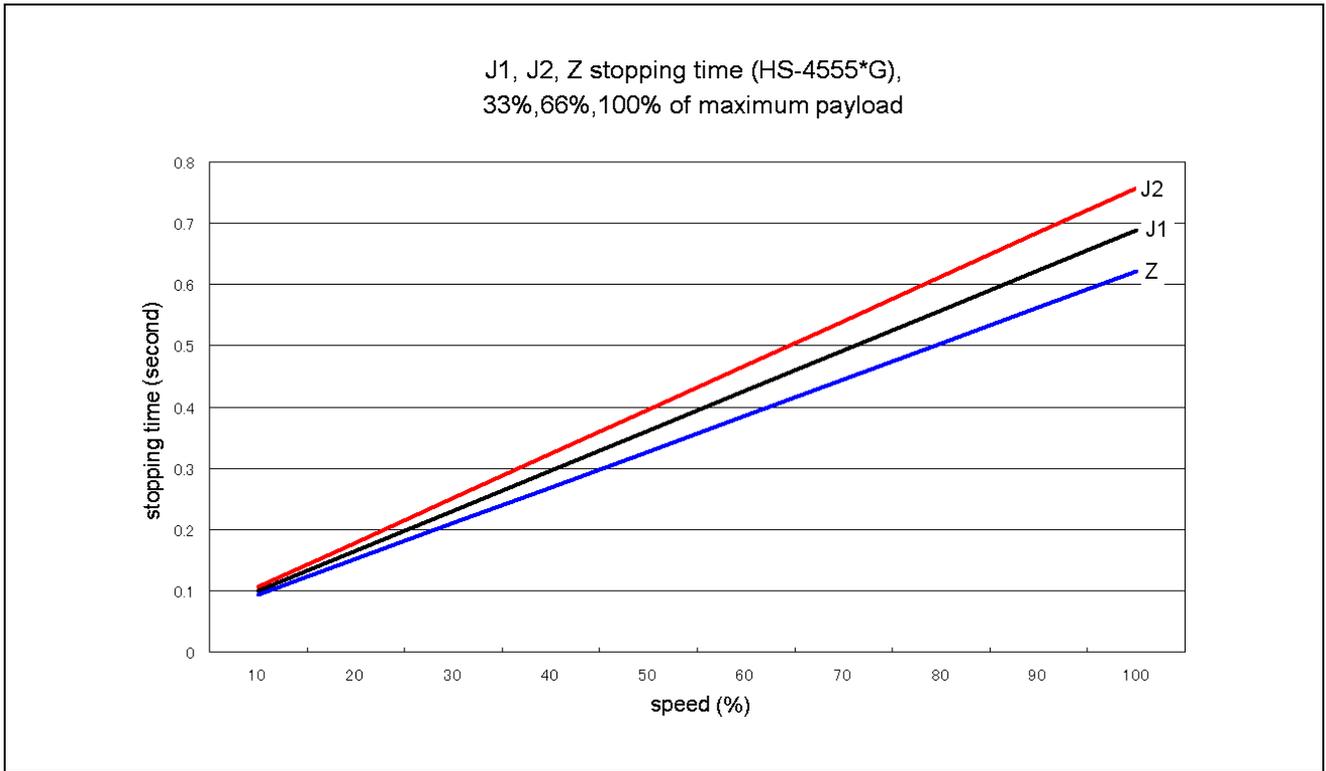


J1, J2 stopping distance vs. speed at an emergency stop (HS-4545*G series)

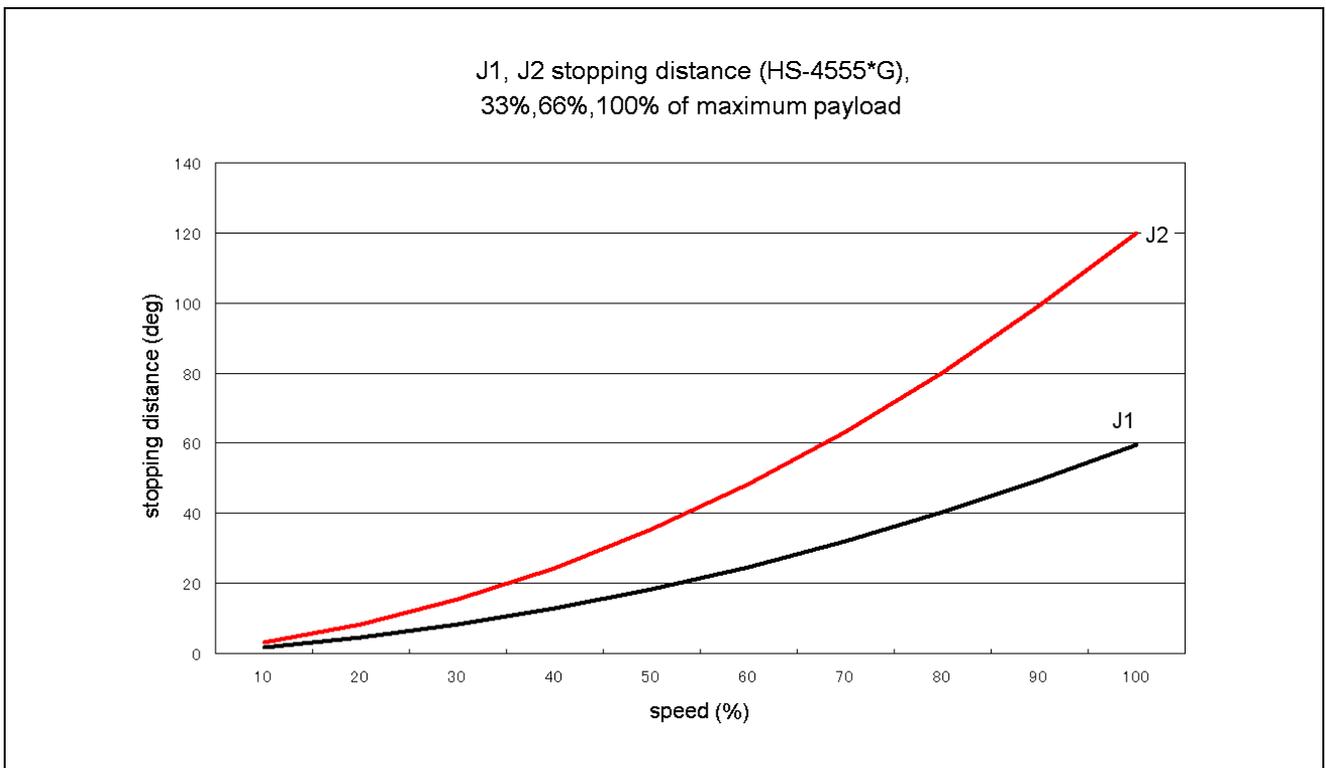


Z stopping distance vs. speed at an emergency stop (HS-4545*G series)

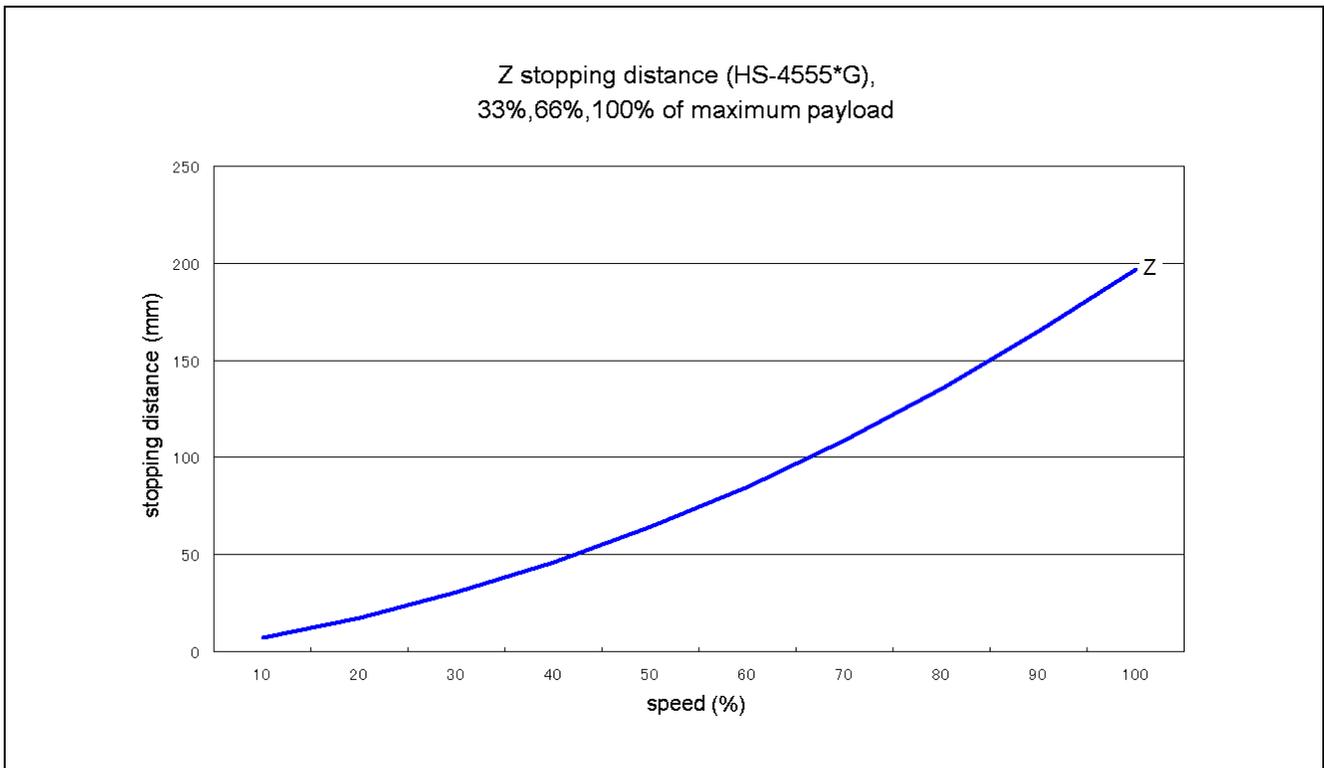
(3) HS-4555*G series (HS-4555*G / HSS-4555*G)



J1, J2, Z stopping time vs. speed at an emergency stop (HS-4555*G series)



J1, J2 stopping distance vs. speed at an emergency stop (HS-4555*G series)



Z stopping distance vs. speed at an emergency stop (HS-4555*G series)

Chapter 4

Specifications of the Robot Controller

4.1 Specifications

The table below lists the specifications of the robot controller.

RC7M Controller Specifications (1) (HS-G series)

Item		Specifications	
Applicable robot		Small-sized, horizontal articulated type (HS-G)	
model		RC7M-HSG4BA-**	
Control system		PTP, CP 3-dimensional linear, 3-dimensional circular	
No. of controllable axes		Up to four axes simultaneously	
Drive system		All axes: Full-digital AC servo	
Language used		DENSO robot language (conforming to SLIM)	
Memory capacity		3.25 MB (equivalent to 10,000 steps, 30,000 points)	
Teaching system		1) Remote teaching 2) Numerical input (MDI)	
External signals (I/O)	Standard I/O	Mini I/O	Input signals: 8 user open points + 11 fixed system points Output signals: 8 user open points + 14 fixed system points Note: In global type, some fixed system points are not used.
		HAND I/O	Input signals: 8 user open points Output signals: 8 user open points
	SAFETY I/O (Only for Global type)		Input signals: 6 fixed system points Output signals: 5 fixed system points
	Parallel I/O board (Option)	2 boards	Input signals: Additional 80 user open points Output signals: Additional 96 user open points
		1 board	Input signals: Additional 40 user open points Output signals: Additional 48 user open points
	DeviceNet board (Option)	Master & slave	Input signals: 1024 points (Master) + 256 points (Slave) Output signals: 1024 points (Master) + 256 points (Slave)
		Master	Input signals: 1024 points Output signals: 1024 points
		Slave	Input signals: 256 points Output signals: 256 points
	CC-Link board (option)	Slave	Input signals: 384 points Output signals: 384 points (including remote registers RWw and RWr)
External communication		RS-232C: 1 line Ethernet: 1 line USB: 2 lines	
Extension slot		3 (For an optional board)	
Self-diagnosis function		Overrun, servo error, memory error, input error, etc.	
Timer function		0.02 to 10 sec. (in units of 1/60 sec.)	
Error display		Error codes will be outputted on the external I/O. Error messages will be displayed in English on the teach pendant (option). Error codes will be displayed on the mini pendant (option).	
Cables	Motor & encoder cable (option)	2 m, 4 m, 6 m, 12 m, 20 m (Standard / Splash-proof)	
	I/O cable (option)	8 m, 15 m (For Mini I/O, HAND I/O, Optional board for parallel I/O and SAFETY I/O)	
	Power cable	5 m	

RC7M Controller Specifications (2) (HS-G series)

Item	Specifications
Environmental conditions (in operation)	Temperature: 0 to 40°C Humidity: 90% RH or less (no condensation allowed)
Power source	Three-phase, 200 VAC-15% to 230 VAC+10%, 50/60 Hz, 1.8 kVA Single-phase, 230 VAC-10 to 230 VAC+10%, 50/60 Hz, 1.8 kVA
Degree of protection	IP20
Weight	Standard type: Approx. 17 kg (38 lbs) Global type with safety board: Approx. 18 kg (40 lbs) Global type with safety box: Approx. 21 kg (46 lbs)

 WARNING

- **DO NOT touch fins. Their hot surfaces may cause severe burns.**
- **DO NOT insert fingers or foreign objects into openings. Doing so may cause bodily injury.**
- **Before opening the controller cover and accessing the inside of the controller for maintenance, be sure to turn off the power switch, disconnect the power cable, and wait 3 minutes or more. This is for protecting you from electric shock.**
- **DO NOT connect or disconnect connector to/from the controller while the power switch is on. Doing so may cause electric shock or controller failure.**

 CAUTION IN INSTALLATION

- **This controller is not designed to be dust-proof, splash-proof, or explosion-proof.**
- **Read operation-manuals before installation.**
- **Do not place anything on the controller.**

4.3 Controller Setting Table

The controller setting table given in Figure below is attached to the controller. It shows the software version, the next replacement dates of the memory backup battery and encoder backup battery, etc.

コントローラ設定表／THE SETPRM LIST

①パラメータ／PARAMETER

ソフトウェアVer.
SOFTWARE Ver.

電池交換日
DATE OF RENEWING BAT.

TYPE

②サブアセンブリ／SUBASSEMBLY

IPM	SLOT5	SLOT6	
BOARD	SLOT3	SLOT4	
	SLOT1	SLOT2	

③その他変更点／OTHER MODIFICATIONS

--

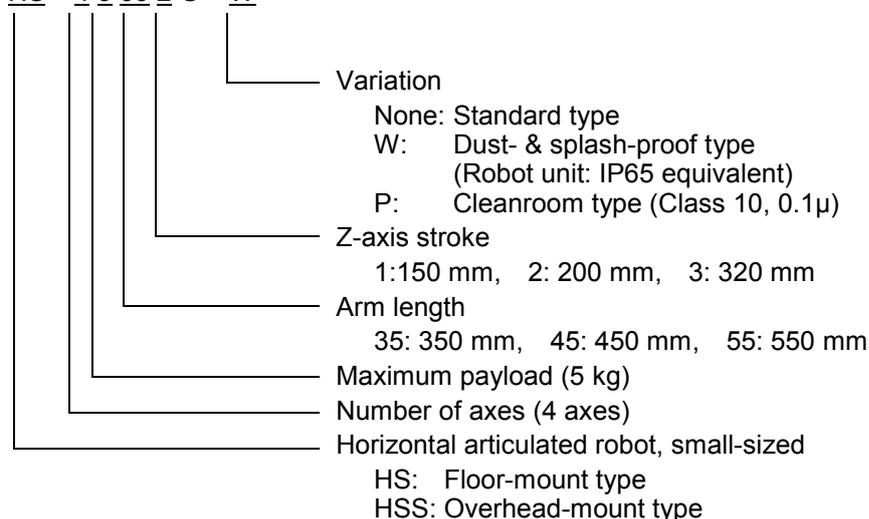
Robot Controller	
MODEL NO.	_____
PART NO.	_____
POWER	_____
CAPACITY	_____
TYP OUTPUT	_____
WEIGHT	_____
CONDITION	_____
SERIAL NO.	_____
YEAR OF PRODUCTION	_____
DENSO WAVE INCORPORATED 1, Yoshiike, Kusagi, Agui-cho, Chita-gun, Aichi 470-2297, JAPAN	

<Content THE SETPRM LIST>

SOFTWARE Ver.	The version of the main software for the controller is entered.
DATE OF RENEWING BAT.	The next replacement dates of the memory backup battery and encoder backup battery are entered.
TYPE	The model of the robot system is entered. The coding of the set model is described below.
SUBASSEMBLY	The type and position of the controller IPM board are described.

Small-sized, horizontal articulated robot (HS/HSS-G series)

HS - 4 5 35 2 G - W



Chapter 5 Warranty

DENSO robots are manufactured under strict quality control. In case of failure, we warranty the robot under the following conditions:

Warranty Period

The warranty shall be effective for one year from the date of purchase.

Warranty Coverage

DENSO WAVE shall repair the robot free of charge when a failure occurs and is attributable to the design, manufacture or material of the robot within the warranty period in spite of proper use.

Items Not Covered

Failures, which arise from one of the following, shall not be covered by the warranty even if the robot is under warranty:

- (1) Failures caused by improper repair, modification, transfer or handling by you or a third party;
- (2) Failures caused by the use of a part or oil/fat other than those specified in the related manuals;
- (3) Failures caused by a fire, salt damage, earthquake, storm/flood or other acts of God;
- (4) Failures caused by the use of the robot in an environment other than the environment specified in the related manuals, such as dust and water ingress;
- (5) Failures caused by a worn-out consumable, such as a fan filter;
- (6) Failures caused by improper performance or non-performance of lubrication, maintenance or inspections stated in this owner's manual; and
- (7) Damages other than the robot repair costs.

Chapter 6 Appendix

6.1 Conformity with Standards by Robot Model

For information on conformity with standards, refer to "Conformity with Standards by Robot Model" in the Additional Information section of the RC7M controller manual pack CD SUPPLEMENT.

Horizontal Articulated Robot HS-G SERIES

GENERAL INFORMATION ABOUT ROBOT

First Edition	July 2005
Twelfth Edition	October 2011
Thirteenth Edition	February 2013

DENSO WAVE INCORPORATED

2Q**C

The purpose of this manual is to provide accurate information in the handling and operating of the robot. Please feel free to send your comments regarding any errors or omissions you may have found, or any suggestions you may have for generally improving the manual.

In no event will DENSO WAVE INCORPORATED be liable for any direct or indirect damages resulting from the application of the information in this manual.

