WISE Servo Driver and Motor

Selection Guide

(2nd Edition)

(For WSDV series)

Weihong Electronic Technology Co., Ltd.

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Preface

About This Manual

This manual is intended for manufacturers. If you use the system for the first time, you need to read through the manual. If you are experienced with the system, you can search for the desired info via the contents.

With 3 chapters, this manual can be divided into 4 parts, as follows:

1) Part 1: preface, introducing general information of this manual as well as contact information of some driver manufacturers.
2) Part 2: overview of product. Chapter 1 mainly introduces product features, combination of drivers and motors, and typical examples of wiring diagrams.
3) Part 3: introductions to driver, including chapter 2, introducing naming rules of the driver, and its specifications as well as dimensions.
4) Part 4: introductions to motor, including chapter 3, introducing naming rules of the motor, its specifications and dimensions, pin dispositions of motor side connector as well as calculations for motor selection.

Applicable Product Models

This manual is applicable to WISE (维智) servo driver. Refer to the table below for details:

Product Model	Remarks
WISE (维智) servo driver	At present, there are four models, including WSDV-2R8(0.4kW)；WSDV-5R0(0.75kW)；WSDV-6R8(1.0kW)；WSDV-110(1.5kW). It is herein abbreviated as WISE (维智). For your information, without any special explanations, driver hereinafter in this manual refers to WISE (维智) servo driver.

Contact Us

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Revision History

You can refer to the following table for the revision records of each edition.

Date	Edition	Revision Contents
2015.02	R1	Released for the first time.
2015.06	R2	Add parameter "Recommended load moment of inertia (as much as the moment of inertia)" in the table of motor specifications in chapter 3.2.

Precautions

Precautions can be divided into caution and warning according to the degree of possible loss or injury in case of negligence or omission of precautions stipulated in this manual.

CAUTION: general info, mainly for informing, such as supplementary instructions and conditions to enable a function. In case of negligence or omission of this kind of precautions, you may not activate a function. Note that in some circumstances, negligence or omission of even this kind of precautions could cause physical injury or machine damage.

WARNING: warning info requiring special attention. In case of negligence or omission of this kind of precautions, you may suffer physical injury, or even death, machine damage or other losses.

Content

1 Overview

1.1 Features

WISE (Chinese name as "维智", “维” is one character in Chinese company name “维宏”, and “智” is for intelligence and wisdom. Besides, pronunciation of “维智” sounds like that of English word “wise”) series servo driver is another expansion in motion control industry chain of Weihong Company. It boasts such functions as real-time auto-gain tuning, adaptive mechanical resonance suppression, friction torque compensation, external disturbance observer, gain switching and time register, to name but a few. Thanks to its precise positioning, quick response and ease of use, it has been proven to be an excellent and reliable solution provider when it is used together with Weihong CNC system. Chain-like product combination can effectively reduce components number and type for machine tool builders and facilitate daily maintenance for machines.

1.1.1 Outstanding Positioning Precision and Low-speed Smoothness

It supports encoder with high resolution, reducing variation of torque, improving positioning precision of motor and enhancing smoothness of low-speed motion.

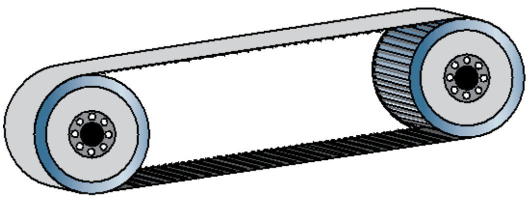


Fig. 1-1 When there is stiffness difference, WISE servo driver can keep motor un-oscillated via gain switching function.

1.1.2 Ease of Use

It features auto calculation of inertia ratio, real-time auto-gain tuning and auto suppression to mechanical resonance.

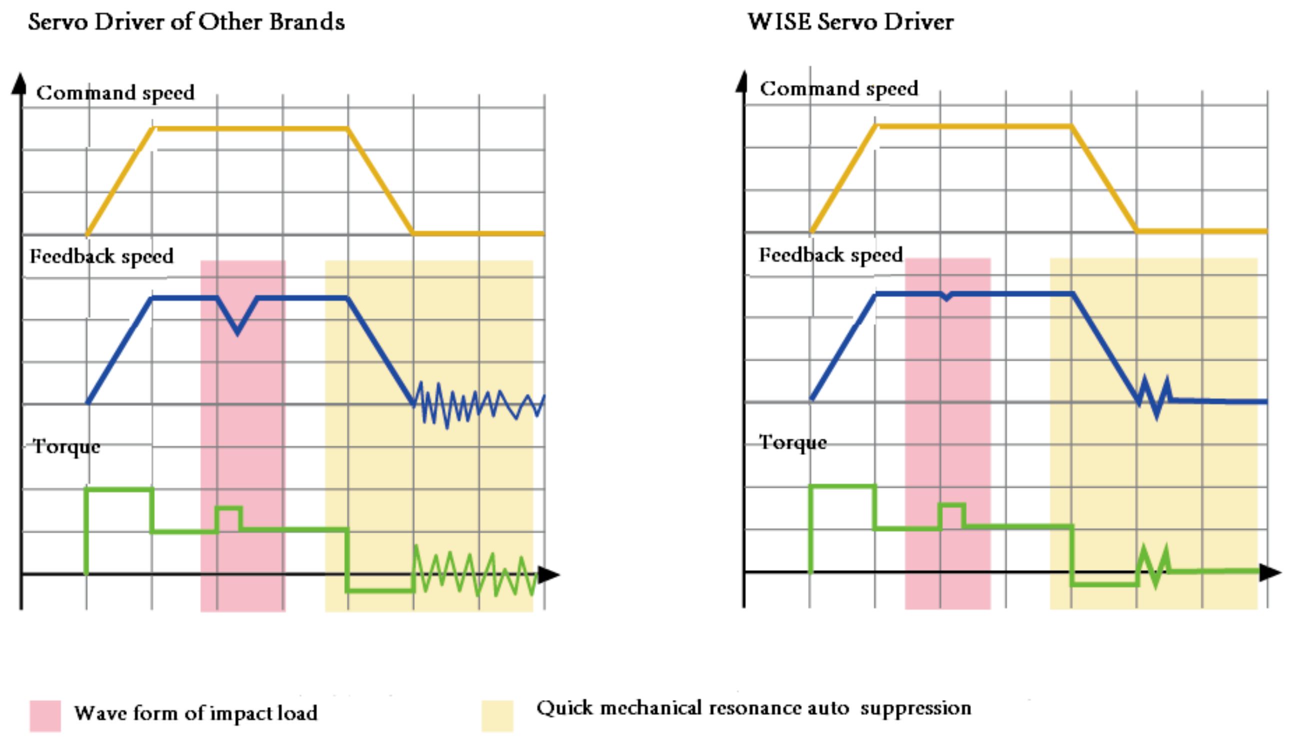


Fig. 1-2 Comparison between counterparts and WISE servo driver

1.1.3 Powerful Support Software

WISE servo driver can be used with the setup support software, “iMotion”, which is user-friendly in HMI, and features functions such as real-time I/O monitoring and auto capture and analysis of waves.

Fig. 1-3 Example of iMotion

With the “iMotion”, you can execute the followings.

- **Parameters Management**

Editing, transmission, receipt, import, export and initialization of parameters can be realized, which is very convenient for operators.

- **Real-time Monitoring**

Monitoring of I/O, existing alarms and history alarms, as well as system running status.

■ **Real-time/Triggered Sampling**

Main data waves in running will be captured with Real-time/Triggered Sampling function, for debugging and analysis.

■ **Debugging**

Rapidly adjust the servo driver stiffness, automatic calculation of inertia ratio.

■ **Mechanical Analysis**

Through FFT algorithm, quickly analyze and find the mechanical resonance point, and automatically setup notch filter to suppress vibration.

■ **Trial Run**

With versatile Trial Run interfaces, various application situations in real practices can be simulated.

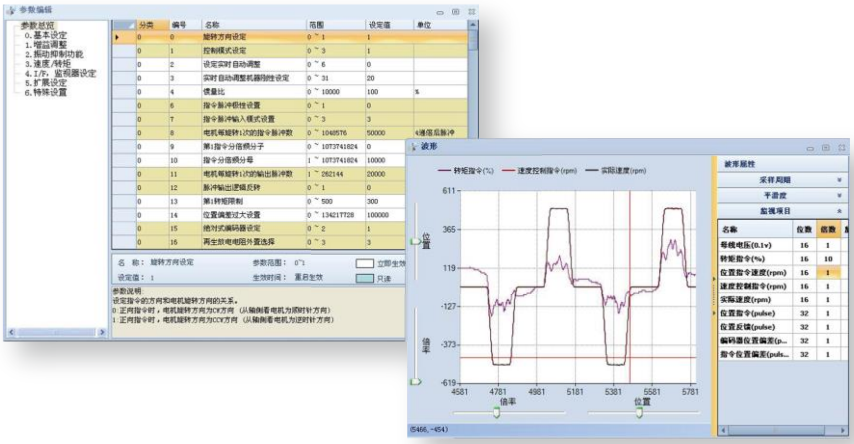


Fig. 1-4 Parameter management interface (left) and real-time sampling interface (right)

1.1.4 Time Registration Function

Double encryption from CNC system and servo driver is supported, which will safeguard manufacturers' legal rights to the greatest degree.

Fig. 1-5 Time registration function which will be released soon

1.1.5 Widely Applied in Various Industries

WISE (维智) servo driver adopts advanced control algorithm and can realize digital control of torque, rotational speed and position with the help of IPM intelligent module. It features excellent positioning precision and low-speed smoothness, on-line/off-line inertia recognition and real-time auto-gain tuning. Operations are easy and concise. It can be widely applied in industries including milling and engraving, water jet cutting, laser cutting, glass cutting, metal cutting, robot manipulator and textile industry, etc.

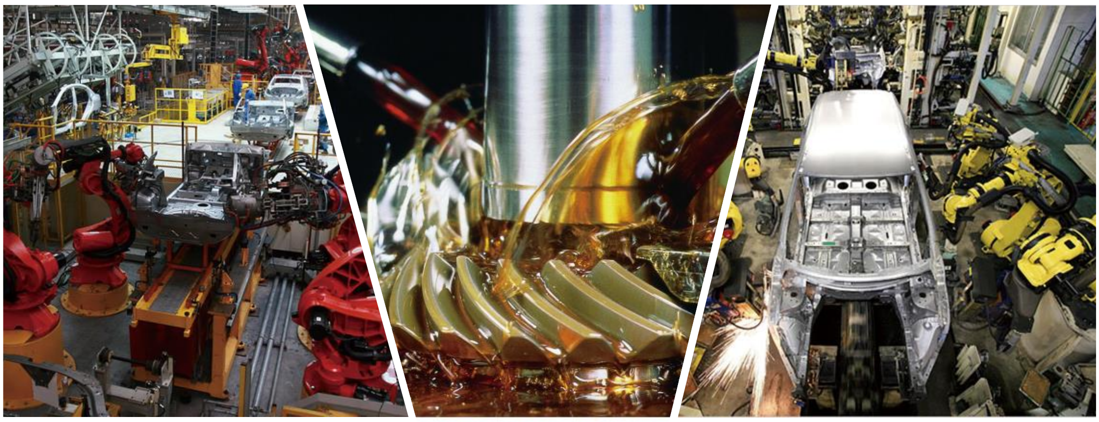


Fig. 1-6 Examples of applicable industries

1.2 Table of Combination of Servo Driver and Motor

Table 1 Combinations of WISE (维智) AC servo drivers and applicable motors

Driver	Model of Applicable Motor	Rated Power(kW)	Inertia
WSDV-2R820PSB	MHMD042G1□	0.4	High inertia
WSDV-5R020PSB	MHMD082G1□	0.75	High inertia
WSDV-6R820PSB	MDME102GC□M/ MHME102GC□M	1.0	Middle/High inertia
WSDV-11020PSB	MDME152GC□M/ MHME152GC□M	1.5	Middle/High inertia
NOTE	Symbol “□” represents the motor structure. Please refer to naming rules of the motor model in following pages.		

1.3 Typical Example of Wiring Diagram

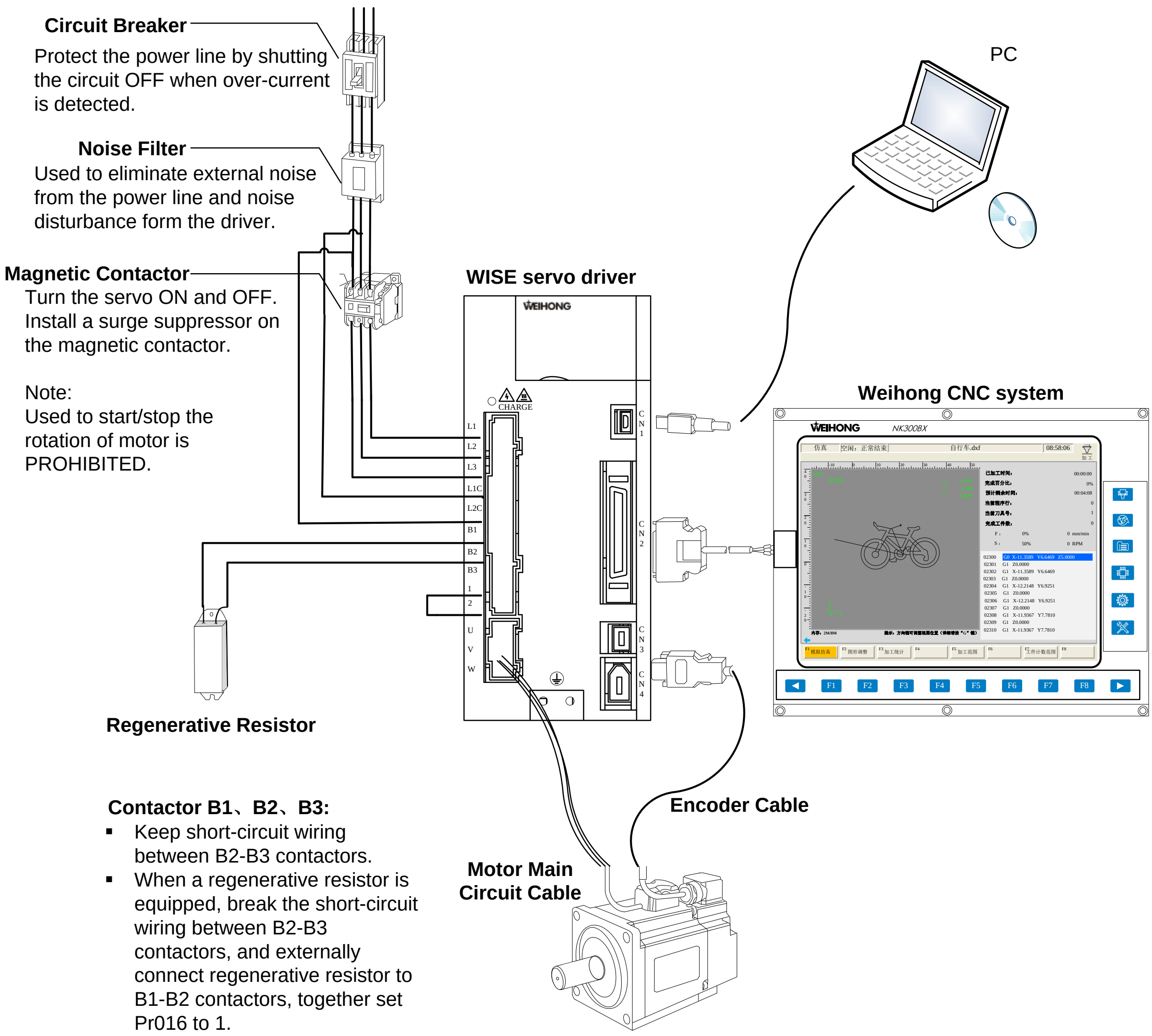


Fig. 1-7 Typical example of wiring diagram

WARNING

When externally wiring to a regenerative resistor, over-temperature protection MUST be provided.

Install over-temperature protection fuse and thermostat in the regenerative resistor. And once fuse action occurs, it cannot restore to previous state.

Please install the regenerative resistor on non-combustion substances.

2 WISE (维智) Driver

2.1 Ordering Information of the WISE (维智) Servo Driver

Contents of nameplate of WISE (维智) series servo driver, as shown Fig. 2-1, consists of series name + permissible current specification + voltage specification + contactor specification + encoder feedback type + control mode.

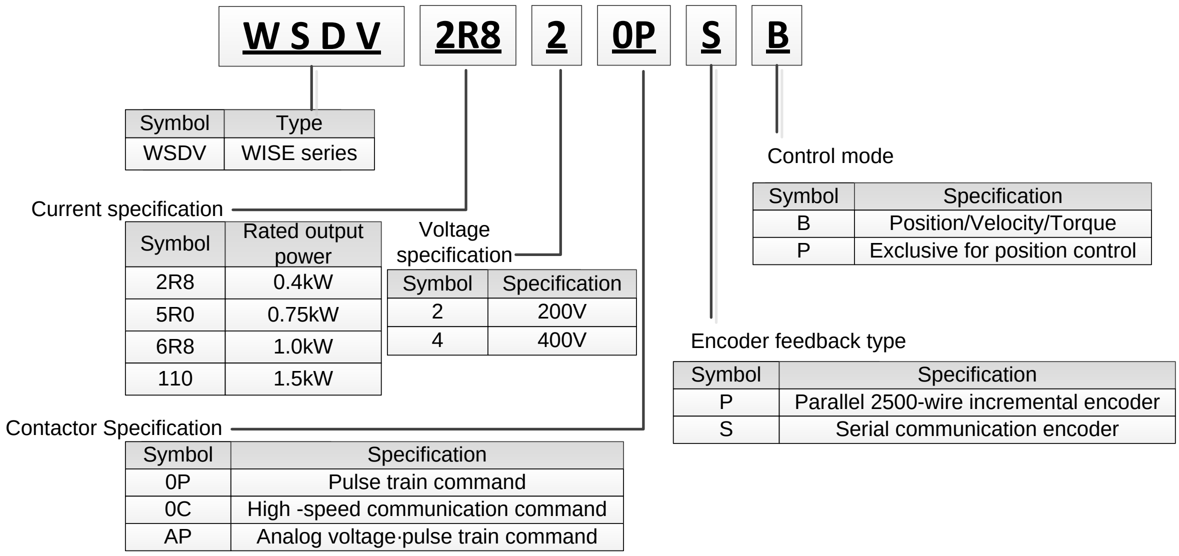


Fig. 2-1 WISE ordering options

2.2 Technical Specification

Table 2 Table of technical specifications

Basic specifications		
Main-circuit power	WSDV-2R8 WSDV-5R0 WSDV-6R8	Single/3-phase 200V～240V $^{+10\%}_{-15\%}$ 50/60Hz
	WSDV-110	3-phase 200V～240V $^{+10\%}_{-15\%}$ 50/60Hz
Control circuit power	Signle phase 200V～240V $^{+10\%}_{-15\%}$ 50/60Hz	
Encoder feedback	17-bit(131072 resolution)7-wire serial absolute encoder; 20-bit(1048576 resolution)5-wire serial incremental encoder; 2500-wire(10000 resolution)ABZ incremental encoder.	

<table>
<tr><th colspan="4">Basic specifications</th></tr>
<tr><td>Pulse+Direction input signal</td><td colspan="3">2 differential inputs (one for pulse differential input and the other for direction differential input).</td></tr>
<tr><td>Pulse output</td><td colspan="3">Feed out encoder feedback pulse(A,B and Z-phase)in line driver.</td></tr>
<tr><td>Communication function</td><td colspan="3">Connection with PC ("iMotion" software) via USB.</td></tr>
<tr><td>Control input</td><td colspan="3">8 inputs for general purposes, signals are:
①Alarm clear input (A-CLR) ②Internal command velocity selection (INTSPD1, INTSPD2, INTSPD3) ③Positive direction over-travel inhibition input (POT) ④Negative direction over-travel inhibition input (NOT) ⑤Command pulse inhibition (INH) ⑥SRV-ON ⑦Zero-speed clamp (ZEROSPD) ⑧Gain switching (GAIN) etc.</td></tr>
<tr><td>Control output</td><td colspan="3">7 outputs for general purposes, among which alarm output ALM is designated to SO3, and the rest of 6 outputs are:
①External brake release signal (BRK-OFF) ②Servo-Ready output (S-RDY) ③Positioning complete signal (INP) ④Zero-speed clamp detection signal (ZSP) ⑤Torque in-limit signal (TLC) ⑥Spped consistent (V-COIN) ⑦Speed arrival (AT-SPEED) ⑧Warning (WARN1) ⑨Velocity in-limit (V-LIMIT).</td></tr>
<tr><td>Control mode</td><td colspan="3">① Position control ②Velocity control ③Torque control</td></tr>
<tr><th colspan="4">Functions</th></tr>
<tr><td rowspan="7">Position control</td><td>Control input</td><td colspan="2">①Deviation counter clear; ②Command pulse input inhibition;
③Command dividing gradual increase switching; ④Gain swithcing input, etc</td></tr>
<tr><td>Control output</td><td colspan="2">Positioning complete output.</td></tr>
<tr><td rowspan="4">Pulse input</td><td>Max. pulse input frequency</td><td>Line drive: 1Mpps;
Photocoupler: 200kpps.</td></tr>
<tr><td>Pulse input mode</td><td>Differential input. Selectable with parameter(①Positive/Negative; ② A and B-phase; ③Command and direction)</td></tr>
<tr><td>Electronic gear (Division/Multiplication of command pulse)</td><td>Use the electronic gear ratio within the range 1/1000times to 1000 times.</td></tr>
<tr><td>Filter</td><td>Command smoothing filter, FIR type filter, primary delay filter</td></tr>
<tr><td>Pulse output</td><td colspan="2">A, B and C-phase: line driver output.
Division pulse number: 1~1/4 of the encoder resolution setup value.</td></tr>
<tr><td rowspan="3">Velocity control</td><td>Control input</td><td colspan="2">①Internal command velocity selection 1;
②internal command velocity selection 2;
③internal command velocity selection 3;
④Zero-speed clamp</td></tr>
<tr><td>Control output</td><td colspan="2">Speed arrival</td></tr>
<tr><td>Internal</td><td colspan="2">Switching the internal 8 speed is enabled by command</td></tr>
</table>

Basic specifications		
	velocity command	input.
	Velocity command Acc./Dec. adjustment	Individual setup of acceleration and deceleration is enabled,with 0s/1000 r/min to 10s/1000 r/min. Sigmoid acceleration/deceleration is also enabled.
	Zero-speed clamp	0-clamp of internal velocity command with speed zero clamp input is enabled.
Torque control	Control input	Zero-speed clamp input.
	Control output	Speed arrival.
	Velocity limit	Velocity limit can be enabled through parameter setting.
	Toruqe command filter	One first-order low-pass filter, four notch filter.
Protective funcitons		
Hardware Protection	Over-voltage, under-voltage, over-current, under-current, over-speed, over-load, over-load of brake resistor, over-heat of driver and encoder error etc.	
Software protection	Register error, initialization failure, I/O allocation abonormal, too large position variation, etc	
Error history	Up to 14 alarm data can be traced.	

2.3 Dimensions

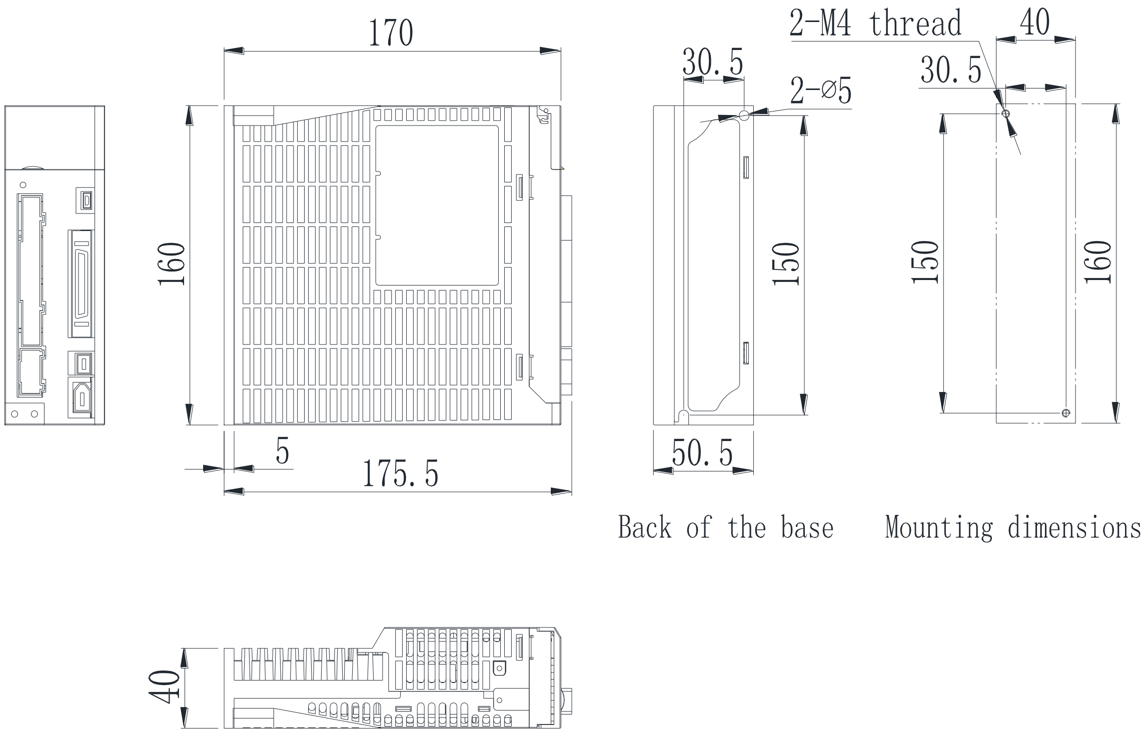


Fig. 2-2 Dimensional drawing of driver WSDV-2R8

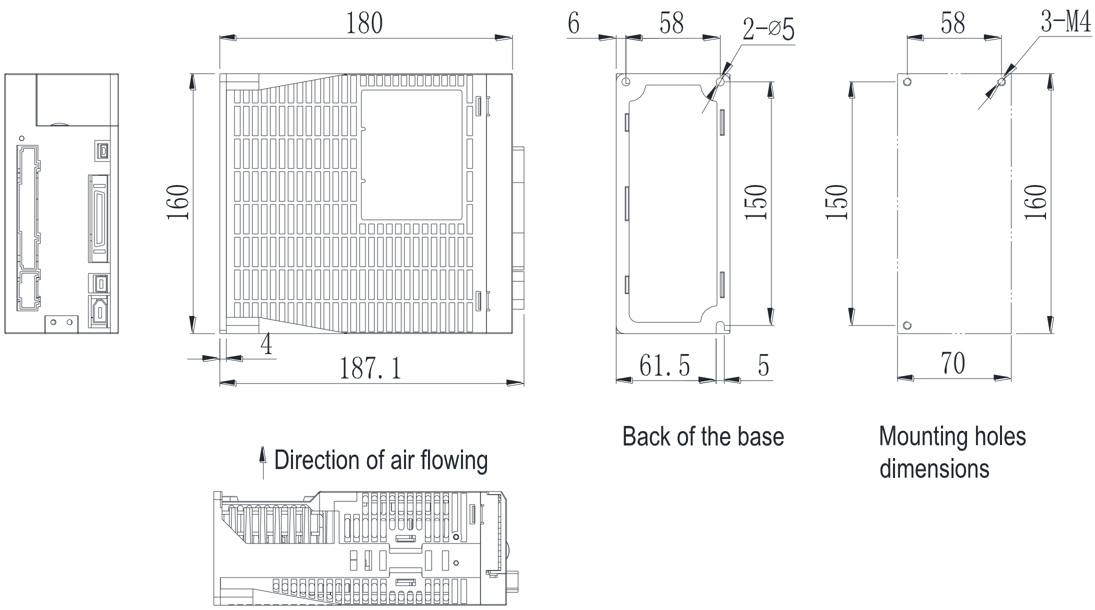


Fig. 2-3 Dimensional drawing of driver WSDV-5R0 and WSDV-6R8

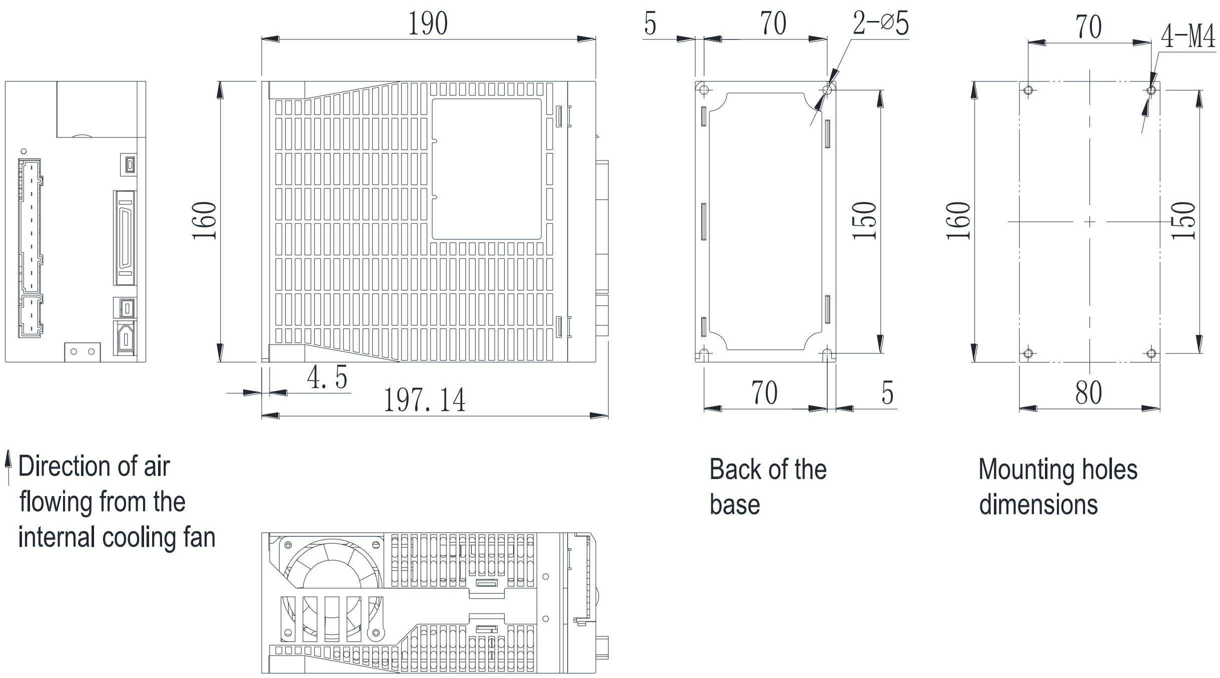


Fig. 2-4 Dimensional drawing of driver WSDV-110

3 Servo Motor

3.1 Ordering Information of Servomotor Model

Contents of servomotor nameplate consist of product series name + rated power + voltage specification + encoder specification + design order + motor structure, as shown below:

MHMD 04 2 G 1 U

Symbol	Specifications
MSME	Low inertia（1.0kW）
MDME	Medium inertia（1.0kW~1.5kW）
MHMD	High inertia（0.4kW~0.75kW）
MHME	High inertia（1.5kW）

Rated output power

Symbol	Rated output power
04	0.4kW
08	0.75kW
10	1.0kW
15	1.5kW

Voltage specification

Symbol	Specification
2	200V
4	400V

Rotary encoder specification

Symbol	Format	Pulse count	Resolution	Wire count
G	Incremental	20-bit	1048576	5-wire
S	Absolute	17-bit	131072	7-wire

Design order

1：**Standard**

Motor structure

MHMD

Symbol	Shaft		Holding brake		Oil seal	
	D-cut	Key way	Without	With	Without	With
A	●		●		●	
B	●			●	●	
C	●		●			●
D	●			●		●
S		●	●		●	
T		●		●	●	
U		●	●			●
V		●		●		●

MSME(1.0kW)
MDME、MHME

Symbol	Shaft		Holding brake		Oil seal	
	D-cut	Key way	Without	With	Without	With
C	●		●			●
D	●			●		●
G		●	●			●
H		●		●		●

Fig. 3-1 Ordering options of servo driver

3.2 Technical Specifications and Dimensions

3.2.1 MHMD Series

Table 3 MHMD series servomotor specifications

Series	MHMD	
Rated output power(kW)	0.4	0.75
Applicable driver model	WSDV-2R820PSB	WSDV-5R020PSB
Rated torque(N•m)	1.3	2.4
Max. torque(N•m)	3.8	7.1
Rated rotational speed/Max. rotational speed(rpm)	3000/5000	3000/4500

Series		MHMD	
Motor inertia($\times 10^{-4}$kg•m^2)	Without brake	0.67	1.51
	With brake	0.7	1.61
Recommended the max. ratio of load inertia against the rotor (of the motor) inertia		30 times or less	20 times or less
Transformer capacity(KVA)		0.9	1.3
Encoder		20-bit incremental encoder or 17-bit abosulte encoder	
Mass(KG)(Brake: Without/With)		1.4/1.8	2.5/3.5
LL	Without brake	118	127
	With brake	154.5	164
LR		30	35
S		14	19
LA		70	90
LB		50	70
LC		60	80
LE		3	3
LF		6.5	8
LH		43	53
LZ		4.5	6
Key (D-cut/Key-way)	LW	25	25
	LK	22.5	22
	KW	5h9	6h9
	KH	5	6
	RH	11	15.5
	TP	M5 depth 10	M5 depth 10

CAUTION

When actual value of load rotating inertia is larger than the recommended value listed in above table, please consult us.

◆ **Dimensional Drawing**

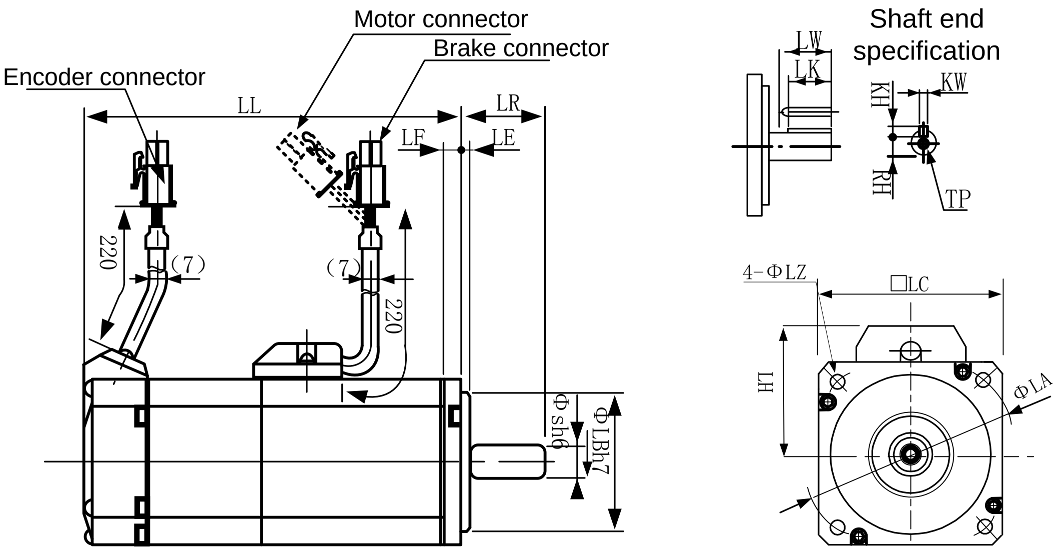


Fig. 3-2 Dimensional drawing of MHMD series servomotor

◆ **Brake specifications (To remain braking state, exciting here represents releasing. It cannot be used to brake when motor is rotating.)**

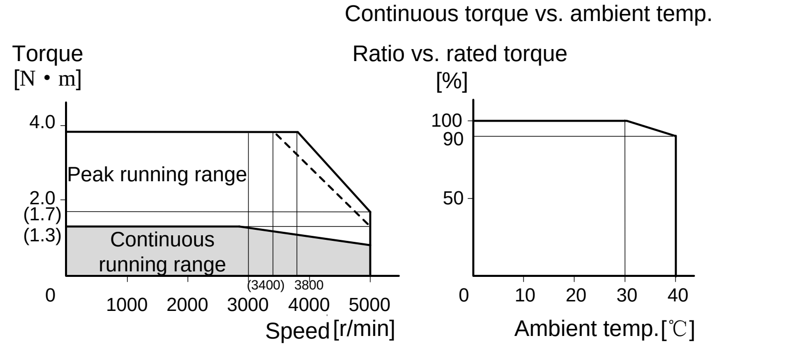
Series	MHMD	
Rated output power(kW)	0.4	0.75
Static friction torque(N・m)	1.27 or more	2.45 or more
Engaging time(ms)	50 or less	70 or less
Releasing time(ms)	15 or less	20 or less
Exciting current DC(A)	0.36	0.42
Releasing voltage DC(V)	1 or more	1 or more
Exciting voltage DC(V)	24±1.2	24±1.2

CAUTION Releasing time values represents the ones with DC-cutoff using a varistor.

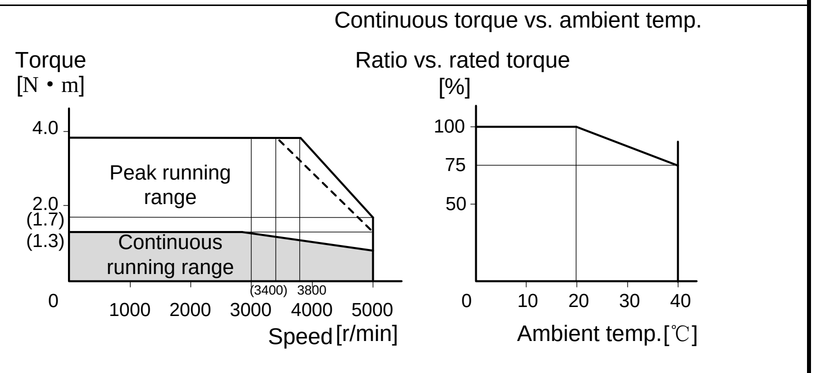
◆ **Torque characteristics (Dotted line represents torque at 10% less voltage)**

MHMD 0.4kW

Without oil seal

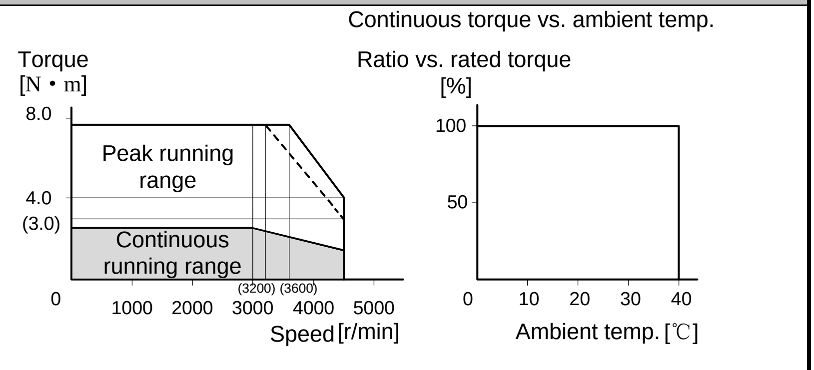


With oil seal

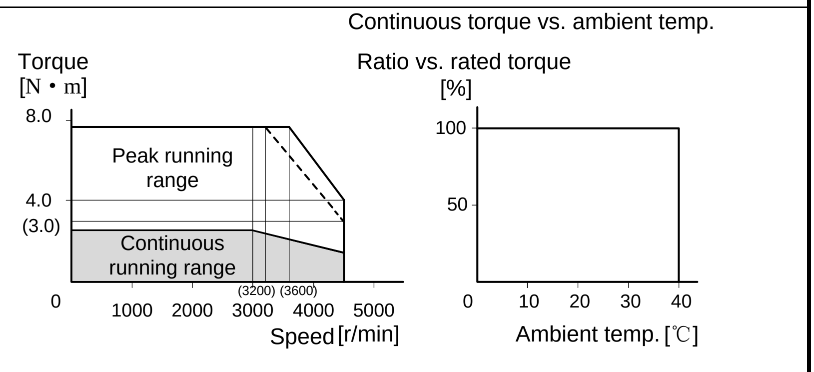


MHMD 0.75kW

Without oil seal



With oil seal



3.2.2 MDME/ MHME Series

Table 4 MDME/ MHME servomotor specifications

Series		MDME	MHME	MDME	MHME
Rated output power(kW)		1.0		1.5	
Applicable driver model		WSDV-6R820PSB		WSDV-11020PSB	
Rated torque(N•m)		4.77	4.77	7.16	7.16
Max. torque(N•m)		14.3	14.3	21.5	21.5
Rated rotational speed /Max. rotational speed(rpm)		2000/3000	2000/3000	2000/3000	2000/3000
Motor inertia(kg• cm-4)	Without brake	4.6	24.7	6.7	37.1
	With brake	5.9	26	7.99	38.4
Recommended load moment of inertia (as much as the moment of inertia)		10 times or less	5 times or less	10 times or less	5 times or less
Transformer capacity(KVA)		1.8	1.8	2.3	2.3
Encoder		20-bit incremental encoder or 17-bit abosulte encoder			
Mass (KG)(Brake: Without/With)		5.2/6.7	6.7/8.1	6.7/8.2	8.6/10.1
LL	Without brake	140	173	157.5	192.5
	With brake	165	198	182.5	217.5
LR		55	70	55	70
S		22	22	22	22
LA		145	145	145	145
LB		110	110	110	110
LC		130	130	130	130
LD		165	165	165	165
LE		6	6	6	6
LF		12	12	12	12
LG		60	60	60	60
LH		116	116	116	116
LM	Without brake	94	129	111.5	146.5
	With brake	119	154	136.5	171.5
LZ		9	9	9	9
Key	LW	45	45	45	45
	LK	41	41	41	41
	KW	8h9	8h9	8h9	8h9
	KH	7	7	7	7
	RH	18	18	18	18

CAUTION

When the actual value of load rotating inertia is larger than the one listed in above table, please contact us.

◆ **Dimensional drawing**

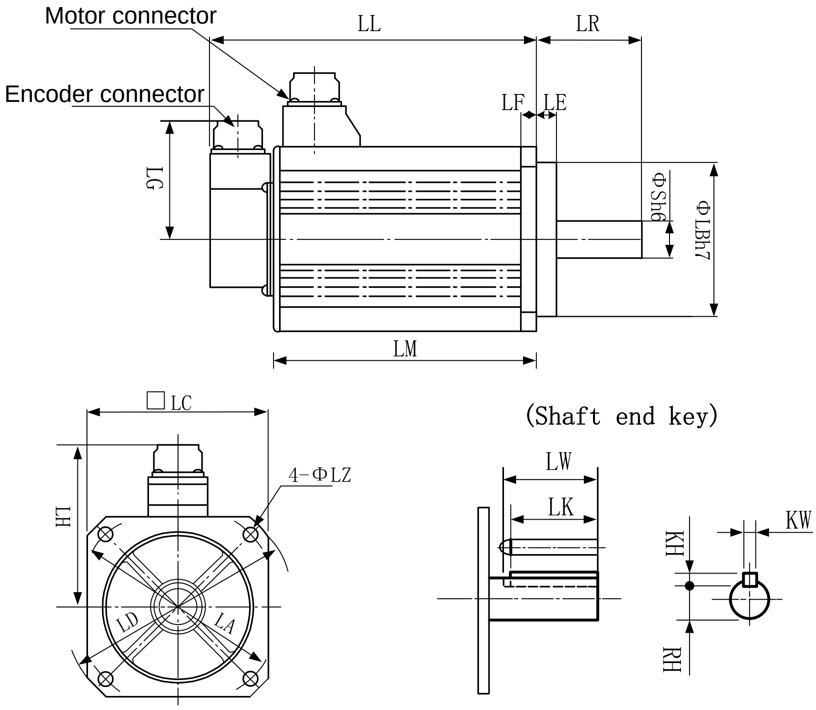


Fig. 3-3 Dimensional drawing of MDME/MHME series servomotor

◆ **Brake specifications**

To enable the holding brake, exciting here represents releasing. It cannot be used to brake when motor is rotating.

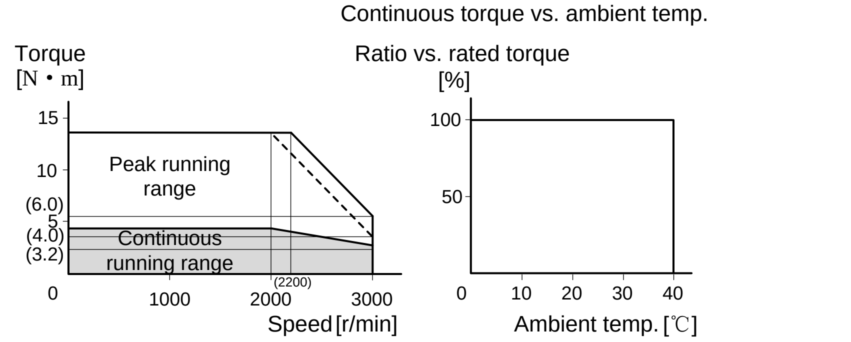
Series	MDME		MHME	
Rated output power(kW)	1.0	1.5	1.0	1.5
Static friction torque(N・m)	4.9 or more	13.7 or more	4.9 or more	13.7 or more
Engaging time(ms)	80 or less	100 or less	80 or less	100 or less
Releasing time(ms)	70 or less	50 or less	70 or less	50 or less
Exciting current DC(A)	0.59±10%	0.79±10%	0.59±10%	0.79±10%
Releasing voltage DC(V)	2 or more	2 or more	2 or more	2 or more
Exciting voltage DC(V)	24±2.4	24±2.4	24±2.4	24±2.4

CAUTION Releasing time values represents the ones with DC-cutoff using a varistor.

◆ **Torque characteristics (Dotted line represents torque at 10% less voltage)**

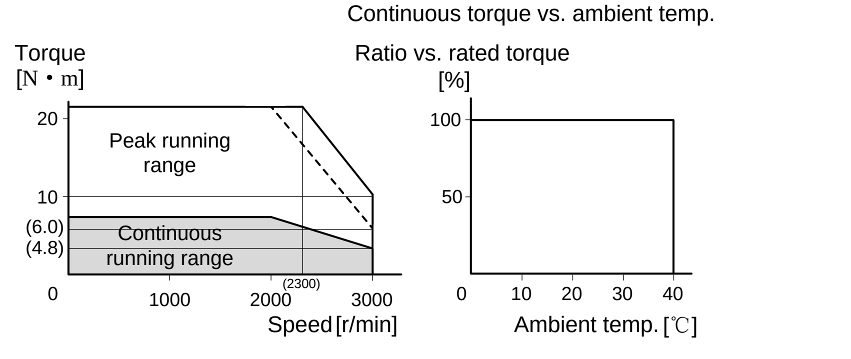
MDME/MHME 1.0kW

With oil seal



MDME/MHME 1.5kW

With oil seal



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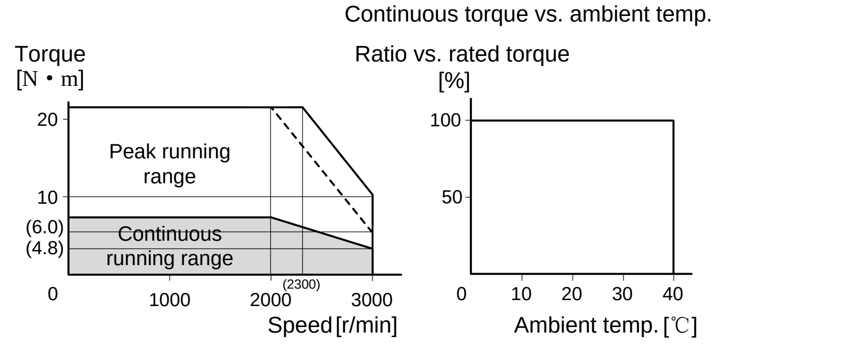
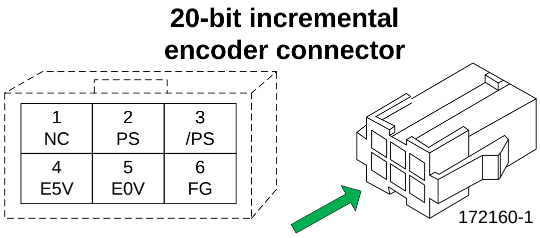
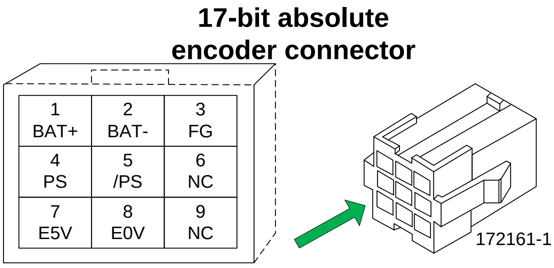


3.3 MHMD Series Motor Side Connector

When motor MHMD(0.4kW,0.75kW) is used, please refer to chapter 3.3.1 and 3.3.2 for correct wiring.

3.3.1 Pin Disposition of Connector for Encoder Cable





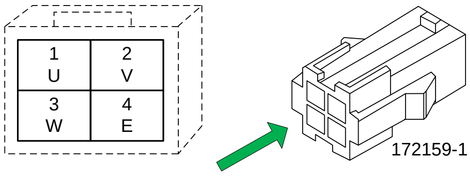
Pin No.	Utility
1	NC
2	Signal positive
3	Signal negative
4	Power 5V
5	Power 0V
6	Ground shield

Pin No.	Utility
1	Battery positive
2	Battery negative
3	Ground shield
4	Signal positive
5	Signal negative
6	NC
7	Power 5V
8	Power 0V
9	NC

WARNING DO NOT connect anything to NC pins.

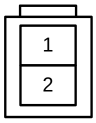
3.3.2 Pin Disposition of Connector for Motor Cable and Brake Cable

Motor connector



Pin No.	Utility
1	U-phase
2	V-phase
3	W-phase
4	Ground wire

Brake connector



Pin No.	Utility
1	Brake
2	Brake

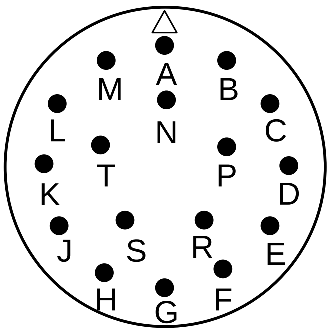
WARNING DO NOT connect anything to NC pins.

3.4 Pin Disposition of Connector for MDME/ MHME Motor Side Connector

When MDME/MHME(1.0kW, 1.5kW) motor is used, refer to chapter 3.4.1 and 3.4.2 to connect all components.

3.4.1 Pin Disposition of Connector for Encoder Cable

IP65 motor encoder connector



N/MS3102A20-29P

20-bit incremental encoder connector

Pin No.	Utility
A	NC
B	NC
C	NC
D	NC
E	NC
F	NC
G	Power 0V
H	Power 5V
J	Ground shield
K	Signal positive
L	Signal negative
M	NC
N	NC
P	NC
R	NC
S	NC
T	NC

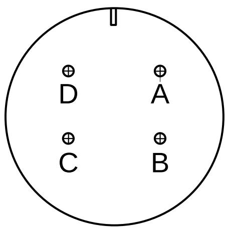
17-bit absolute encoder connector

Pin No.	Utility
A	NC
B	NC
C	NC
D	NC
E	NC
F	NC
G	Power 0V
H	Power 5V
J	Ground shield
K	Signal positive
L	Signal negative
M	NC
N	NC
P	NC
R	NC
S	Battery negative
T	Battery positive

WARNING DO NOT connect anything to NC pins.

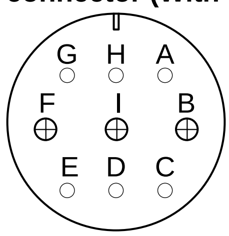
3.4.2 Pin Disposition of Connector for Motor/Brake Cables

Motor connector (Without brake)



JL04V-2E20-4PE-B-R

Motor connector (With brake)



JL04V-2E20-18PE-B-R

Pin No.	Utility
A	U-phase
B	V-phase
C	W-phase
D	Ground wire

Pin No.	Utility
G	Brake
H	Brake
A	NC
F	U-phase
I	V-phase
B	W-phase
E	Ground wire
D	Ground wire
C	NC

WARNING DO NOT connect anything to NC pins.

3.5 Calculations for Motor Selection

3.5.1 Select Motor Capacity

3.5.1.1 Confirm Driving System Structure

On most occasions, when you want to choose a motor, you need to take the structure of driving system into consideration first. Following are some typical examples of driving system.

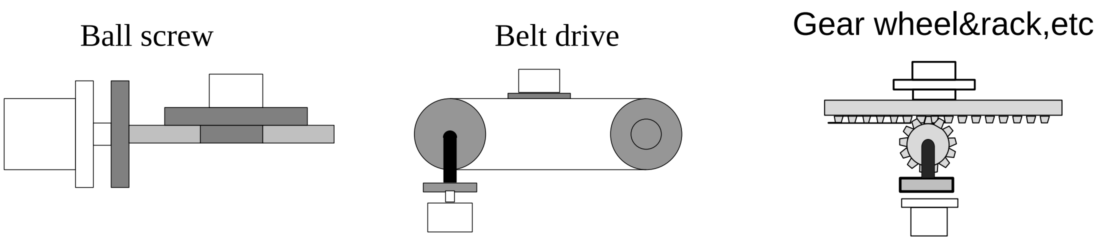


Fig. 3-4 Typical examples of driving system

In addition, you need to confirm some detailed specifications of parts, such as ball screw length, guide travel as well as belt diameter, etc.

3.5.1.2 Decide the Running mode

You need to consider following aspects to decide the motor running mode: acceleration & deceleration time, constant speed time, time for stopping, cycle time and movement distance.

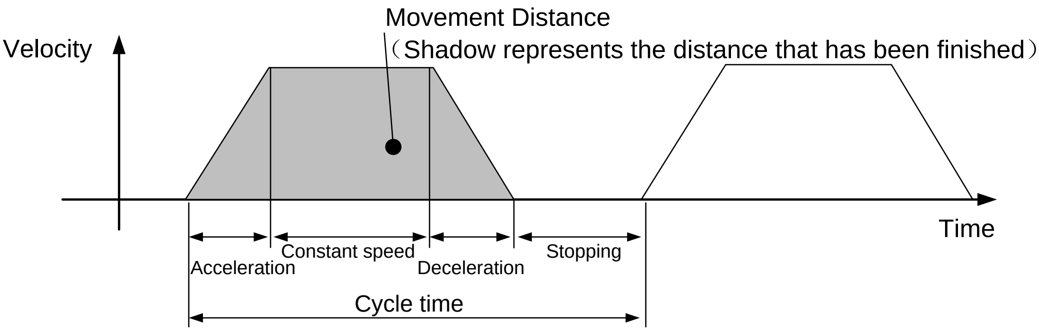


Fig. 3-5 Motor Running mode

CAUTION

Running mode affects the selection of motor capacity to a great extent. If there is no demanding requirement on the acceleration/deceleration time and stopping time, you can make them longer as desired, therefore, a motor with relatively small capacity can be chosen.

3.5.1.3 Calculate Load Inertia and Inertia Ratio

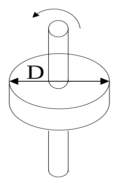
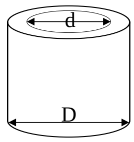
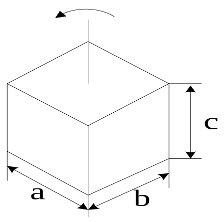
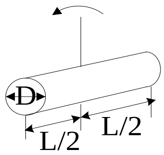
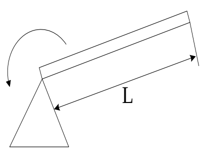
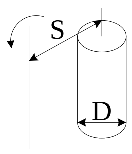
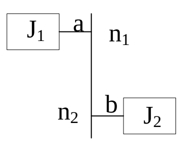
Inertia is the power or force used to maintain a certain motion state.

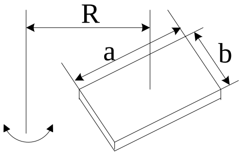
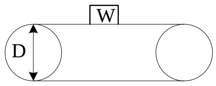
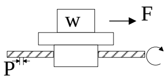
Inertia ratio (J_L/J_M) is the result of equivalent value of load inertia to servomotor shaft (with symbol "J_L")

divided by rotating inertia value of the motor (with symbol "J_M"). The parameter for inertia ratio of WISE driver is Pr004, whose default value is 250, namely, 2.5 times of the value of rotating inertia value of the motor.

According to general standards, for motor with 0.75kW less capacity, inertia ratio is 20 times or less, while for ones with 1.0kW less capacity, it is 10 times or less.

If more quick response is required, the inertia ratio should be smaller; on the contrary, if acceleration time can be several seconds, a larger inertia ratio can be enabled. Please note that unit of motor inertia listed on the product catalog is "$\times 10^{-4}$kg • m^2".

Shape	**Formula for J**	**Shape**	**Formula for J**
Disc 	$J = \frac{1}{8} WD^2 [kg \cdot m^2]$ W:Mass [kg] D:Outer diamater [m]	Hollow cylinder 	$J = \frac{1}{8} W(D^2 + d^2) [kg \cdot m^2]$ W:Mass [kg] D:Outer diameter [m] d:Inner diameter [m]
Prism 	$J = \frac{1}{12} W(a^2 + b^2) [kg \cdot m^2]$ W:Mass [kg] a,b,c:Lengths of three sides of the prism [m]	Homogeneous cylinder rod 	$J = \frac{1}{48} W(3D^2 + 4L^2) [kg \cdot m^2]$ W:Mass [kg] D:Outer diameter [m] L:Length [m]
Straight rod 	$J = \frac{1}{3} WL^2 [kg \cdot m^2]$ W:Mass [kg] L:Length of rod [m]	Cylinder rod away from the rotating center 	$J = \frac{1}{8} WD^2 + WS^2 [kg \cdot m^2]$ W:Mass [kg] D:Outer diamter [m] L:Length [m]
Rotary axis away from the cube center	$J = W(\frac{a^2 + b^2}{12} + R^2) [kg \cdot m^2]$ W:Mass[kg] a,b:Length/width of cube [m] R:Length [m]	Reducer 	Convert to inertia ratio of a axis $J = J_1 + (\frac{n_2}{n_1})^2 J_2 [kg \cdot m^2]$ n_1:rotational speed of a axis [r/min] n_2:rotational speed of b axis [r/min]

Shape	Formula for J	Shape	Formula for J
			
Conveyor 	$J = \frac{1}{4}WD^2[kg \cdot m^2]$ W:Mass[kg] D:Diameter of the wheel [m] J without the wheel	Ball screw 	$J = J_1 + \frac{W \times P^2}{4\pi^2}[kg \cdot m^2]$ W:Mass [kg] P:Rail travel [m] J_1:J of ball screw [kg•m²]

If you don't know the mass [kg], calculate according to the following formula.

Mass W[kg]=Density ρ [kg/m^3]× Volume V[m^3]

Here are density references of some typical substances.

Iron ρ =7.9×10^3[kg/m^3] Aluminum ρ =2.8×10^3 [kg/m^3] Brass ρ =8.5×10^3 [kg/m^3]

3.5.1.4 Calculate the Torque

1) Peak torque

Peak torque refers to the max. torque required in running, mainly in acceleration and deceleration stages.

The value is approximate 80% less of the max. torque of the motor. If the value is negative, a regenerative resistor may be needed.

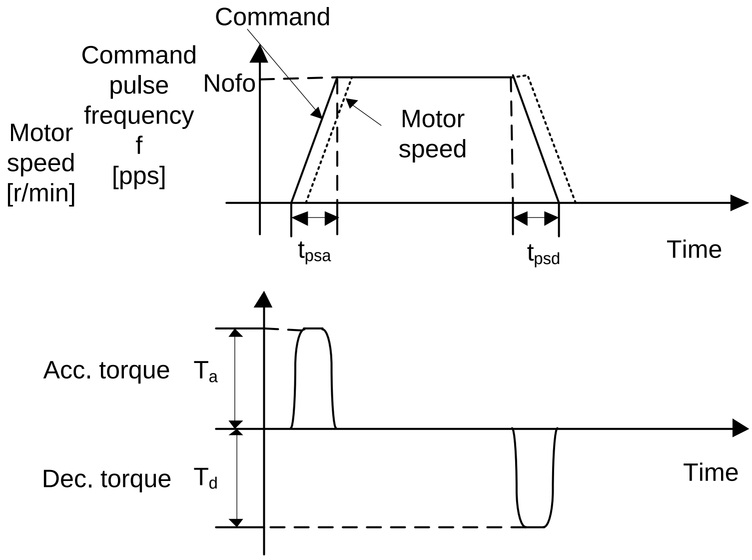


Fig. 3-6 Illustration of peak torque

Acceleration torque: $T_a = \frac{(J_L + J_M)\times 2\pi N}{t_{psa}} + \text{Running torque}$ (Unit: N • m)

Deceleration torque: $T_d = \frac{(J_L + J_M)\times 2\pi N}{t_{psd}} - \text{Running torque}$ (Unit: N • m)

J_L: Load moment of inertia (unit: kg • m^2)

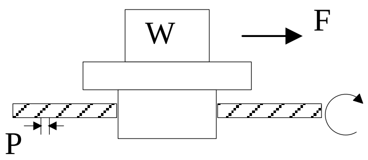
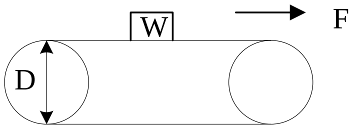
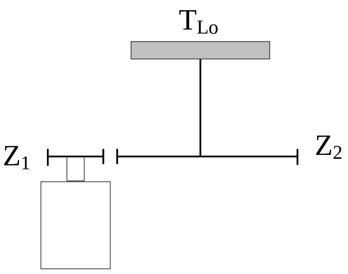
J_M: Rotor moment of inertia (unit: kg • m^2)

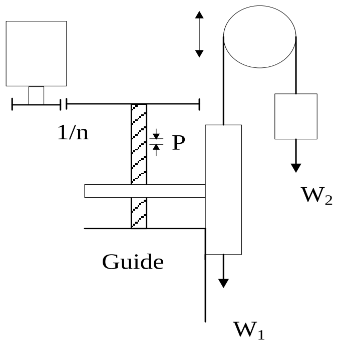
N: Motor rotational speed (unit: r/s)

2) Constant Torque and Holding Torque when Stopping

Constant torque and holding torque when stopping are the torque required when motor keeps rotating for a long time, whose value is approximate 80% less of rated torque of the motor. If the value is negative, a regenerative resistor may be needed.

Calculate torques of different driving systems according to the following formulas.

<table>
<tr><th>Driving system</th><th>Formula for T</th></tr>
<tr><td>Ball screw
</td><td>Constant torque $T_f = \frac{P}{2\pi\eta}(\mu gW+F)$
W:Mass [kg] η :Mechanical effiency
P:Guide travel [m] μ :Friction coefficient
F:External force [N] g:Gravitational acceleration 9.8[m/s^2]</td></tr>
<tr><td>Belt driving system
</td><td>Constant torque $T_f = \frac{D}{2\pi\eta}(\mu gW+F)$
W:Mass[kg] η :Mechanical effiecncy
D:Guide travel [m] μ :Friction coefficient
F:External force [N] g:Gravitational acceleration 9.8[m/s^2]</td></tr>
<tr><td>Rotating parts
</td><td>Constant torque $T_f = \frac{1}{n}\times\frac{1}{\eta}\times T_{L0}+T_F$
T_{L0}:Load torque T_F:Load friction torque
1/n:Electronic gear ratio $n=\frac{Z_2}{Z_1}$
η :Mechanical effiency</td></tr>
</table>

Driving system	Formula for T
Vertical axis 	Ascending $T_f = T_U + T_F$ Decending $T_f = -T_U \times \eta^2 + T_F$ T_F:Friction torque of moving parts $T_U = \frac{(W_1+W_2)}{2\pi\eta} \times g \times P$ $T_F = \frac{\mu(W_1+W_2)}{2\pi\eta} \times g \times P$ W_1:Load mass [kg] W_2:Balancing mass [kg]

3) Effective Torque

Effective torque can be figured out according to the formula below, whose value is approximate 80% less of rated torque of the motor.

$$T_{rms} = \sqrt{\frac{T_a^2 \times t_a + T_f^2 \times t_b + T_d^2 \times t_d}{t_c}}$$

T_a: Acceleration torque [N•m] t_a: Acceleration time [s] t_c: Cycle time [s]

T_f: Constant torque [N•m] t_b: Constant speed time [s] (Rotating time + Stopping time)

T_d: Deceleration torque [N•m] t_d: Deceleration time [s]

3.5.1.5 Rotational Speed of Motor

Max. rotational speed means the permissible max. rotational speed of the motor in running period, whose value is approximate less than rated rotational speed. However, when enabling the max. rotational speed, you should pay special attention to the torque and rising temperature.

$$V_{max} = \frac{\text{Movement distance}}{\frac{\text{Acc. time}}{2} + \frac{\text{Dec. time}}{2} + \text{Constant speed time}}$$

3.5.2 Example of Motor Selection

3.5.2.1 Example of Motor Selection for Ball Screw System

1) Ball Screw Structure

The structure of ball screw is illustrated as follows:

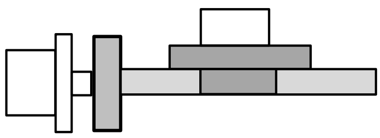


Fig. 3-7 Structure of ball screw

Mass of part W_A=10[kg] Ball screw length B_L=0.5[m]

Ball screw diameter B_D=0.02[m] Ball screw pitch B_P=0.02[m]

Ball screw efficiency B_η=0.9 Movement distance 0.3[m]

Coupling inertia $J_C=10\times10^{-6}$[kg • m²](you can refer to the value listed in product catalog or use the calculation result.)

2) Running mode

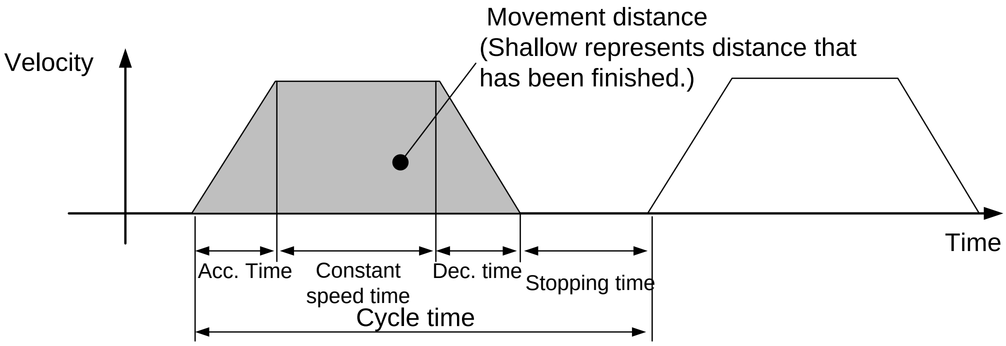


Fig. 3-8 Running mode

Acceleration time	t_a=0.1[s]	Constant speed time	t_b=0.8[s]
Deceleration time	t_d=0.1[s]	Cycle time	t_c=2[s]
Movement distance	0.3[m]		

3) Mass of the Ball Screw

$$B_W = \rho\times\pi\times\left(\frac{B_D}{2}\right)^2 B_L = 7.9\times10^3\times\pi\times\left(\frac{0.02}{2}\right)^2\times0.5 = 1.24(kg)$$

4) Load Inertia

$$J_L = J_C + J_B = J_C + \frac{1}{8}B_W\times B_D^2 + \frac{W_A\times B_P^2}{4\pi^2}$$

$$= 0.00001 + \left(1.24\times0.02^2\right)/8 + 10\times0.02^2/4\pi^2$$

$=1.73\times10^{-4}$[kg•m²]

5) Preselect Motor

If a motor with output capacity of 0.2kW is selected, then $J_M=0.14\times10^{-4}$[kg•m²].

6) Inertia Ratio

$J_L/J_M=1.73\times10^{-4}/0.14\times10^{-4}$[kg•m²]=12.3 times <30 times

If a motor with output capacity of 0.1kW is selected, then $J_M=0.051\times10^{-4}$[kg•m²]. The result is 33.9 times, larger than 30 times.

7) Max. Velocity (Vmax)

$$V_{\max} = \frac{\text{Movement distance}}{\frac{\text{Acc. times}}{2} + \frac{\text{Dec. time}}{2} + \text{Constant speed time}}$$ =0.3/0.9=0.334[m/s]

8) Rotational Speed

You need to convert it to N[r/min]. The guide travel per revolution of ball screw will be B_P=0.02[m]

N=0.334/0.02=16.7[r/s]=16.7×60=1002[r/min]<3000[r/min] (Rated rotational speed of motor (0.2kW))

9) Calculate the Torque

Constant Torque: $T_f = \frac{P}{2\pi\eta}(\mu gW+F) = \frac{0.02}{2\pi \times 0.9}\left(0.1\times 9.8\times 10+0\right)$

=0.035[N•m]

Acceleration torque: $T_a = \frac{(J_L + J_M)\times 2\pi N}{t_{psa}} + \text{Running torque}$

$$= \frac{(1.73\times 10^{-4} + 0.14\times 10^{-4})\times 2\pi \times 16.7}{0.1} + 0.035$$

=0.196+0.035=0.231[N•m]

Deceleration torque: $T_d = \frac{(J_L + J_M)\times 2\pi N}{t_{psd}} - \text{Running torque}$

=0.196-0.035=0.161[N•m]

10) Confirm the Max. Torque

Acceleration torque =T_a=0.231[N•m]<1.91[N•m] (the Max. torque of motor (0.2kW))

11) Confirm the Effective Torque

$$T_{rms} = \sqrt{\frac{T_a^2 \times t_a + T_f^2 \times t_b + T_d^2 \times t_d}{t_c}} = \sqrt{\frac{0.231^2 \times 0.1 + 0.035^2 \times 0.8 + 0.161^2 \times 0.1}{2}}$$

=0.067[N•m]<0.64[N•m] (the rated torque of motor (0.2kW))

12) Confirm Motor Selection

Taking all calculations above into consideration, you can find that despite there is relatively large torque allowance when choosing motor (0.2kW), it is a suitable choice considering inertia ratio.

3.5.2.2 Example of Motor Selection for Belt Driving System

1) Belt Driving System Structure:

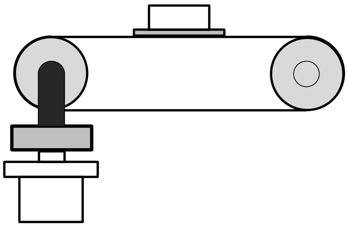


Fig. 3-9 Structure of belt driving system

Mass of part W_A=10[kg]

Belt diameter P_D=0.05[m] (you can refer to the value listed in product catalog or use calculation result.)

Mass of driving wheel W_P=0.5[kg]

Ball screw efficiency B_η=0.8

Coupling inertia J_C=0[kg•m^2](Motor shaft is connected directly.)

2) Running Mode

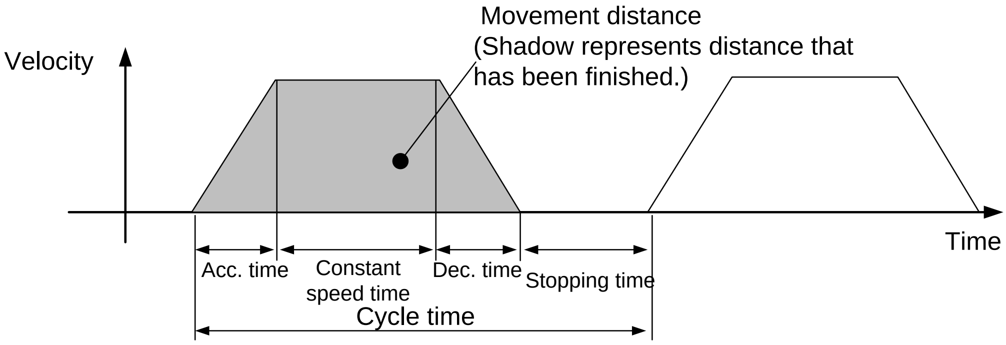


Fig. 3-10 Running mode

Acceleration time t_a=0.1[s]

Constant speed time t_b=0.8[s]

Deceleration time t_d=0.1[s]

Cycle time t_c=2[s]

Movement distance 1[m]

3) Load Inertia

$$J_L = J_C\text{(Coupling)}+J_B\text{(Belt driving application)}+J_P\text{(Driving wheel)}$$

$$= J_C + \frac{1}{4}W_A \times P_D^2 + \frac{1}{8}W_P \times P_D^2 \times 2$$

$$=0+\frac{1}{4}2\times 0.05^2+\frac{1}{8}\times 0.5\times 0.05^2\times 2$$

=0.00156=15.6$\times$10^{-4}[kg•m^2]

4) Preselect Motor

When a motor with output capacity of 0.75kW is selected, then J_M=0.87$\times$10^{-4}[kg•m^2]

5) Inertia Ratio

J_L/J_M=15.6×10^{-4}/0.87×10^{-4}[kg•m^2]=17.9 times <20 times

6) Max. Velocity

$$V_{\max} = \frac{\text{Movement distance}}{\frac{\text{Acc. time}}{2} + \frac{\text{Dec. time}}{2} + \text{Constant speed time}} = 1/0.9 = 1.111[\text{m/s}]$$

7) Rotational Speed

You need to convert it to N [r/min]. Per revolution of driving wheel $\pi \times P_D$=0.157[m]

N=1.111/0.157=7.08[r/s]=7.08×60=424.8[r/min]<3000[r/min]

8) Calculate the Torque

Constant torque: $$T_f = \frac{P}{2\eta}(\mu g W_A + F) = \frac{0.05}{2\times 0.8}(0.1\times 9.8\times 2+0)$$

=0.061[N•m]

Acceleration torque: $$T_a = \frac{(J_L + J_M)\times 2\pi N}{t_{psa}} + \text{Running torque}$$

$$= \frac{(15.6\times 10^{-4} + 0.87\times 10^{-4})\times 2\pi \times 7.08}{0.1} + 0.061$$

=0.751+0.061=0.812[N•m]

Deceleration torque: $$T_d = \frac{(J_L + J_M)\times 2\pi N}{t_{psd}} - \text{Running torque}$$

=0.751-0.061=0.69[N•m]

9) Confirm the Max. Torque

Acceleration torque =T_a=0.812[N•m]<7.1[N•m](the max. torque of motor (0.75kW))

10) Confirm the Effective Torque

$$T_{rms} = \sqrt{\frac{T_a^2 \times t_a + T_f^2 \times t_b + T_d^2 \times t_d}{t_c}} = \sqrt{\frac{0.812^2 \times 0.1 + 0.061^2 \times 0.8 + 0.69^2 \times 0.1}{2}}$$

=0.241[N•m]<2.4[N•m](rated torque of motor (0.75kW))

11) Confirm Motor Selection

Taking all calculations above into consideration, you will find that despite there is relatively large torque allowance when motor (0.75kW) is selected, it is a suitable choice considering inertia ratio.