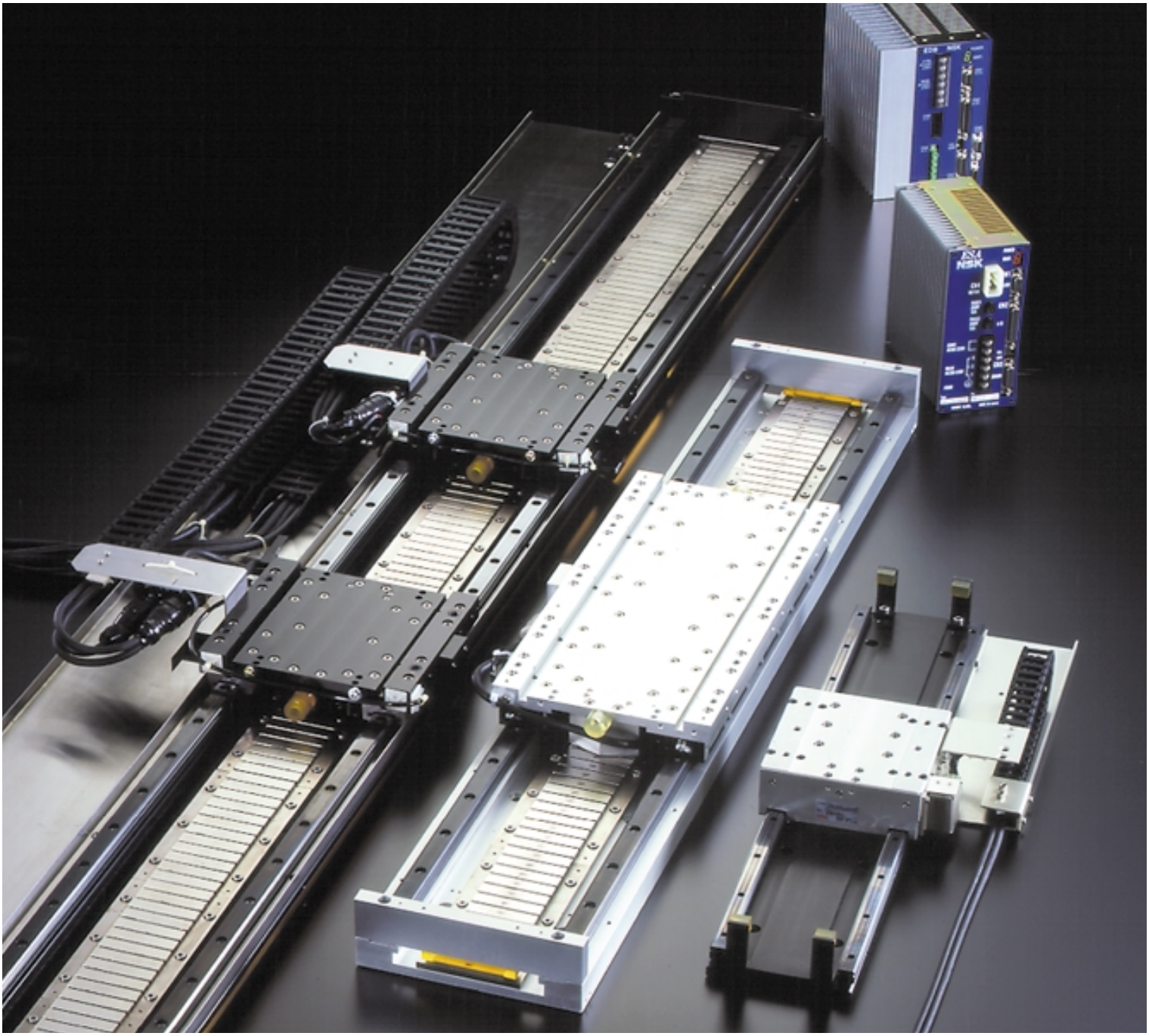
MOTION & CONTROL
NSK

Megathrust Motors

PM Series/Y Series

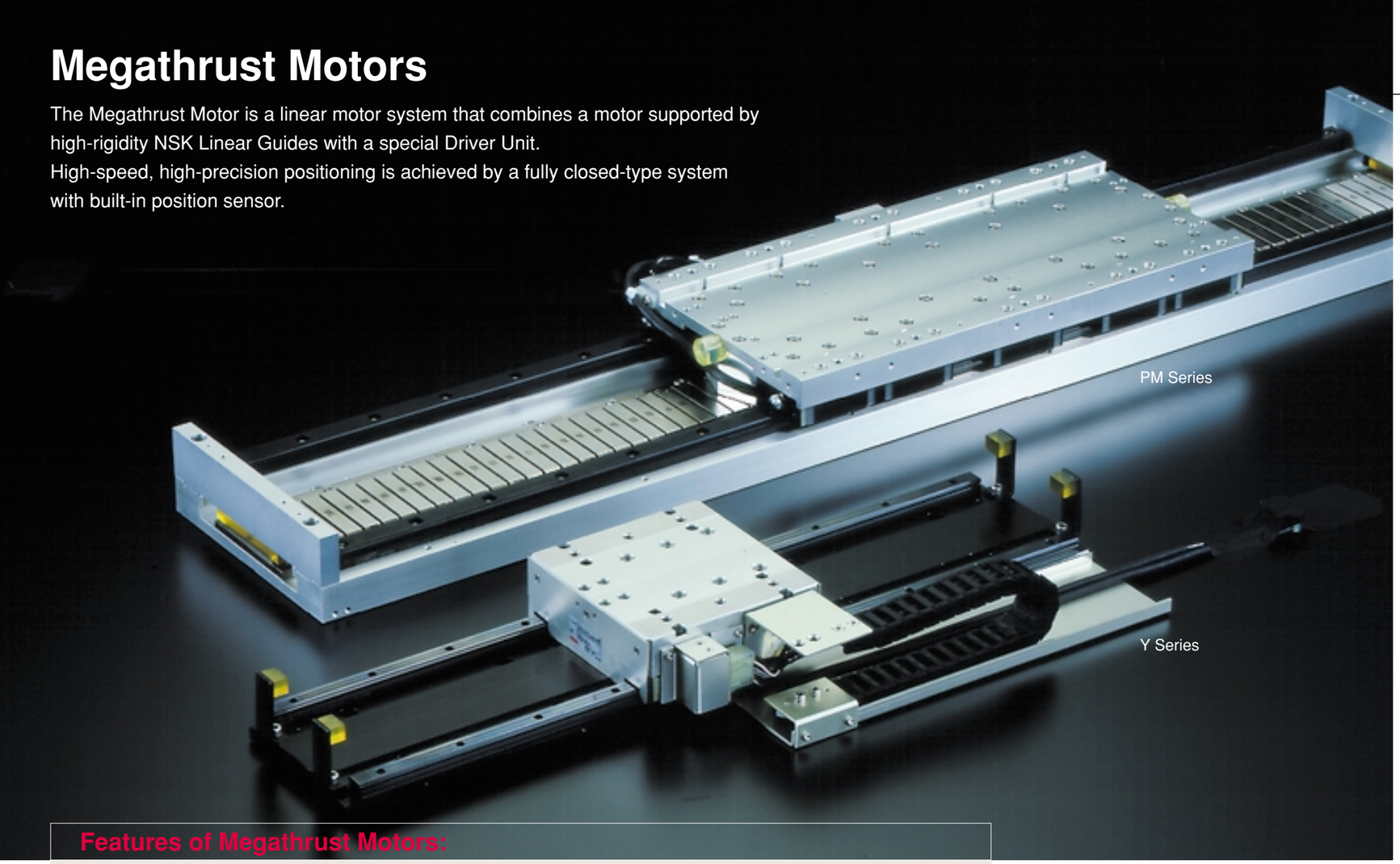
Maximum speed 2 000 mm/s, 1 μm resolution
NSK Megathrust Motors greatly contribute to
cutting-edge precision technology.

New!



Megathrust Motors

The Megathrust Motor is a linear motor system that combines a motor supported by high-rigidity NSK Linear Guides with a special Driver Unit.
High-speed, high-precision positioning is achieved by a fully closed-type system with built-in position sensor.



Features of Megathrust Motors:

① **Built-in position sensor** ····· A resolver or linear scale is built-in as a position sensor (no loss of control due to fully closed control).

② **High speed and high resolution** ····· Maximum speeds of 2 000 mm/s (for the PM Series) and 1 800 mm/s (for the Y Series) are possible as well as high resolution up to 0.5 μm.

③ **High thrust** ····· High thrust is provided in a compact design. The thrust of the Megathrust Motor indicates the actual thrust applicable in acceleration/deceleration excluding the sliding resistance of the guide.

④ **Low noise** ····· Motor construction using a permanent magnet and NSK S1™ Series Precision Linear Guides enables high thrust with low noise even in the high-speed range (PM Series).

⑤ **Excellent flatness and longer stroke transfer** ····· Unlike a ball screw system, no consideration is required for speed limitations such as critical speed. Longer stroke transfer is achieved by butting rack bases. The low cross-sectional shape (PD1, PD2, PD3, YA2, YB2, and YB3) does not change even with longer stroke.

⑥ **Multi-slider system** ····· Independently controlled multiple sliders are installed on one axis.

⑦ **Cleanliness** ····· The direct motor drive exhibits reduced dispersion of lubricant and excellent cleanliness. LG2 grease for clean environments can be applied.

⑧ **Maintenance-free operation** ····· By applying the NSK K1™ lubrication unit on the guide, long-term maintenance-free operation for five years or over 10 000 km can be achieved without replenishment.

⑨ **Operating environment** ····· The motors can be used in indoor environments of 0˚C ~ 40˚C operating temperature, 20% ~ 80% humidity, and with no dust, condensation, or corrosive gas.

Features of the Megathrust Motor PM Series and Y Series

The Megathrust Motor product lineup includes the PM Series and the Y Series, both taking full advantage of the features of a linear motor. Features of the PM Series and Y Series are listed in Table 1. Select either type according to usage conditions.

- The PM Series maintains high thrust with low noise up to the high-speed range by using a permanent magnet.
- The Y Series allows easy adjustment after set up, as sliding resistance is small when the servo motor is OFF, and the resolver is used as a position sensor. Not requiring a permanent magnet, it is low-cost and, not attracting metal particles, environmentally friendly.

Speed-thrust of PD1 (400 N) and YB3 (588 N) (Reference)

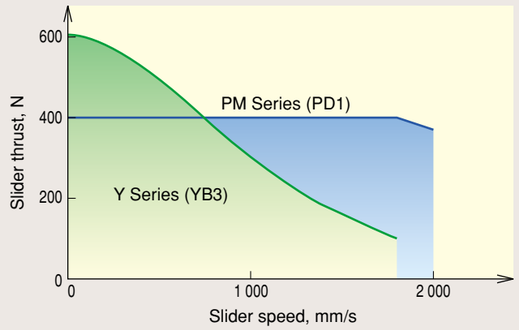


Table 1 Features of PM and Y Series

Item	PM Series	Y Series
Position sensor	Linear scale	Resolver (Linear scale also available)
Resolution (μm)	1/0.5	1/0.5 0.5 available only for linear scale
Positioning accuracy (μm)	(30/1 000) × (stroke) + 5 Stroke unit: mm	Resolver (Guaranteed only with resolution) Linear scale (Scale accuracy)
Repeatability (μm)	±1	±1
Maximum speed (mm/s)	2 000/1 500	1 800/600
Speed–thrust property	Constant thrust output up to the high-speed range	Large thrust in the low-speed range
Available duty of peak thrust	Approx. 14%	100%
Applicable Driver Unit	EDB Driver Unit	ESA Driver Unit
Applicable butt connection	Maximum 30 m	Maximum 10 m (YA2, YB2, YB3)

⚠ As the PM Series uses a powerful magnet, it has the property of attracting all metals. Although the magnet part is protected by a cover, careful handling is required to prevent foreign matter such as metal dust or tools affecting the proper functioning of the motor. Full attention must also be given to the operator as the magnet may cause medical instruments, such as pacemakers, to malfunction.

How to Select Megathrust Motors

In selecting Megathrust Motors, the important factors are maximum acceleration, maximum speed, load (mass and size), and duty.

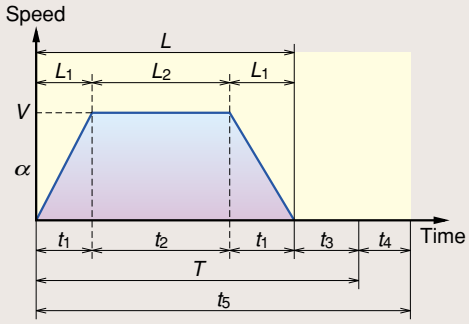
✻ Calculation formulas

① Find peak thrust F ·····F = maximum acceleration × (mass of load + mass of slider) × η (safety factor) (Reference 1)
② Obtain average thrust·····Obtain the average thrust by the drive pattern of actual operation. (Reference 2)
③ Select Series of motors ·····Confirm that the peak thrust obtained in ① falls within the usable range through the speed and thrust properties of the motor. Especially for the Y Series, pay attention to the peak thrust variation depending on speed. For the PM Series, confirm that the average thrust falls within the rated thrust range.
④ Confirm the mass of load ·····Confirm that the load is within the permissible mass of load and transportable moment for the selected motor size.
⑤ Calculate the travelling life·····Calculate the travelling life using the maximum load applied to the linear guide according to the load conditions. (Reference 3)
⑥ Confirm necessity of external regeneration resistance ·····Confirm necessity of regeneration resistor through the operating conditions. (Reference 4)

(Reference 1) Positioning time of Megathrust Motors

The positioning time of Megathrust Motors can be determined using the mass of the load, the mass of the slider, and the speed–thrust properties. Conditions and calculation formulas required are shown as follows:

M_1: Mass of load (kg) M_2: Mass of slider (kg)
V: Travelling speed (m/s) α: Acceleration (m/s²)
F1: Thrust under acceleration (N), F2: Thrust under constant velocity (N),
F3: Thrust under deceleration (N), F5: Sliding resistance with no load on guide (N)
t_1: Acceleration/deceleration time (s) t_2: Travelling time (s)
t_3: Setting time (s) t_4: Stop time (s) t_5: Cycle time (s)
L: Travelling distance (mm) L_1: Acceleration/deceleration distance (mm)
L_2: Constant velocity travelling distance (mm)
T: Positioning time (s)
η: Safety factor (1.0 for PM Series and 1.5 for Y Series)



✻ Calculation formulas

- Thrust $F = \eta (M_1 + M_2) \alpha$,
- Speed $V = \alpha t_1$
- Constant velocity traveling distance $L_2 = Vt_2$
- Acceleration/deceleration distance $L_1 = (1/2) V$, $t_1 = (1/2) \alpha t_1^2$
- Positioning time $T = 2t_1 + t_2 + t_3$

Required repeatability (μm)	±1~±10	±10~±50	±50~±500
Setting time t_3 (s)	0.2	0.1	0.05

✻ The targets of setting times are stated in the table. Please note that the setting time is not absolute as it is influenced by the rigidity of the mounting mechanism of the motor and the mass of the load.

✻ Since the thrust of a Megathrust Motor indicates the actual thrust excluding sliding resistance, it is not necessary to take sliding resistance into consideration when determining the peak thrust as long as the mass of load and transportable moment is within the permissible range.

(Reference 2) Calculation of average thrust of Megathrust Motors (PM Series)

In selecting Megathrust Motors (PM Series), it is necessary to simultaneously determine the maximum necessary thrust and the average thrust required for the operating pattern actually used.

✻ Calculation formulas

F1: Thrust under acceleration, F2: Thrust under constant velocity, F3: Thrust under deceleration, μ: 0.01(target)
F5: Please refer to the table for sliding resistance when no load is applied to the guide.

- Thrust under constant velocity $F2 = ((M_1 + M_2) \times 9.8) \times \mu + F5$
- Thrust under acceleration $F1 = \eta (M_1 + M_2) \times \alpha + F2$
- Thrust under deceleration $F3 = \eta (M_1 + M_2) \times \alpha - F2$

For calculating average thrust, it is necessary to consider sliding resistance.

F5: Sliding resistance with no load on guide (N)

	PD1	PD2	PD3
F5	40	60	80

t_1: Acceleration/deceleration time, t_2: Constant velocity travelling time
t_3: Setting time, t_4: Stop time, t_5: Cycle time
$t_5 = t_1 \times 2 + t_2 + t_3 + t_4$ Average thrust $F(\text{average}) = \sqrt{(F1)^2 \times t_1 + (F2)^2 \times t_2 + (F3)^2 \times t_1)/t_5}$

(Reference 3) Calculation of travelling life of Megathrust Motors

The approximate travelling life of a Megathrust Motor (PM Series) can be assumed by the following calculation formulas. If lifetime falls short of the required travelling life, use a motor construction with an additional supplementary guide, or separately design a table receiving a load mass to use the Megathrust Motor as a driving source.

✻ Calculation formulas

Obtain the maximum load W applied on one ball slide (considered as a static load) under conditions of no external shock or vibration.

For a simple load (where the center of the slider and the center of gravity of the load mass are matched on the plane surface): $W = (M_1 + M_2)/(\text{number of bearings})$

In case of load acting as moment load: Moment load component W1 = (carrying load × eccentric value of gravity-center position/guide space in the direction of moment)/2

$$W = (M_1 + M_2)/(\text{number of ball slides}) + W1$$

Calculate the travelling life of a guide at maximum load W (N).

Travelling life L (km) = $50 \times [C \text{ (basic dynamic load rating of the guide)}/fw/(W + K)]^3$

✻ Please consult NSK if travelling life is smaller than the required design life.

✻ Hardness coefficient is defined as 1.0. Load coefficient fw is 1.0 to 3, depending on usage conditions; this should usually be set to 1.2.

✻ C and K values are as shown in the following table.

C and K

	PD1	PD2	PD3
C	8 500	8 500	8 500
K	450	450	540

(Reference 4) Selection of regeneration resistor (PM Series)

① Find the energy possessed by a Megathrust Motor at deceleration.

Energy is obtained as the sum of kinetic energy and potential energy. h: height (m)

Kinetic energy = $\frac{1}{2} \times (M_1 + M_2) \times V^2$ Potential energy = $(M_1 + M_2) \times 9.8 \times h$

✻ For horizontal drive, it is not necessary to consider potential energy.

② Obtain deceleration time.

a (maximum deceleration) = peak thrust/$(M_1 + M_2)$

t (deceleration time) = V/a or deceleration time for the operating pattern

③ Regeneration damping capacity of internal regeneration resistor (in case of EDB Driver Unit)

Regeneration damping capacity = 240 × t + 40

④ When energy possessed at deceleration is smaller than regeneration damping capacity, an external regeneration resistor is not required. However, when it is larger, an external regeneration resistor is required.

⑤ In case of stopping in 0.5 s when moving a load mass of 200 kg at 2 m/s,

✻ Energy possessed at deceleration: 400 (J) (the sum of kinetic energy and potential energy)

✻ Regeneration energy consumed by the Driver Unit and motor body: 160 (J) 160 = 240 × 0.5 + 40

✻ Regeneration energy consumed by the Driver Unit and motor body becomes less than the energy possessed at deceleration, so that an external regeneration resistor is required.

⑥ Damping capacity of an external regeneration resistor (Determined depending on Driver Unit specifications.)

For an EDB Driver Unit,

✻ External regeneration resistor: RH 220 B 100 (Ω)

✻ Power consumption at regeneration ON: 1 400 (W)

✻ Regeneration energy which has to be consumed with an external regeneration resistor: 240 (J) = 400 –160

✻ Power consumption of an external regeneration resister: 480 (W) = 240 (J) ÷ 0.5 (s)
No problem occurs as long as power consumption is 1400 (W) or less.

✻ Use with natural cooling: No problem occurs so long as average duty consumes 350 (W) or less (with other than deceleration time taken as zero).

✻ Limit of usage rate at forced cooling: When duty consumes power of more than 350 (W), usable consumed power can be increased by applying forced cooling to regeneration resistance.

Selection Examples of Megathrust Motors

Selection examples of PM Series

[Conditions] Can a motor with a load of 40 kg travel a stroke length of 1 000 mm in one second? What will the average thrust be when the standard motion cycle per reciprocation is ten seconds?
Where, the maximum speed is 2 000 mm/s, acceleration is over 4.9 m/s^2 (0.5 G), and repeatability to the stop position is ±20 μm.

- As acceleration is over 4.9 m/s^2 (0.5 G), the approximate thrust can be calculated as $40 \times 4.9 = 196$ N. Required thrust is achieved by adding the approximate thrust to the accelerating mass of the slider at 4.9 m/s^2 while taking the safety factor η into consideration.

- PM Series (PD1: 400 N peak thrust) is initially selected and studied for use conditions.
  If the resolution is 1 μm, maximum speed is satisfied with 2 000 mm/s. Use conditions are also met with 40 kg permissible mass of load.
  Required thrust F at 6 m/s^2 acceleration and 7 kg mass of slider becomes
  $(\eta = 1.0) \times (40 + 7) \times 5 = 235$ N,
  less than the peak thrust (370N) of PD1 at 2 000 mm/s
  Acceleration time with $t_1 = \alpha / V$ becomes
  $t_1 = 2/5 = 0.4$ (s)
  Acceleration/deceleration distance L_1 is
  $L_1 = (1/2) \times V \times t_1 = 0.4$ (m) = 400 (mm)
  Constant velocity travelling time t_2 is
  $t_2 = L_2/V = (1\,000 - 800)/2\,000 = 0.1$ (s)
  Travelling time T considering setting time $t_3 = 0.1$ (s) becomes
  $T = 2 \times t_1 + t_2 + t_3 = 2 \times 0.4 + 0.1 + 0.1 = 1.0$ (s)
  An average thrust {F} becomes one reciprocation travel in ten seconds and thus,
  $\{F\} = \{((F = 280)^2 \times 0.4 + (F = 190)^2 \times 0.4 + (F = 45)^2 \times 0.1) \times 2/10\ (s)\}^{1/2} = 96$ N
  is obtained and becomes 150 N or less rated thrust.
  PD1 can be used with all conditions fully satisfied.

Selection examples of Y Series

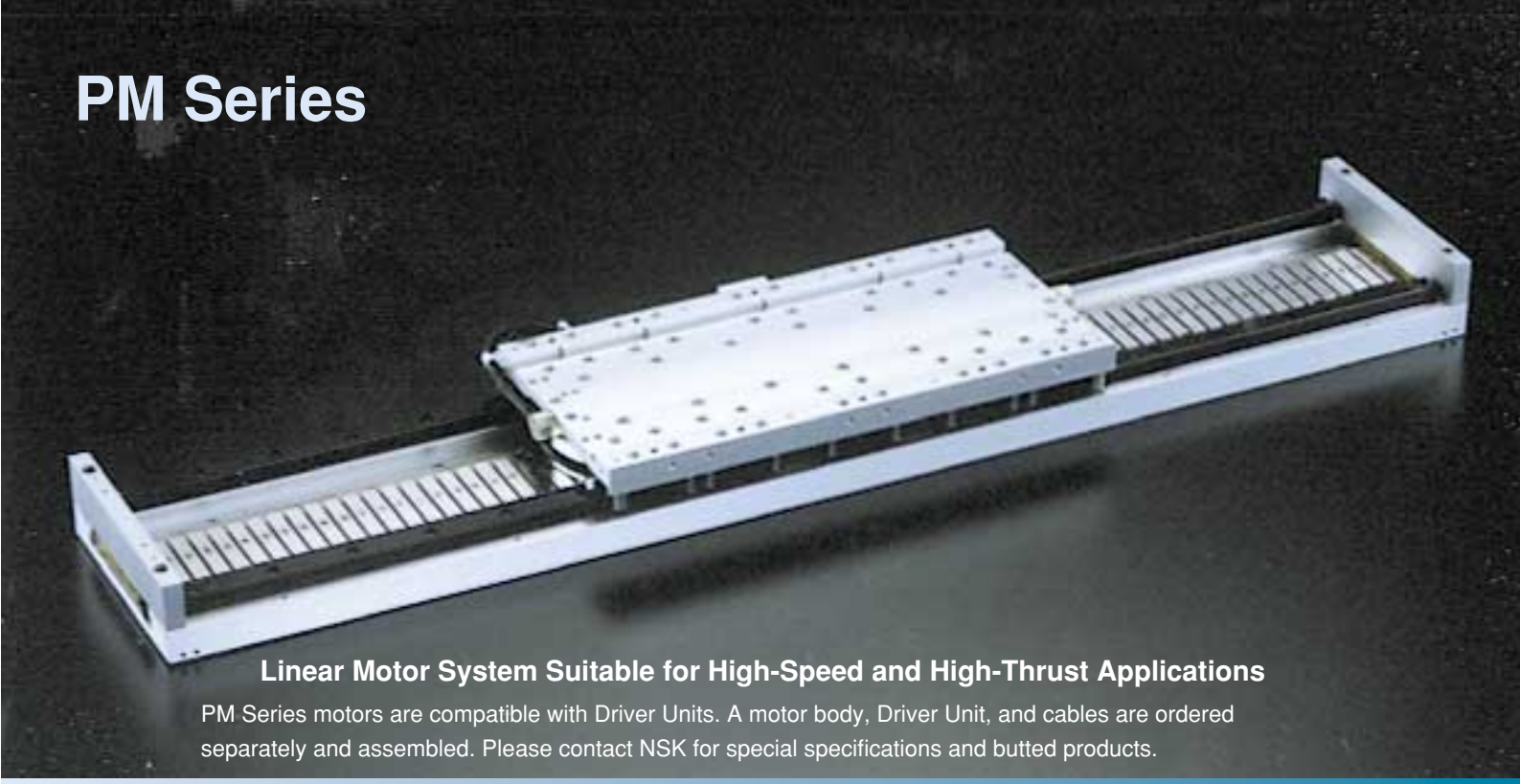
[Conditions] How many seconds are required for a motor with 5 kg mass of load to travel a stroke length of 1 000 mm? Where, the maximum speed at operation is 1 200 mm/s, acceleration time is 0.25 (s), and repeatability to the stop position is ±10 μm.

- Acceleration with $V = \alpha t_1$ becomes
  $\alpha = 1.2/0.25 = 4.8$ (m/s^2)

- Y Series (YA2: 196 N peak thrust) is initially selected and studied for use conditions.
  The maximum speed of 1 800 mm/s of the resolver satisfies the condition of over 1 200 mm/s.
  Permissible mass of load of 40 kg satisfies use conditions.
  Required thrust with 4.8 (m/s^2) acceleration and 6 kg mass of slider is
  $(\eta = 1.5) \times (5 + 6) \times 4.8 = 79$ N
  Thus, the motor can be used, as the peak thrust is under 90 N at 1 200 mm/s for YA2 (refer to properties of speed–thrust of Y Series).

  Distance required for acceleration/deceleration becomes
  $(1/2) \times 1\,200 \times 0.25 = 1\,500$ mm
  Travelling distance of constant velocity is
  $1\,000 - 150 \times 2 = 700$ mm
  thus, the travelling time becomes
  $0.25 \times 2 + 700/1\,200 + 0.2 = 1.28$ (s)

PM Series



Linear Motor System Suitable for High-Speed and High-Thrust Applications

PM Series motors are compatible with Driver Units. A motor body, Driver Unit, and cables are ordered separately and assembled. Please contact NSK for special specifications and butted products.

1-1. Reference number (PM Series: Reference number of motor body)

Example: **ML- PD1 1 120 - A E A 001**

- ML-: Megathrust Motor
- PD1: PM Series motor type
- 1: Number of sliders (1: one slider, 2: two sliders)
- 120: Base length (cm) (120: 120 cm, A02: 1 020 cm, B04: 2 040 cm)
- -: Coupling code (–: integrated, T: coupled)
- A: Power voltage specification (A: AC 200V)
- E: Sensor type (E: linear scale)
- A: Scale resolution (A: 0.5 μm, B: 1 μm)
- 001: Series number

1-2. Motor specifications

Type / Item			PD1	PD2	PD3
Peak thrust		(N)	400	800	1 200
Rated thrust		(N)	150	300	450
Permissible mass of load		(kg)	40	80	120
Transportable moment	Rolling	(N•m)	50	80	120
	Pitching	(N•m)	70	150	220
	Yawing	(N•m)	80	160	240
Mass of slider		(kg)	7	14	21
Mass of base (rack base)		(kg/m)	19		
Maximum speed		(mm/s)	2 000/1 500		
Resolution of position sensor		(μm)	1/0.5		
Repeatability		(μm)	±1		
Positioning accuracy		(μm)	(30/1 000) × (Stroke) +5* Stroke unit: mm		
Position sensor			Optical linear scale**		
Number of guide bearings per slider			4	8	10
Bearing space		(mm)	148 × 100	148 × 220	148 × 340
Basic load rating per guide bearing		(N)	C Dynamic load rating: 8 500 C_0 Static load rating: 16 100		

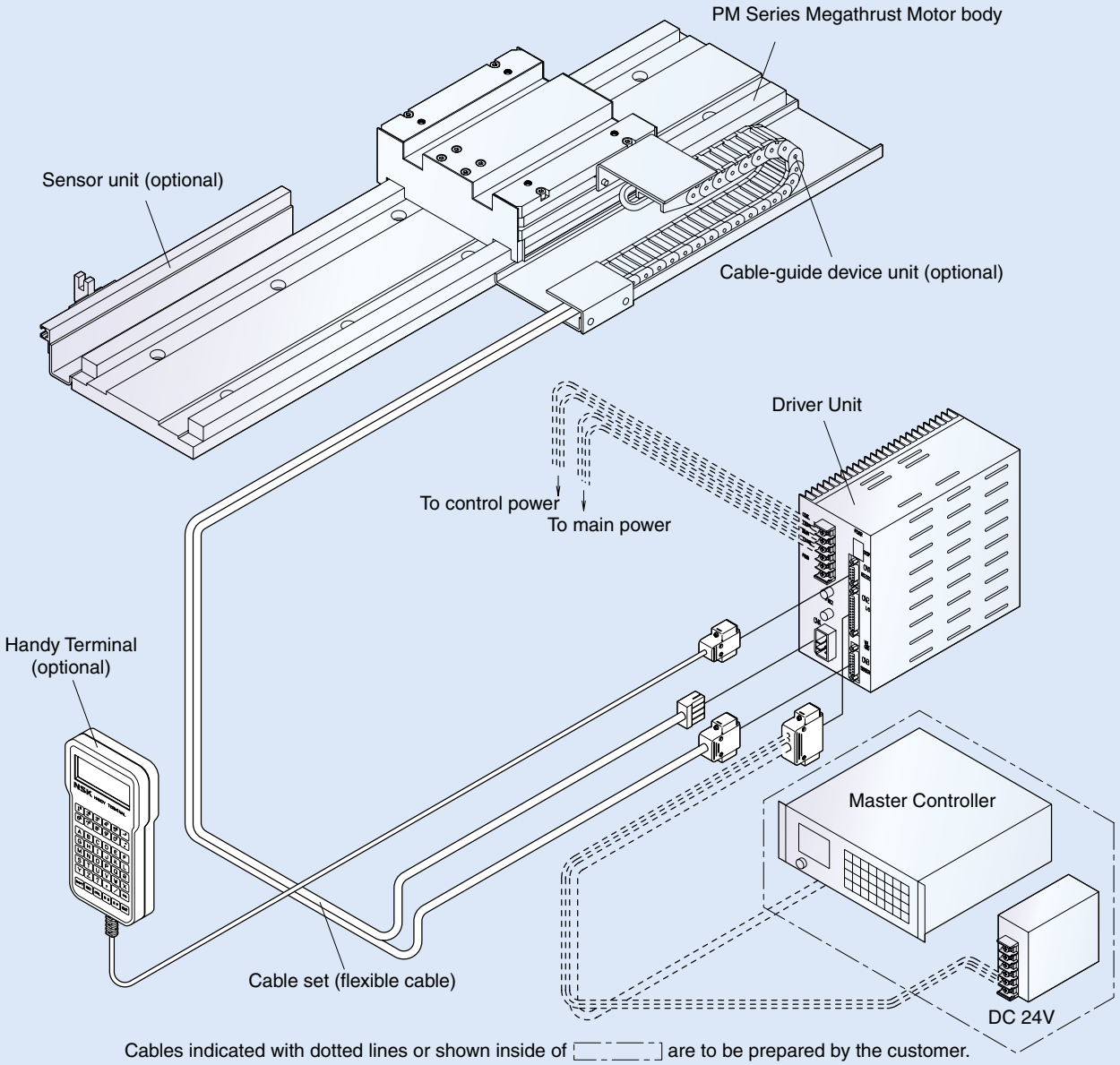
* Positioning accuracy is measured at 20˚C with no temperature variation. ** A glass scale is available as a special requirement.

1-3. Properties of speed and thrust

Fig. 1 Properties of speed and thrust

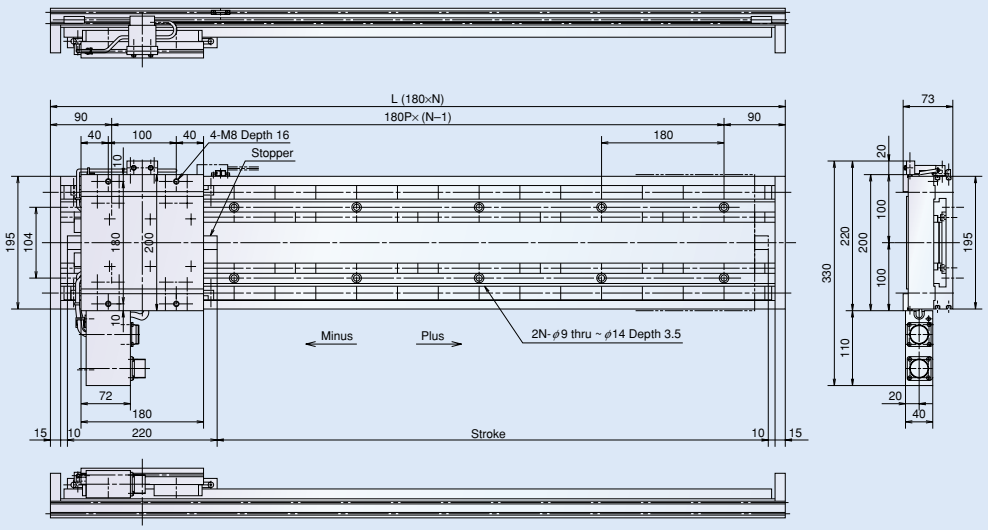
1-4. System configuration (PM Series)

Fig. 2 System configuration



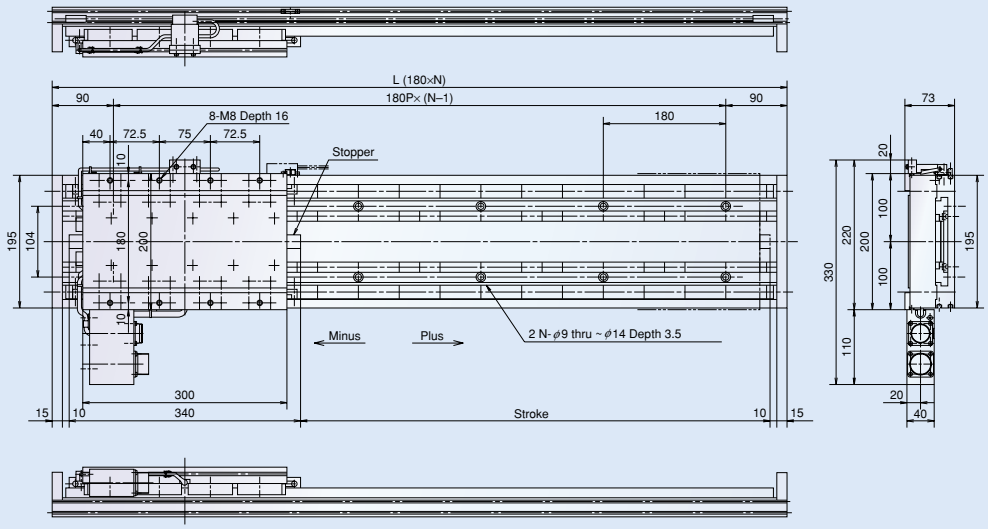
1-5. Dimensions

Fig. 3 PD1



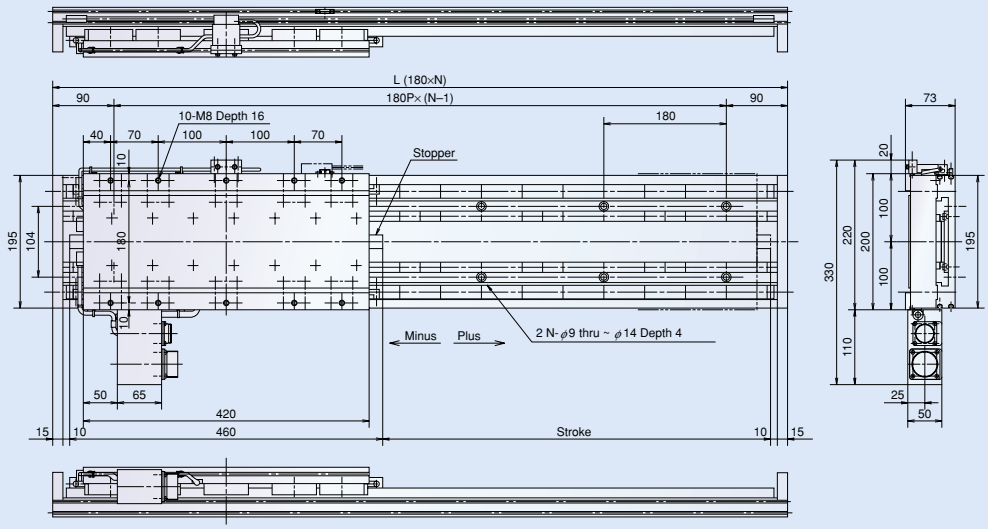
Standard reference number	Total base length (mm)	Stroke (mm)	Mass (kg)
ML-PD11054-AEB001	540	270	18
ML-PD11072-AEB001	720	450	21
ML-PD11090-AEB001	900	630	24
ML-PD11108-AEB001	1 080	810	28
ML-PD11126-AEB001	1 260	990	31
ML-PD11144-AEB001	1 440	1 170	35
ML-PD11162-AEB001	1 620	1 350	38
ML-PD11180-AEB001	1 800	1 530	42
ML-PD11198-AEB001	1 980	1 710	45
ML-PD11216-AEB001	2 160	1 890	48

Fig. 4 PD2



Standard reference number	Total base length (mm)	Stroke (mm)	Mass (kg)
ML-PD21054-AEB001	540	150	25
ML-PD21072-AEB001	720	330	28
ML-PD21090-AEB001	900	510	31
ML-PD21108-AEB001	1 080	690	35
ML-PD21126-AEB001	1 260	870	38
ML-PD21144-AEB001	1 440	1 050	42
ML-PD21162-AEB001	1 620	1 230	45
ML-PD21180-AEB001	1 800	1 410	49
ML-PD21198-AEB001	1 980	1 590	52
ML-PD21216-AEB001	2 160	1 770	55

Fig. 5 PD3



Standard reference number	Total base length (mm)	Stroke (mm)	Mass (kg)
ML-PD31054-AEB001	540	30	32
ML-PD31072-AEB001	720	210	35
ML-PD31090-AEB001	900	390	38
ML-PD31108-AEB001	1 080	570	42
ML-PD31126-AEB001	1 260	750	45
ML-PD31144-AEB001	1 440	930	49
ML-PD31162-AEB001	1 620	1 100	52
ML-PD31180-AEB001	1 800	1 290	56
ML-PD31198-AEB001	1 980	1 470	59
ML-PD31216-AEB001	2 160	1 650	62

1-6. How to butt the PM Series

Butt connection of the PM Series

Longer stroke can be achieved by butting the motor base (stator) for the PM Series. The base length to be butted is the standard base length (whole-number multiples of 180 mm). A maximum base length of 30 m is available. (Cable length is also available up to a maximum of 30 m.) Butted-type PM Series are shipped from the factory in a base unit.
For butting the base, customers are required to carry out simple work such as adjustment of center deviation and parallelism of the linear guide installed on the base. (A set-up manual for the base is enclosed at shipment.)

Outline of the set-up manual

1. Preliminary setting of the base
2. Correction of center deviation and adjustment of parallelism of the guide rail
3. Fixing the scale track of the linear scale
4. Fixing the linear scale along the scale track
5. Alignment adjustment of the scale head
6. Confirmation of the signal output

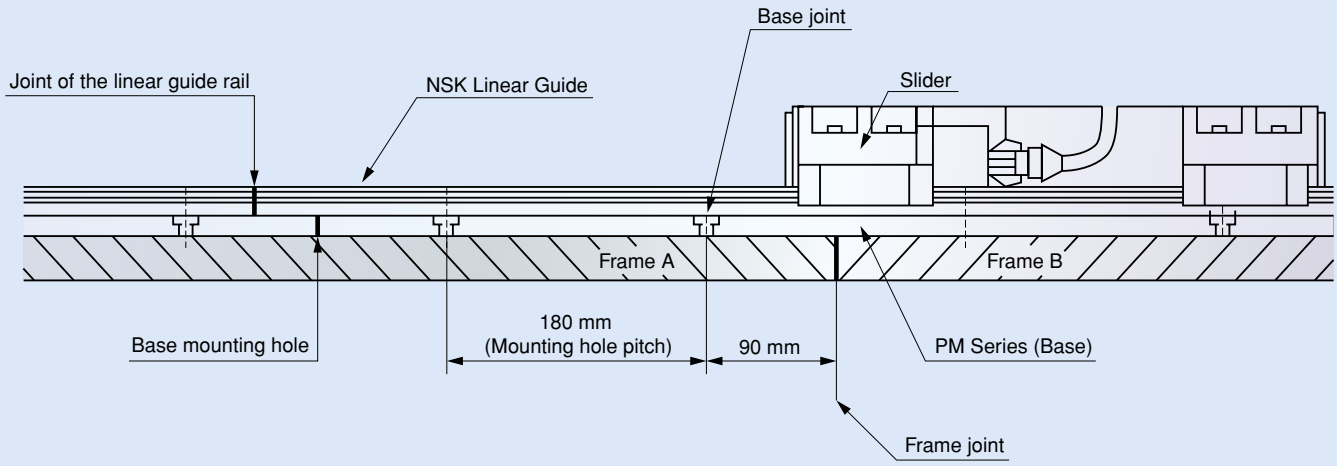
* Please apply the linear scale enclosed at shipment.

In case the motor is disassembled for transportation, carefully detach it according to the manual. Linear scales can be reused.

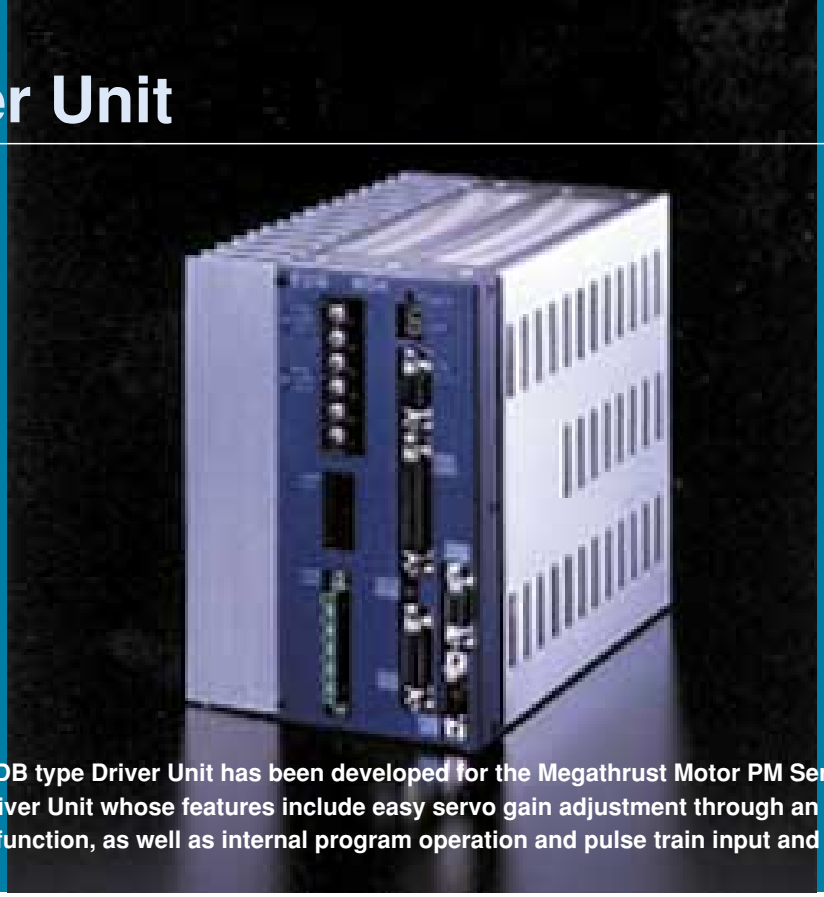
Instructions for manufacturing a mounting frame for a Megathrust Motor

Mounting frames for Megathrust Motors should preferably be manufactured as an integrated construction and not in separate pieces. In case of separate pieces, any height difference in the frame joint should be minimized to avoid center deviation when mounting the base. Furthermore, the frame joint should not be matched with the base joint.
To prevent any center deviation in the vertical direction, we recommend that the frame joint is shifted from the base joint by two pitches of the base mounting hole. The base of the Megathrust Motor (PM Series) is made of aluminum.
The frame should be designed to have enough strength to receive motor and load mass since the base itself is not durable enough to support a large load mass. In particular, the motor can be used at high speed and with powerful thrust, and consideration should be given to the large reaction force generated by such acceleration.

Fig. 6



EDB Driver Unit



The proprietary EDB type Driver Unit has been developed for the Megathrust Motor PM Series. A user-friendly Driver Unit whose features include easy servo gain adjustment through an integrated automatic tuning function, as well as internal program operation and pulse train input and analog input operations.

1-7. Reference number

Example: **M-EDB- LPD1 A E A 5 ✻✻**

- M-EDB- : EDB type Driver Unit
- LPD1 : Applicable motor type
- A : Power voltage specification A: AC 200V
- E : Sensor type E: linear scale
- A : Scale resolution A: 0.5 μm, B: 1 μm
- 5 : Driver Unit function
- ✻✻ : Series number

1-8. Specifications

Table 2 General specifications

Input power voltage	3-phase AC200V/230V±10% 50/60Hz
Input power capacity	1.8KVA (PD1) 3.4KVA (PD2) 5.0KVA (PD3)
Mass	4.0 kg
Environmental condition (at operation)	Temperature 0°C ~ 50°C, Humidity 20% ~ 90% (No condensation), No dust
Entry current	Controlled power 15A or less, Main power 30A or less
Leakage current	3.5 mA (Driver unit single piece)

Table 3 Function specifications

Input signal	Pulse train input	Maximum input pulse frequency: 800 kpps Input pulse type: PLS/MNS system(1)
	Control input	Emergency stop, servo on, internal program selection (maximum 64 steps), positioning start, Control input Home return operation start, home position limit switch, jog, jog travel direction command, integral control off, over travel, analog speed • thrust command (±10 VDC)
Output signal	Position feedback signal	Output signal format: line driver A/B-Phase • Z-phase: depending on scale specification
	Control output	Driver Unit ready, in position, servo status
Protection function		Excess position error , soft-thermal over, over travel, control power voltage drop, position sensor error, magnetic pole sensor error, power module alarm, regeneration error, main power voltage error, over speed
Communication		Serial RS-232C communication, transmission speed: 9 600 bps

* (1) The PLS/MNS system can be switched to the pulse/direction system or to the A/B-phase system.

EDB Driver Unit

1-9. Input/output signal specifications

Table 4 CN2 Connector DB-25 PF-N Connector cover DB-C 2-J 9 (Manufactured by Japan Aviation Electronics Industry, Ltd.)

Input/output	Signal name	Pin No.	Name	Contents
Input signal	PLSP+	8	PLS pulse train (+)	Moves in plus direction by pulse train input. (Select pulse train or A-phase by switch.)
	PLSP–	21	PLS pulse train (–)	
	MNSP+	7	MNS pulse train (+)	Moves in minus direction by pulse train input. (Select direction designation or B-phase by switch.)
	MNSP–	20	MNS pulse train (–)	
	EMST	12	Emergency stop	Quickly stops the motor by a dynamic brake.
	SVON	25	Servo on	Turns the servo on.
	OTP	9	Over travel limit (+)	Over travel input signal in plus direction.
	OTM	22	Over travel limit (–)	Over travel input signal in minus direction.
	CLR	10	Clear	Clears alarm and position deviation counter.
	HOS	23	Home return start	Starts Home return operation.
	HLS	11	Home limit switch	After Home return operation started, determines home by switching signal to ON/OFF.
	IOFF	24	Integral control off	Switches over ON/OFF of integral and gain reduction.
	DC24	13	DC 24V external supply	External power for input signal (DC 24V, 0.2A or more).
Output signal	DRDY+	15	Driver Unit ready (+)	Indicates that operation preparation is completed. (Opens when Driver Unit is not ready and during alarms.)
	DRDY–	2	Driver Unit ready (–)	
	IPOS	14	In position	Indicates that positioning is completed.
	SVST	3	Servo condition	Indicates servo-on/off condition of the motor.
	COM	1	Output signal common	Common signal for in position and servo condition.

Table 5 CN5 Connectors DB-37 PF-N Connector covers DC-C 8-J 13-F 1-1 (Manufactured by Japan Aviation Electronics Industry, Ltd.)

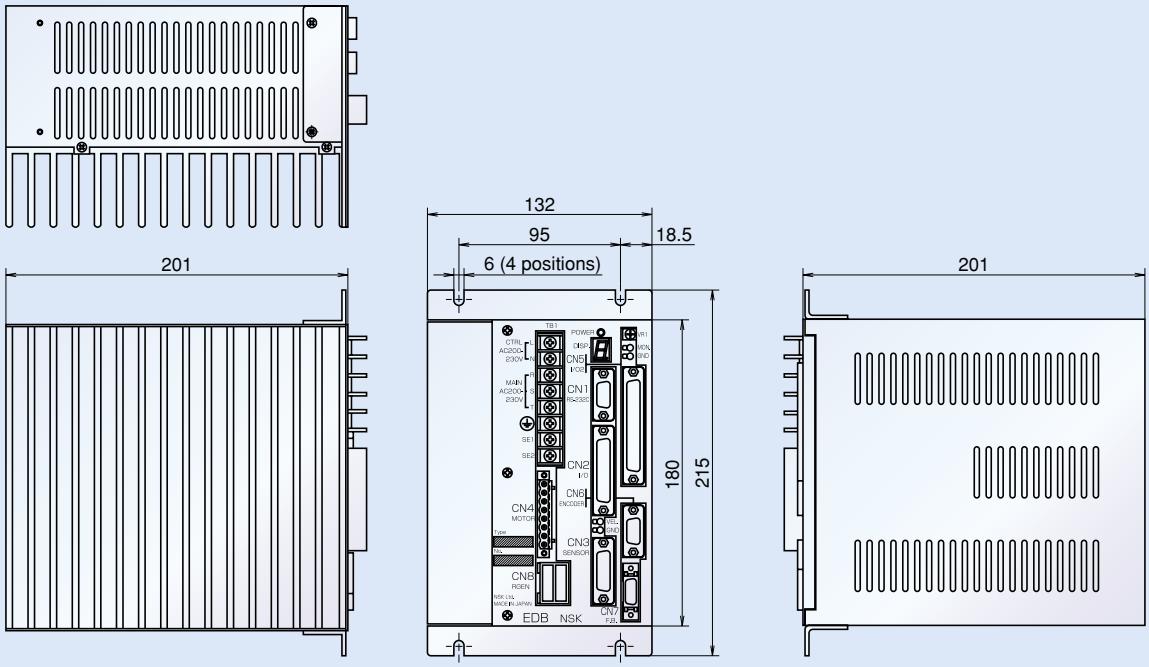
Input/output	Signal name	Pin No.	Name	Contents
Input signal	DC24	19	DC 24V external supply	External power for input signal (over DC 24V, 0.2 A).
	RUN	17	Positioning start	Starts selected channel.
	PRG0	11	Internal program channel switch 0	Selects execution channel (channel 0 to 63) by combination of ON/OFF of internal program channel switch 0 to 5.
	PRG1	12	Internal program channel switch 1	
	PRG2	13	Internal program channel switch 2	
	PRG3	14	Internal program channel switch 3	
	PRG4	15	Internal program channel switch 4	
	PRG5	16	Internal program channel switch 5	
	JOG	30	Jog drive	Starts jog drive.
	DIR	31	Rotation direction indicator	Sets jog drive direction.
	AIN+	8	Analog command input	Input terminal for selecting analog input of speed and thrust mode.
	AIN–	7	GND for analog input	
Output signal	HOME	21	Home return completed	Completes Home return operation and indicates that home position is held.
	HCMP	22	Home determined	Indicates that home position is determined.
	COM	1	Output signal common	Common signal for in position and servo condition.
	MON+	27	Monitor output	Output terminal of several monitors.
	MON–	26	Monitor output GND	

Table 6 CN 7 Connectors DX-40 M-20 P Connector covers DX 30 M-20-CV (Manufactured by Hirose Electric Co., Ltd.)

Input/output	Signal name	Pin No.	Name	Contents
Input signal	PA	6	Position feedback signal A-phase	Pulse signal indicating the motor movement. Output with a line driver. (OCZ: open collector output.)
	∗PA	16	Position feedback signal ∗A-phase	
	PB	7	Position feedback signal B-phase	
	∗PB	17	Position feedback signal ∗B-phase	
	PZ	5	Position feedback signal Z-phase	
	∗PZ	15	Position feedback signal ∗Z-phase	
	OCZ	14	Position feedback signal Z-phase	
	SGND	1	Position feedback signal GND	

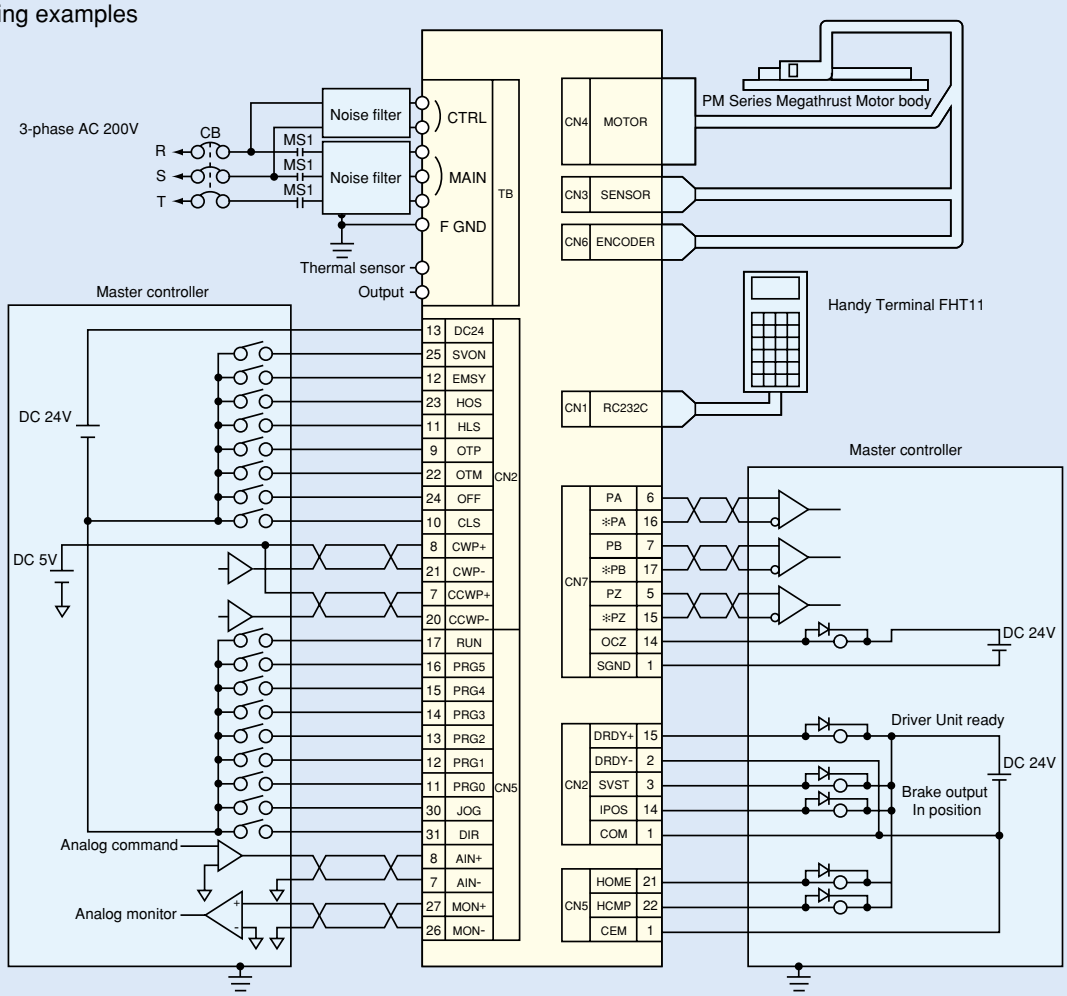
1-10. Dimensions

Fig. 7 Dimensions



1-11. Wiring examples

Fig. 8 Wiring examples



Cable Set for PM Series

NSK Megathrust Motors use robot cables with excellent elasticity.

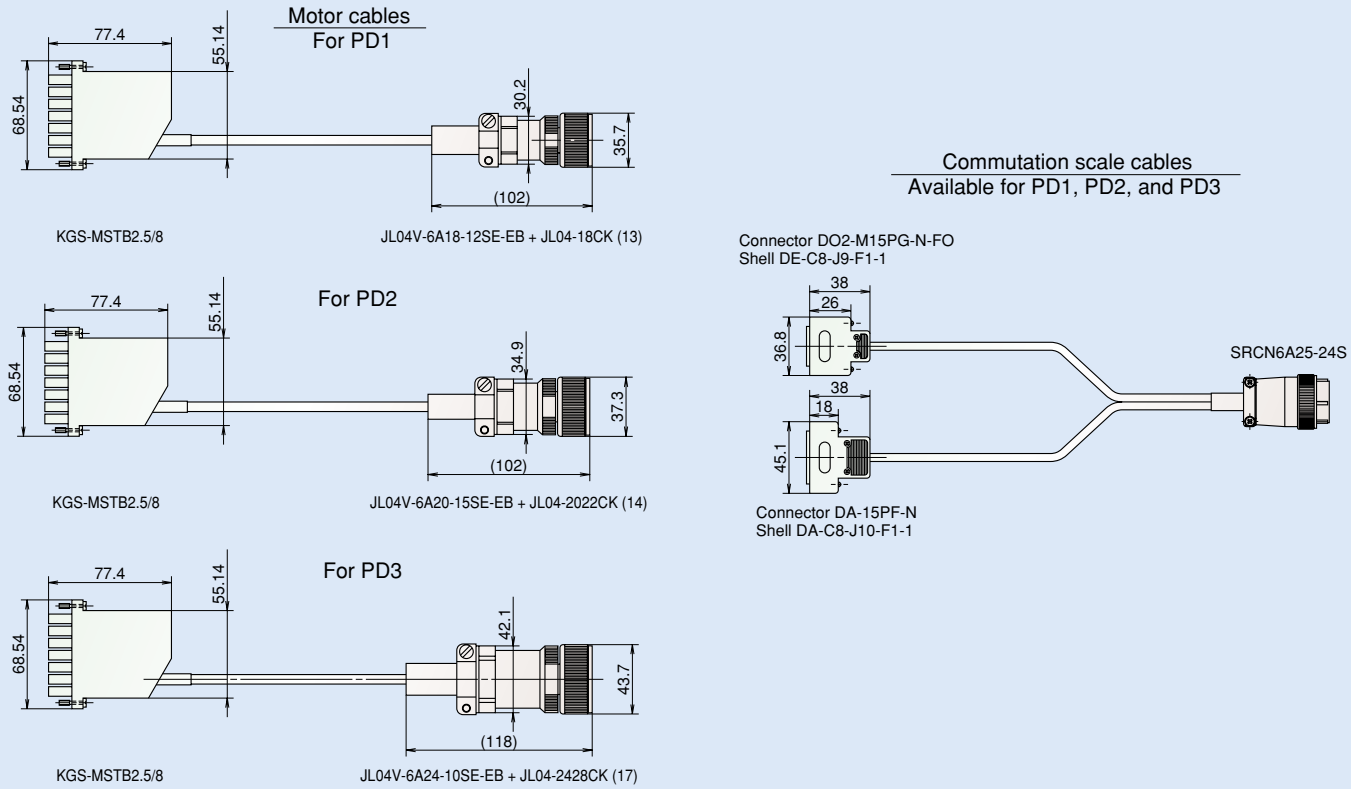
1-12. Construction of reference numbers

Example: **ML-C** **004** **DB** ******

- **ML-C**: Cable set for Megathrust Motors
- **004**: Cable set length 004: 4m
- **DB**: Applicable Driver Unit (EDB Driver Unit)
- ******: Serial number

1-13. Dimensions

Fig. 9 Dimensions of the cable set for PM Series

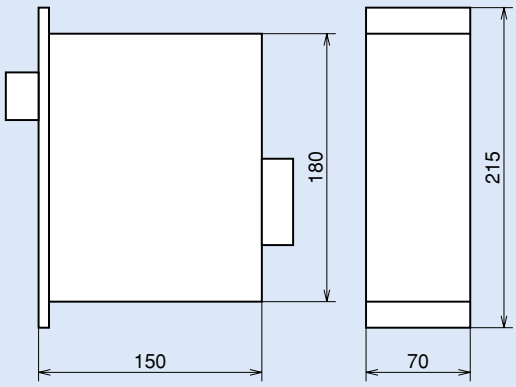


1-14. Optional components

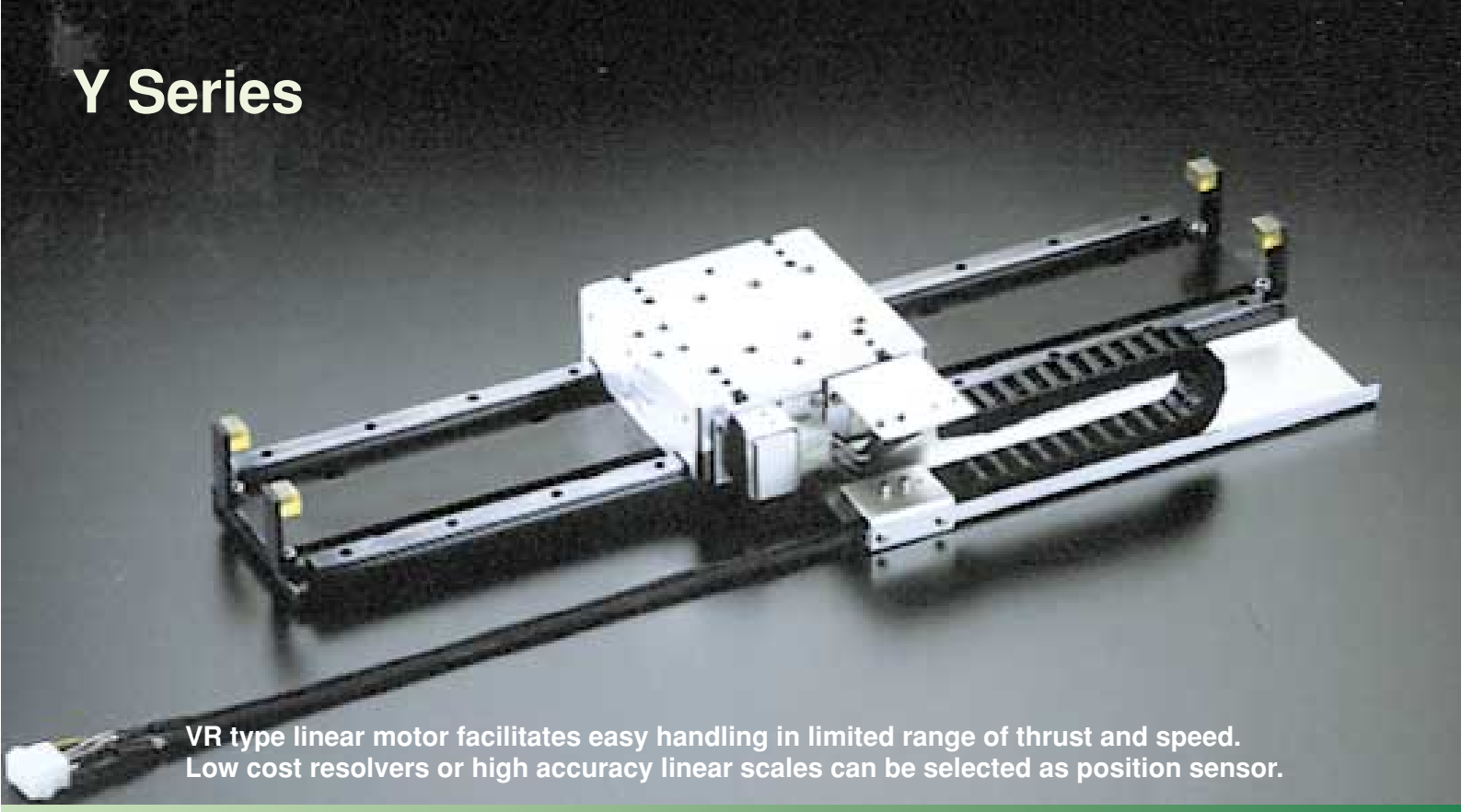
Products	Notes
Cable guide equipment	Protection device of flexible cables (Applicable stroke: 500 mm, 1 000 mm, 1 500 mm, and 2 000 mm)
Sensor for home return and over travel	Sensor for home return and over travel
Cover	Protection cover for motor body, cable, and linear guide (Maximum: total base length of 1 080 mm)
Regeneration resistor unit	Required for large acceleration/deceleration (Reference 4)

- External regeneration resistance
  - Regeneration resistor type: M-FZ214 (RH 220 B 100 (Ω J))
  - Power consumption at regeneration ON: 1 400 (W)

Fig. 10 Dimensions of the external regeneration resistance unit



Y Series



VR type linear motor facilitates easy handling in limited range of thrust and speed.
Low cost resolvers or high accuracy linear scales can be selected as position sensor.

2-1. Reference number (Y Series: Reference number of the system)

Example: **ML - YA2 1 120 001 A A 13 C**

- **ML** – Y Series Megathrust Motor
  YZ1, YA1, YA2, YB1, YB2, YB3
- **1** – Number of sliders
  1: one slider
  2: two sliders
- **120** – Length of rack base
  120: 120 cm
  A02: 1 020 cm, B04: 2 040 cm
  (Standard length: 480, 600, 840, 1 200, 1 560, 2 040 mm)
- **001** – Series number of motor (Linear scale feedback type: 9 ✻✻)
- **A** – Driver Unit type (ESA type: A) standard
- **A** – Power voltage specification
  (A: AC 200V, C: AC 100V)
- **13** – Series number of Driver Unit design
  Resolver feedback type
  (Standard: 13, with analog input: 15)
  Linear scale feedback type: F✻
  Special application: F✻
- **C** – Standard cable (4 m length)
  No symbol: special cable

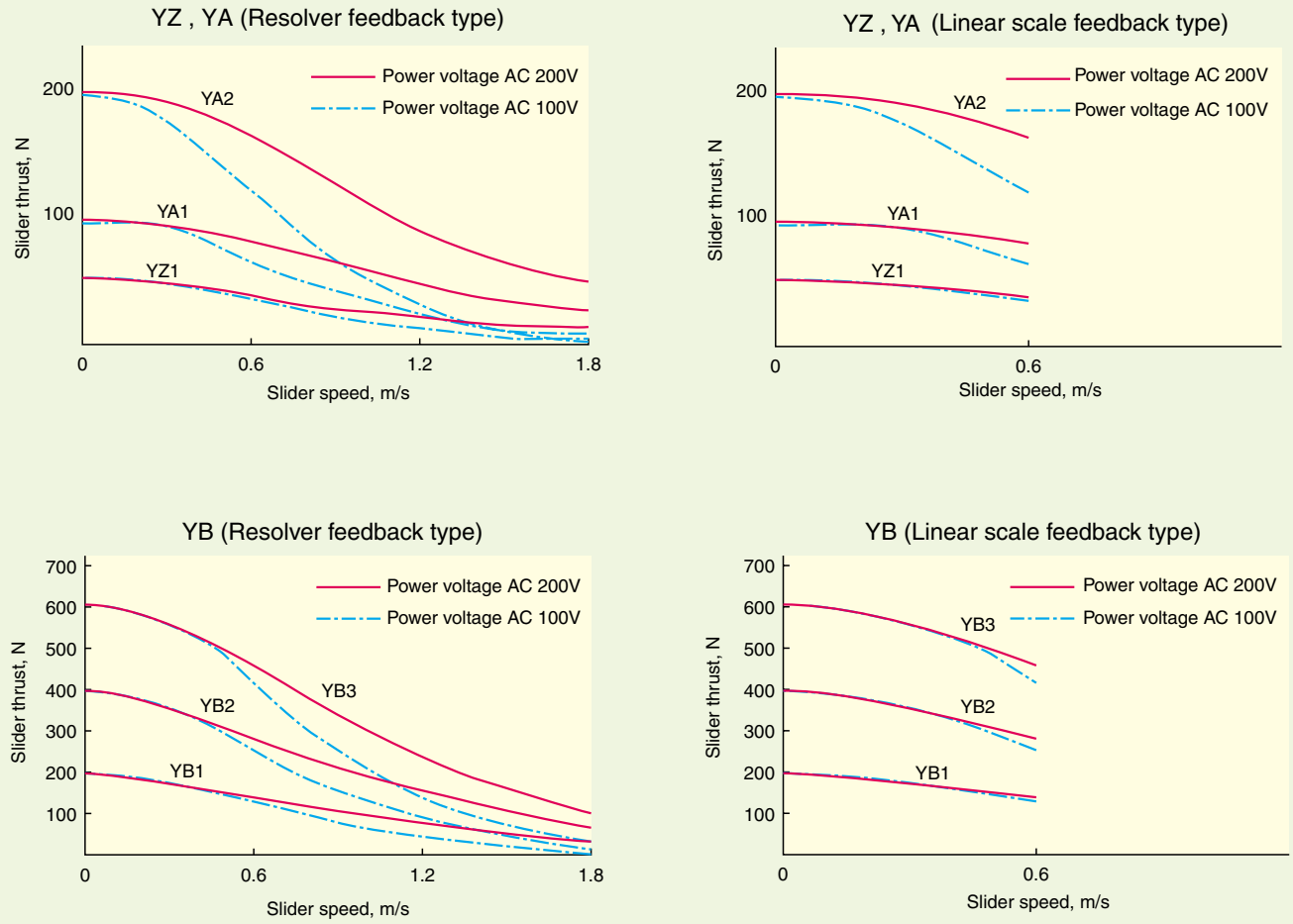
2-2. Motor specifications

Type / Item			YZ1	YA1	YA2	YB1	YB2	YB3
Peak thrust		(N)	49	98	196	196	392	588
Permissible mass of load		(kg)	10	20	40	40	80	120
Transportable moment	Rolling	(N•m)	16	40	75	95	140	200
	Pitching	(N•m)	13	55	125	120	250	420
	Yawing	(N•m)	13	60	140	130	280	460
Mass of slider		(kg)	2	4	6	7	10	15
Mass of base (rack base)		(kg/m)	9	16		29		
Maximum speed		(mm/s)	1 800 (600)			1 800 (600)		
Resolution of position sensor		(μm)	1/0.5			1/0.5		
Repeatability		(μm)	±1			±1		
Positioning accuracy		(μm)	–(50)			–(50)		
Position sensor			Resolver (linear scale)			Resolver (linear scale)		

*Positioning accuracy is measured at 20˚C with no temperature variation.

2-3. Properties of speed and thrust

Fig. 11 Properties of speed and thrust



2-4. Effective stroke

Six types of length (480 mm to 2 040 mm) are available for the standard rack base of the Megathrust Motor Y Series. The effective stroke per each motor to the length of rack base is shown in Table 7. The stroke can be extended by the butting method, except for types YZ1, YA1, and YB1. In this system, three types of standard rack base (1 200, 1 560, and 2 040 mm) are combined for a rack base of length of 2 040 mm or more.

Table 7 Effective stroke

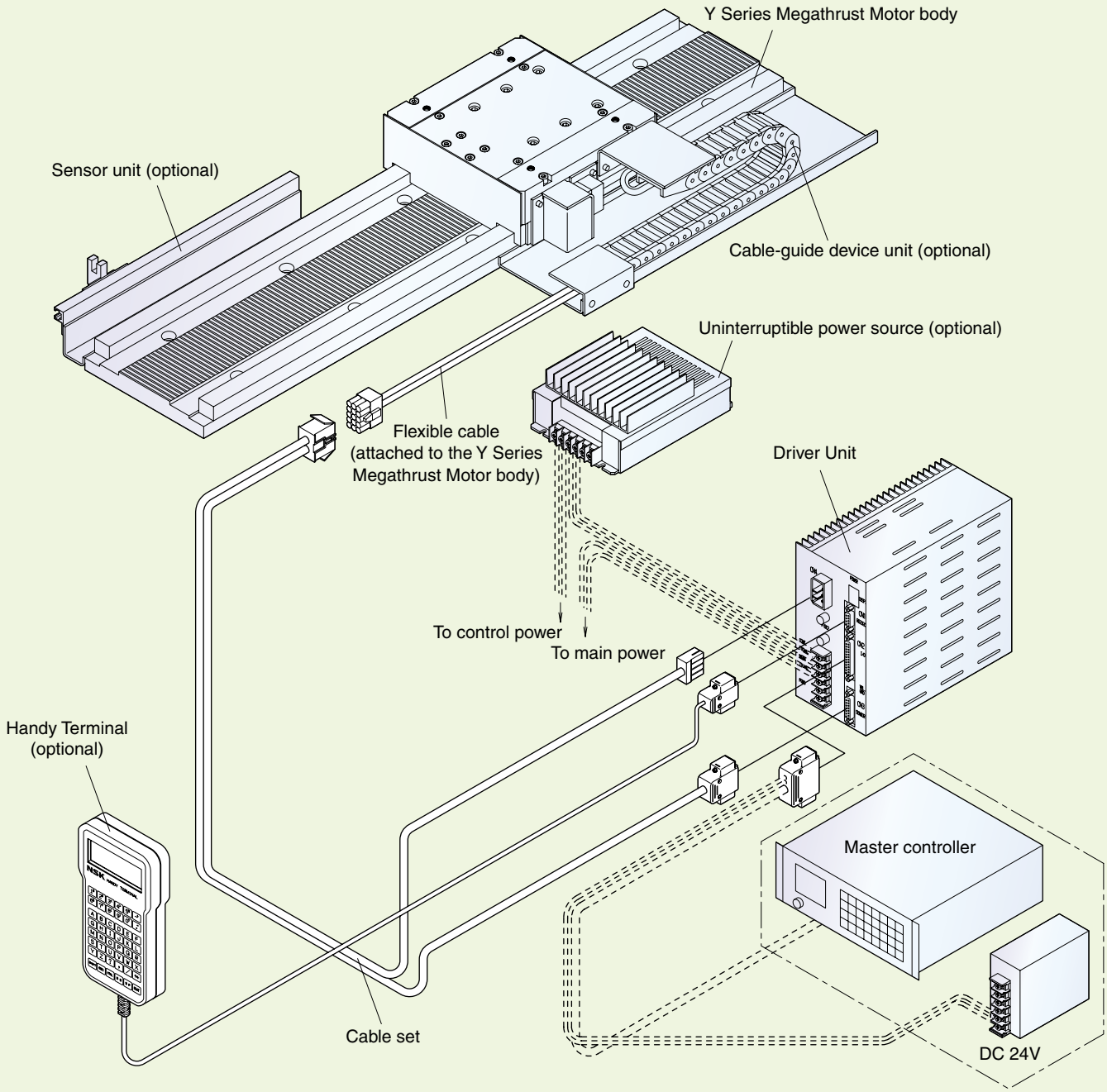
Unit: mm

	Motor type						Base length	Combination of bases	Base specifications
	YZ1	YA1	YA2	YB1	YB2	YB3			
Effective stroke	310	310	205	310	205	100	480	420 × 1	Integrated type rack base specifications
	430	430	325	430	325	220	600	600 × 1	
	670	670	565	670	565	460	840	840 × 1	
	1 030	1 030	925	1 030	925	820	1 200	1 200 × 1	
	1 390	1 390	1 285	1 390	1 285	1 180	1 560	1 560 × 1	
	–	1 870	1 765	1 870	1 765	1 660	2 040	2 040 × 1	

Notes : Lengths not stated in this table are also available. Please contact NSK for details.
Linear motors capable for long stroke are delivered with separate rack bases. Customers can simply assemble according to the set up manual for the base included with the motors.
All assembly is to be carried out by the customer.

2-5. System configuration

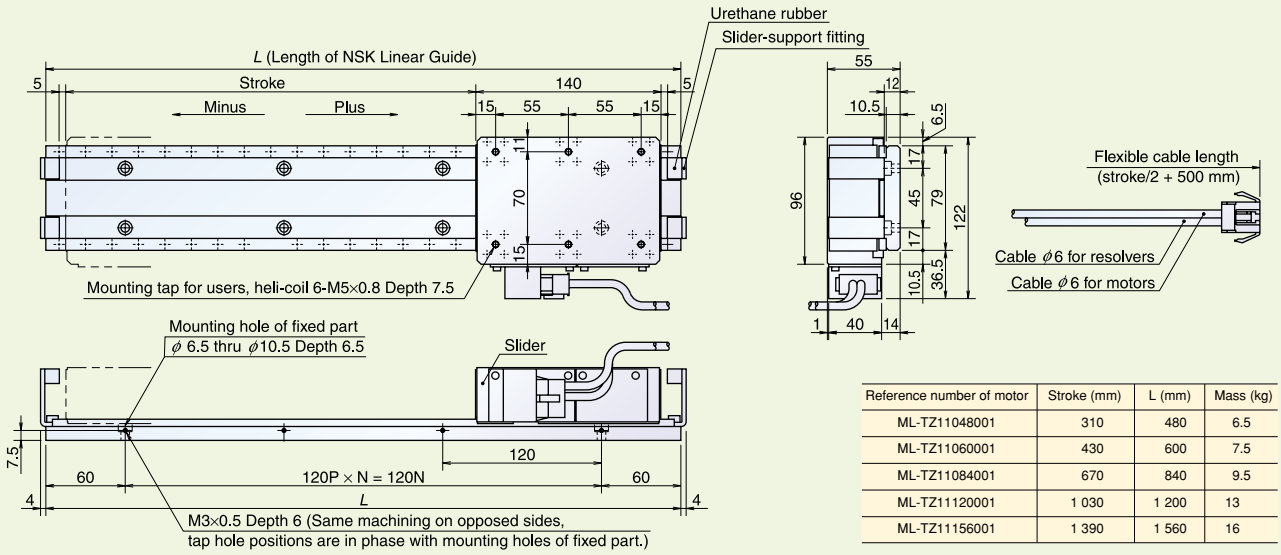
Fig. 12 System configuration



Cables indicated with dotted lines or shown inside of ⬚ are to be prepared by the customer.

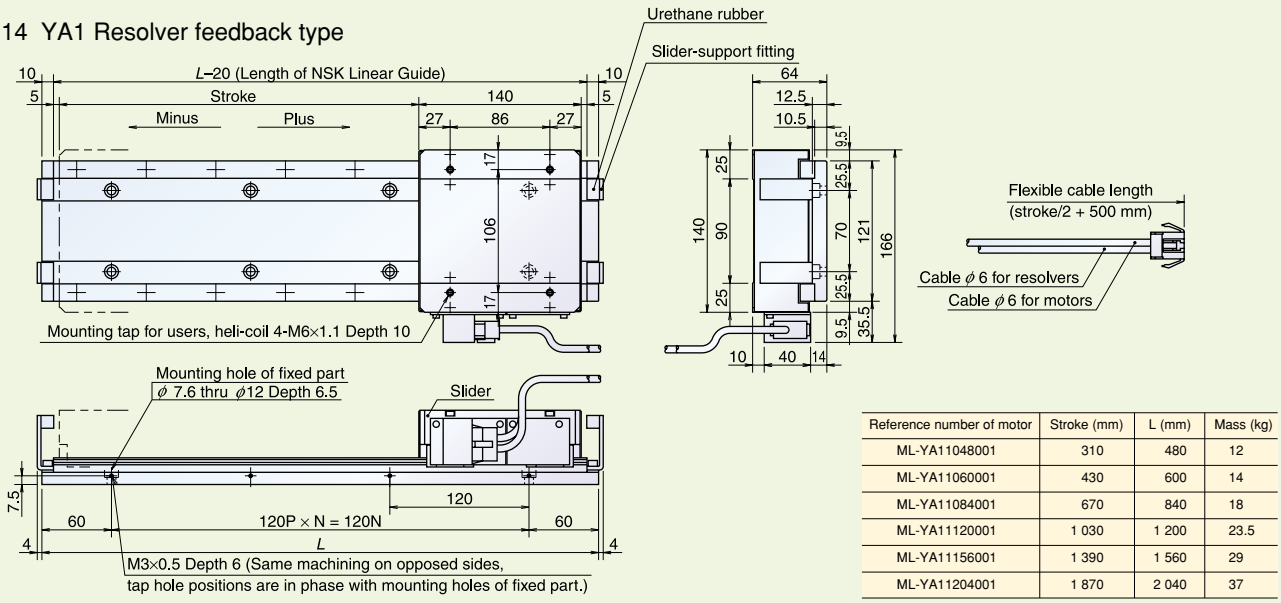
2-6. Dimensions

Fig. 13 YZ1 Resolver feedback type



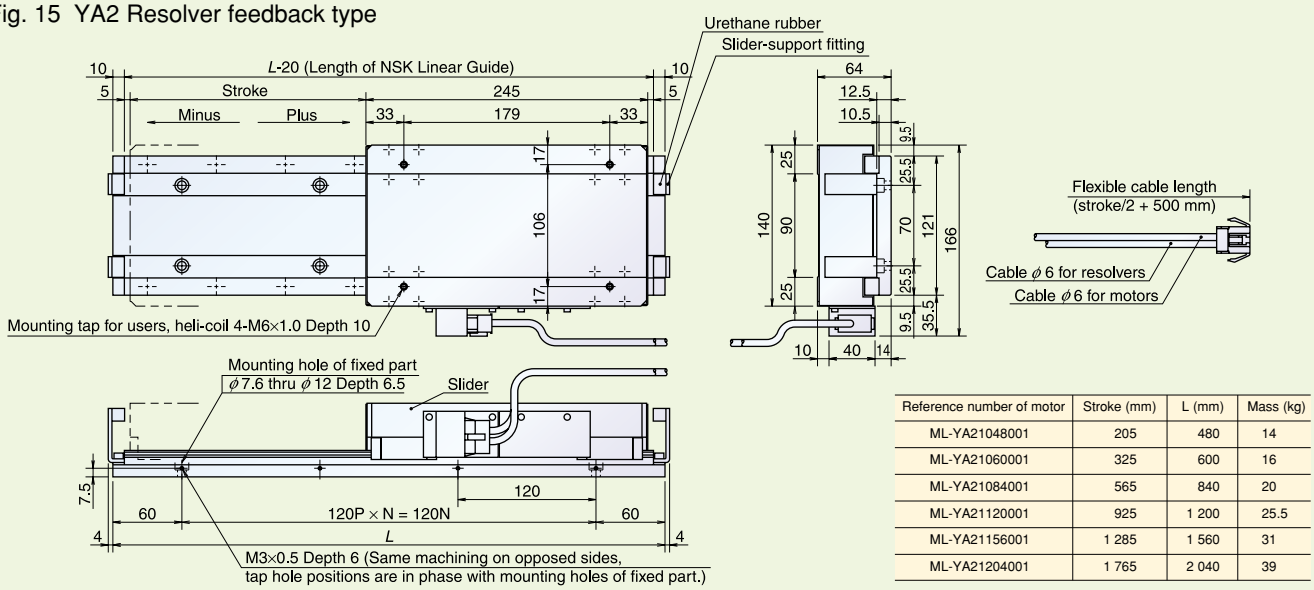
Reference number of motor	Stroke (mm)	L (mm)	Mass (kg)
ML-TZ11048001	310	480	6.5
ML-TZ11060001	430	600	7.5
ML-TZ11084001	670	840	9.5
ML-TZ11120001	1 030	1 200	13
ML-TZ11156001	1 390	1 560	16

Fig. 14 YA1 Resolver feedback type



Reference number of motor	Stroke (mm)	L (mm)	Mass (kg)
ML-YA11048001	310	480	12
ML-YA11060001	430	600	14
ML-YA11084001	670	840	18
ML-YA11120001	1 030	1 200	23.5
ML-YA11156001	1 390	1 560	29
ML-YA11204001	1 870	2 040	37

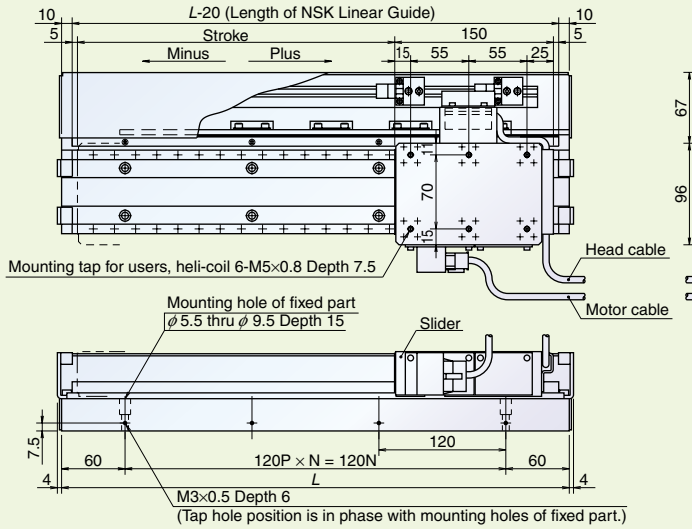
Fig. 15 YA2 Resolver feedback type

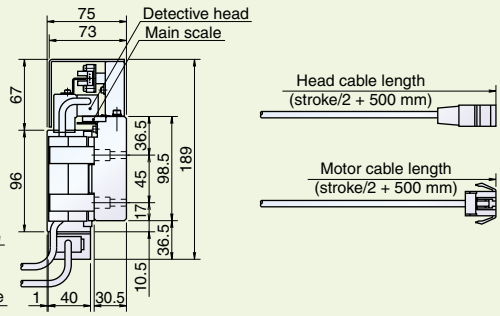


Reference number of motor	Stroke (mm)	L (mm)	Mass (kg)
ML-YA21048001	205	480	14
ML-YA21060001	325	600	16
ML-YA21084001	565	840	20
ML-YA21120001	925	1 200	25.5
ML-YA21156001	1 285	1 560	31
ML-YA21204001	1 765	2 040	39

2-7. Dimensions

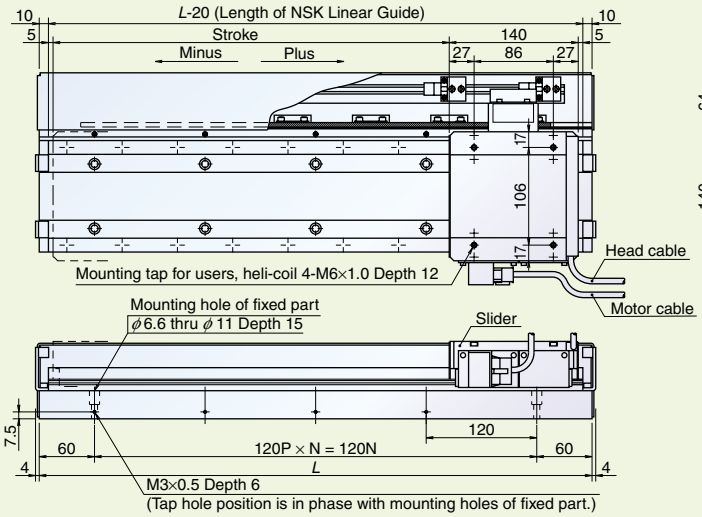
Fig. 16 YZ1 Linear scale feedback type

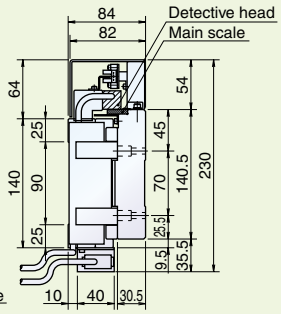




Reference number of motor	Stroke (mm)	L (mm)	Mass (kg)
ML-YZ11048901	300	480	15.5
ML-YZ11060901	420	600	19
ML-YZ11084901	660	840	26
ML-YZ11120901	1 020	1 200	36
ML-YZ11156901	1 380	1 560	46

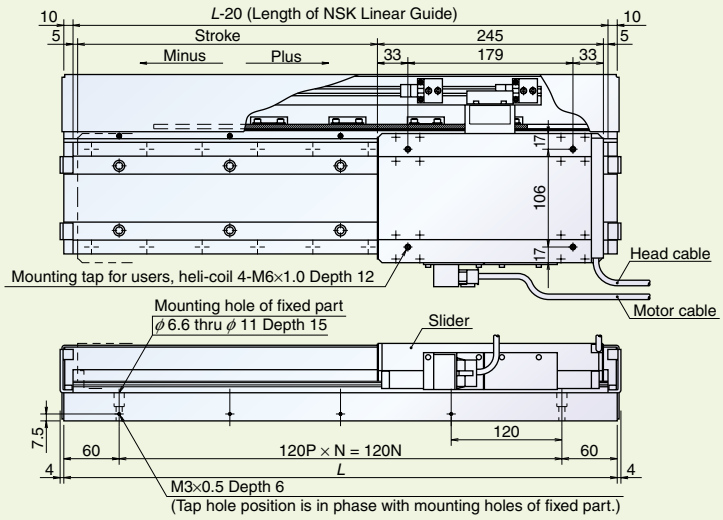
Fig. 17 YA1 Linear scale feedback type

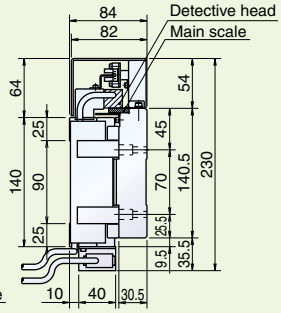




Reference number of motor	Stroke (mm)	L (mm)	Mass (kg)
ML-YA11048901	310	480	24
ML-YA11060901	430	600	29
ML-YA11084901	670	840	39
ML-YA11120901	1 030	1 200	54
ML-YA11156901	1 390	1 560	69

Fig. 18 YA 2 Linear scale feedback type

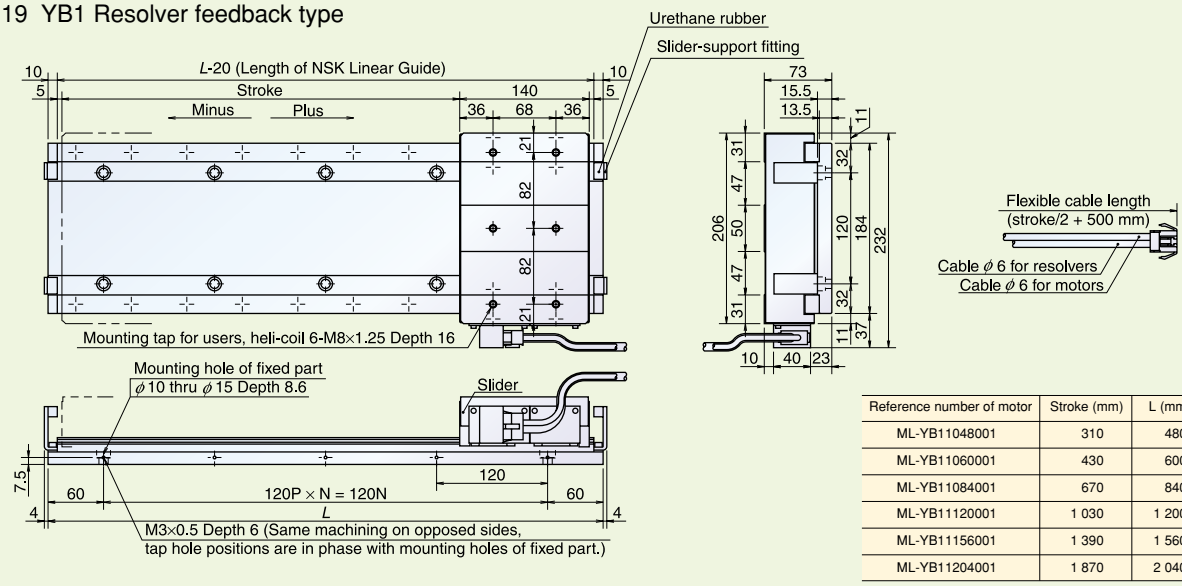




Reference number of motor	Stroke (mm)	L (mm)	Mass (kg)
ML-YA21048901	205	480	26
ML-YA21060901	325	600	31
ML-YA21084901	565	840	41
ML-YA21120901	925	1 200	56
ML-YA21156901	1 285	1 560	71

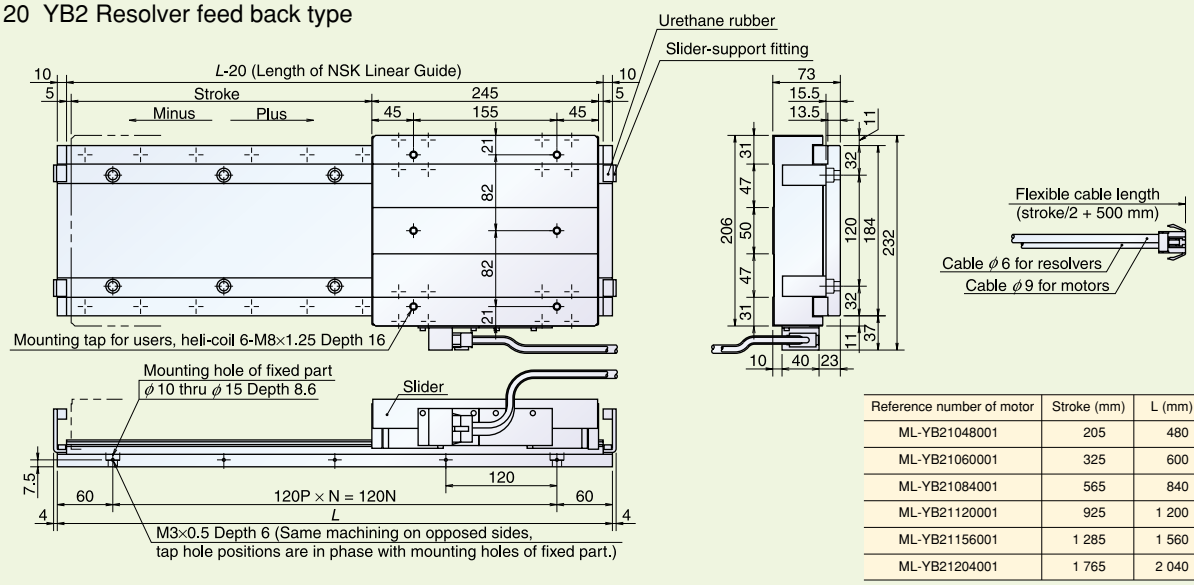
2-8. Dimensions

Fig. 19 YB1 Resolver feedback type



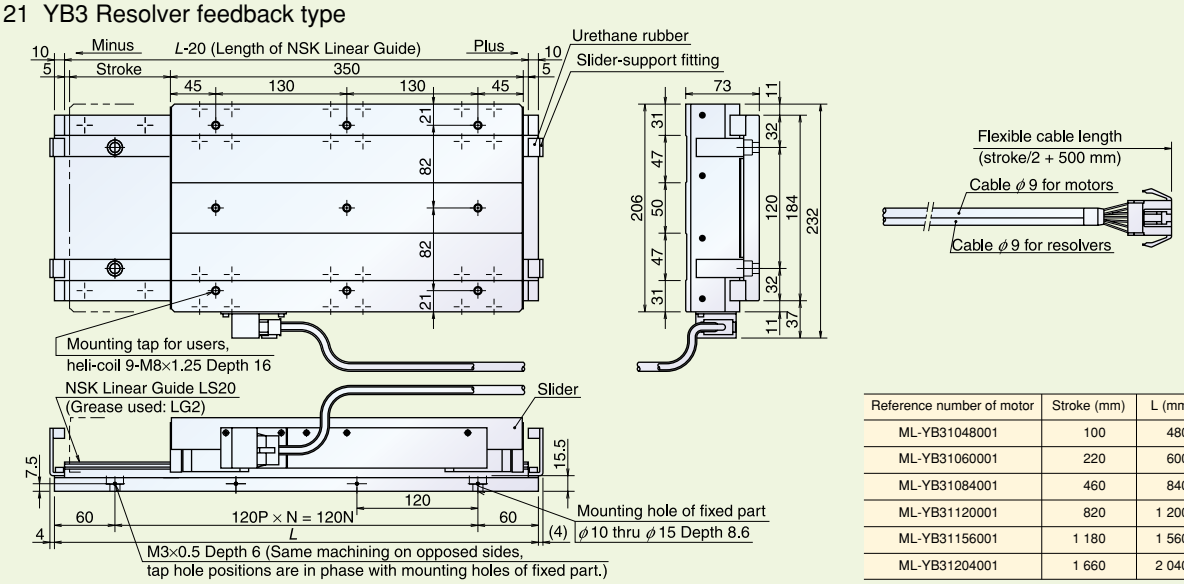
Reference number of motor	Stroke (mm)	L (mm)	Mass (kg)
ML-YB11048001	310	480	21
ML-YB11060001	430	600	24.5
ML-YB11084001	670	840	31.5
ML-YB11120001	1 030	1 200	42
ML-YB11156001	1 390	1 560	52.5
ML-YB11204001	1 870	2 040	66.5

Fig. 20 YB2 Resolver feed back type



Reference number of motor	Stroke (mm)	L (mm)	Mass (kg)
ML-YB21048001	205	480	24
ML-YB21060001	325	600	27.5
ML-YB21084001	565	840	34.5
ML-YB21120001	925	1 200	45
ML-YB21156001	1 285	1 560	55.5
ML-YB21204001	1 765	2 040	69.5

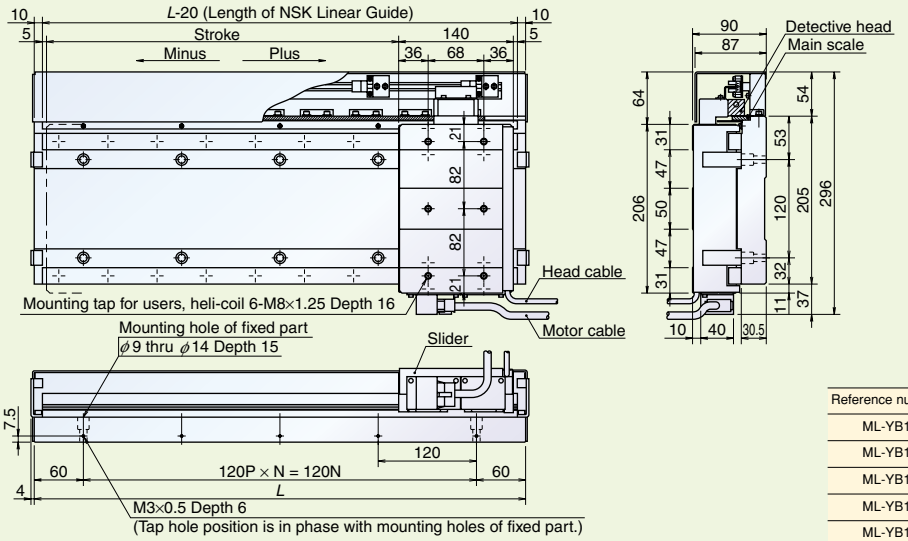
Fig. 21 YB3 Resolver feedback type



Reference number of motor	Stroke (mm)	L (mm)	Mass (kg)
ML-YB31048001	100	480	29
ML-YB31060001	220	600	32.5
ML-YB31084001	460	840	39.5
ML-YB31120001	820	1 200	50
ML-YB31156001	1 180	1 560	60.5
ML-YB31204001	1 660	2 040	74.5

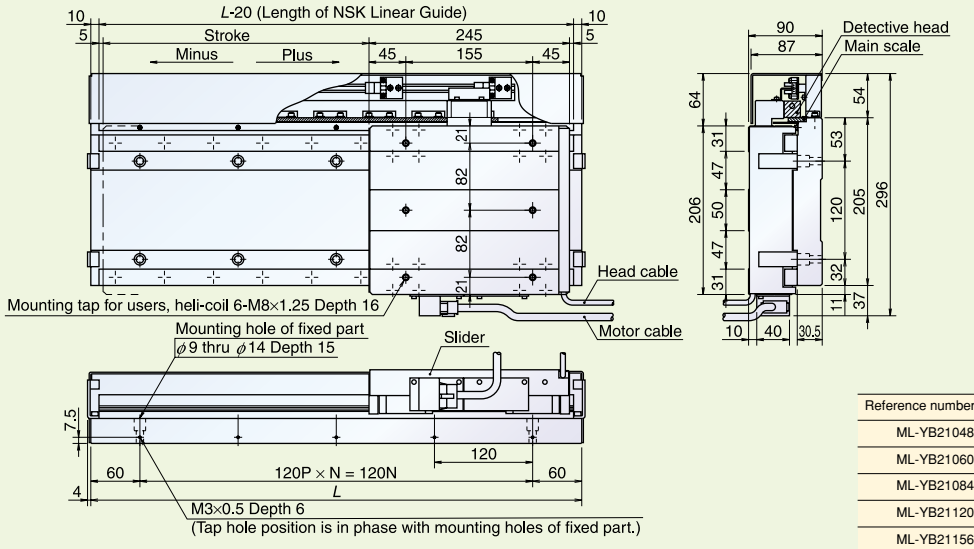
2-9. Dimensions

Fig. 22 YB1 Linear scale feedback type



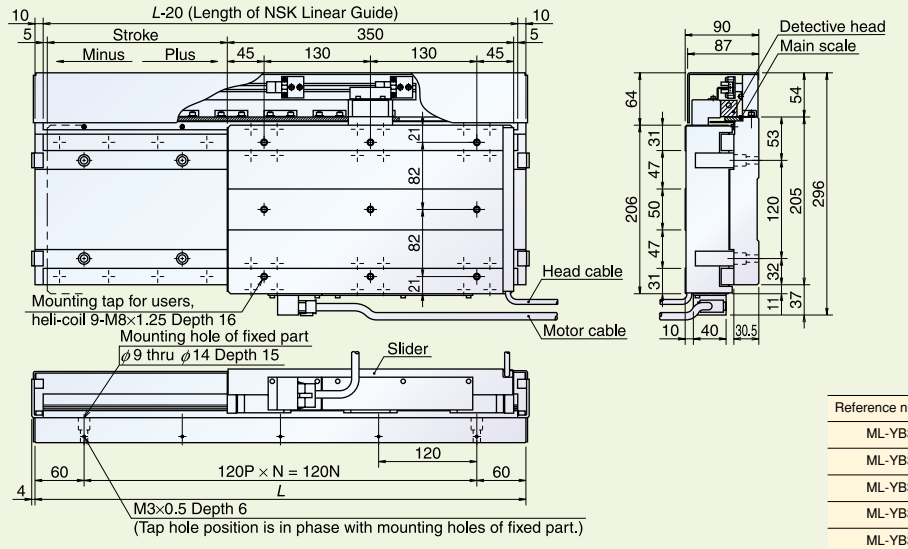
Reference number of motor	Stroke (mm)	L (mm)	Mass (kg)
ML-YB11048901	310	480	36
ML-YB11060901	430	600	43.5
ML-YB11084901	670	840	58
ML-YB11120901	1 030	1 200	80
ML-YB11156901	1 390	1 560	102

Fig. 23 YB2 Linear scale feedback type



Reference number of motor	Stroke (mm)	L (mm)	Mass (kg)
ML-YB21048901	205	480	39
ML-YB21060901	325	600	46.5
ML-YB21084901	565	840	61
ML-YB21120901	925	1 200	83
ML-YB21156901	1 285	1 560	105

Fig. 24 YB3 Linear scale feedback type



Reference number of motor	Stroke (mm)	L (mm)	Mass (kg)
ML-YB31048901	100	480	44
ML-YB31060901	220	600	51.5
ML-YB31084901	460	840	66
ML-YB31120901	820	1 200	88
ML-YB31156901	1 180	1 560	110

2-10. How to butt Y Series

Butt connection of Y Series

Longer stroke can be achieved by butting the motor rack bases (stator) for the Y Series. The butting method is applicable for a stroke of over 2 040 mm rack base length.

Total length is determined by incorporating rack bases with three different lengths (1 200, 1 560, and 2 040 mm). This method cannot be applied to all the Megathrust Motors but is limited to the following:

- Resolver feedback type Megathrust Motor
- Motor type YA2, YB2, and YB3

The total length of rack bases applying the butting method and the combination of an effective stroke and rack base are shown in the following table.

Table 8

Unit: mm

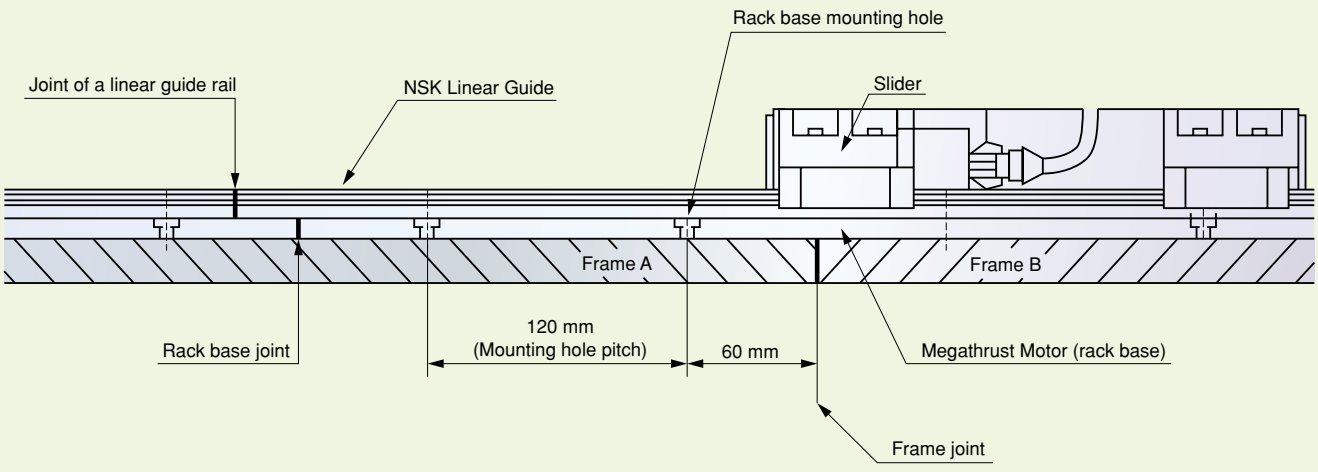
Motor type	YA2	YB2	YB3	Total length of rack base (L)	Combination of rack base
Effective stroke	2 125	2 125	2 020	2 400	1 200 × 2
	2 845	2 845	2 740	3 120	1 560 × 2
	3 325	3 325	3 220	3 600	(1 560 × 1) + (2 040 × 1)
	3 805	3 805	3 700	4 080	2 040 × 2
	4 885	4 885	4 780	5 160	(1 560 × 2) + (2 040 × 1)
	5 845	5 845	5 740	6 120	2 040 × 3
	6 925	6 925	6 820	7 200	(1 560 × 2) + (2 040 × 2)
	7 885	7 885	7 780	8 160	2 040 × 4
	8 965	8 965	8 860	9 240	(1 560 × 2) + (2 040 × 3)
	9 925	9 925	9 820	10 200	2 040 × 5

Instructions for manufacturing a mounting frame for a Megathrust Motor

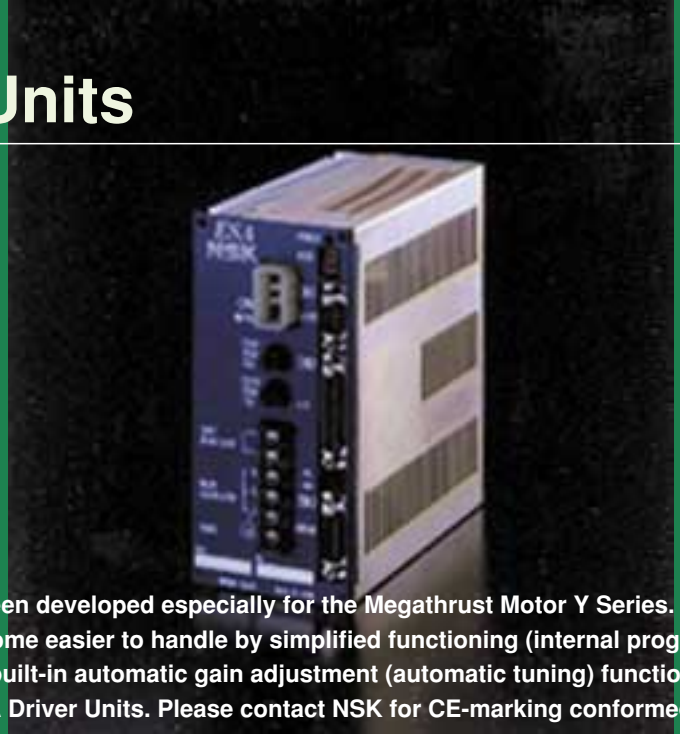
Mounting frames for Megathrust Motors should preferably be manufactured as an integrated construction and not in separate pieces. In case of separate pieces, any height difference in the frame joint should be minimized to avoid center deviation when mounting the base. Furthermore, the frame joint should not be matched with the rack base joint.

To prevent any center deviation in the vertical direction, we recommend that the frame joint is shifted from the base joint by two pitches of the base mounting hole.

Fig. 25



ESA Driver Units



The ESA Driver Unit has been developed especially for the Megathrust Motor Y Series. Servo gain tuning has become easier to handle by simplified functioning (internal program operation and pulse train input operation) and built-in automatic gain adjustment (automatic tuning) function. Two types of ESA 13 and 15 are available in ESA Driver Units. Please contact NSK for CE-marking conformed products.

2-11. Reference number (Driver Unit)

Although the reference number of the Megathrust Motor includes the motor, Driver Unit and cable set, regarded as an entire system, in case a Driver Unit is separately required, e.g. as a spare, use the following reference number.

Example: **M-ESA-L** **YA2** **A** **13**

- M-ESA-L: ESA drive unit for Megathrust Motors
- YA2: Motor type of Y Series Megathrust Motor
- A: Power voltage specification — A: AC 200V, C: AC 100V
- 13: Series number — 15: ESA15 (with analog input), 13: ESA13 (standard)

2-12. Specifications of ESA Driver Unit (Resolver feedback type)

Table 9 General specifications

Driver Unit reference number			M-ESA-L***A13	M-ESA-L***C13
	Standard	ESA13	M-ESA-L***A13	M-ESA-L***C13
	With analog input	ESA15	M-ESA-L***A15	M-ESA-L***C15
Input power voltage			Single or 3-phase AC 200V/220V 50/60 Hz	AC 100V/110V 50/60 Hz
Input power capacity			YZ1 (0.2 KVA) YA1, YA2 (0.9 KVA)	YZ1 (0.2 KVA) YA1, YA2 (0.7 KVA)
			YB1, YB2, YB3 (1.2 KVA)	YB1, YB2, YB3 (1.0 KVA)
Mass			2.5 kg (ESA13)/3 kg (ESA15)	
Environmental condition			Temperature 0°C ~ 50°C, Humidity 20% ~ 90% (No condensation), Indoor use, No dust or corrosion gas	

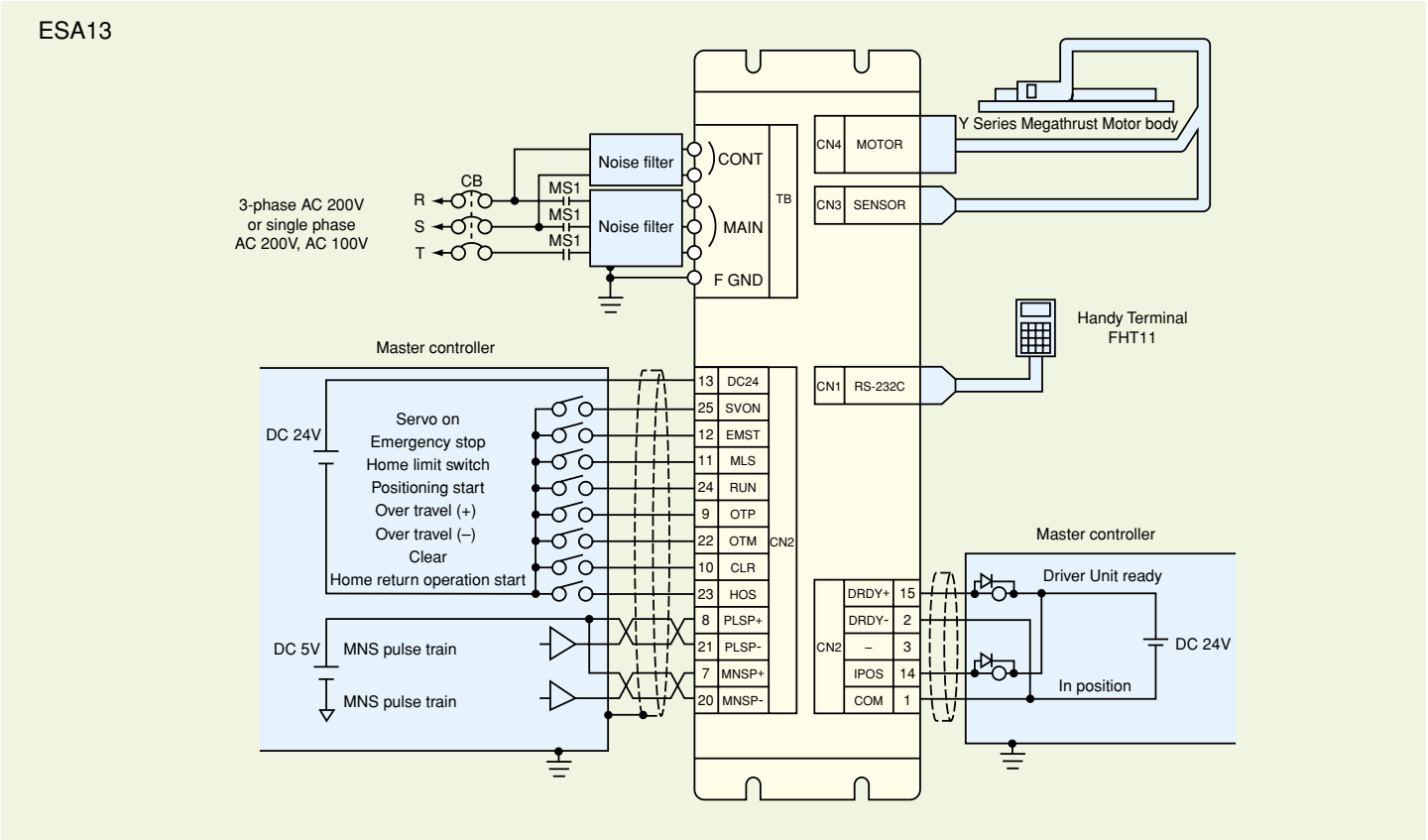
*Please contact NSK for a linear scale feedback type.

Table 10 Function specifications

Positioning command formats		Internal program operation (ESA15: maximum 64 steps, ESA13: maximum 16 steps) Pulse train input operation, RS-232C communication operation
Input signal	Pulse train input	Maximum input pulse frequency: 614.4 kpps Input pulse type: PLS/MNS system(1)
	Control input	Emergency stop, servo on, internal program selection, home position limit switch, positioning start,analog speed command (±DC 10V: ESA15 only), integral control off (ESA15 only), jog, over travel
Output signal	Position feedback signal	Output signal mode: line driver (in Z-phase can only be switched to the open collector) Resolution: A/B-phase = 16 μm/pulse, Z-phase = 1 pulse/4.096 mm
	Output for control	Driver Unit ready, in position
Position sensor resolution		Position sensor resolution is automatically switched or set at 12 bit. Position sensor resolution is set at 10 bit.
Alarm function		Excess position error, over travel, controller error, resolver error,motor over-current, heatsink over-heating, main power voltage error, control power voltage drop
Monitor function		Analog speed monitor, alarm status, RS-232C communication monitor (parameter, program content, position data, alarm message)
Communications		Serial RS-232C communication, transmission speed: 9 600 bps
Others		Automatic gain adjustment (automatic tuning) function using RS-232C communication commands

(1) The PLS/MNS format can be switched to the pulse/direction format or to the A/B-phase format.
*Analog speed command and integral control off are available only for ESA15.

2-13. Wiring example of ESA 13



2-14. Specifications of type ESA 13 input/output signal

Table 10 CN 2 Connectors DB-25PF-N Connector covers DB-C 2-J 9 (Manufactured by Japan Aviation Electronics Industry, Ltd.)

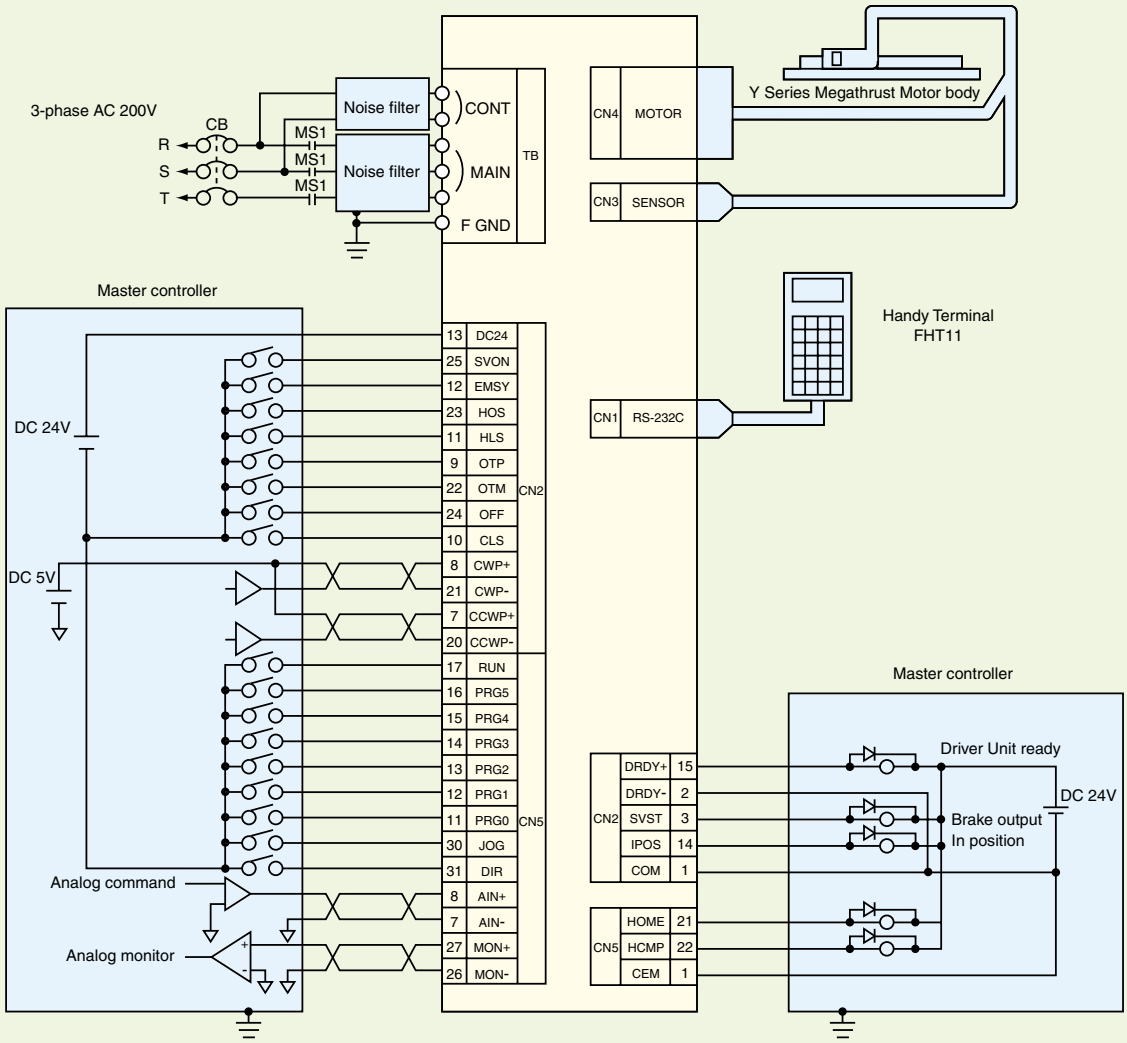
Input/output	Signal name	Pin No.	Name	Contents
Input signal	PLSP+	8	PLS pulse train (+)	Moves in plus direction by pulse train input. (Select pulse train or A-phase by switch.)
	PLSP–	21	PLS pulse train (–)	
	MNSP+	7	MNS pulse train (+)	Moves in minus direction by pulse train input. (Select direction designation or B-phase by switch.)
	MNSP–	20	MNS pulse train (–)	
	EMST	12	Emergency stop	Quickly stops the motor by a dynamic brake.
	SVON	25	Servo on	Turns the servo on.
	OTP	9	Over travel limit (+)	Over travel input signal in plus direction.
	OTM	22	Over travel limit (–)	Over travel input signal in minus direction.
	CLR	10	Clear	Clears alarm and position deviation counter.
	HOS	23	Home return start	Starts Home return operation.
	HLS	11	Home limit switch	After Home return operation started, determines home by switching signal to ON/OFF.
	RUN	24	Positioning start	Starts selected channel.
	DC24	13	DC 24V external supply	External power for input signal (over DC 24V, 0.2 A).
Output signal	CHA	6	Position feedback signal A-phase	Pulse signal indicating the motor movement. Output with a line driver. (OCZ: open collector output.)
	⁎CHA	19	Position feedback signal *A-phase	
	CHB	5	Position feedback signal B-phase	
	⁎CHB	18	Position feedback signal *B-phase	
	CHZ	4	Z-phase position feedback signal MSB	
	⁎CHZ	17	Position feedback signal *Z-phase	
	SGND	16	Signal ground for position feedback signal	
	DRDY+	15	Driver Unit ready (+)	Indicates that operation preparation is completed.
	DRDY–	2	Driver Unit ready (–)	(Opens when drive unit is not ready and during alarms.)
	IPOS	14	In position	Indicates that positioning is completed.
	—	3	—	—
	COM	1	Output signal common	Common signal for in position and servo condition.

*The signal of pin No. 10 and 23 can be changed by setting changes from the RS-232C as follows:

Input Signal	RPG2	10	Internal program channel switch 2	Selects the execution channel by combination of ON/OFF of the channel switches 2 and 3.
	RPG3	23	Internal program channel switch 3	

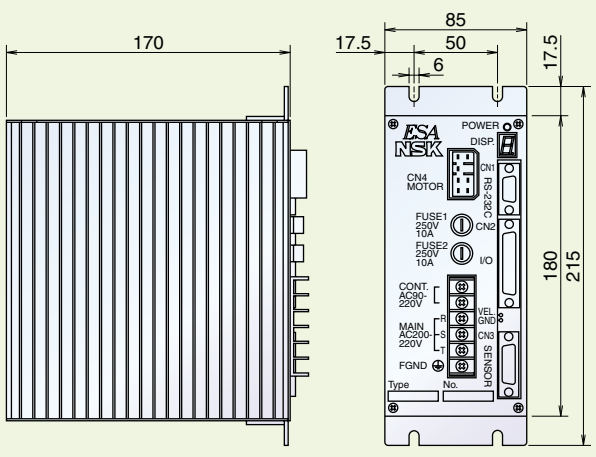
2-15. Wiring example of ESA 15

ESA15

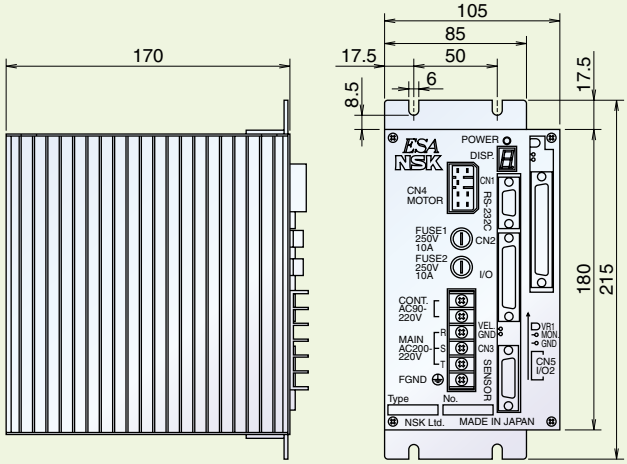


2-16. Dimensions

ESA13



ESA15



Cable sets for Y Series

NSK Megathrust Motors use robot cables with excellent elasticity.

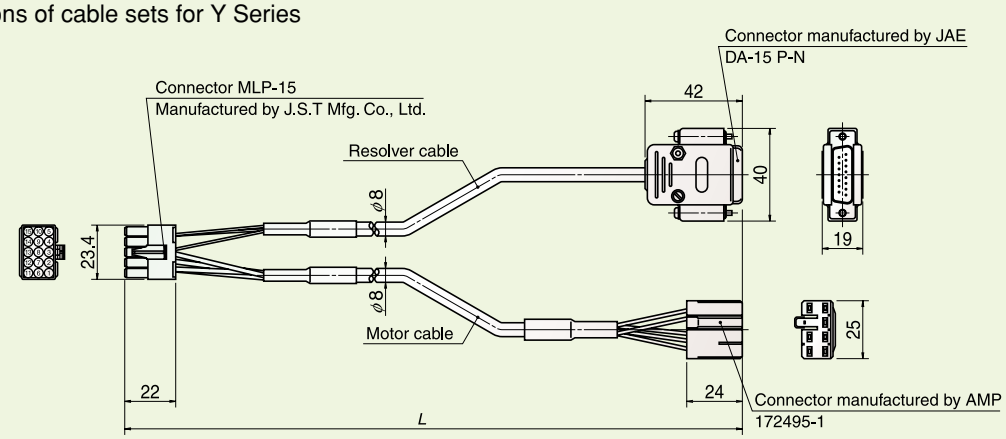
2-17. Reference number

Example: **ML-C** **005** **MS** **05**

- **ML-C**: Cable set for Megathrust Motors
- **005**: Cable set length, 005: 5m
- **MS**: Applicable Driver Unit, MS: For ESA Driver Unit
- **05**: Series number

2-18. Dimensions

Fig. 26 Dimensions of cable sets for Y Series



2-19. Optional uninterruptable power source (Reference number: M-FZ 041) (specially for Y Series)

This uninterruptable power source is used to provide an electronic brake function. If the power is connected to a Megathrust Motor, braking force occurs without mechanical equipment when power fails.
However, since the braking force is only generated in about two seconds after power fails, it cannot be used for negative braking of the upper and lower axes. The applicable range of the uninterruptable power source is shown in Fig. 27. YB3 using the EDA Driver Unit with 200V main power voltage (mass of slider: 15 kg), when 85 kg mass of load and 100 kg total mass are driven at 0.6 m/s, the brake action can function within the range in Fig. 27. However, when the mass of load of the same 85 kg is driven at 1 m/s, the braking action cannot function out of the range of . In such cases, alternative braking mechanisms have to be studied.

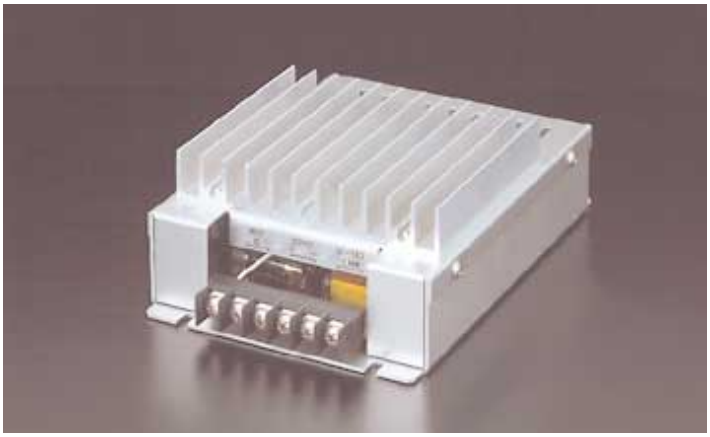
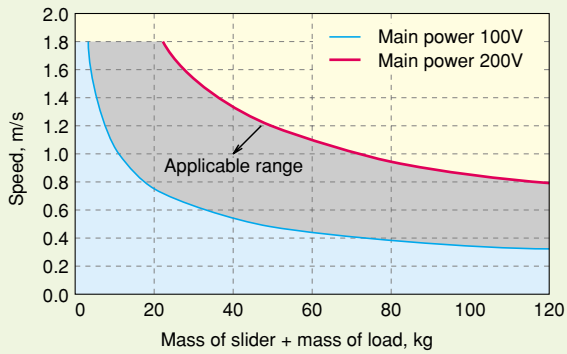


Fig. 27 ESA Driver Unit



Approximate braking distance is obtained by the following formula.

$$\text{Braking distance } L = \frac{1}{2} V^2 \frac{m}{F}$$

Where, V: Usable speed (m/s)
m: Total mass of moving part including mass of slider (kg)
F: Braking force classified by motor type
(please refer to Table 10)

Table 11 Braking force classified by motor type

Motor type	Braking force F (N)
YZ1	50
YA1	100
YA2	200
YB1	170
YB2	330
YB3	500

Handy Terminal

Available for PM Series and Y Series

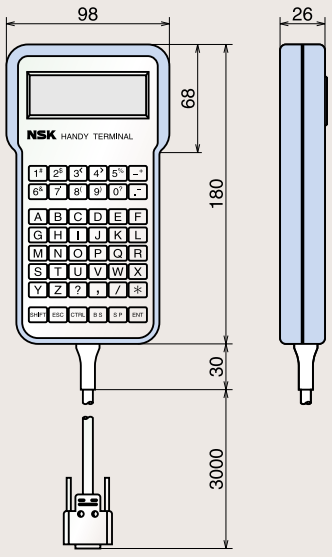
The Handy Terminal FHT-11 is a communication terminal for the Driver Unit, using an RS-232C interface.
This terminal can be easily used by simply connecting it to the CN1 connector.

- Easily-viewable LCD screen displays 4 lines of 20 characters each
- No external power required
- A wide range of characters can be handled (Alphanumeric + special characters in conformity with ASCII code)
- Reference number: M-FHT11

1. Specifications

Power voltage	DC 5V ±5%
Power consumption	200 mW
Applicable ambient temperature	0 ~ 50 ˚C
Applicable ambient humidity	35 ~ 85% RH (No freeze)
Applicable ambient atmosphere	No corrosive gas
Storage ambient temperature	–10 ~ +65 ˚C
RS-232C communication specifications	Transmission speed: 9 600 bps
	Data bit: 8 bit
	Stop bit: 2 bit Start bit: 1 bit
	Parity check: No
Transfer data	ASCII code
Usable connector	DE-9 P-N (Manufactured by Japan Aviation Electronics Industry, Ltd.)
Fitting cover	DE-CI-J6 (Manufactured by Japan Aviation Electronics Industry, Ltd.)
Body mass	Approx. 250g (Excluding cables)

2. Shape and dimensions



3. Arrangement of connector pins (DE-9 P-N use)

Terminal number	1	2	3	4	5	6	7	8	9
Signal code	RXD	RTS	TXD	DTR	DSR	SG	CTS	+5V	FG