YASKAWA

9 Things to Consider When Specifying Servo Motors

Ensuring Optimal Servo System Performance for your Application

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There are many things to consider when selecting the right servo system for a particular application. This tutorial will help with selecting a servo system that will perform at the optimal level for the selected application.   Look at the following nine areas for the best results.

1. Selection of Motor Size

The three most important criteria when starting with the motor are:

- Speed
- Torque
- Rotor inertia.

The first two are pretty obvious and are typically calculated using “sizing” programs that are offered by various manufacturers. In these programs you can enter the types of moves in the application, and the software will calculate the torque and speed requirements based on the load and the type of transmission (gearbox, belt, rack and pinion, ballscrew, etc.).

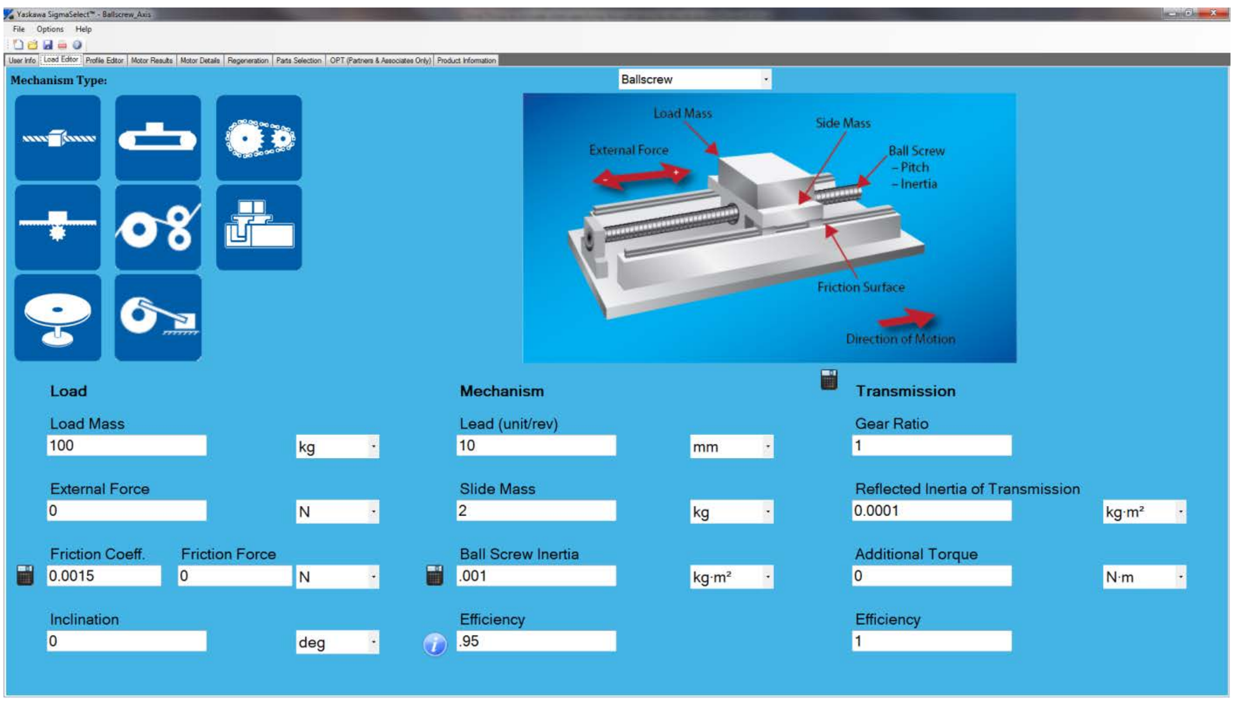


Figure 1: Software can help in sizing a servo system. This typical load/mechanism entry screen from Yaskawa SigmaSelect servo sizing software shows a diagram calling out external force, load mass, side mass, pitch, and inertia of the ball screw, friction, and motion direction.

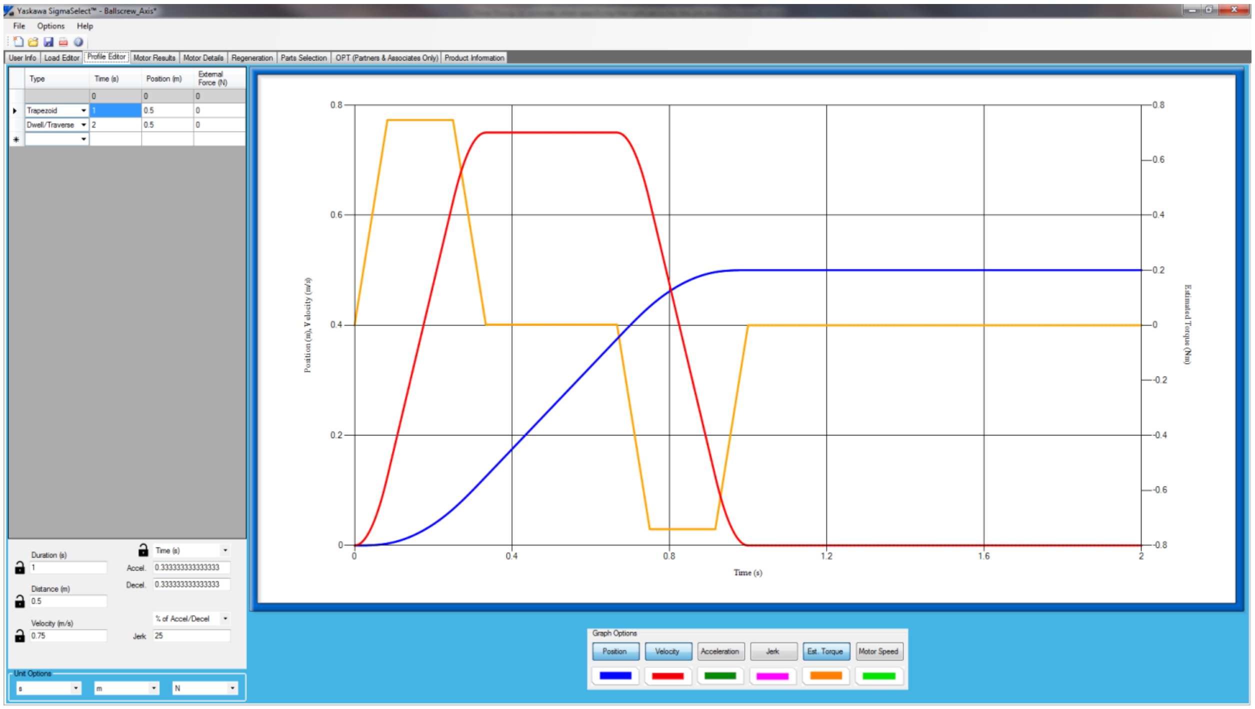


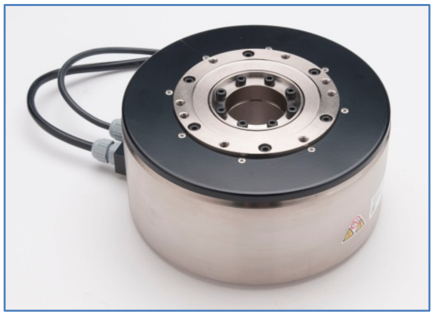
Figure 2: Speed/Torque curve from Yaskawa SigmaSelect servo sizing software plotting position (m) and velocity (m/s) on the vertical axis and time in seconds, horizontally.

The inertia is less intuitive but no less important. Because there is some compliance in the majority of couplings and the mechanical transmissions to which they are connected, it is vital that the reflected inertia of the load is not too large when compared to the motor's rotor inertia.

Tuning becomes increasingly difficult as this ratio rises. As tuning algorithms become more advanced and microprocessors get faster, the allowable ratios have increased, but the traditional 10:1 load-to-motor inertia ratio is always a safe bet.

2. Load Connection

Should the motor be coupled directly or not? There is also a class of servo that allows for the load to be directly mounted onto the rotor of the motor. With this minimal compliance and low acceleration and deceleration rates, inertia ratios of over 100:1 are possible. The sizing software provided by the manufacturer is the best place to manipulate these design criteria to ensure that the system's inertias are within the proper bounds.



Yaskawa direct drive servo motors allow for fewer mechanical components.

3. Regenerative Energy Processing

Another consideration in many applications is the ability for the servo system to handle the regenerative energy created by the motor and the load. This leads to the amplifier section of the servo system. When the motor's torque is applied in one direction but the rotor is moving in the opposite direction, the motor will regenerate energy back to the amplifier. This is because the basic designs of a motor and a generator are the same.

Applying energy to the winding of a motor will create a magnetic field that will cause the rotor with its permanent magnets to rotate. Likewise, when the motor rotor turns, the permanent magnets will induce energy into the windings. This regenerative energy is handled by the drive in many ways. Some smaller drives will use the bus capacitors to absorb this energy while larger drives have an internal resistor through which the energy is dissipated as heat. The sizing software from the manufacturer will typically report the need for regeneration energy processing.

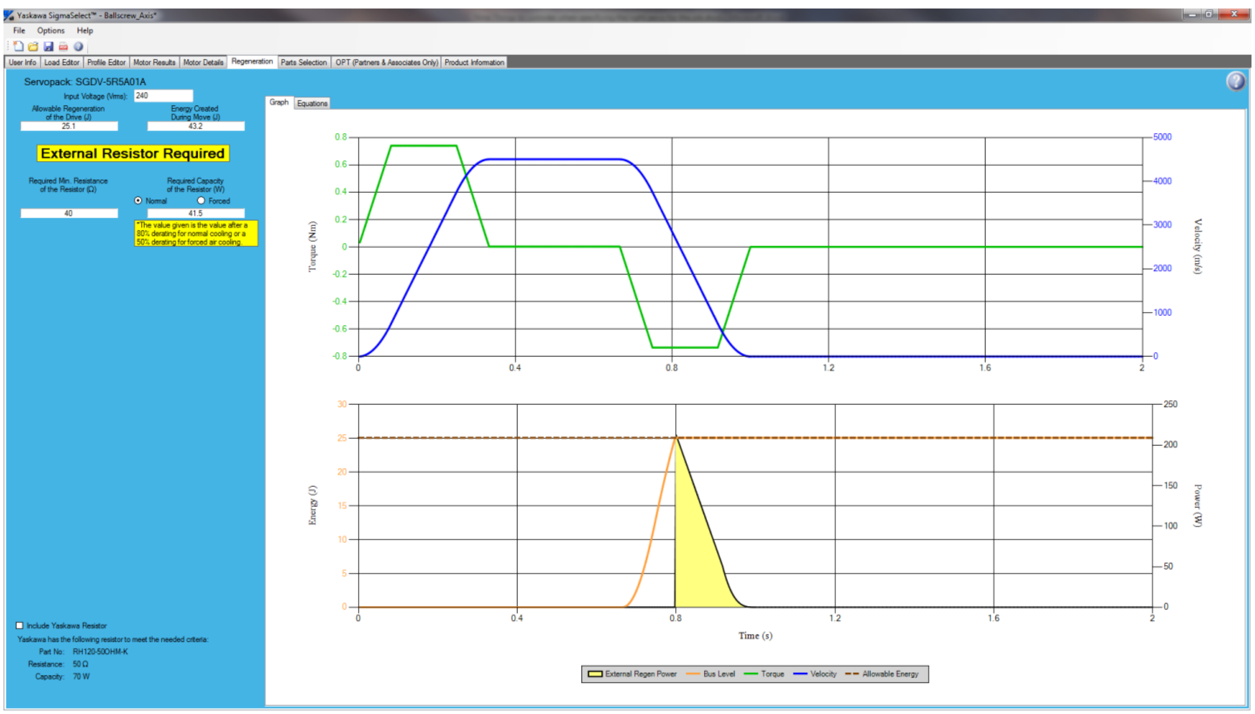


Figure 3: Calculations may show that an external regeneration resistor is required when using the Yaskawa SigmaSelect servo sizing software.

4. Active Line Regeneration

Larger systems have converters that can allow for the energy to be returned to the power line that supplies the power for the system. The amount of regenerative power that the drive can handle is another concern when designing the allowable inertial mismatch between the motor and the load when selecting a servo system.

It is common to connect power resistors external to the amplifier when dealing with excessive regenerative energy applications. These applications are typically vertical where gravity is a factor and when decelerating large inertial loads quickly. Besides the regen capacity, the amplifier obviously needs to be able to provide the right voltage and current for the motor to reach the required speed and torque. Sizing the power requirements for the motor and amplifier is just the beginning.

5. Control System Requirements

Next, the requirements on the control side need to be addressed. Let's start back at the motor. A servo system will always have a feedback device by definition. Today, it is typically a high resolution encoder or a resolver. It is important for the feedback device to have the appropriate resolution for the repeatability and accuracy that match required positioning tolerances. The amplifier also must be compatible with the type of signal coming from the feedback device on the motor.

6. Positioning Resolution

Encoders have traditionally used a pulse train on two channels to transmit the information of position, speed, and direction back to the amplifier. However, since the resolution of these encoders has increased, some manufacturers now use serial encoders that send packets of this information at a high rate instead of a pulse train. These serial encoders can transmit higher resolution signals that are significantly more noise immune and also can provide other types of information. This additional information can include the motor temperature and even the motor part number.

In servo systems where the motor and the amplifier are provided by the same manufacturer, the ability of the feedback device to identify the motor to the amplifier allows it to setup internal parameters for the optimal performance and the protection of the motor automatically.

7. Communication Connectivity

Yaskawa SigmaLogic single-axis motion sequencer with AOI compatibility with Rockwell Control & CompactLogix PLCs

Once there is a matching motor and amplifier that has the power and a feedback device with the necessary resolution for the required application, it's time to consider the command signal between the amplifier and the motion controller. For single-axis applications it is common to have the controller built into or attached to the side of the amplifier. Some of these applications are integrated into a large controls system. A programmable logic controller (PLC) or programmable automation controller (PAC) may be responsible for controlling the entire cell or line and communicating to the single-motion axis via digital input/output (I/O) or a communication protocol, such as EtherNet/IP or ModbusTCP/IP.

8. Control Interface Selection

Yaskawa MP3300iec Machine Controller with MECHATROLINK-III Motion Network can serve up to 32 axes and communicate with various Ethernet devices via OPC, Modbus TCP/IP, EtherNet/IP and/or custom communication interfaces

In a multi-axis application the controller is usually separate. Traditionally, the command signal provided by the controller was a ±10 V signal that either represented a torque or a speed command. Today, most manufacturers provide network-based solutions. These network-based solutions require less wiring, handle higher resolution feedback, and gather more diagnostic information from the amplifier. There are many motion networks available, and each provides their advantages and disadvantages.

9. Motion Control Network Selection

Many of newer networks are based on Ethernet hardware and therefore take advantage of its ever increasing speed and decreasing cost. However, just because there is an RJ-45 connector on the amplifier, it doesn't mean that it is compatible with the associated controller or the rest of the network. The protocols running on those networks define the compatibility. EtherCat, MECHATROLINK-III, and Powerlink are among a few Ethernet-based networks.