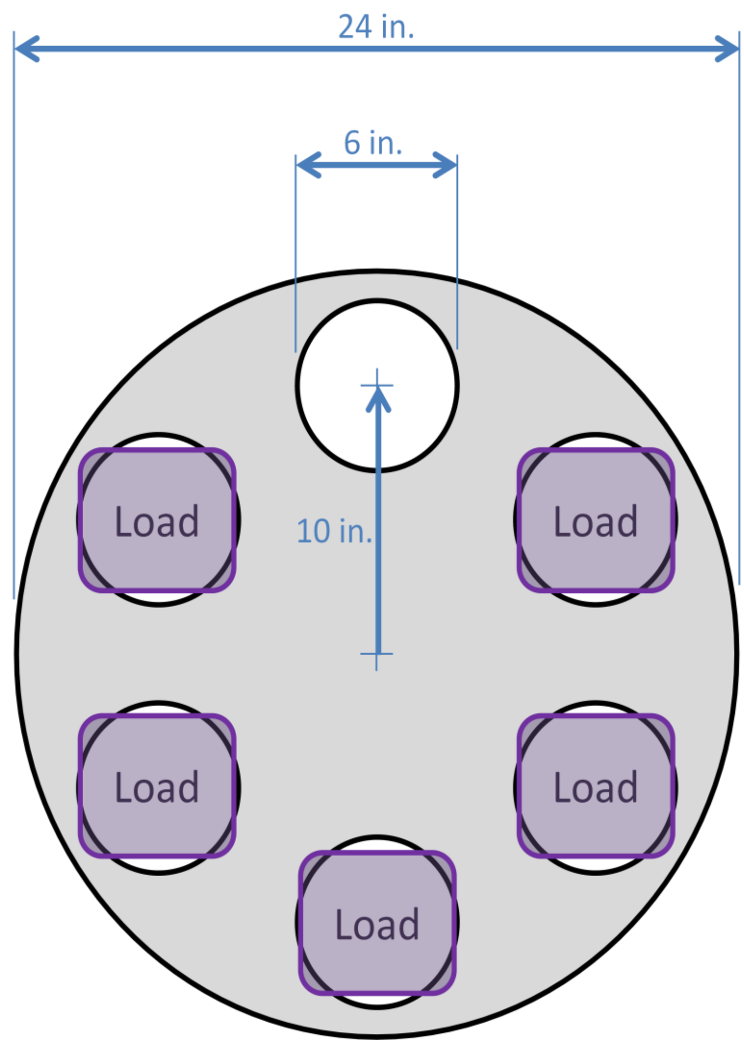
SigmaSelect™ Tutorial

Application: Rotary table

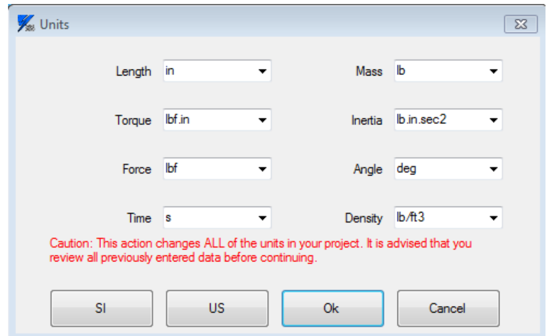
A rotary table is used to move 10 pound parts through a series of machining operations. The base of the table is an aluminum plate that is 24" in diameter and 0.75" thick. There are six holes in the table to hold the parts. These holes are 6" in diameter, and centered at a distance of 10"from the center of the table. During motion, five of these six stations will have a part.



The table will move the load from station to station every six seconds. The move should take no longer than 0.5 seconds.

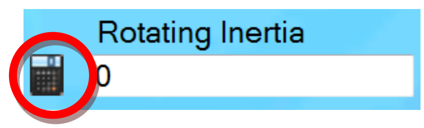
The user would like a direct drive motor and Servopack that runs off of 200VAC three-phase power. Also provide the part numbers for any necessary cables (3m) and regenerative resistors if needed. It will be controlled over Mechatrolink-II using an MP2300Siec controller.

Since the application data is in imperial units, it will be helpful to globally change the units that SigmaSelect uses. You can change the units for each field individually as well, but this step will make it easier. To change the units, go to the Options menu and select the Units option. Then click the “US” button to change to imperial units. Manually change the length unit from feet to inches.



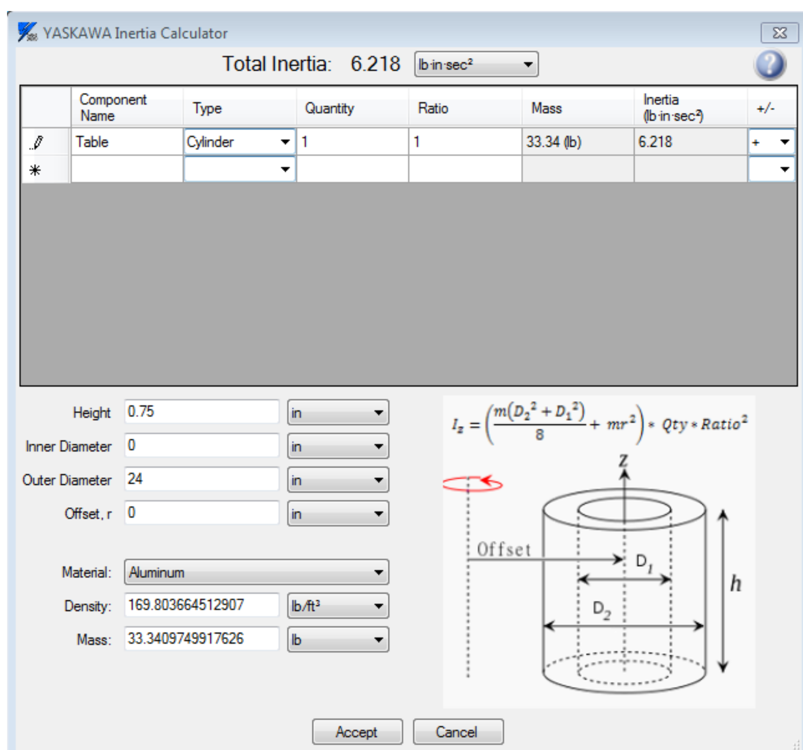
Modeling the mechanics of this system begins with selecting the **Rotation Table** mechanism type in the **Load Editor** tab.

Next, select the **Inertia Calculator** next to the **Rotating Inertia** entry field.

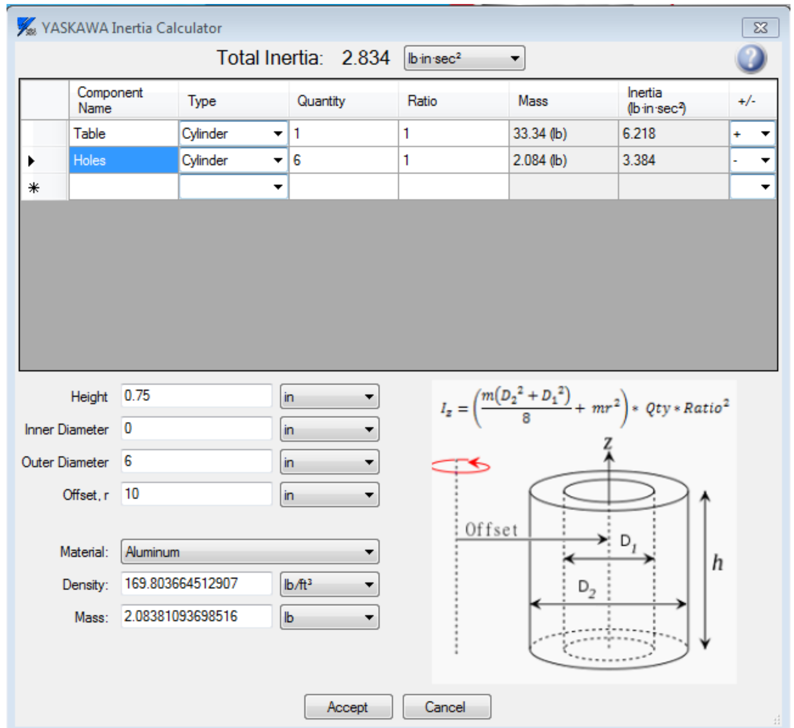


The inertia of the system can be calculated in three parts: The table, the holes, and the loads.

Start with the inertia of the table itself as if it had no holes in it and no parts on it. It is modeled as a solid disc of aluminum, 24” in diameter and 0.75” thick. In the first line of the inertia calculator, set the **Component Name** to “Table” and select “Cylinder” as its **Type**. In the fields at the bottom, fill in the **Height** as 0.75” (the table’s thickness) and the **Outer Diameter** as 24”. Select aluminum as the **Material** and the inertia for that component will be calculated.

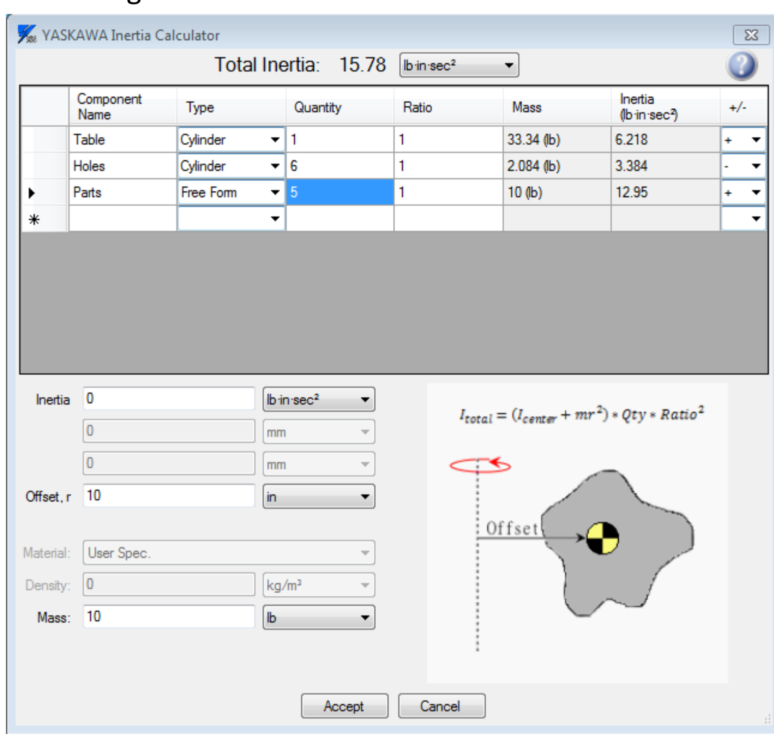


Next, subtract out the holes that are in the table. On the next row of the inertia calculator table, choose a **Component Name** of “Holes” and a **Type** of “Cylinder”. Since there are six holes, change the **Quantity** to 6. Because the inertia of the holes is to be *subtracted* from the inertia of the table, change the **+/-** field to - (minus).



In the fields at the bottom, the **Height** remains 0.75” (since the holes go all the way through the table) and the **Outer Diameter** is 6 inches. Next we must enter an **Offset** since these holes’ centers are not the center of rotation of the table. The offset is the distance from the center of the table to the center of the hole, or 10 inches.

Lastly, we must put in the weight for the parts that are being moved. We don’t have specific information as to the shape of these parts, nor are we given their individual inertias. Therefore they must instead be modeled as point masses (as if it were a single point that weighed ten pounds). In the third row of the inertia calculator, choose a **Component Name** of “Parts” and choose **Type** “Free Form”. Set the **Quantity** to 5 since there are five parts on the table during motion. Make sure that the **+/-** column is set to + for this entry since we are adding this inertia.



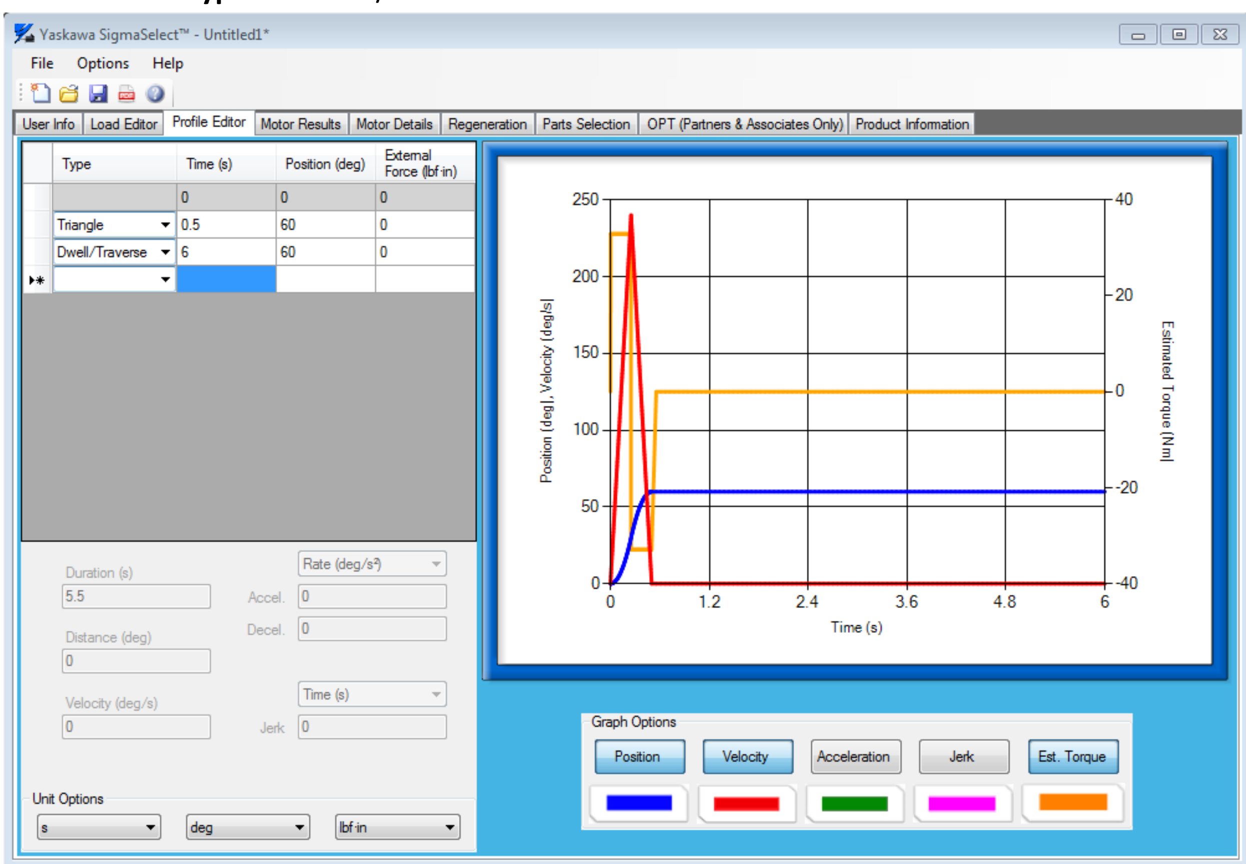
To calculate the inertia of this load, just enter the **Mass** of 10 pounds and the **Offset** of 10” (the center of the hole and presumably the center of the load mass as well). This will calculate the inertia due to the off-centered mass of the parts.

Next we must enter the move data in the **Profile Editor** tab. The specifications say that the move should take no more than 0.5 seconds, and make the move every 6 seconds.

To enter the move, first select the move **Type** of "Triangle". A triangular profile will have the slowest acceleration rates and therefore use less torque than a trapezoidal move, so they're often a good place to start when you're given limited move information. Enter a move **Time** of 0.5 s and a **Position** of 60 degrees (six stations on a 360° table is 60° between stations).

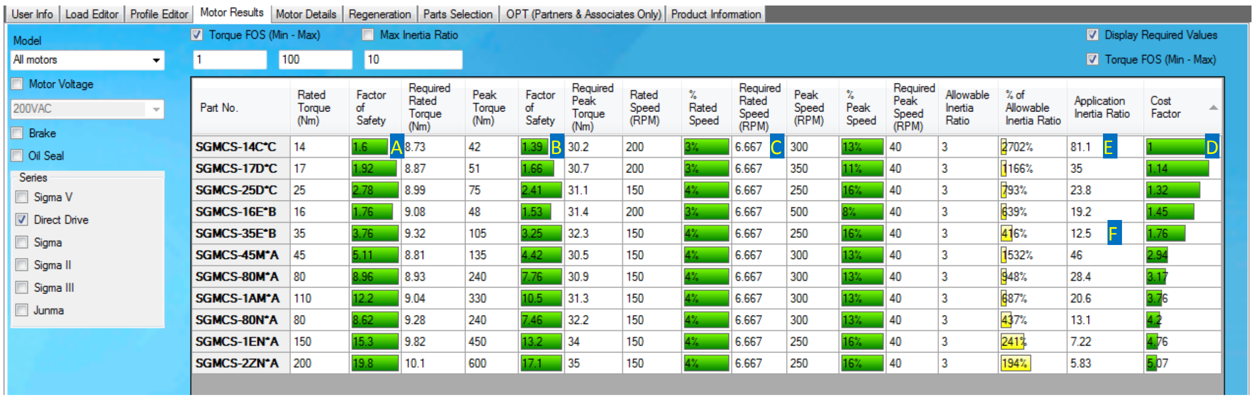
	Type	Time (s)	Position (deg)	External Force (lbf·in)
		0	0	0
	Triangle	0.5	60	0
▸*				

Next we must enter the dwell time for the move. Since we make a move every six seconds, and the move takes 0.5 seconds, it stands to reason that the dwell time is 5.5 seconds. The time entry in the profile editor is cumulative, however, so the correct way to enter the move profile is to choose a **Type** of "Dwell/Traverse" and a **Time** of 6 seconds.



Next, go to the **Motor Results** tab and analyze the data to choose the best motor. First, choose the “Direct Drive” option and uncheck the “Sigma-5” option. This will show all of the Direct Drive motors that have enough torque and speed capability for the application. There are other factors to consider, however, so analyze the data carefully to find the right motor for the application.

One important factor is cost, so sort the list of motors by their **Cost Factor**. Do this by clicking on the heading **Cost Factor**. This will display the relative costs of the motor/drive combination with the least expensive option given a value of 1. For example, a motor with a cost factor of 1.76 will cost 76% more than the cheapest option.

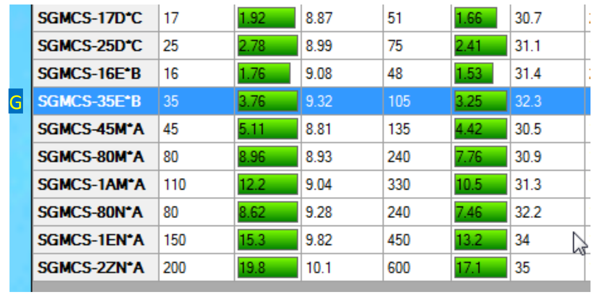


Part No.	Rated Torque (Nm)	Factor of Safety	Required Rated Torque (Nm)	Peak Torque (Nm)	Factor of Safety	Required Peak Torque (Nm)	Rated Speed (RPM)	% Rated Speed	Required Rated Speed (RPM)	Peak Speed (RPM)	% Peak Speed	Required Peak Speed (RPM)	Allowable Inertia Ratio	% of Allowable Inertia Ratio	Application Inertia Ratio	Cost Factor
SGMCS-14C*C	14	1.6 A	8.73	42	1.39 B	30.2	200	3%	6.667 C	300	13%	40	3	2702%	81.1 E	1 D
SGMCS-17D*C	17	1.92	8.87	51	1.66	30.7	200	3%	6.667	350	11%	40	3	1166%	35	1.14
SGMCS-25D*C	25	2.78	8.99	75	2.41	31.1	150	4%	6.667	250	16%	40	3	793%	23.8	1.32
SGMCS-16E*B	16	1.76	9.08	48	1.53	31.4	200	3%	6.667	500	8%	40	3	639%	19.2	1.45
SGMCS-35E*B	35	3.76	9.32	105	3.25	32.3	150	4%	6.667	250	16%	40	3	416%	12.5 F	1.76
SGMCS-45M*A	45	5.11	8.81	135	4.42	30.5	150	4%	6.667	300	13%	40	3	1532%	46	2.94
SGMCS-80M*A	80	8.96	8.93	240	7.76	30.9	150	4%	6.667	300	13%	40	3	948%	28.4	3.17
SGMCS-1AM*A	110	12.2	9.04	330	10.5	31.3	150	4%	6.667	300	13%	40	3	687%	20.6	3.76
SGMCS-80N*A	80	8.62	9.28	240	7.46	32.2	150	4%	6.667	300	13%	40	3	437%	13.1	4.2
SGMCS-1EN*A	150	15.3	9.82	450	13.2	34	150	4%	6.667	250	16%	40	3	241%	7.22	4.76
SGMCS-2ZN*A	200	19.8	10.1	600	17.1	35	150	4%	6.667	250	16%	40	3	194%	5.83	5.07

Initially, it looks like the SGMCS-14C*C motor is a good option. It’s got plenty of **Rated Torque** (1.6 times as much as it needs - see A), plenty of **Peak Torque** (1.39 times as much as it needs - B), and plenty of **Peak Speed** overhead (only 6.667rpm is required, and this motor is capable of 300rpm - C). It is also the cheapest of the direct drive options (D). However, there is one major problem with this motor: The **Application Inertia Ratio** of 81.1:1 is very high. This means that the load inertia is 81.1 times the inertia of the motor’s rotor (E). A high inertia ratio leads to difficulties in tuning and control, and is ideally as close to 1:1 as possible. An inertia ratio of 10:1 is a general rule of thumb for controllability, but this depends on a lot of factors. Since this load will presumably be directly coupled to the motor, and because the move is relatively slow, a slightly higher gear ratio is possible. Based on this information, the SGMCS-35E*B (12.5:1 inertia ratio - F) is a better choice.

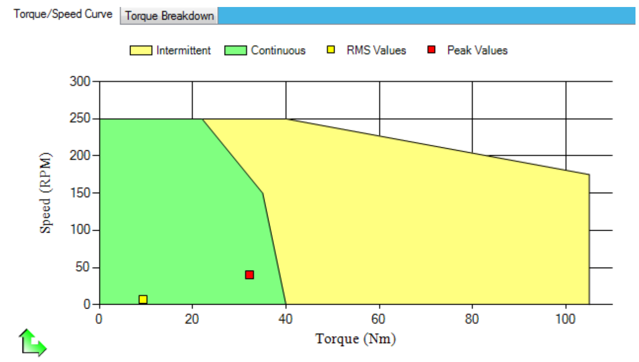
There is often confusion about the specification of **Allowable Inertia Ratio**. This specification indicates the maximum load *only* if you’re decelerating at Peak Torque from Rated Speed. It is important to make sure that the capacity of the dynamic braking resistor is not exceeded. Since this application is running well below the rated torque and at a very slow speed, it is acceptable to run at an inertia ratio above the **Allowable Inertia Ratio** specification.

To view motor details, select the motor (SGMCS-35E*B) by clicking on the motor In the **Part No.** column (G), and then select the **Motor Details** tab. (You can also select multiple motors by holding the Ctrl key when you select the motors.)

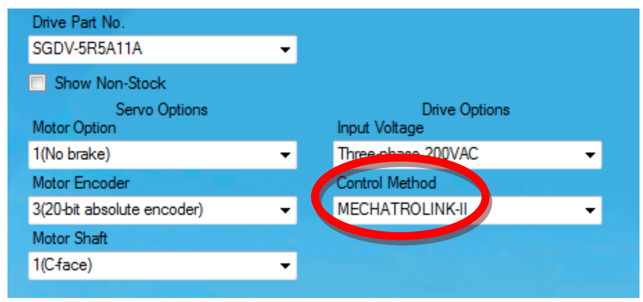


SGMCS-17D*C	17	1.92	8.87	51	1.66	30.7
SGMCS-25D*C	25	2.78	8.99	75	2.41	31.1
SGMCS-16E*B	16	1.76	9.08	48	1.53	31.4
SGMCS-35E*B	35	3.76	9.32	105	3.25	32.3
SGMCS-45M*A	45	5.11	8.81	135	4.42	30.5
SGMCS-80M*A	80	8.96	8.93	240	7.76	30.9
SGMCS-1AM*A	110	12.2	9.04	330	10.5	31.3
SGMCS-80N*A	80	8.62	9.28	240	7.46	32.2
SGMCS-1EN*A	150	15.3	9.82	450	13.2	34
SGMCS-2ZN*A	200	19.8	10.1	600	17.1	35

The **Motor Details** tab shows the RMS and peak values and where they fall on the speed/torque curve for the selected motor. The yellow "RMS Values" dot should fall in the continuous region of the speed/torque curve. The red "Peak Values" dot can be in either the continuous or the intermittent region of the curve.

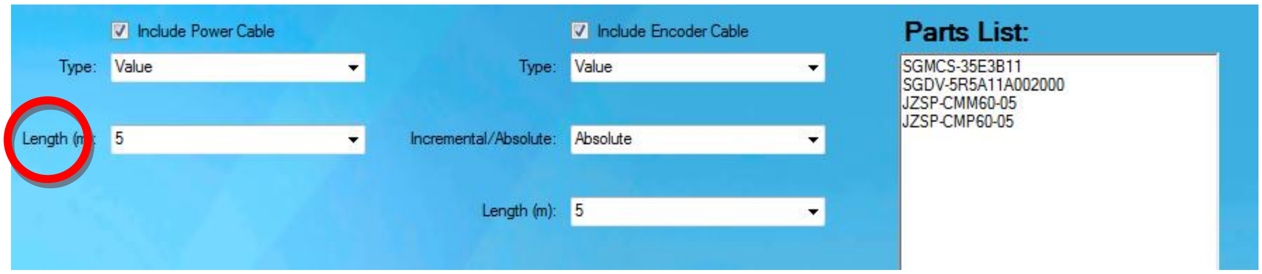


If the motor fits the needs of the application, finalize the motor and Servopack part numbers by selecting the appropriate **Servo Options** and **Drive Options**. In our case, we have to select the **Control Method** of "MECHATROLINK-II".



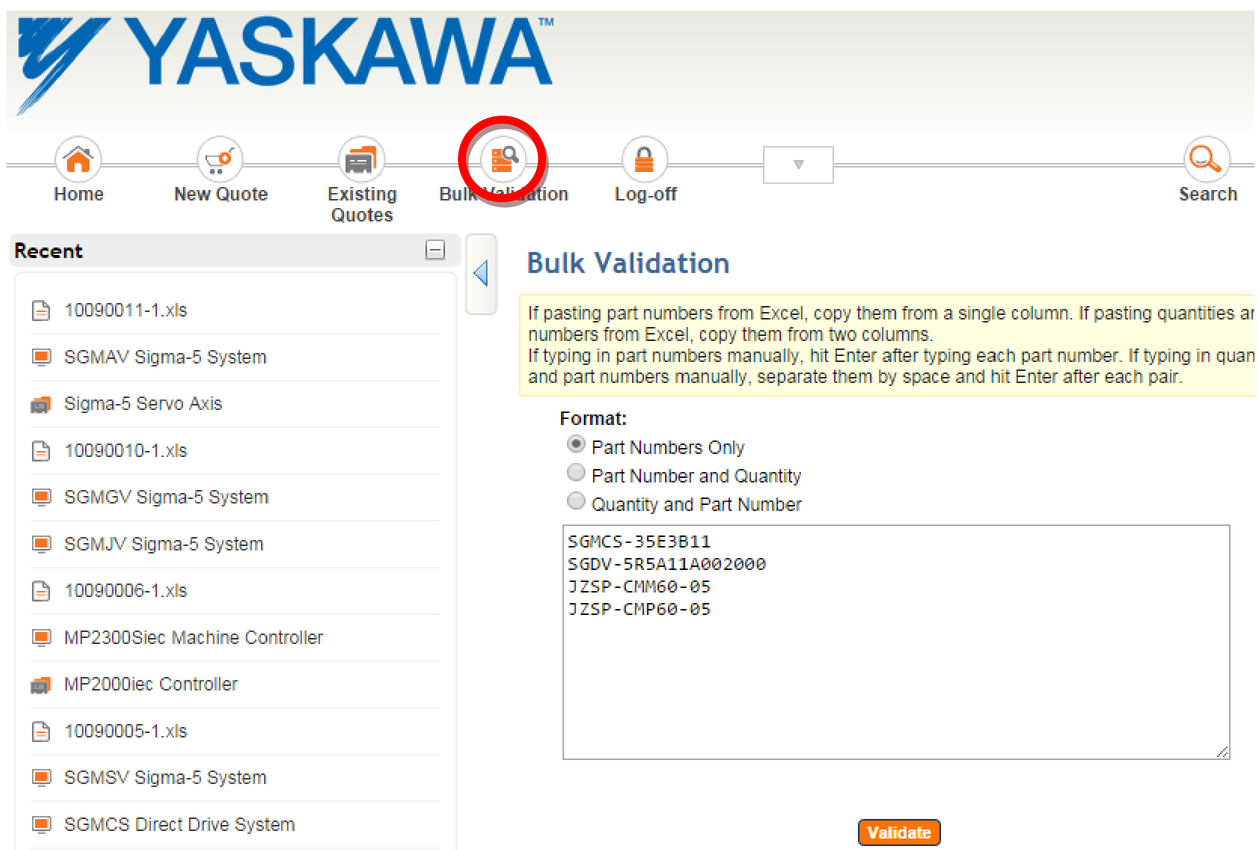
The **Regeneration** tab will show you if any external regeneration resistors are required. In this application, the drive has more than enough built-in capacity, so no external regeneration is needed.

The **Parts Selection** tab is used to select the cables for this application. Change the **Length** to "5" meters as required by the customer and the part numbers will be generated. The parts list on the right will show the full part numbers for the motor, Servopack, and cables.



The items in the parts list can be copied for use in Yaskawa's Online Pricing Tool (OPT), found in the OPT tab. This tool is available only to Yaskawa associates and approved partners. Contact your sales representative for more information.

In OPT, use the Bulk Validation option and paste in the part numbers generated on the "Parts Selection" tab. This will show pricing information for the parts and generate a quote if required.



Finally, it is possible to create a PDF file with all of the information used in the sizing so that it can be presented to the customer or preserved for future reference. To generate the PDF report, click the PDF icon in the toolbar.