

Step by Step: Sizing a Robot with MotoSize using Solid Edge

Introduction:

It is always important to have the correct mass data for your End-Of-Arm Tool (EOAT) for sizing the correct robot model and using that tool data in the robot's controller.

Below are step by step instructions to configure Solid Edge CAD data, export it to MotoSize, and calculate the results.

STEP 1: Check CAD model Integrity

In Solid Edge verify the following, in the Assembly:

1. All relevant components are represented (anything that will generate enough mass.) This includes fasteners if they are numerous.
2. Verify there are no duplicate components embedded in the assembly.
3. All relevant models are solid bodies; not just surfaces (surfaces have no volume for mass to be calculated).
4. All manufactured models have the correct material applied (steel, aluminum, plastics, rubber, etc.), giving it mass.
5. All purchased components have either the correct material applied, or the mass is over-ridden with a value provided by the manufacturer.
6. In addition to the tool mass, the mass of the part, being picked, needs to be represented, since it can significantly impact the overall mass properties.
 - a. Select the largest, heaviest part that the tool will pick.

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STEP 2: Setup two Coordinate Systems

It is critical that the two coordinate systems are accurately located. It will affect the center of gravity and moments of inertia. The first coordinate system needs to be located at the connection point of the robot flange and the tool...see Figure 1. The second coordinate system needs to be located at the center of mass with its XYZ orientation matching Figure 1

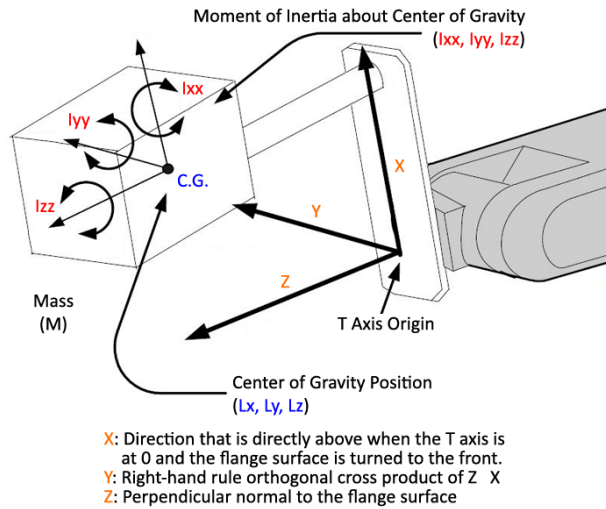
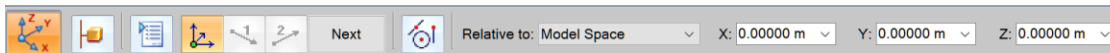
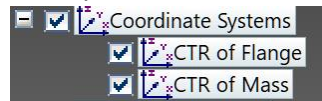


Figure 1: Reference for Proper Alignment

1. In the Solid Edge Features Tab Select **Coordinate System** and choose to key data or use geometry to define it.
2. Use the Ribbon bar to define the location and orientation of each coordinate system.



3. In the Pathfinder, rename the coordinate systems to CTR of Flange and CTR of Mass.



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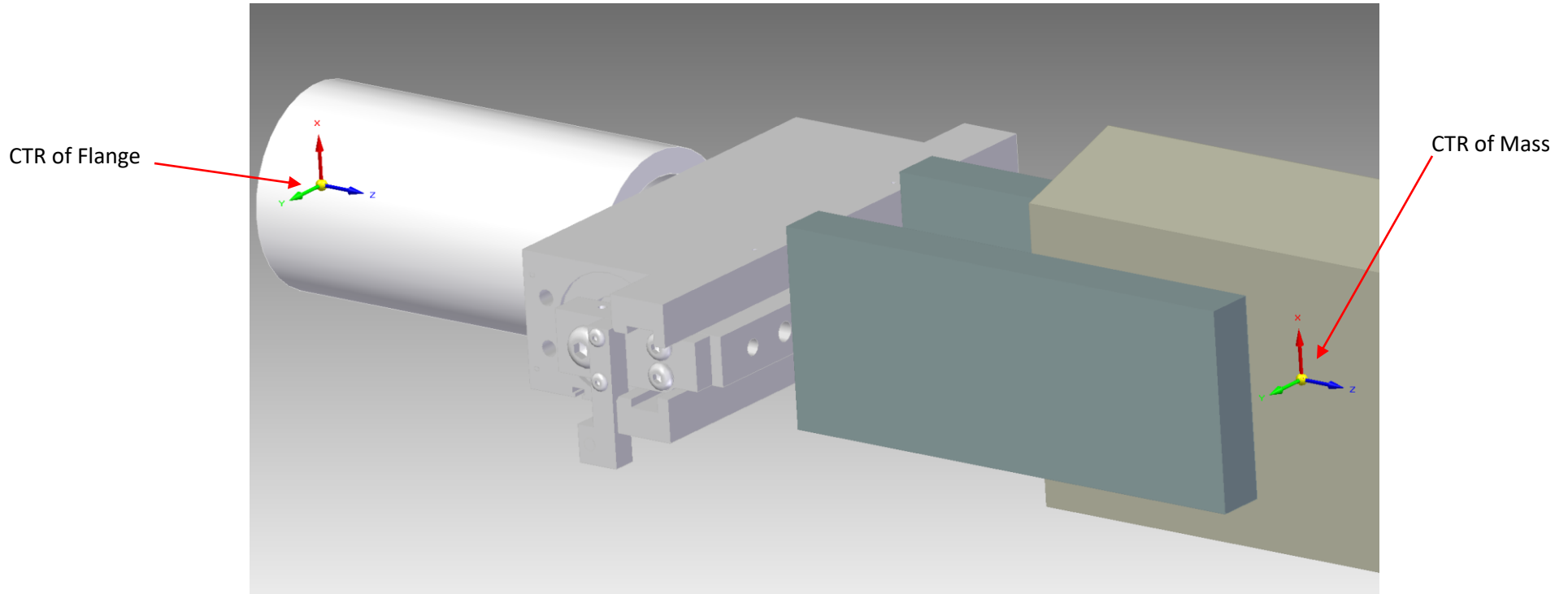


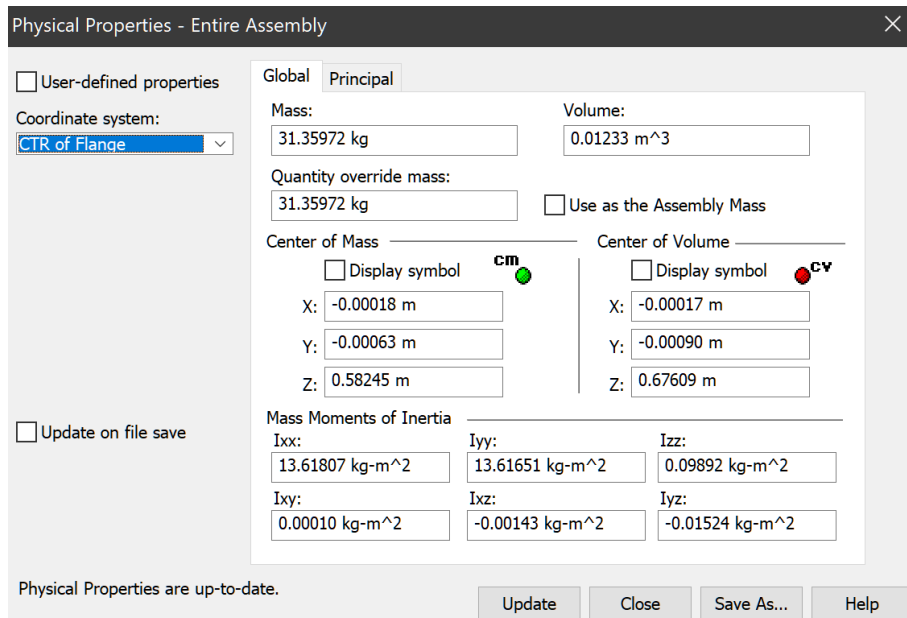
Figure 2: Two different Coordinate Systems needed in Solid Edge

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STEP 3: Configure and Output the Mass Data

After the models and origin have been configured, the next step is the mass properties output.

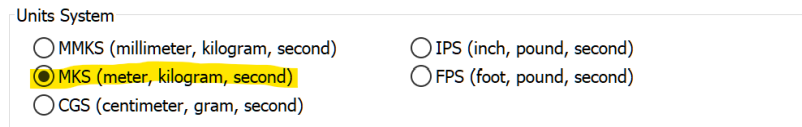
It can be found in the Inspect Tab, **MV Properties**



The sample Mass Properties to the left displays how the results should look.

1. Verify that the units are set to Kilogram and meters, using the **Application Button/Info/File Units**.
2. Select the coordinate system **CTR of Flange**
3. Select **Save As** to save out a text file.
4. Name the file **CTR of Flange**.
5. Save and close the file.
6. Select the coordinate system **CTR of Mass**
7. Select **Save As** to save out a text file.
8. Name the file **CTR of Mass**.
9. Save and close the file.
10. **WARNING:** Do not manually edit the text files. Any change to the syntax will prevent MotoSize from recognizing the data structure.

Figure 3: Mass Properties



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STEP 4: Enter the Data in MotoSize

Login to MotoSize.motoman.com

At the main page select the option for **CHECK ROBOT VIA CALCULATED DATA**

At the Data Input Screen:

1. Select the button **Import Data From CAD**

Robot Selection Filters

Controller Type: YRC1000 Application Specific Robot: Handling Number of Axes: 4

Mechanical Description of End of Arm Load

Tooling Reference Diagram

Mass: 0 kg

Mass Center from Flange

Moment of Inertia

Product of Inertia

Lx: 0 m lxx: 0 kg-m² lxy: 0 kg-m²

Ly: 0 m lyy: 0 kg-m² lxz: 0 kg-m²

Lz: 0 m lzz: 0 kg-m² lyz: 0 kg-m²

Peripheral Equipment

Location A Location B Location C

Mass: 0 kg Mass: 0 kg Mass: 0 kg

CG Offset: 0 mm CG Offset: 0 mm

EQUIPMENT MOUNTING LOCATIONS

SHOWN WITH "1" AXIS MOTOR REMOVED FOR CLARITY

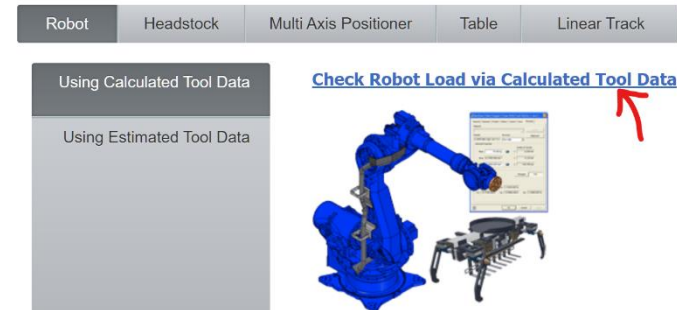
2. Select Solid Edge

Solid Edge SolidWorks

PTC Creo Inventor

3. Browse for the recently created text files and load based off the image below. Select **Go to Configuration Page**.

NOTE:
The accuracy of the results directly corresponds to the accuracy of the input data.



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Ctr of Flange file

Choose File CTR of Flange.txt

Ctr of Mass file

Choose File CTR of Mass.txt

Go To Configuration Page

- Back on the Data Entry Screen the mass, center of mass, and moments of Inertia will be filled in.

Evaluate Arm Load

Clear Input Fields

Save Robot Input Data

Import Existing Input Data

Import Data from CAD

View Existing Robot Report

Robot Selection Filters

Controller Type: YRC1000 Application Specific Robot: Handling Number of Axes: 4 Show Only Active Robots

Mechanical Description of End of Arm Load

Tooling Reference Diagram

Mass: 114.2874 kg

Mass Center from Flange		Moment of Inertia		Product of Inertia	
Lx:	0.00125 m	Ixx:	6.42772 kg-m ²	Ixy:	0.04516 kg-m ²
Ly:	0.00102 m	Iyy:	7.47228 kg-m ²	Ixz:	0.01369 kg-m ²
Lz:	0.24713 m	Izz:	8.88955 kg-m ²	Iyz:	0.04463 kg-m ²

Peripheral Equipment

Location A	Location B	Location C
Mass: 0 kg	Mass: 0 kg	Mass: 0 kg
CG Offset: 0 mm	CG Offset: 0 mm	

Select Robot:

- PL190
- PL320
- PL500

- Selection of the robot model can be assisted by using the Controller, Application, and Axes filters.
- If any Peripheral equipment will be mounted to the robot, enter the data in the available fields. The drawing at the bottom of the screen can assist.
- Once all data is filled in, select the Evaluate **Arm Load** button.

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STEP 5: Review the Results

If a 4-axis arm was selected

Create New Robot Report

Save Robot Input Data

View Existing Robot Report

% Color Key

- < 75%
- 75 - 89.9%
- 90 - 99.9%
- 100% and >

Evaluation Results

Robot: Robot Part #:

Application: Assembly Part #:

of Axes:

	Rated Max	Application	% Max
Payload			
Mass:	<input type="text" value="190"/>	<input type="text" value="114.287"/> kg	<input type="text" value="60.2"/> %
Moment			
Moment Arm Rating			
Moment of Inertia			
T-Axis:	<input type="text" value="90.0"/>	<input type="text" value="8.89"/> kg-m ²	<input type="text" value="9.9"/> %
B-Axis:	<input type="text"/>	<input type="text"/>	<input type="text"/>
R-Axis:	<input type="text"/>	<input type="text"/>	<input type="text"/>
Peripheral Equipment			
Loc A:	<input type="text" value="190"/>	<input type="text" value="0.0"/> kg	<input type="text" value="60.2"/> %
	<input type="text"/>	<input type="text"/>	<input type="text"/>
Loc B:	<input type="text"/>	<input type="text"/>	<input type="text"/>
	<input type="text"/>	<input type="text"/>	<input type="text"/>
Loc C:	<input type="text"/>	<input type="text"/>	<input type="text"/>

This payload includes wrist load

As can be seen, everything is green. This model can safely perform its tasks up to 100% speed.

Damage starts when any value hits 100%

This damage causes wear and tear to each axis gear drive.

If all values are below 100% then the robot will run normally, barring any external forces or external collisions.

Let's dive into the results of a 4-axis robot:

1. The first result is always mass. If over on mass, then either change the robot or change the tool.
2. The Moment Arm Rating displays the EOAT Cg (X) in relation to different curves of load limits. This X is well within the max load limit of 190Kg.
3. The moment of inertia only affects the T-axis for this model, and it is very low. A high value exceeding 100% would be a problem if the program required the T-axis to actively rotate.

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If a 6-axis arm was selected

	Rated Max	Application		% Max
Payload				
Mass:	180	114.287	kg	63.5 %
Moment				
T-Axis:	63	0.184	kgf-m	0.3 %
B-Axis:	102	53.959	kgf-m	52.9 %
R-Axis:	102	53.959	kgf-m	52.9 %
Moment of Inertia				
T-Axis:	46.3	8.89	kg-m ²	19.2 %
B-Axis:	90.0	32.948	kg-m ²	36.6 %
R-Axis:	90.0	32.948	kg-m ²	36.6 %
Peripheral Equipment				
Loc A:			kg	
			kgf-m	
Loc B:	30	0.0	kg	0.0 %
	5	0.0	kgf-m	0.0 %
Loc C:	250	0.0	kg	0.0 %

This payload is separate from wrist load

This payload is separate from wrist load

As can be seen, everything is green. This model can safely perform its tasks up to 100% speed.

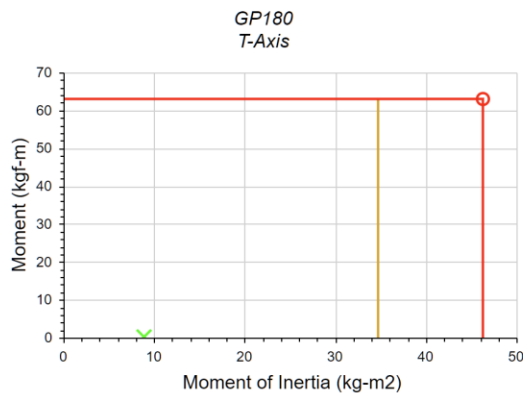
Damage to the robot starts when any value hits 100%

This damage causes wear and tear to each axis gear drive.

If all values are below 100% then the robot will run normally, barring any external forces or external collisions applied.

Let's dive into the results of a 6-axis robot:

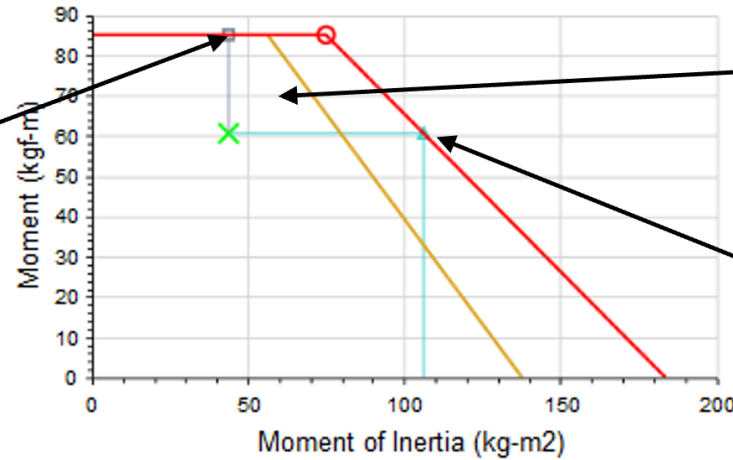
1. The first result is always mass. If over on mass, then either change the robot or change the tool.
2. Moment Rating displays the percentage of static moment for the R, B, and T axes. If an axis is red and is being used against gravity, then there will be a problem.
3. The moment of inertia also affects the R, B, and T-axes. A high value exceeding 100% would be a problem if the program required any of the upper axes to actively rotate.
4. Below the summary are the Derating charts for the R, B, and T axes. They visually show where each axis lies related to the moment and moment of inertia.



Rated Max: 46.3 kg-m², 63 kgf-m

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Allowable moment if inertia constant



Application load point under red lines is OK

Allowable inertia if moment constant

- Given your Moment of Inertia (43.784 kg-m^2), you could increase your Moment up to (85.0 kgf-m)
- △ Given your Moment (60.57 kgf-m), you could increase your Moment of Inertia up to (106.273 kg-m^2)
- Rated Max: 75.0 kg-m^2 , 85 kgf-m
- × Application: 43.784 kg-m^2 , 60.57 kgf-m

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At the bottom of the results are the Input values.

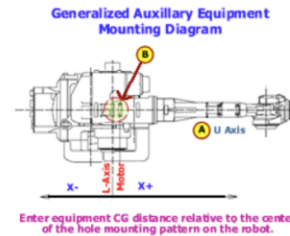
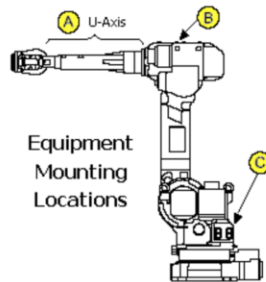
Input Parameters

Mechanical Description of End of Arm Load

			Mass:	<input type="text" value="114.2874"/>	kg
<u>Mass Center from Flange</u>			<u>Moment of Inertia</u>		
Lx:	<input type="text" value="0.00125"/>	m	Ixx:	<input type="text" value="6.42772"/>	kg-m ²
Ly:	<input type="text" value="0.00102"/>	m	Iyy:	<input type="text" value="7.47228"/>	kg-m ²
Lz:	<input type="text" value="0.24713"/>	m	Izz:	<input type="text" value="8.88955"/>	kg-m ²
			Ixy:	<input type="text" value="0.04516"/>	kg-m ²
			Ixz:	<input type="text" value="0.01369"/>	kg-m ²
			Iyz:	<input type="text" value="0.04463"/>	kg-m ²

Peripheral Equipment

<u>Location A</u>		<u>Location B</u>		<u>Location C</u>	
Mass:	<input type="text" value=""/>	kg	Mass:	<input type="text" value="0"/>	kg
CG Offset:	<input type="text" value=""/>	mm	CG Offset:	<input type="text" value="0"/>	mm



Assuming the tool is a completed design, these values can be programmed into the actual robot controller's tool data.

It is more accurate than using hand calculations or letting the controller estimate the tool data.

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STEP 6: Saving the Results

Once satisfied with the results, they can be saved to a PDF, or the results can be saved as an XML file.

Most people, though, prefer the PDF.

1. Select **Create New Robot Report**

The screenshot shows the 'Evaluation Results' form. On the left, there are three buttons: 'Create New Robot Report', 'Save Robot Input Data', and 'View Existing Robot Report'. Below these is a '% Color Key' with two boxes: a green box for '< 75%' and a yellow box for '75 - 89.9%'. The main form has the following fields: 'Robot: GPI80', 'Robot Part #: 1', 'Application: General, Handling', 'Assembly Part #: 1', and '# of Axes: 6'. Below these is a table with columns 'Rated Max', 'Application', and '% Max'. Under the 'Payload' section, there is a row for 'Mass' with values 180, 114.287 kg, and 63.5%. Under the 'Moment' section, there is a row for 'T-Axis' with values 63, 0.184 kgf-m, and 0.3%. There is also a partially visible row for 'R-Axis'.

	Rated Max	Application	% Max
Payload			
Mass:	180	114.287 kg	63.5 %
Moment			
T-Axis:	63	0.184 kgf-m	0.3 %
R-Axis:	102	57.050 kgf-m	53.0 %

2. Fill in the Customer field and any other optional field desired

The screenshot shows the 'Summary Report' form. It has a note: '* These fields must be completed before viewing the report.' The form contains the following fields: 'Customer: *', 'Installation:', 'Engineer:', 'Tool ID:', 'Robot ID:', 'Serial Number:', 'Date: 03/19/2022 * (mm/dd/yyyy)', 'Comment:', and 'Tooling Image: Choose File No file chosen'. At the bottom, there is a 'View Report' button.

3. A useful option is to include an image of the actual tool. Just select the Tooling Image button and choose any image file.

4. When ready, select **View Report**

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5. The finished report will appear...just select **Printer Friendly Page**

Printer Friendly Page

% Color Key

- < 75%
- 75 - 89.9%
- 90 - 99.9%
- 100% and >

Summary Report

This report will NOT be saved until the report is downloaded by clicking the "Save Report" button below.

Report Details

Customer: Installation:

Engineer: Tool ID:

Robot ID: Serial Number:

Date:

Comment:

1. The printer friendly page will display message reminding the user to verify their browser background graphics are checked in the printer settings.
 - a. If not, then the color key will be gray only and harder to interpret.
2. Select the **Hide** button to remove the message,
3. Use the browser to print to PDF (built-in to Chrome and Edge browsers)
4. Done

If the colors in the report do not print correctly, ensure that background color and image printing is enabled in your browser.
Click the "Hide" button before printing this page.

MotoSize Robot Summary Report

Report Details

Customer: Installation:

Engineer: Tool ID:

Robot ID: Serial Number:

Date:

Comment:

Version: Robot model data (3/11/2021 5:09:12 PM); Website calculations (2022-02-8)

NOTE:
The accuracy of the results directly corresponds to the accuracy of the input data.

% Color Key

- < 75%
- 75 - 89.9%
- 90 - 99.9%
- 100% and >

Evaluation Results

Robot: Robot Part #:

Application: Assembly Part #:

of Axes:

	Rated Max	Application	% Max
Download			
Mass:	<input type="text" value="180"/>	<input type="text" value="114,287"/> kg	63.5 %
Moment:			
T-Axis:	<input type="text" value="63"/>	<input type="text" value="0,184"/> kgf-m	63 %
B-Axis:	<input type="text" value="107"/>	<input type="text" value="0,1402"/> kgf-m	62 %