Using Motion Analyzer

Allen-Bradley • Rockwell Software Rockwell Automation

Using Motion Analyzer: Hands-On Lab

Training Lab Manual

Using Motion Analyzer

About This Hands-On Lab

This lab introduces you to Rockwell Automation's motion sizing and system analysis software, Motion Analyzer. The software allows you to enter information about the moving axes of your machine (the load and the actuator that is moving it) as well as your required move or cycle profile in order to select the appropriate servo motor and drive combination. Motion Analyzer additionally allows machine designers to optimize their machine design using advanced analysis tools.

You will enter the information for (3) common types of mechanical actuators and search for a valid motor and drive combination for each. The following sections explain what you'll be doing in this lab session, and what you will need to do to complete the hands-on exercises.

What You Will Accomplish In This Lab

As you complete the exercises in this hands-on session, you will:

- Learn how to use Motion Analyzer software
- Learn what type of information is required by the software
- Gain exposure to the advanced analysis and optimization tools in Motion Analyzer

Who Should Complete This Lab

This hands-on lab is intended for individuals who:

- Would like to learn more about sizing motion systems
- Would like to learn more about using Motion Analyzer software

Lab Materials

For this Hands-On lab, we have provided you with the following materials that will allow you to complete the labs in this workbook.

Hardware

This hands-on lab uses no hardware.

Software

This hands-on lab uses the following software:

- Motion Analyzer V4.4 (available for download at www.ab.com/motion)

Lab Files

- This hands-on lab requires no additional files.
- A "Motion Application Data Checklist" document is provided for reference. Print this file to gather the required information for each axis of motion and use it when working with Motion Analyzer on your next motion system.

Document Conventions

Throughout this workbook, we have used the following conventions to help guide you through the lab materials.

This style or symbol:	Indicates:
Words shown in bold italics (e.g., ***RSLogix 5000*** or ***OK***)	Any item or button that you must click on, or a menu name from which you must choose an option or command. This will be an actual name of an item that you see on your screen or in an example.
Words shown in bold italics, enclosed in single quotes (e.g., *'Controller1'*)	An item that you must type in the specified field. This is information that you must supply based on your application (e.g., a variable). **Note:** When you type the text in the field, remember that you do not need to type the quotes; simply type the words that are contained within them (e.g., Controller1).
	The text that appears inside of this gray box is supplemental information regarding the lab materials, but not information that is required reading in order for you to complete the lab exercises. The text that follows this symbol may provide you with helpful hints that can make it easier for you to use this product. Most often, authors use this "Tip Text" style for important information they want their students to see.

Note: If the mouse button is not specified in the text, you should click on the left mouse button.

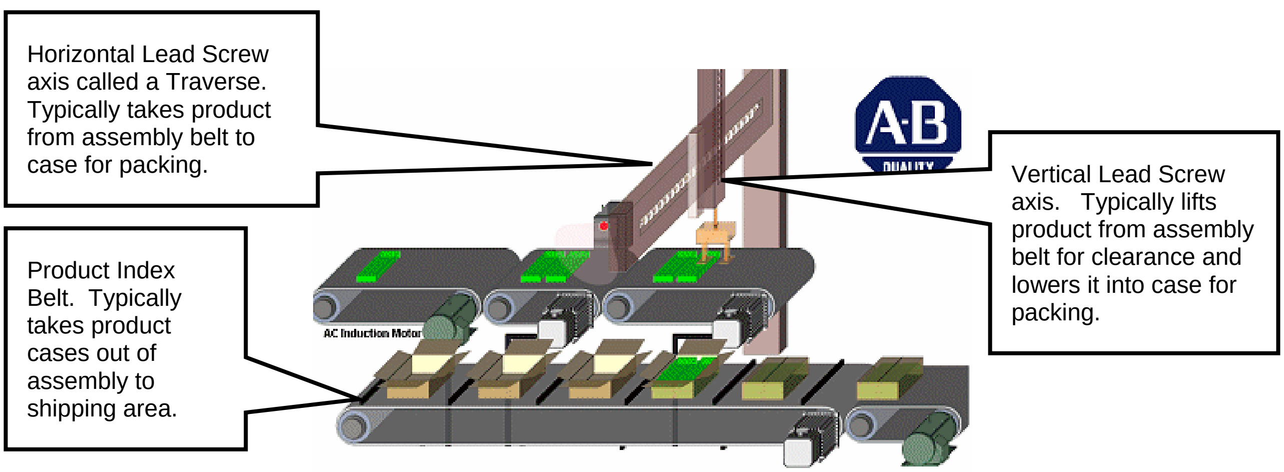


Fig.1 Typical Pick and Place Machine

Lab 1: Sizing a Belt Driven Actuator (20 minutes)

This lab session addresses the sizing and selection of (3) different axes of motion:

- A belt driven indexing conveyor
- A horizontal lead screw actuator
- A vertical lead screw actuator

A Pick and Place machine example (see Fig. 1) will be the source of data for each of the labs. Pick and Place machines are used in the consumer products industry for a wide variety of product transfer applications. The machine typically takes a product or products from machines such as wrappers, cartoners or fillers, and places them into a case, which then is ready for palletizing or shipment.

About This Lab

In this lab, you will use Motion Analyzer to select a servo motor and drive for the Pick and Place machine's Product Index Belt. You will:

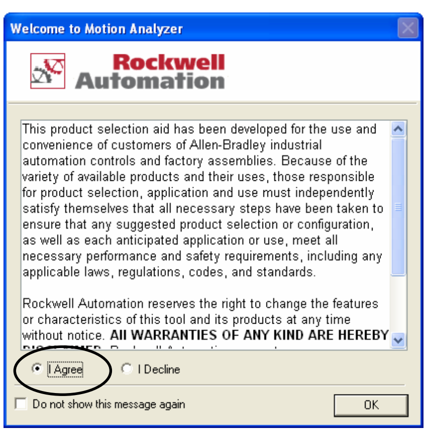
- Learn how to navigate in Motion Analyzer software
- Setup Motion Analyzer's default values to suit your needs
- Create a new application
- Enter the required data for the Product Index Belt application

Follow the steps below to complete Lab Section 1.

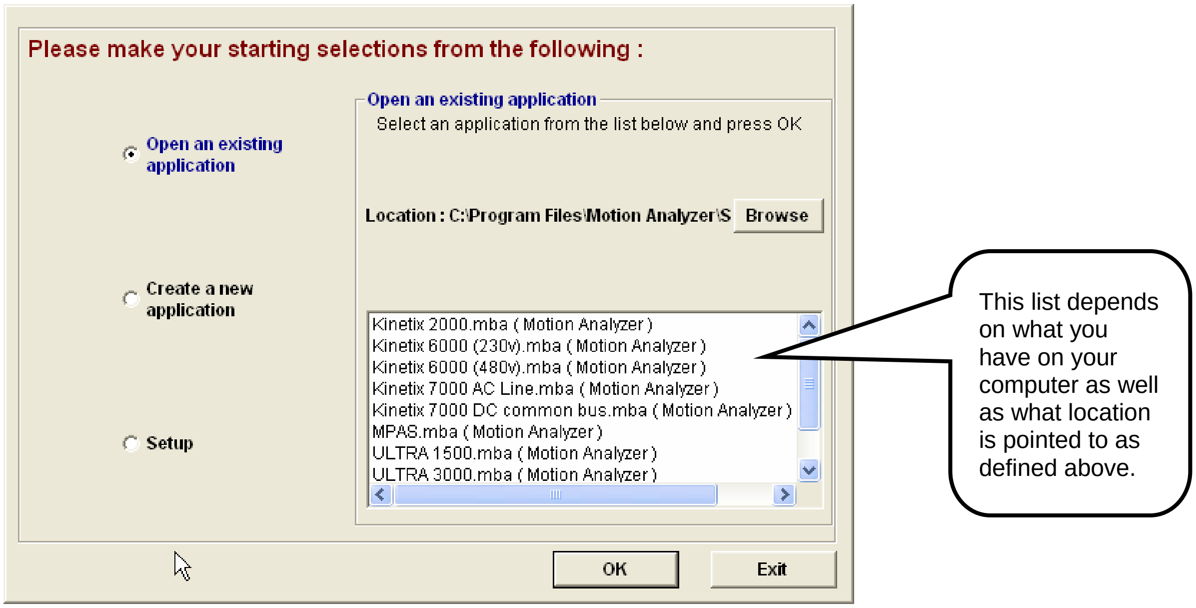
Navigation in Motion Analyzer Software

1. **Open Motion Analyzer** sizing software by double-clicking on the shortcut in the upper right corner of the desktop.

2. After reading the terms, select **I Agree** and press the **OK** button.



3. A selection screen will open:

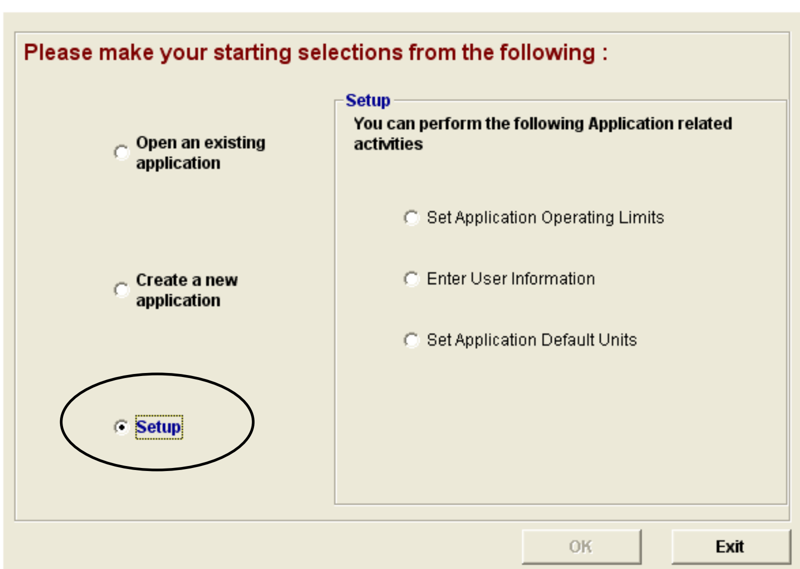


4. Your choices are defined as follows:

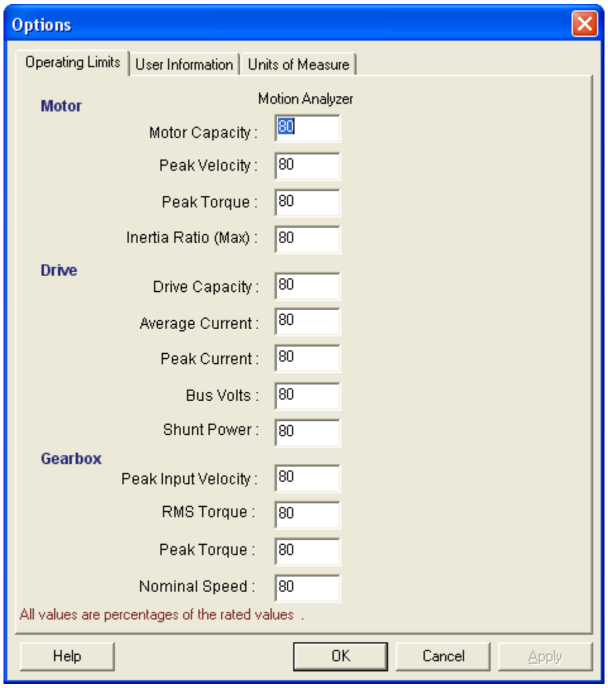
- **Open an existing application** – Open any file created in the listed directory. Note: You will see the listing of any file created in the default directory. To look into another directory simply use the **browse** function.
- **Create a new application** – Start a new Motion Analyzer file.
- **Setup** – For the new application file, change the user information, units of measurement and operating limits.

Setting up User Defaults

5. Click on the **Setup** button and notice that there are (3) selections available.



6. Select **Set Application Operating Limits.**

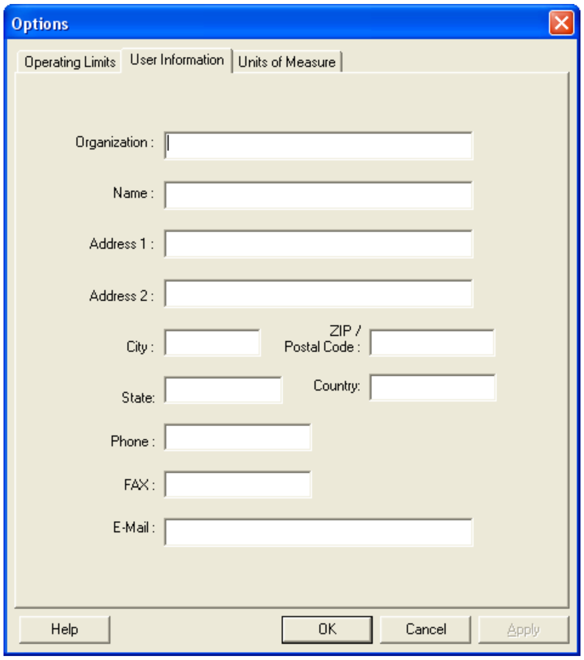


The automatic selection process is affected by the limits entered in this table. Each of the motor/amplifier/gearbox variables listed in the table is a *percentage of the rated values* listed. The idea here is to choose operating limits based on the reliability of the data that is entered. Think of this page or table as a *safety factor* when selecting a combination. Keep the numbers as shown.

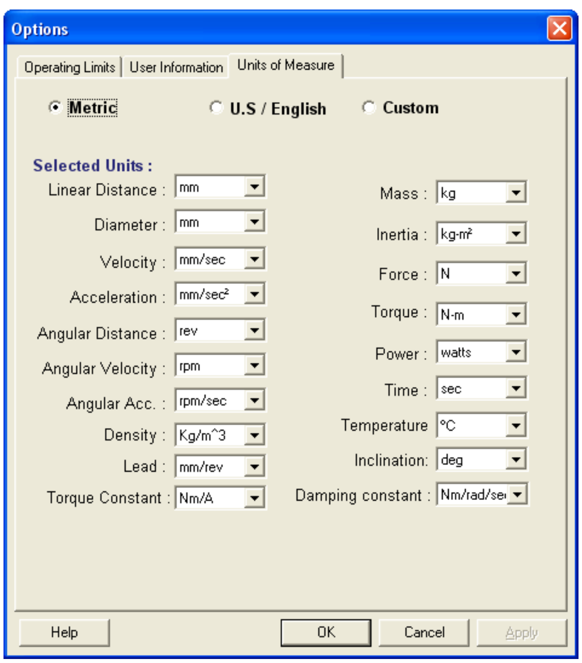
If entered data (load, transmission, profile and environment information) is absolutely reliable, these limits *could* all be set to 100% utilization but we all know that some information may not be totally accurate or we may encounter some unknowns during the implementation of the application.

- "Peak Velocity" and "Bus Volts" are the most easily defined so keep these numbers at 90% or higher.
- "Peak Torque", "Peak Current" and "Average Current" are less reliable so keep these numbers at 80%.
- "Winding Temperature" is the most sensitive to errors so 80 % would be normal.

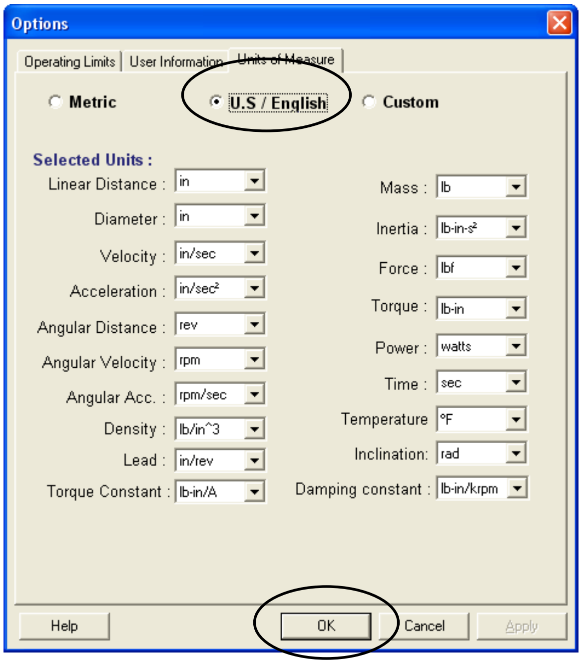
7. Select the **User Information** tab. Your information may be entered here so that your name, email, phone number and company name will automatically appear on any reports. If you are preparing this system for another user (your customer, for instance), another screen will prompt you for their information when a system report is generated.



8. Select the **Units of Measure** tab.

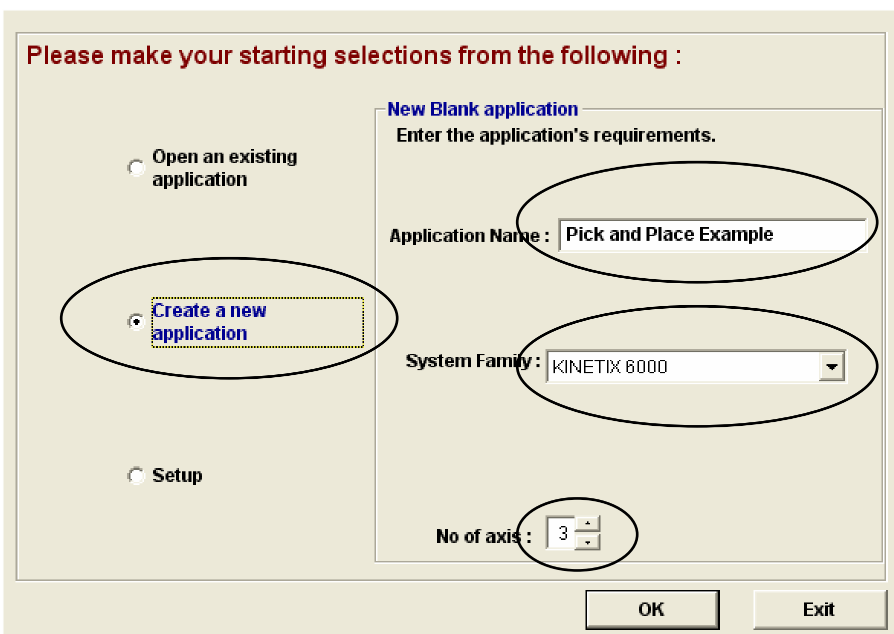


9. Change the default units to **U.S./English** and select **OK** to save and exit.

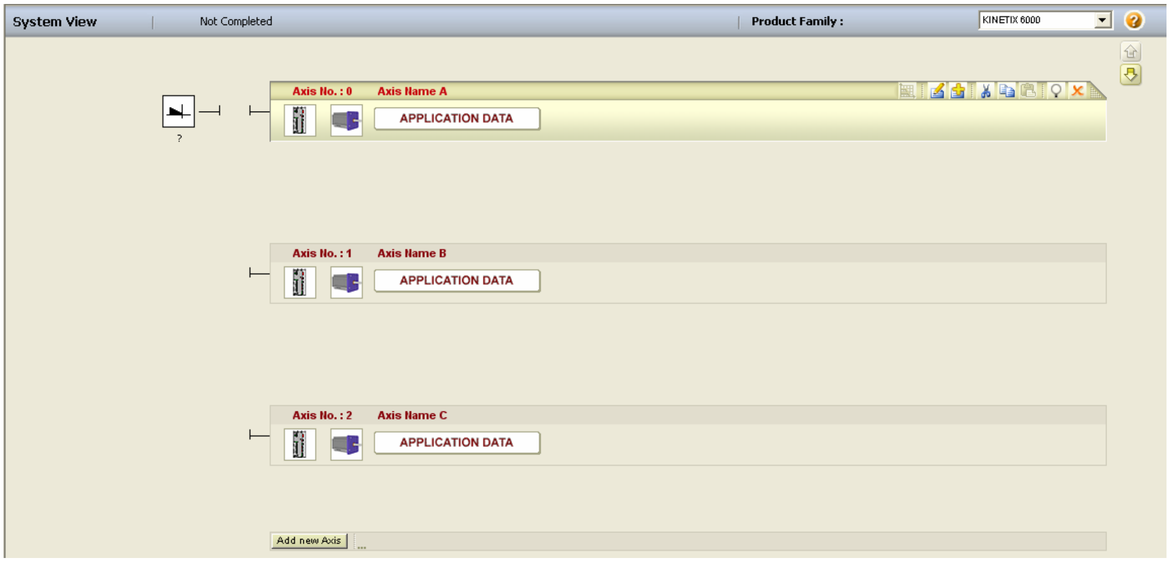


Creating an New Application

10. Select the **Create a new application** radio button. Enter "**Pick and Place Example**" for the Application Name, **Kinetix 6000** for the System Family and increment the No. of Axis to "**3**." Select **OK**.

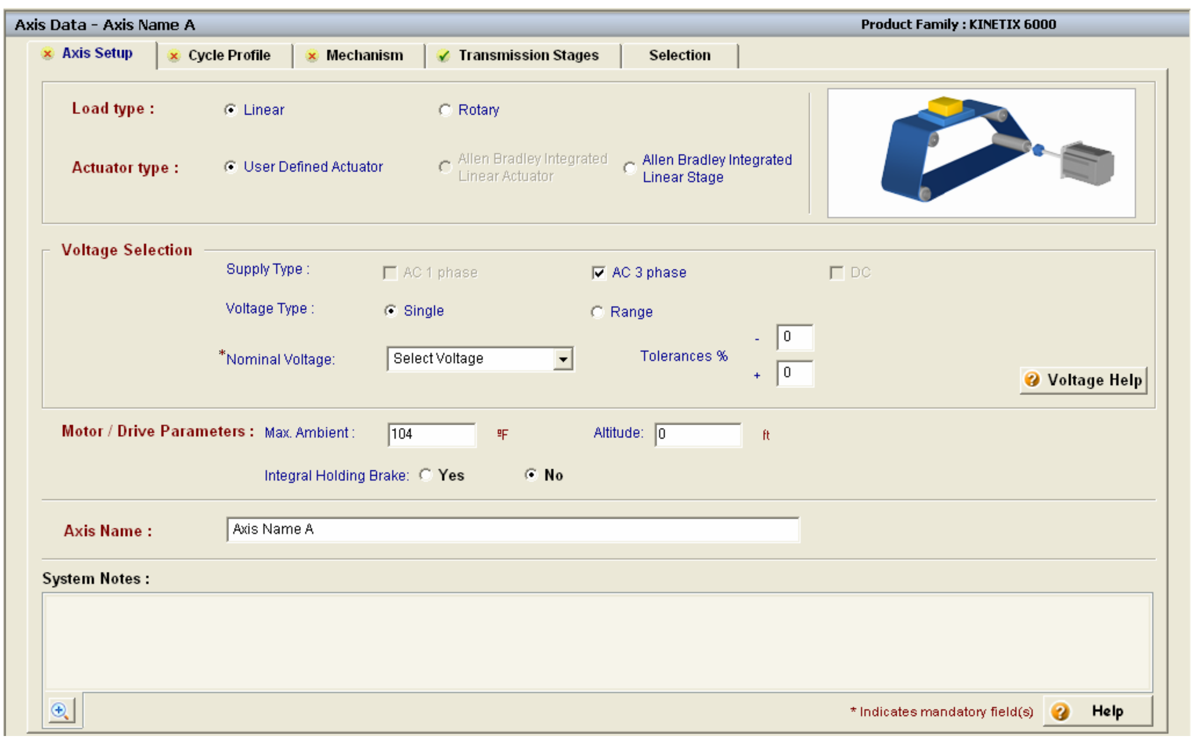


11. The **System View** screen displays our (3) axis system. At this point, minimal information is shown. As we proceed with our sizing exercise, additional information will populate this screen. At the end of the sizing exercise, information such as motor and drive part numbers, actuator types, etc. will be viewable from this screen.



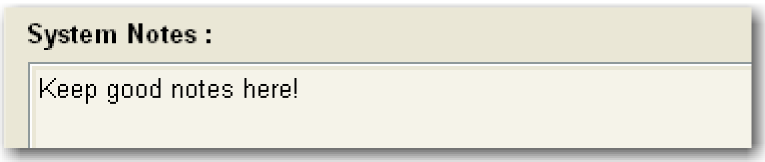
12. To begin entering data for an axis, click on the **Application Data** button.

13. The **Axis Data** page displays basic setup options for the axis.



On this page, you choose whether your axis is linear or rotary, and whether the axis is built from user-provided components or one of Rockwell Automation's MP-Series Integrated Linear Actuators or Stages. The voltage (or range of voltages) that will be provided to the drives is defined here, and you can enter a typical ambient temperature or altitude for the motor's operating environment. If your axis requires a (factory only) holding brake, you can make this selection here. Finally, this is where you can give the axis a meaningful name.

14. At the bottom of the screen, click on the area marked **System Notes**. This is where you can enter important information about the system, or keep track of assumptions that were made in the sizing process. This data will be printed on the system report and it will remind you that these assumptions need verified. It is not uncommon to have missing data during this process.



15. Let's get started entering information about the belt indexer axis.

There are (7) steps to sizing a motion application in Motion Analyzer. They are:

(1) Determine application **preferences**

(2) Specify the machine's **cycle profile,** or worst case move

(3) Specify **load type**

(4) Specify **actuator type**

(5) Specify **transmission stage(s)**

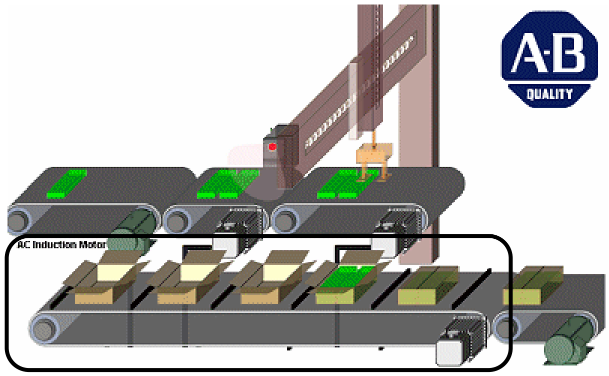
(6) Search for a suitable **motor/drive combination** for the application

(7) Select **shunt** (if required) and system module (for Kinetix 2000/6000 drives)

Let's follow the (7) steps outlined above to enter our application data.

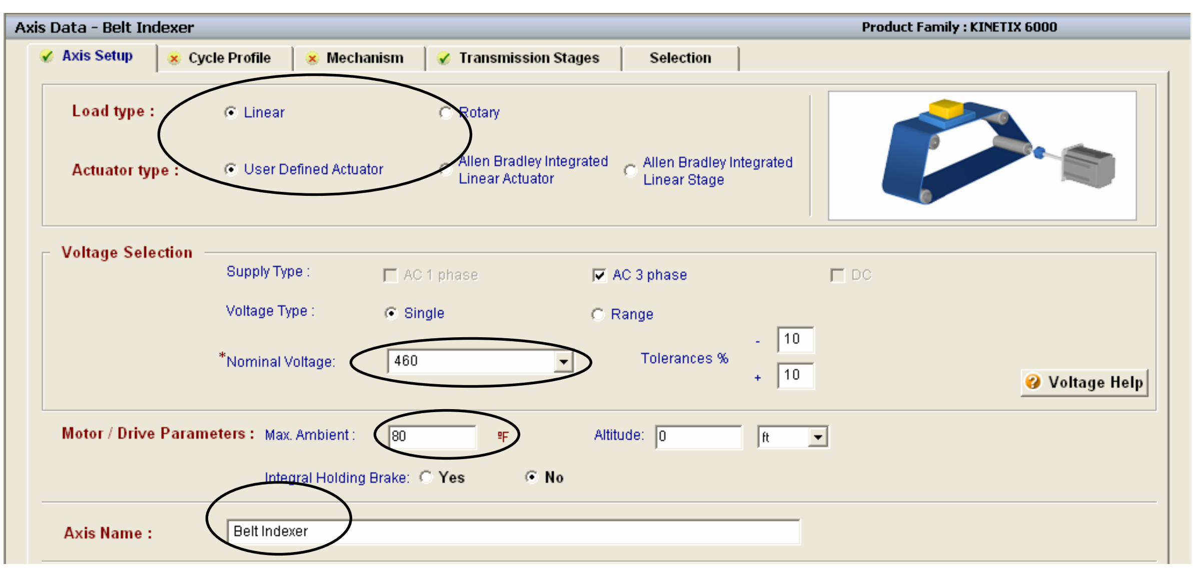
Entering the Belt Indexer Information

16. Here is the data that was provided for the **belt indexer** axis:



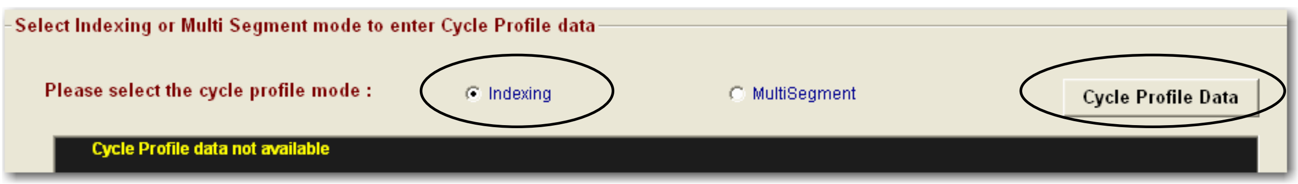
- Package weight (i.e. total weight on belt at any one time) = **5lbs.**
- Belt Actuator:
  - Belt Weight = 3 lbs.
- Drive Rolls, Quantity (2):
  - 4" diameter
  - 24" long
  - Rolled Steel
- Motor Coupling Moment of Inertia = 2.6g-cm^2
- Move 10" in 1 sec. and dwell for 1 sec.

17. Fill out the **Axis Setup** data for the Belt Indexer as shown below. Our plant has **460Vac** and the system operates in an **80 degree** (F) environment.

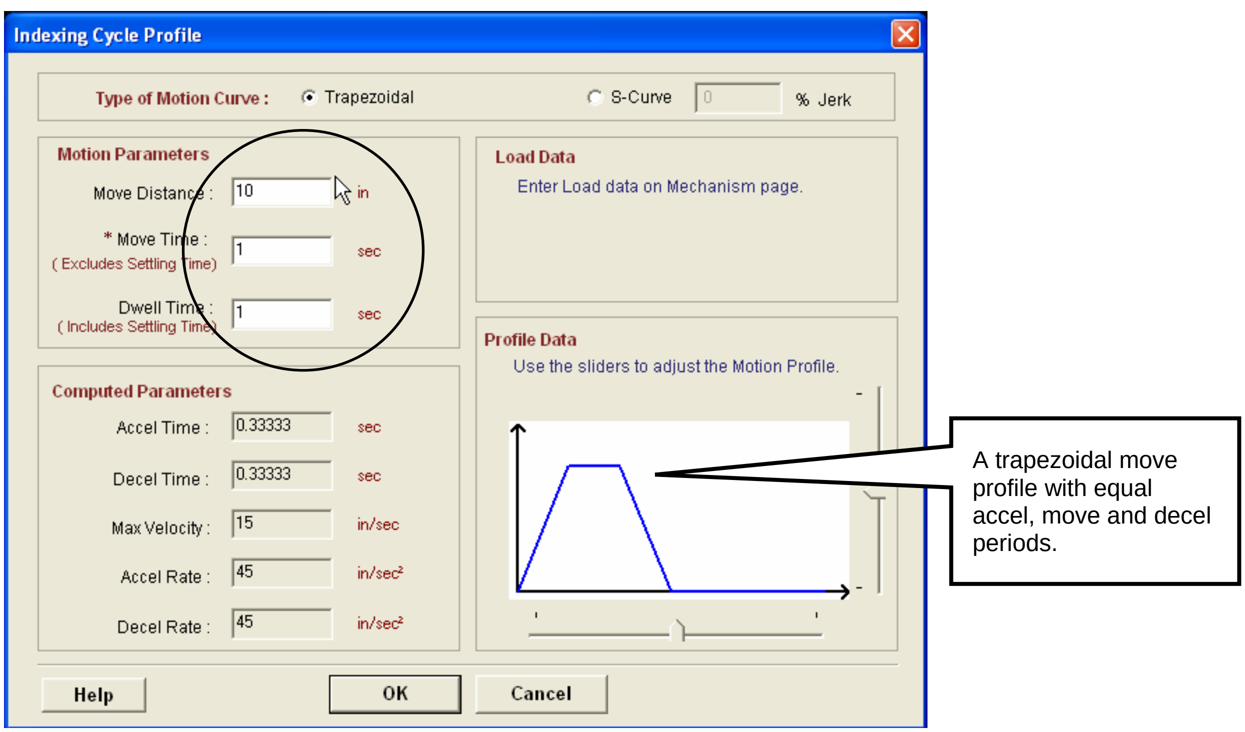


18. The tabs across the top lead you through entering the required data. The *green check mark* means that you have completed a tab and the *red "x"* indicates that more data is needed. Move on to the **Cycle Profile** tab.

19. Our required cycle profile is a simple point to point move (move 10" in 1 sec. and dwell for 1 sec), so we are going to use the **Indexing** move profile. If the profile had more moves, changes in speeds or changes in loads/forces, we would need to use the MultiSegment entry. Click on the **Cycle Profile Data** button.

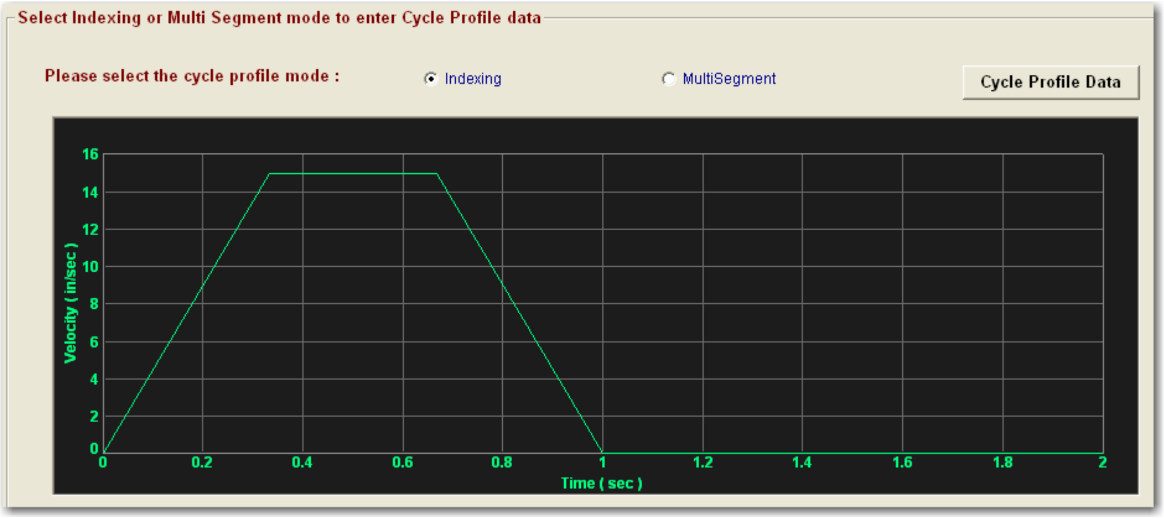


20. Simply enter the **cycle values** as provided. We could have entered the Load Data here, but there is a better place on the Mechanism tab for this information. We assume a **trapezoidal** move profile with equal acceleration, move and deceleration times (the 1/3 rule). Notice how the **accel** and **decel** values have been calculated for you, as well as the **maximum velocity** required to achieve our move profile. Press **OK** when complete.

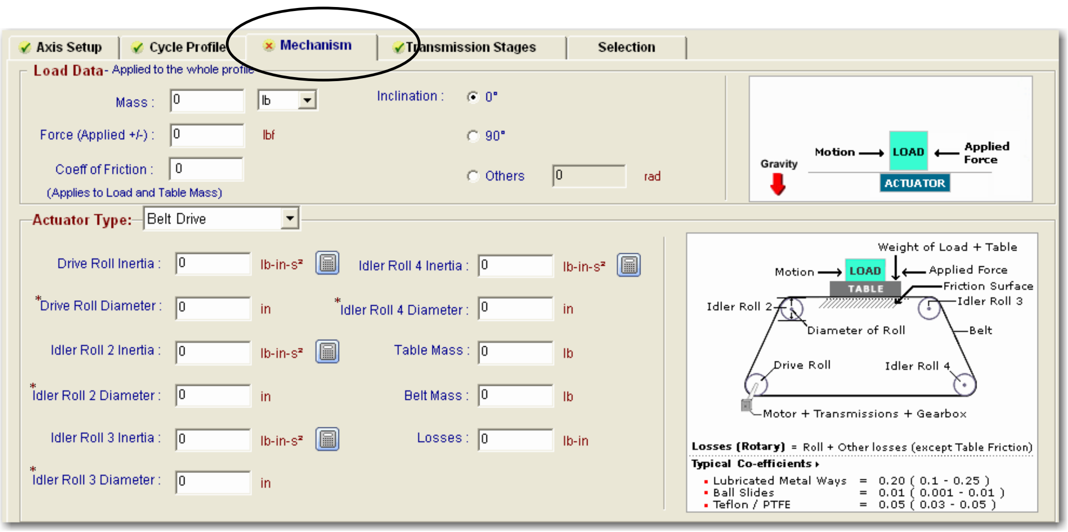


It is important to include your *dwell* time in the cycle profile, because the software assumes that the move is performed over and over with no stopping. The dwell tells the software to factor in resting periods for the thermal modeling of the motor and drive. You may end up with a motor and drive larger than you need if you omit this dwell period.

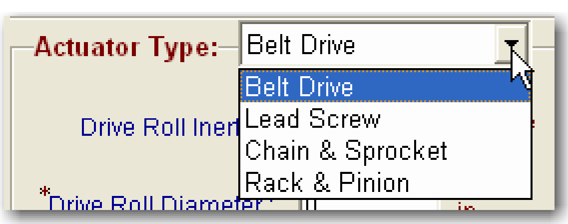
21. The **cycle profile** should appear as shown.

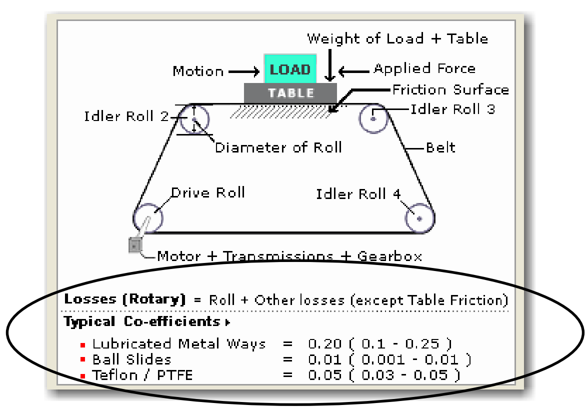


22. Click on the **Mechanism** tab to continue.

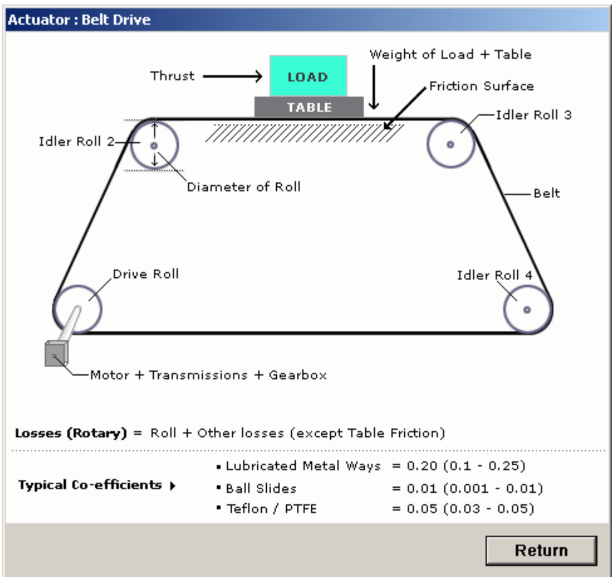


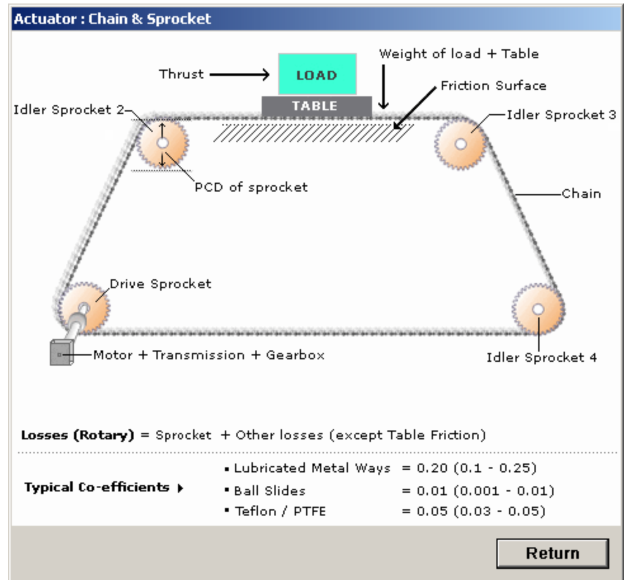
23. This tab includes extremely helpful diagrams of the different types of actuators supported by Motion Analyzer. The actuators are selected from the pull down menu for **Actuator Type.** Notice how the input parameters and the diagram change for each type of actuator. Helpful values for terms like *coefficient of friction* are included as well.

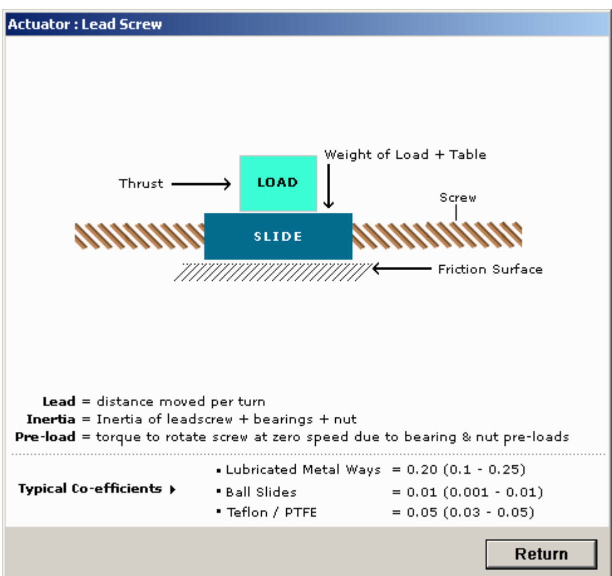


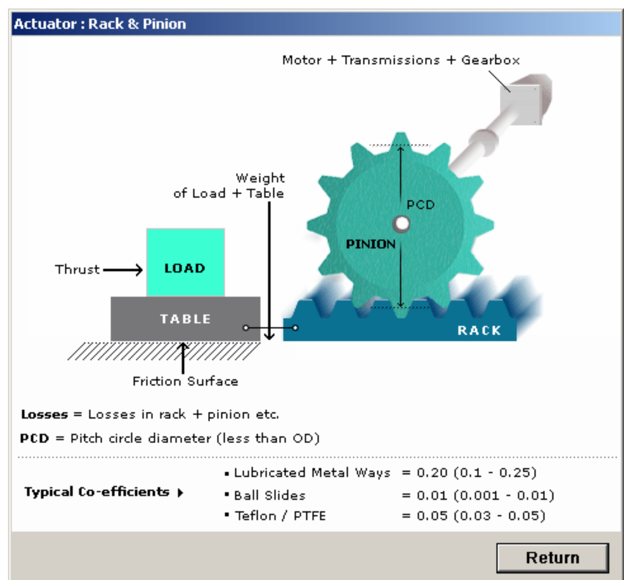


We have **(4) Actuator Types**; Belt Drive, Lead Screw, Chain & Sprocket, and Rack & Pinion. The four actuator diagrams are as follows:



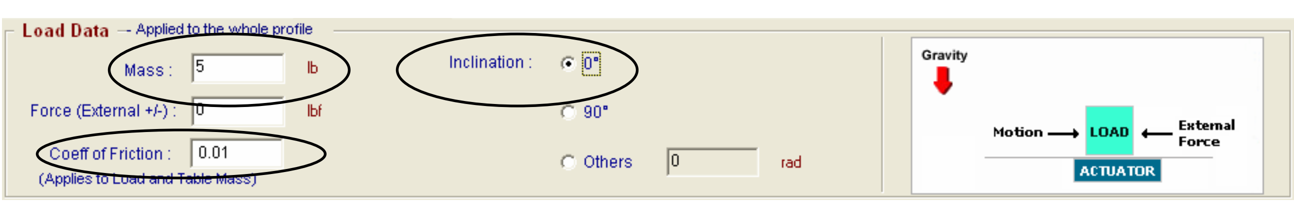




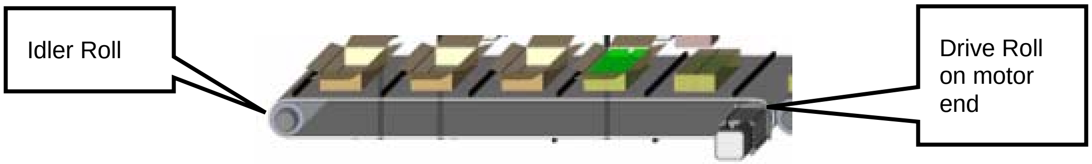


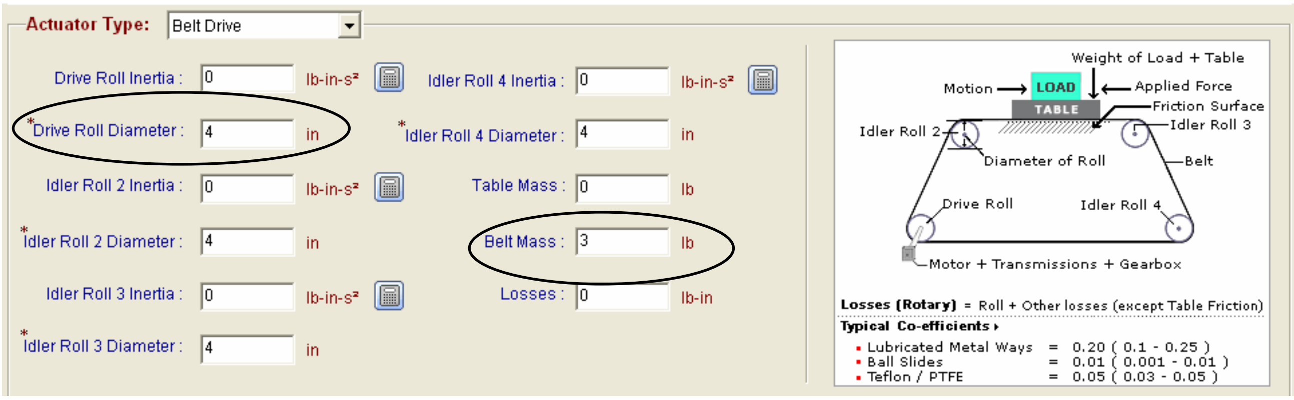
24. Select the **Belt Drive** Actuator Type for our application.

25. Locate the **Load Data** section. Using our axis data, enter a **Mass of 5 lbs**. to account for the weight of the packages on the belt. Since our drive rolls are typically made with roller bearings, we can use the **coefficient of friction** for a Ball Slide, which is listed as **0.01**. You should add this to your list of items to be verified in the System Notes if you are not sure. Leave the Inclination angle at **(0) degrees** since we're working with a horizontal axis.

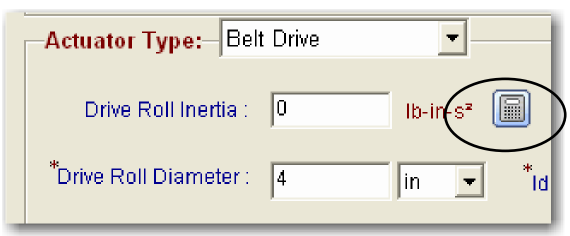


26. In the **Actuator Type** section, enter a **Belt Mass of 3 lbs**. and a **Drive Roll Diameter of 4"**. The software automatically enters this same diameter for Idler Roll 2, 3 and 4. Here is a reminder of how the rolls are arranged:



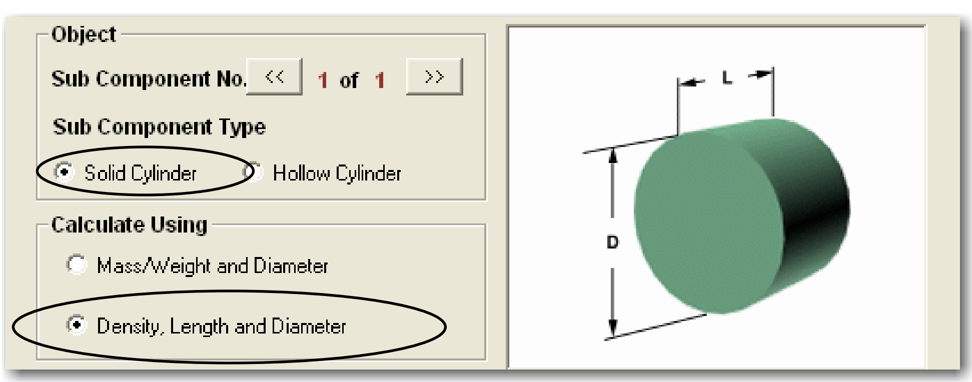


27. Motion Analyzer includes helpful inertia calculators to aid in the process of finding the total inertia of simple or complex rotating objects. Click on the Inertia Calculator button next to the Drive Roll Inertia box.

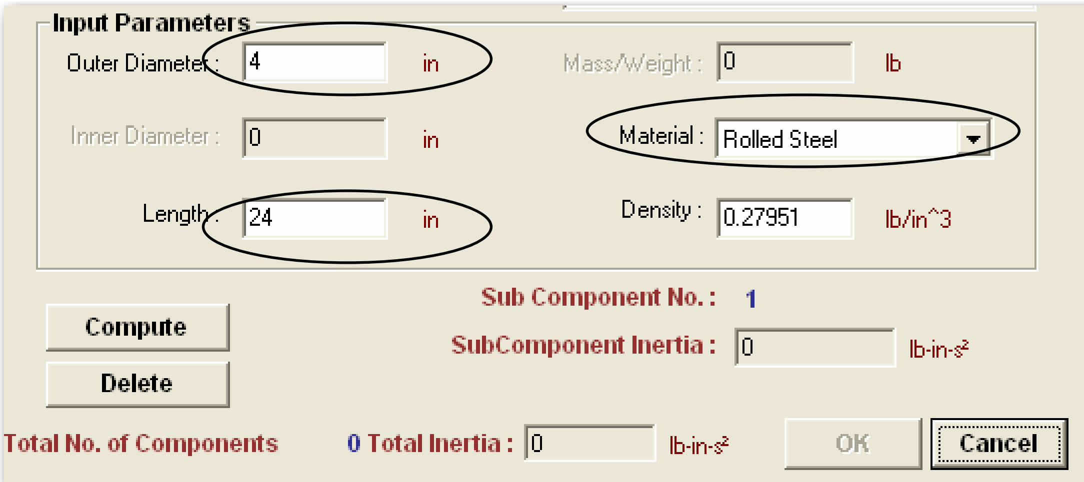


The Inertia Calculator tool lets us model the rotating object as solid or hollow, based on the weight or the size of the material and can even model a composite load made of many types of material layers, or *sub-components*.

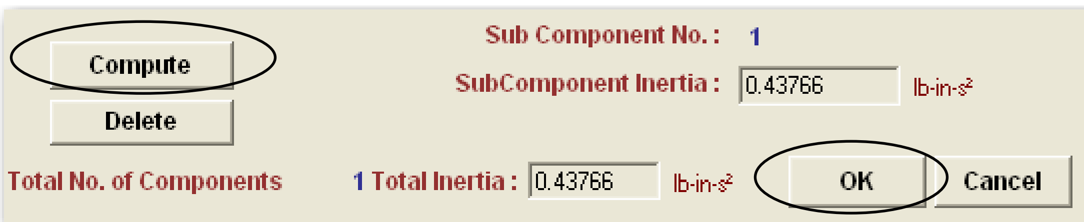
28. Our **Drive Roll** is a solid hunk of steel, so select the **Solid Cylinder** radio button. We don't know the weight of the roll, but the tool can model a steel object based on dimensions, so select the "**Density, Length and Diameter**" button.



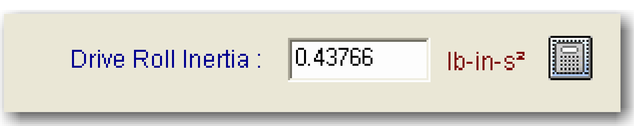
29. Enter an **Outer Diameter of 4"** and a **Length of 24"**. Finally, use the drop-down menu to select **Rolled Steel** for your **Material**.



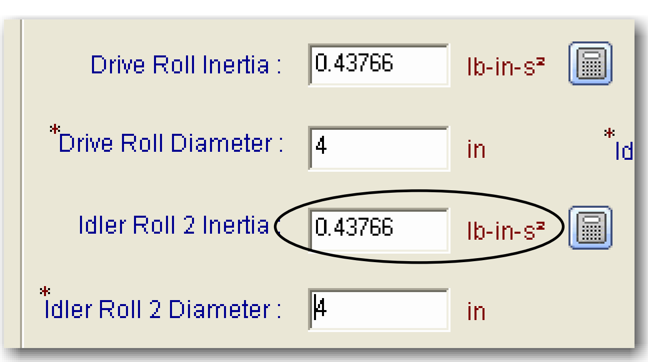
30. Click the **Compute** button. The software calculates the total inertia (j) for this component. If we had additional components, we could move to the next sub-component. Click **OK** to exit.



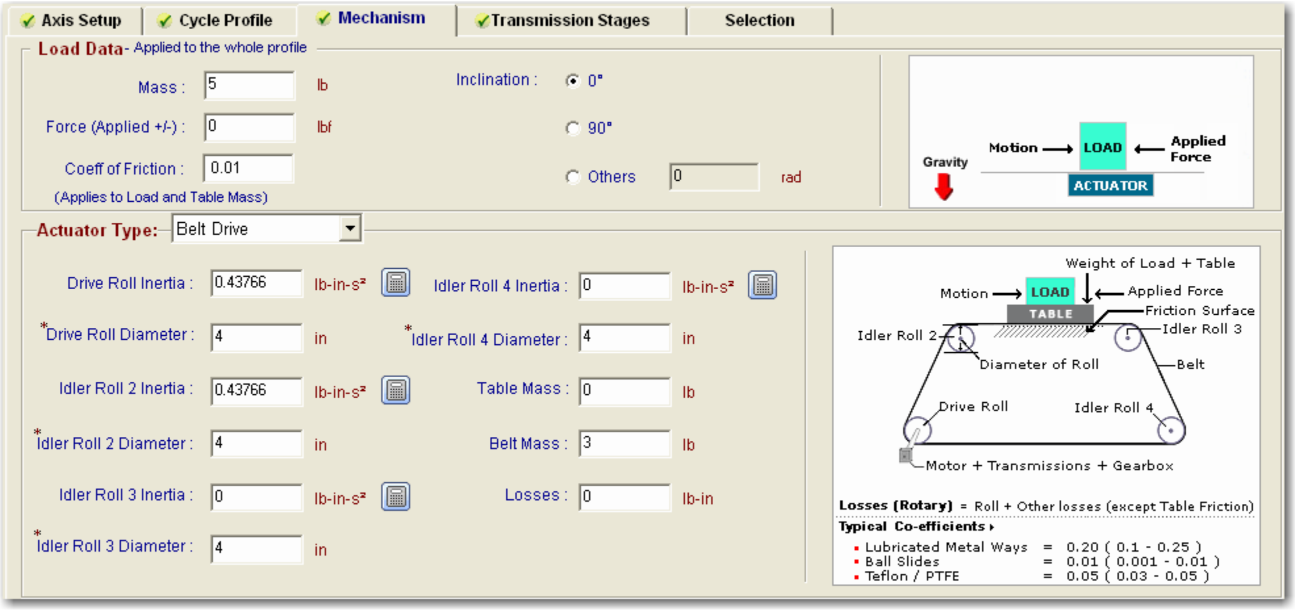
31. Your **Drive Roll Inertia** should be as follows:



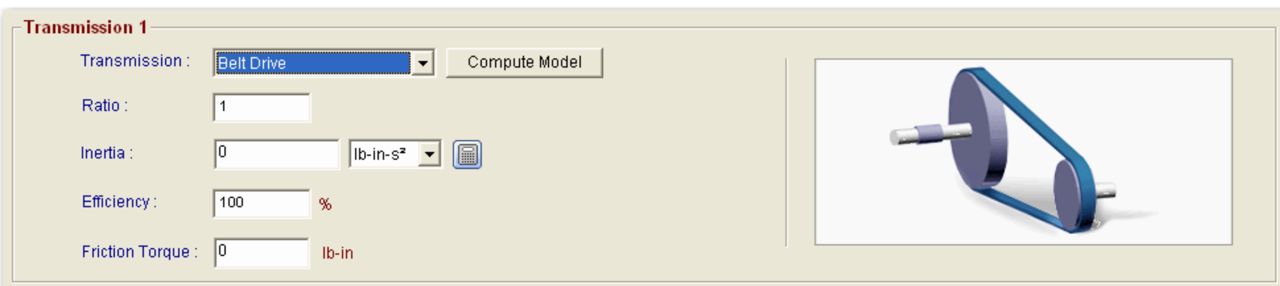
32. Since the Drive Roll and Idler Roll are the same geometry and material, simply **copy and paste** the **Drive Roll Inertia** value into the **Idler Roll 2 Inertia** field. You don't need to fill in anything for the remaining idlers, since this axis only has (2) rolls. If you have more idlers than the (4) provided, note that you can simply add the inertia values together and enter the total in one of the spaces provided.

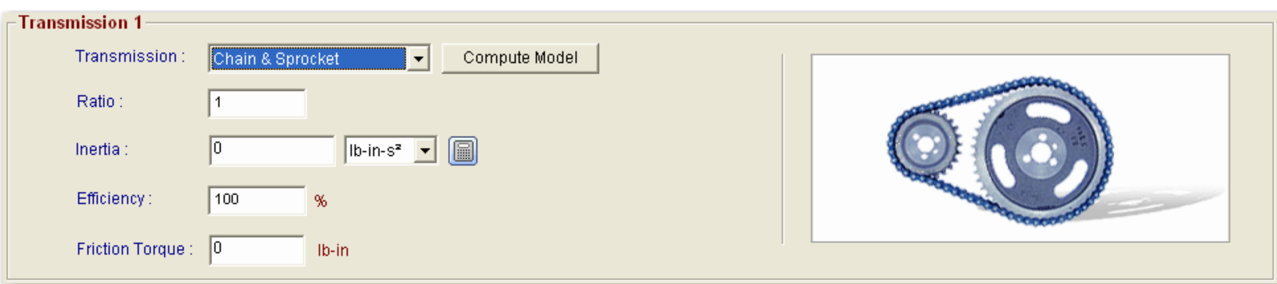


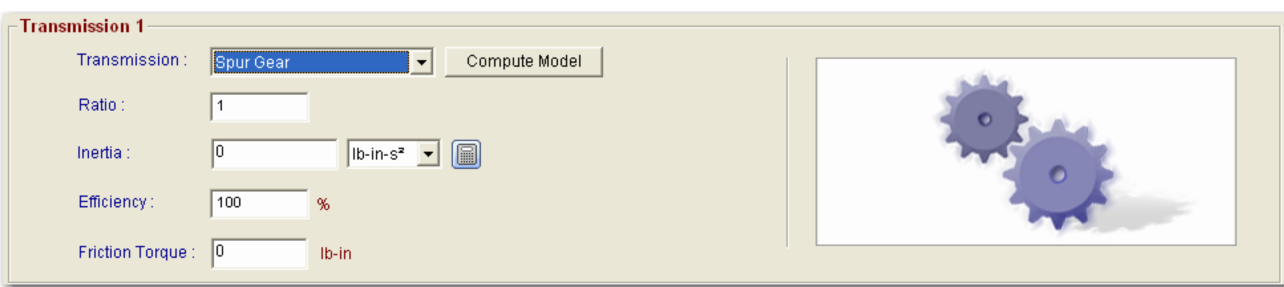
33. Your **Mechanism** tab should look as follows:



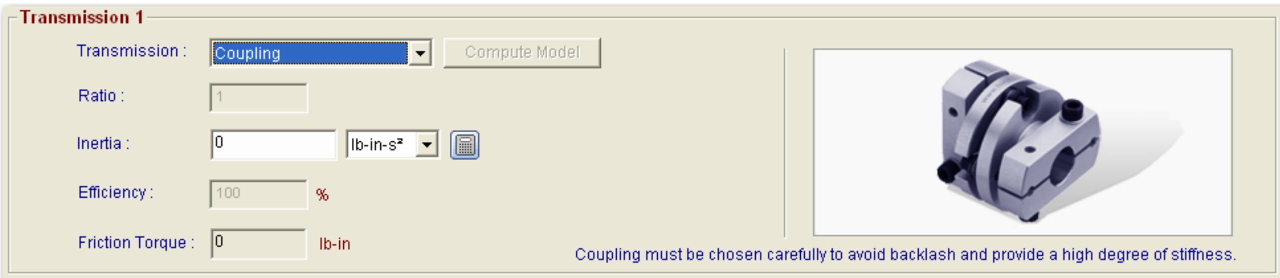
34. Move to the **Transmission Stages** tab. This tab allows you to enter the mechanical information for any rotating devices connected between the motor shaft and actuator. Use the drop-down menu to view the **(4) available models** and their associated **diagram**. A helpful **Compute Model** is also provided for each to aid in entering the required data.



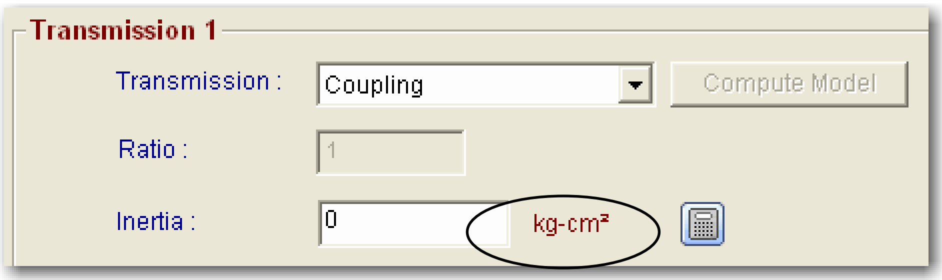




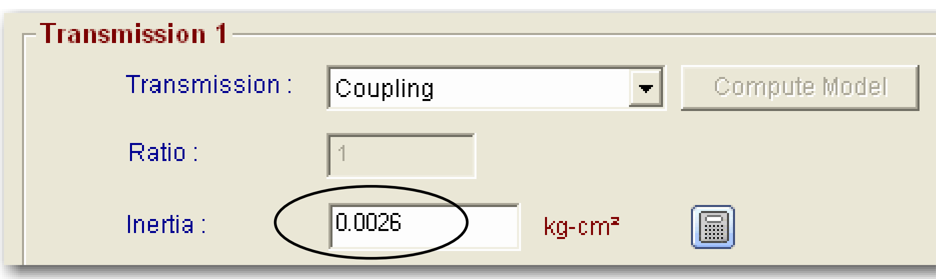
35. Select a **Coupling** for our system, as mentioned in the machine data section.



36. We see that the motor coupling has a moment of Inertia = 2.6g-cm^2. This would come from the coupling vendor's data sheets. Carefully change the **units** first, using the drop-down menu, and then enter the value. Doing this in the wrong order converts the value. The closest unit to the one we need is **kg-cm^2**, so we will have to convert.



37. Enter **0.0026** for the converted **Inertia** value.

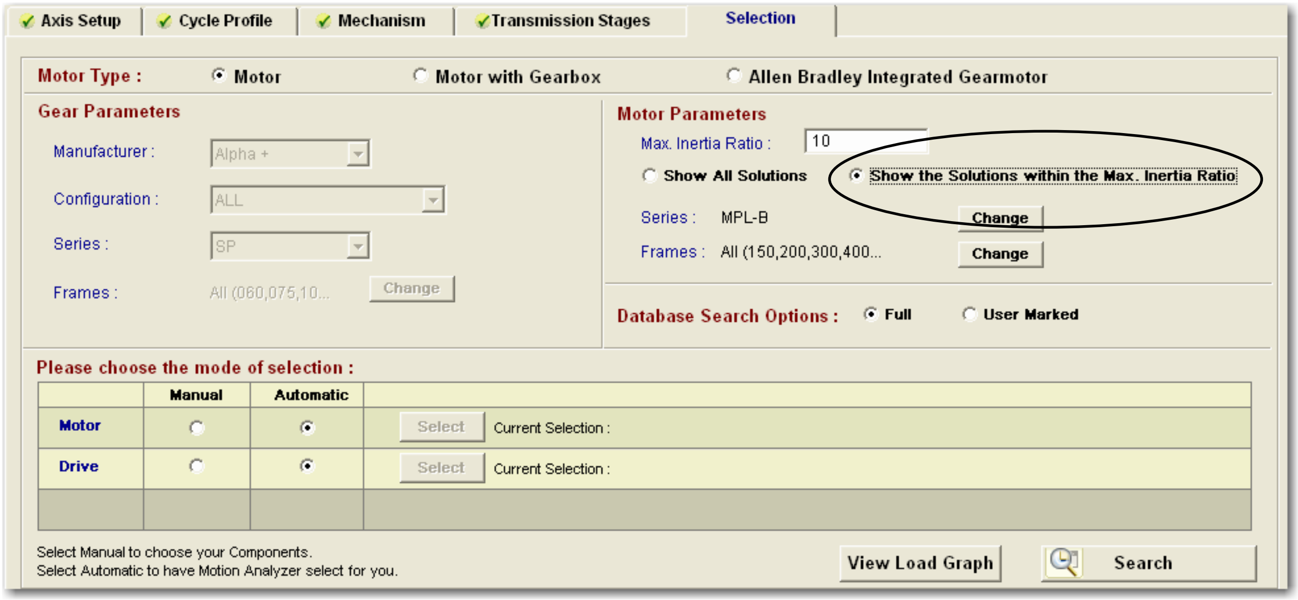


Finding a Valid Solution

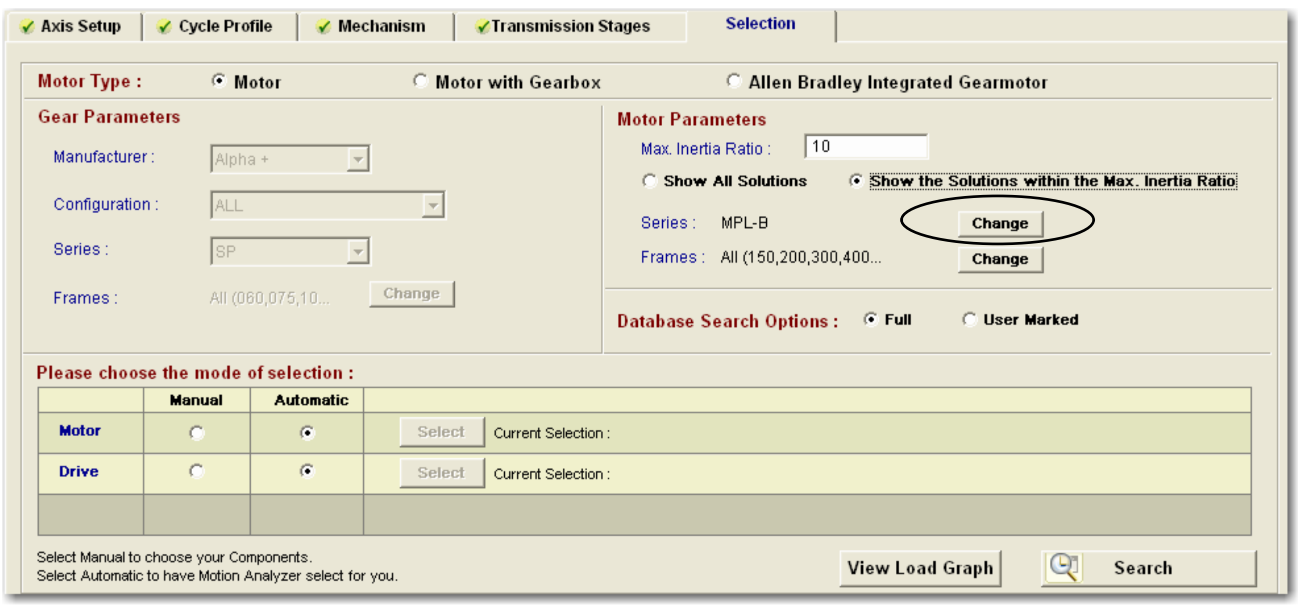
38. We have finished entering the application data and now we can select a motor and drive. Move to the **Selection** tab.

This tab allows us to set our *selection preferences*. We can specify whether to include or exclude a gearbox. We can specify which motor families to include, even down to the frame size of the motor. By default, the MPL Series motors are chosen. These motors are fine for most applications.

39. Press the button to **Show the Solutions within the Maximum Inertia Ratio** (load to motor mismatch). We will exclude solutions above 10:1 in order to insure system stability. This is a concern when trying to position accurately.

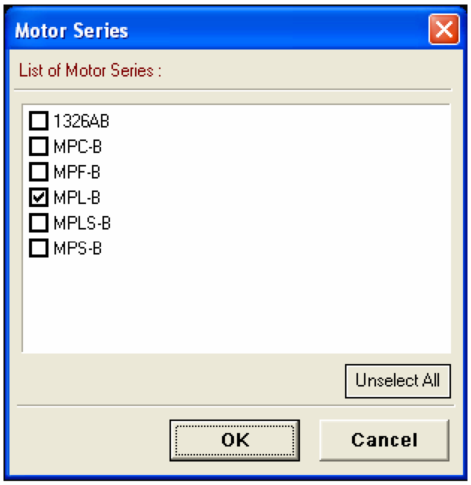


40. If you had special requirements for your motor (food grade or wash down environment or if you just had a size and space restriction), you could direct Motion Analyzer to choose from a different set of motors. Click on the **Change** button next to the motor **Series**.

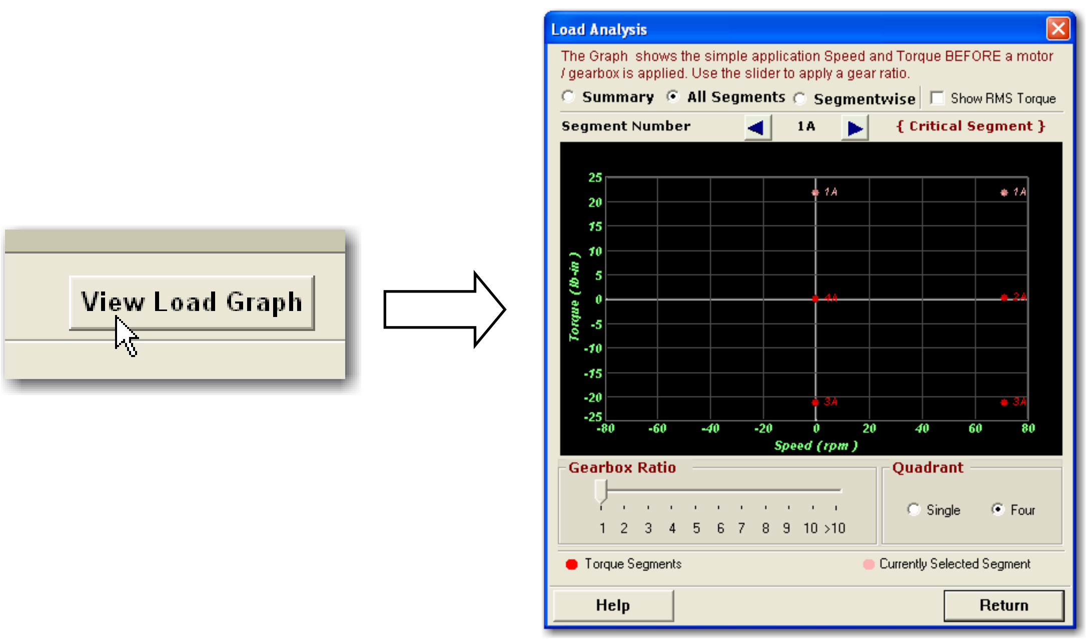


41. Here you can see the other choices that are compatible with our 460Vac Kinetix 6000 drive family. We will not be changing our selection. Press **OK** to continue.

- **1326AB** motors are chosen for medium inertia applications.
- **MPC** motors are not available.
- **MPF** motors are the food grade version of the MPL motor.
- **MPL** motor(s) are the most commonly used motor. They are great for low inertia applications.
- **MPS** motors are the Stainless Steel wash down rated version of the MPL motor.

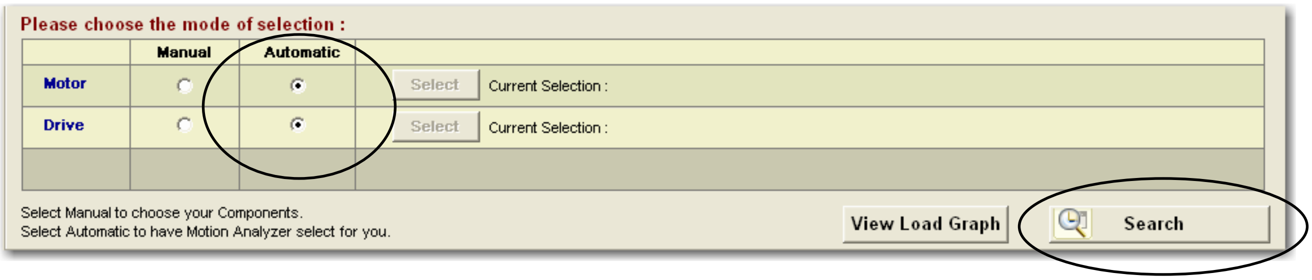


42. A helpful tool provided in Motion Analyzer is the **View Load Graph** feature. If you are having trouble finding a valid motor and drive combination with the automatic search tool, it may be that your solution requires too much torque or speed than the selected motors can produce. Click on this button to see our requirements.

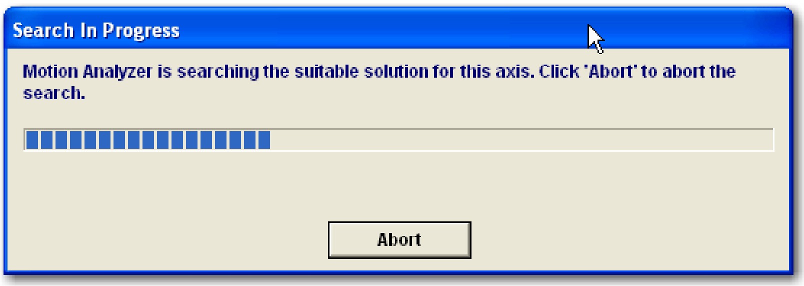


43. It seems that our required speed (RPM) is very low, considering that these motors can go up to 5000-6000 RPM. The torque does not seem high, so we will try to proceed. Press **Return** to close the tool.

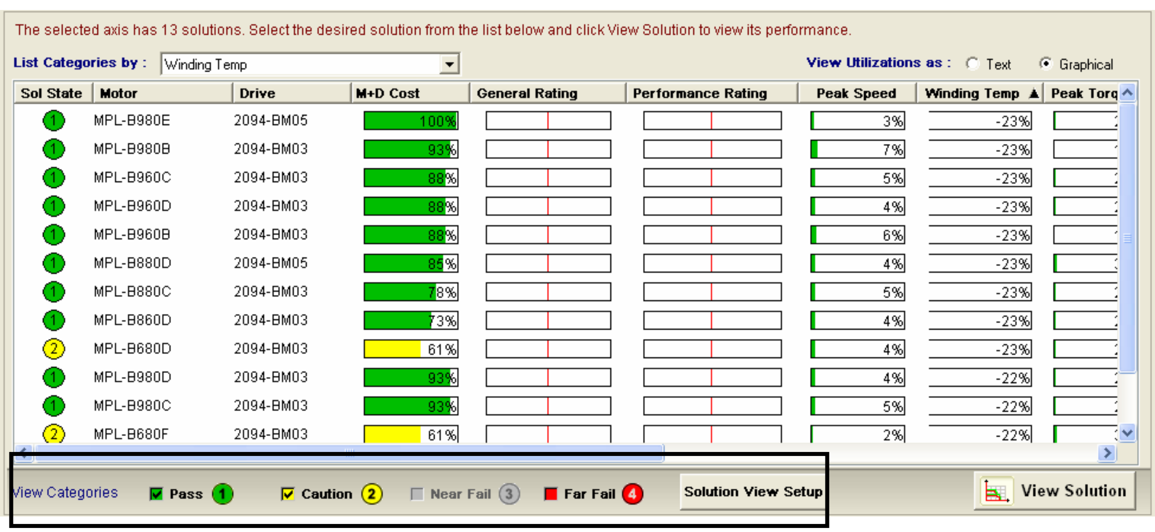
44. With the selection mode set to **Automatic** for the motor and the drive, press the **Search** button.



45. **Wait** while the software searches for all valid solutions (based on your preferences).



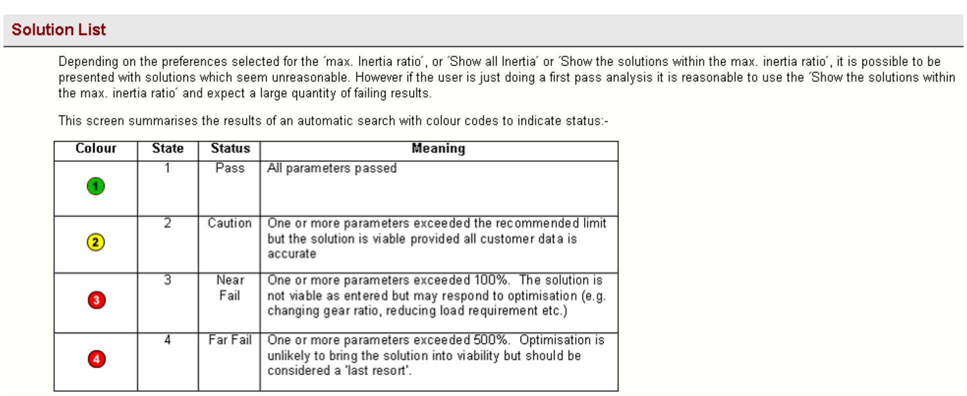
46. Motion Analyzer displays the list of *viable* motor and drive combinations. The list can be sorted in a variety of ways, based on your needs, and the color codes indicate whether a parameter exceeds your "safety margin" setting or exceeds the capacity of the product (usually when manually chosen). The motors displayed are actually quite large, due to our high inertia.


The selected axis has 13 solutions. Select the desired solution from the list below and click View Solution to view its performance.

List Categories by : Winding Temp — View Utilizations as : Text / Graphical

Sol State	Motor	Drive	M+D Cost	General Rating	Performance Rating	Peak Speed	Winding Temp	Peak Torq
1	MPL-B980E	2094-BM05	100%			3%	-23%	
1	MPL-B980B	2094-BM03	93%			7%	-23%	
1	MPL-B960C	2094-BM03	88%			5%	-23%	
1	MPL-B960D	2094-BM03	88%			4%	-23%	
1	MPL-B960B	2094-BM03	88%			6%	-23%	
1	MPL-B880D	2094-BM05	85%			4%	-23%	
1	MPL-B880C	2094-BM03	78%			5%	-23%	
1	MPL-B860D	2094-BM03	73%			4%	-23%	
2	MPL-B680D	2094-BM03	61%			4%	-23%	
1	MPL-B980D	2094-BM03	93%			4%	-22%	
1	MPL-B980C	2094-BM03	93%			5%	-22%	
2	MPL-B680F	2094-BM03	61%			2%	-22%	

View Categories — Pass (1) — Caution (2) — Near Fail (3) — Far Fail (4) — Solution View Setup — View Solution

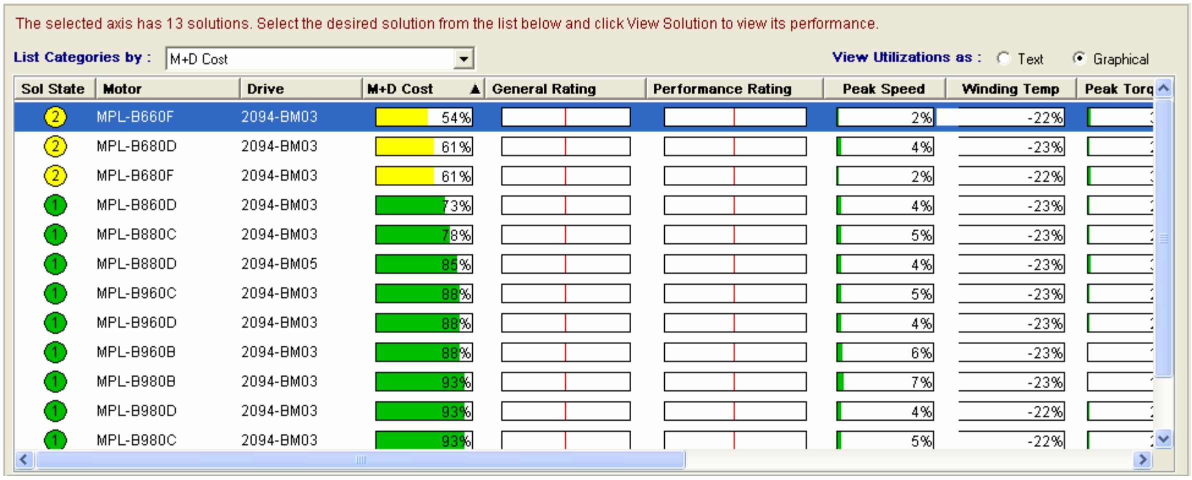

Solution List

Depending on the preferences selected for the 'max. Inertia ratio', or 'Show all Inertia' or 'Show the solutions within the max. inertia ratio', it is possible to be presented with solutions which seem unreasonable. However if the user is just doing a first pass analysis it is reasonable to use the 'Show the solutions within the max. inertia ratio' and expect a large quantity of failing results.

This screen summarises the results of an automatic search with colour codes to indicate status:-

Colour	State	Status	Meaning
1	1	Pass	All parameters passed
2	2	Caution	One or more parameters exceeded the recommended limit but the solution is viable provided all customer data is accurate
3	3	Near Fail	One or more parameters exceeded 100%. The solution is not viable as entered but may respond to optimisation (e.g. changing gear ratio, reducing load requirement etc.)
4	4	Far Fail	One or more parameters exceeded 500%. Optimisation is unlikely to bring the solution into viability but should be considered a 'last resort'.

47. Let's sort our solutions *by cost* in ascending order. Click on the **M+D Cost** (motor and drive) column as shown below. 100% is defined as the highest priced solution. All of the solutions are listed as solution state value of 1 or passing (green). Slide the lower **scroll bar** to view the other operating parameters (or any *offending* values in the case of a solution state other than 1).



First, you will only want to look at solutions with a Solution State of "1" because that indicates no criteria failed, or is within the safety margin. Then you will most likely want to pick a solution that has the best cost or inertia ratio. When you consider the inertia ratio, you ideally would like to minimize it but that is always based on how much bandwidth you really need in the application. If it is a point to point move where some overshoot can happen, you could possibly go 10:1 or less and probably be ok. If it is a high bandwidth requirement such as something that does contouring, etc., you try to match it lower, say 3:1 or less. Ideally, you try to match the motor rotor inertia to the load so that they act in unison.

If you look at the drive, you will want to make sure the peak currents/torques are below 80% since any type of loss or friction that is not accounted for may mean the difference from doing an acceleration and deceleration. Motion Analyzer is only as good as what you enter into it. If you look at the motor, you will want to make sure Motor Winding Temperature less than 60% to make up for losses or friction that was not accounted for.

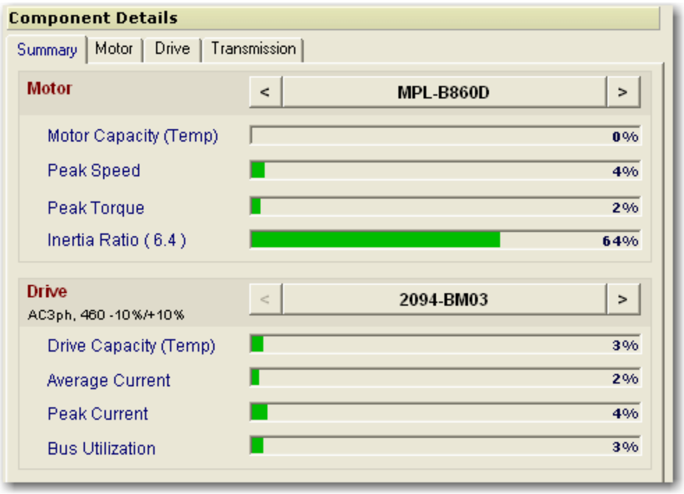
Bus utilization of the drive is next important because if it is exceeded, then there isn't enough DC Bus to spin the motor at the required V/1000rpm that the application needs. Peak Velocity in the motor section tells you what the motor can and can't do based on the input voltage. If the bus utilization is too high, then the motor can not make that move. Many times you need to increase the input voltage, if you can or change to a different motor winding or in the long run, change the cycle profile and/or work with the mechanics.

You can also tell a lot from the speed torque curve. If you are seeing a lot of torque required but only at very low speeds, some kind of reduction may help to improve that situation. Generally, it moves the points down and to the right because the motor generates less torque but requires much higher speed.

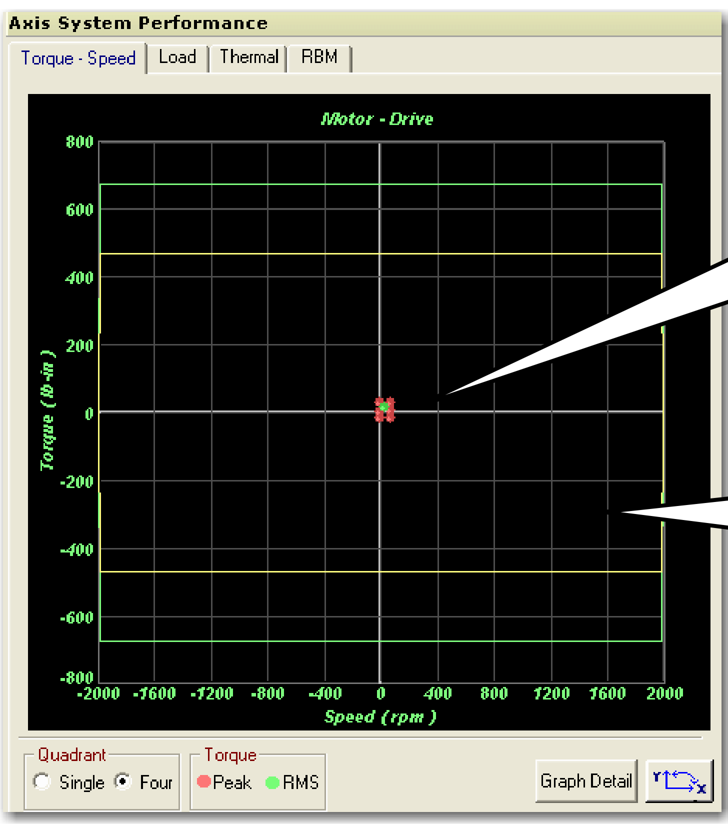
For motors that have a low rpm and high RMS torque, you will want to consider a gearbox.

48. Highlight the **first all green solution** in the list and click on **View Solution** to see its performance.

49. The **bar graphs** for this motor and drive combination are all green, which is good. Since most of the values are extremely low, it looks like this motor was chosen strictly based on the **high inertia value** of the drive rolls. The “64%” is from our 10:1 limit (6.4:1 is 64% of 10:1).

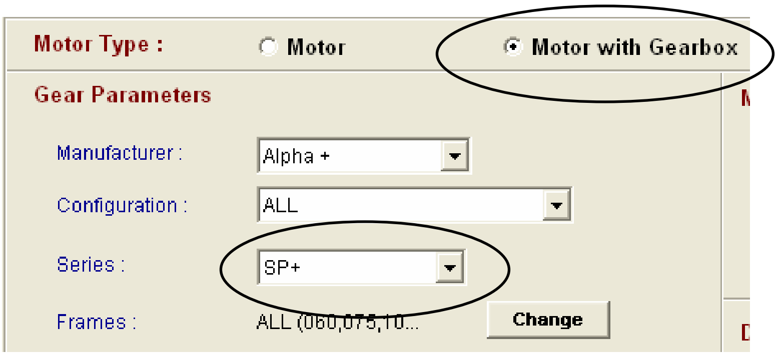


50. Next, look at the **Torque-Speed** curve. Here we see that both the Peak and RMS Torque values are within the *continuous* portion (the yellow lines) of the Torque-Speed curve. The continuous portion means that the motor and drive can safely operate there indefinitely and will not overheat. Occasionally, the torque values can spike into the Peak region, typically for accelerating the load, but this adds to overheating the motor or drive. The software models the amount of time the motor and drive are in the peak zone when calculating the “Capacity” values.



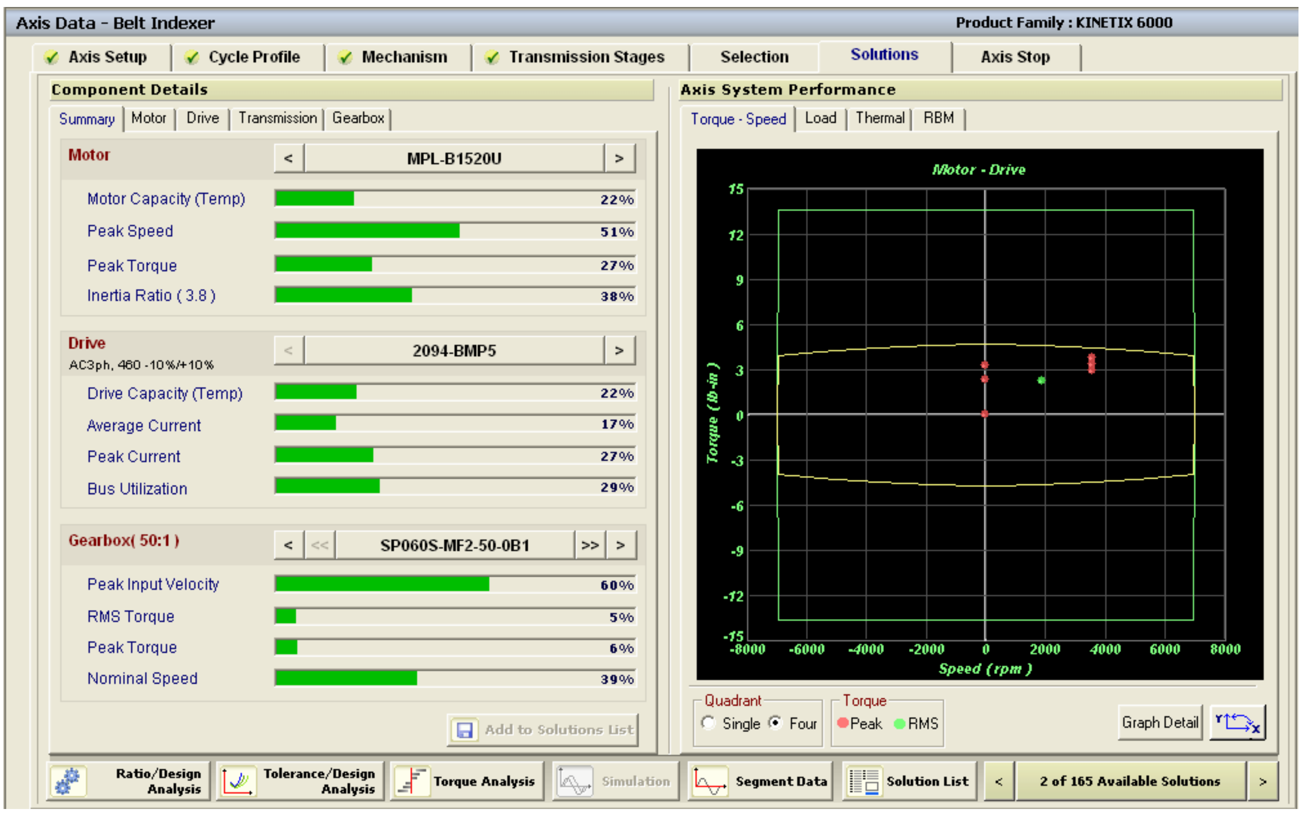
51. Although this is a valid solution, the data indicates that a **gearbox** would probably have been in order so that a smaller motor and drive could have been chosen. The cost of the additional gearbox versus the savings of a smaller motor and drive are often a wash, so this is not necessarily a *bad* solution. *It is actually quite common, however, to use a gearbox with a belt type actuator.*

52. *To actually make this change*, return to the **Selection** tab and **Search** again with an **Alpha +** gearbox chosen. Also verify that the "SP+" Series is selected, as follows:



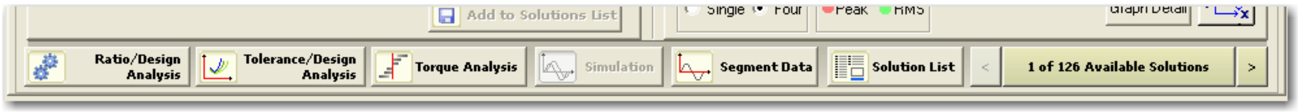
53. Press **Search** and use your skills to select the best, low-cost solution in the list.

54. Your new lost-cost solution **results** might look similar to this (*many* possibilities are available):



A simple gearbox now allows us to use one of the smallest motors and drives available. Why? Because the high inertia of the idler rolls is reduced by the *square* of the gear ratio (50^2 = 2500), while the motor speed requirement only increases 1:1 with the gear ratio. Ah, physics!

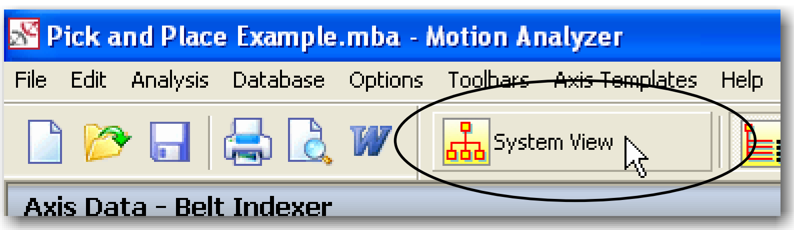
55. There are many **additional analysis tools** included with Motion Analyzer, shown at the bottom of the screen. Each one helps optimize the motor and drive selection and possibly remove costs from the system.



- **Ratio/Design Analysis** gives great insight on what the best gear ratio (or belt reduction ratio) may be, based on the motor and drive parameters.
- **Tolerance/Design Analysis** offers the ability to examine the crucial system parameters as one system variable changes, such as line speed or product weight.
- **Torque Analysis** and **Segment Data** help to investigate what aspect of the system require the most torque during a duty cycle. It is often surprising where the losses or requirements are originating.

Look for additional (advanced) labs available on these topics.

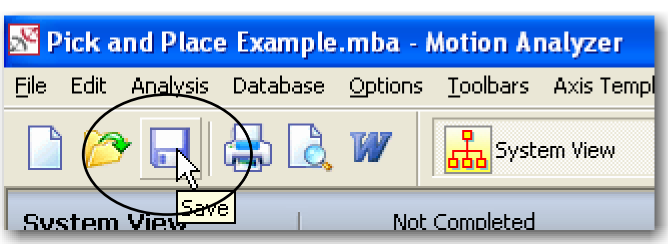
56. Return to the **System View**.



57. Observe all of the **icons** that represent our selected components. Our motor, drive (and gearbox, if chosen) selection are even specified.

Drive, motor, gearbox, coupling, belt actuator and cycle profile (shown above).

58. Be sure to **save your work**. Confirm any prompts and choose a location to save your file.



Lab 2: Sizing a Horizontal Lead Screw (10 Minutes)

About This Lab

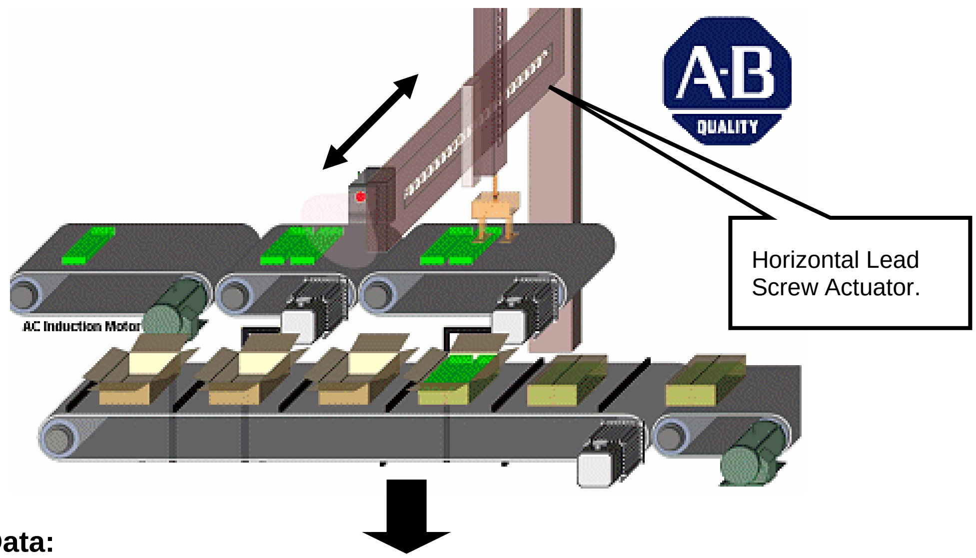
In the first lab, we gained experience with a belt driven system. Now we will work with a horizontal lead screw axis; the Traverse axis on our Pick and Place machine. In this lab, you will:

- Use the MultiSegment Cycle Profile tool for entering complex move profiles
- Select a motor and drive for your lead screw axis
- Analyze your system choices with the Ratio/Design Analysis tool.

Follow the steps below to complete Lab Section 2.

Using the MultiSegment Cycle Profile Tool

Let’s continue where Lab #1 left off. Unlike the Belt Indexer axis, this axis employs a *linear actuator* to convert the motor’s rotary motion into linear motion. The application specifications are listed below:



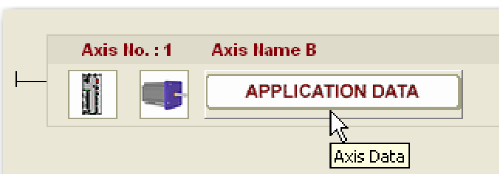
Horizontal Axis Data:

- Package weight to be moved = 1 lb
- Total Slide Mass (Includes Mass of Vertical Axis) = 90 lbs
- Coefficient of Friction = 0.01 (= 1%)
- Lead Screw Specification:
  - Lead = 1”/rev
  - Length = 50”
  - Diameter = 1”
  - Material = Steel
  - Efficiency = 90%
- Motor Coupling Moment of Inertia = 2.6g-cm^2
- Bi-directional move of 24” in 6 seconds overall. See cycle drawing.

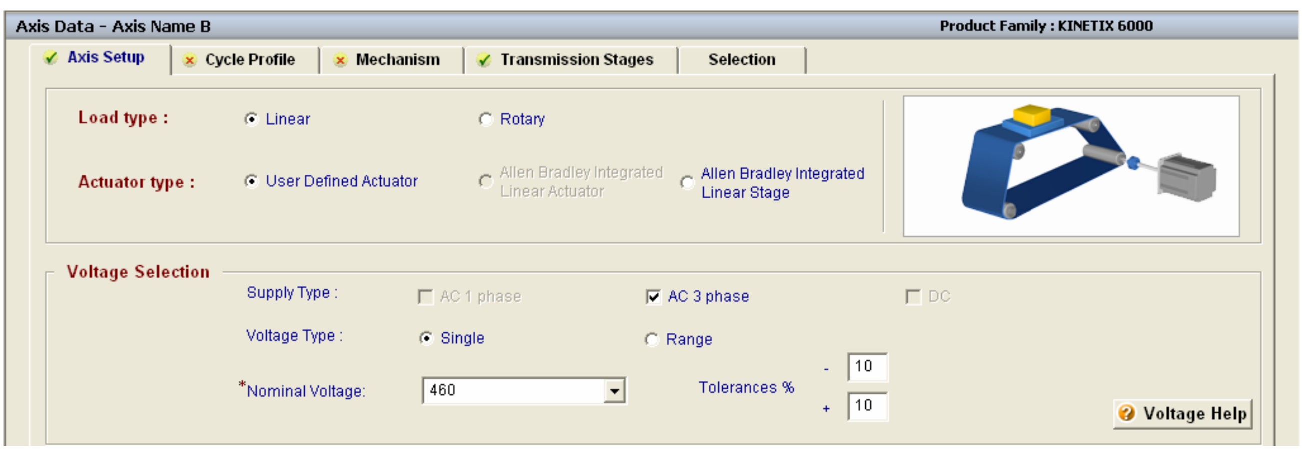
The required **Velocity Profile** is shown below. This profile incorporates *triangular* velocity moves to limit acceleration and reduce the peak torque requirement. Triangular velocity profiles are preferred for point to point moves.

The move profile is described as "moving the product to the **placing point**, pausing for 1 second to drop it off, moving back to the **picking point** and pausing for 1 second to pick up the next product."

1. Click on the **Application Data** button for the second axis.

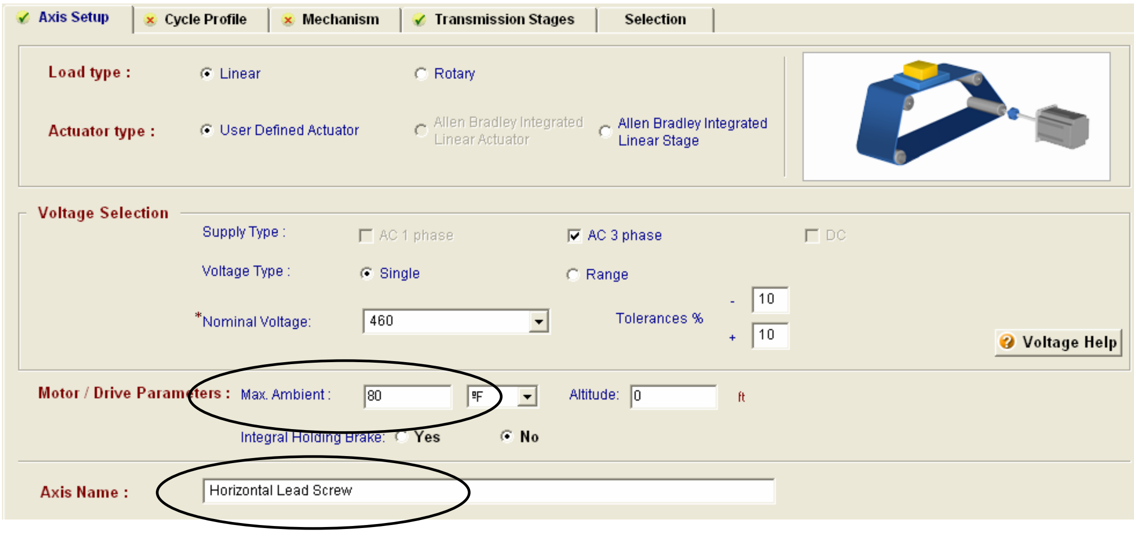


2. The **Axis Data** screen is shown. The **Axis Setup** tab has the typical default values, but the voltage is set to 460Vac from the previous axis' settings. Since input power is only provided to the first Kinetix 6000 drive, all drives will have the same **460Vac** rating.



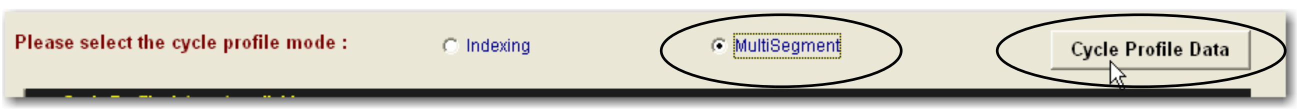
*We certainly could have chosen to use an "Allen Bradley Integrated Linear Stage" rather than a "User Defined Actuator" because the Allen Bradley Integrated Linear Stage product (**MPAS**) has a position range of up to **76 inches.***

3. Change the **Ambient Temperature** setting to our **80 degrees** (F) from before, and change the **Axis Name** to "**Horizontal Lead Screw**."

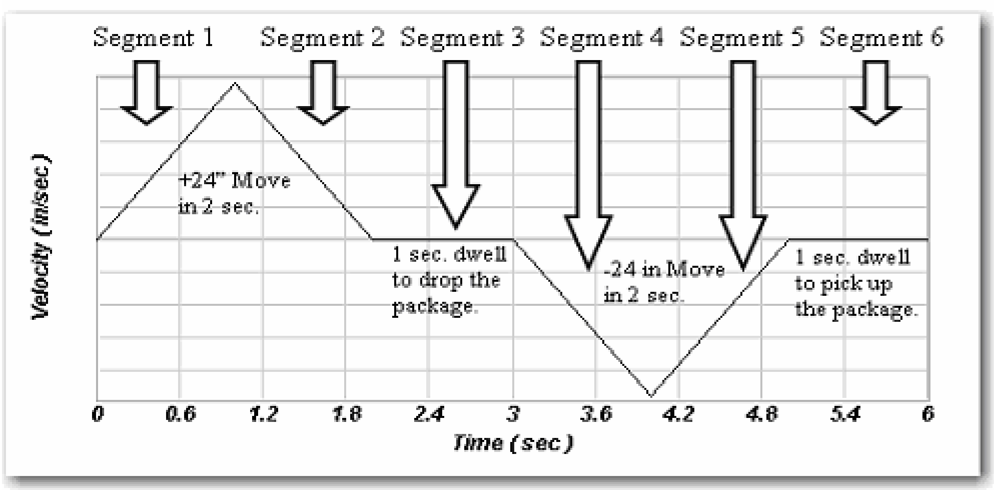


4. Move to the **Cycle Profile** tab.

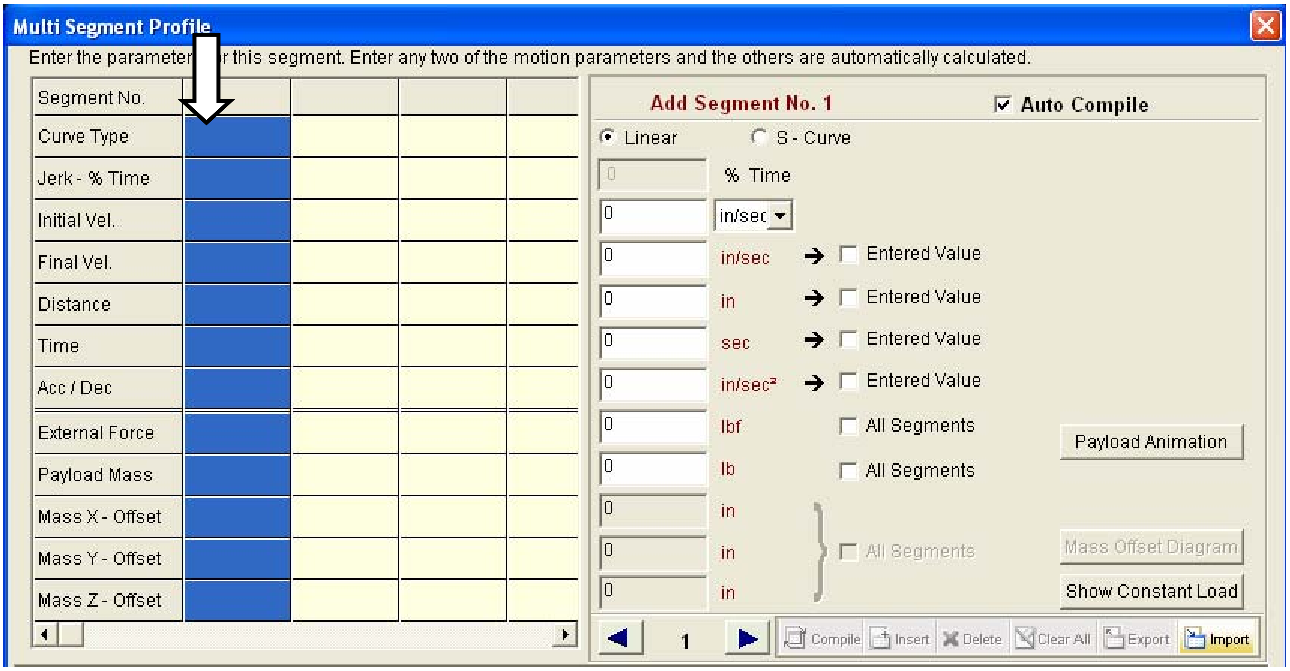
5. Since this move profile has more than one simple point to point move, we will need to use the MultiSegment editor. Select **MultiSegment** radio button and hit the **Cycle Profile Data** button.



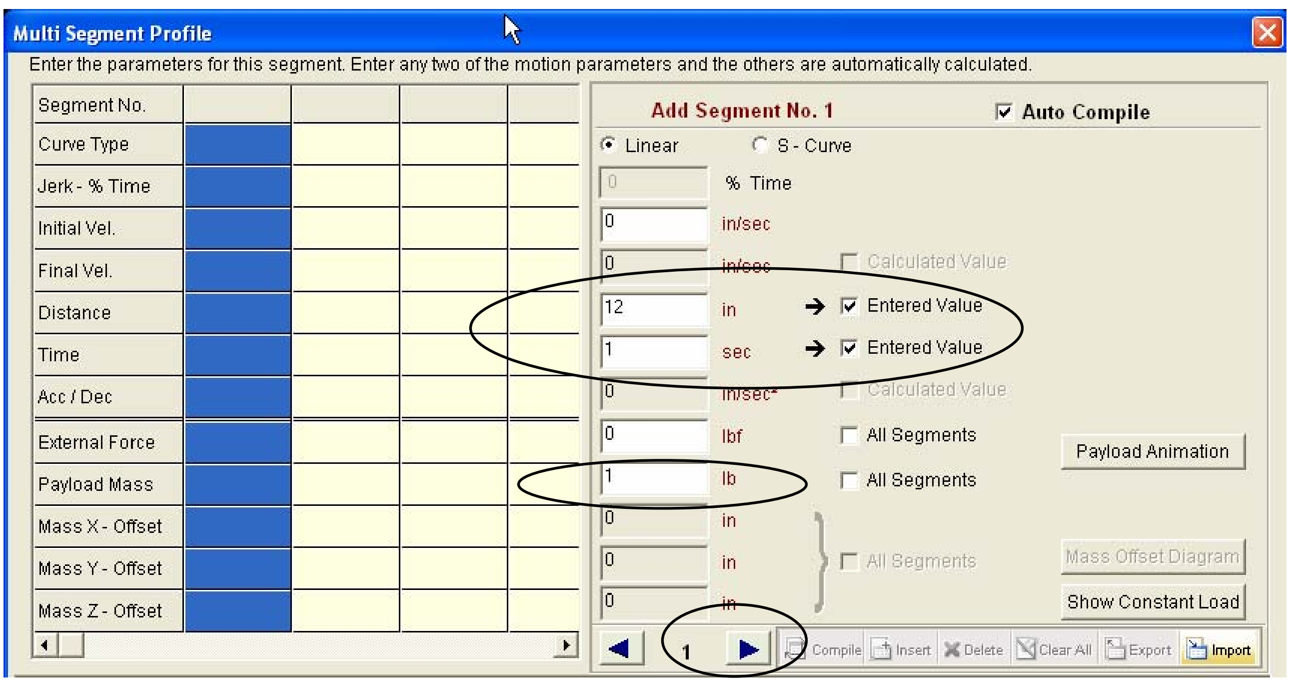
This tool offers more capabilities, but is more complicated to use. Here is our required move profile by move segment:



We will use the editor to place Segment 1 data here:

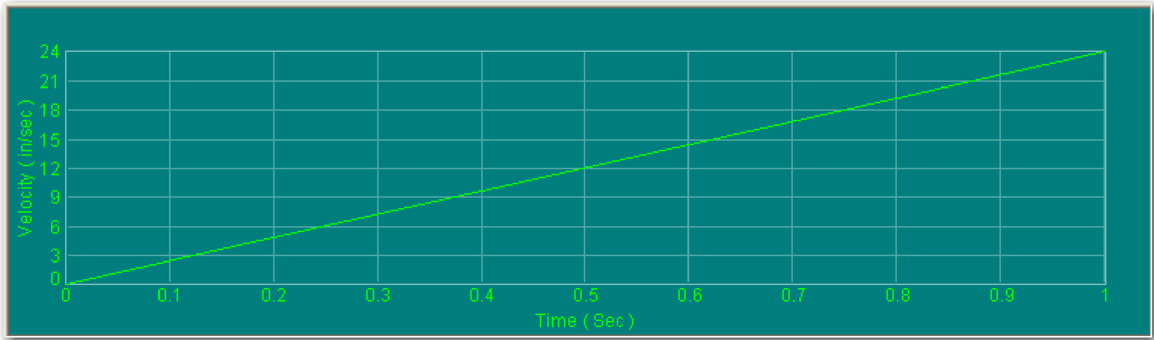


6. Since we've decided on a triangular profile, enter the midpoint position of **12"** and a time of **1 sec**. To enter this data, select the "**Entered Value**" boxes shown below. Finally, enter a **Payload Mass** of **1 lb.**

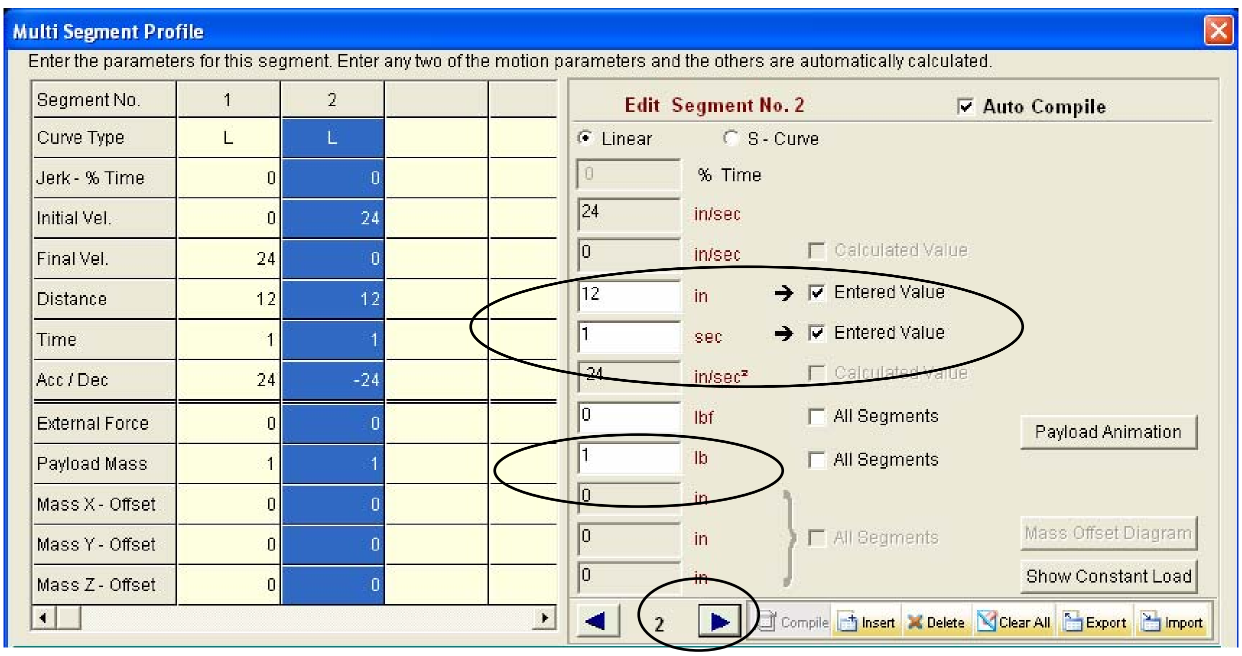


7. Click on the **right arrow** button to move to the next segment column.

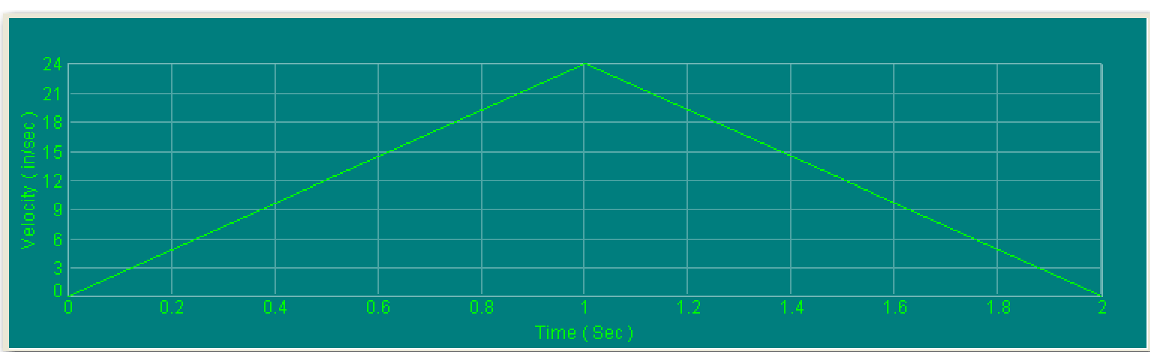
Motion Analyzer has calculated some additional parameters and is displaying segment 1 as a line on the graph.



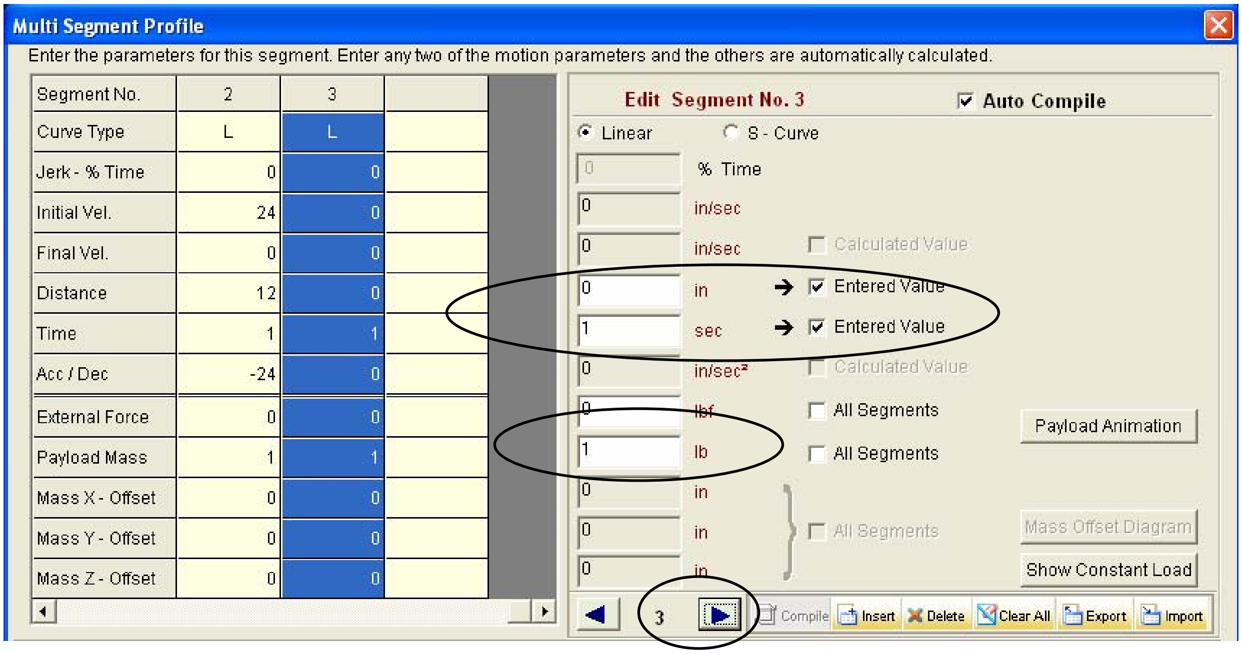
8. For segment 2, enter a **Distance of 12”**, a **Time of 1 sec**. and a **Load of 1 lb**. Then advance to the **next** segment.



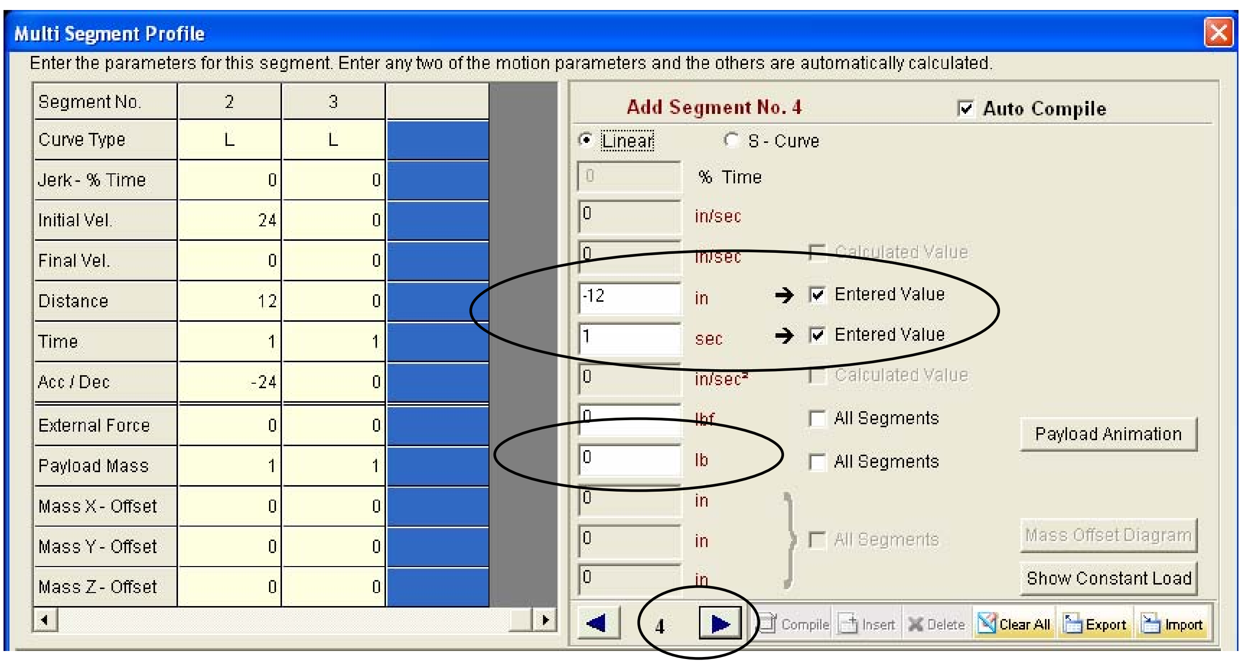
9. Your profile should now look like this:



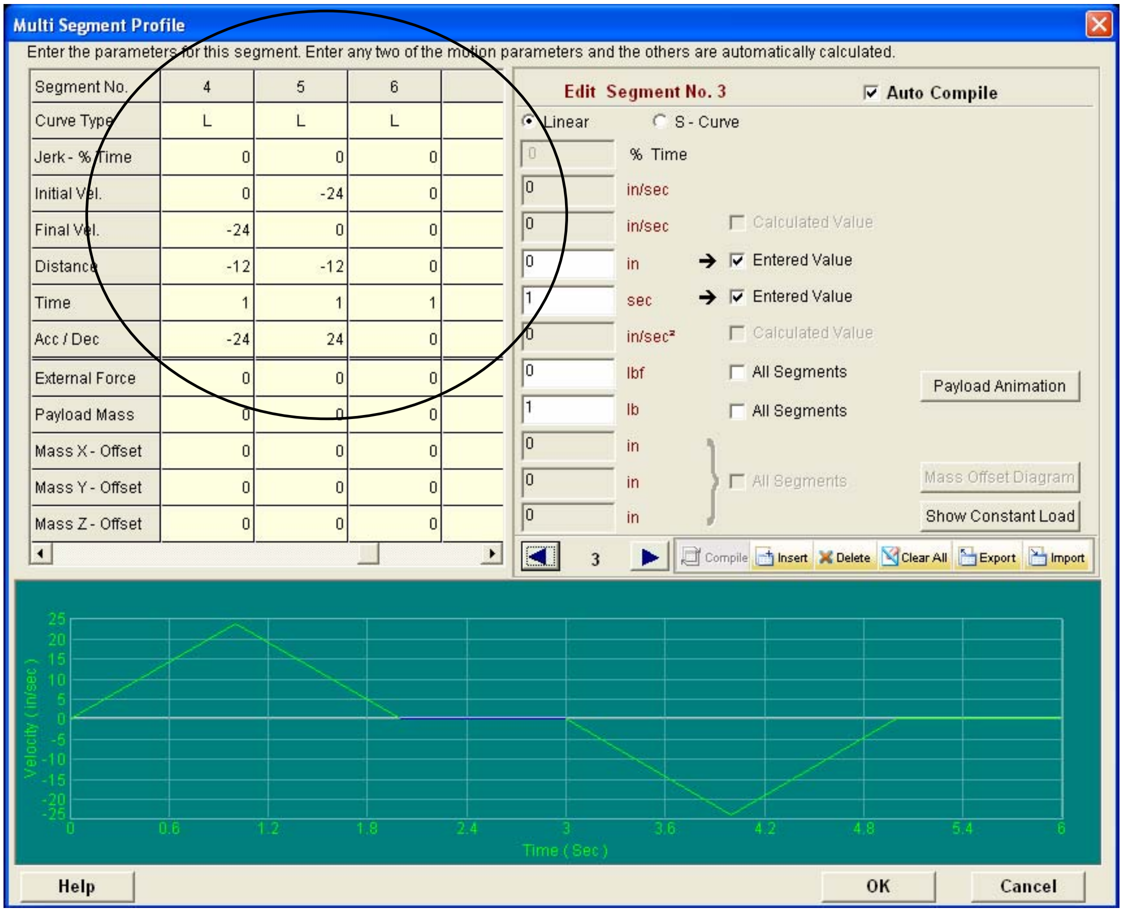
10. Segment 3 is our 1 second *dwell* or rest period. We enter this by using a **zero Distance** as shown below. Move to the **next** segment.



11. The next (3) segments are basically just like the ones we just entered, only the machine is moving back to the starting point after dropping off our package. We will accomplish this by entering negative values for Distance and zero values for Load, as shown. Move to the next segment.

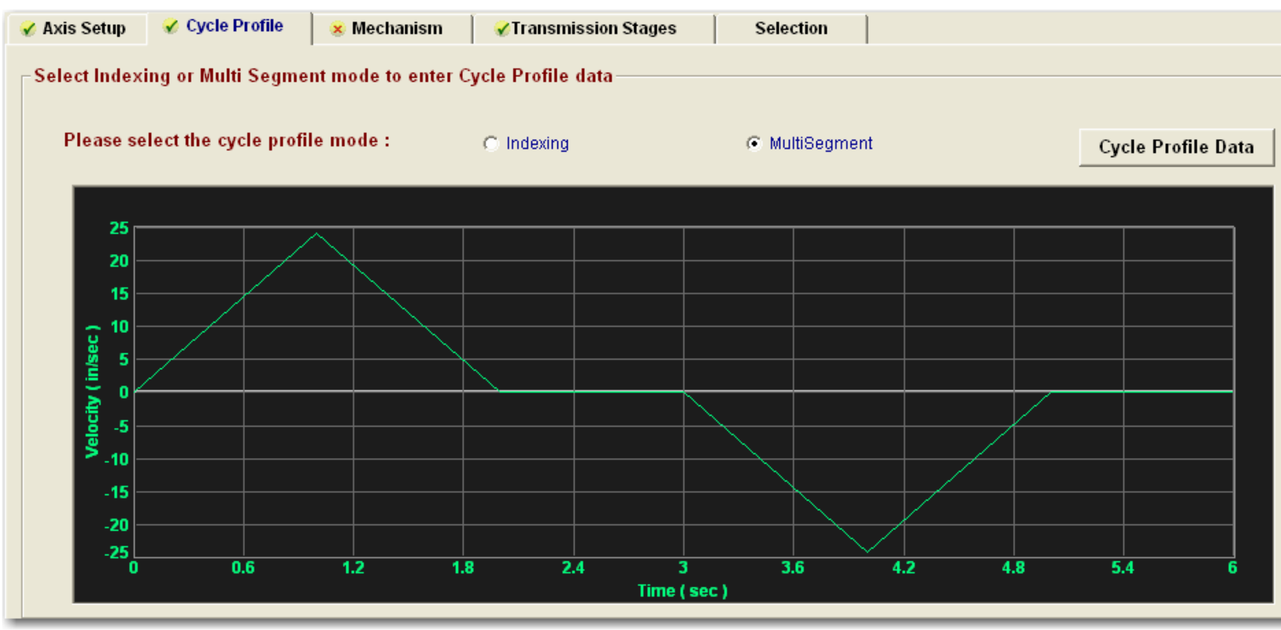


12. Finish **segments 5 and 6** using the skills you learned above. Your profile should look like this:



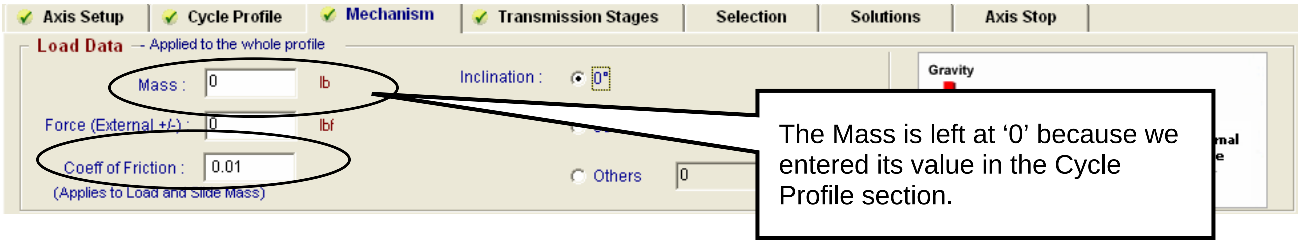
13. Press **OK** to close the Profile editor.

14. You have completed the **Cycle Profile** tab.

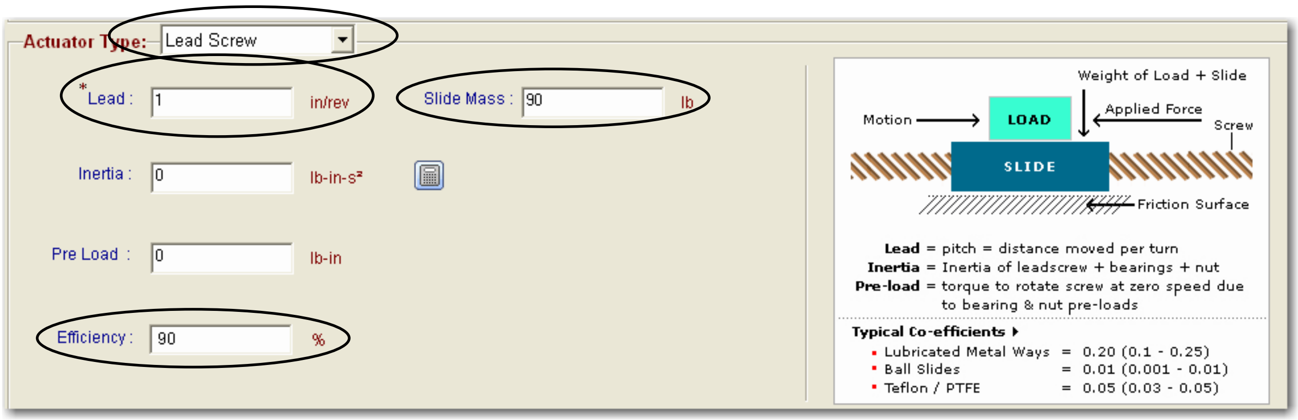


15. Move to the **Mechanism** tab.

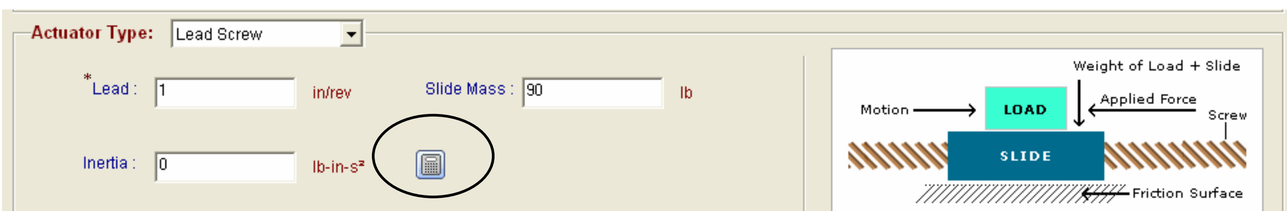
16. Enter the Horizontal axis' **Load** data from our application information.



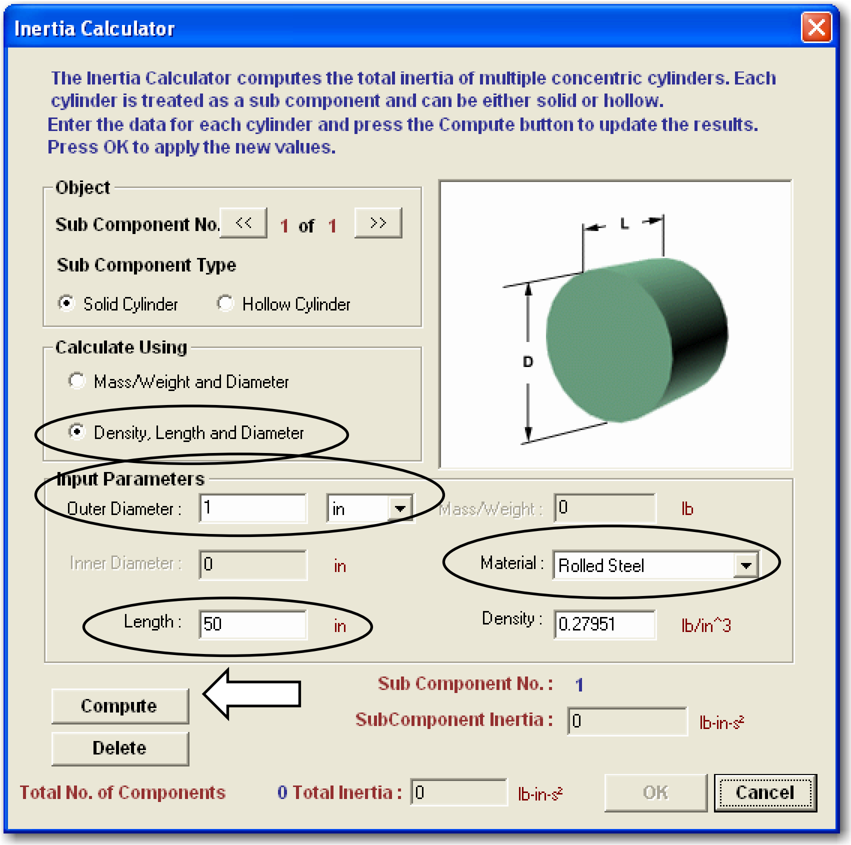
17. Use the drop-down selector to choose a **Lead Screw** for the **Actuator Type**. Enter the known **data** as shown.



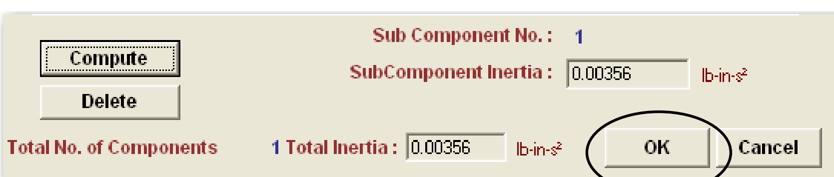
18. Click on the **Inertia Calculator**.



19. Once again, we know the dimensions of the rotating screw. Select **Density, Length and Diameter** and enter the data for the steel lead screw. Press **Compute** when ready.

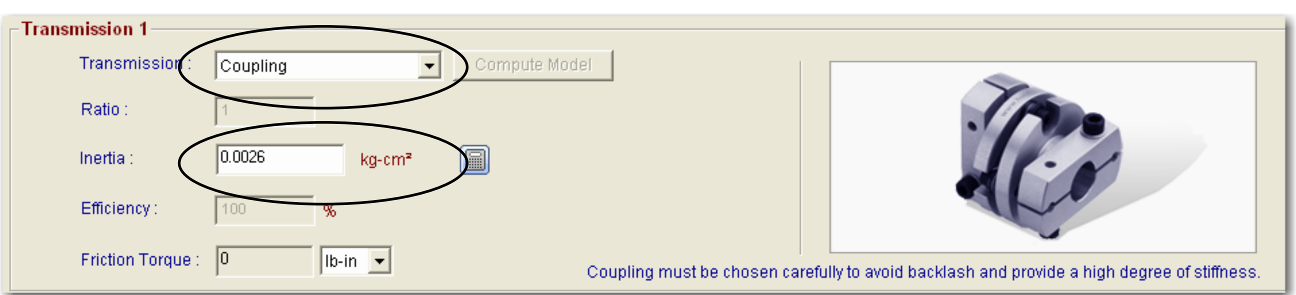


20. Press **OK** when complete.



21. Move to the **Transmission Stages** tab.

22. Enter the **coupling** between the motor and lead screw just like we did for the belt actuator in the last lab. Be sure to set your **units** for the Inertia field first and then enter the **converted value**.

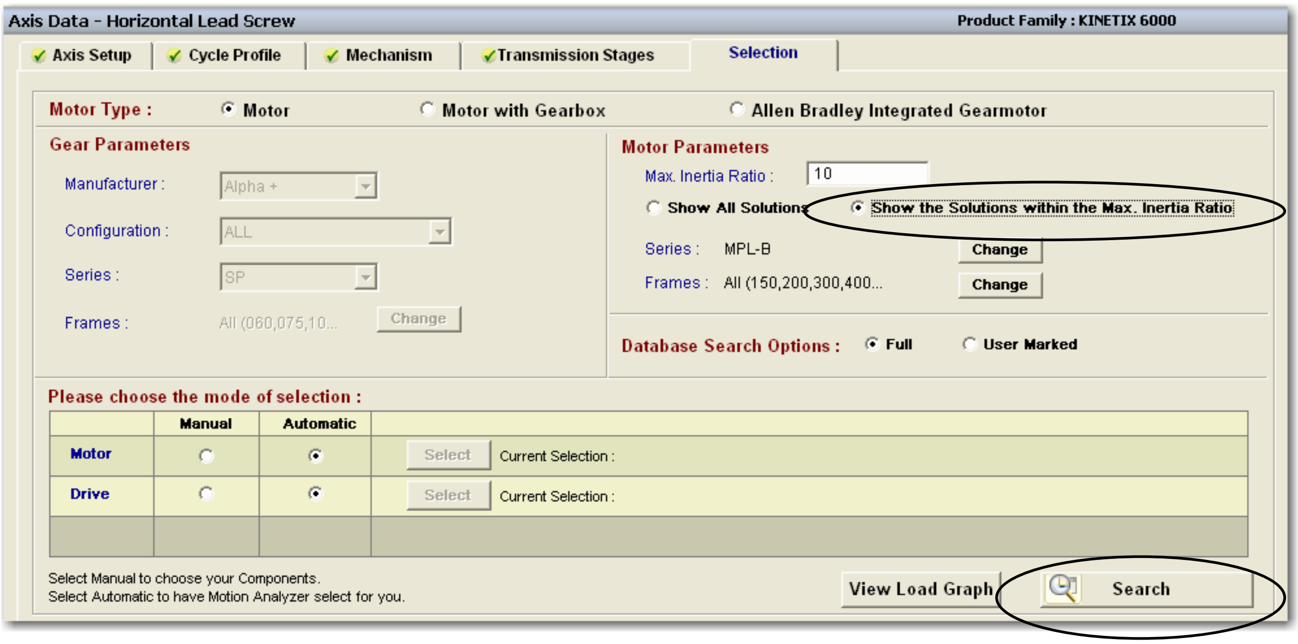


23. Move to the **Selection** tab.

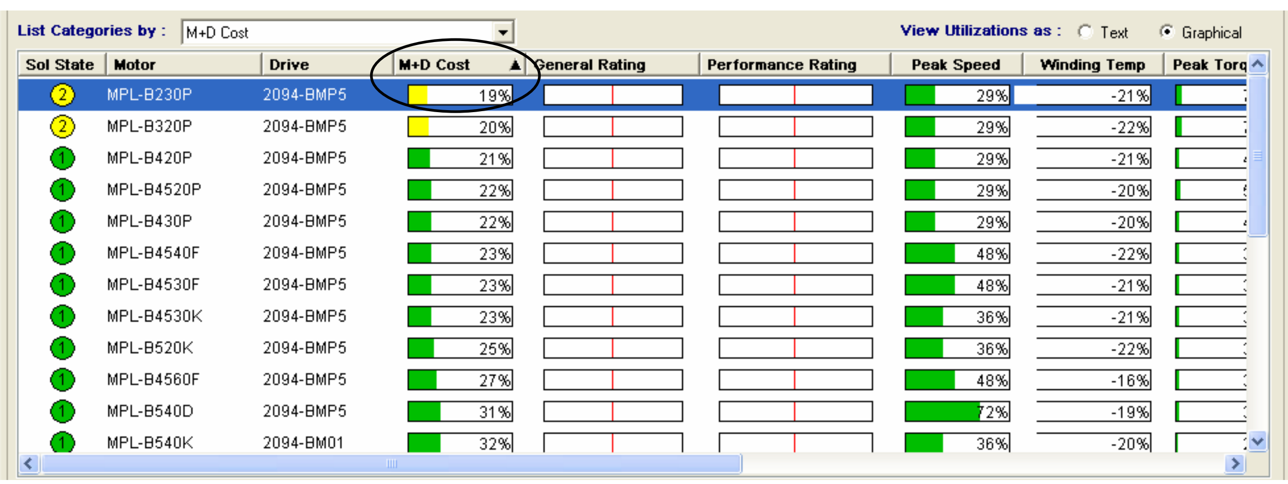
Select a Motor and Drive

We have entered all of the known information and it is time to select the motor and drive. *When using lead screw actuators, you are not typically required to use a gearbox.*

24. We will once again **exclude solutions beyond a 10:1 inertia mismatch** and allow the software to automatically search for our motor and drive combination. Press **Search** when ready.



25. Sort the list by cost (**M+D Cost**) once again.

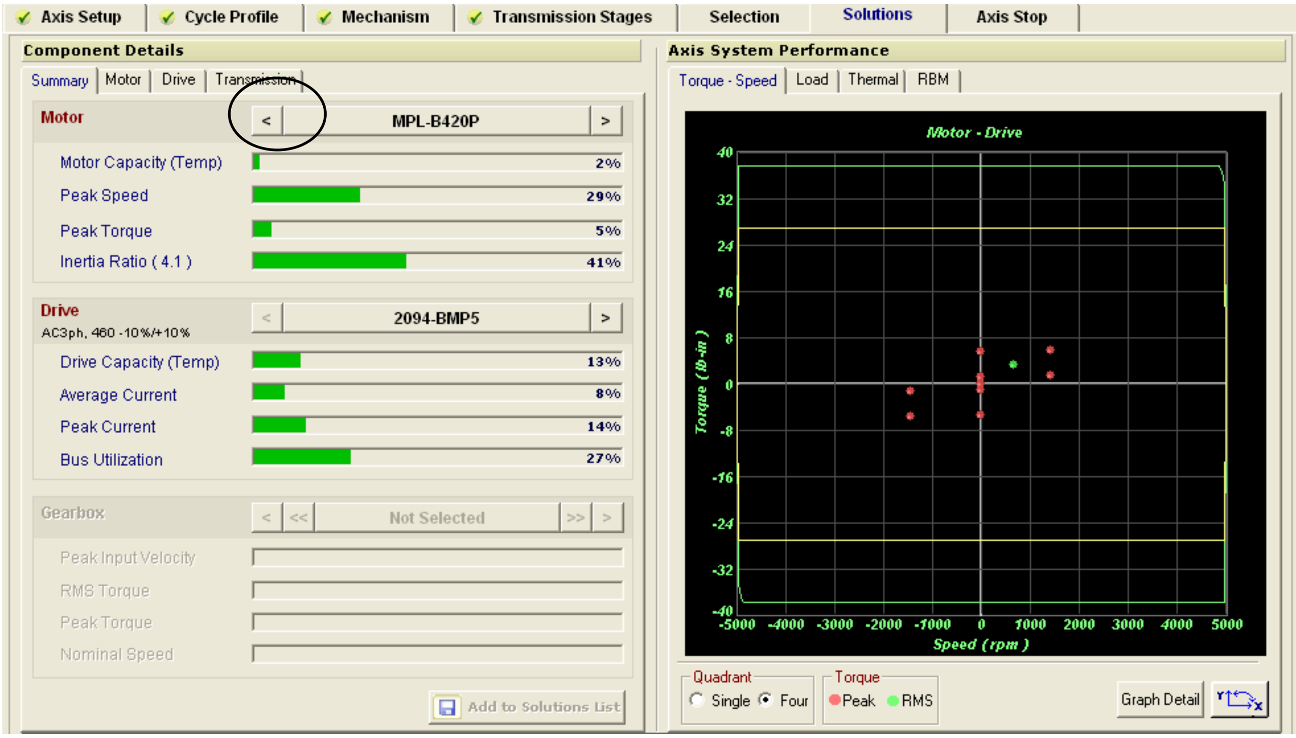


26. You can see that the first two solutions are flagged as a Solution State 2, meaning "Caution." Use the **scroll bars** to move over far enough to see that **Inertia Ratio** is causing this rating. It has exceeded our 80% safety margin.

27. Double-click on the **third solution** in the list, the MPL-B420P motor with the 2094-BMP5 drive.

The bar graphs are all green and the Torque-Speed curve shows continuous and peak data points within the correct regions.

28. The required speed and torque are actually quite low for this motor. Why didn't the software choose a smaller motor? You can easily review the results of other motors (or drives) using the handy Previous/Next buttons in the bar graph area. Use the **Previous button** to view the performance of smaller motors.

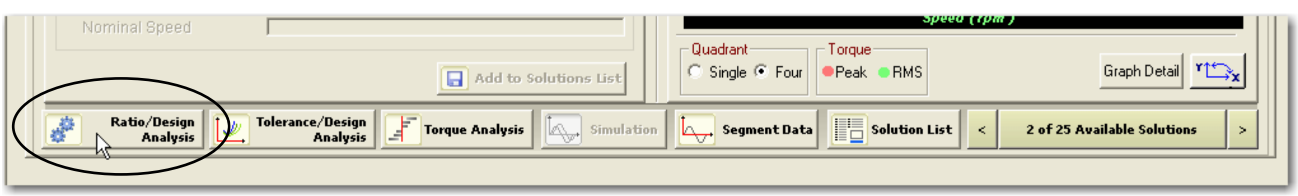


29. It looks like Inertia is the reason this motor was chosen. Use the **Next button** to return to the **MPL-B420P** motor selection.

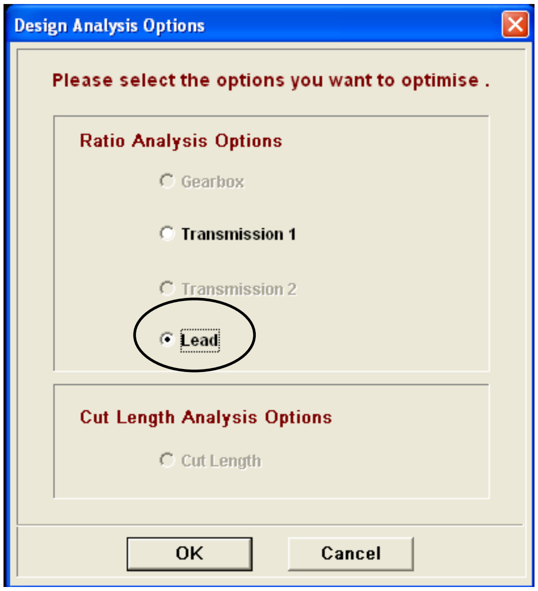
Using the Ratio/Design Analysis Tool

This is a great solution for our existing data with plenty of safety margin. But what if there something that we could change now (in the design phase) that would allow us to use an even smaller motor? We mentioned that gearbox reduction is *not* typically required when using lead screws. This is because the reduction comes from the screw itself. Our screw moves 1 inch for every motor revolution. What would happen if we chose a screw that took 2 or more revolutions to move an inch? Now we are leveraging motor velocity to gain torque and inertia reduction! We can use Motion Analyzer's *Ratio/Design Analysis* tool to find the best lead screw for our needs.

30. Click on the **Ratio/Design Analysis** button at the bottom of the **Solutions** screen.



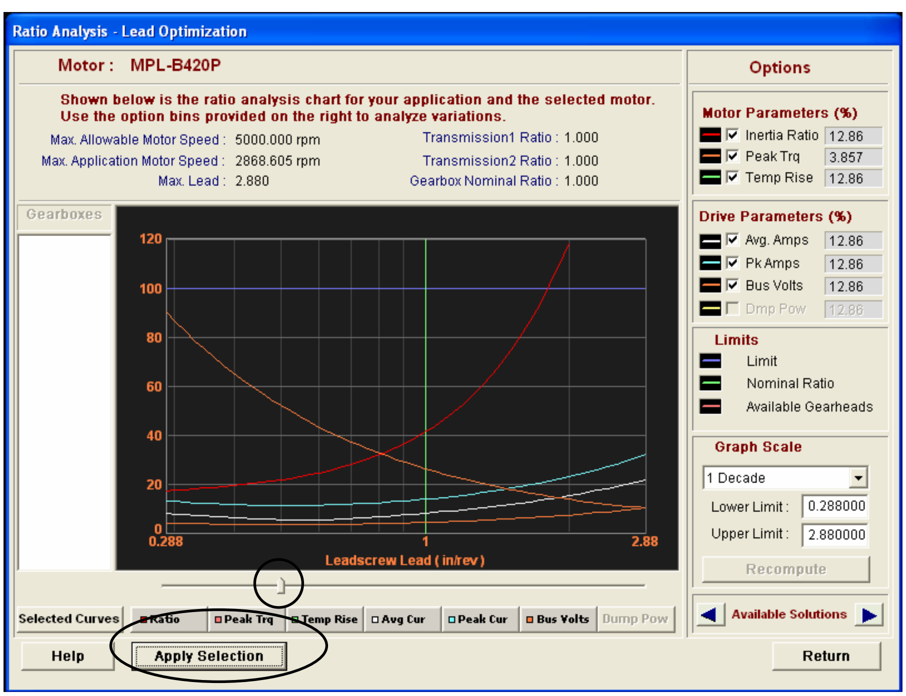
31. Choose the lead screw **Lead** option and press **OK**.



This same tool could also be used to you assist in choosing the optimum gearbox ratio and even a belt and pulley ratio.

32. The idea here is **use the Ratio slider bar** to find a solution with the lowest torque values, without sending the other values above 100%. It looks like **Bus Volts** (orange) and **Inertia** (red) are going to be our upper limits.

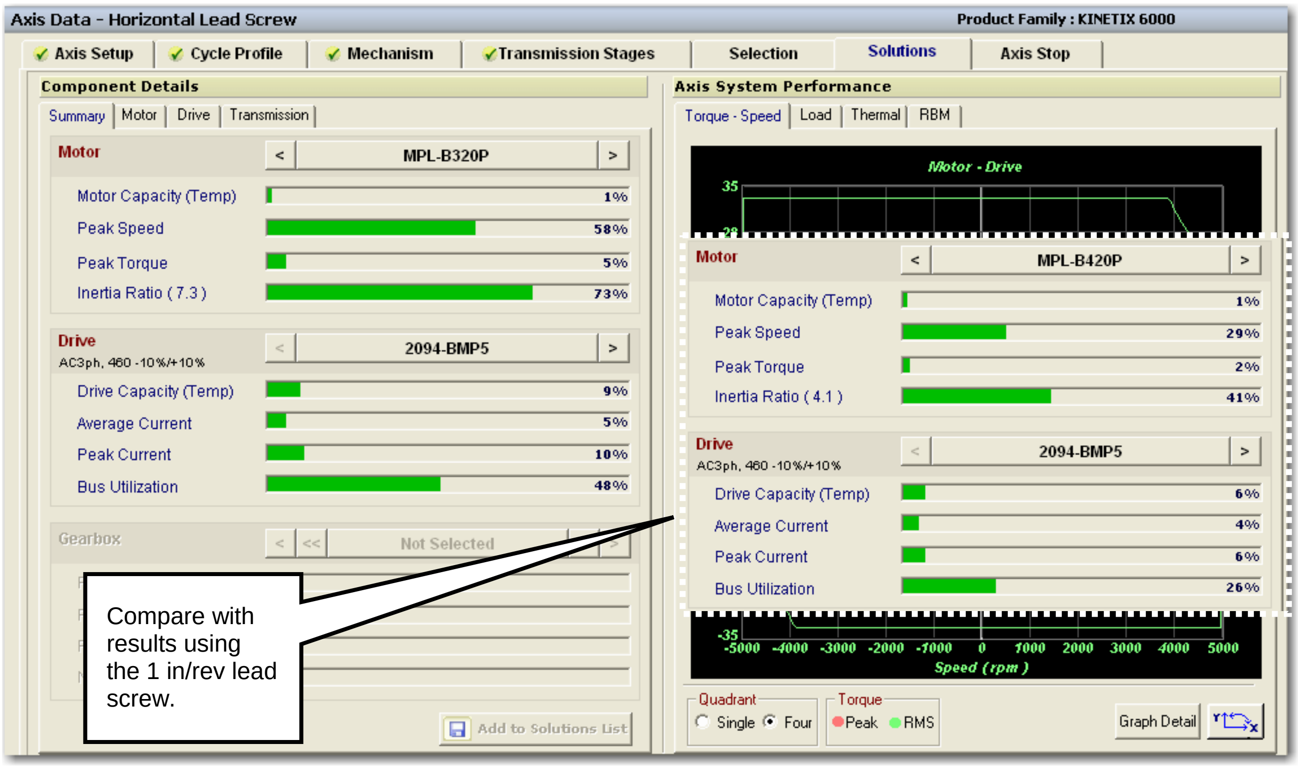
33. The graph shows that a lead of about 0.80 has the lowest values for nearly everything, but that may not be a significant enough change to make a difference. Besides, screws are not readily available in that lead. What about a **0.5 lead**? Place the slider there and press the **Apply Selection** button. **Confirm** the prompt to view the results.



34. It looks like this change leaves us with plenty of margin for our key motor and drive values, plus the inertia ratio dropped from 4.1 to 2.2. This indicates that a *smaller motor could possibly do the job*! Press **Return** when complete. A full comparison is shown below.

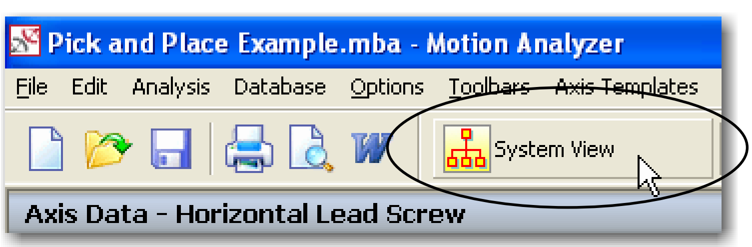
35. The Ratio tool indicates that going below the 0.5 lead value requires more Bus Voltage than we can provide. Press **Return** until you are back at the original Torque-Speed curve.

36. *To actually make this recommended change*, return to the **Mechanism** tab and change the Lead value to **0.5 in/rev**. **Search** for a smaller motor for this axis. It looks like an **MPL-B320P** motor with our 2094-BMP5 drive are the lowest cost solution within our tolerances.



We could suggest to the mechanical design team that a "1/2" lead ball screw might be a better overall solution, but either are valid solutions.

37. Return to the **System View**.



38. Be sure to **save your work**. Confirm any prompts and choose a location to save your file.

Lab 3: Sizing a Vertical Lead Screw (10 minutes)

About This Lab

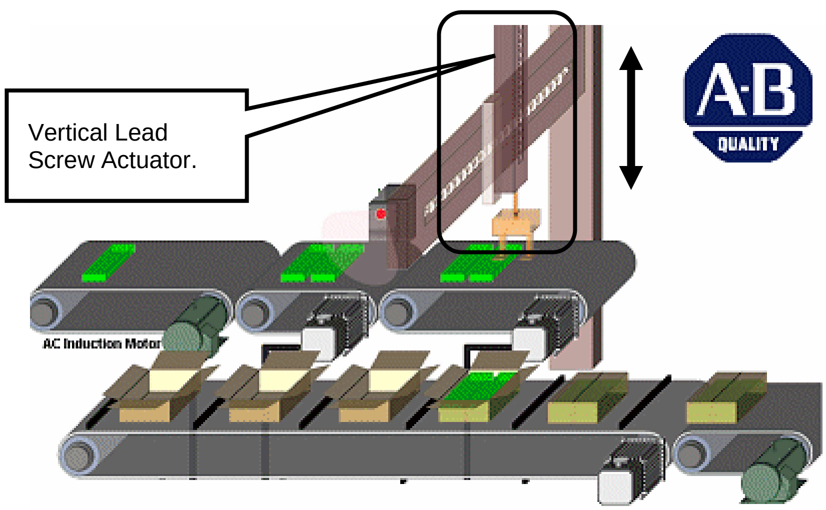
We've completed sizing a horizontal lead screw, so we understand what is involved with this type of actuator. What happens when we use a lead screw in a vertical application? What are the effects of gravity on the motor and drive? What additional considerations are we responsible for investigating? In this lab, you will:

- Reuse axis data from an existing axis
- Edit the MultiSegment Move Profile Data
- Select a motor and drive for your vertical lead screw axis
- Analyze the system using the Shunt Analysis tool

Follow the steps below to complete Lab Section 3.

Reusing Existing Axis Data

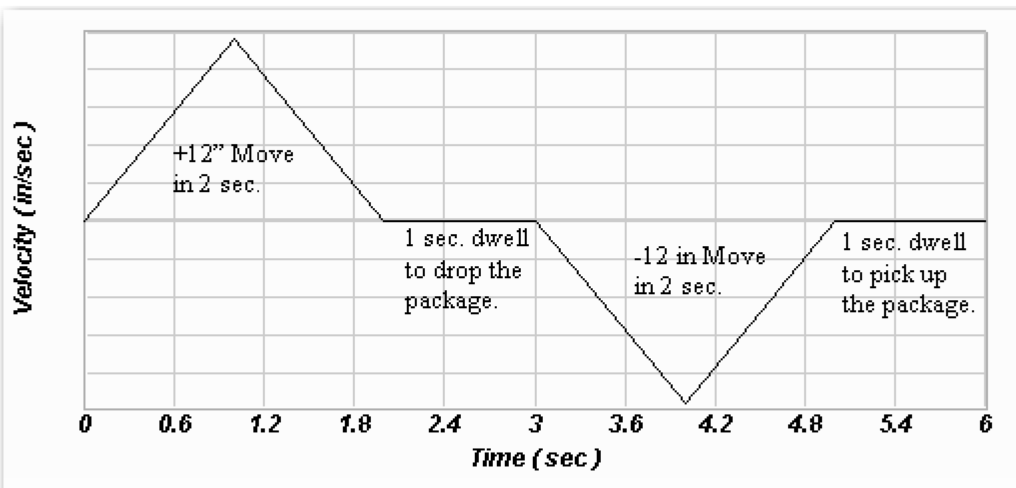
If you've already created an axis of motion similar to your current axis in Motion Analyzer, you can easily copy and paste the data as a quick starting point. In this section of the lab, you will use the axis data from the previous lab (the horizontal lead screw) as the starting point for sizing the vertical lead screw axis.



Vertical Axis Data:

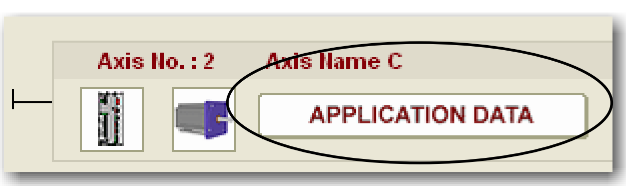
- Package weight to be moved = 1 lb
- Total Slide Mass = 50 lbs
- Coefficient of Friction = 0.01 (=1%)
- Lead Screw Specification:
  - Lead = 1"/rev
  - Length = 24"
  - Diameter = 1"
  - Material = Steel
  - Efficiency = 90%
- Motor Coupling Moment of Inertia = 2.6g-cm^2
- Bi-directional move of 12" in 6 seconds overall. See cycle drawing.

It looks like the Total Slide Mass and the Move Profile are the only differences in the axis data. The required **Velocity Profile** for the vertical axis is shown below.



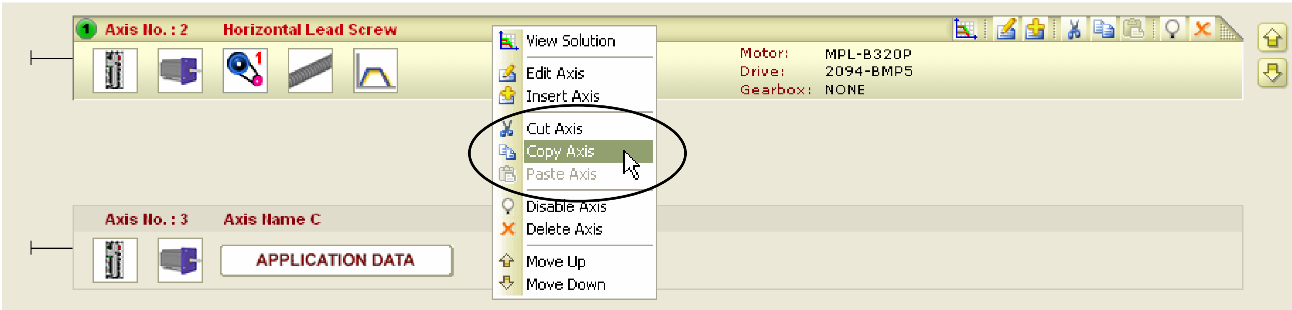
The move profile is described as "lifting the product from the **picking point**, pausing for 1 second while the horizontal moves over, lowering the product back down to the **placing point** and pausing for 1 second to release the product."

1. Click on the **Application Data** button for the third axis.

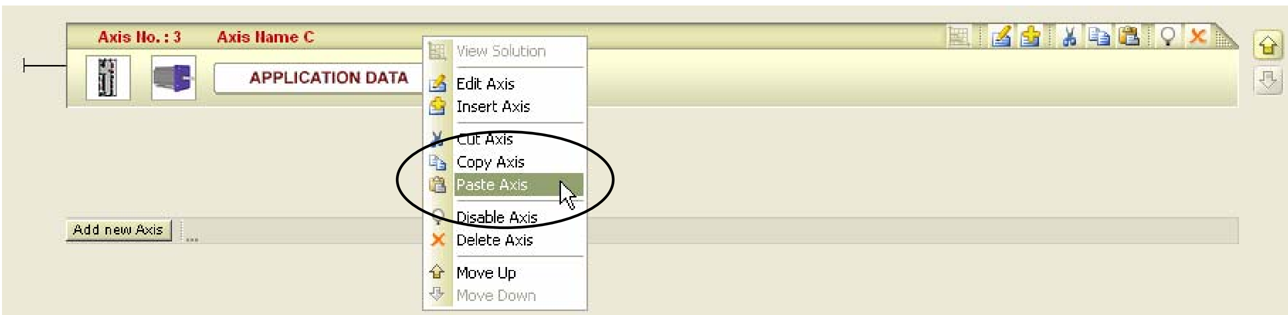


We would normally begin manually entering the data at this point, but we can use the horizontal axis data to get us to a faster start.

2. **Right-click** on the Horizontal Lead Screw axis and select **Copy Axis**.



3. Next, **right-click** on the third axis and select **Paste Axis**. Confirm by answering **Yes** to the prompt.



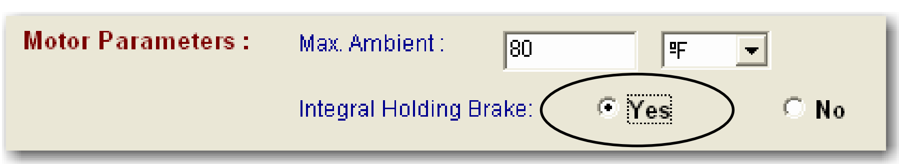
The information is brought in.

4. **Double-click** on the third axis to begin editing the data for the vertical axis.

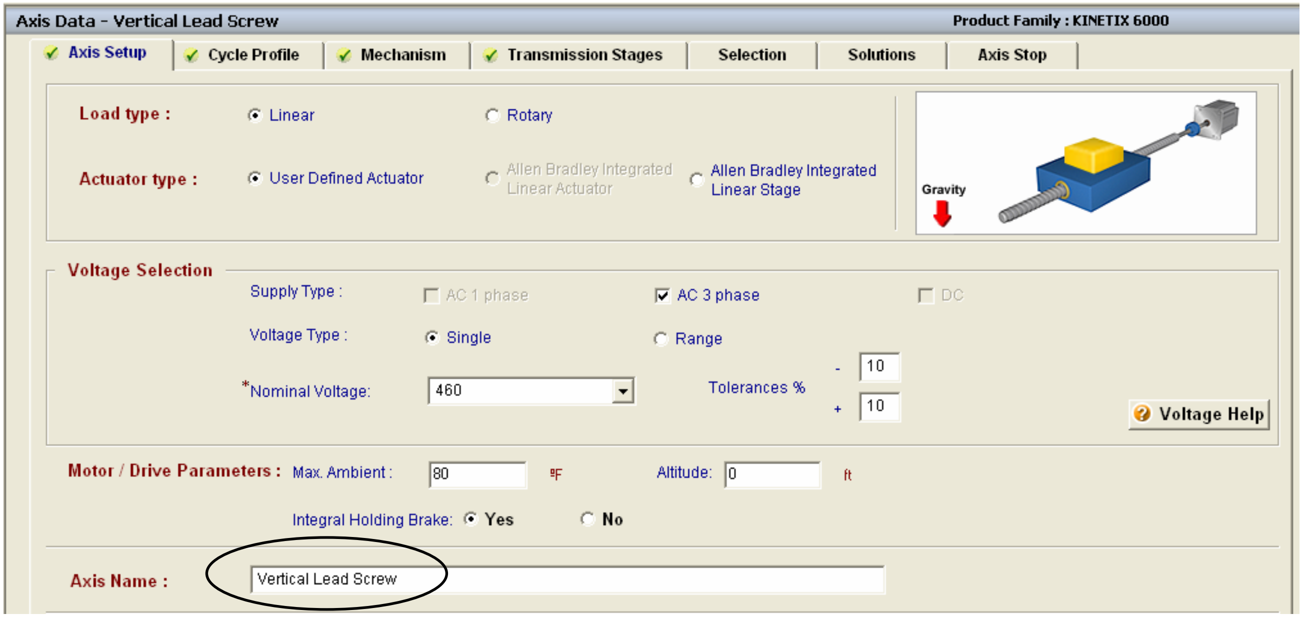
5. Begin on the **Axis Setup** tab.

> NOTE: If power is ever removed from this vertical axis, the motor would not have the ability to hold (or stop) the load from falling. Therefore, we need to select an option that will do so. Since this is a **factory only option**, so we must be careful to remember to add it before we place an order.

6. Select the **Integral Holding Brake** option.



7. Finally, change the name of the axis to **Vertical Lead Screw**.



8. Proceed to the **Cycle Profile** tab.

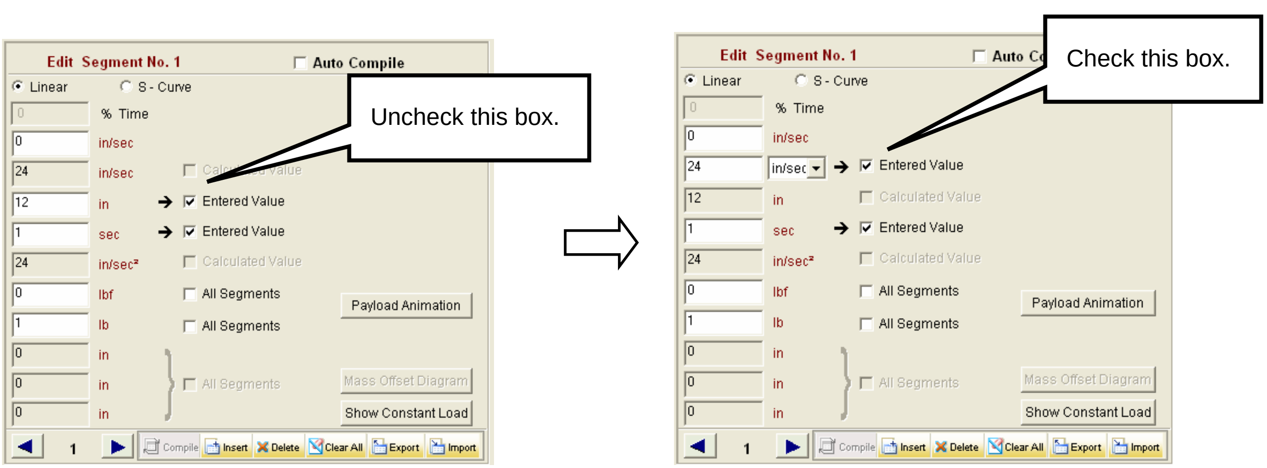
Edit the Move Profile Data

In this section of the lab, you will need to change the 24" move profile to a 12" move profile.

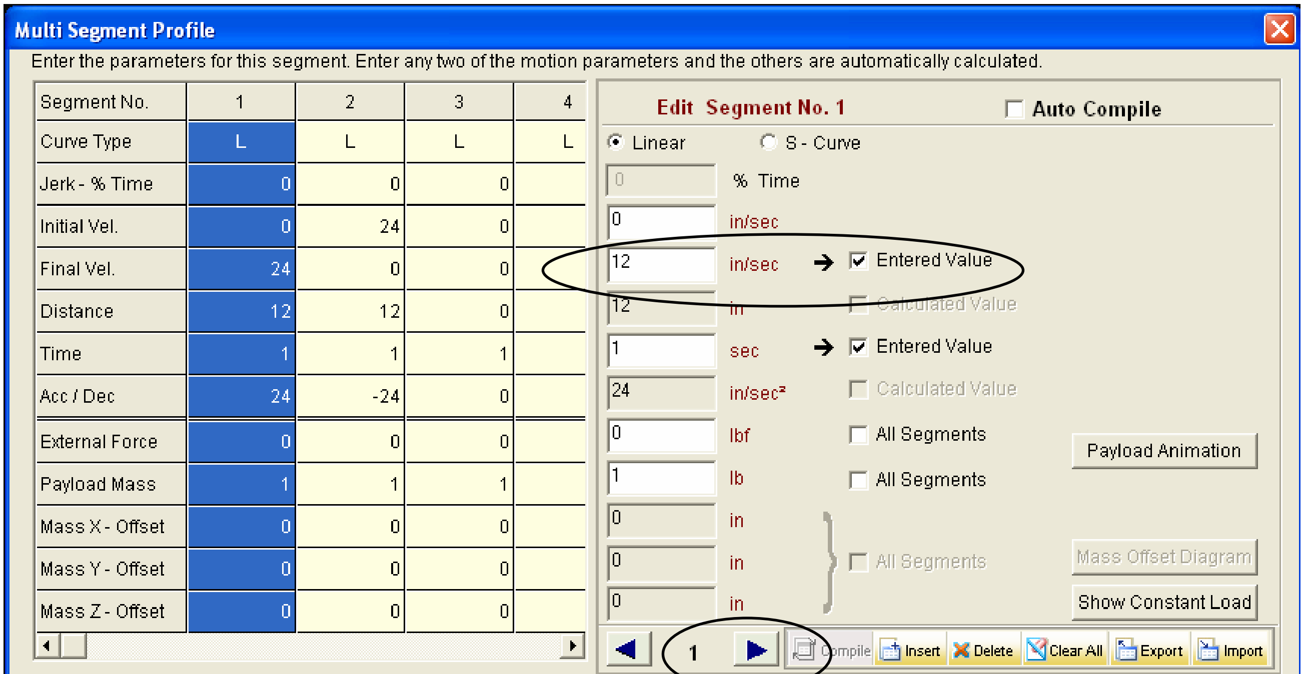
9. With the **MultiSegment** option selected, click on the **Cycle Profile Data** button.

10. To do this *without getting compile errors*, turn off Auto Compile by **un-checking the Auto Compile box**.

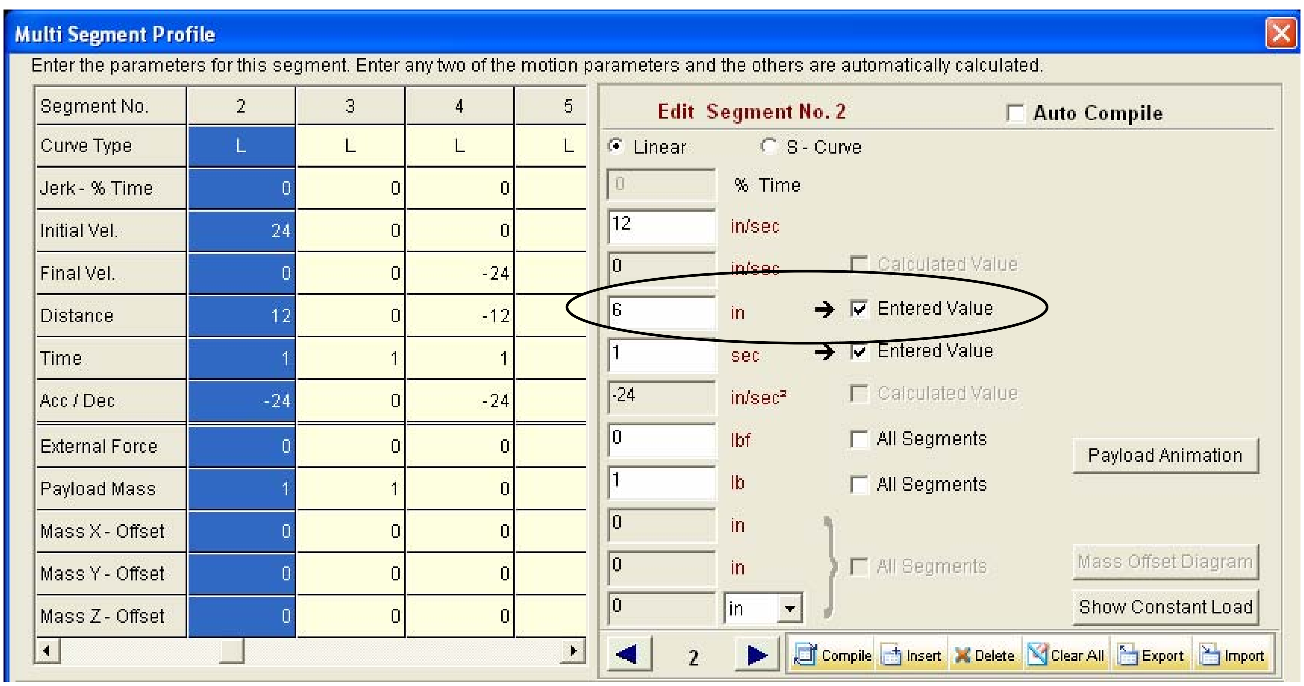
11. In segment 1, the easiest way to change the move profile without causing discontinuity with the next segments is to change the selected Entered Values. **Uncheck the box for Distance** and **check Final Velocity**.



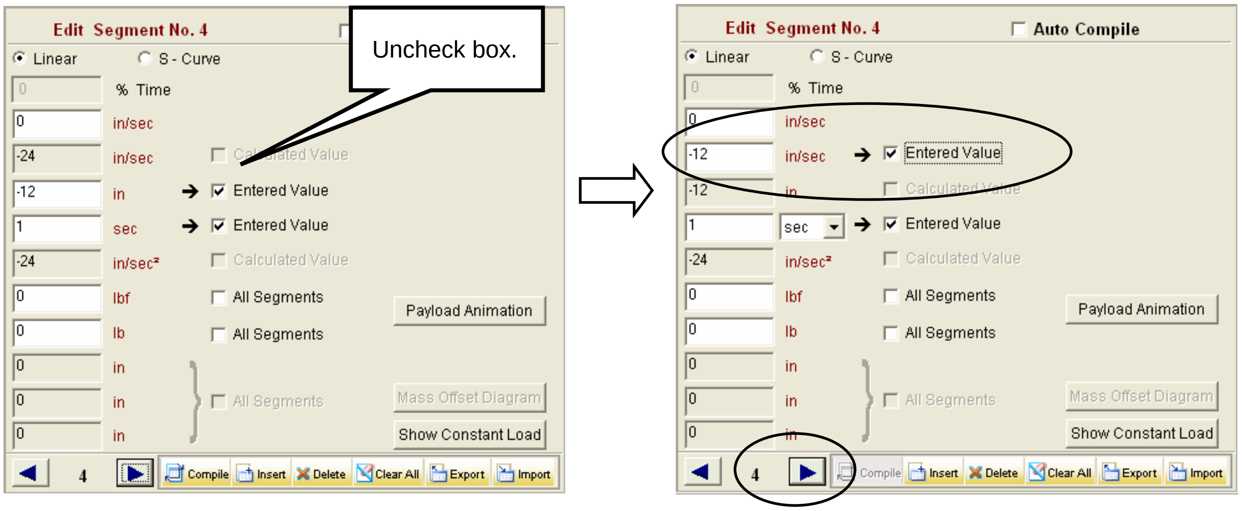
12. Then **change the 24 in/sec value to 12 in/sec**. Press the **right arrow**.



13. For segment 2, simply change the **Distance value to 6"**. We don't need to change anything for the dwell period in segment 3.

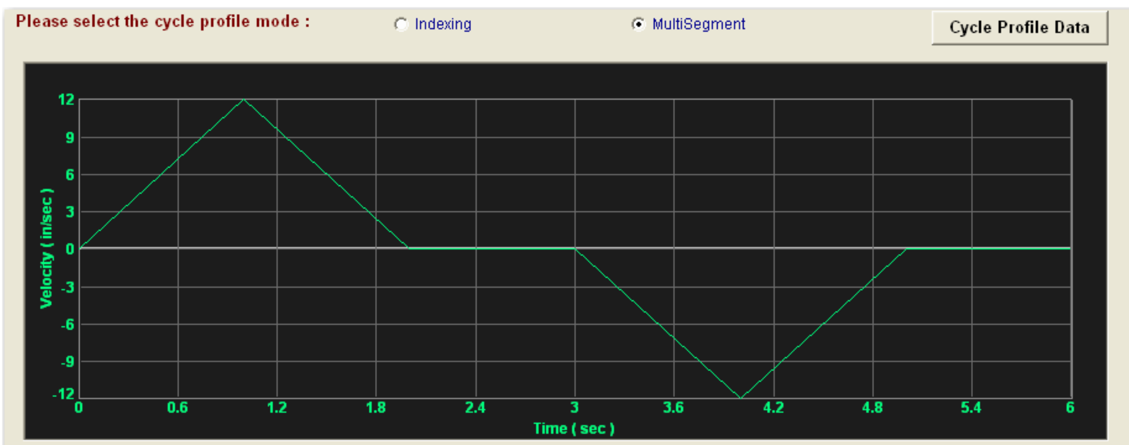


14. In segment 4, **uncheck the box for Distance** and **check Final Velocity**. Then **change the -24 in/sec value to -12 in/sec**. Press the **right arrow**.



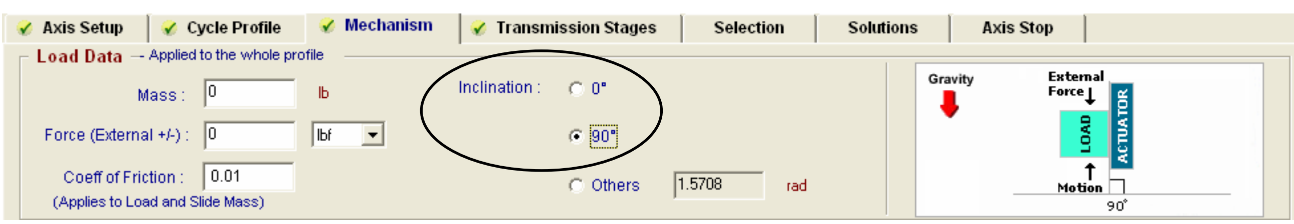
15. Finally, change segment 5 to a **-6" move**, as above. Press **OK** when complete.

16. Your move profile should look as follows.



17. Move to the **Mechanism** tab.

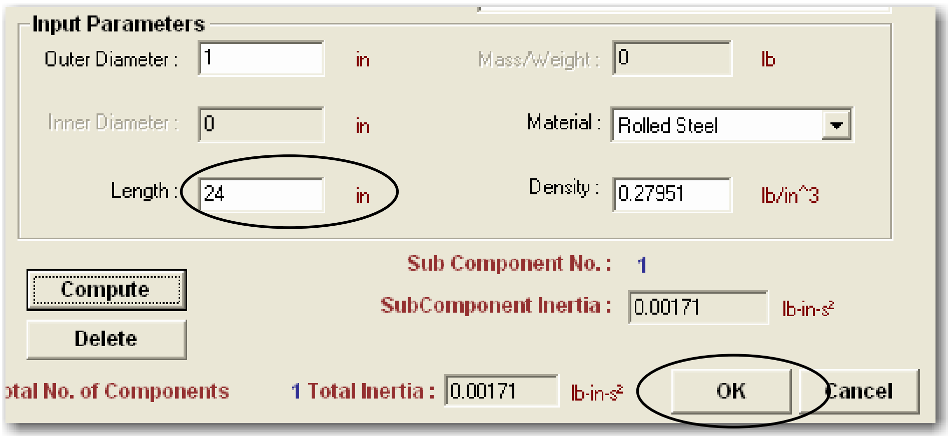
18. Most importantly, change the **Inclination** value to **90 degrees**, to reflect our vertical axis. Press **OK** when the brake message appears.



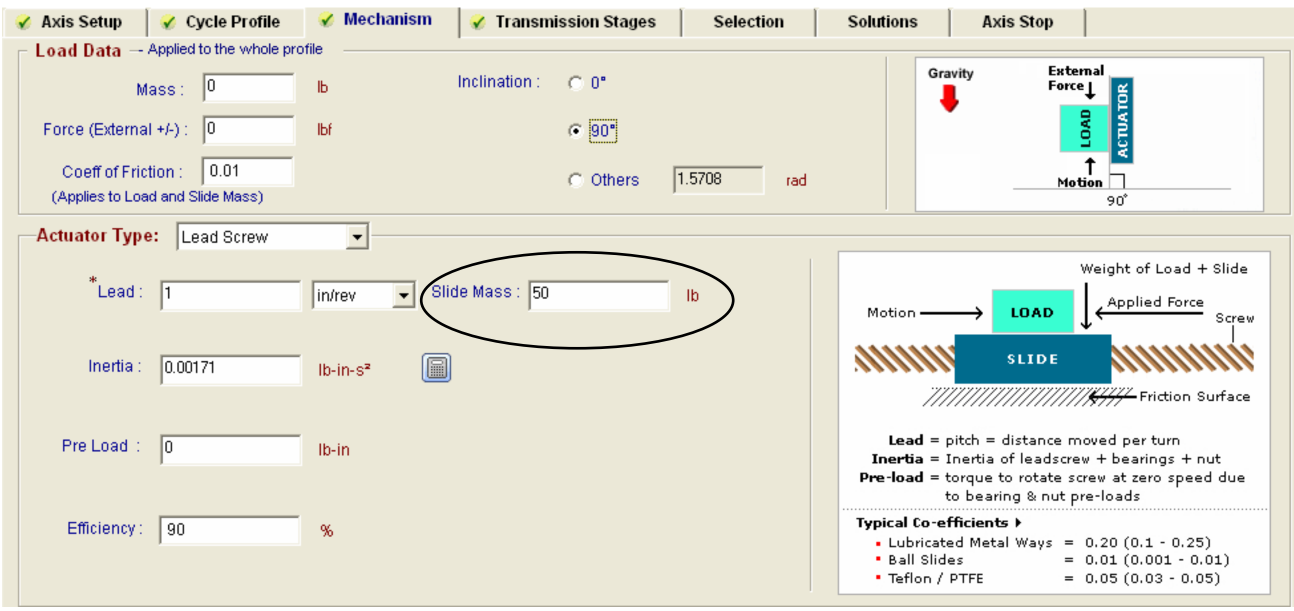
19. If it isn't already, set the **Lead value to 1 in/rev** from the application data. We will be much less affected by inertia on this smaller axis.

20. Click on the **Inertia Calculator** button.

21. Change the **Length** value to **24"** and press the **Compute** button. Press **OK** when complete.



22. Change the **Slide Mass** to **50 lbs**. Your vertical lead screw data should look as follows:

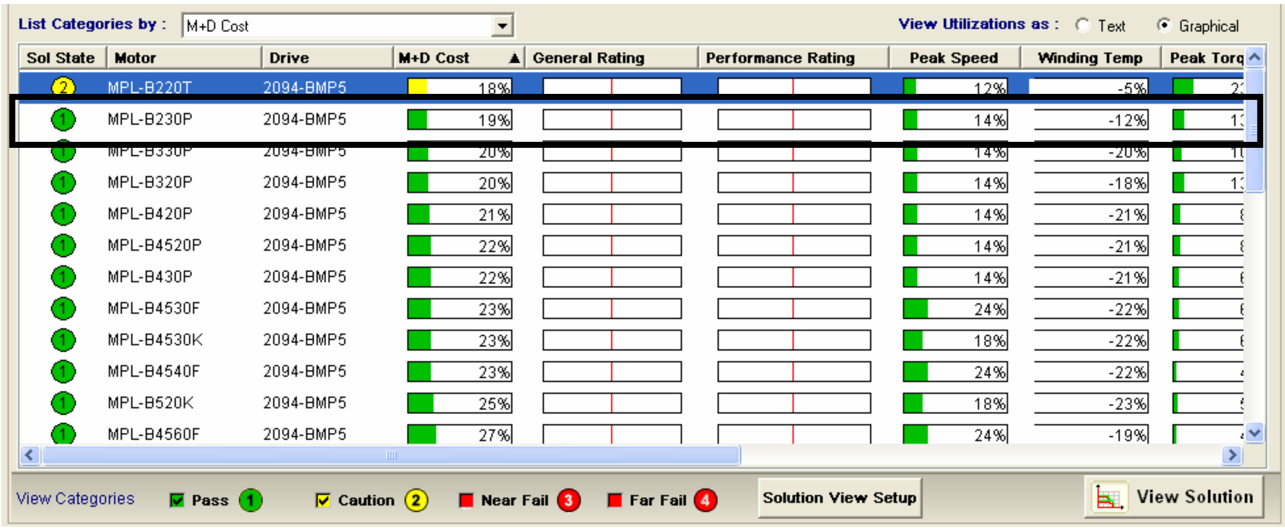


23. The coupling is the same as from the horizontal axis, so move to the **Selection** tab.

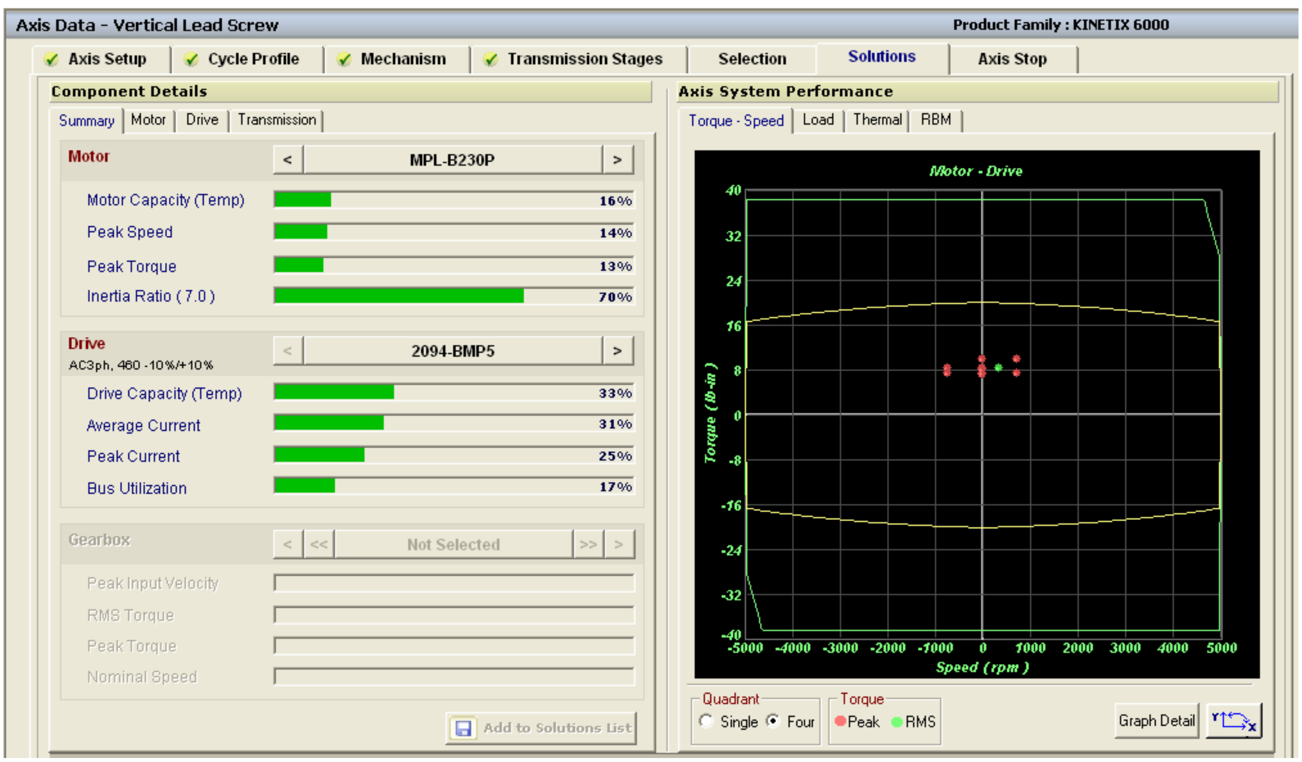
Select the Motor and Drive

24. All of our preferences came over from the previous axis, so press the **Search** button to begin looking for a valid solution.

25. When the list appears, be sure that it is sorted by **M+D Cost** again and open the **first green solution** in the list.



26. This solution looks great and the motor and drive are some of the smallest that we offer. We are satisfied.

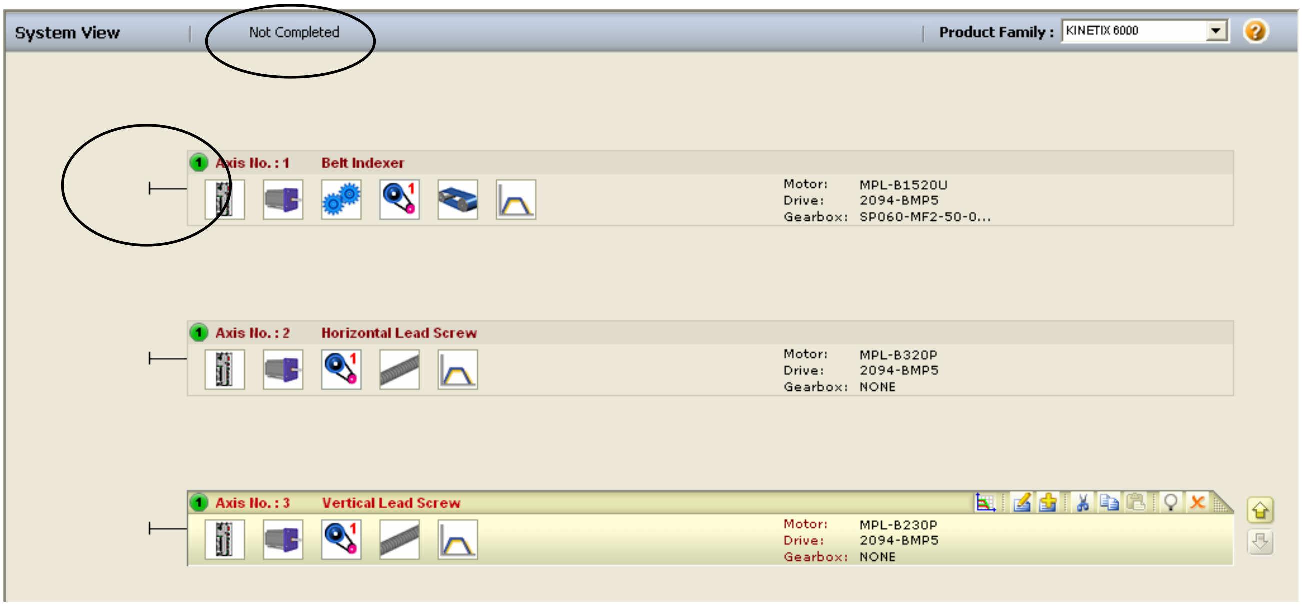


27. Return to the **System View** as before.

28. **Save** your work.

Analyze the System Shunt Requirements

You may have noticed the prompt that keeps appearing when you save your work. It mentions a system shunt. There are also some clues in the System View that alert us to the fact that we are not done yet.



Kinetix 2000 and 6000 drives are multi-axis drives and include (1) integrated axis module where the AC supply voltage is provided and up to (7) additional axis modules. The integrated axis modules contain a converter that creates an internal DC bus voltage on the backplane which powers the additional axis modules. The integrated axis module must be sized large enough to provide the required DC power to the axis modules.

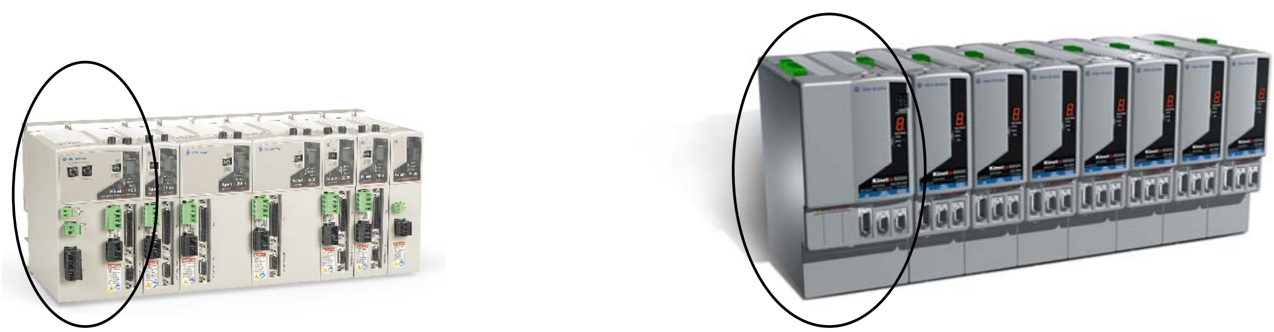
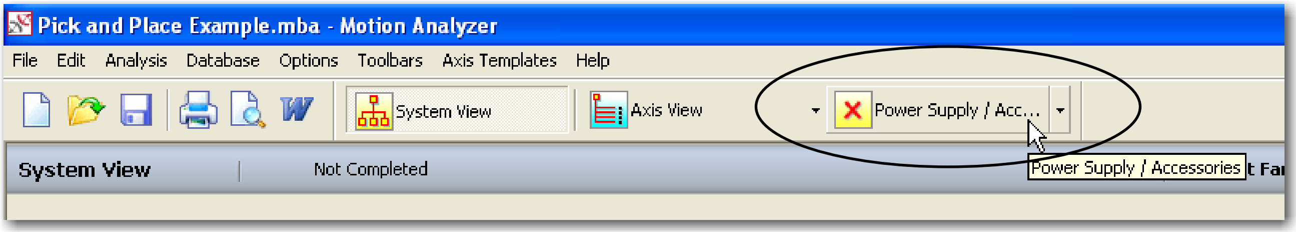


Fig. 2 The left-most drive is the Integrated Axis Module and the others are expansion Axis Modules

Additionally, most servo drives contain a shunt resistor that helps to prevent the internal power bus from an overload. This is typically a concern when stopping the axis; especially when stopping a vertical axis from falling because gravity is working against you. Kinetix 2000 and 6000 drives can share their shunt capacity across the backplane, so if one drive requires additional stopping power and another drive has extra capacity, they work together. This can save on shunt costs and space requirements.

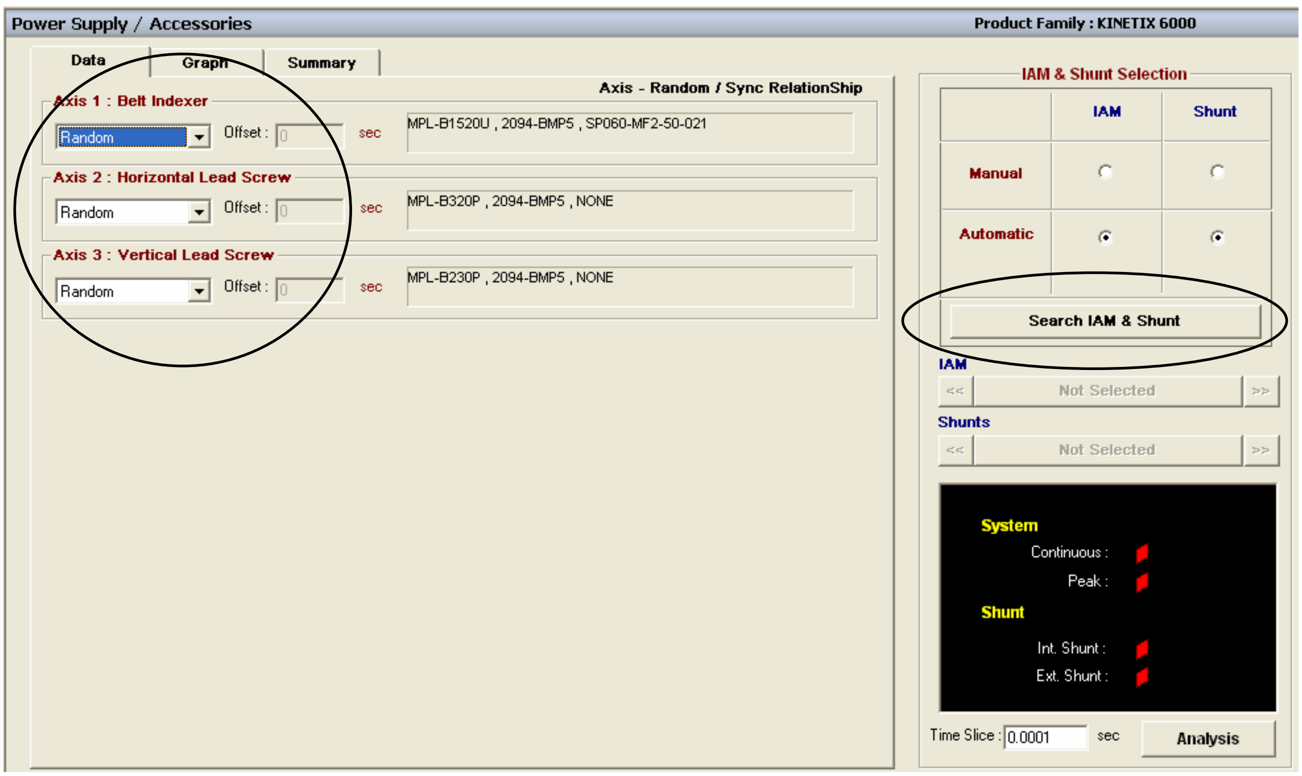
Motion Analyzer contains tools to assist you in determining the needs of your system.

29. To select the proper integrated axis module and determine if your system requires additional shunting components, click on the **Power Supply / Accessories** button at the top of the screen.

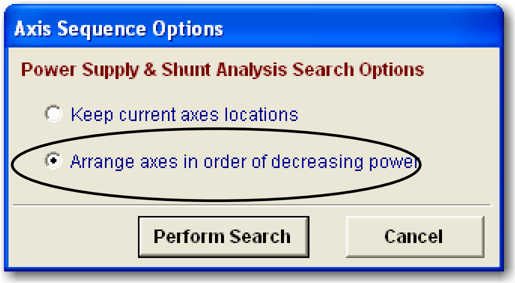


The phase relationship between the various axis profiles in a common DC bus system affects the peak bus current requirement. For example, if all axes accelerate simultaneously, the bus current demand will be much greater than if each accelerates in turn. Drop-down boxes allow the user to set the axes for random or synchronized operation if you know this relationship.

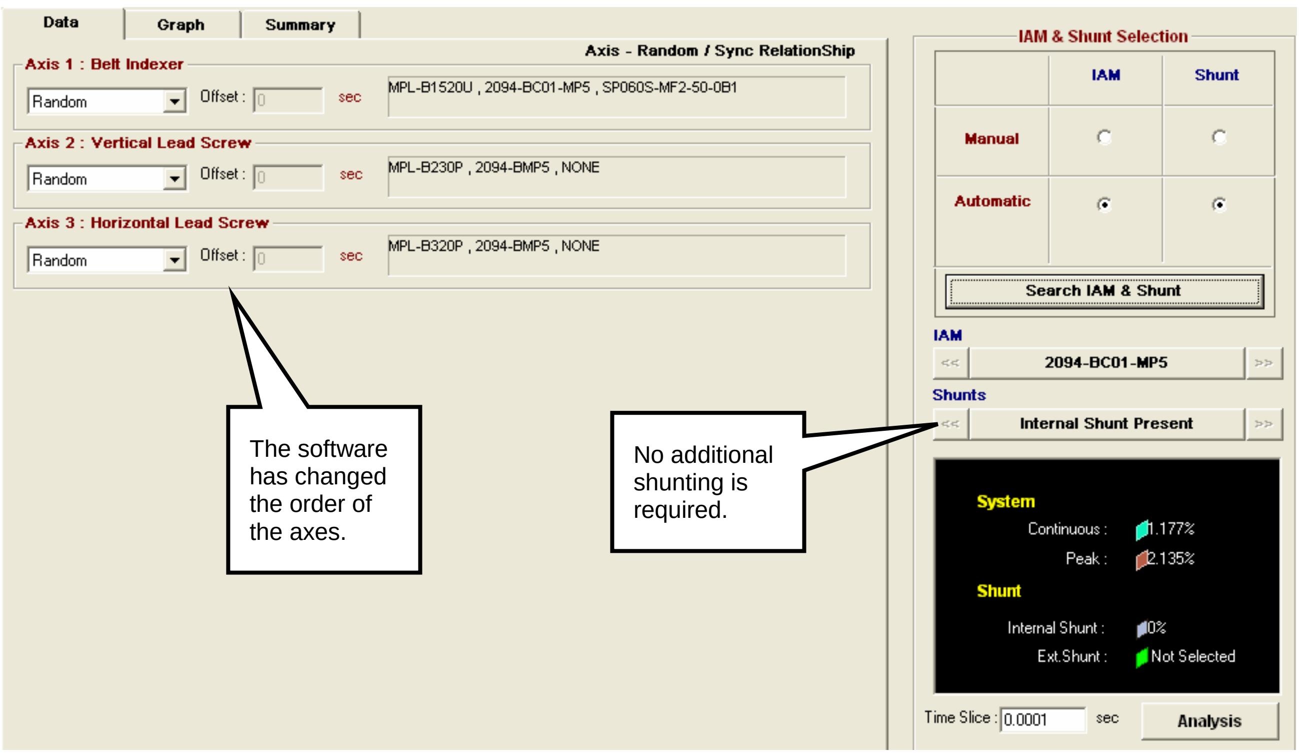
30. The "safe" setting for system sizing is all "Random." In this case, the worst case current demand for each axis is automatically lined up by adjusting the phase relationship of the axis profiles. Leave the axes set to **Random** for our system. Press the **Search IAM & Shunt** button to automatically size and select your required components.



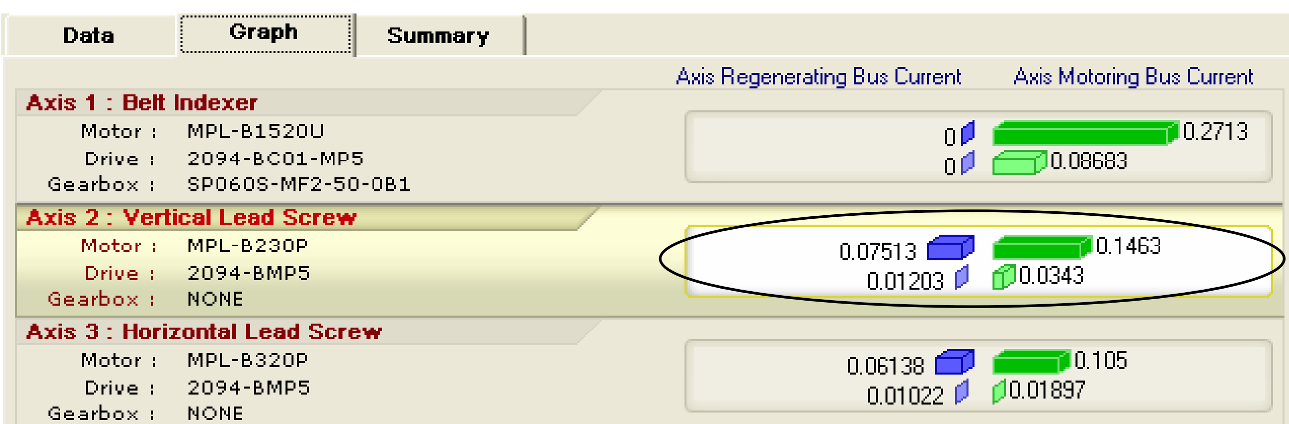
31. Unless you know that Axis 1 is the largest, select "**Arrange axes in order of decreasing power**" and press **Perform Search**.



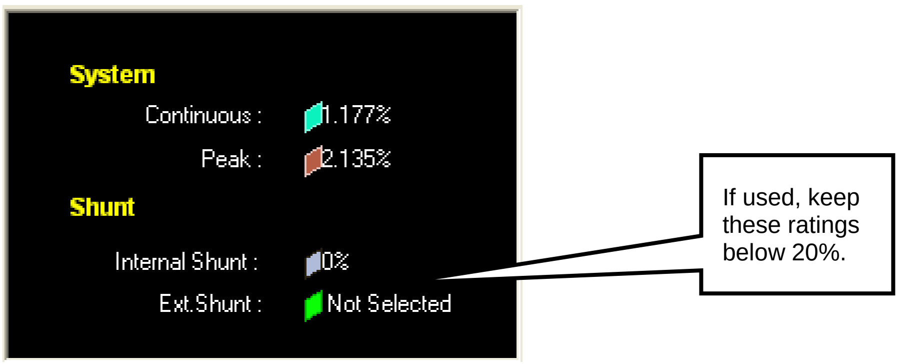
32. The software is not requiring any additional shunting components. The internal shunts are sufficient in this application.



33. If you select the **Graph** tab, you can see that the Vertical axis does require the drive to absorb some regenerative bus current.



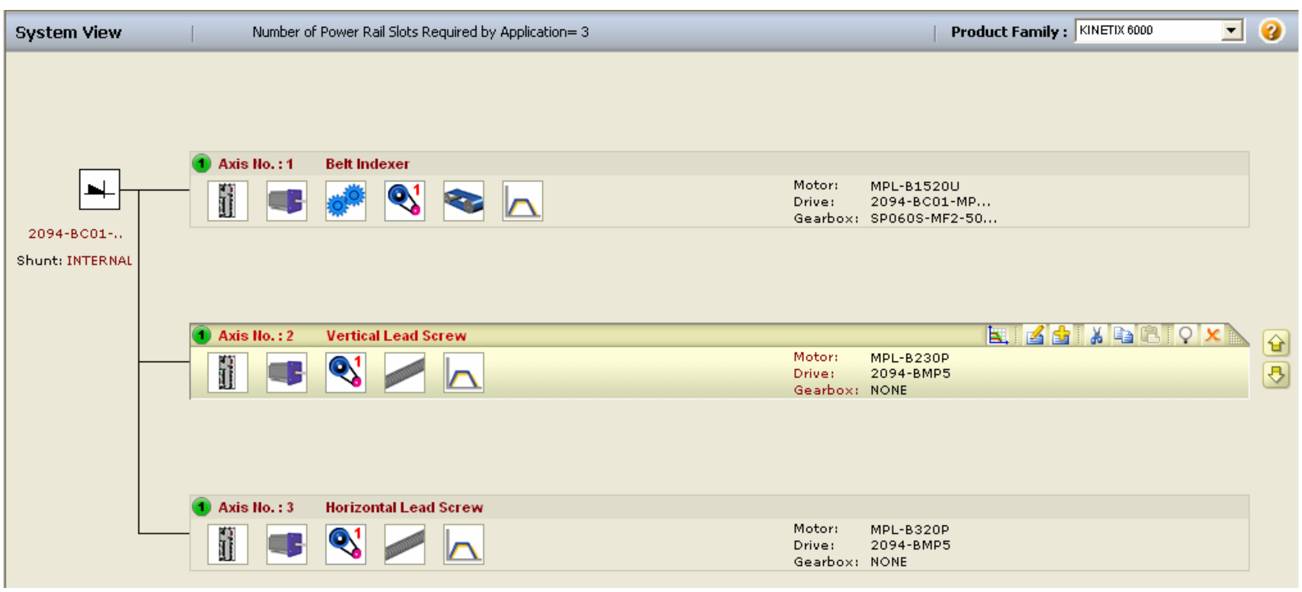
NOTE: If your system requires external shunting, be sure to keep the continuous usage percentage below 20%. These types of chopper/resistor sets are typically rated for a 20% duty cycle. If you are an inverter drive user, you already know this.



34. Return to the **System View** as before.

35. **Save** your work.

Your system is now complete! You can see the new order of the axes, as well as any motor, drive and gearbox part numbers. What about cables and accessories? There must be an easy tool for finding these, right?



Continue on with the Extra Task if you would like to use Motion Selector to create a complete bill of material for your motion system.

Extra Task: Using Motion Selector (20 Minutes)

About This Lab

In the Extra Task, you can use the Motion Selector tool to create a complete bill of material for your motion system. Motion Selector does not include the controller items, such as your CompactLogix L43 controller, but it does include all motion-related components. This can include servo motors, drives and cables, as well as the motion module for your CompactLogix system and the SERCOS fiber cables to connect them all together. In this lab, you will:

- Open Motion Selector and start with your Motion Analyzer file from labs 1-3 above
- Use Motion Selector's wizard tools to choose your axis components
- Choose the motion accessories that complete your bill of material

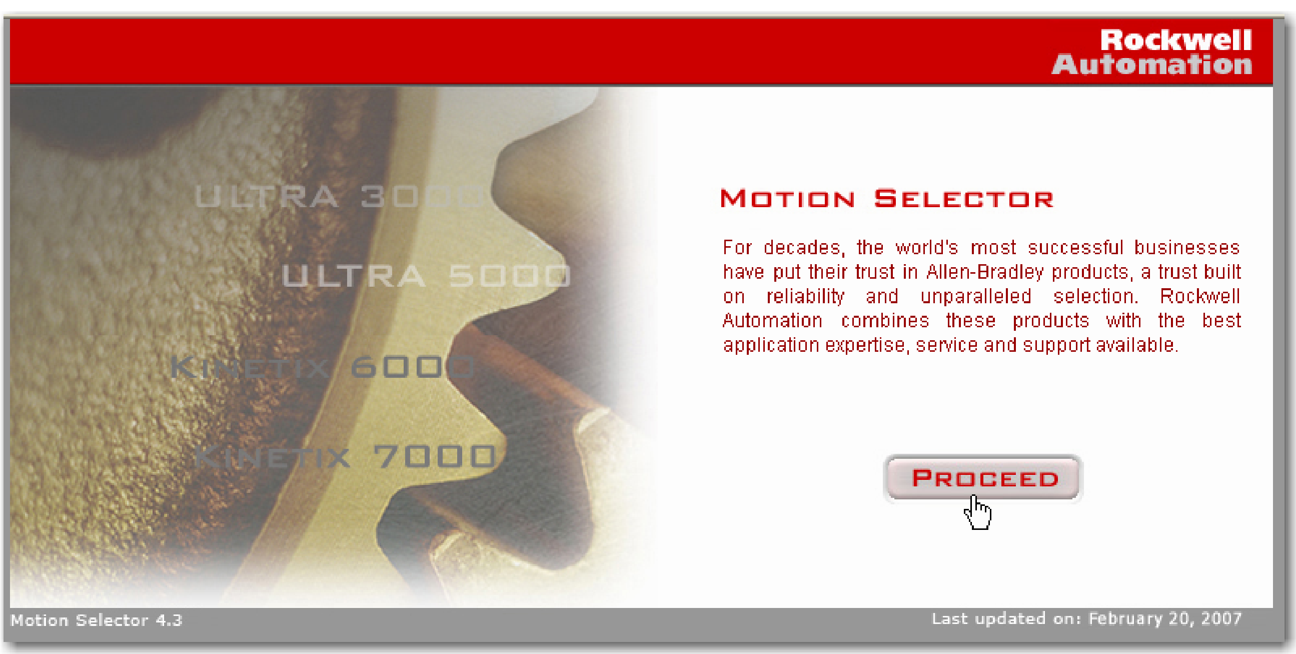
Follow the steps below to complete the Extra Task.

Open Motion Selector

Motion Selector is installed when you install Motion Analyzer, but runs separately. There should be desktop icons for each tool, or you can find them in the Start → Programs → Rockwell Automation tree.

1. **Open Motion Selector** by double-clicking on the shortcut in the upper right corner of the desktop.

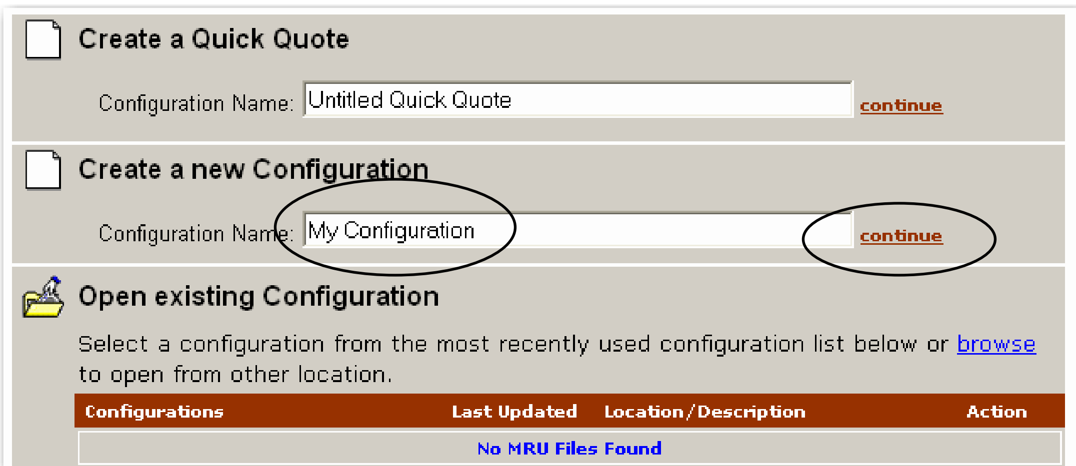
2. Click on the **Proceed** button from opening screen.



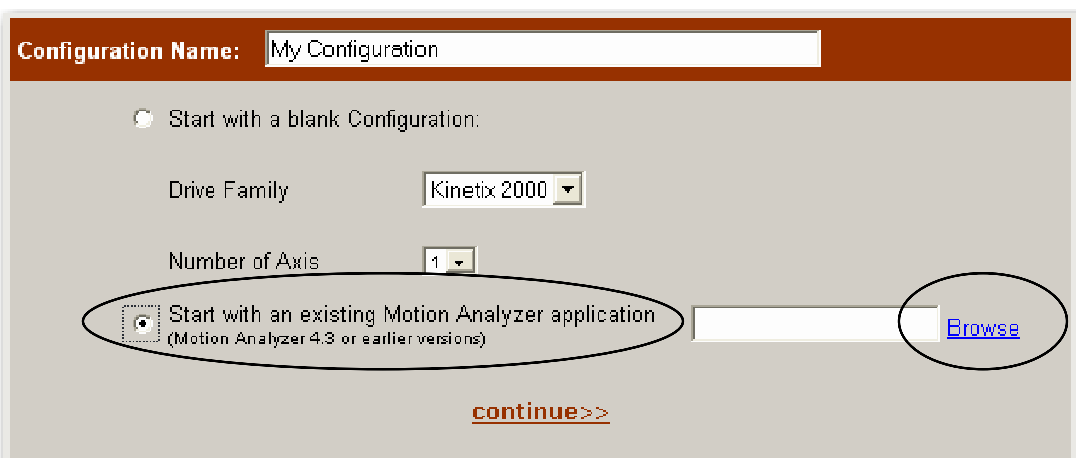
3. Your choices are defined as follows:

- **Create a Quick Quote** – After selecting the drive platform, you are given a list of all motors, cables and accessories for that platform. You simply enter a quantity for the items that you need and can then create a bill of material of them when you are done. *This selection requires that you know the part numbers of the items that you need.*
- **Create a new Configuration** – This selection allows you to select a drive platform and walks you through the (10) steps necessary to select a drive, motor, cables and all required accessories for each axis in your system. Although you do have to know your drive and motor part number, you can start with the ones already selected in *Motion Analyzer* simply by pointing to the completed system file. Selecting the rest of the components using this method is much more wizard driven.
- **Open existing Configuration** – This selection allows you to continue working with a Motion Selector project that you previously saved to a file.

4. We will start with our existing Motion Analyzer file by selecting the second option. Give it the name "**My Configuration**" and press **continue**.

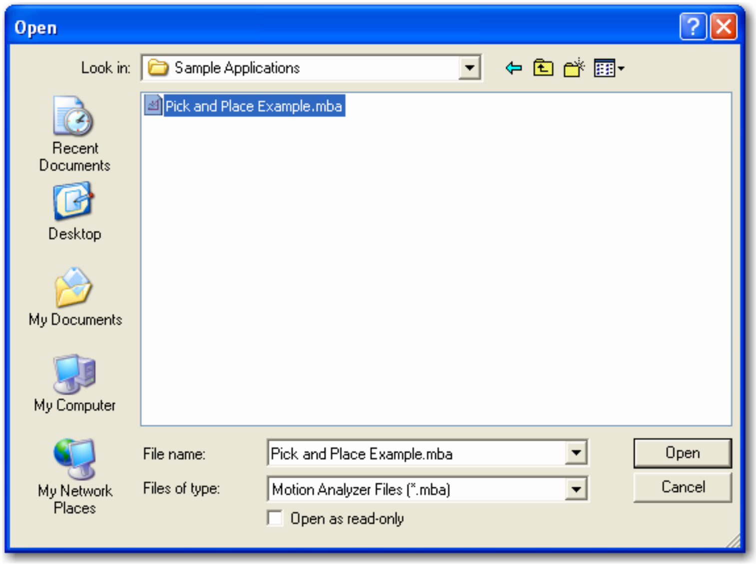


5. Select the **Start with an existing Motion Analyzer application** option and press **Browse** to locate your existing file.



6. Browse to the location of your file, in this case, **C:\Program Files\Motion Analyzer\Sample Applications**.

7. Select your “**Pick and Place Example**” file and press **Open**.

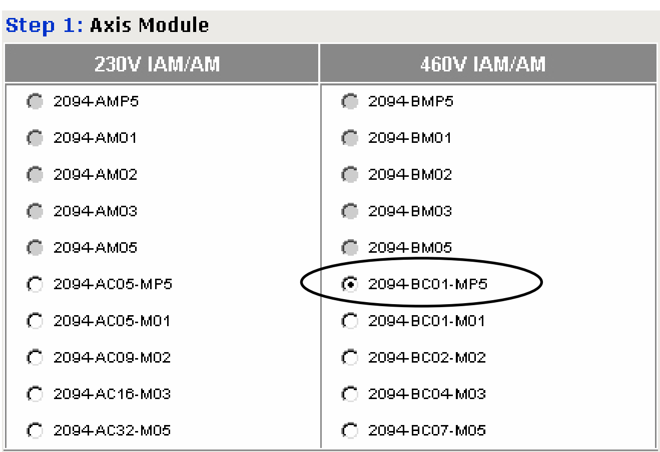


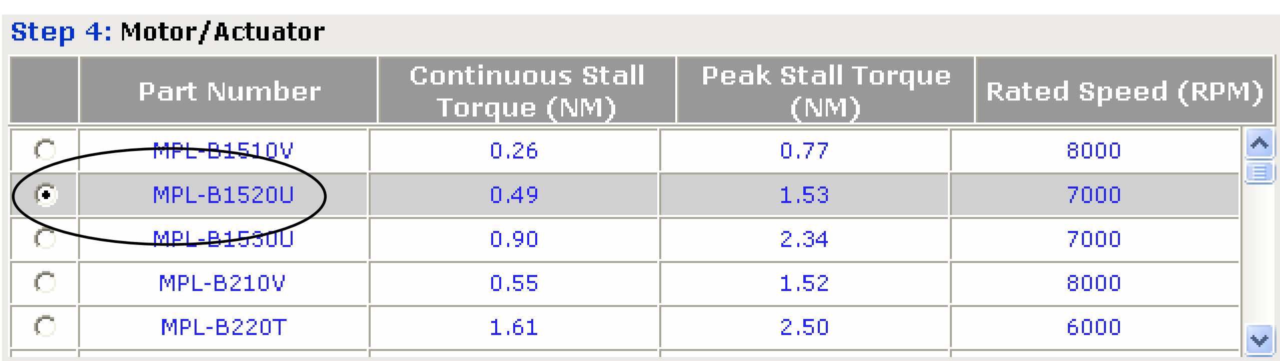
8. Press **continue**.

Using Motion Selector

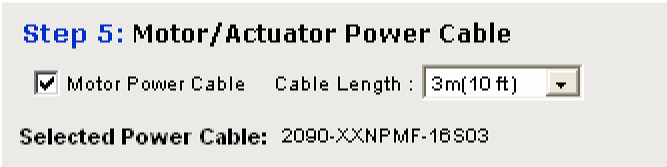
The selection of the motor and drive has already been completed for you, based on your selections from the Motion Analyzer file.

9. Axis 1 is our belt indexing axis and we can see **Steps 1-4**, have been selected for us.





10. For **Step 5**, **check the box** to include a motor power cable, and then use the drop-down list to select the **3m (10ft) cable**.



11. **Step 6** lets you choose either a pre-made cable or one with flying leads, but this also requires a connector. The note tells us that the connector is available in the Accessories section. Check the box for the **Universal** (flying lead) cable and select **3m (10ft)** as above.

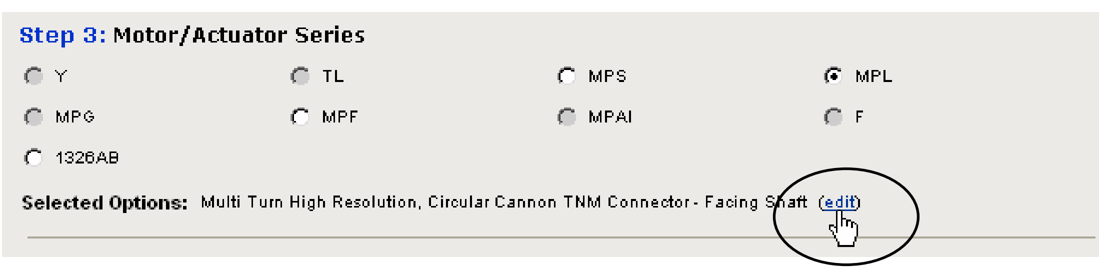
12. We don't need a brake cable for our belt indexing axis, so **skip Step 7**.

13. Resistive Brake Modules are used to dynamically stop a moving axis in the event of a drive loosing power. Our safety auditor says that this system doesn't require this option, so we will **skip Steps 8 and 9**.

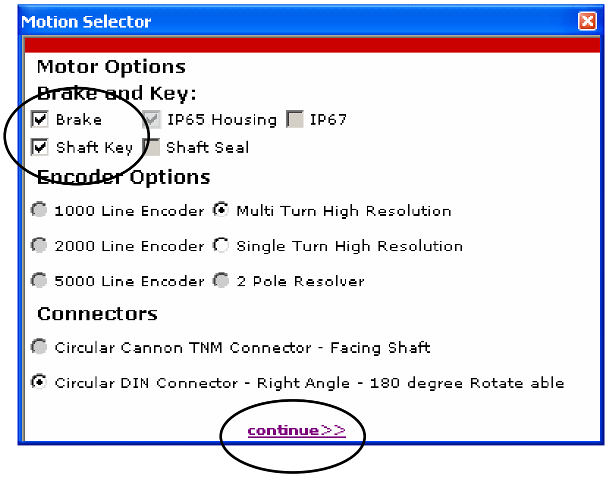
14. **Skip Step 10**, since Kinetix drives already include these particular connector sets as shipped. We will choose additional connectors (for our control I/O and feedback) in the Accessories section.

15. Press **continue** to move on to the next axis.

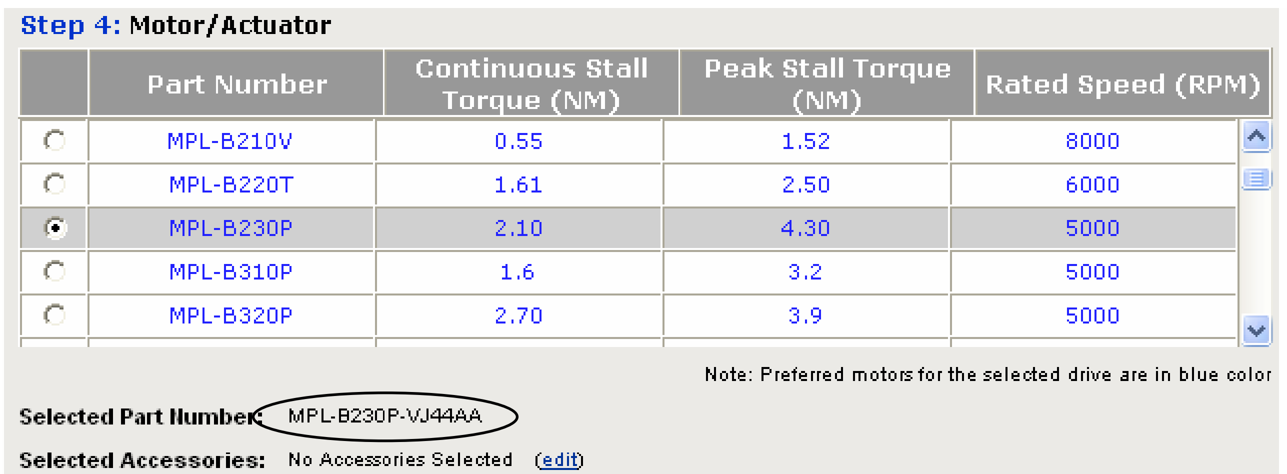
16. Axis 2 is our *vertical* lead screw axis, which requires a motor brake. Steps 1-2 are fine for our needs, but click on the **Edit** button in **Step 3**.



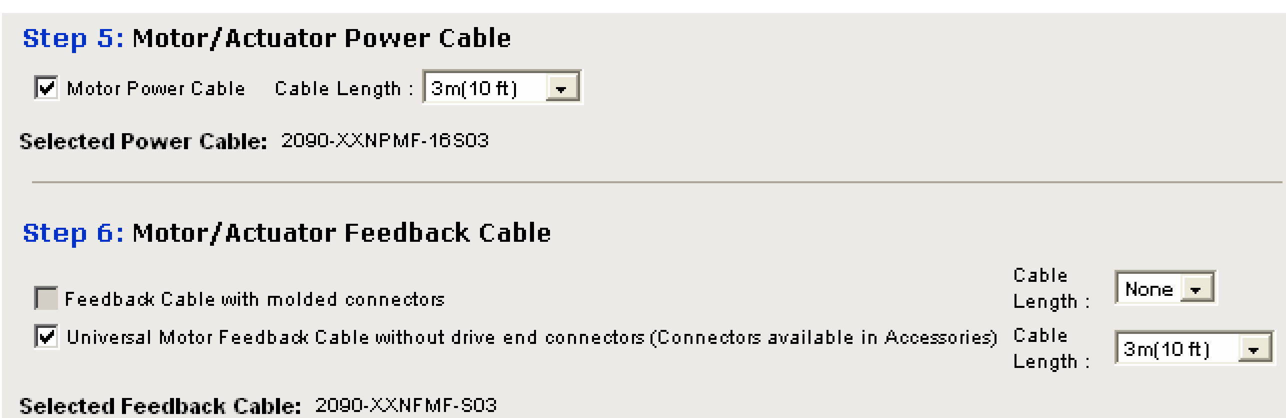
17. Check the box for the **Brake** option, but the *MPL-B15xx* and *MPL-B2xx* motors are only available with a shaft key, so also check the **Shaft Key** option. Press **continue** to close the window.



18. **Step 4** now shows a motor with the brake option (the '44').



19. In **Steps 5 and 6**, select a **3m (10ft)** power cable and the Universal feedback cable.



20. **Step 7** would *normally* allow us to select a brake cable for our vertical axis. Note that the MPL motor that we have chosen includes the brake wiring in the motor power cable, so we do **NOT** need to select this option (greyed out anyway).

21. **Skip Steps 8, 9 and 10**, as on the previous axis.

22. Press **continue** to start working on the final axis.

36. **Skip steps 1-4** since the motor and drive have already been selected through our Motion Analyzer file.

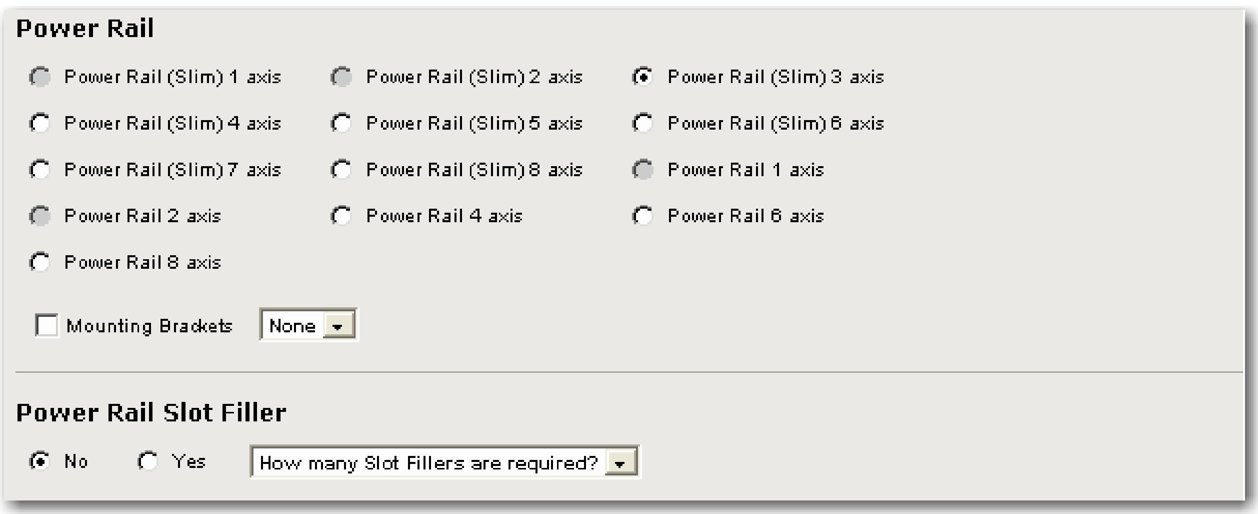
23. In **Steps 5 and 6**, select the same **3m cables** as above.

24. **Skips Steps 7-10**, as above.

25. Press **continue** to choose the system components and accessories.

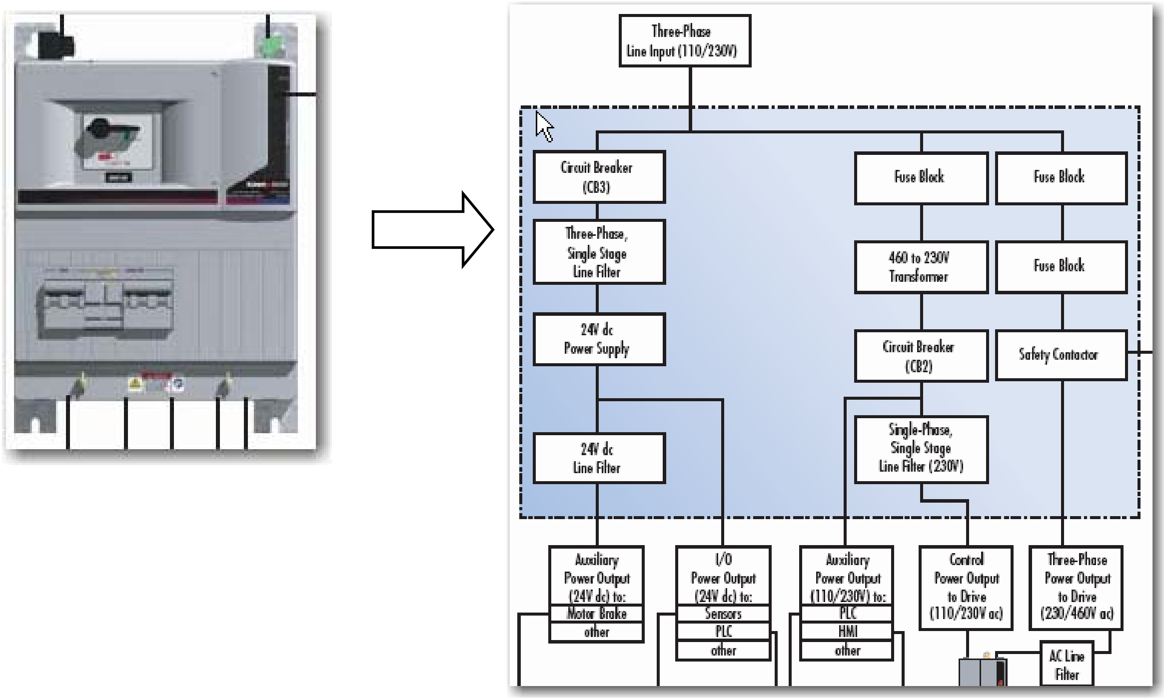
Choose the System Components

A 3-axis Power Rail was chosen for our 3-axis system. If we chose to select a larger Power Rail (for future expansion), we would need to select enough Power Rail Slot Fillers to safely cover all of these open slots. Here, **no change** is required.

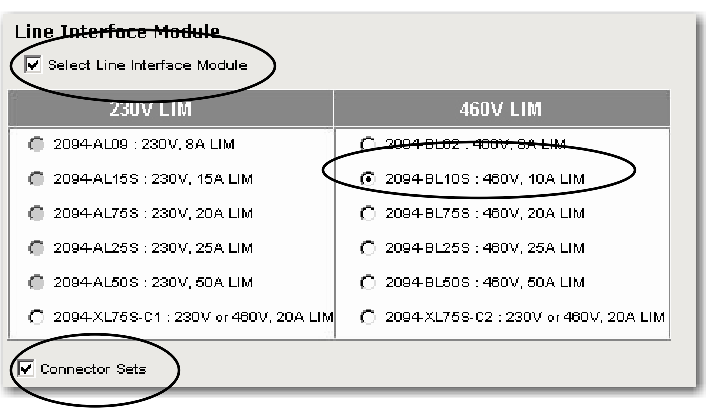


26. No shunt options are chosen, of course.

Notice, however, the option for the Line Interface Module. This product can include the line disconnect switch, the disconnect circuit breaker, power transformers, filters, 24Vdc power supplies and even the safety rated line contactor. *Who doesn't need all of these in their system?*



27. Choose the **Select Line Interface Module** option and select the **2094-BL10S** unit, since our system requires under 10A of current (based on our 2094-BC01-MP5 integrated axis module). **Check the box** to include any necessary **Connector Sets** for convenience.

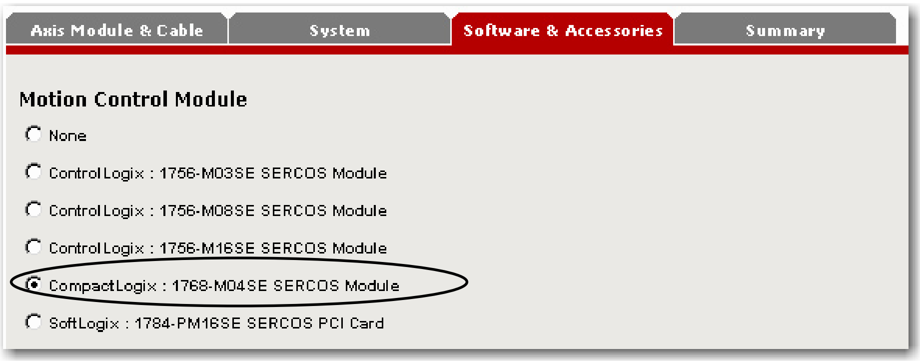


28. The line interface module (LIM) option includes the circuit breaker and the contactor, and some LIMs even include an AC line filter for CE applications. This is going to save a lot of installation, mounting and wiring time. Press **continue**.

Choose the Motion Accessories

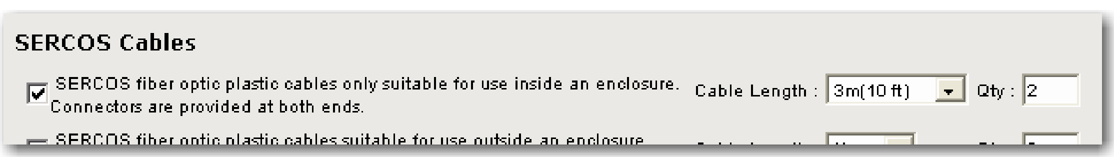
In this final section of the lab, you will add any of the required motion accessories or desired options to your bill of material.

29. We'll assume that we've used Integrated Architecture Builder to select our *control* system, so now we just need the motion components to make it complete. On the **Software & Accessories** tab under **Motion Control Module**, select the **1768-M04SE**. This is the 4-axis SERCOS motion module for the CompactLogix L43 controller.



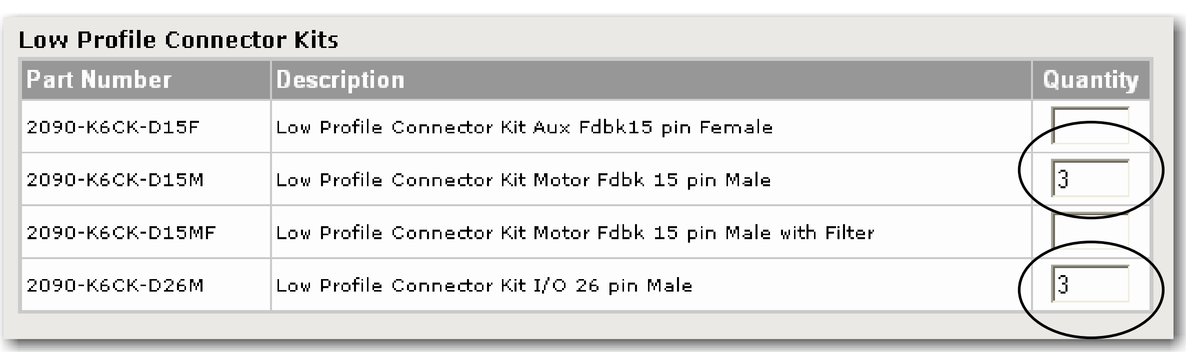
Since SERCOS is a ring-style topology, we will need to select fiber-optic cables to go from the motion module *and back*.

30. In the **SERCOS Cables** section, **check the first box** for using cables within an enclosure, and select the **3m (10ft)** length. Be sure to enter a **quantity of 2** (since this is a ring topology) as well.



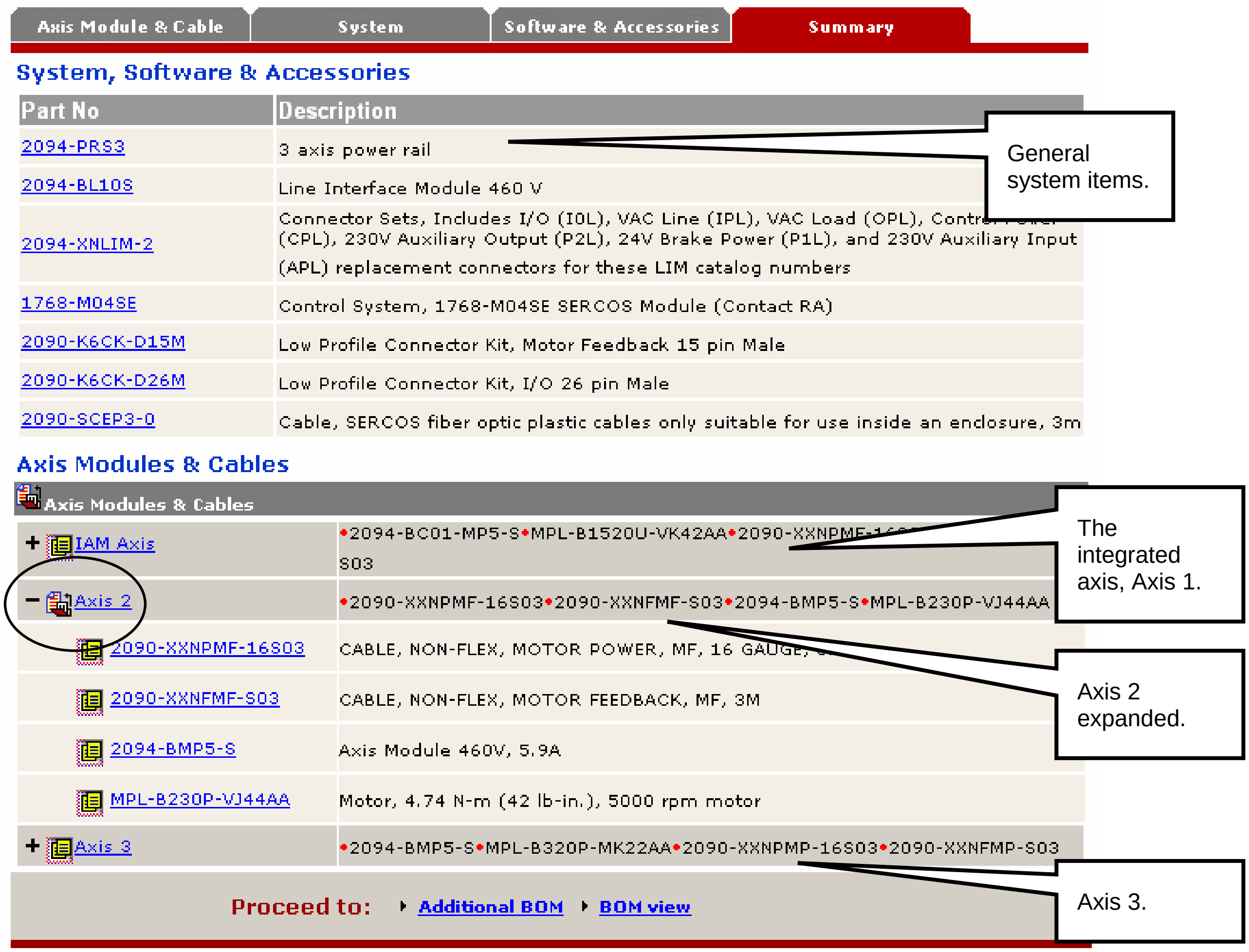
31. Move down several sections to the **Low Profile Connector Kits** section. This is where we will find the connector kits for the flying lead feedback cables, drive control I/O and even any auxiliary feedback devices, since each Kinetix drive supports an additional axis of auxiliary feedback right on board!

32. For our 3-axis system, choose **(3**) **motor feedback connectors** and **(3) control I/O connectors**, as shown below. The control I/O connector includes things like the drive enable signal, homing and over-travel limits and our brake relay for our vertical axis.



33. There are *many* other accessories that we could choose for our system, but let's take a look at the bill of material. Press **continue**.

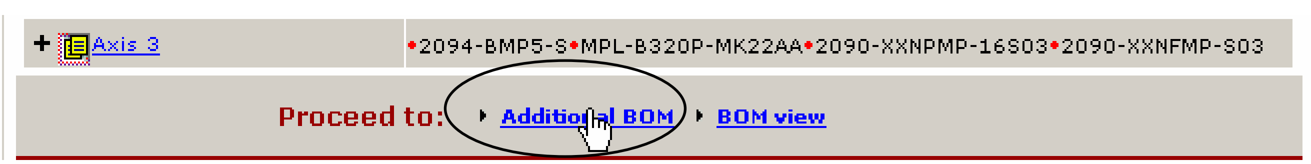
34. The **Summary** tab shows the items we've selected for the general system and for each of the axes. You can view the axis details by **expanding** them, if you wish.



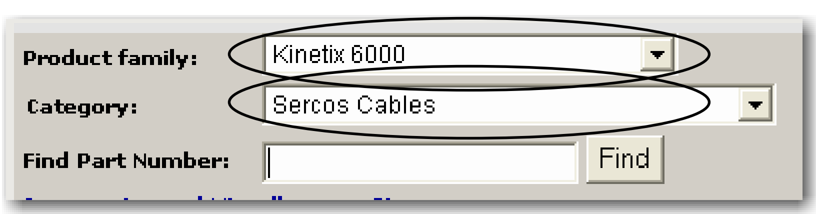
Part No	Description
2094-PRS3	3 axis power rail
2094-BL10S	Line Interface Module 460 V
2094-XNLIM-2	Connector Sets, Includes I/O (IOL), VAC Line (IPL), VAC Load (OPL), Control Power (CPL), 230V Auxiliary Output (P2L), 24V Brake Power (P1L), and 230V Auxiliary Input (APL) replacement connectors for these LIM catalog numbers
1768-M04SE	Control System, 1768-M04SE SERCOS Module (Contact RA)
2090-K6CK-D15M	Low Profile Connector Kit, Motor Feedback 15 pin Male
2090-K6CK-D26M	Low Profile Connector Kit, I/O 26 pin Male
2090-SCEP3-0	Cable, SERCOS fiber optic plastic cables only suitable for use inside an enclosure, 3m

+ IAM Axis	•2094-BC01-MP5-S•MPL-B1520U-VK42AA•2090-XXNPMF-16S03•2090-XXNFMF-S03
− Axis 2	•2090-XXNPMF-16S03•2090-XXNFMF-S03•2094-BMP5-S•MPL-B230P-VJ44AA
2090-XXNPMF-16S03	CABLE, NON-FLEX, MOTOR POWER, MF, 16 GAUGE, 3M
2090-XXNFMF-S03	CABLE, NON-FLEX, MOTOR FEEDBACK, MF, 3M
2094-BMP5-S	Axis Module 460V, 5.9A
MPL-B230P-VJ44AA	Motor, 4.74 N-m (42 lb-in.), 5000 rpm motor
+ Axis 3	•2094-BMP5-S•MPL-B320P-MK22AA•2090-XXNPMP-16S03•2090-XXNFMP-S03

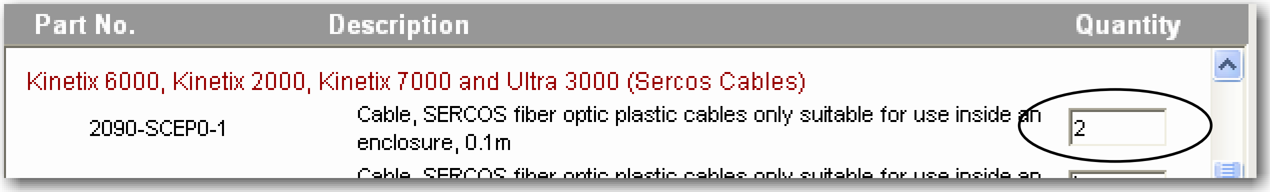
35. There are actually (2) more cables that we need to add. The SERCOS topology requires small jumpers between our Kinetix drives. Click on the **Additional BOM** link to select them.



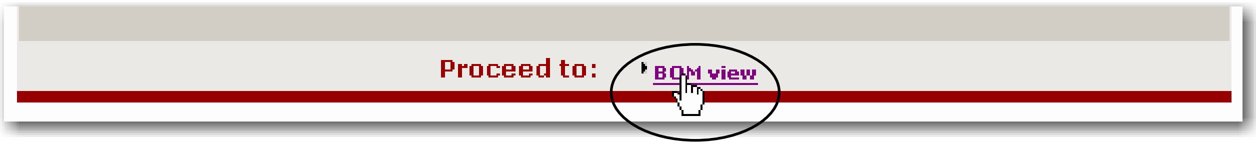
36. Use the drop-down menus to narrow your search down to the following:



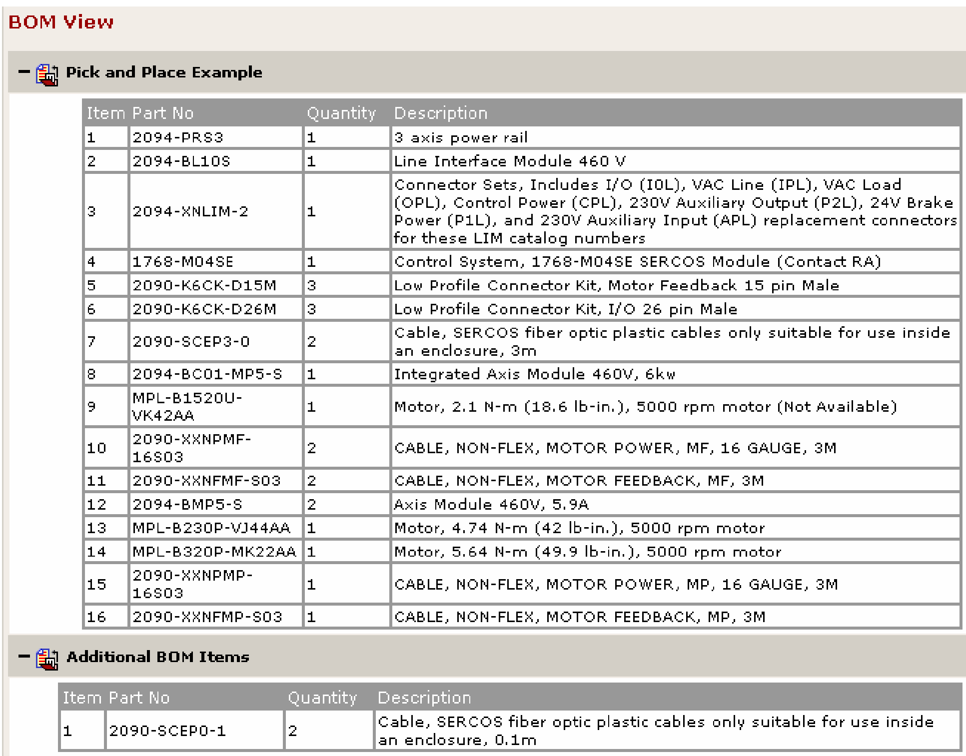
37. When the cables appear, select a **quantity of (2)** of the first cables in the list; **2090-SCEP0-1**. These are 0.1m jumper cables that connect between Kinetix 2000 and 6000 drives only.



38. Click on the **BOM View** link to continue.



39. Your **complete bill of material** should display (you will have to expand the sections).



BOM View

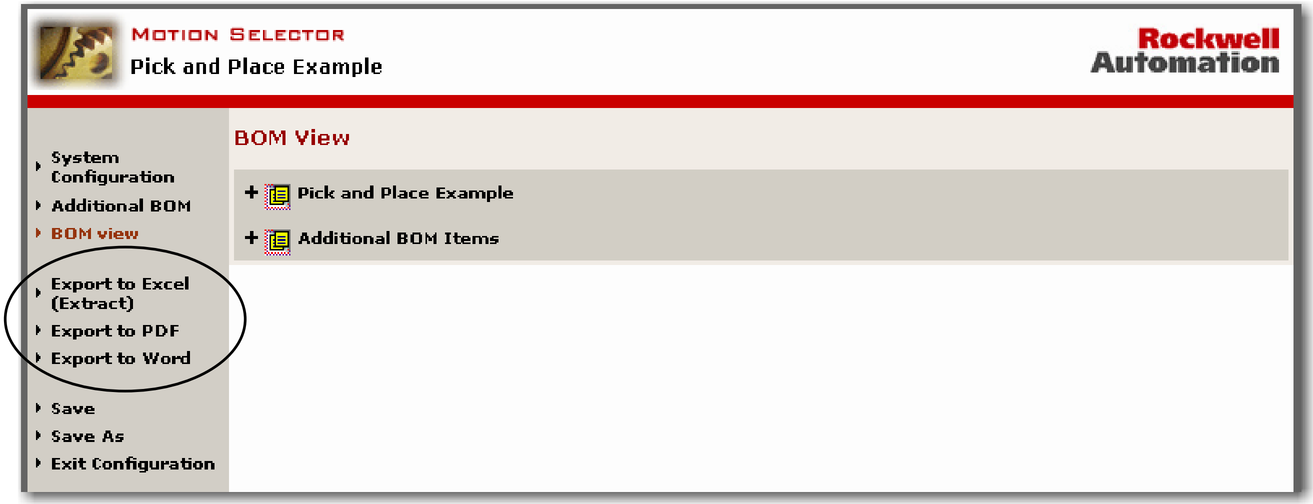
Pick and Place Example

Item	Part No	Quantity	Description
1	2094-PRS3	1	3 axis power rail
2	2094-BL10S	1	Line Interface Module 460 V
3	2094-XNLIM-2	1	Connector Sets, Includes I/O (IOL), VAC Line (IPL), VAC Load (OPL), Control Power (CPL), 230V Auxiliary Output (P2L), 24V Brake Power (P1L), and 230V Auxiliary Input (APL) replacement connectors for these LIM catalog numbers
4	1768-M04SE	1	Control System, 1768-M04SE SERCOS Module (Contact RA)
5	2090-K6CK-D15M	3	Low Profile Connector Kit, Motor Feedback 15 pin Male
6	2090-K6CK-D26M	3	Low Profile Connector Kit, I/O 26 pin Male
7	2090-SCEP3-0	2	Cable, SERCOS fiber optic plastic cables only suitable for use inside an enclosure, 3m
8	2094-BC01-MP5-S	1	Integrated Axis Module 460V, 6kw
9	MPL-B1520U-VK42AA	1	Motor, 2.1 N-m (18.6 lb-in.), 5000 rpm motor (Not Available)
10	2090-XXNPMF-16S03	2	CABLE, NON-FLEX, MOTOR POWER, MF, 16 GAUGE, 3M
11	2090-XXNFMF-S03	2	CABLE, NON-FLEX, MOTOR FEEDBACK, MF, 3M
12	2094-BMP5-S	2	Axis Module 460V, 5.9A
13	MPL-B230P-VJ44AA	1	Motor, 4.74 N-m (42 lb-in.), 5000 rpm motor
14	MPL-B320P-MK22AA	1	Motor, 5.64 N-m (49.9 lb-in.), 5000 rpm motor
15	2090-XXNPMP-16S03	1	CABLE, NON-FLEX, MOTOR POWER, MP, 16 GAUGE, 3M
16	2090-XXNFMP-S03	1	CABLE, NON-FLEX, MOTOR FEEDBACK, MP, 3M

Additional BOM Items

Item	Part No	Quantity	Description
1	2090-SCEP0-1	2	Cable, SERCOS fiber optic plastic cables only suitable for use inside an enclosure, 0.1m

40. Motion Selector provides several convenient options for **exporting and formatting** your bill of material. You may wish to experiment with these.



41. **Save** your file if you wish and **Exit Configuration** when you are done.

This concludes the Motion Analyzer lab.