An idea gives pleasure on the technology.

Motro Compo

Catalogue No.T12-1596

QuinTep®

5 PHASE STEP MOTOR AND DRIVER

Small size, High torque, High speed & Low rotor inertia

TAMAGAWA SEIKI CO.,LTD.

QuinTep®

5 PHASE STEP MOTOR AND DRIVER

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What is Step motor?

Generally Step motor receives some pulse signals from external devices, pulls its rotor by the electro-magnetic force that is induced in the stator windings and rotates its output shaft by the angle proportional to the number of pulses.

Its rotational speed is defined by the frequency of input pulses and its rotational angle is defined by the amount of pulses. On the other hand the unit step angle is defined by the mechanical structure of a rotor and a stator.

The Step motor is also called as Stepping motor, Stepper or Pulse motor because no standard of specification is established, and then Tamagawa Seiki Co., Ltd. unifies to call it as Step motor.

SPECIAL FEATURES OF STEP MOTORS

Capable of controlling precise position in open loop

- Rotational angle is proportional to the number of input pulses.
- Rotational speed is proportional to the input pulse rate (pulse frequency).
- Angle error (Positioning error) is very small and is not accumulated.

Capable of holding the static position stable by self-holding torque

- Biggest self-holding torque (Holding torque) is generated in the state of exciting the motor windings.
- Even in the state of non-exciting, some self-holding torque (Detent torque) is generated because the permanent magnet is used.

Capable of responding fast to the starting, stopping and reversing with its superior acceleration

No maintenance is needed for the mechanical wear as is often the case with brushes for DC motors

Merit of 5-Phase Step motors

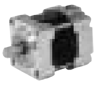
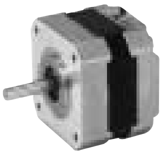
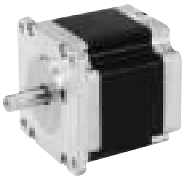
5-phase step motors have the superior characteristics of resolution, vibration, performance and others compared with 2-phase step motors.

(1) High resolution : 0.72° for full step and 0.36° for half step. These are the resolution of 2.5 times compared with 2-phase step motors.

(2) Low vibration and smooth rotation, because the torque ripple is small and the variation of operating torque is extremely small.

(3) Fast response : The out of synchronization caused by resonance rare in the range of low and middle rotational speed unlike the conventional 2-phase step motor, and it is capable of controlling the fast positioning by means of slow-up and slow-down because of its having 2.5 times of step resolution.

TABLE OF MAJOR SPECIFICATIONS

Model	Outline Dimensions	Type Number			Rated Voltage	Rated Current	Holding* Torque	Body Length
		Basic Type	Output Shaft		V/Phase	A/Phase	N · m (Kgf · cm)	mm
	mm		Single	Dual				
09	□24 	TS3664	N1E1	N11E1	1.58	0.35	0.017 (0.17)	30.5
		TS3664	N1E2	N11E2	0.83	0.75	0.017 (0.17)	30.5
		TS3664	N2E3	N12E3	2.35	0.35	0.028 (0.28)	46.5
		TS3664	N2E4	N12E4	1.28	0.75	0.028 (0.28)	46.5
17	□42 	TS3667	N1E1	N11E1	2.63	0.35	0.13 (1.3)	33
		TS3667	N1E2	N11E2	1.28	0.75	0.13 (1.3)	33
		TS3667	N1E3	N11E3	0.67	1.4	0.13 (1.3)	33
		TS3667	N2E4	N12E4	3.33	0.35	0.18 (1.8)	39
		TS3667	N2E5	N12E5	1.65	0.75	0.18 (1.8)	39
		TS3667	N2E6	N12E6	0.9	1.4	0.18 (1.8)	39
		TS3667	N3E7	N13E7	1.65	0.75	0.24 (2.4)	47
		TS3667	N3E8	N13E8	0.9	1.4	0.24 (2.4)	47
23	□60 	TS3624	N1E1	N21E1	1.95	0.75	0.45 (4.5)	48.5
		TS3624	N1E2	N21E2	1.12	1.4	0.45 (4.5)	48.5
		TS3624	N2E3	N22E3	2.55	0.75	0.8 (8)	56.5
		TS3624	N2E4	N22E4	1.54	1.4	0.8 (8)	56.5
		TS3624	N3E5	N23E5	2.52	1.4	1.5 (15)	86.5
		TS3624	N3E6	N23E6	1.82	2.8	1.5 (15)	86.5
34	□86 	TS3630	N1E1	N21E1	2.46	1.4	2.1 (21)	64.5
		TS3630	N1E2	N21E2	2.1	2.8	2.1 (21)	64.5
		TS3630	N2E3	N22E3	3.82	1.4	4.1 (41)	96.5
		TS3630	N2E4	N22E4	1.88	2.8	4.1 (41)	96.5
		TS3630	N3E5	N23E5	2.38	2.8	6.3 (63)	126.5

✻ Holding torque is the value at 4-phase exciting by the rated current.
(The torque conversion rate is 1 N · m ≒ 10kgf · cm)

DRIVER SPECIFICATIONS Bi-polar Pentagon Constant Current Driving

					MICRO - STEP	
Type number		**AU9112**	**AU9118**	**AU9119**	**AU9116**	**AU9151**
Input power supply	Direct current (DC)	17 ~ 40V	———		21.6 ~ 26.4V	———
	Alternate current (AC)	———	90 ~ 110V, 50/60Hz, single phase		———	90 ~ 125V, 50/60Hz, single phase
	Current consumption	3A Max.	3.5A Max.	6.5A Max.	3A Max.	3.5A Max.
Applicable motors	□24 TS3664	○	———	———	○	———
	□42 TS3667	○	———	———	○	———
	□60 TS3624	○	○	○	○	○
	□86 TS3630	———	○	○	———	○
Pulse rate vs. Torque characteristics		P16, 18, 22	P23, 24, 26	P24, 26	P16, 19, 22, 23	P24, 26
Driving current		1.4A Max./phase		2.8A Max./phase	1.4A Max./phase	
Setting of driving current		Set by variable resistor			Set by digital switches	
Setting of automatic current-down		Reduce to 60% at stationary	Set by variable resistor (25 ~ 75%)		Set by digital switches (27 ~ 90%)	
Setting of functions (by dip-switches)	Input signals	Switching of CW/CCW pulse input (2 clock mode) / PULSE/DIR input (1 clock mode)				
	Step angle	Switching of FULL/HALF step			80 interpolation Max. to the basic step angle	
	Current-down	Fixed	ON/OFF switching			
	Driving voltage	Fixed	HIGH/LOW switching		Fixed	HIGH/LOW switching
	Built-in test	———	Switching of low speed rotation / none			
Input signals	Driving pulse	Triggered at the edge of OFF to ON of photo-coupler, CW rotation for ON of DIR input				
	Hold-OFF	Excitation of motor is OFF for photo-coupler ON.				
	Switching of micro-step angle	———			Capable of setting 2 kinds of interpolation	
	Current-down	———				ON/OFF switching
Output signals & Origin reference point		———	Photo-coupler ON for each 7.2° in case of the basic step angle of 0.72°			
Outline drawing		Fig.1	Fig.2		Fig.1	Fig.2
Operating temperature & humidity		0 ~ 40°C 90%RH Max.				
Storage temperature & humidity		–10 ~ 70°C 90%RH Max.				

OUTLINE

	A	B	C
AU9112	93	45	32
AU9116	105	74	38

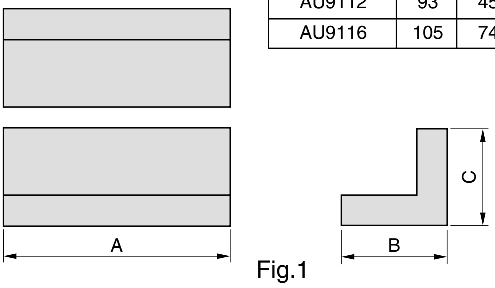


Fig.1

	A	B	C
AU9118	170	39	130
AU9119	215	57	150
AU9151	170	39	130

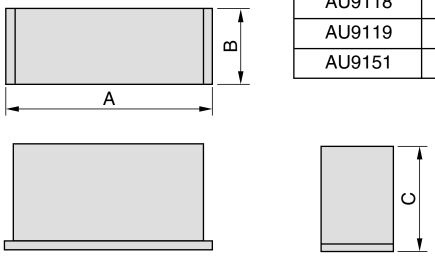
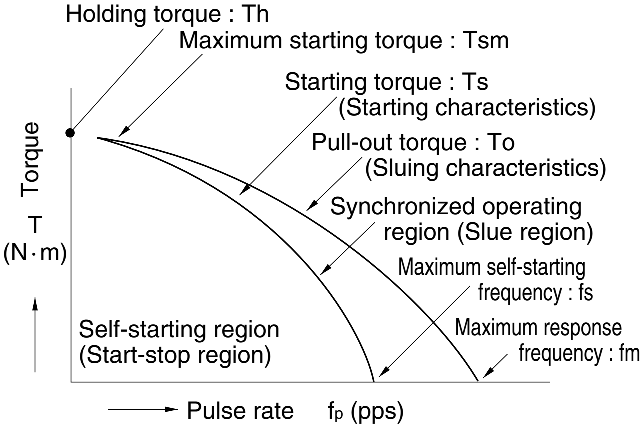


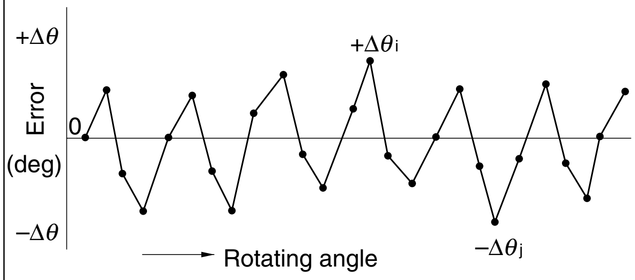
Fig.2

DEFINITIONS OF TERMS FOR STEP MOTORS

Extracted from JEM-TR157-1996

Items	Terms	Symbols	Units	Definitions
1	Winding resistance	R	Ω	DC resistance of stator winding for one phase
2	Winding inductance	L	mH	Maximum value of inductance of stator winding for one phase
3	Rotor inertia	J_M	kg · m²	Moment of rotor inertia related to its axis $J_M = \frac{GD^2}{4}$
4	Detent torque	T_d	N · m	Maximum torque that is generated when any angle deviation is made by applying external torque in non-exciting state for the motor using a permanent magnet on its rotor.Also it is called as non-exciting holding torque or residual torque.
6	Step angle	θ_a	° (deg)	Theoretical rotational angle of shaft corresponding to one command pulse in defined exciting sequence.
7	Basic step angle	θ_f	° (deg)	The step angle when it is driven by 1-phase exciting. For VR type : $\theta_f = \frac{360°}{m \cdot Z}$ For PM type and HB type : $\theta_f = \frac{360°}{2m \cdot Z}$ m : Number of phase of step motor z : Number of rotor teeth or number of pairs of magnetic poles
8	Rated current	I_R	A	Nominal winding current defined in considering the saturation of magnetic circuit, temperature rise, etc.
9	Rated voltage	V_R	V	Applied voltage necessary to flow its rated current. $V_R = R \cdot I_R$
10	Holding torque	T_h	N · m	Maximum torque that is generated when any angle deviation is made by applying external torque in the defined exciting condition. Also it is called as maximum static torque.
11	Pulse rate	f_p	pulse/s	Input signal for driving a step motor, which is represented by number of pulses per unit time. Also it is called as pulse frequency. Pulse per second (pulse/s) is used as the unit, or pps may be used if it causes no doubt.
12	Maximum self-starting frequency	f_s	pulse/s	Maximum input pulse frequency that can start itself to synchronize with the input pulse frequency applied from outside as a step function in no load condition.
13	Maximum response frequency	f_m	pulse/s	Maximum input pulse frequency that can operate synchronously in no load condition.
14	Starting torque	T_s	N · m	Maximum load torque that can start itself at a certain input pulse frequency.
15	Starting torque characteristics	$T_s (f_p)$	N · m	Characteristic curve of starting torque related to input pulse frequency. Also it is called as starting characteristics.
17	Pull-out torque	T_o	N · m	Maximum torque that can operate synchronously at a certain input pulse frequency.
18	Pull-out torque characteristics	$T_o (f_p)$	N · m	Characteristic curve of pull-out torque related to input pulse frequency. Also it is called as sluing characteristics.

Items	Terms	Symbols	Units	Definitions
19	Self-starting region	——	——	The region where the motor can start and stop, synchronizing with its input pulse frequency with a step function
20	Synchronizing operation region	——	——	The region where the rotor can continue to rotate synchronously when its pulse frequency or its load torque is increased over the self-starting region. Also it is called as slue region.
21	Pulse rate vs. inertia characteristics	$f_{SL}(J_L)$	pulse / s	Relation between moment of load inertia and a self-starting frequency. Generally when its moment of load inertia increases, its self-starting frequency decreases and it is shown by the following equation if the friction torque of load is negligible. $f_{SL} = \frac{f_s}{\sqrt{1+\frac{J_L}{J_M}}}$ Where f_{SL} : Self-starting frequency with load (pulse/s) f_s : Self-starting frequency without load (pulse/s) J_L : Moment of load inertia (kg · m^2) J_M : Moment of rotor inertia (kg · m^2)
22	Pulse rate vs. torque characteristics	$T(f_p)$	N · m	Characteristic curve of generating torque related to the input pulse frequency (pulse rate). 
23	Angle accuracy	——	——	The accuracy of rotating angle, depending on (1) Static angle error (2) Step angle error
24	Static angle error	ε_p	%	The rotor is rotated step by step from any angle by means of flowing the rated current to its winding in defined exciting pattern with no load. Then the difference between the theoretical angle and practical angle is measured over 360° and the average of maximum absolute positive and negative values is defined as static angle error and represented as follows. $\varepsilon_p = \pm \frac{[\,\lvert +\Delta\theta_i \rvert + \lvert -\Delta\theta_j \rvert\,]}{2\theta_s} \times 100(\%)$ Where ε_p : Static angle error··························(%) $+\Delta\theta_i$: Max. positive value $(\theta_i - {}_i\theta_s)$·········(deg) $-\Delta\theta_j$: Max. negative value $(\theta_j - {}_j\theta_s)$········(deg) θ_s : Theoretical step angle···················(deg)

Items	Terms	Symbols	Units	Definitions
24	Static angle error	ε_p	%	
25	Step angle error	ε_p	%	The rotor is rotated step by step from any angle by means of flowing the rated current to its winding in defined exciting pattern with no load. Then the difference between the theoretical angle and practical angle for each step is measured over 360° and their maximum positive and negative values are defined as angle error and represented as follows. $\varepsilon_s = \frac{+\Delta\theta_i}{\theta_s} \times 100(\%)$ and $\varepsilon_s = \frac{-\Delta\theta_j}{\theta_s} \times 100(\%)$ Where ε_s : Step angle error……………………(%) $+\Delta\theta_i$: Maximum positive value $(= \theta_i - \theta_{i-1} - \theta_s)$ ……………………(deg) $-\Delta\theta_j$: Maximum negative value $(= \theta_j - \theta_{j-1} - \theta_s)$ ……………………(deg) θ_s : Theoretical step angle ……………(deg)
26	Hysteresis error	$\Delta\theta_h$	° (deg)	Maximum difference in all static angle errors between CCW and CW rotation of motor shaft.

■ Vernier drive

Generally a step motor is rotated by each basic step angle or the half of it, but can be driven by interpolated step angle (e.g. 1/16, ··· ,1/256) by means of controlling the winding current. Also this driving technique is called as Micro-step or Mini-step driving.

■ Slow-up, Slow-down

For driving a step motor in high speed using its synchronizing operation range, the control technique of slow-up and slow-down should be used. This technique uses a linear pattern, an exponential pattern and a S-character pattern.

(1) Slow-up
  To accelerate the motor with proper gradient in driving frequency as to rotate it to synchronize with the input pulses.

(2) Slow-down
  To decelerate the motor with proper gradient in driving frequency as to rotate it to synchronize with the input pulses.

■ Resonance

Resonance means an unstable operating state of a rotor where its vibration is suddenly amplified or the output torque is suddenly decreased at particular input frequencies. It is called as out of control.

■ Closed loop control

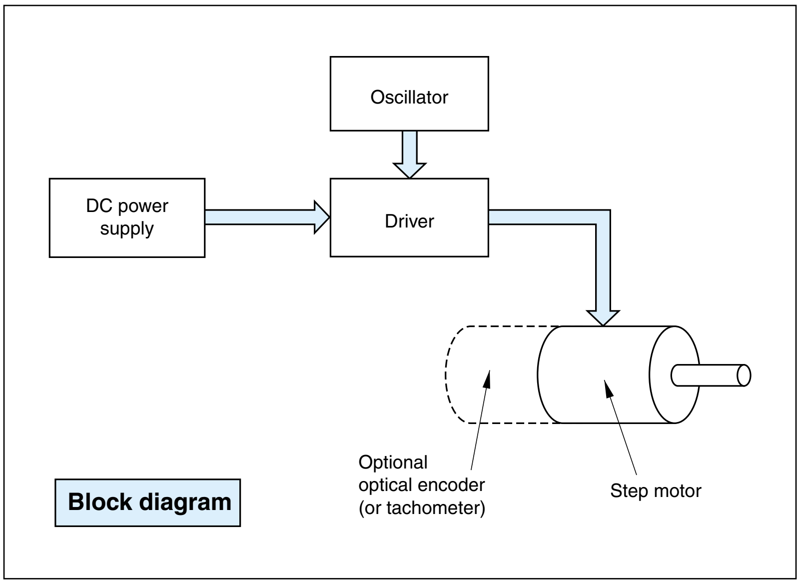
A driving technique of a motor that detects the rotational angle of step motor and switches the exciting phases corresponding to the motion of a rotor. Encoder may be used for detecting the rotational angle.

DRIVING MODE OF STEP MOTOR

For driving a step motor, it is necessary to excite its windings by DC voltage and current in sequence. Therefore proper driver for step motor is needed. An oscillator, driver and DC power supply as shown in right figure are necessary as minimum components.

For improving the angle accuracy and damping characteristics of a step motor, an optical encoder or other sensors may be added, and then an adequate amplifier for feedback may be needed.

Also the damping characteristic can be improved by a mechanical damper.



Full-step driving mode

In this method step motors are driven in the basic step angle (0.72°), using generally 4-phase exciting pattern. (Refer to the exciting sequence for 4-phase exciting pattern below.)

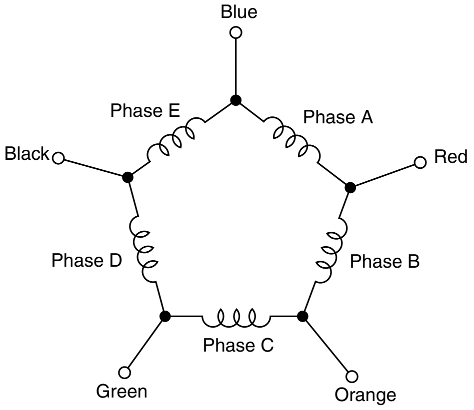
Half-step driving mode

In this method step motors are driven in half of the basic step angle (0.36°), using generally 4-5 phase exciting pattern.
(Refer to the exciting sequence for 4-5 phase exciting method below.)

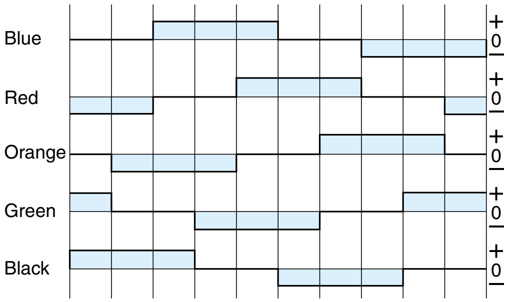
Micro-step driving mode

In this method step motors are driven in 1/N of the basic step angle and the rotation of a motor can be smoothed by means of the electrical interpolation by controlling the current for each winding.

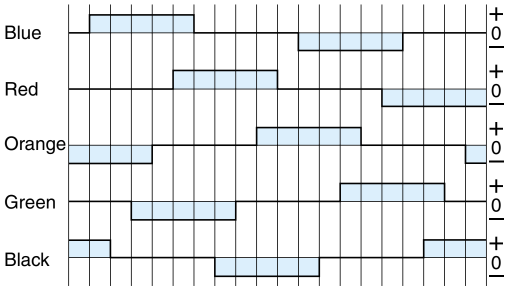
Internal connection of motor



Exciting sequence



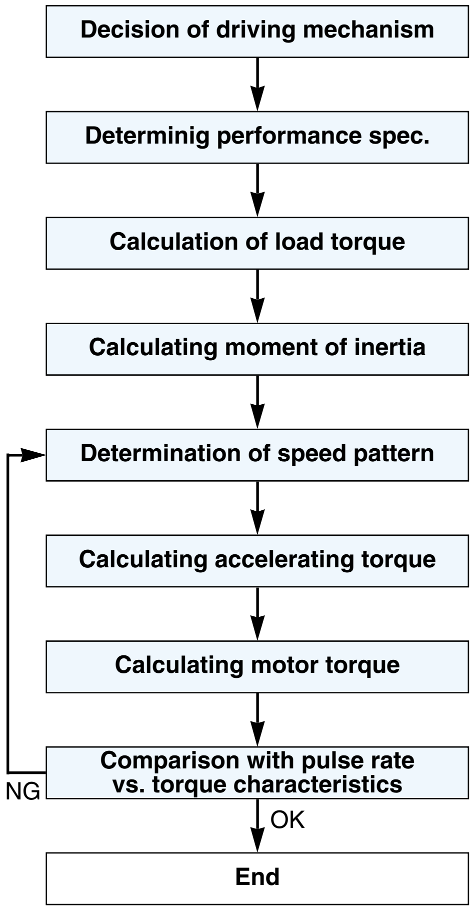
4-phase exciting pattern



4-5 phase exciting pattern

SELECTION PROCEDURES FOR STEP MOTORS

Selection by torque calculation



Decide the driving mechanism such as ball screws, belts, etc. Detail specifications such as dimensions of each part and friction coefficient are required.

Determine the performance that is required for the system such as mechanical resolution, positioning time, etc.

Calculate necessary torque to drive the load.

Calculate the moment of inertia converted to the motor axis for the driving mechanism and weight of work.

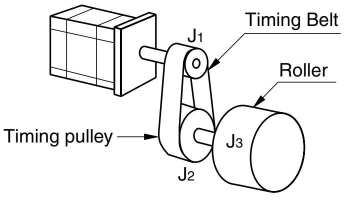
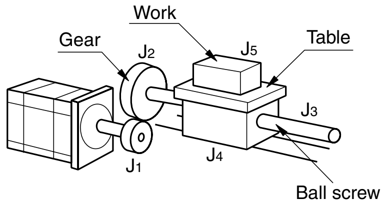
Determine the speed pattern by using the distance of movement and its required time.

Calculate the acceleration torque by using the speed pattern and moment of inertia.

Calculate the required motor torque by means of adding load torque and acceleration torque and multiplying some safety factors for margins.

Select the motor that is capable of driving the load by comparing the required motor torque with pulse rate vs. torque characteristics.

Basic equations

Factor Driving mechanism	Resolution (Unit movement) & step angle	Speed & pulse frequency
Basic equation	$\ell = \ell_0 \cdot \frac{\theta_s}{i}$ [cm/step]	$\nu = \ell \cdot f$ [cm/s] $f = \frac{\nu}{\ell}$ [pps]
Belt driving mechanism  	$\ell = \frac{\pi D}{360} \cdot \frac{\theta_s}{i}$ [cm/step] $D = \frac{360\ell i}{\pi \theta_s}$ [cm]	$\nu = \frac{\pi D}{360} \cdot \frac{\theta_s}{i}$ [cm/s] $f = \frac{360 i \nu}{\pi D \theta_s}$ [pps]
Ball screw driving mechanism  	$\ell = \frac{P}{360} \cdot \frac{\theta_s}{i}$ [cm/step] $P = \frac{360\ell i}{\theta_s}$ [cm/rev]	$\ell = \frac{P}{360} \cdot \frac{\theta_s}{i} \cdot f$ [cm/step] $f = \frac{360 i \nu}{P \theta_s}$ [pps]

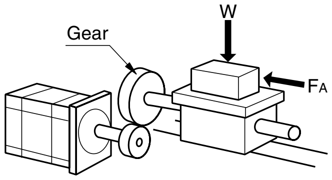
Rotational speed and pulse frequency at final stage	Moving distance & number of pulses	Total moment of inertia applied to motor axis
$N = \frac{\theta_s f}{6i}$ [min^{-1}] $f = \frac{6iN}{\theta_s}$ [pps]	$\ell\tau = A \cdot \ell$ [cm] $\ell\tau = \nu \cdot t$ [cm] $A = \frac{\ell\tau}{\ell}$ [pulse] $A = f \cdot t$ [pulse]	J_L : Moment of inertia converted to motor axis J_n : Moment of inertia for each section $J_L = J_1 + \frac{J_2 + J_3}{i^2}$ [kg · cm^2] $J_L = J_1 + \frac{J_2 + J_3 + J_4 + J_5}{i^2}$ [kg · cm^2]

ℓ = Resolution (Unit step) [cm/step]
ℓ_0 = Unit movement at final stage [cm/deg]
θ_s = Step angle [deg/step]
i = Reduction gear ratio
P = Lead pitch [cm/rev]
ν = Moving speed [cm/s]
f = Pulse frequency [pps]
D = Diameter of final stage pulley [cm]
A = Number of pulse [pulse]
$\ell\tau$ = Moving distance [cm]
t = Required time [s]

Equations of load torque

Torque conversion : [N · m] = 10.2kgf · cm

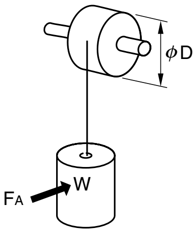
Driving by ball screw



$$T_L = \left(\frac{F \cdot P}{2\pi\eta} + \frac{\mu F_0 P_0}{2\pi}\right)\frac{1}{i}\ [\text{kgf} \cdot \text{cm}]$$

$$F = F_A + W(\sin\alpha + \mu\cos\alpha)\ [\text{kgf}]$$

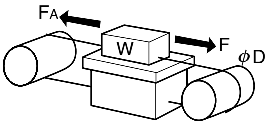
Driving by pulley

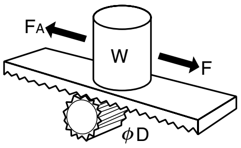


$$T_L = \frac{(\mu F_A + W)}{2\pi} \cdot \frac{\pi D}{i}$$

$$= \frac{(\mu F_A + W)D}{2i}\ [\text{kgf} \cdot \text{cm}]$$

Driving by wire/belt
Driving by rack & pinion

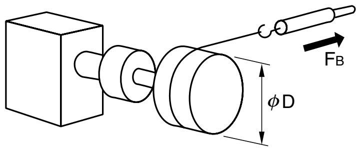




$$T_L = \frac{F}{2\pi\eta} \cdot \frac{\pi D}{i} = \frac{FD}{2\eta i}\ [\text{kgf} \cdot \text{cm}]$$

$$F = F_A + W(\sin\alpha + \mu\cos\alpha)\ [\text{kgf}]$$

Method of direct measurement

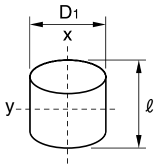


$$T_L = \frac{F_B D}{2}\ [\text{kgf} \cdot \text{cm}]$$

F = Axial load [kgf]
F_0 = Pressurized load [kgf]
μ_0 = Friction coefficient of pressurized nut (0.1 ~ 0.3)
η = Efficiency (0.85 ~ 0.95)
i = Reduction gear ratio
P = Lead pitch [cm/rev]
F_A = External force [kgf]
F_B = Starting force of main shaft [kgf]
W = Total weight of work and table [kgf]
μ = Friction coefficient of slipping surface (0.05)
α = Inclination [deg]
D = Diameter of final stage pulley [cm]

Equations of moment of inertia

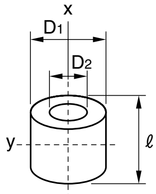
Moment of inertia of cylinder



$$J_x = \frac{1}{8} W D_1^2 = \frac{\pi}{32} \rho \ell D_1^4 \ [\mathrm{kg \cdot cm^2}]$$

$$J_y = \frac{1}{4} W \left(\frac{D_1^2}{4} + \frac{\ell^2}{3} \right) [\mathrm{kg \cdot cm^2}]$$

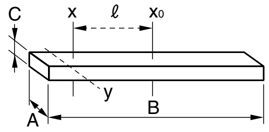
Moment of inertia of hollow cylinder



$$J_x = \frac{1}{8} W (D_1^2 + D_2^2) = \frac{\pi}{32} \rho \ell (D_1^4 - D_2^4) \ [\mathrm{kg \cdot cm^2}]$$

$$J_y = \frac{1}{4} W \left(\frac{D_1^2 + D_2^2}{4} + \frac{\ell^2}{3} \right) [\mathrm{kg \cdot cm^2}]$$

Moment of inertia related to the axis not to pass its center of gravity

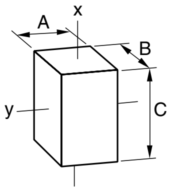


$$J_x = J_o = W \ell^2 \ [\mathrm{kg \cdot cm^2}]$$

$$J_y = \frac{1}{12} W (A^2 + B^2 + 12 \ell^2) \ [\mathrm{kg \cdot cm^2}]$$

ℓ = Distance between x-axis and x_0-axis [cm]

Moment of inertia of rectangular solid



$$J_x = \frac{1}{12} W (A^2 + B^2) = \frac{1}{12} \rho ABC (A^2 + B^2) \ [\mathrm{kg \cdot cm^2}]$$

$$J_y = \frac{1}{12} W (B^2 + C^2) = \frac{1}{12} \rho ABC (B^2 + C^2) \ [\mathrm{kg \cdot cm^2}]$$

Moment of inertia of a linear moving solid

$$J = W \left(\frac{\nu}{\omega} \right)^2 = W \left(\frac{A}{2\pi} \right)^2 [\mathrm{kg \cdot cm^2}]$$

A = Unit movement [cm/rev]

Density

Iron	$\rho = 7.9 \times 10^{-3}$ [kg/cm³]
Aluminum	$\rho = 2.8 \times 10^{-3}$ [kg/cm³]
Brass	$\rho = 8.5 \times 10^{-3}$ [kg/cm³]
Nylon	$\rho = 1.1 \times 10^{-3}$ [kg/cm³]

J_x = Moment of inertia related to x-axis [kg · cm²]
J_y = Moment of inertia related to y-axis [kg · cm²]
J_o = Moment of inertia related to x_0-axis that is passed its center of gravity [kg · cm²]
W = Mass [kg]
D_1 = Outer diameter [cm]
D_2 = Inner diameter [cm]
ρ = Density [kg/cm³]
ℓ = Length [cm]

Calculation of required torque T_M [kgf · cm]

[N · m] = 10.2kgf · cm

(1) Calculation of load torque T_L [kgf · cm]

Load torque means the friction resistance occurred at the contact point of driving mechanism and is varied depending on the kind of driving mechanism and the weight of work.

(2) Calculation of acceleration torque Ta [kgf · cm]

Acceleration torque means the necessary torque to operate during acceleration and deceleration

① Case of self-starting operation : Acceleration torque

$$Ta = \frac{(J_o + J_L)}{g} \times \frac{\pi \cdot \theta_s \cdot f^2}{180 \cdot n}$$

② Case of accelerating or decelerating : Acceleration torque

$$Ta = \frac{(J_o + J_L)}{g} \times \frac{\pi \cdot \theta_s}{180} \times \frac{f_2 - f_1}{t_1}$$

J_o = Moment of rotor inertia [kg · cm²]
J_L = Total moment of inertia [kg · cm²]
g = Acceleration of gravity [cm²/s]
θ_s = Step angle [°]
f_2 = Operating pulse frequency [Hz]
f_1 = Starting pulse frequency [Hz]
t_1 = Acceleration (Deceleration) time [s]
n = $3.6°/\theta_s$

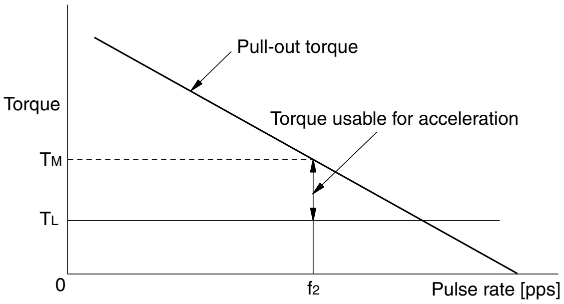
(3) Calculation of required torque T_M [kgf · cm]

The required torque is that of adding load torque and acceleration torque necessary to a step motor. The required torque to a step motor is calculated by the following equation.

Required torque= (Load torque + Acceleration torque) x Safety factor
T_M [kgf · cm] T_L [kgf · cm] Ta [kgf · cm]

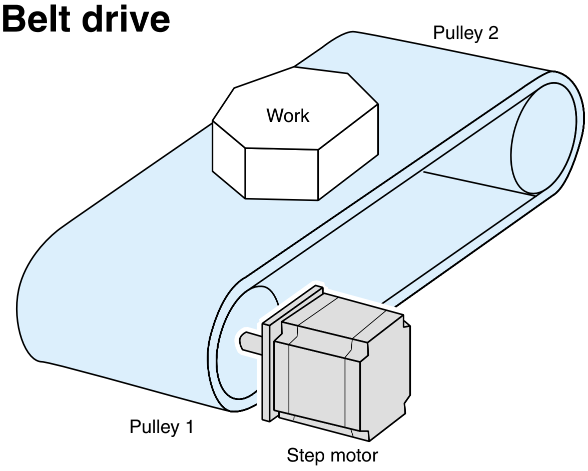
$$= (T_L + Ta) \times S$$

The motor to be used should be selected in the range where the required torque is within the pull-out torque in the pulse rate vs. torque characteristics.



EXAMPLE OF MOTOR SELECTION

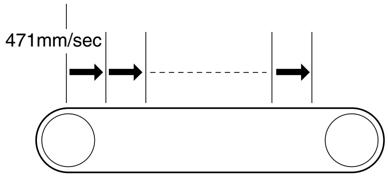
Belt drive



Mechanical specifications and requirements

Total mass of belt and work	W = 2.5 [kg]
Diameter of pulley 1 & 2	D_1, D_2 = 5 [cm]
Thickness of pulley 1 & 2	L_1, L_2 = 1 [cm]
Material of pulley 1 & 2	Iron, $\rho = 7.9 \times 10^{-3}$ [kg/cm³]
Friction coefficient of work guide	$\mu = 0.04$
Efficiency of belt & pulley	$\eta = 0.9$
Resolution of positioning	$\Delta\ell = 0.4$ [mm/step]
Movement for once	$\ell = 471$ [mm]
Positioning time	$t_0 = 1$ [sec]

Operating pattern



1. Calculate the resolution necessary to the motor.

Position increment per 1 pulse (0.72°/step) is as follows :

$$\text{Position increment} \quad \Delta\ell = \frac{50 \times 3.14 \times 0.72}{360} = 0.314 \text{ [mm/step]}$$

2. Determine the operating pattern.

The number of pulses and pulse frequency to be applied should be calculated as follows.

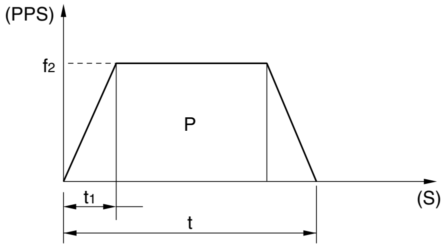
① Convert the movement at a time to the number of pulses.

$$\text{Number of pulse} = \frac{\text{Movement at a time}}{\text{Movement per 1 pulse}} = \frac{471}{0.314} = 1{,}500 \text{ [pulse]}$$

② Calculate the pulse frequency.

$$\text{Pulse frequency} = \frac{\text{Number of pulses, P}}{\text{Positioning time, t}} = \frac{1{,}500}{1} = 1{,}500 \text{ [pps]}$$

For transmitting 1,500 pulses in 1 second, the pulse frequency of 1,500 pps is needed.



The pattern for acceleration and deceleration operation should be determined. Assuming that the time for acceleration and deceleration is 0.25 second respectively, calculate the pulse frequency as follws :

$$\text{Pulse frequency} \quad f_2 = \frac{\text{Number of pulses}}{\text{Positioning time, t} - \text{Acc/Dec time, } t_1}$$

$$= \frac{1{,}500}{1 - 0.25}$$

$$= 2{,}000 \text{ [pps]}$$

3. Calculate the necesary operating torque.

Torque conversion :[N · m] = 10.2kgf · cm

Calculate the load torque.

Linear load, $F = \mu W = 0.04 \times 2.5 = 0.1$ [kgf]

Load torque, $T_L = \frac{F \cdot D_1}{2\eta} = \frac{0.1 \times 5}{2 \times 0.9} = 0.28$ [kgf · cm]

Calculate the acceleration torque.

① Calculate the moment of inertia.

- Moment of inertia of the pulley 1 (J_{D1})

$$J_{D1} = \frac{\pi}{32} \rho L_1 D_1{}^4 = \frac{\pi}{32} \times 7.9 \times 10^{-3} \times 1 \times 5^4 = 0.48 \text{ [kgf} \cdot \text{cm}^2\text{]}$$

- Moment of inertia of the pulley 2 (J_{D2})

$$J_{D2} = J_{D1} = 0.48 \text{ [kgf} \cdot \text{cm}^2\text{]}$$

- Moment of inertia of the belt and work (J_W)

$$J_W = W\left(\frac{D_1}{2}\right)^2 = 2.5 \times \left(\frac{5}{2}\right)^2 = 15.63 \text{ [kgf} \cdot \text{cm}^2\text{]}$$

- Total moment of inertia (J_L)

$$J_L = J_{D1} + J_{D2} + J_W = 0.48 + 0.48 + 15.63 = 16.59 \text{ [kgf} \cdot \text{cm}^2\text{]}$$

② Calculate the acceleration torque.

$$\text{Acceleration torque, } T_a = \frac{(J_0 + J_L)}{g} \times \frac{\pi \cdot \theta_s}{180} \times \frac{f_2}{t_1}$$

$$= \frac{(J_0 + 16.59)}{980.7} \times \frac{3.14 \times 0.72}{180} \times \frac{2000}{0.25} = 0.1\, J_0 + 1.7 \text{ [kgf} \cdot \text{cm]}$$

$T_a = 0.1\, J_0 + 1.7$ [kgf · cm]

③ Calculate the necessary operating torque.

Necessary
operating torque, T_M = (T_L + T_a) x 2 ← Safety factory
= (0.28 + 0.1 J_0 + 1.7) x 2
= 0.2 J_0 +4
= 0.2 x 0.175 + 4
≒ 4.04 [kgf · cm]

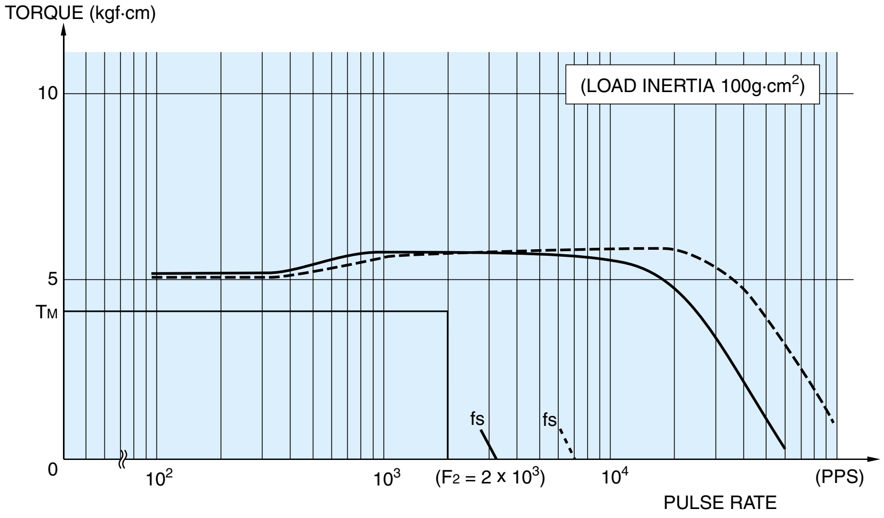
4. Finally determine the motor.

Calculate the necessary operating torque for each moment of rotor inertia according to the equation of Page 21 and above.

	Moment of rotor inertia, J_0 [kg · cm²]	Necessary operating torque, T_M [N · m] (kgf · cm)
TS3624N1E2 AU9118	0.175	0.4 (4.04)

Draw the necessary performances on the pulse rate vs. torque characteristics curve.
Considering the chart below, it is capable to operate in combination with TS3624N1E2 and AU9118.

TS3624N1E2 & AU9118



⚠ CAUTIONS FOR HANDLING for using properly in safety

Cautions for using Step motors

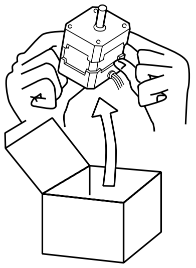
Step motor is one of precise instruments and assumed that users should read and understand properly the contents described here for handling, as well as the individual specifications.

Before using the products, understand all information including safety guide to them.

The minimum contents for safety are described here.

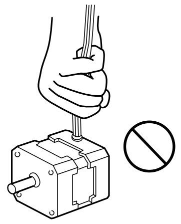
■ Cautions for opening package

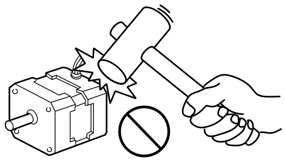
1. After opening the package, the products should be examined visually if there are any cracks or other defects on their external appearance at first. And confirm that right products are delivered.

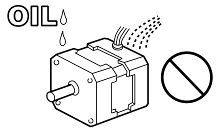


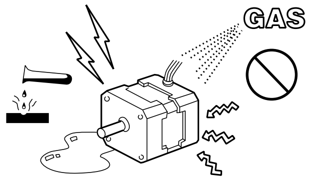
■ Cautions for transporting and mounting

1. Never catch at any lead wire or shaft to bring the motors, because it may cause some defects or injuries.
2. Never apply any shock, or any axial or radial load to the shaft, because it may cause some defects.
3. The motors have not water-proof nor oil-proof structure, so they cannot be used in the place splashed with any water or oil, or in any oil bath.
4. Never use the motors in the area with inflammable or explosive liquid or gas, or with excessive humidity or vapor. Never apply any excessive vibration, shock or humidity.



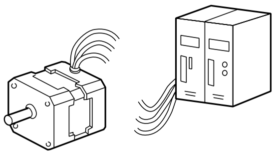






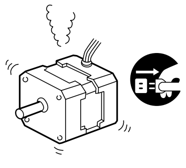
■ Cautions for wiring

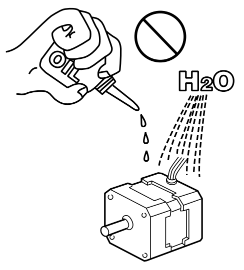
1. Examine the connection, exciting mode and phase sequence, because any wrong wiring may cause reverse rotation or abnormal operation.
2. Connect the case to ground without fail.
3. When dielectric strength or insulation test for motors is conducted, remove the connection from their controllers. Never conduct these tests unnecessarily, because it may cause to hasten their deterioration.



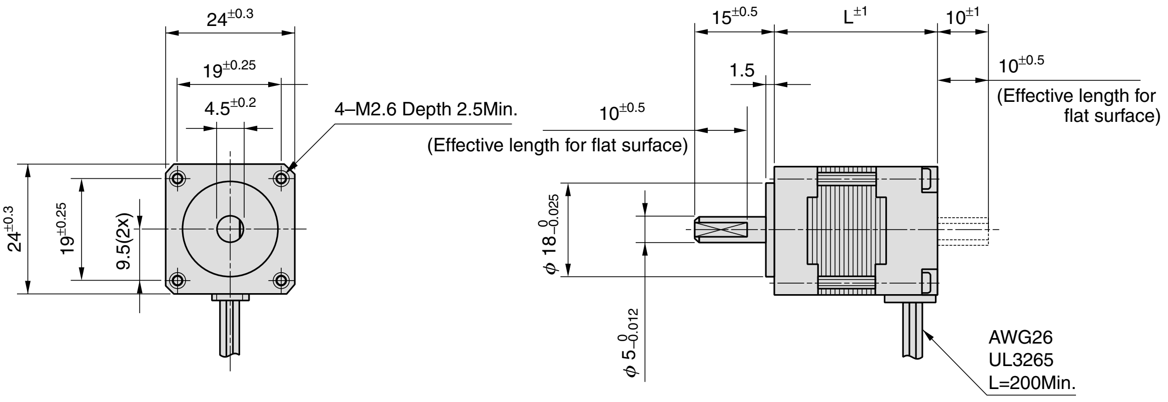
■ Cautions for operation

1. Contact us previously when the driving current over its rating may be flowed.
2. The motors may abnormally be heated up depending on their load condition or the drivers combined. Use the motors in the surface temperature of 90 °C Max.
3. All performances of the motors should be used within their specifications.
4. Step motors may develop resonance state. In this case, use them to avoid the resonance points.
5. The pulse rate vs. torque characteristics of the motors varies depending on their load condition or the drivers combined. Make a proper adjustment for them.
6. When any abnormal smelling, noise, smoking, heating-up, vibration, etc. has occurred, stop the operation immediately and turn off the power supply.
7. Do not splash any oil or water on the motors.





MODEL 09 0.72° HB TYPE



Unit of all dimensions is mm.

Type number		Rated voltage V/ Phase	Rated current A/ Phase	Winding resistance Ω/ Phase	Holding torque N · m (kgf·cm)	Motor length L mm	Rotor inertia g · cm²	Mass g	Combined driver / Charact.			
Single shaft	Dual shafts								AU9112	AU9116	AU9118	AU9151
TS3664N1E1	TS3664N11E1	1.58	0.35	4.5	0.017 (0.17)	30.5	4.2	70	Fig.1-1	——	——	——
TS3664N1E2	TS3664N11E2	0.83	0.75	1.1	0.017 (0.17)	30.5	4.2	70	Fig.1-2	Fig.2-1	——	——
TS3664N2E3	TS3664N12E3	2.35	0.35	6.7	0.028 (0.28)	46.5	8.3	120	Fig.1-3	——	——	——
TS3664N2E4	TS3664N12E4	1.28	0.75	1.7	0.028 (0.28)	46.5	8.3	120	Fig.1-4	Fig.2-2	——	——

- Operating temperature range : −20 ~ +50 °C
- Insulation resistance : 100 M Ω, Min. by DC 500 V Megohm meter
- Dielectric strength : AC 500 V, 1 minute
- End play : 0.075 mm, Max. at the load of 9.8 N (1 kgf)
- Radial play : 0.025 mm, Max. at the load of 4.9 N (0.5 kgf)
- Permissible temperature rise : 80 deg, Max. by resistance method

NOTE : Do not allow the surface temperature of the motor case to rise above 90°C during operation.

PULSE RATE VS TORQUE CHARACTERISTICS (Pull-out Torque)

DRIVER AU9112

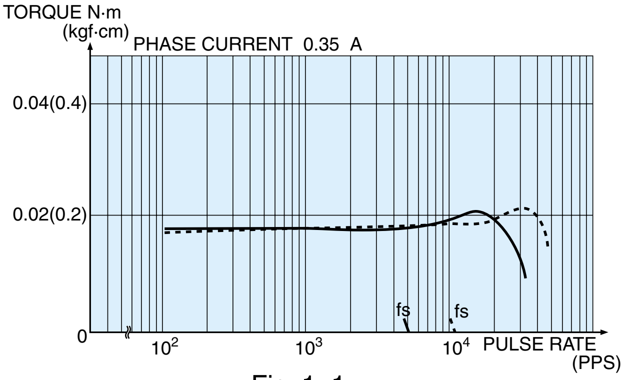


Fig. 1–1

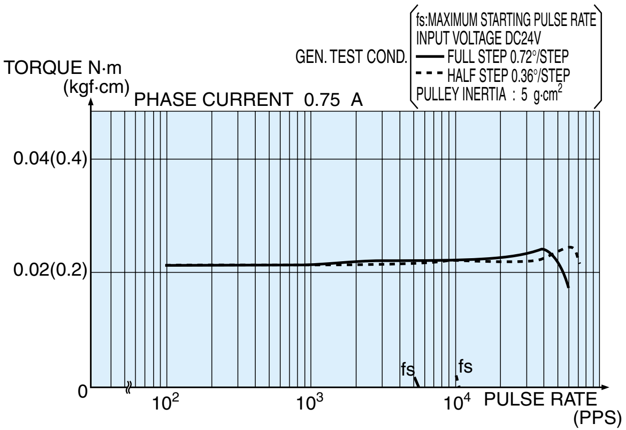


Fig. 1–2

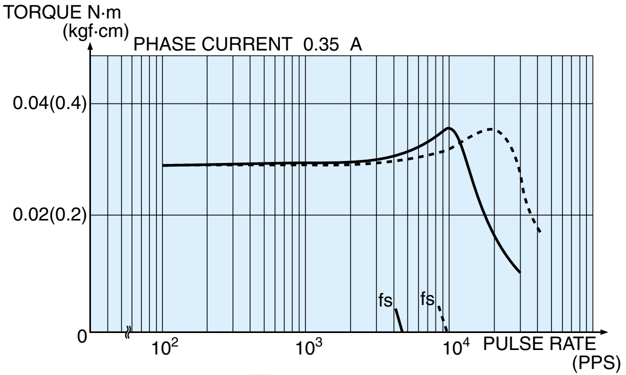


Fig. 1–3

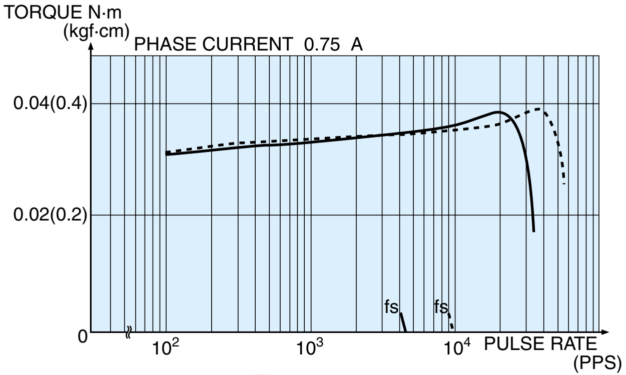


Fig. 1–4

DRIVER AU9116

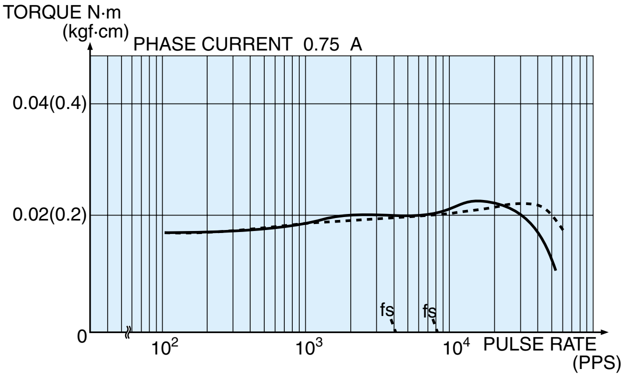


Fig. 2–1

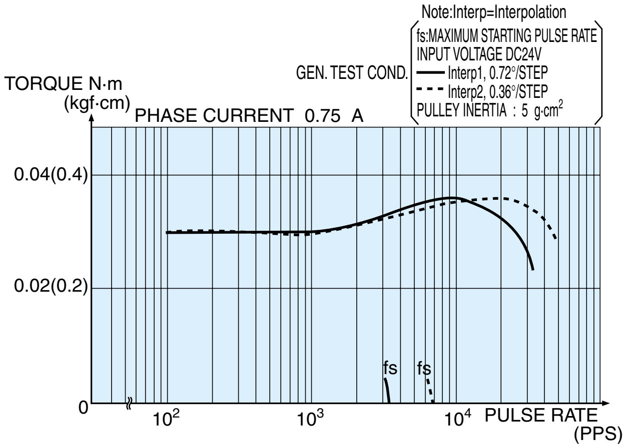
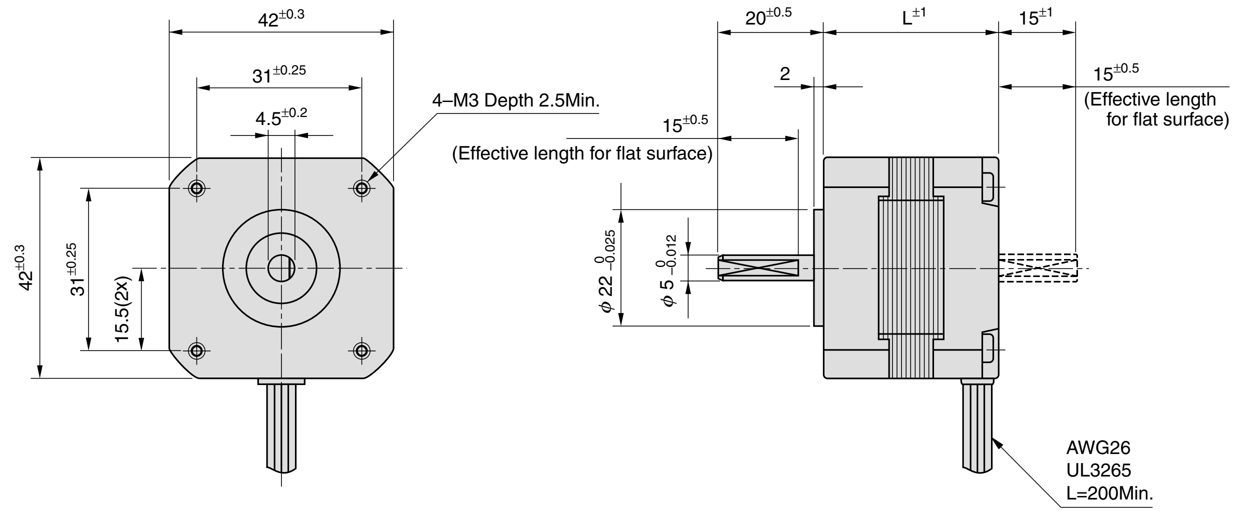


Fig. 2–2

MODEL 17 0.72° HB TYPE



Unit of all dimensions is mm.

Type number		Rated voltage	Rated current	Winding resistance	Holding torque	Motor length	Rotor inertia	Mass	Combined driver / Charact.			
Single shaft	Dual shafts	V/ Phase	A/ Phase	Ω/ Phase	N · m (kgf·cm)	L mm	g · cm²	g	AU9112	AU9116	AU9118	AU9151
TS3667N1E1	TS3667N11E1	2.63	0.35	7.5	0.013 (1.3)	33	35	200	Fig.3-1	——	——	——
TS3667N1E2	TS3667N11E2	1.28	0.75	1.7	0.013 (1.3)	33	35	200	Fig.3-2	Fig.4-1	——	——
TS3667N1E3	TS3667N11E3	0.67	1.4	0.48	0.013 (1.3)	33	35	200	Fig.3-3	Fig.4-2	——	——
TS3667N2E4	TS3667N12E4	3.33	0.35	9.5	0.018 (1.8)	39	54	240	Fig.3-4	——	——	——
TS3667N2E5	TS3667N12E5	1.65	0.75	2.2	0.018 (1.8)	39	54	240	Fig.3-5	Fig.4-3	——	——
TS3667N2E6	TS3667N12E6	0.9	1.4	0.64	0.018 (1.8)	39	54	240	Fig.3-6	Fig.4-4	——	——
TS3667N3E7	TS3667N13E7	1.65	0.75	2.2	0.024 (2.4)	47	68	310	Fig.3-7	Fig.4-5	——	——
TS3667N3E8	TS3667N13E8	0.9	1.4	0.64	0.024 (2.4)	47	68	310	Fig.3-8	Fig.4-6	——	——

- Operating temperature range : −20 ~ +50 °C
- Insulation resistance : 100 M Ω, Min. by DC 500 V Megohm meter
- Dielectric strength : AC 500 V, 1 minute
- End play : 0.075 mm, Max. at the load of 9.8 N (1 kgf)
- Radial play : 0.025 mm, Max. at the load of 4.9 N (0.5 kgf)
- Permissible temperature rise : 80 deg, Max. by resistance method

NOTE : Do not allow the surface temperature of the motor case to rise above 90°C during operation.

PULSE RATE VS TORQUE CHARACTERISTICS (Pull-out Torque)

DRIVER AU9112

GEN. TEST COND.
fs:MAXIMUM STARTING PULSE RATE
INPUT VOLTAGE DC24V
—— FULL STEP 0.72°/STEP
- - - HALF STEP 0.36°/STEP
PULLEY INERTIA : 5 g·cm²

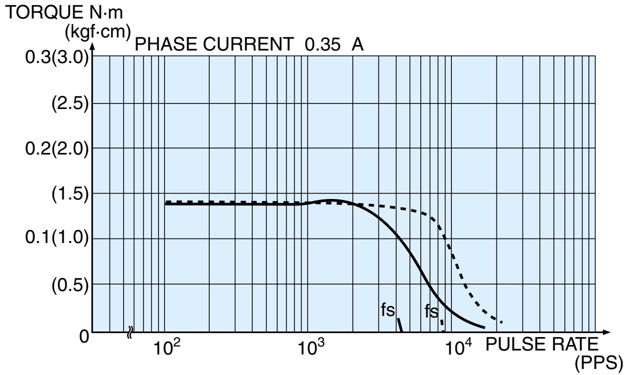


Fig. 3–1

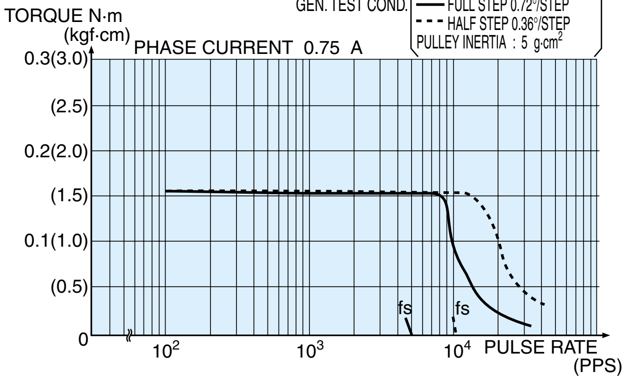


Fig. 3–2

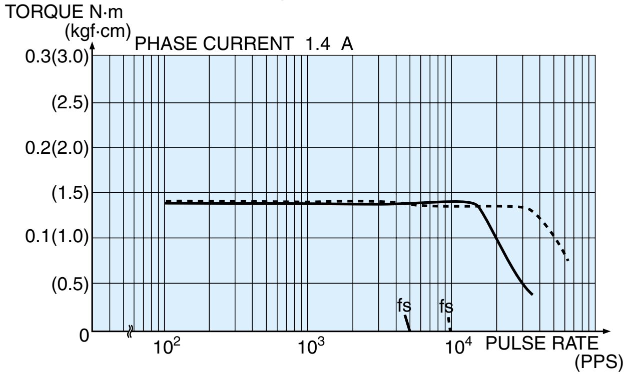


Fig. 3–3

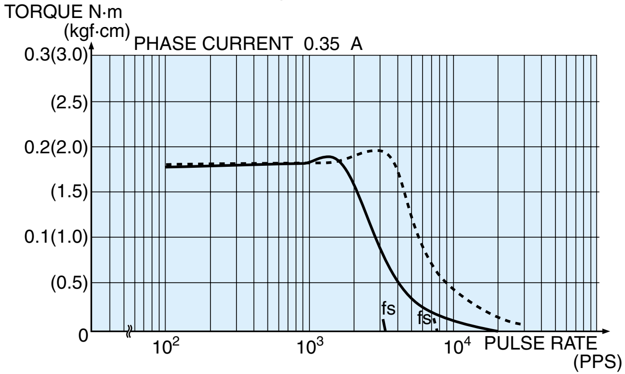


Fig. 3–4

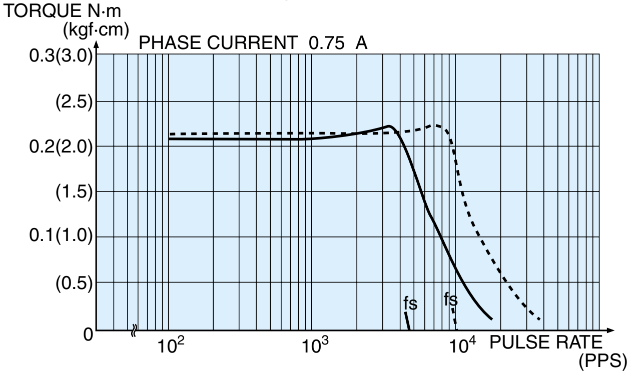


Fig. 3–5

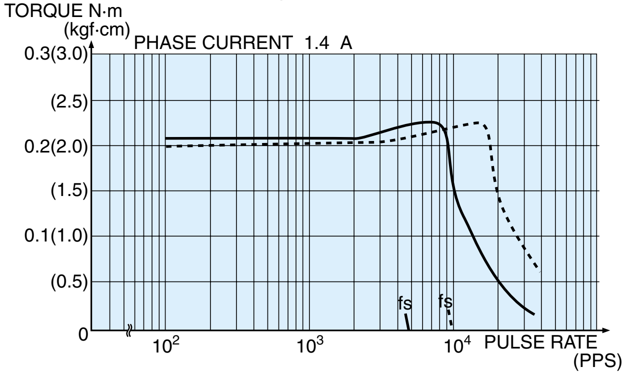


Fig. 3–6

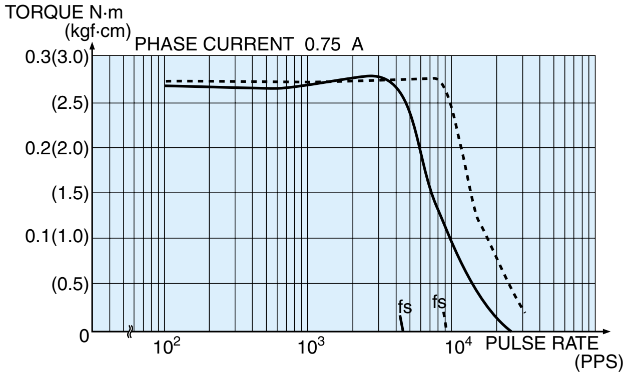


Fig. 3–7

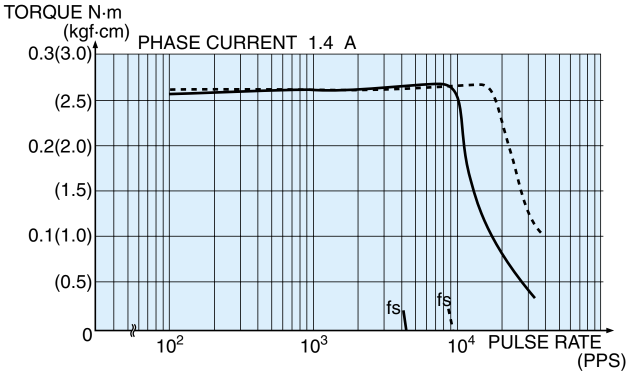


Fig. 3–8

PULSE RATE VS TORQUE CHARACTERISTICS (Pull-out Torque)

DRIVER AU9116

Note:Interp=Interpolation

GEN. TEST COND.
fs:MAXIMUM STARTING PULSE RATE
INPUT VOLTAGE DC24V
— Interp1, 0.72°/STEP
- - - Interp2, 0.36°/STEP
PULLEY INERTIA : 5 g·cm^2

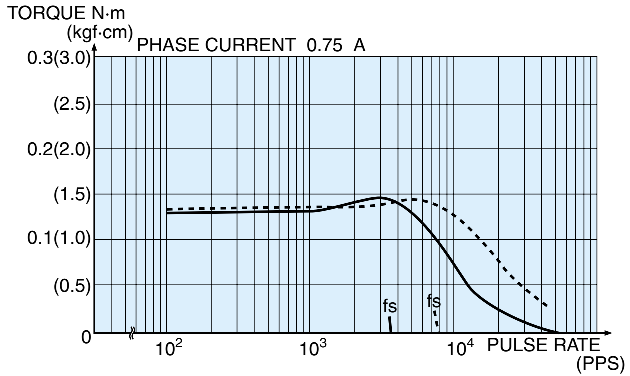


Fig. 4–1

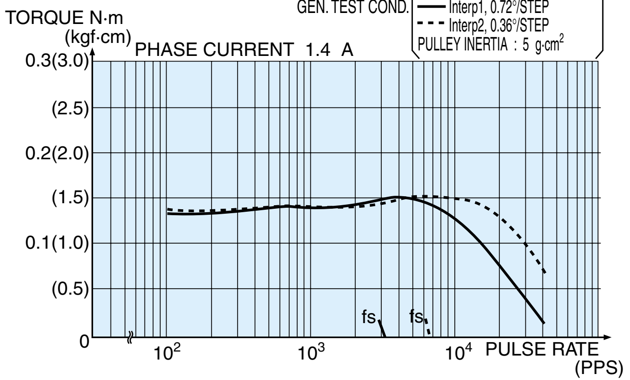


Fig. 4–2

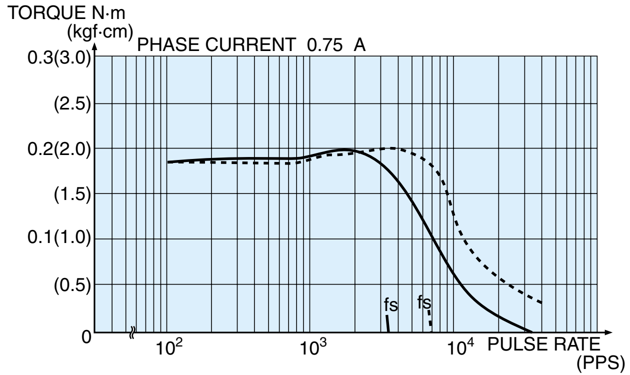


Fig. 4–3

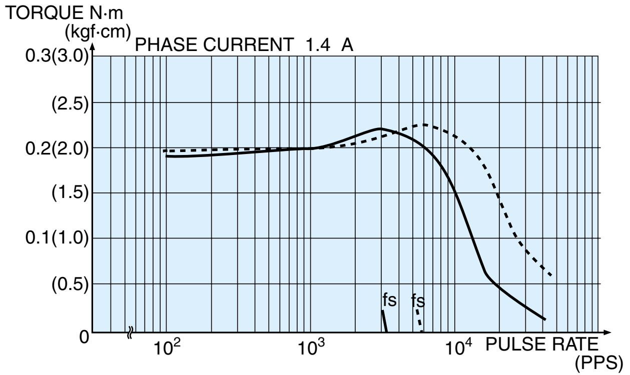


Fig. 4–4

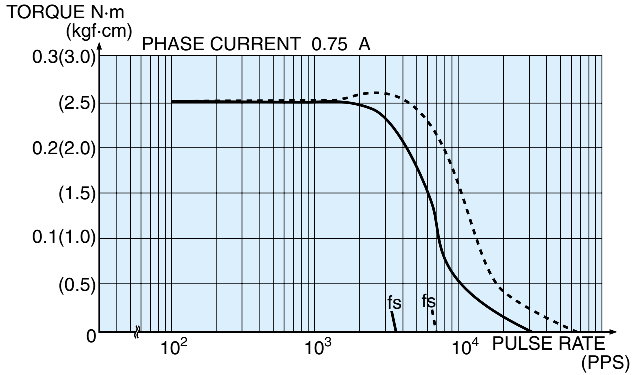


Fig. 4–5

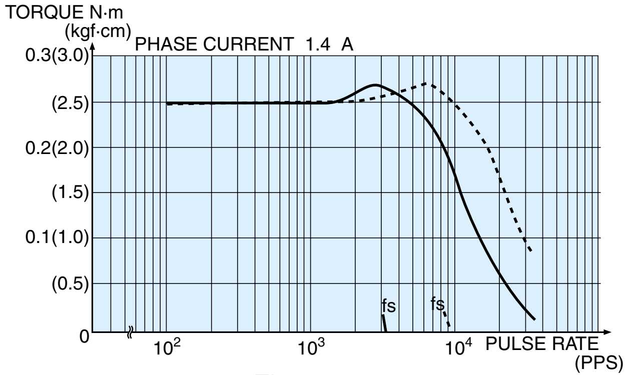


Fig. 4–6

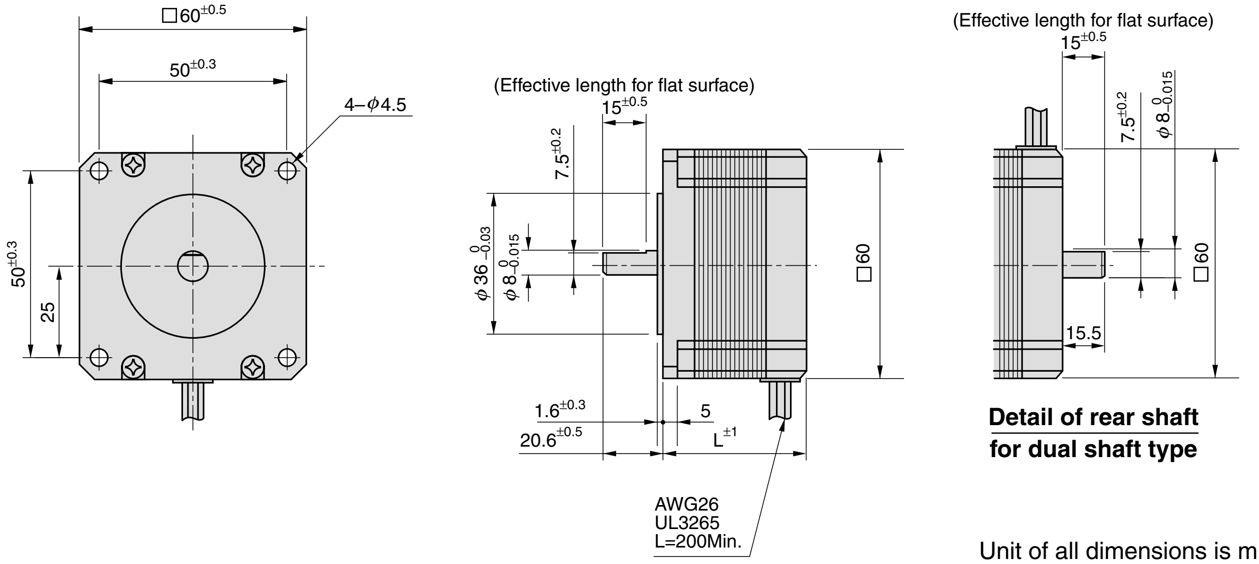
CONVERSION TABLE FOR MOMENT OF INERTIA

B A	lb·ft^2	lb·ft·s^2 or slug-ft^2	lb·in^2	lb·in·s^2	oz·in^2	oz·in·s^2	kg·cm^2	kg·cm·s^2	g·cm^2	g·cm ·s^2
lb·ft^2	1	3.108 X 10^{-2}	144	.373	2.304 X 10^{3}	5.968	421.40	0.4297	4.214 X 10^{5}	429.71
lb·ft·s^2	32.174	1	4.633 X 10^{3}	12	7.413 X 10^{4}	192	1.356 X 10^{4}	13.825	1.356 X 10^{7}	1.383 X 10^{4}
lb·in^2	6.944 X 10^{-3}	2.158 X 10^{-4}	1	2.590 X 10^{-3}	16	4.144 X 10^{-2}	2.926	2.984 X 10^{-3}	2.926 X 10^{3}	2.984
lb·in·s^2	2.681	8.333 X 10^{-2}	386.1	1	32.174	16	1.130 X 10^{3}	1.152	1.130 X 10^{6}	1.152 X 10^{3}
oz·in^2	4.340 X 10^{-4}	1.349 X 10^{-5}	6.250 X 10^{-2}	1.619 X 10^{-4}	1	2.59 X 10^{-3}	0.183	1.865 X 10^{-4}	182.901	0.186
oz·in·s^2	0.168	5.208 X 10^{-3}	24.13	6.250 X 10^{-2}	386.088	1	70.616	7.201 X 10^{-2}	7.201 X 10^{4}	72.008
kg·cm^2	2.373 X 10^{-3}	7.376 X 10^{-5}	0.3417	8.851 X 10^{-4}	5.467	1.416 X 10^{-2}	1	1.0197 X 10^{-3}	1000	1.0197
kg·cm·s^2	2.327	7.233 X 10^{-2}	335.109	0.8679	5.362 X 10^{3}	13.887	980.665	1	9.807 X 10^{5}	1000
g·cm^2	2.373 X 10^{-6}	7.376 X 10^{-8}	3.417 X 10^{-4}	8.851 X 10^{-7}	5.467 X 10^{-3}	1.416 X 10^{-5}	10^{-3}	1.0197 X 10^{-6}	1	1.0197 X 10^{-3}
g·cm ·s^2	2.327 X 10^{-3}	7.233 X 10^{-5}	0.3351	8.680 X 10^{-4}	5.362	1.389 X 10^{-2}	.9807	10^{-3}	980.667	1

CONVERSION TABLE FOR TORQUE

B A	lb·ft	lb·in	oz·in	dyne·cm	N·m	mN·m	kg·cm	g·cm
lb·ft	1	12	192	1.356 X 10^{7}	1.356	1.356 X 10^{3}	13.825	13.825 X 10^{4}
lb·in	8.333 X 10^{-2}	1	16	1.130 X 10^{6}	0.113	1.130 X 10^{2}	1.152	1.152 X 10^{3}
oz·in	5.208 X 10^{-3}	6.250 X 10^{-2}	1	7.062 X 10^{4}	7.062 X 10^{-3}	7.062	7.201 X 10^{-2}	72.01
dyne·cm	7.376 X 10^{-8}	8.851 X 10^{-7}	1.416 X 10^{-5}	1	10^{-7}	10^{-4}	1.0197 X 10^{-6}	1.0197 X 10^{-3}
N·m	0.7376	8.851	141.8	10^{7}	1	1000	10.197	1.0197 X 10^{4}
mN·m	7.376 X 10^{-4}	8.851 X 10^{-3}	0.1416	10^{4}	10^{-3}	1	1.0197 X 10^{-2}	10.197
kg·cm	7.233 X 10^{-2}	0.8679	13.877	9.8066 X 10^{5}	9.8066 X 10^{-2}	98.066	1	1000
g·cm	7.233 X 10^{-5}	8.680 X 10^{-4}	1.389 X 10^{-2}	980.67	9.8066 X 10^{-5}	9.8066 X 10^{-2}	10^{-3}	1

MODEL 23 0.72° HB TYPE



Detail of rear shaft for dual shaft type

Unit of all dimensions is mm.

Type number		Rated voltage V/ Phase	Rated current A/ Phase	Winding resistance Ω/ Phase	Holding torque N · m (kgf·cm)	Motor length L mm	Rotor inertia g · cm²	Mass g	Combined driver / Charact.				
Single shaft	Dual shafts								AU9112	AU9116	AU9118	AU9119	AU9151
TS3624N1E1	TS3624N21E1	1.95	0.75	2.6	0.45 (4.5)	48.5	175	500	Fig.5-1	Fig.6-1	Fig.7-1	——	Fig.9-1
TS3624N1E2	TS3624N21E2	1.12	1.4	0.8	0.45 (4.5)	48.5	175	500	Fig.5-2	Fig.6-2	Fig.7-2	——	Fig.9-2
TS3624N2E3	TS3624N22E3	2.55	0.75	3.4	0.8 (8)	56.5	220	700	Fig.5-3	Fig.6-3	Fig.7-3	——	Fig.9-3
TS3624N2E4	TS3624N22E4	1.54	1.4	1.1	0.8 (8)	56.5	220	700	Fig.5-4	Fig.6-4	Fig.7-4	——	Fig.9-4
TS3624N3E5	TS3624N23E5	2.52	1.4	1.8	1.5 (15)	86.5	440	1200	Fig.5-5	Fig.6-5	Fig.7-5	——	Fig.9-5
TS3624N3E6	TS3624N23E6	1.82	2.8	0.65	1.5 (15)	86.5	440	1200	——	——	——	Fig.8.1	——

- Operating temperature range : −20 ~ +50 °C
- Insulation resistance : 100 M Ω, Min. by DC 500 V Megohm meter
- Dielectric strength : AC 500 V, 1 minute
- End play : 0.075 mm, Max. at the load of 9.8 N (1 kgf)
- Radial play : 0.025 mm, Max. at the load of 4.9 N (0.5 kgf)
- Permissible temperature rise : 80 deg, Max. by resistance method

NOTE : Do not allow the surface temperature of the motor case to rise above 90°C during operation.

PULSE RATE VS TORQUE CHARACTERISTICS (Pull-out Torque)

DRIVER AU9112

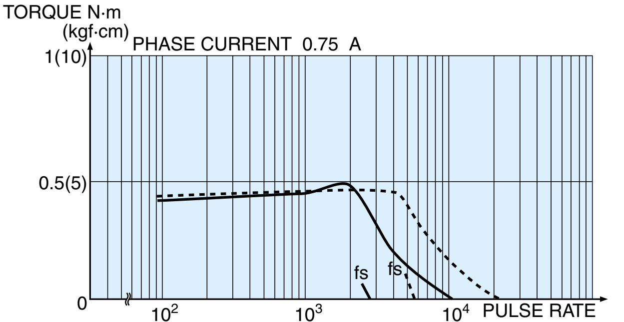
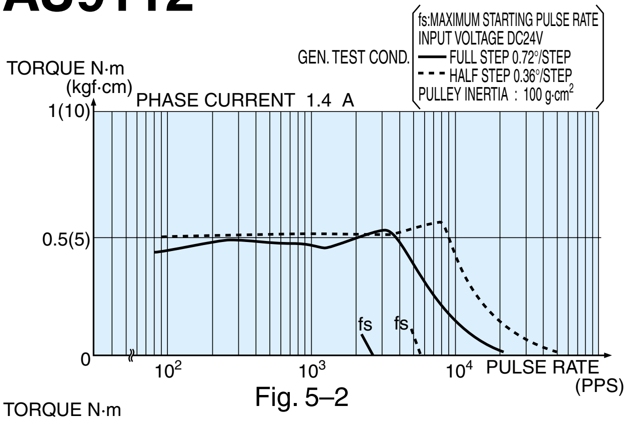


Fig. 5–1



GEN. TEST COND.
fs:MAXIMUM STARTING PULSE RATE
INPUT VOLTAGE DC24V
—— FULL STEP 0.72°/STEP
- - - HALF STEP 0.36°/STEP
PULLEY INERTIA : 100 g·cm^2

Fig. 5–2

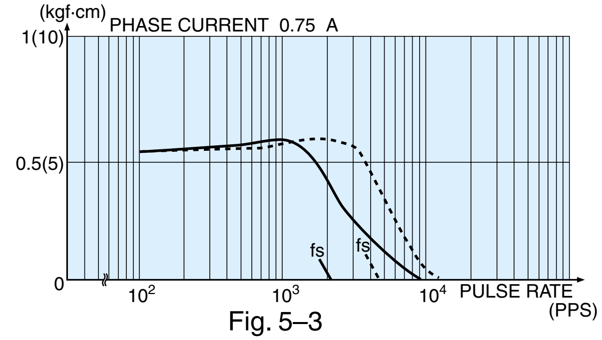


Fig. 5–3

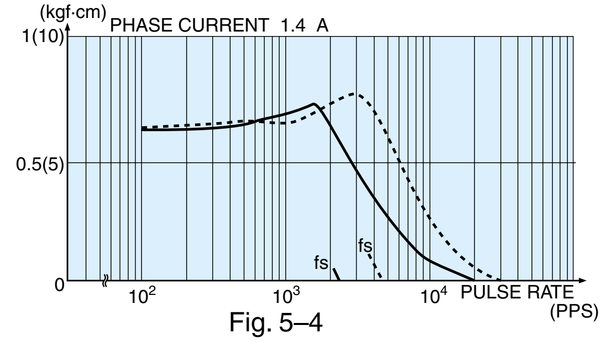


Fig. 5–4

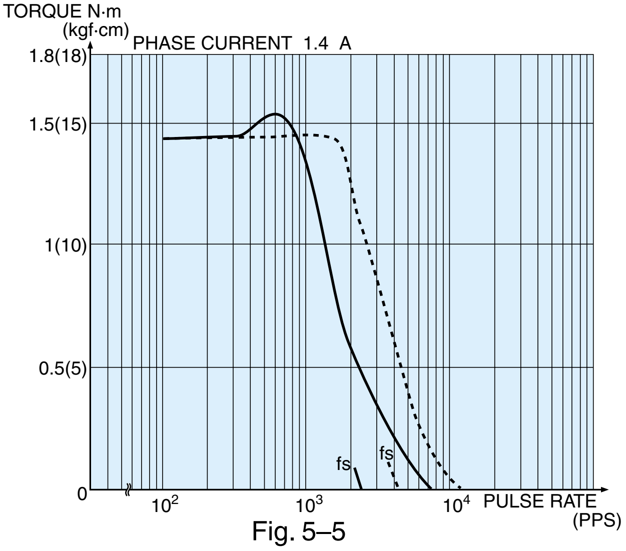


Fig. 5–5

DRIVER AU9116

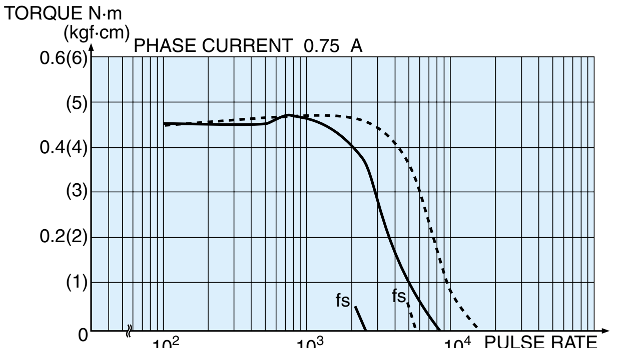
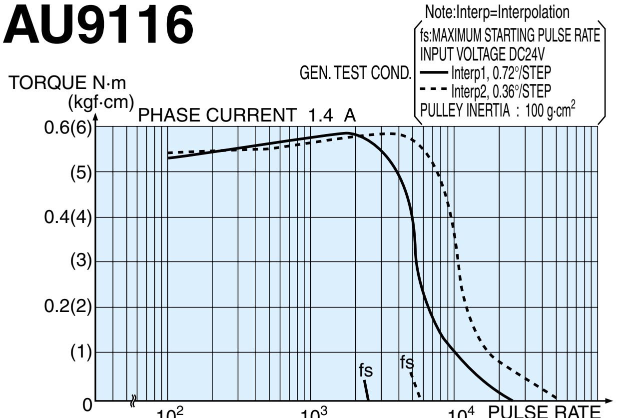


Fig. 6–1



Note:Interp=Interpolation
GEN. TEST COND.
fs:MAXIMUM STARTING PULSE RATE
INPUT VOLTAGE DC24V
—— Interp1, 0.72°/STEP
- - - Interp2, 0.36°/STEP
PULLEY INERTIA : 100 g·cm^2

Fig. 6–2

DRIVER AU9116

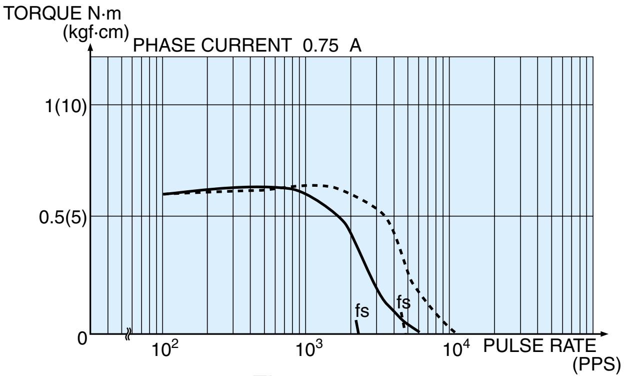


Fig. 6–3

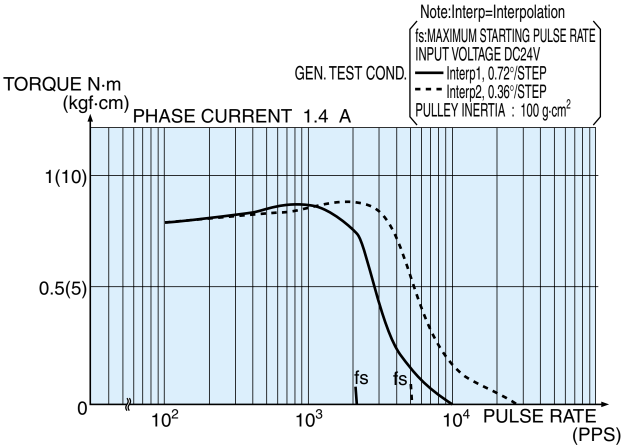


Fig. 6–4

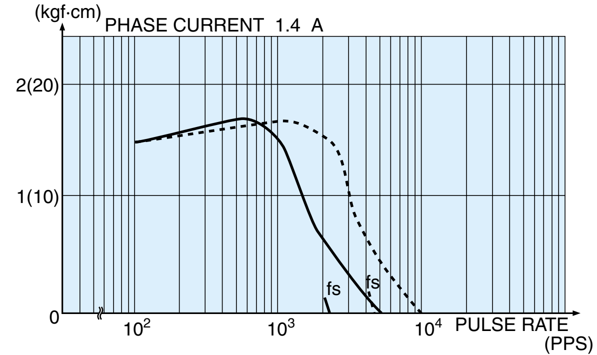


Fig. 6–5

DRIVER AU9118

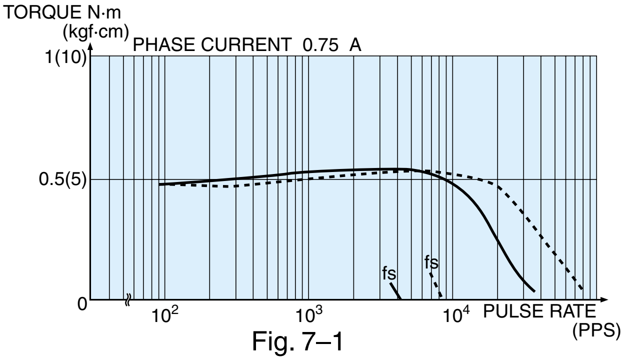


Fig. 7–1

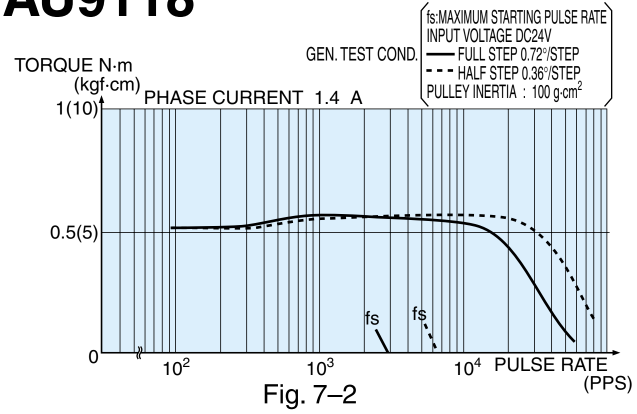


Fig. 7–2

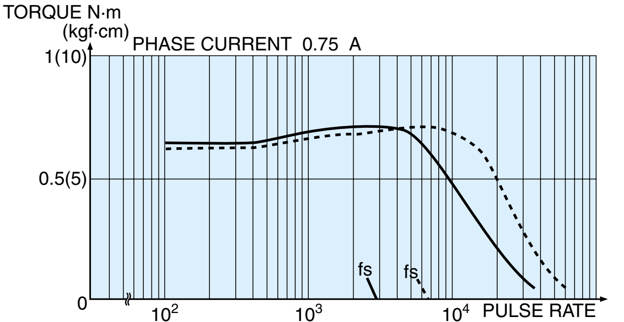


Fig. 7–3

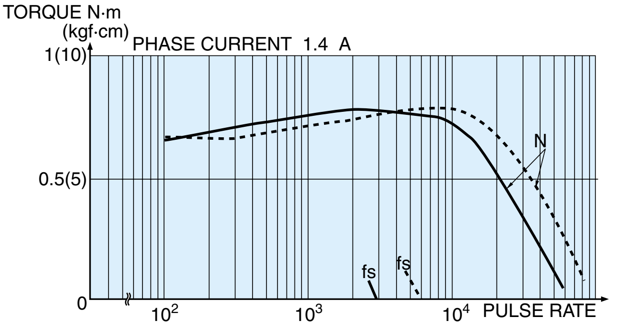


Fig. 7–2

DRIVER AU9118

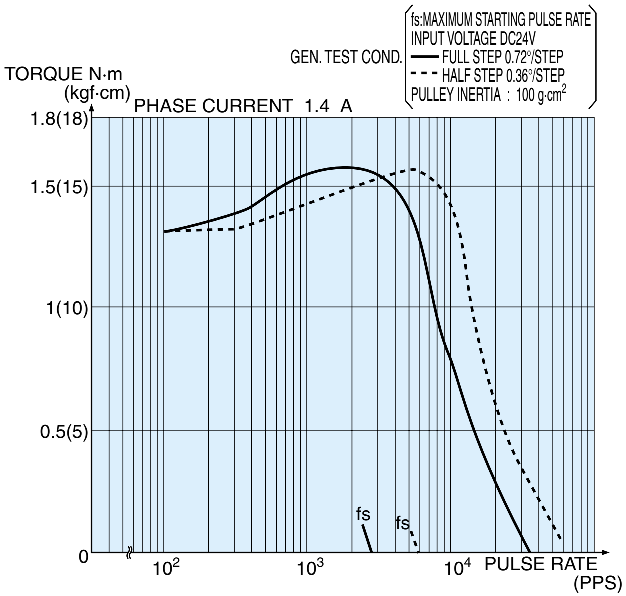


Fig. 7–5

DRIVER AU9119

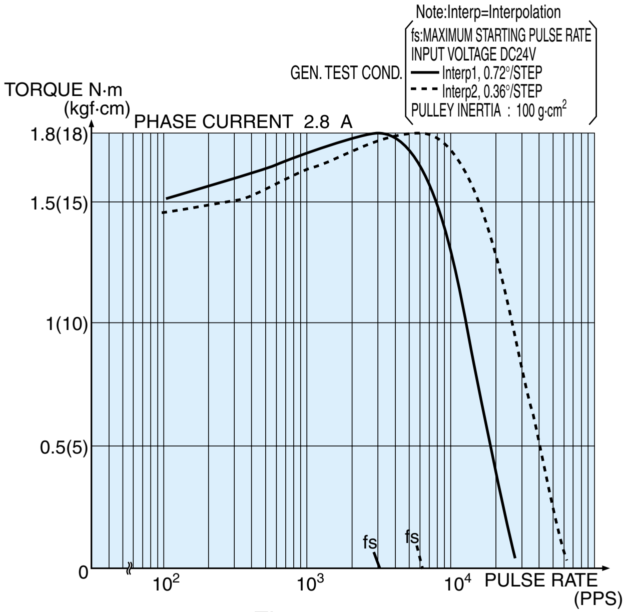


Fig. 8–1

DRIVER AU9151

Note:Interp=Interpolation

GEN. TEST COND.
fs:MAXIMUM STARTING PULSE RATE
INPUT VOLTAGE DC24V
Interp1, 0.72°/STEP
Interp2, 0.36°/STEP
PULLEY INERTIA : 100 g·cm²

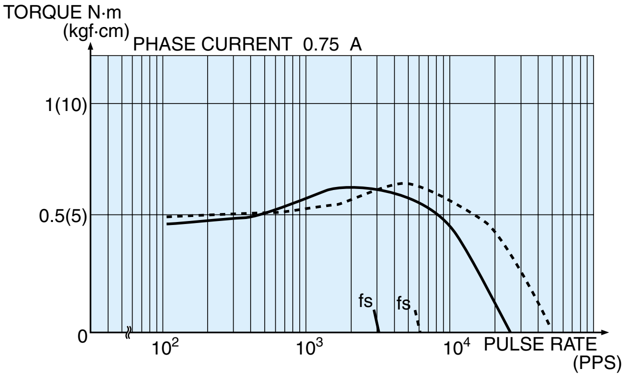


Fig. 9–1

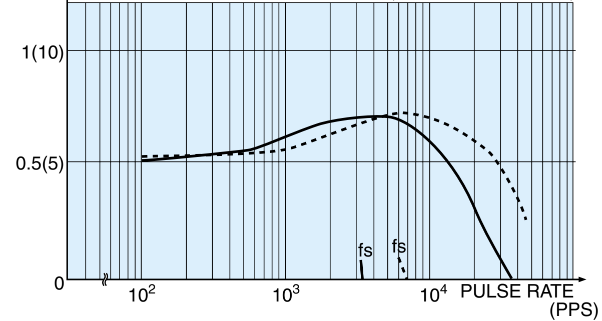


Fig. 9–2

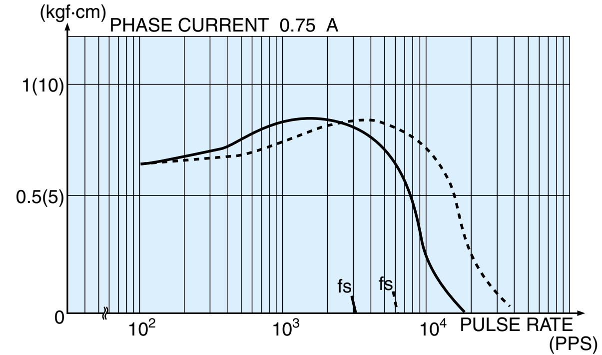


Fig. 9–3

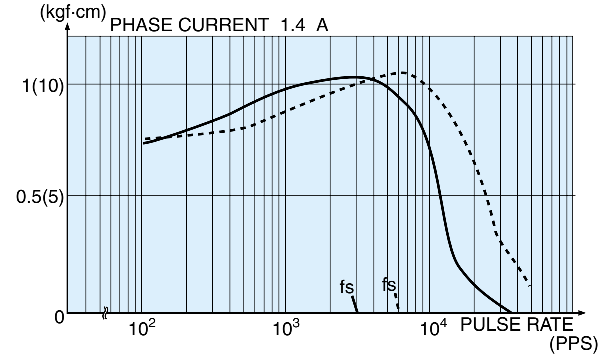


Fig. 9–4

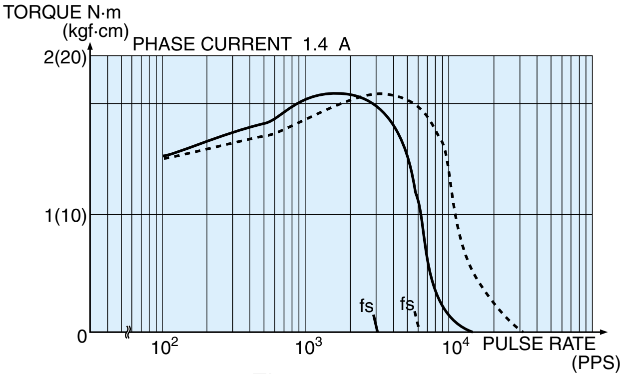
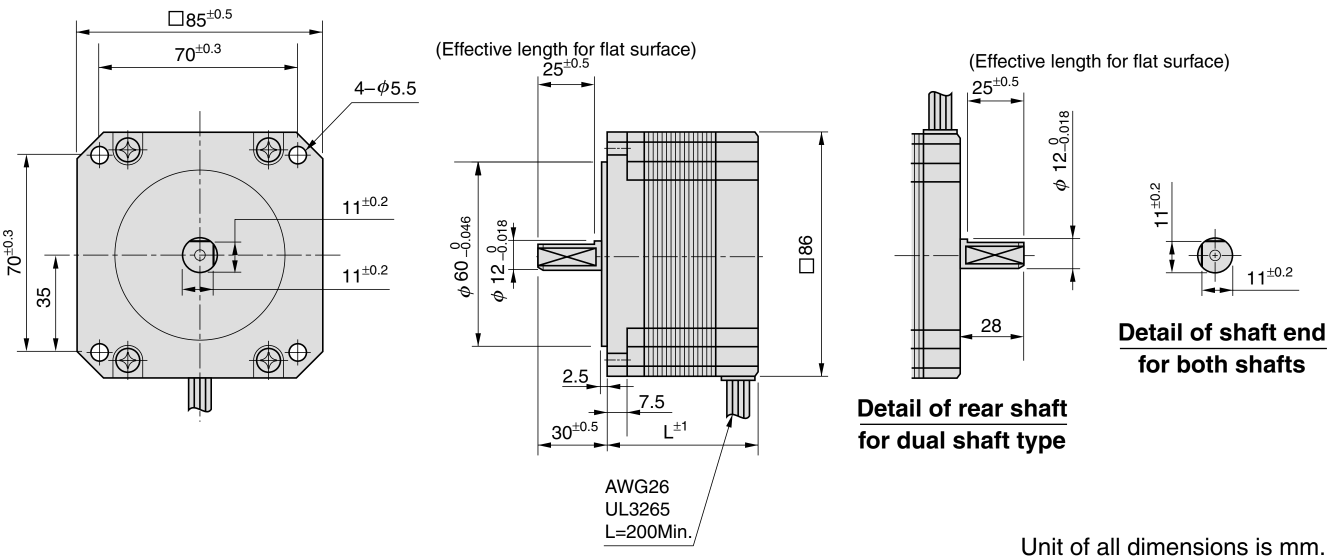


Fig. 9–5

MODEL 34 0.72° HB TYPE



Unit of all dimensions is mm.

Type number		Rated voltage V/ Phase	Rated current A/ Phase	Winding resistance Ω/ Phase	Holding torque N · m (kgf·cm)	Motor length L mm	Rotor inertia g · cm²	Mass g	Combined driver / Charact.				
Single shaft	Dual shafts								AU9112	AU9116	AU9118	AU9119	AU9151
TS3630N1E1	TS3630N21E1	2.46	1.4	1.76	2.1 (21)	64.5	900	1800	——	——	Fig.10-1	——	Fig.12-1
TS3630N1E2	TS3630N21E2	2.1	2.8	0.57	2.1 (21)	64.5	900	1800	——	——	——	Fig.11-1	——
TS3630N2E3	TS3630N22E3	3.82	1.4	2.73	4.1 (41)	96.5	2000	3000	——	——	Fig.10-2	——	Fig.12-2
TS3630N2E4	TS3630N22E4	1.88	2.8	0.67	4.1 (41)	96.5	2000	3000	——	——	——	Fig.11-2	——
TS3630N3E5	TS3630N23E5	2.38	2.8	0.85	6.3 (63)	126.5	3000	4000	——	——	——	Fig.11-3	——

- Operating temperature range : −20 ~ +50 °C
- Insulation resistance : 100 M Ω, Min. by DC 500 V Megohm meter
- Dielectric strength : AC 500 V, 1 minute
- End play : 0.075 mm, Max. at the load of 9.8 N (1 kgf)
- Radial play : 0.025 mm, Max. at the load of 4.9 N (0.5 kgf)
- Permissible temperature rise : 80 deg, Max. by resistance method

NOTE : Do not allow the surface temperature of the motor case to rise above 90°C during operation.

PULSE RATE VS TORQUE CHARACTERISTICS (Pull-out Torque)

DRIVER AU9118

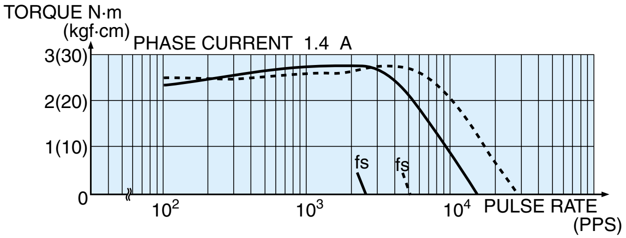


Fig. 10–1

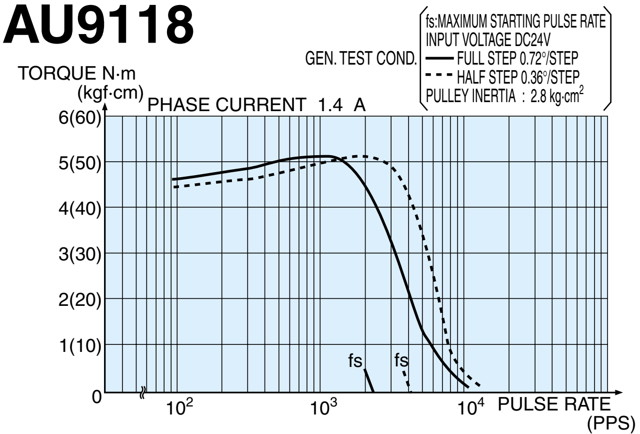


Fig. 10–2

DRIVER AU9119

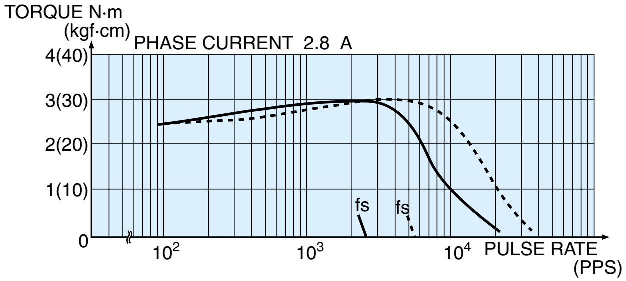


Fig. 11–1

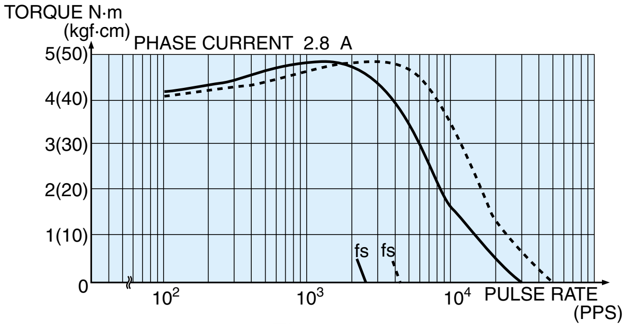


Fig. 11–2

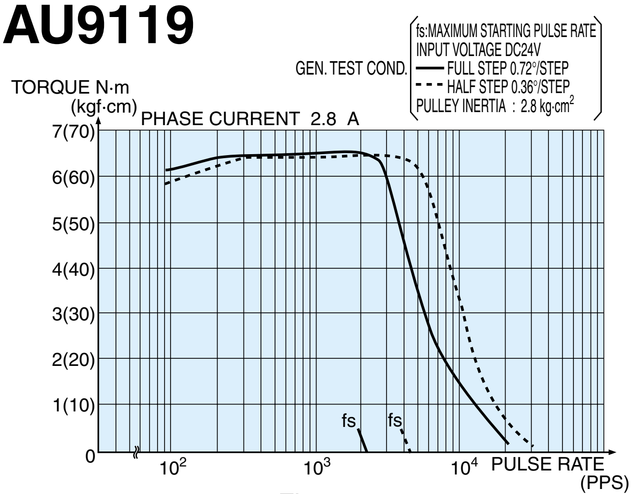


Fig. 11–3

DRIVER AU9151

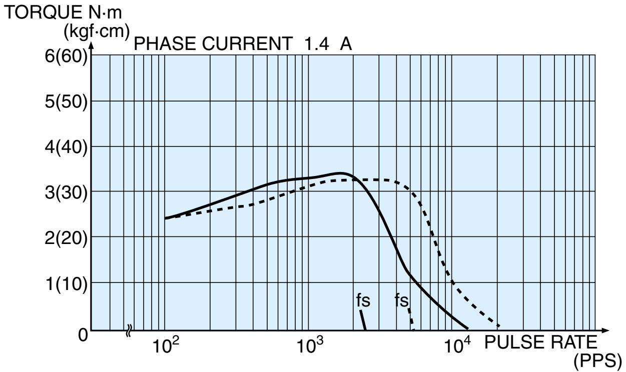


Fig. 12–1

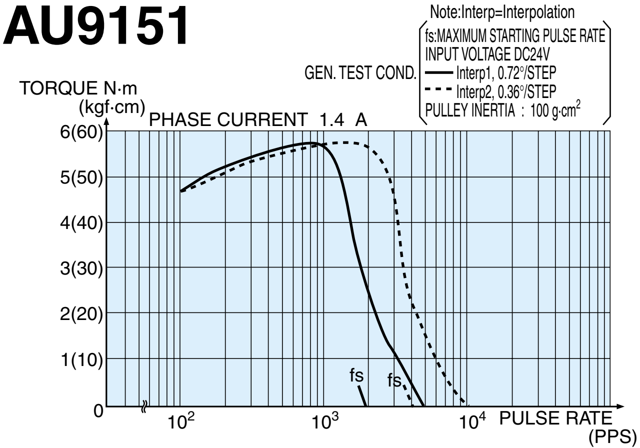


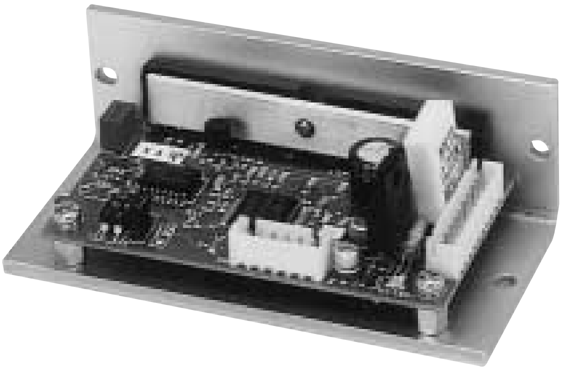
Fig. 12–2

QuinTep DRIVER FOR DC POWER SUPPLY

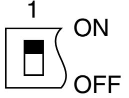
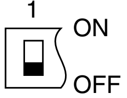
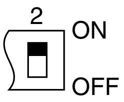
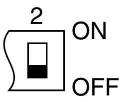
AU9112

SPECIAL FEATURES

- **DC 24 V (DC 40 V Max.), 1.4 A/phase Max.**
- **Exciting mode of FULL/HALF step**
- **Capable of switching the input signals of 1 pulse mode & 2 pluse mode**
- **Automatic current-down function**
- **Low price**
- **Small size and light weight**



SPECIFICATIONS

<table>
<tr><th colspan="2">Items</th><th colspan="3">Specifications</th></tr>
<tr><td colspan="2">Power supply</td><td colspan="3">DC + 17 ~ 40V 3A, Max. (Total consumption of current)</td></tr>
<tr><td colspan="2">Output current
(1.4 A/phase at shipping)</td><td colspan="3">1.4A Max./phase
The voltage corresponding to the output current is transmitted between CP1-CP2. (2 [V] = 1 [A/phase])
Capable of setting the current to the desired value in 0 ~ 1.4 A/phase by the variable resistor RV1</td></tr>
<tr><td colspan="2">Exciting mode
(4-5 phase exciting pattern at shipping)</td><td>(Full step : 0.72°/STEP)
4 phase excitation
Dip-switch  </td><td colspan="2">(Half step : 0.36°/STEP)
4-5 phase excitation
Dip-switch  </td></tr>
<tr><td colspan="2">Input signal circuit</td><td colspan="3">Photo-coupler, input resistance : 390 Ω, Refer to the connection diagram.</td></tr>
<tr><td rowspan="6">Input
signal
(2 pulse input at shipping)</td><td rowspan="3">1 pulse input
PULSE
DIR</td><td rowspan="3">Dip-switch  </td><td colspan="2">Photo-coupler current of DIR signal & rotational direction</td></tr>
<tr><td>ON</td><td>CW rotation</td></tr>
<tr><td>OFF</td><td>CCW rotation</td></tr>
<tr><td>2 pulse input
CW
CCW</td><td>Dip-switch  </td><td colspan="2">Note : Photo-coupler current that is not applied by any input pulse should be OFF. The input pulse of CW and CCW should not be applied simultaneously</td></tr>
<tr><td>Enable</td><td colspan="3">Non-exciting for the photo-coupler current ON.
Exciting for the photo-coupler current OFF.</td></tr>
<tr><td colspan="4">Pulse width : 5 μ s, Min., Rising-up time : 1 μ s, Max.
Pulse interval : 5 μ s, Min., Pulse frequency : 50 Kpps Max.
Pulse voltage : "1" = 4 ~ 12 V, "0" = 0.5 ~ –12 V
Triggered at the edge of OFF to ON of photo-coupler current</td></tr>
<tr><td colspan="2">Automatic current-down</td><td colspan="3">The output current at stationary is reduced down to approx. 60% of operation.</td></tr>
<tr><td colspan="2">Operating temperature & humidity</td><td colspan="3">0 ~ 40°C 90% RH Max. without any dew condensed.</td></tr>
<tr><td colspan="2">Storage temperature & humidity</td><td colspan="3">–10 ~ 70°C 90% RH Max. without any dew condensed.</td></tr>
<tr><td colspan="2">Mass</td><td colspan="3">Approximate 95g</td></tr>
</table>

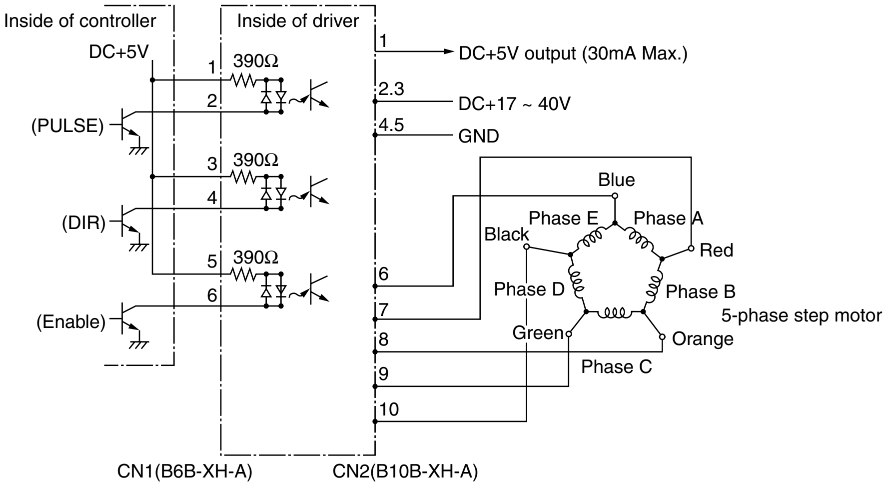
CONNECTION DIAGRAM

Pin assignment of CN1 (B6B-XH-A)

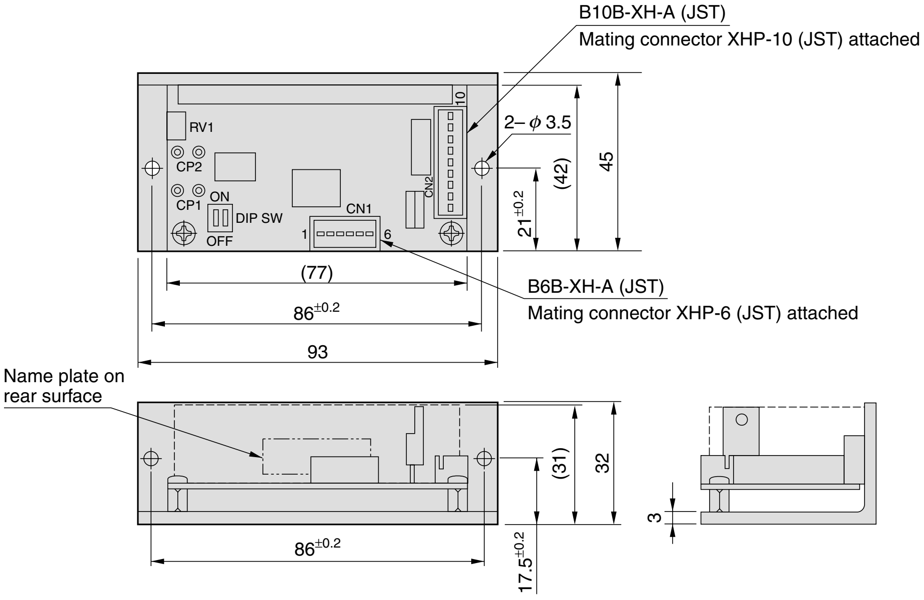
Pin No.	Name	
	1 pulse input	2 pulse input
1	PULSE +	CW +
2	PULSE –	CW –
3	DIR +	CCW +
4	DIR –	CCW –
5	Enable +	
6	Enable –	

Pin assignment of CN2 (B10B-XH-A)

Pin No.	Name
1	DC +5V 30mA Max. output
2	DC + 17 ~ 40V
3	DC + 17 ~ 40V
4	GND
5	GND
6	Motor lead : Blue
7	Motor lead : Red
8	Motor lead : Orange
9	Motor lead : Green
10	Motor lead : Black



OUTLINE DRAWING



Unit of all dimensions is mm.

QuinTep DRIVER FOR AC POWER SUPPLY

AU9118

SPECIAL FEATURES

- **AC 100 V, 1.4 A/phase Max.**
- **Exciting mode of FULL/HALF step**
- **Capable of setting the value of automatic current-down by the variable resistor**
- **Capable of setting the switching of driving voltage**
- **Effective built-in test function**

SPECIFICATIONS

Items	Specifications
Power supply	AC90 ~ 110V 50/60Hz 350VA, Max.
Driving current	Rated current : 1.4 A Max./phase Capableof setting the current by the variable resistor "RUN"
Driving type	Bipolar pentagon constant current drive

Items	Signal name	Functional description	Input resistance	
Input signal	F +	Pulse signal input for 1 clock mode	390 ohms	Pulse width : 5 µ s, Min., Rising-up time : 1 µ s, Max. Pulse interval : 5 µ s, Min., Pulse frequency : 70 Kpps Max. Pulse voltage : "1" = 4 ~ 12 V, "0" = 0.5 ~ –12 V Triggered at the edge of OFF (Logic "0") to ON (Logic "1") of photo-coupler current CCW rotation during R input is "0"
	F –	Positive rotation signal for 2 clock		
	R +	Rotational direction input for 1 clock	390 ohms	
	R –	Reverse rotation signal for 2 clock		
	H.O +	Motor exciting OFF control signal	390 ohms	
	H.O –	Motor exciting OFF for "1"		

Items	Signal name	Functional description	
Output signal	Z.P +	Output signal of exciting at origin	This signal is ON at the exciting sequence of [0] and is transmitted at each 7.2 degrees for the step motor with 0.72° steps. When the step angle is changed after the power supply is turned on, it may not be transmitted.
	Z.P –	ON during exciting at origin	

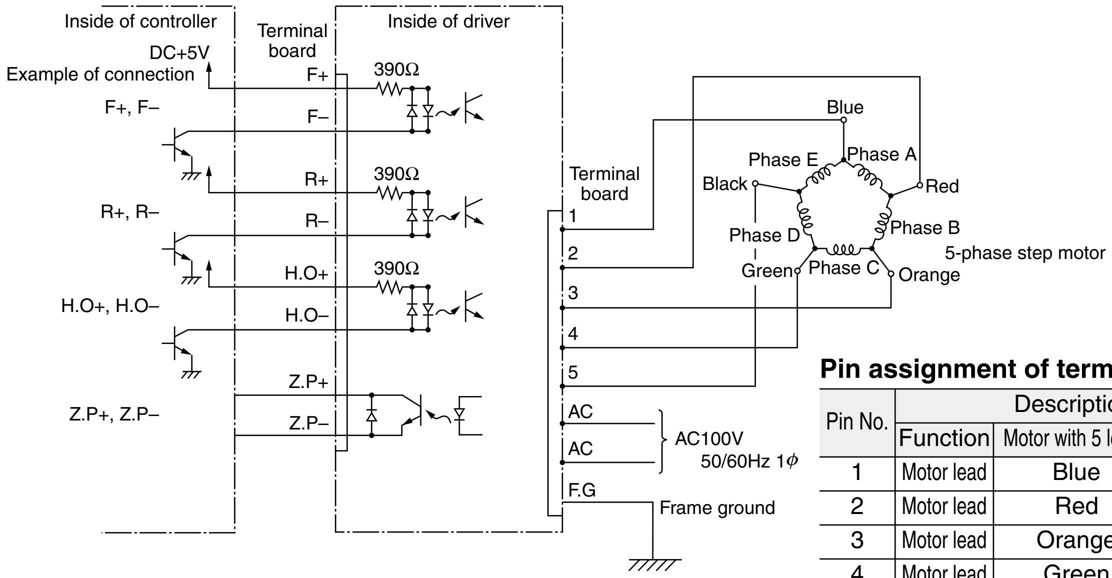
Items	Specifications	
Setting of driving current	The output current to the motor in rotation is set by the variable resistor "RUN"	For setting the current, connect a voltmeter to the check terminal of +C.P– on the upper panel and set the voltage as the equation below by adjusting the variable resistor "RUN" or "STOP". Terminal voltage of CP (V) = (Current to be set) x 4.5 Refer to the setting panel in right figure.
Automatic current-down (50% at shipping)	The output current to the motor at stationary is set by the variable resistor "STOP"	

Items	No.	Symbol	Function	ON (Lever : right)	OFF (Lever : left)
Setting of dip-switches (All OFF at shipping)	1	TEST	Built-in test function	Rotating slowly	Normal
	2	L/H.V	SW of driving voltage	High speed & torque	Normal
	3	C.D	Current-down	Invalid	Valid
	4	2/1 CK	Signal input	1 clock mode	2 clock mode
	5	H/F	Step angle	0.72°/pulse	0.36°/pulse

Refer to the setting panel in right figure.

Items	Specifications
Operating temperature & humidity	0 ~ 40°C 90% RH Max. without any dew condensed.
Storage temperature & humidity	–10 ~ 70°C 90% RH Max. without any dew condensed.
Mass	1.5 kg

CONNECTION DIAGRAM

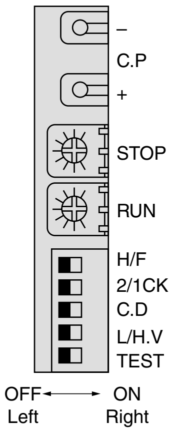


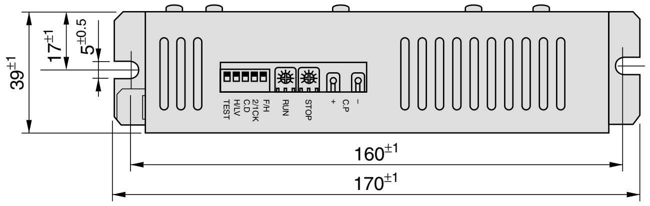
Pin assignment of terminal board

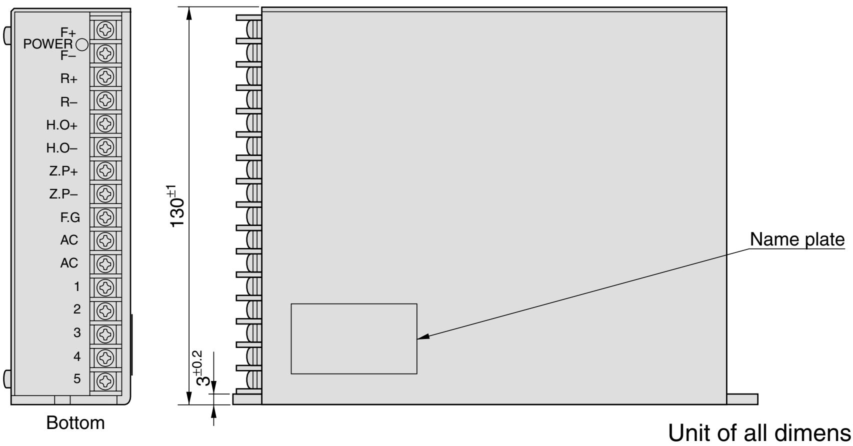
Pin No.	Description of wiring		
	Function	Motor with 5 leads	Motor with 10 leads
1	Motor lead	Blue	Blue + Black
2	Motor lead	Red	Red + Brown
3	Motor lead	Orange	Purple + Orange
4	Motor lead	Green	Yellow + Green
5	Motor lead	Black	White + Gray
AC	Power supply	AC 90 ~ 110 V	
AC	Power supply	AC 90 ~ 110 V	
F.G	Frame ground		
F +	Input signal		
F –	Same as above		
R +	Input signal		
R –	Same as above		
H.O +	Input signal		
H.O –	Same as above		
Z.P +	Output signal		
Z.P –	Same as above		

OUTLINE DRAWING

Setting panel







Bottom

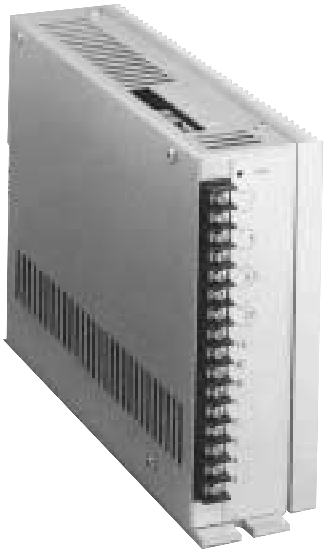
Unit of all dimensions is mm.

QuinTep DRIVER FOR AC POWER SUPPLY

AU9119

SPECIAL FEATURES

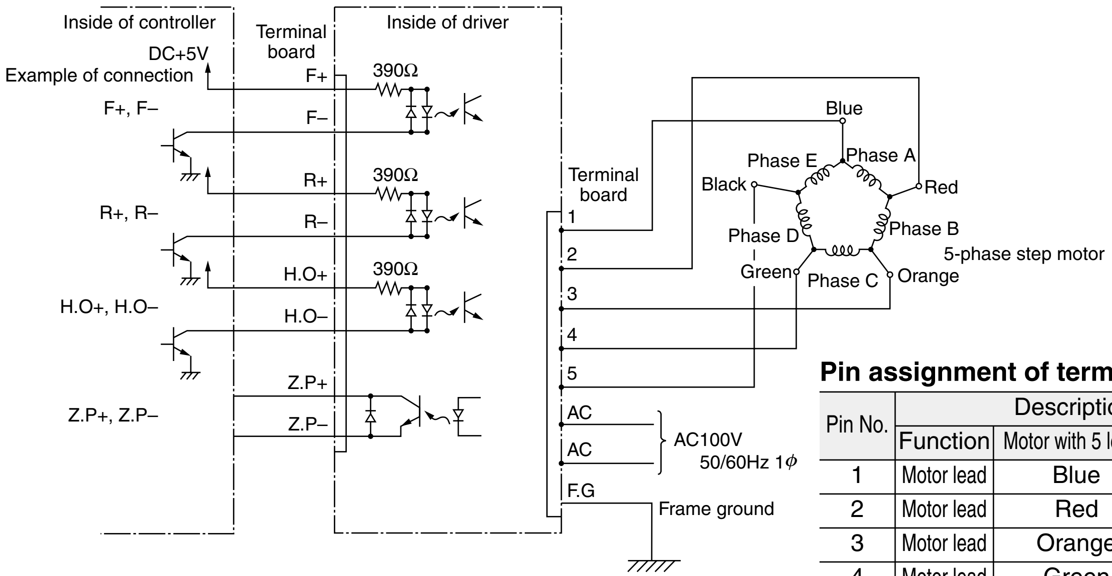
- **AC 100 V, 2.8 A/phase Max.**
- **Exciting mode of FULL/HALF step**
- **Large capacity for output power**
- **Capable of setting the value of automatic current-down by the variable resistor**
- **Capable of setting switching of driving voltage**
- **Effective built-in test function**



SPECIFICATIONS

<table>
<tr><th colspan="2">Items</th><th colspan="3">Specifications</th></tr>
<tr><td colspan="2">Power supply</td><td colspan="3">AC90 ~ 110V 50/60Hz 650VA, Max.</td></tr>
<tr><td colspan="2">Driving current</td><td colspan="3">Rated current : 2.8 A Max./phase
Capable to set the current by the variable resistor "RUN"</td></tr>
<tr><td colspan="2">Driving type</td><td colspan="3">Bipolar pentagon constant current drive</td></tr>
<tr><td rowspan="7">Input signal</td><td>Signal name</td><td>Functional description</td><td>Input resistance</td><td rowspan="7">Pulse width : 5 μ s, Min., Rising-up time : 1 μ s, Max.
Pulse interval : 5 μ s, Min., Pulse frequency : 70Kpps Max.
Pulse voltage : "1" = 4 ~ 12 V, "0" = 0.5 ~ –12 V
Triggered at the edge of OFF (Logic "0") to ON (Logic "1") of photo-coupler current
CCW rotation during R input is "0"</td></tr>
<tr><td>F +</td><td>Pulse signal input for 1 clock mode</td><td rowspan="2">390 ohms</td></tr>
<tr><td>F –</td><td>Positive rotation signal for 2 clock</td></tr>
<tr><td>R +</td><td>Rotational direction input for 1 clock</td><td rowspan="2">390 ohms</td></tr>
<tr><td>R –</td><td>Reverse rotation signal for 2 clock</td></tr>
<tr><td>H.O +</td><td>Motor exciting OFF control signal</td><td rowspan="2">390 ohms</td></tr>
<tr><td>H.O –</td><td>Motor exciting OFF for "1"</td></tr>
<tr><td rowspan="3">Output signal</td><td>Signal name</td><td colspan="2">Functional description</td><td rowspan="3">This signal is ON at the exciting sequence of [0] and is transmitted at each 7.2 degrees for the step motor with 0.72° steps. When the step angle is changed after the power supply is turned on, it may not be transmitted.</td></tr>
<tr><td>Z.P +</td><td colspan="2">Output signal of exciting at origin</td></tr>
<tr><td>Z.P –</td><td colspan="2">ON during exciting at origin</td></tr>
<tr><td colspan="2">Setting of driving current (2.8A at shipping)</td><td colspan="2">The output current to the motor in rotation is set by the variable resistor "RUN"</td><td rowspan="2">For setting the current, connect a voltmeter to the check terminal of +C.P– on the upper panel and set the voltage as the equation below by adjusting the variable resistor "RUN" or "STOP".
Terminal voltage of CP (V) = (Current to be set) x 2.25
Refer to the setting panel in right figure.</td></tr>
<tr><td colspan="2">Automatic current-down (50% at shipping)</td><td colspan="2">The output current to the motor at stationary is set by the variable resistor "STOP"</td></tr>
<tr><td colspan="2">Setting of dip-switches (All OFF at shipping)</td><td colspan="3"><table>
<tr><th>No.</th><th>Symbol</th><th>Function</th><th>ON (Lever : left)</th><th>OFF (Lever : right)</th></tr>
<tr><td>1</td><td>F/H</td><td>Step angle</td><td>0.72°/pulse</td><td>0.36°/pulse</td></tr>
<tr><td>2</td><td>2/1 CK</td><td>Signal input</td><td>1 clock mode</td><td>2 clock mode</td></tr>
<tr><td>3</td><td>C.D</td><td>Current-down</td><td>Invalid</td><td>Valid</td></tr>
<tr><td>4</td><td>H/L.V</td><td>SW of driving voltage</td><td>High speed & torque</td><td>Normal</td></tr>
<tr><td>5</td><td>TEST</td><td>Built-in test function</td><td>Rotating slowly</td><td>Normal</td></tr>
</table>Refer to the setting panel in right figure.</td></tr>
<tr><td colspan="2">Operating temperature & humidity</td><td colspan="3">0 ~ 40°C 90% RH Max. without any dew condensed.</td></tr>
<tr><td colspan="2">Storage temperature & humidity</td><td colspan="3">–10 ~ 70°C 90% RH Max. without any dew condensed.</td></tr>
<tr><td colspan="2">Mass</td><td colspan="3">2.3 kg</td></tr>
</table>

CONNECTION DIAGRAM

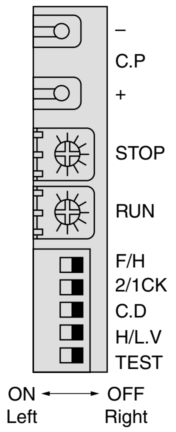


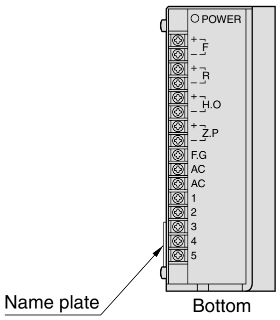
Pin assignment of terminal board

Pin No.	Description of wiring		
	Function	Motor with 5 leads	Motor with 10 leads
1	Motor lead	Blue	Blue + Black
2	Motor lead	Red	Red + Brown
3	Motor lead	Orange	Purple + Orange
4	Motor lead	Green	Yellow + Green
5	Motor lead	Black	White + Gray
AC	Power supply	AC 90 ~ 110 V	
AC	Power supply	AC 90 ~ 110 V	
F.G	Frame ground		
F +	Input signal		
F –	Same as above		
R +	Input signal		
R –	Same as above		
H.O +	Input signal		
H.O –	Same as above		
Z.P +	Output signal		
Z.P –	Same as above		

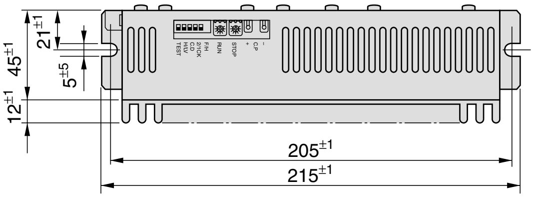
OUTLINE DRAWING

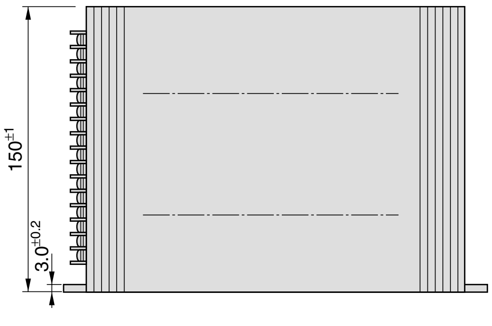
Setting panel





Bottom



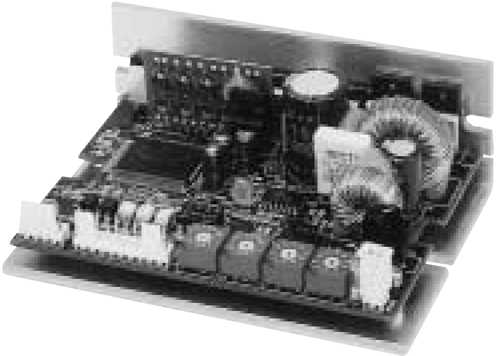


Unit of all dimensions is mm.

QuinTep DRIVER FOR MICRO-STEP, DC POWER SUPPLY

AU9116

SPECIAL FEATURES



- **DC 24 V, 1.4 A/phase Max.**
- **Setting the value of auto-current-down by digital switch**
- **Effective built-in test function**
- **Maximum 80interpolation of basic step angle**

SPECIFICATIONS

Items	Specifications
Power supply	DC + 21.6 ~ 26.4 V
Driving current (1.4 A/phase at shipping)	Rated current : 1.4 A Max./phase Capable of setting the current to 0.4 ~ 1.4 A/phase by the digital switch "RUN"
Driving type	Bipolar pentagon constant current drive

	Signal name	Functional description	Input resistance	
Input signal	F +	Pulse input for 1 clock mode	300 ohms	Pulse width : 0.5 μ s, Min., Rising-up time : 1 μ s, Max. Pulse interval : 0.5 μ s, Min., Pulse frequency : 500 Kpps Max. Pulse voltage : "1" for 4 ~ 8 V & "0" for 0.5 ~ –8 V Triggered at the edge of OFF (Logic "0") to ON (Logic "1") of photo-coupler current CCW rotation during R input is "0"
	F –	Positive rotation input for 2 clock mode		
	R +	Rotational direction input for 1 clock	300 ohms	
	R –	Reverse rotation input for 2 clock		
	H.O +	Motor exciting OFF control signal	390 ohms	
	H.O –	"1" for motor exciting OFF		
	D.S +	Micro-step interpolation selection	390 ohms	
	D.S –	"0" for M1 & "1" for M2		

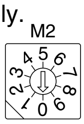
	Signal name	Functional description	
Output signal	Z.PC +	Output signal of exciting at origin	This signal is ON at the exciting sequence of [0] and is transmitted at each 7.2 degrees for the step motor with 0.72° steps. When the step angle is changed after the power supply is turned on, it may not be transmitted.
	Z.PC –	ON during exciting at origin	

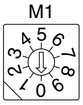
Setting of micro-step interpolation (M1:5, M2:0 at shipping)

In case of starting in only one kind of micro-step, set the interpolation by digital SW M1.
In case of starting in two kinds of micro-step (i.e. using different speed for forward and backward directions), set the number of each interpolation by digital SW M1 & M2 respectively.

Set No.	0	1	2	3	4	5	6	7	8	9
Interpolation	1	2	4	5	8	10	20	40	80	16

(Note 1)

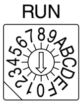




Setting of driving current (Setting C at shipping)

The output current to the motor during rotation is set by the digital switch "RUN" to select from the table below.

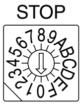
Set No.	0	1	2	3	4	5	6	7	8	9
Current (A)	0.50	0.58	0.66	0.75	0.81	0.88	0.96	1.03	1.10	1.15
					A	B	C	D	E	F
					1.25	1.30	1.40	1.47	1.53	1.60



Automatic current-down (Setting 5 at shipping)

The output current to the motor at stationary is set by the digital switch "STOP" to select from the table below.
The value is set by the percent to RUN current. The current decreases at approx. 150 ms after the last pulse.

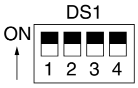
Set No.	0	1	2	3	4	5	6	7	8	9
%	27	31	36	40	45	50	54	58	52	66
					A	B	C	D	E	F
					70	74	78	82	84	90



Setting of dip-switches (All OFF at shipping)

No.	Symbol	Function	ON	OFF
1	TEST	Built-in test function	Rotating at 100 pps	Normal operation
2	2/1 CK	Switching of clock	1 clock mode	2 clock mode
3	C.D	Automatic current-down	Invalid	Valid
4	OP	Enable to use	OFF for use	

(Note 2)

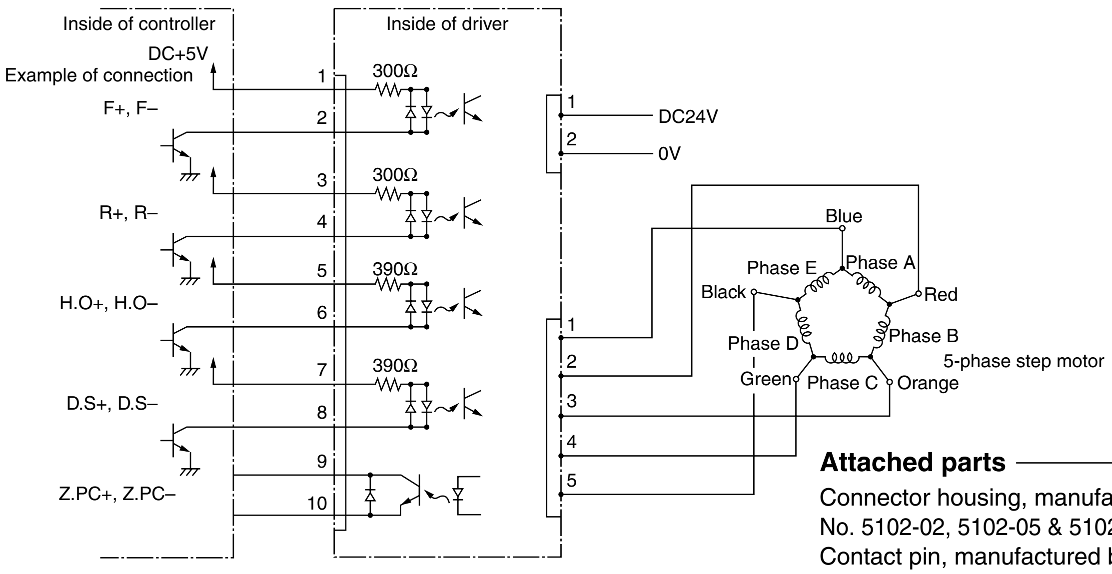


Operating temperature & humidity	0 ~ 40°C 90% RH Max. without any dew condensed.
Storage temperature & humidity	–10 ~ 70°C 90% RH Max. without any dew condensed.
Mass	Approximate 200 g

Note 1 : $\text{Micro-step angle for 1 pulse} = \dfrac{\text{Basic step angle}}{\text{Number of interpolation}}$

Note 2 : Rotating at 100 pps regardless the setting of interpolation. CW rotation at 2 clock input. Rotation set by R input at 1 clock input.

CONNECTION DIAGRAM



Attached parts

Connector housing, manufactured by Molex,
No. 5102-02, 5102-05 & 5102-10 : 1 piece for each
Contact pin, manufactured by Molex,
No. 5103 : 19 pieces

Pin assignment of 5 pin connector (5045-05A)

Connection of motor leads		
Pin No.	Motor with 5 leads	Motor with 10 leads
1	Blue	Blue + Black
2	Red	Red + Brown
3	Orange	Purple + Orange
4	Green	Yellow + Green
5	Black	White + Gray

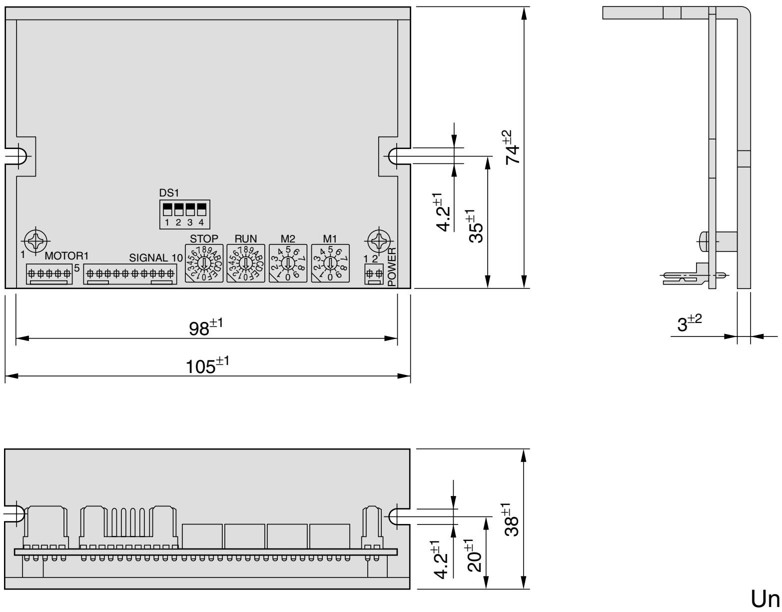
Pin assignment of 2 pin connector (5045-02A)

No.	Description of function
1	DC 24 V Power supply
2	0 V

Pin assignment of 10 pin connector (5045-10A)

Pin No.	Signal name
1	F +
2	F –
3	R +
4	R –
5	H.O +
6	H.O –
7	D.S +
8	D.S –
9	Z.PC +
10	Z.PC –

OUTLINE DRAWING



Unit of all dimensions is mm.

QuinTep DRIVER FOR MICRO-STEP, AC POWER SUPPLY

AU9151

SPECIAL FEATURES

- **AC 100 V, 1.4 A/phase Max.**
- **Driving voltage switching function**
- **Setting the value of auto-current-down by digital switch**
- **Effective built-in test function**
- **Maximum 80interpolation of basic step angle**

SPECIFICATIONS

Items	Specifications
Power supply	AC 90 ~ 125 V 50/60Hz 350 VA, Max.
Driving current (1.4 A/phase at shipping)	Rated current : 1.4 A Max./phase Capable of setting the current to 0.4 ~ 1.4 A/phase by the digital switch "RUN"
Driving type	Bipolar pentagon constant current drive

Items	Signal name	Functional description	Input resistance	
Input signal	F +	Pulse input for 1 clock mode	300 ohms	Pulse width : 0.5 μ s, Min., Rising-up time : 1 μ s, Max. Pulse interval : 0.5 μ s, Min., Pulse frequency : 500 Kpps Max. Pulse voltage : "1" for 4 ~ 8 V & "0" for 0.5 ~ –8 V Triggered at the edge of OFF (Logic "0") to ON (Logic "1") of photo-coupler current CCW rotation during R input is "0"
	F –	Positive rotation input for 2 clock mode		
	R +	Rotational direction input for 1 clock	300 ohms	
	R –	Reverse rotation input for 2 clock		
	H.O +	Motor exciting OFF control signal	390 ohms	
	H.O –	"1" for motor exciting OFF		
	D.S +	Micro-step interpolation selection	390 ohms	
	D.S –	"0" for M1 & "1" for M2		
	C.D +	Automatic current-down signal	390 ohms	Current-down is not performed when either C.D signal or C.D dip-switch is ON.
	C.D –	"0" for automatic current-down		

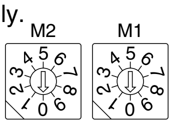
Items	Signal name	Functional description	
Output signal	Z.PC +	Output signal of exciting at origin	This signal is ON at the exciting sequence of [0] and is transmitted at each 7.2 degrees for the step motor with 0.72° steps. When the step angle is changed after the power supply is turned on, it may not be transmitted.
	Z.PC –	ON during exciting at origin	

Setting of micro-step interpolation (M1:5, M2:0 at shipping)

In case of starting in only one kind of micro-step, set the interpolation by digital SW M1.
In case of starting in two kinds of micro-step (i.e. using different speed for forward and backward directions), set the number of each interpolation by digital SW M1 & M2 respectively.

Set No.	0	1	2	3	4	5	6	7	8	9
Interpolation	1	2	4	5	8	10	20	40	80	16

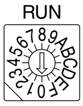
(Note 1)



Setting of driving current (Setting C at shipping)

The output current to the motor in rotation is set by the digital switch "RUN" to select from the table below.

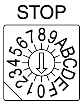
Set No.	0	1	2	3	4	5	6	7	8	9
Current (A)	0.50	0.58	0.66	0.75	0.81	0.88	0.96	1.03	1.10	1.15
					A	B	C	D	E	F
					1.25	1.30	1.40	1.47	1.53	1.60



Automatic current-down (Setting 5 at shipping)

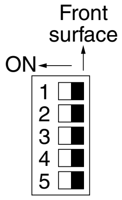
The output current to the motor at stationary is set by the digital switch "STOP" to select from the table below.
The value is set by the percent to RUN current. The current decreases at approx. 150 ms after the last pulse.

Set No.	0	1	2	3	4	5	6	7	8	9
%	27	31	36	40	45	50	54	58	62	66
					A	B	C	D	E	F
					70	74	78	82	86	90



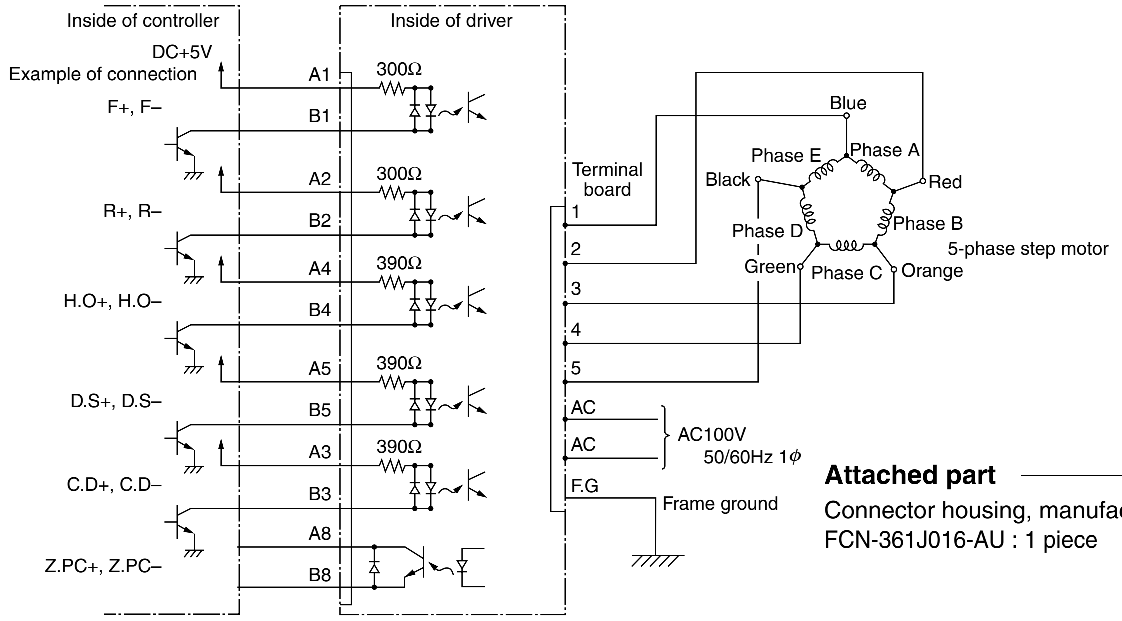
Setting of dip-switches (All OFF at shipping)

No.	Symbol	Function	ON	OFF	
1	TEST	Built-in test function	Rotating at 50 pps	Normal operation	(Note 2)
2	2/1 CK	Switching of clock	1 clock mode	2 clock mode	
3	C.D	Automatic current-down	Invalid	Valid	
4	L/HV	Switching drive-voltage	High speed & torque	Normal operation	
5	OP	Enable to use	OFF for use		(Note 3)



Items	Specifications
Operating temperature & humidity	0 ~ 40°C 90% RH Max. without any dew condensed.
Storage temperature & humidity	–10 ~ 70°C 90% RH Max. without any dew condensed.
Mass	Approximate 750 g

CONNECTION DIAGRAM



Attached part

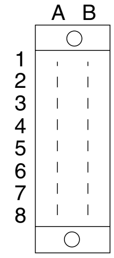
Connector housing, manufactured by Fujitsu, FCN-361J016-AU : 1 piece

Pin assignment of terminal board

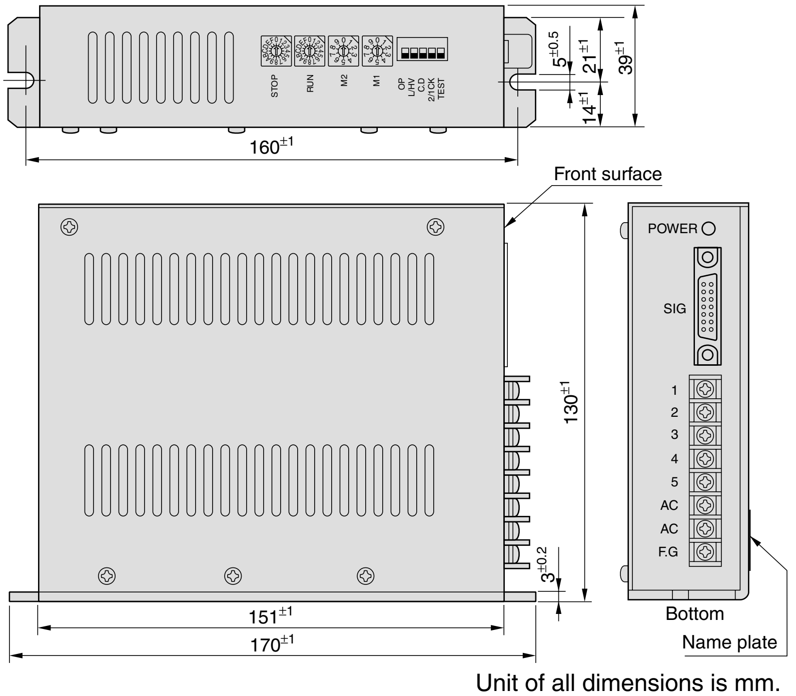
Pin No.	Connection of motor leads		
	Function	Motor with 5 leads	Motor with 10 leads
1	Motor lead	Blue	Blue + Black
2	Motor lead	Red	Red + Brown
3	Motor lead	Orange	Purple + Orange
4	Motor lead	Green	Yellow + Green
5	Motor lead	Black	White + Gray
AC	Power supply	AC 90 ~ 125 V	
AC	Power supply	AC 90 ~ 125 V	
F.G	Frame ground		

Pin assignment of signal connector (Top view)

Pin No.	Symbol	Pin No.	Symbol
A1	F +	B1	F –
A2	R +	B2	R –
A3	C.D +	B3	C.D –
A4	H.O +	B4	H.O –
A5	D.S +	B5	D.S –
A6	NC	B6	NC
A7	NC	B7	NC
A8	Z.PC +	B8	Z.PC –



OUTLINE DRAWING



Note 1 :

$$\text{Micro-step angle for 1 pulse} = \frac{\text{Basic step angle}}{\text{Number of interpolation}}$$

For example, in case of the basic step angle of 0.72 and the number of interpolation of 80,

$$\text{Micro-step angle for 1 pulse} = \frac{0.72}{80} = 0.009 \text{ deg.}$$

Note 2 :

Rotating at 50 pps regardless of the setting of interpolation. CW rotation at 2 clock input. Rotation set by R input at 1 clock input.

Note 3 :

In case of using high speed & torque of L/HV, take good care of the heating-up of the motor.

Unit of all dimensions is mm.

MEMO

MEMO

Tamagawa

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WARRANTY
Tamagawa Seiki warrants that this product is free from defects in material or workmanship under nornal use and service for a period of one year from the date of shipment from its factory. This warranty, however, exculudes incidental and consequental damages caused by careless use of the product by the user. Even after the warranty period, Tamagawa Seiki offers repair service, with charge, in order to maintain the quality of the product. The MTBF (mean time between failures) of our product is quite long; yet, the predictable failure rate is not zero. The user is advised, therefore, that multiple safety means be incorporated in your system or product so as to prevent any consequential troubles resulting from the failure of our product.

All specifications are subject to change without notice.

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