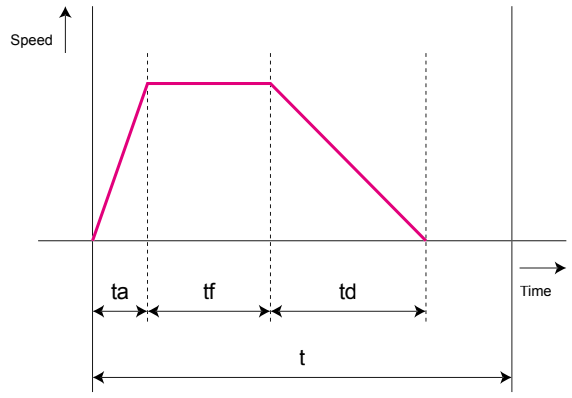
MODEL SELECTION METHOD OF LSA LINEAR SERVO ACTUATOR

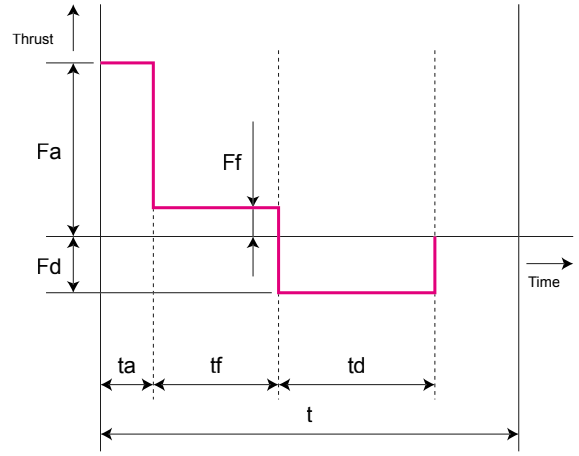
When selecting a linear servo actuator, make sure the following two conditions are met:
Condition① The required thrust for acceleration must not exceed the maximum thrust of the linear servo actuator.
Condition② The required thrust for continuous operation must not exceed the rated thrust of the linear servo actuator.

The above conditions are explained in the example trapezoidal operation below:



Abbreviations:
t : Operation time per cycle (s)
ta : Acceleration time (s)
tf : Travel time at constant speed (s)
td : Deceleration time (s)
tc : Settling time (0.15 s)

The operation pattern shown at left can be modified as below when thrust is expressed by the vertical axis:



Abbreviations:
Fa : Required thrust for acceleration (N)
Ff : Travel resistance (N)
Fd : Required thrust for deceleration (N)

Selection Criteria

Condition① Maximum thrust

For the slider to accelerate as specified, the required thrust for acceleration Fa must be smaller than the maximum thrust of the linear servo actuator.
The maximum thrust of the linear servo actuator varies, depending on the slider speed. Exercise caution when operating in the high-speed range where the maximum thrust tends to drop. (See the diagrams of F-N characteristics during continuous operation, as shown on the opposite page.)

Fa is calculated through the following formula:

$$Fa = (M + m) \cdot a + Ff$$

M : Slider weight

m : Slider capacity (kg)
a : Specified acceleration (m/s^2)* *1G = 9.8 m/s^2
Ff: Frictional force (N)

With the linear servo actuators, the travel resistance changes in accordance with the slider speed and is calculated by the empirical formulas shown below:

Travel resistance for the large type

$$Ff = \frac{50}{3}V \qquad V: \text{Slider speed (m/s)}$$

Travel resistance for the small type

$$\frac{60}{3} \qquad V: \text{Slider speed (m/s)}$$

Condition① is deemed satisfied if the value of Fa obtained above is smaller than the maximum thrust of the linear servo actuator.

Condition② Thrust during continuous operation

Confirm that the thrust during continuous operation Ft, which takes into account the applicable load and duty, is less than the rated thrust of the linear servo actuator. Calculate Ft through the following formula:

$$Ft = \sqrt{\frac{Fa^2 \cdot ta + Ff^2 \cdot tf + Fd^2 \cdot td}{t}}$$

Here, Fd indicates the required thrust for deceleration and is calculated using the formula below:

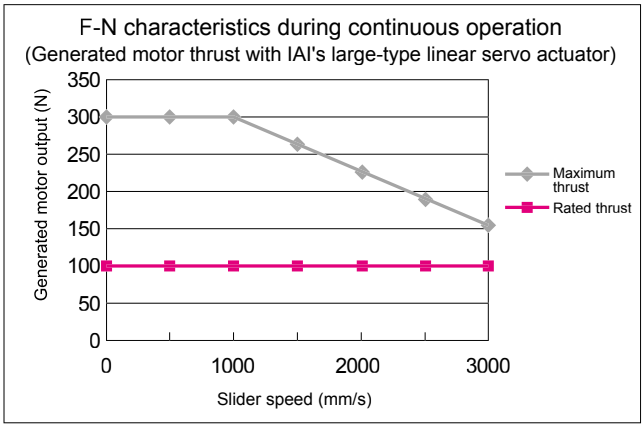
$$Fd = (M + m) \cdot d - Ff$$

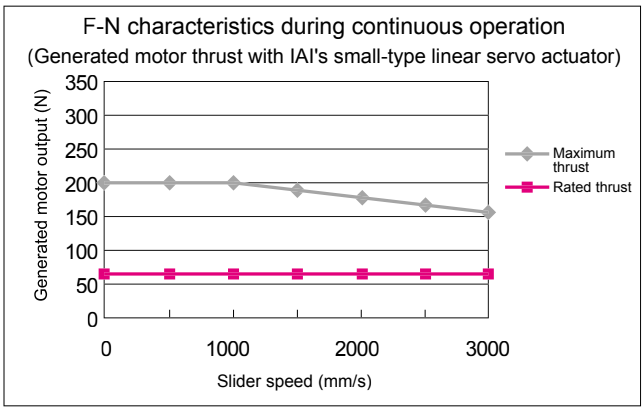
M : Slider weight

m : Slider capacity (kg)
d : Specified deceleration (m/s^2)
Ff: Travel resistance (N)

If the obtained thrust during continuous operation Ft is less than the rated thrust of the linear servo actuator, the above operation can be performed.

The linear servo actuator will perform the operation as long as both conditions ① and ② are satisfied. If either condition cannot be satisfied, take appropriate measures such as reducing the slider capacity, decreasing the acceleration rate or lowering the payload.





[Example]
Let's select a motor based on the selection method explained above.

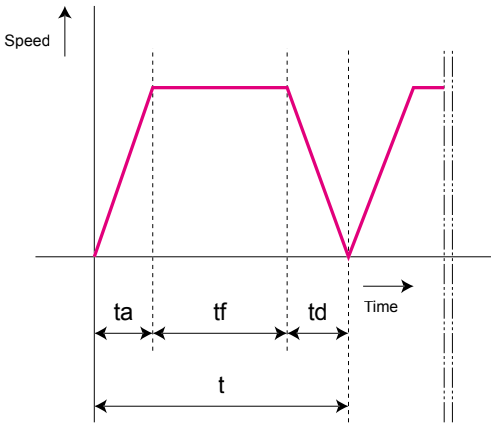
★ Selecting the motor: For large-type linear servo actuator

★ Operating condition

- Speed : 3 m/s
- Acceleration : 19.6 m/s^2 (same value for deceleration)
- Travel distance : 1.5 m
- Slider capacity : 3 kg

  Operate the slider back and forth continuously over a stroke of 1.5 m.

*1G = 9 .8 m/s^2



Now, let's perform calculation by following the steps in the selection method.

Condition ① Obtain the maximum thrust.

Apply the above operation pattern in the calculation formula for maximum thrust as provided above.

$Fa = (M + m) \cdot a + Ff$

Values Used:

M	: Slider weight (kg)	4.3 kg in this example
m	: Slider capacity (kg)	3 kg in this example
a	: Specified acceleration (m/s^2)	19.6 m/s^2 in this example
Ff	: Travel resistance (N)	50 N in this example

From the above, Fa is calculated as follows:
Fa = 7.3 x 19.6 + 50 = 193.08 N
Because the maximum thrust of the large type operating at 3000 mm/s is approximately 150 N, as shown by the thrust vs. speed diagram, the maximum thrust condition is not met.

To meet the condition, the slider speed is reduced to 2000 mm/s.
Fa is now calculated as follows:
Fa = 7.3 x 19.6 + 33.33 = 176.41 N
Because the maximum thrust of the large type operating at 2000 mm/s is approximately 220 N, as shown by the thrust vs. speed diagram, the maximum thrust condition is met.

Condition ② Obtain the thrust during continuous operation.

Apply the above operation pattern in the calculation formula for thrust during continuous operation as provided above.
The slider speed is assumed as 2 m/s, based on the test results for maximum thrust.

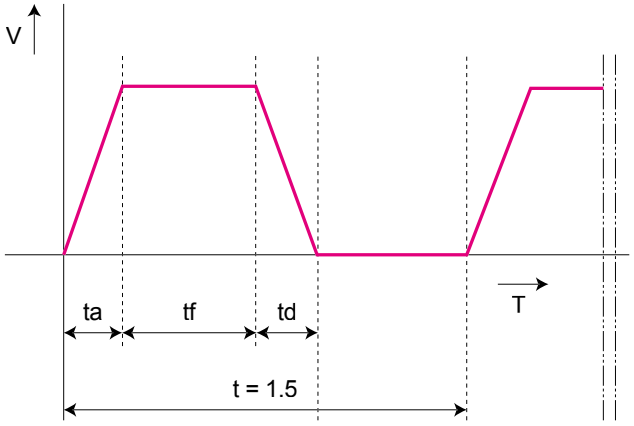
$$Ft = \sqrt{\frac{Fa^2 \cdot ta + Ff^2 \cdot tf + Fd^2 \cdot td}{t}}$$

Values Used:
Fa = 176.41, Ff = 33.33, Fd = 109.75,
ta = td = 0.102 s, tf = 0.648 s, t = 1.002 s (including a settling time of 0.15 s)

From the values above, Ft is calculated as follows:
Ft = 71.51

Because the obtained value not exceeds the rated thrust of the large-type linear servo actuator, or 100 N, this operation pattern can be executed.

Otherwise let's lower the payload slightly.
When calculation is performed again based on t = 1.5 s (including a settling time of 0.15 s), the following result is obtained:



Ft = 58.45 N