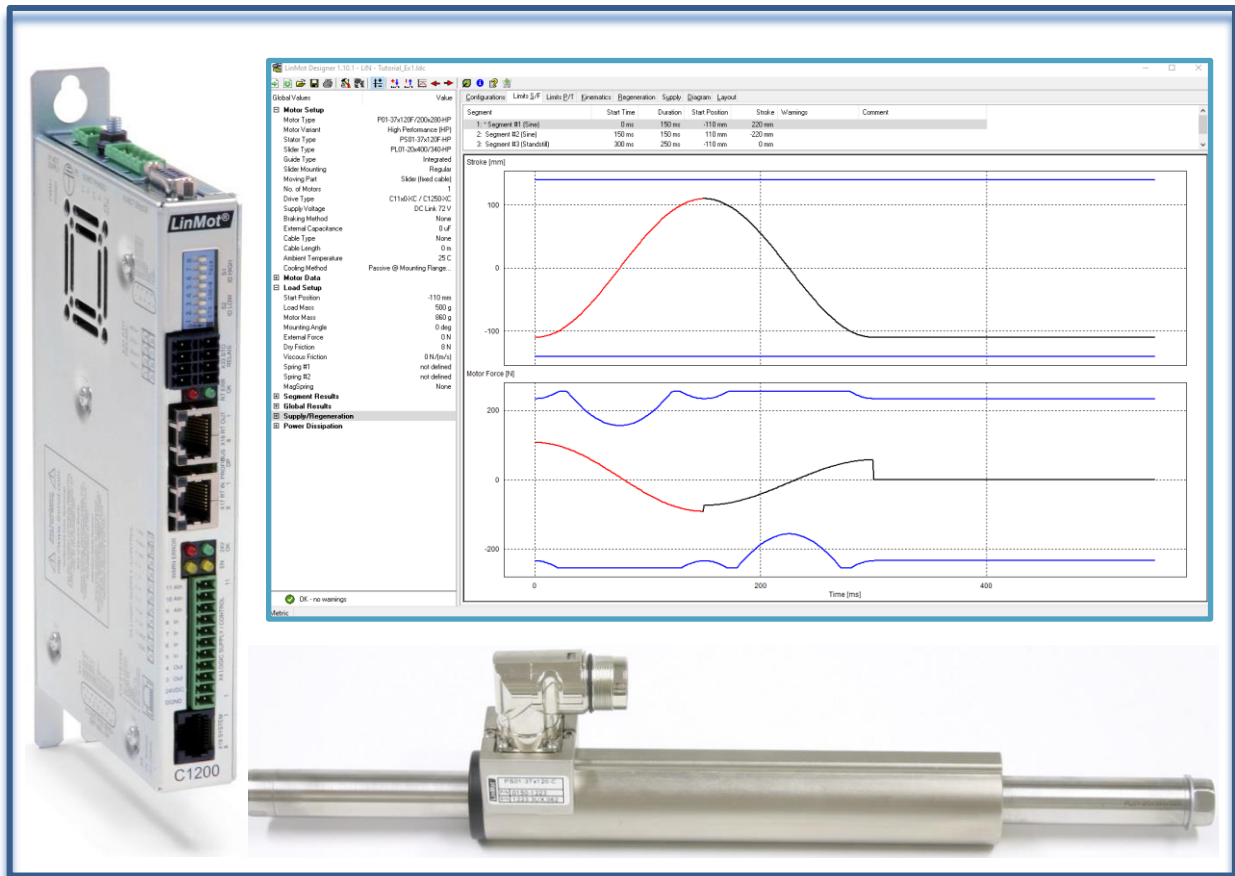


LinMot®



Tutorial LinMot® Designer 1.10.2

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April 29, 2021

Tutorial for the LinMot Designer Motor Sizing Tool

LinMot Designer is a sizing tool for the LinMot motor system. It helps to choose the right linear motor and servo drive for a specific application. It also helps find the right rotary motor for a given linear-rotary application. The tutorial starts with a quick overview of LinMot Designer and then goes on with examples which introduce the use of the LinMot Designer sizing tool. The first example explains the designer functionalities for sizing linear motors in linear applications. Example 2 shows instead how a rotary application can be designed. In example 3 is discussed the import of a custom curve as a motion profile.

Why use a design program?

One can pose the question why at all is required a design program for linear servo motors, if the relationships can be simply explained by the formula $F = m \times a$. The reason is that, for exact drive design, certain additional limiting conditions must be considered during calculation:

- The maximum feeding force produced by a linear motor is speed-dependent in practice and is particularly influenced by the properties of the servo amplifier and the type of supply. As in the case of rotational servomotors, where the maximum torque is reduced with increasing rotational speed, linear motors are subjected to a reduction in maximum force as the speed increases, due to the counter-voltage.
- Long-stroke movements mostly result in the drives running into a force limit during acceleration and braking phases, whereas otherwise maximum speed is the limiting factor.
- For estimating whether a motor does not overheat under given conditions, the power dissipation for an entire motion cycle must be calculated.

The choice of a suitable motor is an iterative process, as the own mass of the moving part of the motor is included in the total mass in motion. This means that the design of a drive becomes an iterative process.

From the academic point of view, it can be exceptionally interesting to consider the above-mentioned factors in drive design. For most users on the other hand, it is more sensible to invest time in constructional considerations while leaving mathematical calculations to a program.

Mode of operation of a design program

Using the LinMot Designer motor sizing program is divided into four steps:

A design program should not only be used to select a drive, but also to promote an integral way of looking at things: What happens if the load mass can be reduced by 10%? What effect has a reduction or increase of the movement time of individual segments? Which movement profile is optimal for this application? All these questions can be computed for different solution variants and displayed graphically by a design program in few minutes.

- **Step 1: Start LinMot Designer and input global Data**
- **Step 2: Segmentation of the Motion**
- **Step 3: Checking the Limits**
- **Step 4: Interactive Optimizing**

Important: LinMot Designer is a sizing program that simulates the behaviour of LinMot linear motors under static and dynamic load conditions. LinMot Designer offers the design engineer quick help in the analysis and optimization of drive technology for a specific task. The simulation and calculation come as close as possible to the behaviour of the linear motor in the real application but is always dependant on the accuracy of the input parameters. It is recommended to discuss and verify the simulation and results with your local LinMot Distributor.

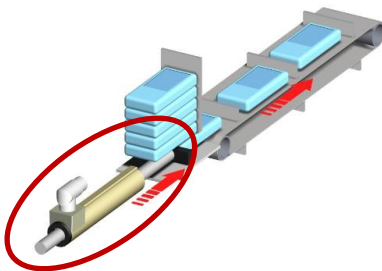
LinMot Designer: Quick Overview

The LinMot Designer simulation is based on both the typical application parameters (motion profile, load definition, additional requirements) as well as the defined motor configuration. The simulation results are represented in diagrams and values. All the important result parameters are automatically checked to its limits. If they are exceeded, warnings are generated.

To select motor configurations for a simulation, a powerful motor configuration selection tool with filter functionality is available.

The following chapters will give you an overview of the user interfaces and the major functionalities of LinMot Designer.

Application



Motion Profile

- Stroke
- Time
- Profile Type

Load

- Load Mass
- Friction
- External Force
- ...

Additional Requirements

- Motor incl/excl Guide
- SSC-Case
- Integrated Drive
- ...



Motor Configuration

Motor / Modules?



Moving Part?

Cooling?

Drive?



Supply?



Motion Profile

The motion profile can be defined as a sequence of motion segments. Each segment can be defined separately. To edit a segment, double-click on the segment itself or right-click on it and then click “Edit”. In the “Edit Segment” dialog it is possible to define the name and the type of curve, its duration and stroke, as well as to leave a comment. Both the name and the comment will be visible in the “Segment Overview”.

It is important to use the same curve type as in the application.

The screenshot displays the LinMot Designer interface with several key components labeled:

- Value of selected Segment:** Points to the 'Segment Results' table in the left sidebar.
- Segment Functions:** Points to the 'Segment Overview' table at the top of the main workspace.
- Segment Overview:** A table listing three segments:

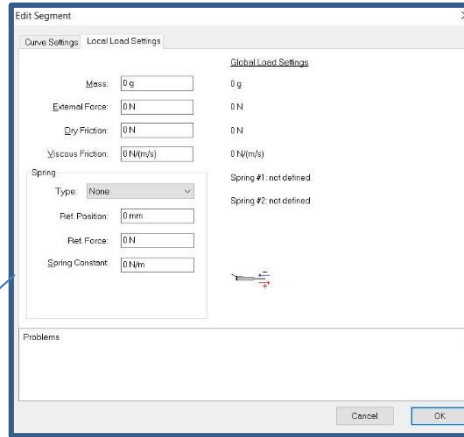
Segment	Start Time	Duration	Start Posi.	Stroke	Warnings	Comment
1. Segment #1 (Sine)	0 ms	200 ms	-75 mm	150 mm		
2. Segment #2 (Standstill)	200 ms	200 ms	75 mm	0 mm		
3. Segment #3 (Sine)	400 ms	200 ms	75 mm	-150 mm		
- Edit Segment:** Points to the 'Edit Segment' dialog box, which contains the following settings:

Stroke Settings		Local Load Settings	
Start Time:	0 ms	Curve Name:	
Start Position:	-75 mm	Curve Type:	Sine
Duration:	200 ms	Max. Speed:	1.18 m/s
Stroke:	150 mm	Acceleration:	18.5 m/s ²
End Time:	200 ms	Deceleration:	18.5 m/s ²
End Position:	75 mm	Comment:	

The main workspace shows a graph of Stroke [mm] vs. Motor Force [N] with three distinct segments: a sine wave, a standstill, and another sine wave. Below the graph are smaller plots for Motor Force [N] and Power Dissipation [W].

Load Definition

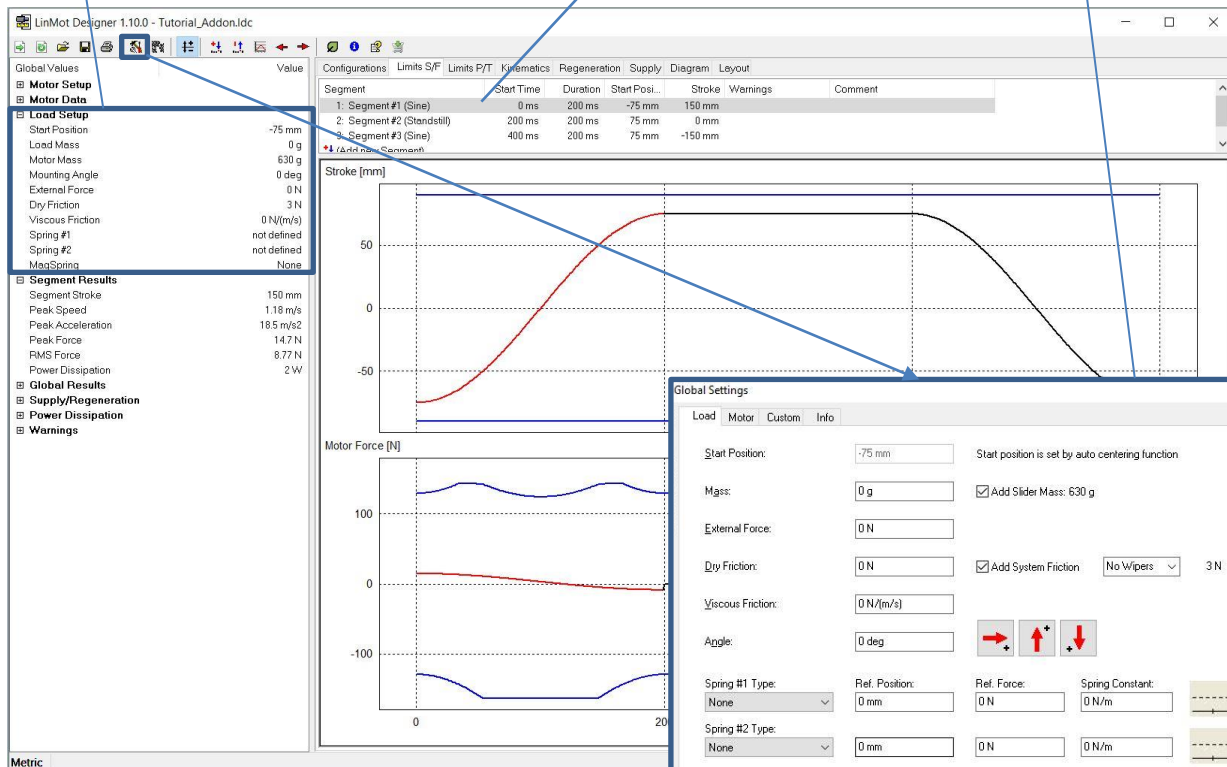
The load can be defined locally (valid only for the corresponding segment) or globally (valid for the whole motion). Local parameters must be defined in the “Edit Segment” dialog, whereas global load parameters can be defined in the “Global Settings” dialog. In both windows, the mass (load) to be moved, the external force acting against the moving part, the added friction and a spring element can be defined. In addition, the system friction, the moving mass of the motor/module, the mounting angle as well as up to 4 MagSpring in parallel can be added in the “Global Settings” dialog.



Load Values

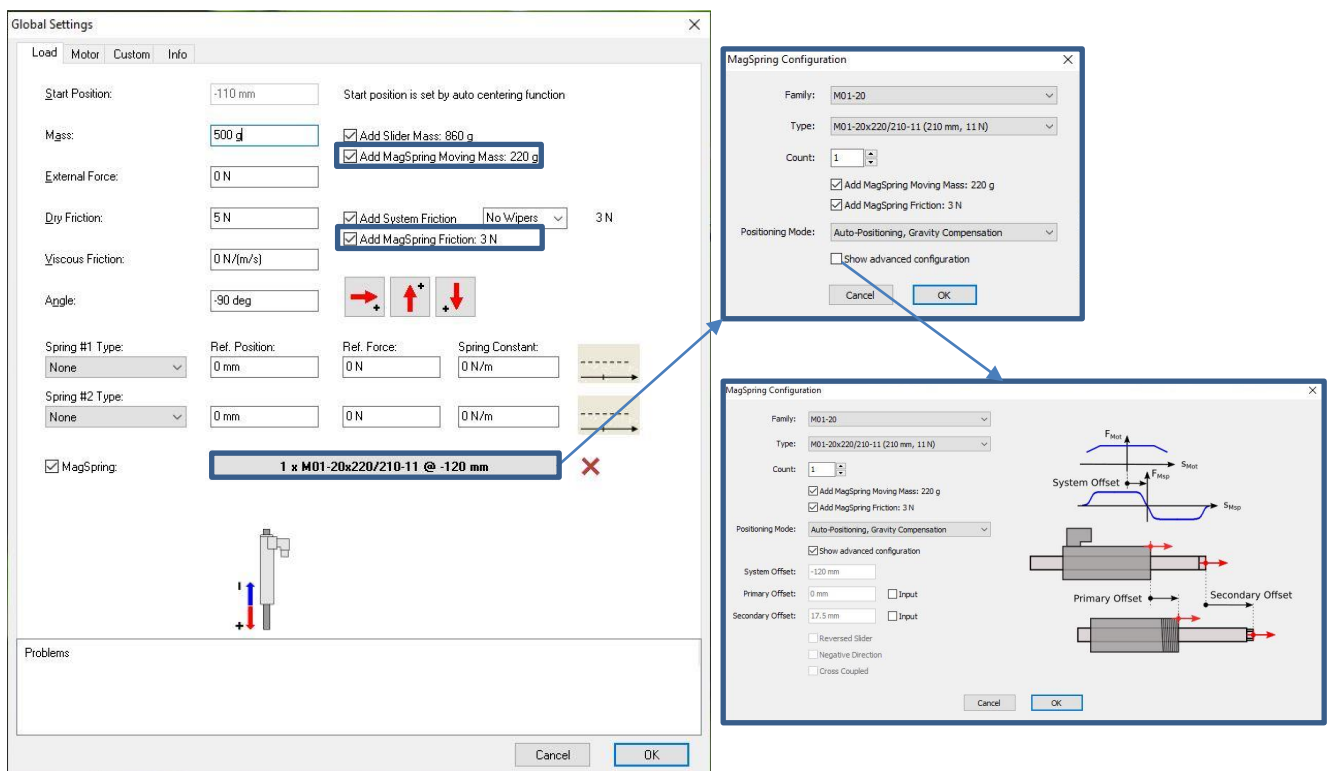
Load Setting (Local @ Segment)

Load Setting (Global)



MagSpring Configuration

To configure and therefore simulate the effect of our Magnetic Springs, click on the “MagSpring: None” button in the “Load” window of the “Global Settings” dialog.



In the “MagSpring Configuration” window it is possible to select the MagSpring Family and Type. For each MagSpring type the stroke and force are shown in brackets and, in addition, the moving mass and friction are automatically added and displayed in the configuration dialog. Once the MagSpring is selected, its moving mass and friction are also added to the “Load” window of the “Global Settings” dialog.

In the “MagSpring Configuration” window it is also possible to edit the position offset between MagSpring and Motor. By default, the MagSpring constant force range is automatically positioned centrally to the stroke (Auto-Positioning mode). This allows for an easy configuration of the MagSpring, and when the stroke of the MagSpring is equal to or greater than the stroke of the motor, then the MagSpring will always be in its constant force range. Nonetheless, LinMot-Designer can also simulate the behavior of the system, if the constant force of the MagSpring is only required in a reduced range of the motor stroke. By changing the “System Offset” (advanced configuration), the position of the active range relative to the motor stroke can be moved.

The MagSpring can be enabled or disabled from the “Load” window by clicking the MagSpring field. When the “Auto-Positioning, Gravity Compensation” mode is active, the MagSpring will be enabled only if the mounting angle is different from 0 deg (automatic deactivation in horizontal mode). A message will appear in the “Problems” field of the “Global Settings” dialog if the defined MagSpring is disabled, if a module with integrated MagSpring is used in horizontal mode, or if the MagSpring compensation mode is not possible.

To move the force range of the MagSpring relative to the motor, check the “Show advanced configuration” box or select the “Manual Positioning” mode. This mode allows to modify the “System Offset”, that represents the position of the relaxed point of the MagSpring ($F_{Msp}=0$) relative to the zero position (ZP) of the motor. If the positioning of MagSpring components (Stator and Slider) is of interest, the “Primary Offset” (relative position of MagSpring stator and motor stator) and the “Secondary Offset” (relative position of MagSpring slider and motor slider) can be defined and/or read out. Because of the dependency of the three values, only two of them can be defined, the third will be calculated. The configuration options “Reverse Slider”, “Negative Direction” and “Cross Coupled” are not supported yet in the current LinMot-Designer release (Version 1.10.2).

Motor Configuration & Filter Selection

The combination of “Motor Type”, “Moving Part” (slider or stator), “Cooling Method” (Passive, Fan, Fluid, Sealing Air), “Drive Type” and “Supply Type” results in thousands of different motor configurations with their own characteristic values (e.g. Stroke, Max. Force, Cont. Force, Max. Acceleration, Slider Length, Stator Length, ...). In the “Configurations” tab, the list of all available motor configurations can be reduced by filter criteria that relate to the application. From the filtered list, a single configuration (motor, moving part, cooling, drive, supply) can be selected for the simulation/calculation.

In the “Typical System Configuration”, by default are selected the typical supply, drive current and moving part. The default supply can be 72V, 1x230VAC or 3x400VAC, depending on the selected drive. By default, are only selected drives whose maximum output current is equal to or greater than the motor maximum current. The default moving part can be either the slider or the stator, depending on the selected module. These default values can be unselected by pressing the blue [x] and will be overwritten if a different value is selected in the “Global Settings” dialog.

With the “Application Requirements” filters it is possible to display the Motors/Modules suited for the application specific stroke, speed and acceleration. In brackets it is shown the segment value for total stroke, peak speed, and peak acceleration. While the stroke filter searches for the best possible motor/module with reference to the stroke, i.e. displays only motors/modules with the next bigger stroke (SS and/or ES), the speed and acceleration filters only exclude configurations that are certainly not suitable, i.e. they display all motors/modules whose (unloaded) maximum speed and maximum acceleration are greater than the maximum speed and the maximum acceleration of the segment definition. Since no load is considered during filtering, even after enabling all filters in the “Application Requirements”, several motors/modules will still be available in the remaining systems that will not succeed in the simulation and will therefore lead to simulation warnings.

The “Application Requirements” filters must be recalculated each time the segment definition is changed, and thus every time the “Configurations” tab is activated a couple of seconds will be needed to update the configuration list.

Remark: By selecting a configuration in the “Configurations” tab, all components, “Motor Type”, “Moving Part”, “Cooling”, “Drive Type” and “Supply Type” are redefined.

The screenshot displays the LinMot Designer 1.10.1 interface. The left sidebar contains the 'Motor Setup' panel with various configuration options like Motor Type, Stator Type, Slider Type, etc. The main window is divided into two panes. The top pane is the 'Configurations Tab' which shows a list of filters such as 'Default Moving Part', 'Application Requirements', 'Stroke (150 mm)', 'Speed (1.18 m/s)', 'Acceleration (18.5 m/s²)', 'Motion Requirements', 'Guided Type', 'Cooling Type', and 'Supply'. The bottom pane is the 'Filtered List' which displays a table of motor configurations. The table has columns for Motor/Module, Moving Part, Cooling, Drive, Supply, Stroke, Extended Stroke, and Max Force. The table lists various motor models and their specifications.

Motor/Module	Moving Part	Cooling	Drive	Supply	Stroke	Extended Stroke	Max Force
[6] P01-23x160/20x160-LC	...	Passi...	72 V DC	20 mm	160 mm	63.5 N	
[6] P01-23x160F/20x160-LC	...	Passi...	72 V DC	20 mm	160 mm	86.4 N	
[4] P01-23x160H/20x160-HP	...	Passi...	72 V DC	20 mm	160 mm	138 N	
[4] P01-23x160H/20x160-HP-L	...	Passi...	72 V DC	20 mm	160 mm	124 N	
[4] P01-23x160H/20x160-HP-SSCP	...	Passi...	72 V DC	20 mm	160 mm	138 N	
[8] P01-23x160H/20x160-HP-SSCP-G02	...	Passi...	72 V DC	20 mm	160 mm	138 N	
[6] P01-23x80/100x160-LC	...	Passi...	72 V DC	100 mm	160 mm	44 N	
[6] P01-23x80F/100x160-HP	...	Passi...	72 V DC	100 mm	160 mm	67.1 N	
[6] P01-23x80F/100x160-HP-L	...	Passi...	72 V DC	100 mm	160 mm	68.4 N	
[6] P01-23x80F/100x160-HP-SSCP	...	Passi...	72 V DC	100 mm	160 mm	67.1 N	
[12] P01-23x80F/100x160-HP-SSCP-G02	...	Passi...	72 V DC	100 mm	160 mm	67.1 N	
[8] P01-37x120F/100x180-HP	...	Passi...	72 V DC	100 mm	180 mm	255 N	
[8] P01-37x120F/80x160-HP	...	Passi...	72 V DC	80 mm	160 mm	210 N	
[8] P01-37x120F/100x180-HP-L	...	Passi...	72 V DC	100 mm	180 mm	229 N	
[8] P01-37x120F/155-HP-SSCP	...	Passi...	72 V DC	147.5 mm	155 mm	255 N	
[8] P01-37x120F/160x180-HP	...	Passi...	72 V DC	160 mm	180 mm	128 N	
[8] P01-37x120F/140x160-HP	...	Passi...	72 V DC	140 mm	160 mm	105 N	
[8] P01-37x120F/160x180-HP-L	...	Passi...	72 V DC	160 mm	180 mm	115 N	
[8] P01-37x120F/155-HP-SSCP	...	Passi...	72 V DC	147.5 mm	155 mm	128 N	
[6] P01-37x120/100x180-LC	...	Passi...	72 V DC	100 mm	180 mm	163 N	
P01-37x120/100x180-LC	Slider	Passive...	A1100	72 V DC	100 mm	180 mm	163 N
P01-37x120/100x180-LC	Slider	Passive...	C11x0XC / C12...	72 V DC	100 mm	180 mm	163 N
P01-37x120/100x180-LC	Slider	Passive...	E12x0-UC	72 V DC	100 mm	180 mm	163 N
P01-37x120/100x180-LC	Stator	Passive...	A1100	72 V DC	100 mm	180 mm	163 N
P01-37x120/100x180-LC	Stator	Passive...	C11x0XC / C12...	72 V DC	100 mm	180 mm	163 N
P01-37x120/100x180-LC	Stator	Passive...	E12x0-UC	72 V DC	100 mm	180 mm	163 N
[6] P01-37x120/80x160U	...	Passi...	72 V DC	80 mm	160 mm	177 N	
[4] P01-37x120F/100x180-HP	...	Passi...	72 V DC	100 mm	180 mm	255 N	
[4] P01-37x120F/80x160U-HP	...	Passi...	72 V DC	80 mm	160 mm	210 N	
[4] P01-37x120F/100x180-HP-L	...	Passi...	72 V DC	100 mm	180 mm	229 N	
[4] P01-37x120F/180-HP-PB24-SSC	...	Passi...	72 V DC	180 mm	180 mm	210 N	
[4] P01-37x120F/180-HP-PB24-SSC-FC	...	Passi...	72 V DC	180 mm	180 mm	210 N	
[6] P01-37x240/20x180-LC	...	Passi...	72 V DC	20 mm	180 mm	190 N	
[6] P01-37x240/40x160U	...	Passi...	72 V DC	40 mm	160 mm	187 N	
[4] P01-37x240F/20x180-LC	...	Passi...	72 V DC	20 mm	180 mm	284 N	
[4] P01-37x240F/40x160U	...	Passi...	72 V DC	40 mm	160 mm	279 N	
[4] P01-48x150G/150x190-HP	...	Passi...	72 V DC	150 mm	190 mm	360 N	
[4] P01-48x150G/120x180U-HP	...	Passi...	72 V DC	120 mm	180 mm	312 N	
[4] P01-48x150G/170-HP-EX	...	Passi...	72 V DC	170 mm	170 mm	312 N	
[4] P01-48x150G/170-HP-EX-FC	...	Passi...	72 V DC	170 mm	170 mm	312 N	
[8] P01-48x150G/155-HP-SSCP	...	Passi...	72 V DC	155 mm	155 mm	360 N	

Filtered List


When working with the motor/module configuration list, it is important to know the following:

1) Content

The list covers **all** available **base motor configurations** (supported combinations of “Motor/Module Type”, “Moving Part”, “Cooling Type”, “Drive Type” and “Supply Type”).

Diverse configuration values are available in different columns (e.g. Stroke, Max. Force, Max. Acceleration, ...).

2) Structured View

The default view is a **structured view**, where the list is sorted by the Motor/Module types (first column) and all configuration variants for a certain motor/module can be showed or hidden by selecting a bold row. A bold row stands for a group of configurations with the same motor/module type. The configuration values at a given row and for a group with the same motor/module type, are only showed if all of the associated configurations have the same value. A “...”-value indicates that the associated configuration values differ from each other. For toggling the structured/non-structured view, use the “Structured View”-Button  or simply click several times on the Motor/Module column header.

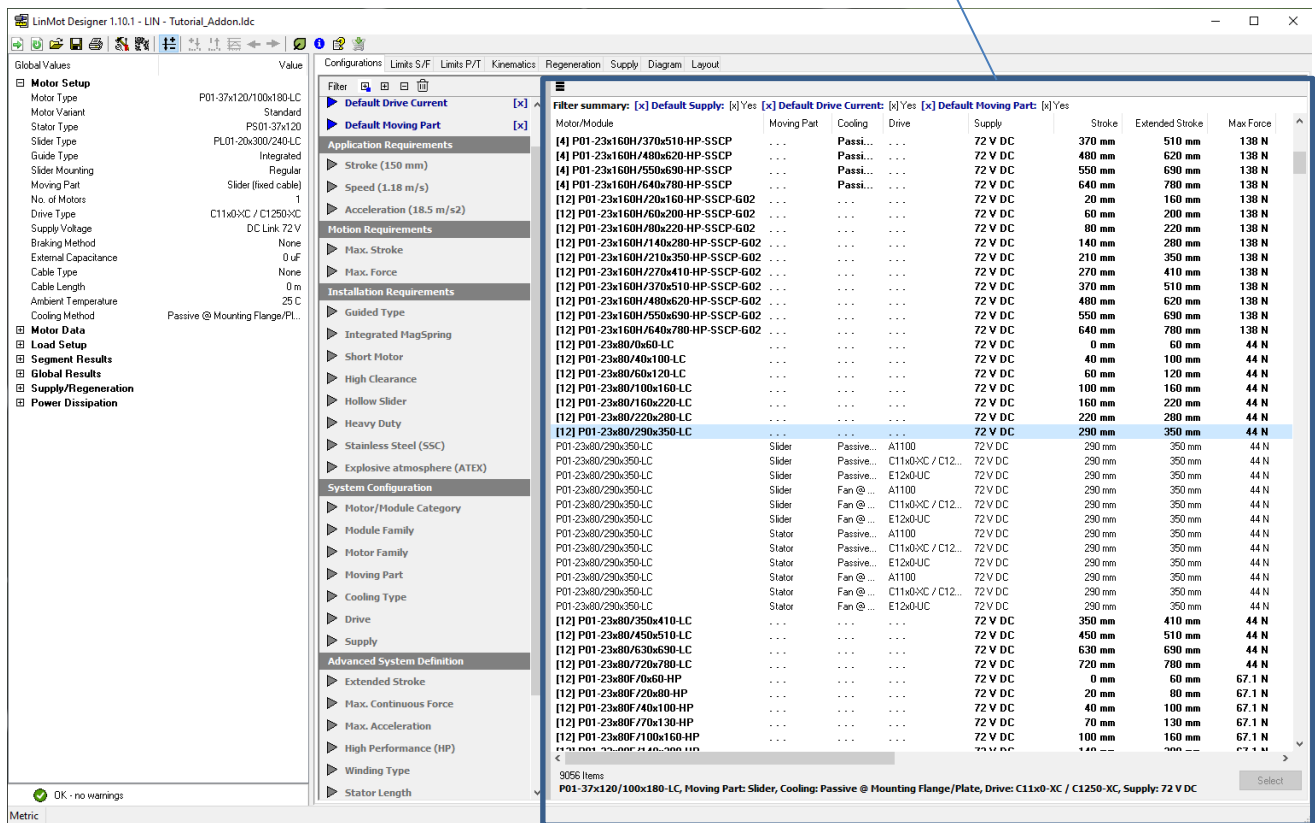
3) Sorting

With a click on a column header, all configurations get **sorted** to the corresponding parameters and are showed in the non-structured view.

4) Selection

A configuration can be selected by double clicking the row or by pushing the “Select” button. A bold configuration group row (in the structured view only) cannot be selected. As soon as a configuration is selected, the global values including simulation results are updated.

Filteres Configuration List



The screenshot displays the LinMot Designer 1.10.1 interface. On the left, the 'Global Values' and 'Motor Setup' sections are visible, showing parameters like Motor Type (P01-37x120/100x180-LC) and Stator Type (FL01-20x300/240-LC). The central 'Filter' panel is expanded to show 'Application Requirements' (Stroke, Speed, Acceleration), 'Motion Requirements' (Max. Stroke, Max. Force), and 'Installation Requirements' (Guided Type, Integrated MagSpring, Short Motor, High Clearance, Hollow Slider, Heavy Duty, Stainless Steel (SSC), Explosive atmosphere (ATEX)). The main table, titled 'Filter summary', lists configurations with columns: Motor/Module, Moving Part, Cooling, Drive, Supply, Stroke, Extended Stroke, and Max Force. A blue arrow points from the caption 'Filteres Configuration List' to the table. The table shows a list of configurations, with the row 'P01-23x80/290x350-LC' highlighted in blue. At the bottom, a 'Select' button is visible next to the configuration details.

Filter

The filter in the “Configurations” tab contains a **menu**, a **configurable filter range** and a **filter summary**. The filter is the **main tool** to **reduce** the big list of available motor/module configurations to a small list of configurations that could match the application. In other words, by filtering you can get rid of all configurations that are certainly not suitable.

The screenshot shows the LinMot Designer software interface with the filter configuration window open. The window is titled "Filter" and has a menu bar with options: Configurations, Limits S/F, Limits P/T, Kinematics, Regeneration, Supply, Diagram, and Layout. The interface is divided into several sections:

- Filter Menu:** Located on the left, it contains a list of filter categories with expand/collapse icons and a blue [x] to reset. Active filters are marked with a blue [x].
 - Application Requirements: Stroke (150 mm), Speed (1.18 m/s), Acceleration (18.5 m/s²)
 - Motion Requirements: Max. Stroke (range 284-820 mm, slider set to 300-400 mm), Max. Force
 - Installation Requirements: Guided Type, Integrated HagSpring, Short Motor, High Clearance, Hollow Slider, Heavy Duty, Stainless Steel (SSC), Explosive atmosphere (ATEX)
 - System Configuration: Motor/Module Category (Linear Motor (124) checked), Module Family, Motor Family (P01-48 (228) checked, P10-54 (60) checked)
- Configurable Filters:** A section with a slider for "Max. Stroke" set between 300 mm and 400 mm.
- Filter Summary:** Located at the top right, it lists active filters: [x] Default Supply, [x] Default Drive Current, [x] Default Moving Part, [x] Max. Stroke, [x] Min 300 mm, [x] Max 400 mm.
- Main Configuration Table:** A table with columns: Motor/Module, Moving Part, Cooling, Drive, Supply, Stroke, Extended Stroke, Max Force. It lists various motor configurations, with the selected row being [12] P10-54x180U/370.

Filter Menu

The filter menu contains buttons to **collapse** and to **expand** the filters as well as to **reset** the filters.

Type of Filters

There are numerical filters (e.g. Stroke), flat list filters (e.g. Guided Type, Cooling Method, ...) and hierarchical list filters with two levels (e.g. Motor Family).

Filter Activity

Active filters are marked with a blue caption and a blue [x] to reset them. In addition, an active filter arises in the filter summary. A filter only gets active when at least one criterion is set.

Number of Configurations

The number in brackets () shows the number of configurations that matches the criteria at the current overall filter state. If no configuration matches the criteria, the number is (0) and the filter caption is grey.

Saving the project will also save the configuration filter setting and therefore, when reopening the project, the last filters settings will already be preconfigured.

Motor Configuration

The motor configuration that is used for the simulation/calculations can be modified in the motor tab of the “Global Settings” window. Also, here the main elements of the configuration (“Motor Type”, “Moving Part”, “Cooling Method”, “Drive Type”, “Supply Type”) can be selected independently (in contrast to the selection via the “Configurations” tab). Clicking the “Motor Type” button will open the “Motor Selection” window, which allows the quick selection of a different motor type, winding type, variant, family, group, or motor category. If a different motor is selected, that has a “Cooling Method”, “Slider Mounting”, “Moving Part” and / or “Drive Type” that are diverse from the previous system configuration, then it will be possible to select if and which elements of the configuration you want to set to their default value.

Motor Setup (Values)

Motor Configuration (edit dialog)

The screenshot displays the LinMot Designer 1.10.0 interface. On the left, the 'Global Values' window shows the 'Motor Setup' section with various parameters and their values. The 'Global Settings' dialog is open, showing the 'Motor' tab with detailed configuration options for the motor, drive, and supply. The 'Motor Selection' dialog is also open, showing a hierarchical selection of motor parameters.

Motor Setup (Values) Table:

Parameter	Value
Motor Type	P02-23Sx80/160x220-LC
Motor Variant	Standard
Stator Type	PS02-23Sx80
Slider Type	PL01-12x290/250-LC
Guide Type	N/A
Slider Mounting	Reversed
Moving Part	Stator (moving cable)
No. of Motors	1
Drive Type	E12x0-UC
Supply Voltage	DC Link 72 V
Braking method	None
External Capacitance	0 uF
Cable Type	None
Cable Length	0 m
Ambient Temperature	25 C
Cooling Method	Fan @ Mounting Flange/Plate

Global Settings - Motor Tab:

- Motor Type: P02-23Sx80/160x220-LC
- Number of Motors: 1
- Cooling Method: Fan @ Mounting Flange/Plate
- Slider Mounting: Reversed
- Ambient Temperature: 25 C (-10 C - 80 C)
- Moving Part: Stator (moving cable)
- User Group: Std
- Motor Variant: Standard
- Stator Type: PS02-23Sx80
- Slider Type: PL01-12x290/250-LC
- Guide Type: N/A
- Stator Mass: 245 g
- Slider Mass: 230 g
- Product Status: Standard product
- Zero Position (ZP): 87 mm
- Extended Stroke (ES): 220 mm
- Standard Stroke (SS): 160 mm
- Max Force @72 V: 44 N
- Force Const @25 C: 11 N/Apk
- Max Current @72 V: 4 Apk
- Resistance @60 C: 11.5 Ohm
- Drive Type: E12x0-UC (Imax=32.0Apk, Vmax=85V)
- Max. Output Current: 32 Apk
- Supply Voltage Range: (24 V - 85 V)
- Supply Type: 72 V DC
- Nominal Supply Voltage: 72 V
- DC Link Voltage: 72 V
- External Capacitance: 0 uF
- Braking Method: None
- Cable Type: None (...or less than ~2.5m)
- Length: 0 m (Max. 30 m)
- Resistance @ 40°C: 0 Ohm
- System Information:
 - Max. Force: 44 N
 - Max. Speed: 6.02 m/s
 - Max. RMS Stall Force: 16 N
 - Max. Elec. Power: 320 W

Motor Selection Dialog:

- Category: Linear Motor
- Group: P01-37
- Family: P01-37x120
- Variant: Standard
- Winding: Standard
- Type: P01-37x120/100x180-LC
- Set system configuration to default values:
 - Cooling Type: Passive @ Mounting Flange/Plate
 - Slider Mounting: Regular
 - Moving Part: Slider
 - Drive: C11x0-XC / C1250-XC

Custom Components

It is possible to define **one custom drive** and **three custom supplies** (different types). All the custom components can be selected in “Global Settings” under the “Motor” selection dialog. The custom drive is always available in the scroll down list of “Drive Type”. The custom supplies are always available in the scroll down list of the “Supply Type”. If the custom components have to be available in the motor configurations list and its filters (“Configurations” tab), then the custom components must be enabled manually (see checkboxes). In the “Custom” selection dialog it is also possible to add the internal capacitance of the custom drive and to define the max current, max gain, and the min / max values of the DC link voltage range.

Motor Setup (Values)
Custom Components (Drive & Supplies)

The screenshot displays the LinMot Designer 1.10.0 interface with three key dialog boxes open:

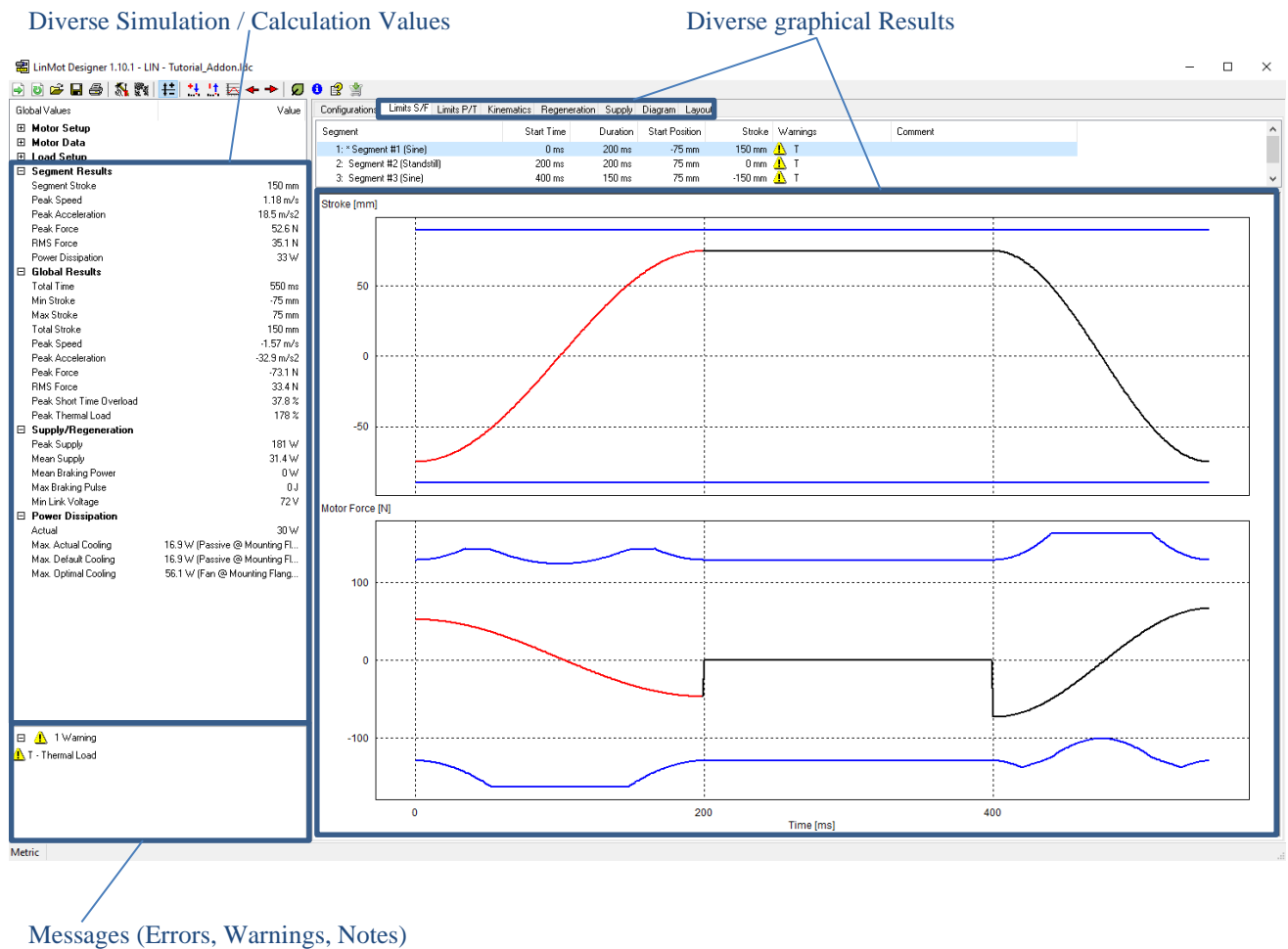
- Motor Setup (Values):** Shows parameters for motor P10-54x120U/430, including Drive Type (Custom (DrvCustom_I1)), Max Drive Current (10 Apk), and Supply Voltage (AC 1Ph x110V).
- Custom Components (Drive & Supplies):** A tree view showing the configuration of custom components. Under 'System Configuration', 'Supply' is expanded to show '1 x 110 V AC (Custom) (166)' selected.
- Global Settings:** A dialog box for configuring the custom drive 'DrvCustom_I1'. It includes:
 - Max Current: 10 Apk
 - Max Gain: 80 %
 - DC link voltage range: 48 V (min) to 750 V (max)
 - Internal Capacitance: 500 uF
 - Default Supply: 1 x 110 V AC (Custom)
 - Custom Supplies table:

	Nominal Supply Voltage	DC Link Voltage
DC Supply:	55 V	55 V
1-Phase AC Supply:	110 V	156 V
3-Phase AC Supply:	400 V	566 V
 - Checkboxes for enabling custom components: Custom Drive (checked), Custom DC Supply (unchecked), Custom 1-Phase AC Supply (checked), and Custom 3-Phase AC Supply (unchecked).

Simulation Results

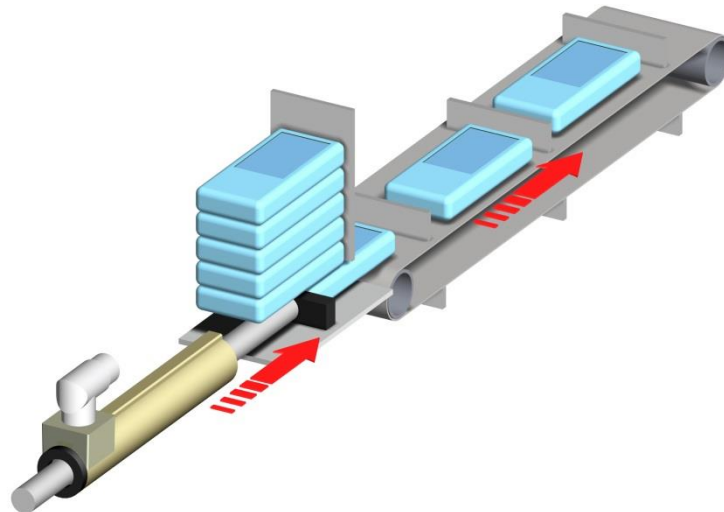
As soon as a new configuration is defined (exit dialog boxes), the simulation results are calculated and updated. If no error or warnings are showed, the current motor configuration with its components can be used for the application.

Remark: The components used in the LinMot-Designer are simulations components. In general, variants of articles are available which are based on a single simulation component.



Example 1: Horizontal linear Movement

In a production line, a pneumatic cylinder pushes 30 products per minute from a stack into a conveyor belt. To increase productivity a faster second production line will be installed, and the pusher has now to handle the products from the two lines. The maximal production rate for the pusher will increase to 109 products per minute.



To handle the 109 products per minute, the minimal cycle time to push one product onto the conveyor belt is **550msec**. To guarantee gentle product handling (and for dynamic reasons), a LinMot linear motor will replace the pneumatic cylinder. The maximum stroke of the movement is **220mm**.

The mechanical construction should not be changed. The weight of this construction (without the slider of the linear motor weight) is **500g**. The product weight itself is **700g**.

The questions to answer during the motor sizing are:

- Which type of **linear motor** may do the job?
- Which size **servo drive** will be needed to control the motor?
- Do we need additional **cooling** or additional **accessories** for the linear motor?
- What is the **minimal cycle time** for this application?

Note: You will find all configurations from this Tutorial in the LinMot Designer folder on your PC (filenames: Tutorial_Ex1.ldc).

Step 1: Start LinMot Designer and input global Data

Starting the LinMot Designer

The last LinMot Designer project will automatically be loaded at start up. To start a new project, click on the “New Linear Project” Button to size a new linear motor/module or click on the “New Rotary Project” Button to size a new rotary motor/module. This will reset all parameters to the default values.

When importing for the first time a project created with an older version of LinMot Designer, you may be asked to select an appropriate replacement drive type, since in the newer Designer version some components (e.g. the drive series E11x0 and B1100 or RS01 motors) are no longer available.



“New Rotary Project” Button
 “New Linear Project” Button

Selecting a motor configuration

To select a motor configuration, select the “Configurations” tab. The next step is to set as many filter criteria (in accordance with the application) so to reduce the motor/module configuration list to a list of potential solutions. Activate the “Application Requirements” filters to exclude all configurations that are certainly not suitable and to display only motors/modules with the next bigger stroke. The application stroke is 220mm. To display all configurations with a motor/module stroke which is within a certain range, for example between 220mm and 300mm, set the “Max. Stroke” filter to the desired limit values. Set the “Motor/Module Category” on “Linear Motor”. If radial forces are expected on the slider, then search for a linear motor with a guide. Because of the rather short stroke and the application type, it is recommended to look only for moving slider configurations. Hence, set the “Moving Part” to “Moving Slider”. As a first configuration search for a motor/module without fan, sealing air or fluid cooling. Therefore, set the “Cooling Method” on “Passive”. Because no stainless-steel motor/module is needed, set the “Stainless Steel (SSC)” filter on “No”.

The screenshot shows the LinMot Designer 1.10.1 interface. The 'Configurations' tab is active, displaying a list of motor configurations filtered by various criteria. The 'Filter' section on the left includes:

- Application Requirements: Stroke (220 mm), Speed (2.3 m/s), Acceleration (48.3 m/s²)
- Motion Requirements: Max. Stroke (320, 164, 760)
- Installation Requirements: Guided Type, Integrated MagSpring, Short Motor, High Clearance, Hollow Slider, Heavy Duty
- System Configuration: Motor/Module Category (Linear Motor (164)), Moving Part (Slider (164)), Cooling Type (Passive (164))

The main table displays the following columns: Motor/Module, Moving Part, Cooling, Drive, Supply, Stroke, Extended Stroke, and Max Force. The selected configuration is P01-37x120F/200x280-HP with a Slider moving part, Passive cooling, C11x0-XC / C1250-XC drive, and 72 V DC supply.

Motor/Module	Moving Part	Cooling	Drive	Supply	Stroke	Extended Stroke	Max Force
[3] P01-23x160/80x220-LC	Slider	Passi...	72 V DC	80 mm	220 mm	63.5 N	
[3] P01-23x160/140x280-LC	Slider	Passi...	72 V DC	140 mm	280 mm	63.5 N	
[3] P01-23x160F/80x220-LC	Slider	Passi...	72 V DC	80 mm	220 mm	86.4 N	
[3] P01-23x160F/140x280-LC	Slider	Passi...	72 V DC	140 mm	280 mm	86.4 N	
[3] P01-23x160H/80x220-HP	Slider	Passi...	72 V DC	80 mm	220 mm	138 N	
[2] P01-23x160H/140x280-HP	Slider	Passi...	72 V DC	140 mm	280 mm	138 N	
[2] P01-23x160H/140x280-HP-L	Slider	Passi...	72 V DC	80 mm	220 mm	124 N	
[2] P01-23x160H/140x280-HP-L	Slider	Passi...	72 V DC	140 mm	280 mm	124 N	
[3] P01-23x80/160x220-LC	Slider	Passi...	72 V DC	160 mm	220 mm	44 N	
[3] P01-23x80/220x280-LC	Slider	Passi...	72 V DC	220 mm	280 mm	44 N	
[3] P01-23x80F/160x220-HP	Slider	Passi...	72 V DC	160 mm	220 mm	67.1 N	
[3] P01-23x80F/220x280-HP	Slider	Passi...	72 V DC	220 mm	280 mm	67.1 N	
[3] P01-23x80F/160x220-HP-L	Slider	Passi...	72 V DC	160 mm	220 mm	60.4 N	
[3] P01-23x80F/220x280-HP-L	Slider	Passi...	72 V DC	220 mm	280 mm	60.4 N	
[4] P01-37x120F/160x240-HP	Slider	Passi...	72 V DC	160 mm	240 mm	255 N	
[4] P01-37x120F/200x280-HP	Slider	Passi...	72 V DC	200 mm	280 mm	255 N	
[4] P01-37x120F/180x260U-HP	Slider	Passi...	72 V DC	180 mm	260 mm	210 N	
[4] P01-37x120F/160x240-HP-L	Slider	Passi...	72 V DC	160 mm	240 mm	229 N	
[4] P01-37x120F/200x280-HP-L	Slider	Passi...	72 V DC	200 mm	280 mm	229 N	
[4] P01-37x120F/220x240-HP	Slider	Passi...	72 V DC	220 mm	240 mm	128 N	
[4] P01-37x120F/260x280-HP	Slider	Passi...	72 V DC	260 mm	280 mm	128 N	
[4] P01-37x120F/220x240-HP-L	Slider	Passi...	72 V DC	220 mm	240 mm	115 N	
[4] P01-37x120F/260x280-HP-L	Slider	Passi...	72 V DC	260 mm	280 mm	115 N	
[3] P01-37x120/200x280-LC	Slider	Passi...	72 V DC	200 mm	280 mm	163 N	
[3] P01-37x120/180x260U	Slider	Passi...	72 V DC	180 mm	260 mm	177 N	
[2] P01-37x120F/160x240-HP	Slider	Passi...	72 V DC	160 mm	240 mm	255 N	
[2] P01-37x120F/200x280-HP	Slider	Passi...	72 V DC	200 mm	280 mm	255 N	
P01-37x120F/200x280-HP	Slider	Passive...	C11x0-XC / C1250-XC	72 V DC	200 mm	280 mm	255 N
P01-37x120F/200x280-HP	Slider	Passive...	E12x0-UC	72 V DC	200 mm	280 mm	255 N
[2] P01-37x120F/180x260U-HP	Slider	Passi...	72 V DC	180 mm	260 mm	210 N	
[2] P01-37x120F/160x240-HP-L	Slider	Passi...	72 V DC	160 mm	240 mm	229 N	
[2] P01-37x120F/200x280-HP-L	Slider	Passi...	72 V DC	200 mm	280 mm	229 N	
[2] P01-37x240F/80x280-LC	Slider	Passi...	72 V DC	80 mm	280 mm	310 N	
[2] P01-37x240F/60x260U	Slider	Passi...	72 V DC	60 mm	260 mm	335 N	
[2] P01-48x150G/210x250-HP	Slider	Passi...	72 V DC	210 mm	250 mm	360 N	
[2] P01-48x150G/180x240U-HP	Slider	Passi...	72 V DC	180 mm	240 mm	312 N	
[2] P01-48x210E/90x240U	Slider	Passi...	72 V DC	90 mm	240 mm	453 N	
[2] P01-48x210E/90x240	Slider	Passi...	72 V DC	90 mm	240 mm	544 N	
[2] P01-48x210E/90x240U	Slider	Passi...	72 V DC	90 mm	240 mm	472 N	
[2] P01-48x240F/90x240	Slider	Passi...	72 V DC	90 mm	240 mm	...	

Once the filter criteria have been set, select from the filtered configuration a smaller motor from the 72V-System, for example the P01-37x120F/200x280-HP with a X1xx0 drive (“C11x0-XC / C1250-XC”). A double click on the row copies the components “Motor/Module”, “Moving Part”, “Cooling”, “Drive” and “Supply” to the Global Values (→ Motor Setup).

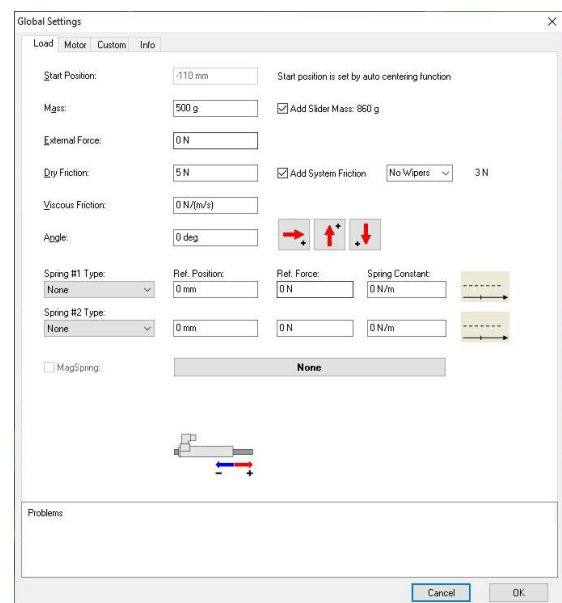
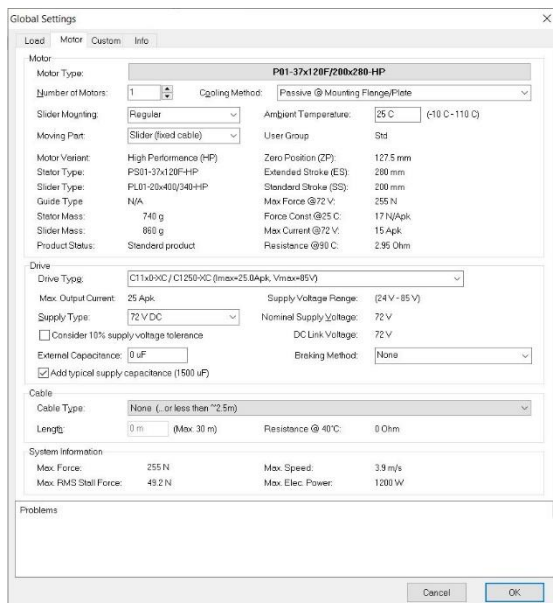
To define the details of the motor configuration, open the “Global Settings” dialog. Open it via the menu button or double clicking a configuration parameter in the Motor Setup (Global Values).



“Edit global Settings” Button

In the “**Motor**” tab of the “Global Settings” dialog, additional configuration parameters can be defined and already defined parameters can be edited. Additional configuration parameters to the motor/module are: “Ambient Temperature” (which influences the RMS-Force), “Number of Motors” (used in master-booster or master-gantry modes), “Slider Mounting” (slider direction relative to the stator), “Consider 10% supply voltage tolerance” (the Designer considers a 10% reduced/increased dc link voltage in its calculations), the “Cable Type” and “Cable Length” (the cable resistance results in a reduction of the force limit - needs to be defined for longer cables), “External Capacitance” (supply capacitance, or if available, capacitance of an external device - affects the Supply/Regeneration), “Add typical supply capacitance” (adds an additional external capacitance of 1500uF - capacitance of a S01-72/11000 power supply, and only for DC drive types), “Braking Method” (allows the selection of one of the following braking methods during regeneration: none, braking resistor or motor winding).

After defining the motion sequence, in the “Global Settings” menu a new motor and drive can be selected to best fit the application.



In the “**Load**” menu, the specifications about the mechanical configuration (mounting angle, friction, start position, etc.) have to be specified according to the application. Direction graphics for motor/modules are also displayed in this window depending on the “Angle” value.

In the example, the maximal stroke is 220mm. Choose a start position that is half of the total stroke, so to have the motion symmetrical to the Zero Position (ZP) of the linear motor. A symmetrical motion relative to the Zero Position will give the best performance for the motion. If the “Auto centering mode” button is pressed, then the start position will be set automatically.



“Auto centering mode” Button

The constant mass of the pusher construction (500g) has to be set in the “Global Settings”. The 700g product mass will be set later in the “Local Settings”, as it has to be considered only for the forward (push) motion. Besides the mass of the construction, the program will automatically add the mass of the moving part of the motor. In the construction of this application the slider is the moving part, so “Add Slider mass” has to be selected.

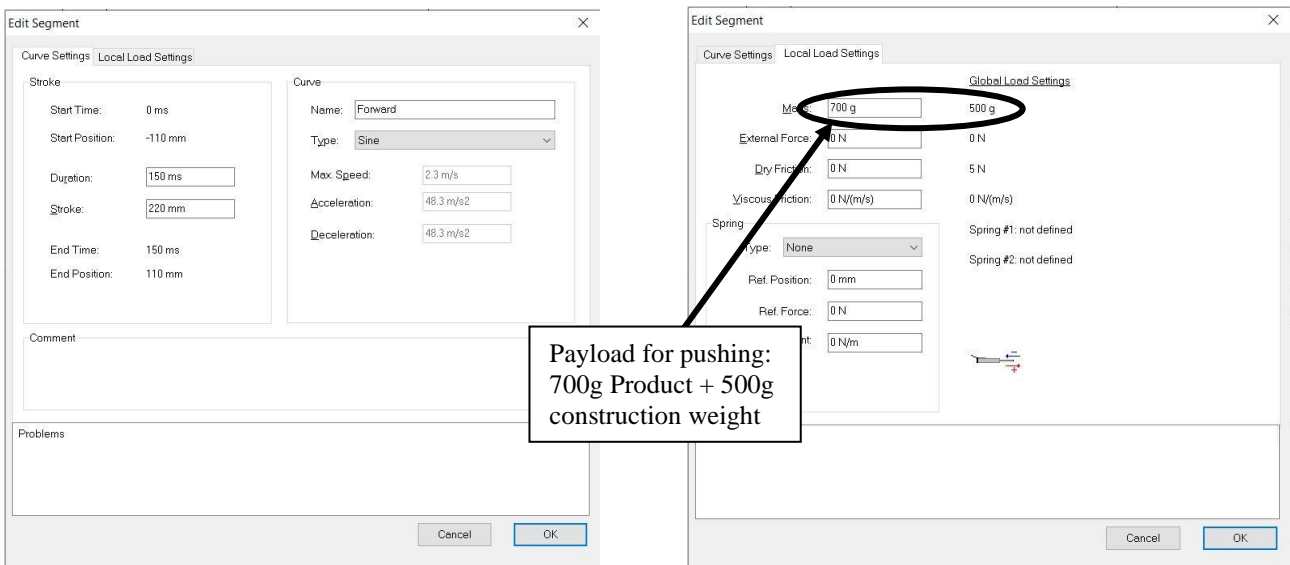
Step 2: Segmentation of the Motion

During the segmentation of the movement, the complete motion is subdivided into individual integral movement sections. In this example the entire motion can be divided into three different segments (e.g. “controlled forward movement”, “fast backward movement”, “Standstill”).

Motion	Stroke	Time	Total Payload
Forward	220mm	150msec	1200g
Backward	-220mm	150msec	500g
Standstill	0 mm	250msec	500g

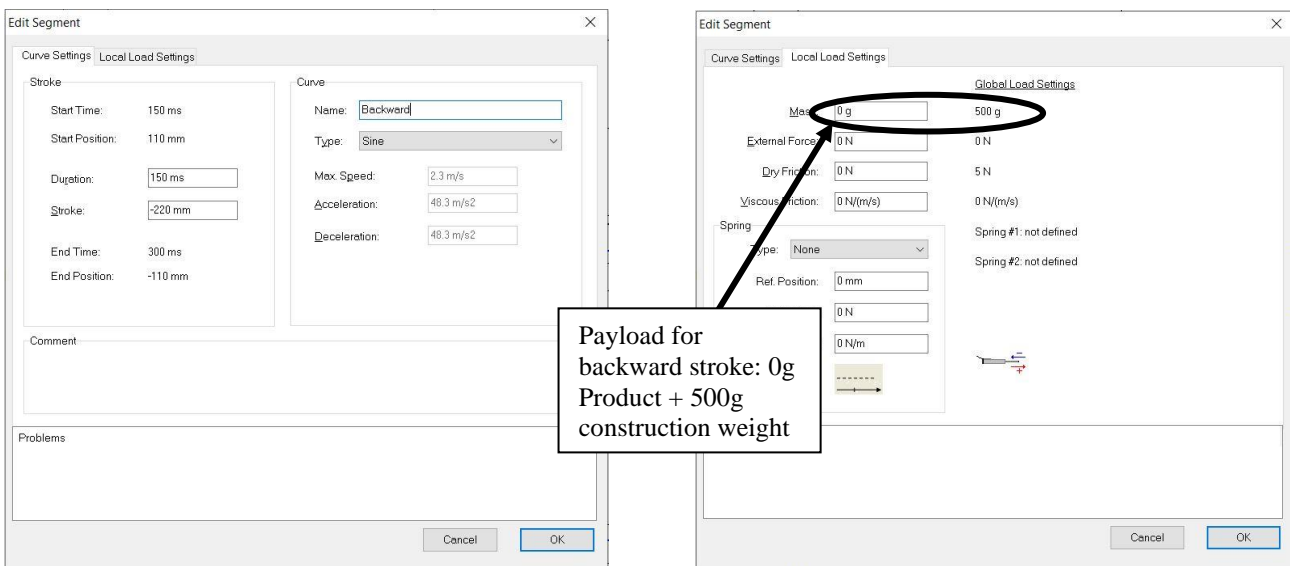
Define the “Forward” Motion

Open the “Edit Segment” window for the first segment of the motion (double click on text “1 Sine”). In the “Curve Settings” window specify the 220mm of stroke for the forward movement (pushing). In this segment we must also consider the additional mass of the product (construction and slider mass will be considered automatically).



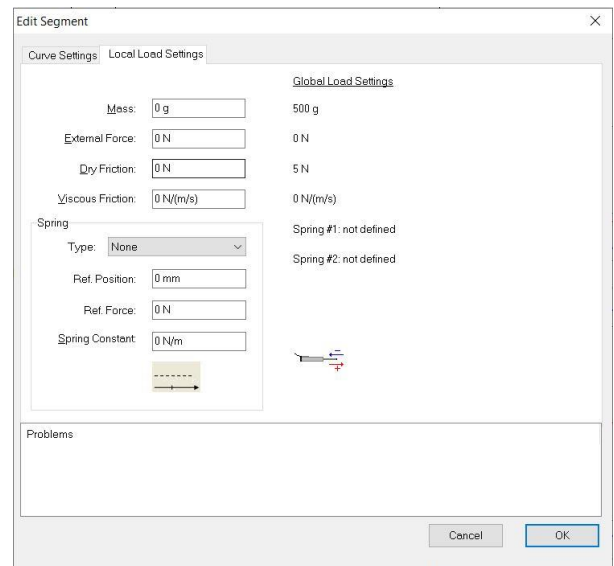
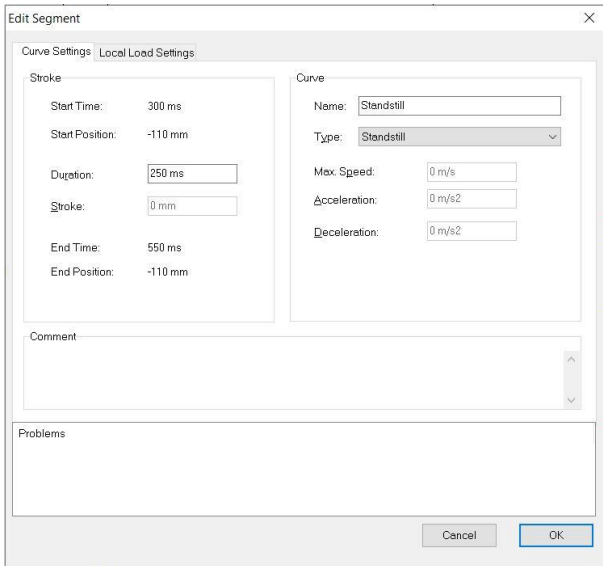
Define the “Backward” motion

Add a new segment for the backward stroke and open the “Edit Segment” window (double click on text “Add new segment”). In the “Curve Settings” window specify the -220mm of stroke for the backward movement. An additional mass is not added, since for the backward movement there is no additional payload.

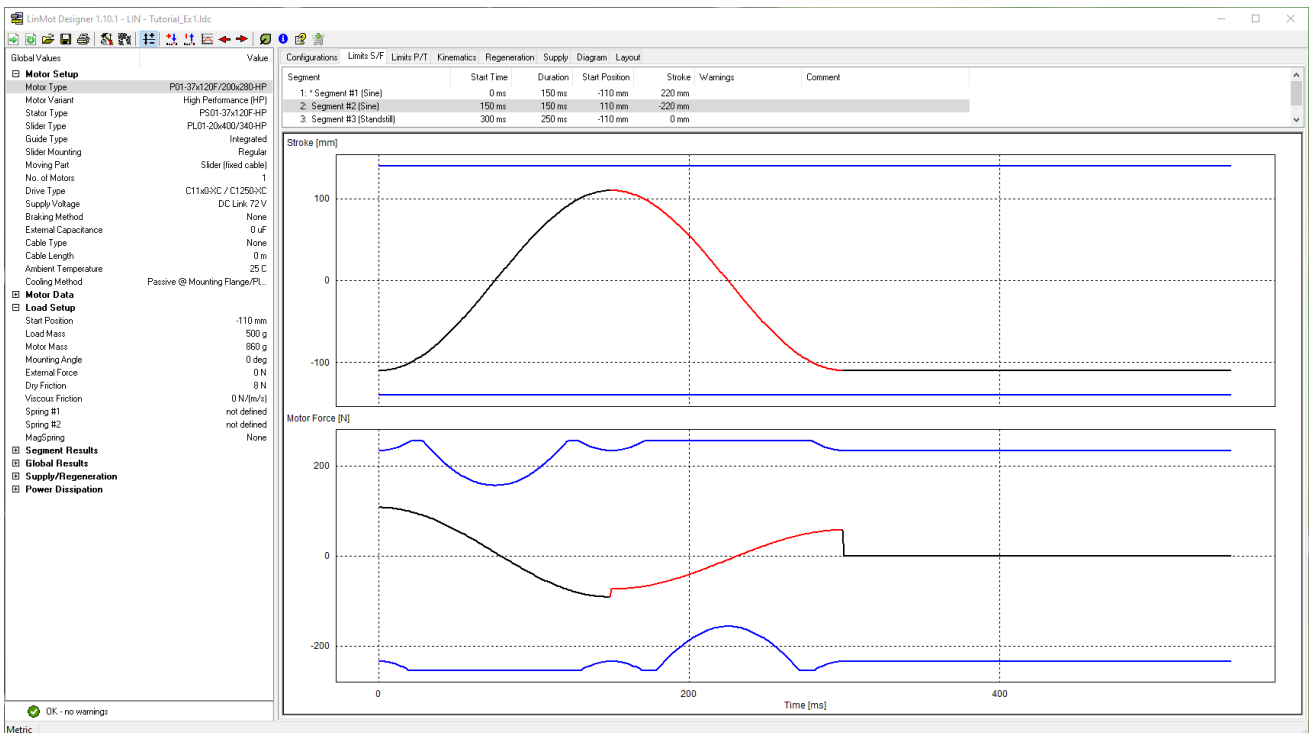


Define the “Standstill” time

Add a new segment for the standstill part of the motion sequence and define the motion according with the screenshots. It is important to specify the entire cycle of the motion (including standstill time) in order to obtain correct results for the RMS force and thermal load calculations.



After defining the entire motion sequence, the desktop of the LinMot Designer will have the following appearance. If there are any “Local Load Settings” defined in an existing segment, a “*” is shown as prefix to the corresponding segment name.



Step 3: Checking the Design

For the defined application, LinMot Designer calculates diverse physical parameters that are important for the design. The most important dynamic parameters are shown in diagrams as time-dependent values (Stroke, Motor Force, Power Dissipation, Short Time Overload, Thermal Load, Speed, Acceleration, Electrical Power, Link Voltage, Link Brake Energy Pulse and Link Supply Power). In the “Global Values” window, relevant static parameters as well as peak-, rms- and mean-values of dynamic parameters are displayed.

Whenever the current configuration of the design is changed, several checks are made by the designer, and its results are displayed as a separate message at the bottom of the Global Settings window. If all checks are positive, an “Ok – no warnings” with a green symbol is showed as message. Otherwise, at least one error or warning message is displayed. Notes can be displayed even if the design is ok.

Message Type	Symbol	Description	Example
Ok	✔	General message when no warning and no errors are present.	The design is ok. Some helpful Notes can still be displayed.
Error	⚠	The calculation cannot be performed correctly due to an invalid configuration	Stroke Error: The stroke of the motion is bigger than the max stroke of the motor/module.
Warning	⚠	The limit value of a system component is exceeded. The system must be changed.	Thermal Warning: The motor/module is overheating with the current configuration.
Note	ℹ	If a “soft” limit is exceeded, a configuration is suboptimal or unusual and thus possibly unintended.	Acceleration Note: If the “soft” acceleration limit is exceeded, the service life may be affected when ball bearing components are used.

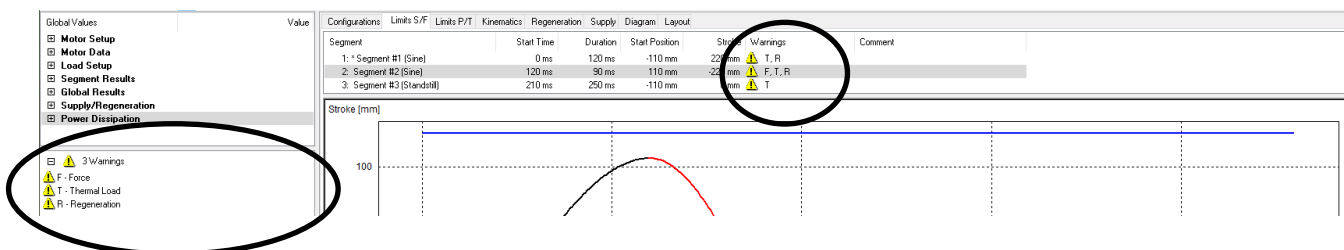
A realisation of the defined application will only be successful, if the dynamic parameters do not exceed their corresponding limits and therefore none of the following errors or warnings are displayed:

Dynamic parameter	Flag
Stroke	S ⚠
Force	F ⚠
Short Time Overload Protection Value	O ⚠
Thermal Load	T ⚠
Regeneration	R ⚠
Acceleration Reserve	Ar ⚠
Speed Jump	J ⚠
End Position	E ⚠
Acceleration	A ℹ
Motor Support	⚠

Note: The Stroke (S), Speed Jump (J), End Position (E) and Motor Support are displayed as errors by the current version of LinMot-Designer (Version 1.10.1) instead of warnings, while the Acceleration parameter (A) is displayed as a note.

Flags in the “Curve Settings” window show in which segment(s) the corresponding limits are exceeded. In addition to the dynamic parameter check, also a system check is done. If the selected motor is not supported by the selected drive, a “Motor Support” error is generated and displayed in the “Global Values” window. Error, warning and note messages are also showed locally in different dialogs. Not all of which are also showed in the global message display.

Reducing the duration of the segments will cause more warning to appear.



(These warnings were generated by reducing the duration of the first and second segment in the example)

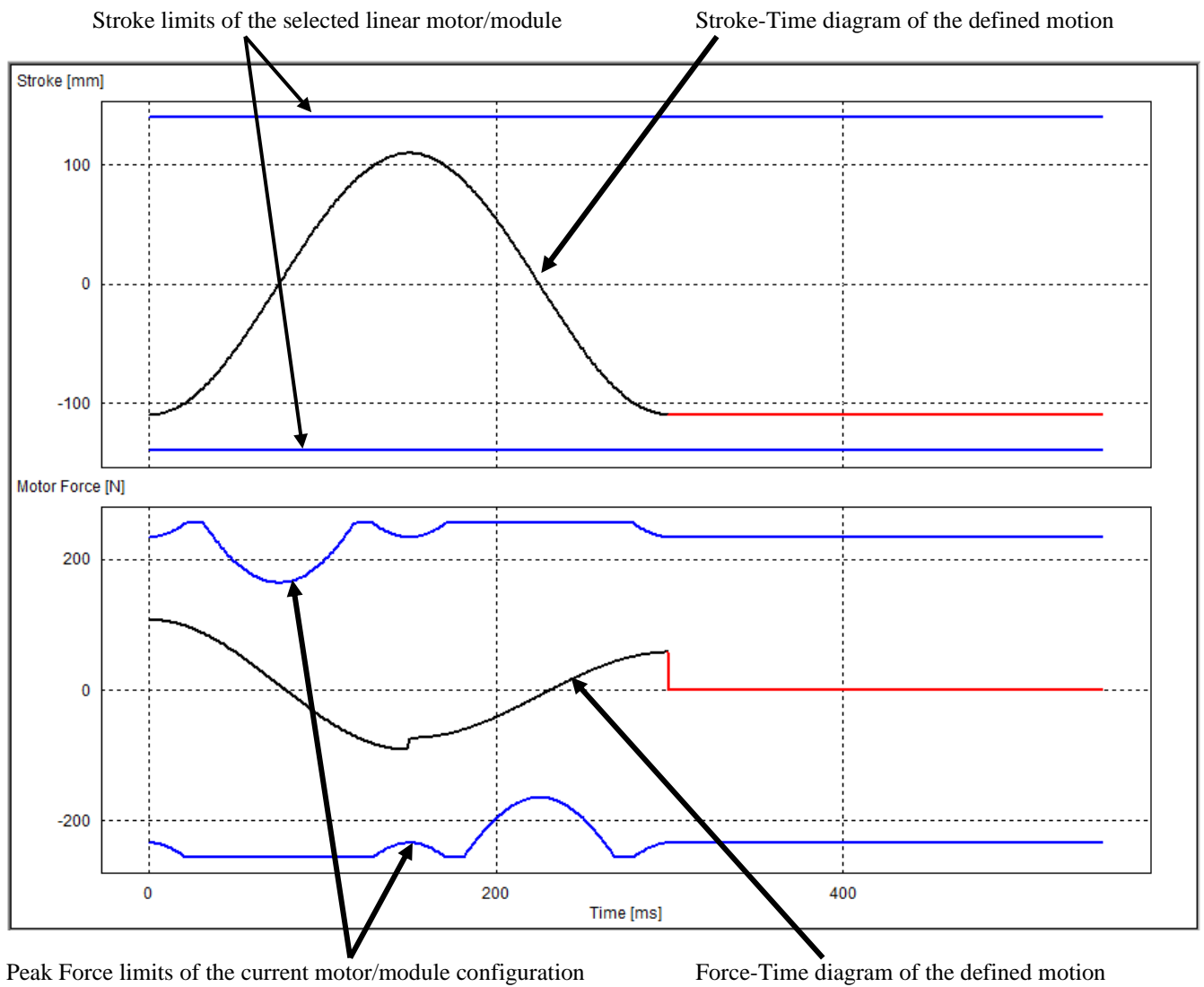
In the “**Limits S/F**” window, the mechanical parameters “Stroke” and “Force” of the motion are shown in time-diagrams together with their corresponding limits. In the “**Limits P/T**” window, the thermal parameters “Power Dissipation” (without limits), “Short Time Overload Protection Value” and “Thermal Load” are shown in time-diagrams together with their limits. The “**Regeneration**” window contains the “Electrical Power”, the “Link Voltage” and the “**Link Brake Energy Pulse**”. The latest signal is the reason for generating the regeneration warning.

Stroke Limits

The Stroke and its limits are shown in the upper diagram of the “Limit S/F” window. The graph of the motion (black-red line) has to be within the limits (blue lines) for the selected linear motor. If the stroke of the motion is too long, a motor type with a longer maximal stroke must be selected. The maximal stroke of the linear motor should be selected close to the maximum stroke needed in the application, in order to minimize the moving mass (slider). The motion should be symmetrical to the Zero Position (0mm) of the motor. If the motion is not symmetrical the parameter “Start Position” has to be adjusted in the “Global Settings” window (see Step 2).

Dynamic Force Limits

The Force diagram shows the dynamic force the linear motor has to produce during the motion (black-red line). The peak force limits for the selected linear motor are also displayed (blue lines). If the force that the motor has to produce is within the motor limits, then the selected motor can perform the requested motion. If the motor force is not within the limits, then a different linear motor or servo drive has to be selected. If the requested force is still not within the limits, extending the execution time in the critical segments or reducing the payload will help to get within the requested motor force.



Note: Peak force limits of a linear motor depends on the actual position (see stroke force diagram in the data sheets) and on the actual velocity (peak force is decreasing with higher velocities). The peak force may change if another linear motor is selected due to differences in slider mass.

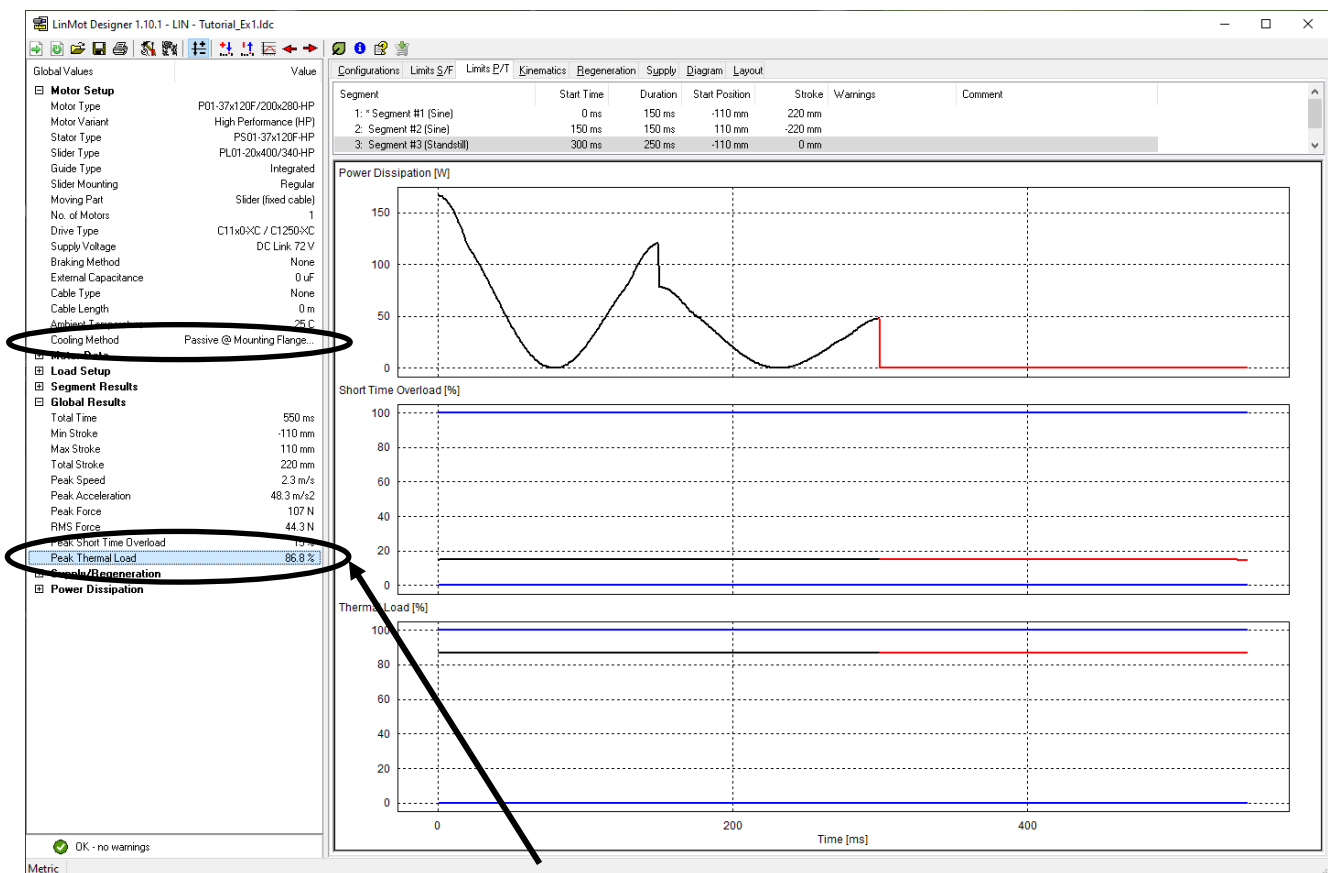
Short Time Overload

The power losses in the motor coils, given by the **Power Dissipation**, will first heat up the motor winding prior to the other parts of the motor. A short time overload protection mechanism of the LinMot servo drives prevents the motors from overheating in case of rapid increasing winding temperature due to high power dissipation values. The **Short Time Overload Protection Value** (black-red line) is independent from the motor cooling and approximately constant for short cycle times. The minimal value is 0% and the limit is at 100% (blue lines).

Thermal Load

The power losses in the motor coils, given by the Power Dissipation, will heat up the motor. Depending on the ambient temperature and the cooling method, the corresponding **Thermal Load** (black-red line) of the motor will result. For short cycle times, the value will approximately be constant. The minimal value is 0% and the limit is at 100% (blue lines). At a Thermal Load of 100%, the thermal hardware protection would turn off the linear motor in the real application (at a case temperature around 65°C). To reduce the thermal load, use the more efficient cooling method (“Fan” in place of “Flange”) at “Global Settings”) or use a motor with higher continuous force.

Note: The Short Time Overload Protection Value and the Thermal Load are calculated for the thermal steady state.



The Peak Short Time Overload Protection Value is definitely under the limit. The Peak Thermal Load is slightly under the limit, so the linear motor will not overheat in the application. If the payload or the friction increase (or the cycle time is reduced), the Thermal Load will increase and exceed the limit. Then, the linear motor will need to be mounted on a flange with fan cooling.

Acceleration

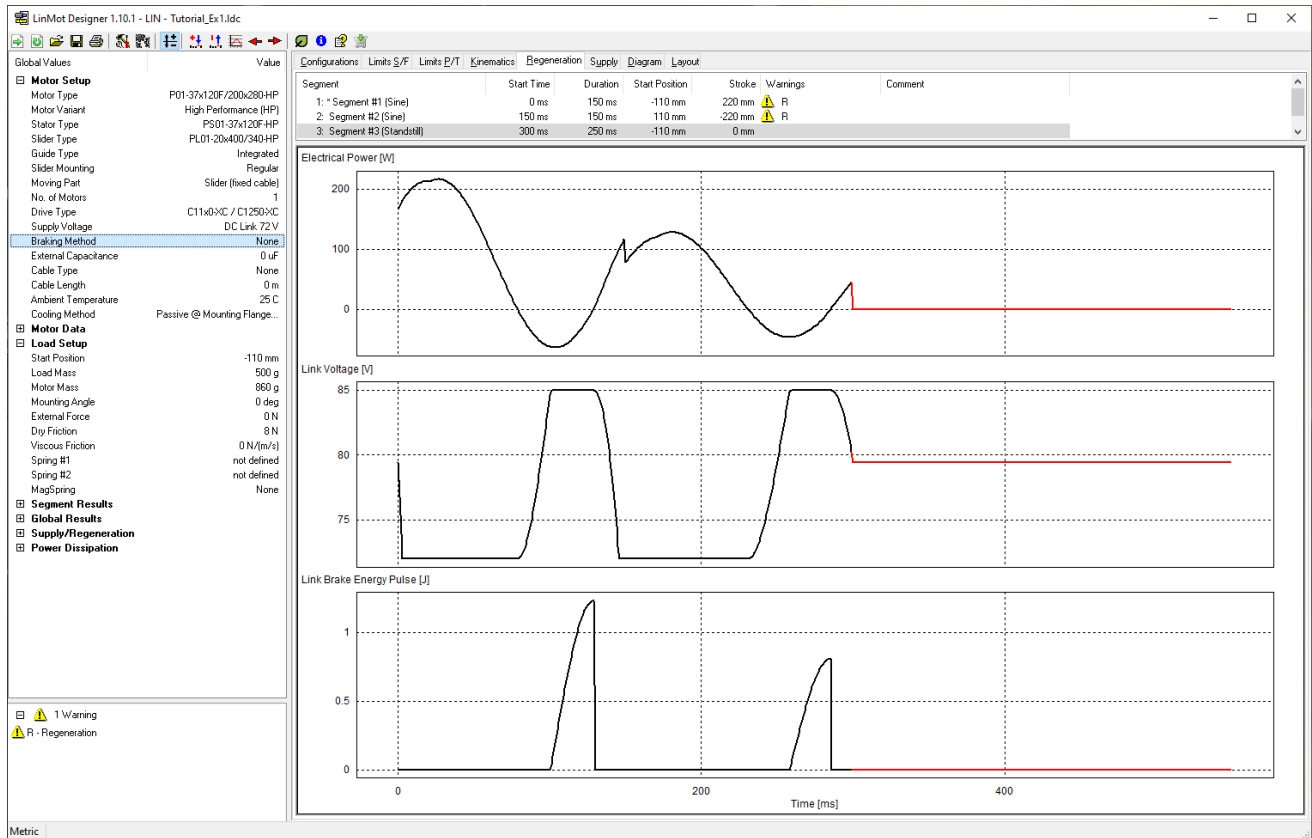
The acceleration is monitored for all linear motors with guides (modules) and when it exceeds a certain value the Acceleration Note is activated. This note indicates that too high acceleration values of the motion may influence the typical motor/module lifetime.

Regeneration

Usually, DC link power supplies have an output capacitance that can be used as an external capacitance of the drive. For a DC Supply Type, LinMot Designer adds by default a typical supply capacitance of 1500uF. If the output capacitance of the supply differs from this value, then the correct value should be entered as an external capacitance in the motor configuration window (“Global Settings”). In this example, if we clear the box “Add typical supply capacitance”, then a Regeneration Warning will appear (see figure on next page).

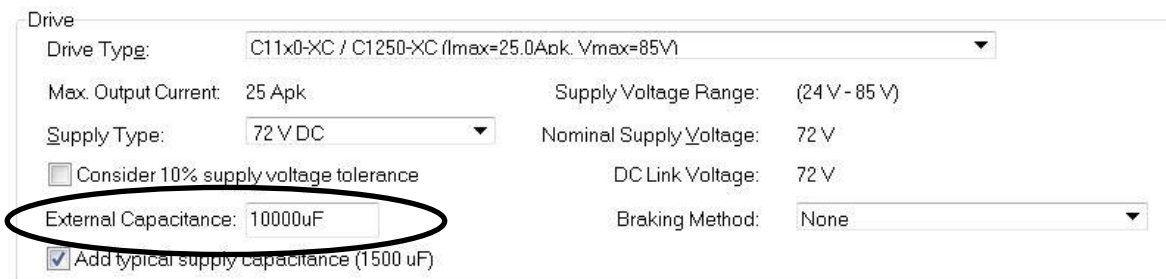
During a whole motion cycle, the motor can temporarily work as generator (usually during braking phases) where electrical power can be transferred from the motor back to the drive. Such a phase leads to an increase of the dc link voltage in the drive.

In the Regeneration tab, the first graph (time diagram) shows the **Electrical Power** from the drive to the motor. If the value is negative, the motor works as generator. The second diagram shows the **Link Voltage**, increasing when the electrical power is negative. If the generated energy is big enough so that the link voltage reaches the maximum link voltage of the drive, then it is necessary to transfer all the additional generated energy to the outside. The common way is the use of a braking resistor supported by the drive. The brake energy pulses, that have to be dissipated in a regeneration resistor (so that the link voltage does not exceeds the max. allowed link voltage), are shown in the **Link Brake Energy Pulse** diagram.



In order to get rid of the Regeneration Warning, there are several possibilities:

a) If the output capacitance of the supply is not enough, then **increase** the dc **link capacitance** of the drive with an external capacitance.



b) Use an appropriate braking resistor, or if available the motor regeneration mode. In these cases, set the “Braking Method” entry to “Braking Resistor” or “Motor Winding” to confirm that a braking resistor or the motor itself will be used to dissipate the excess of energy (in this way the Regeneration Warning will not be showed any more).

Notice: The motor regeneration mode can be used only with some drive types (special regeneration mode that must be enabled in LinMot Talk).

c) Modification of the motion profile. Sometimes, it helps to increase the brake force by increasing the Deceleration value at Point to Point (VAI) curves.

In the *Additional Information* chapter of the tutorial, under Regeneration, a block diagram can be found showing the steps that should be followed when a Regeneration Warning appears, as well as the output capacitance values of the standard power supplies and a table showing the supported regeneration modes of each drive.

Note: The designer rather makes a worst-case calculation. So, a Regeneration Warning, especially in connection with small energy pulses can, but does not have to be a problem if the application is driven without an appropriate regeneration mode.

Acceleration Reserve at Standstill

This acceleration parameter is the ratio between the “Max Force” of the drive system (servo drive & motor) and the moving mass. It is a constant value within a segment. It changes from segment to segment with the change of the moving mass. This acceleration value has always to be bigger than the *limit of 10N/kg*. Concerning the example, for the Max Force value of 113N, the maximum moving mass is 11.3kg. In case of an Acceleration Reserve Warning, reduce the load mass or choose another motor/drive so that the Max Force value gets bigger.

Speed Jump

The “Speed Jump” Error is generated when the speed jumps at the motion segment borders. This error can only be generated when the “Speed Change Linear” curve type is used incorrectly and in such a way that it leads to speed discontinuities from one motion segment to another (i.e., the end speed of one segment is different from the initial speed of the next segment).

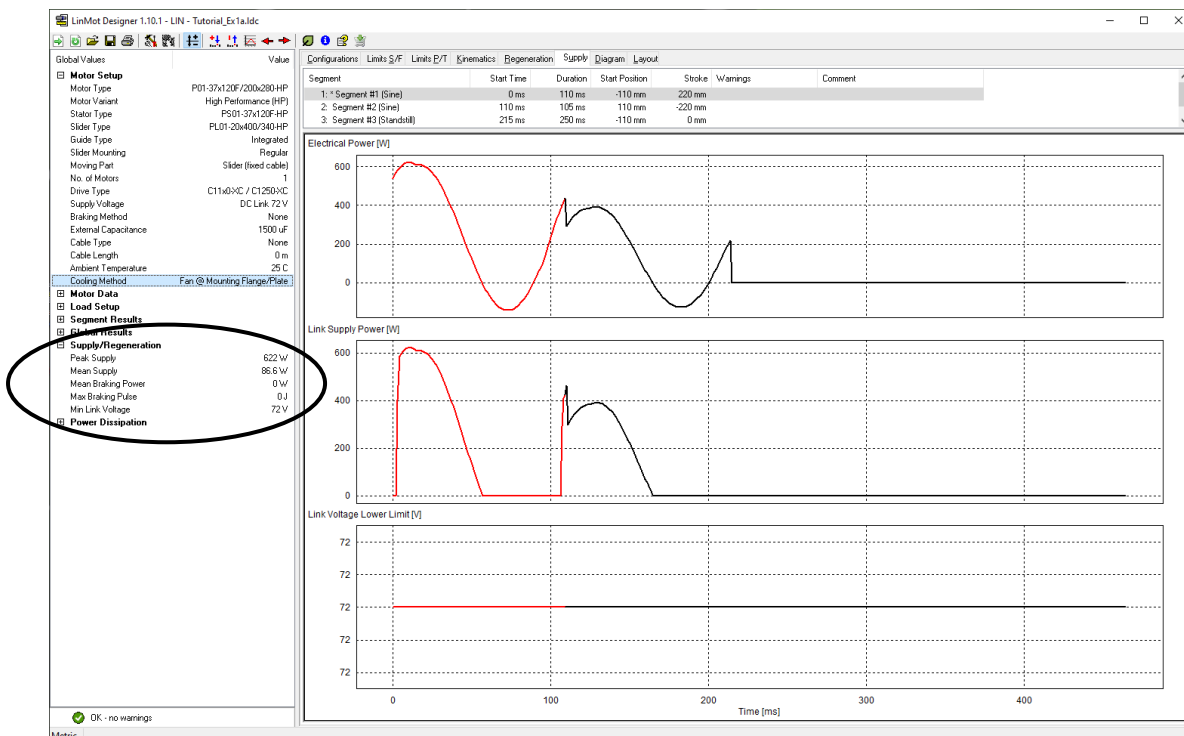
See Example 3 for more information on the different curve types.

End Position

When entering the sequence of motion segments, the end position of the last segment should correspond to the start position of the first segment. This is important because LinMot Designer continuously simulates the defined motion profile and therefore a final position different from the initial position will lead to a discontinuity in the stroke, and hence to the “End Position” Error. The “End Position” error only applies during the simulation of a linear motor.

Power Information

For a designed system, the power information can be found in the Global Values under *Supply/Regeneration* and in the *Supply* tab. LinMot Designer calculates the required electrical power of the motor (*Electrical Power*) and also the corresponding supply power (*Link Supply Power*) for feeding the dc link of the drive. This information can be used to select an appropriate power supply for the application. The power supply must be able to deliver the calculated dc link power added by the power loss of the drive, whereas the latter makes around up to 10% of the electrical motor power. Depending on the dc link capacitance, the electrical power waveform and the allowed temporary drop of the dc link voltage (→ *Link Voltage Lower Limit*), the required power of the supply must be between 110% of the Mean Supply value (absolute minimum) and 110% of the Peak Supply value. To go for sure, use a supply with a power above 110% of the Peak Supply value.



Step 4: Interactive Optimizing

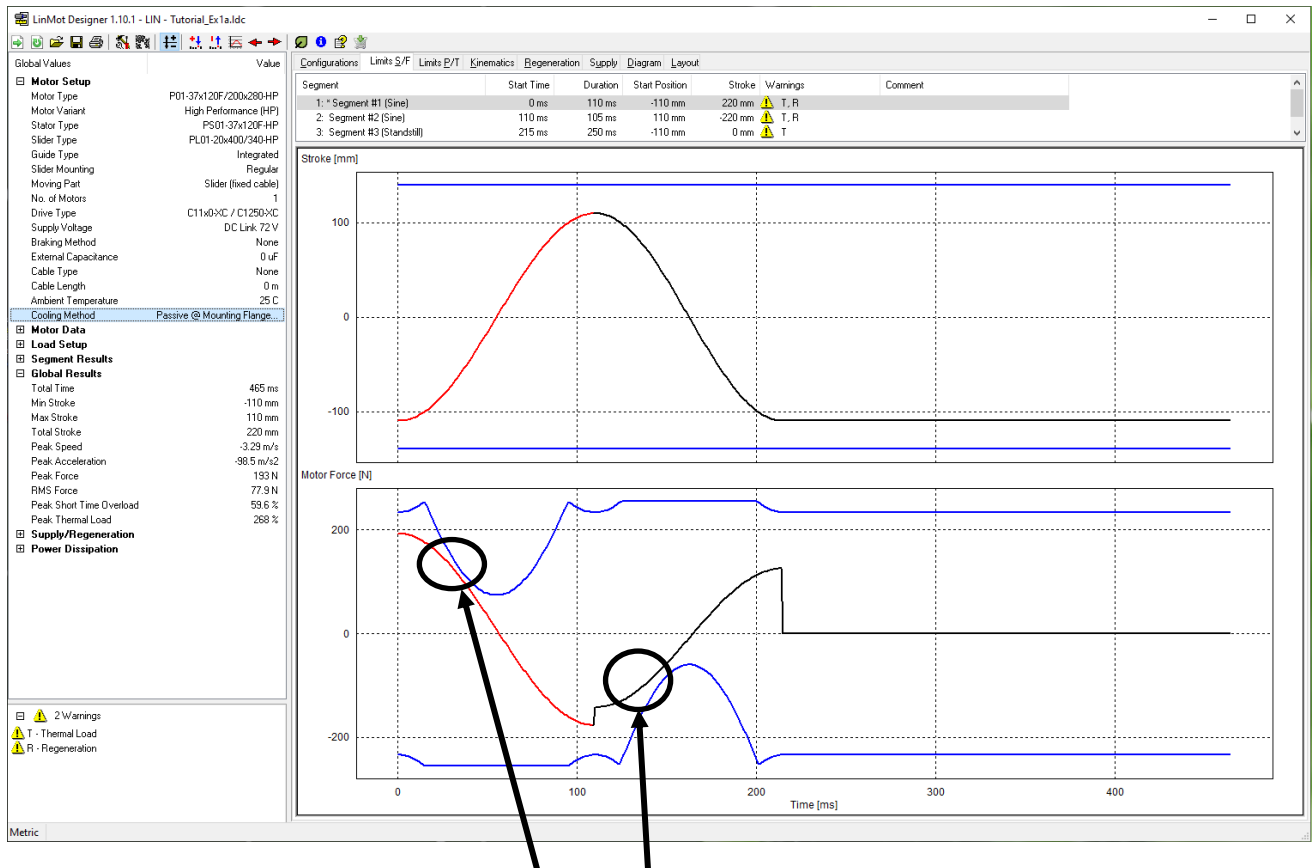
Motor and Servo Drive

With enough capacitance in the dc link, no warnings are generated anymore. So, a system with the selected linear motor type **P01-37x120F/200x280-HP** and a servo drive of one of the Series **C11x0-XC / C1250-XC** with 72V supply will be a solution for this project.

In your LinMot Designer folder you will find the file “Tutorial_Ex1.ldc” with the LinMot Designer data for this project.

Optimizing the motion time

If the application requires even faster cycles, the motion times can be minimized for the selected linear motor by reducing the time for the different segments. The time can be reduced as long as the force needed stays within the peak force limits from the selected linear motor.



Limiting parameters for minimal motion time

Minimizing the motion time in our example shows that the minimal times will be around 110ms for the forward (push) movement and 105ms for the backward movement.

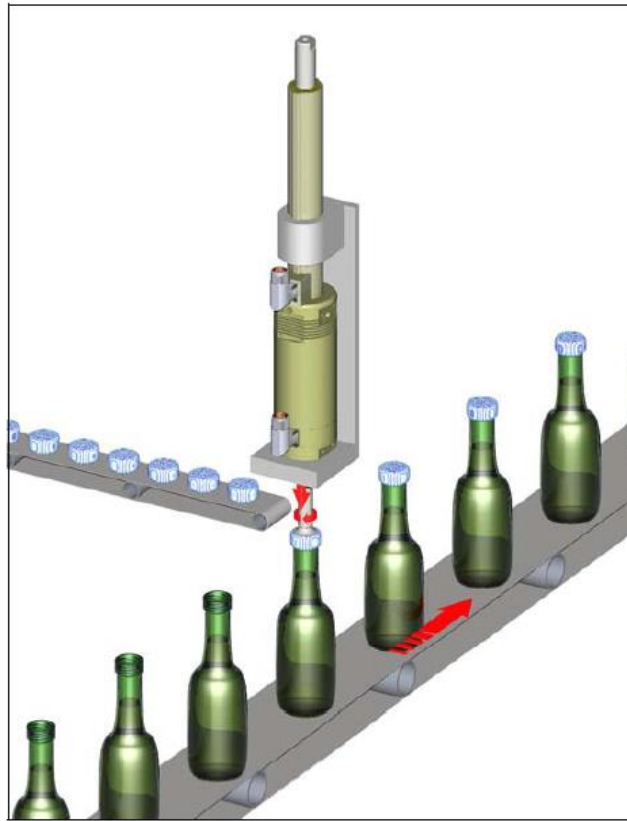
Reducing the time for the forward and backward motion will increase the Peak Thermal Load over the 100%-limit (268% → Thermal Load Warning) if the motor is mounted with the standard flange (Cooling Method: Passive). With a change of the Cooling Method to “Fan”, the Peak Thermal Load decreases under its limit to 81.8%.

By changing to the “Fan” cooling method, it is additionally possible to reduce the standstill time to 150ms. This will result in a Peak Thermal Load of 98.2%, which is still within the motor limits.

Because of the Regeneration Warning, the use of a regeneration resistor (or one of the other discussed actions) is necessary. If you are aware of that, you can disable the warning by selecting the appropriate “Braking Method”.

Example 2: Rotating Movement

The following Example refers to an application for capping of bottles. To screw the cap on the bottle, a combination of a linear and a rotating movement is required, hence predestined to use a Linear-Rotary Motor from the LinMot PR01 or PR02 series. The linear part of the linear rotary motor PR01/PR02 can be designed and checked analog to example 1. In this example is discussed the sizing of the rotary part of the linear rotary motor PR01/PR02. The configuration of this example is saved as “Tutorial_Ex2.ldc”.

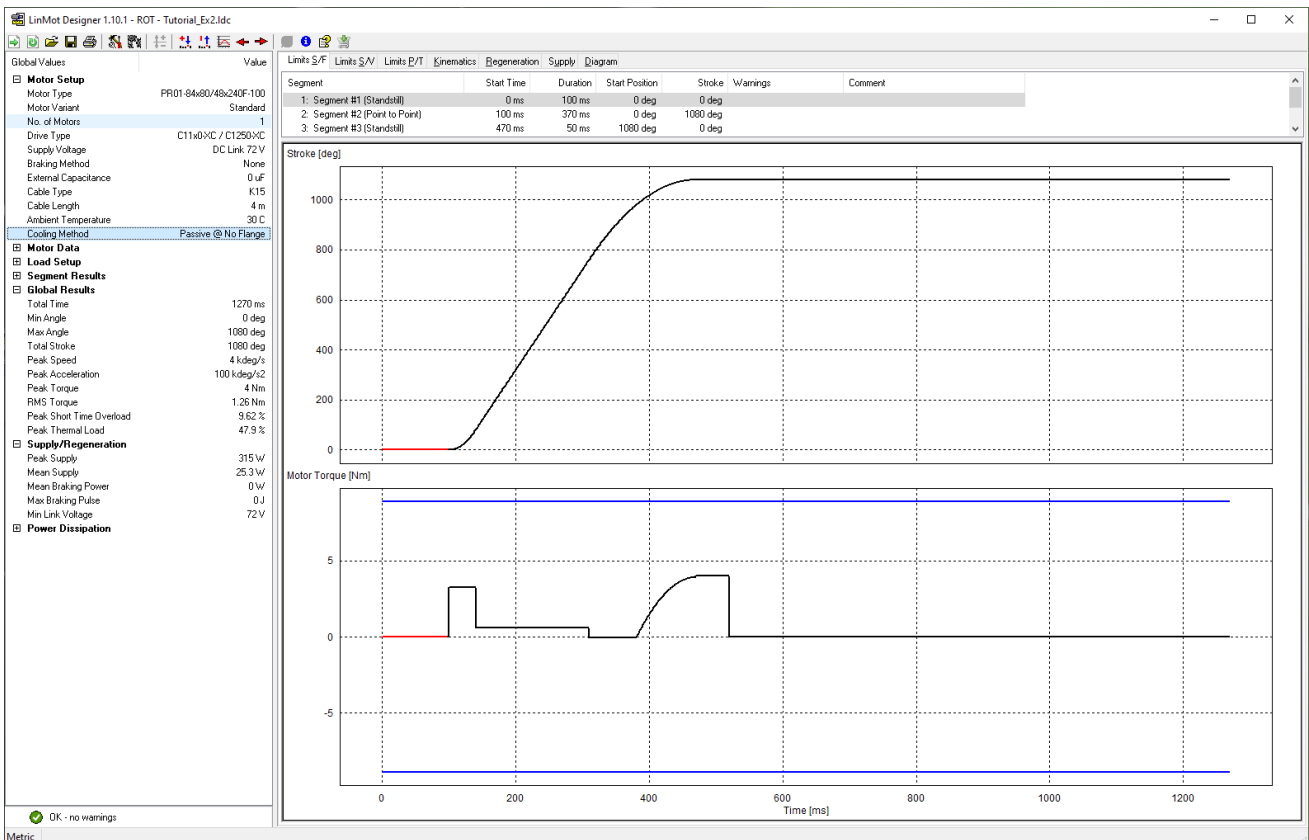


Cycle of the application:

- 1) Moving cap with capping head to the bottle thread (linear movement)
- 2) Screwing the cap on the bottle (linear and rotary movement)
- 3) Tightening the cap with increasing torque to an upper limit (linear and rotary movement)
- 4) Stop tightening, torque to zero (standstill)
- 5) Moving capping head back to start position (linear movement)

Requirements for rotary motor:

- T_Cycle: **1.3s** (**2'770 bottles/hour**)
- T_Screw&Tighten: **< 0.5s**
- Stroke Screw&Tighten: **1080deg** (**3 turns**)
- Stroke Tighten: **100deg** (**ca. 1/4 turn**)
- J_CappingHead: **13.1 kg/cm²**
- J_Cap: **negligible**
- Friction torque: **0.6Nm**
- Max. tightening Torque: **4Nm**




Segment and load definition

1) Standstill

No rotation, while the cap is moved linearly to the top of the bottle.

2) Point to Point

Screwing process with a constant friction torque of 0.6Nm (global definition). During the tightening process at the last 100 degrees, the torque increases towards the limit torque of 4Nm. This behavior can be simulated with a global spring:

Spring #1 Type: Ref. Position: Ref. Torque: Spring Constant: 

The Moment of Inertia of the capping head is defined in the Global Load Settings.

3) Standstill

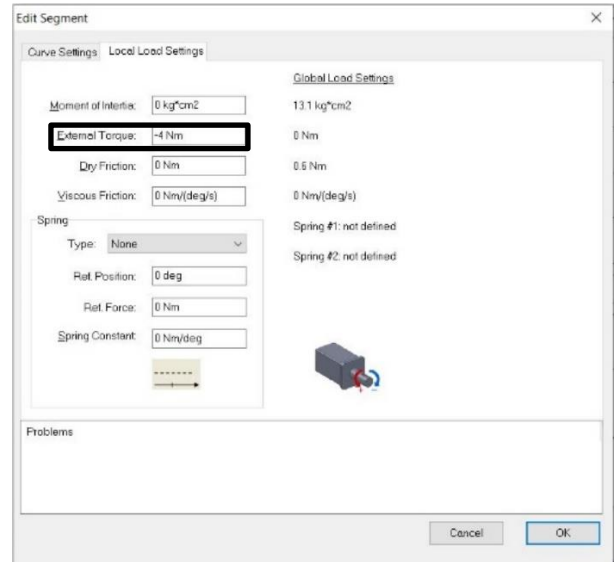
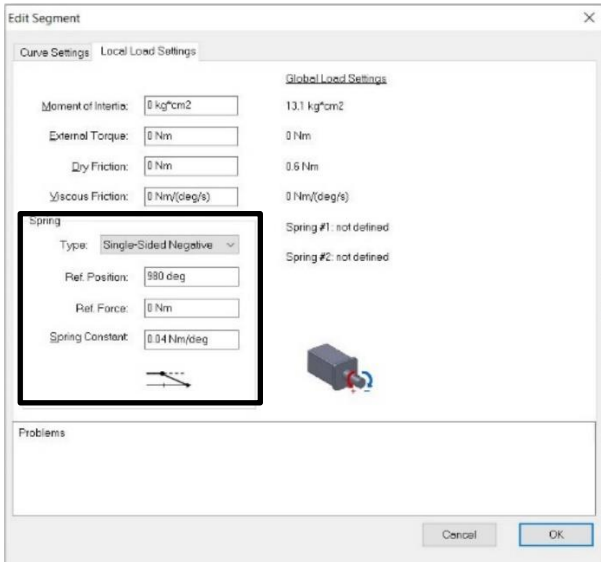
Keep the limit tightening torque of 4Nm for 50ms.

4) Standstill

Release the tightening torque to zero by compensating the spring torque through an external torque of 4Nm in the segment. The duration of 750ms are used to move the capping head up linearly, to pick a new cap and to replace the capped bottle by an uncapped one.

In the simulation above, the torque increase during the tightening process was simulated with a global spring; then in segment 4 a local external force of 4Nm was added to simulate the release of the tightening torque (thus bringing the motor torque to 0Nm).

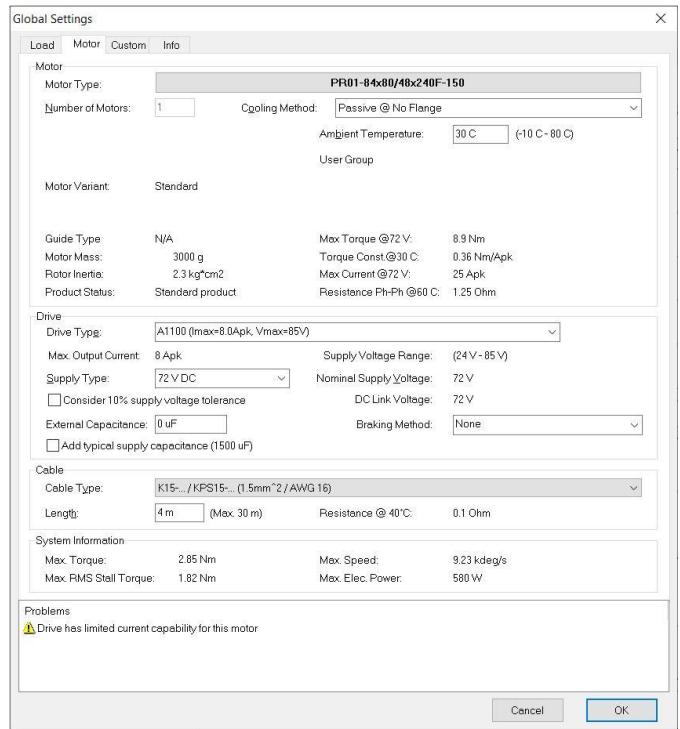
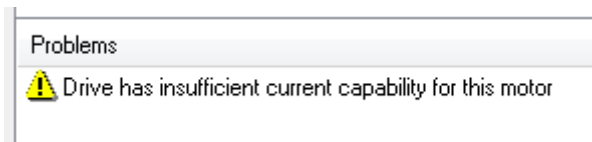
The same behaviour can also be simulated with a local single-sided negative spring during segment 2 (screwing process) and a local external torque of -4 Nm during segment 3 (tightening).



Definition of the motor system

For this application a motor from the PR01-84x80 family was selected as the smaller sizes do not have enough peak torque or stall torque. The PR02-88x76 from the PR02 group can also be used.

If the drive type is changed for example to a A1100, the smaller max. current of the drive will result in a smaller peak torque (2.85Nm instead of 8.9Nm) and the motor will no longer have sufficient torque causing thus the torque warning to appear. A warning is also generated and showed in the Problems window of the Global Settings when the drive has insufficient current capability for the motor.



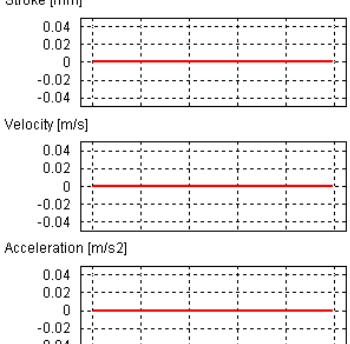
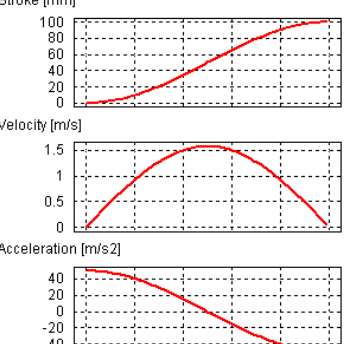
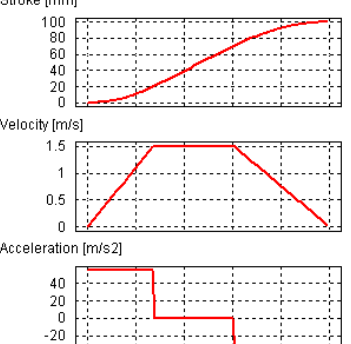
Results

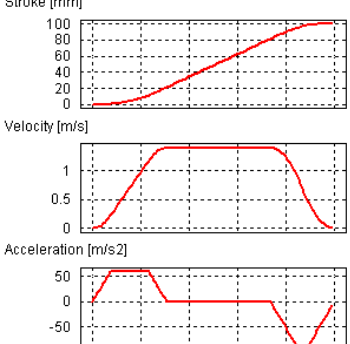
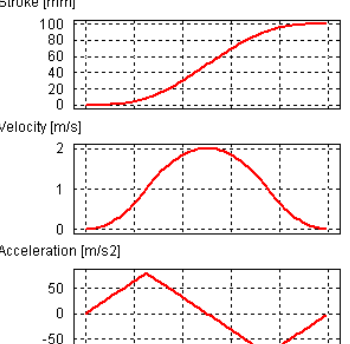
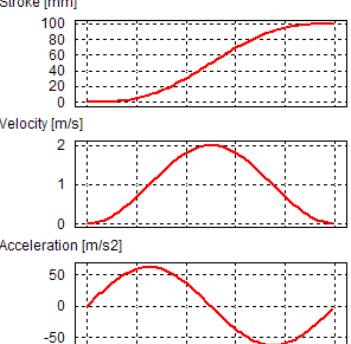
This simulation shows, that the rotary part of the application can be realized with the selected system. With a peak thermal load of less than 50% at an ambient temperature of 30°C, the motor will not be working at its thermal limit. So, there is still potential to increase the speed of the capping process.

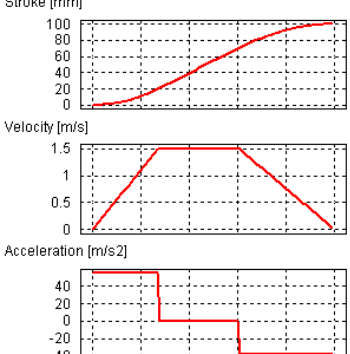
When sizing a rotary project, a warning will be generated if the velocity limit of the motor is exceeded. The velocity and its limits are shown in the lower diagram of the "Limit S/V" window. The graph of the motion (black-red line) has to be within the limits (blue lines) for the selected rotary motor.

Example 3: Importing custom Curves

To define the motion profile, LinMot Designer provides different curve types that can be defined by a few parameters:

Standstill	Sine	Point to Point
Parameters: <ul style="list-style-type: none"> • Time 	Parameters: <ul style="list-style-type: none"> • Time • Stroke 	Parameters: <ul style="list-style-type: none"> • Stroke • Max. velocity • Acceleration • Deceleration
		

Limited Jerk	Minimal Jerk	Besthorn
Parameters: <ul style="list-style-type: none"> • Stroke • Max. velocity • Max. acceleration • Max. deceleration • Jerk 	Parameters: <ul style="list-style-type: none"> • Time • Stroke 	Parameters: <ul style="list-style-type: none"> • Time • Stroke
		

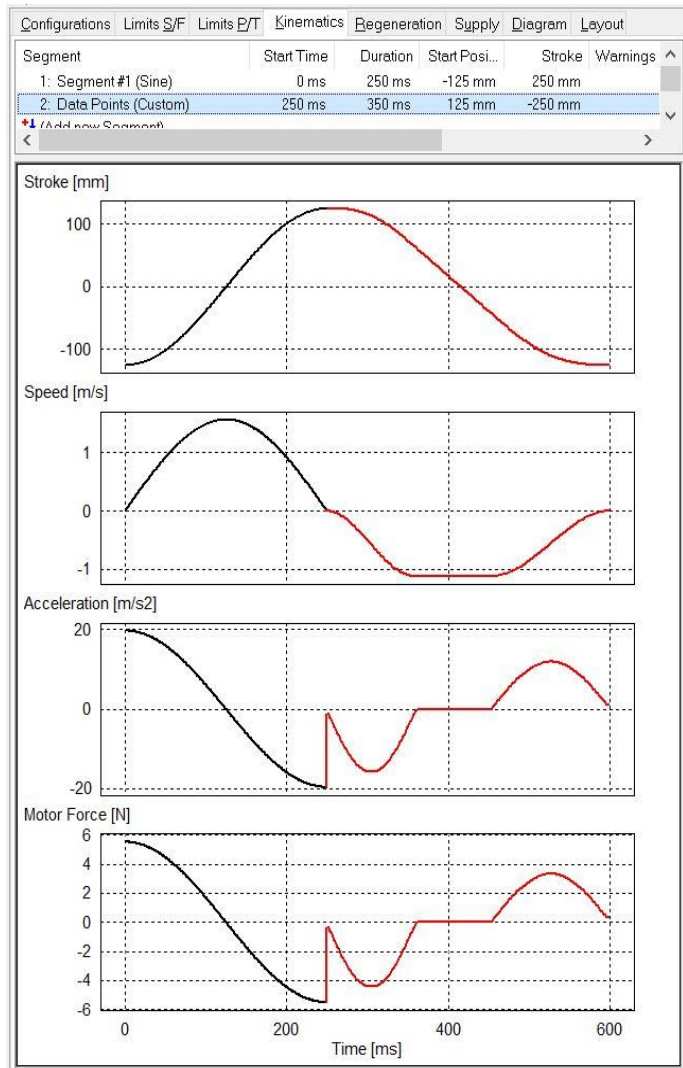
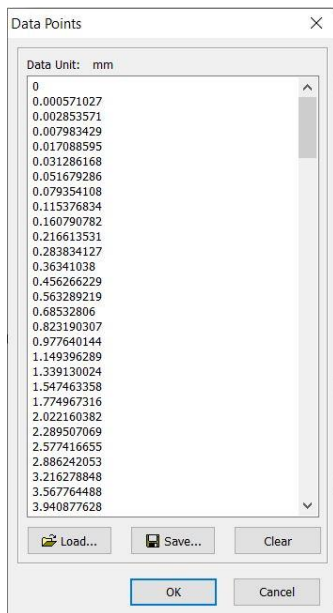
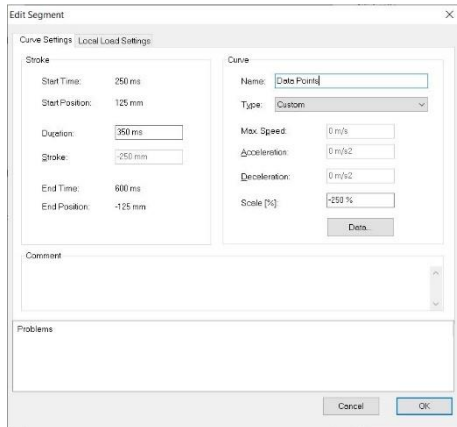
Speed Change Linear
Parameters: <ul style="list-style-type: none"> • Time • End Velocity


It is also possible to import a custom motion profile or just a segment of it into LinMot Designer. To do that, choose the **“Custom”** curve type. Open the **“Data Points”** window to define the custom position vector. There are two possibilities to do that:

1. **Load** the *csv-File*, where the numerical values of the position vector are saved.
2. **Copy** the vector from any other program and **paste** it into the Data Points window

The numerical data vector is interpreted in the data unit as it is defined under **“Measurement Settings”** of LinMot Designer.

In the Curve Settings dialog box, the curve time and the scale factor for the stroke have to be defined.

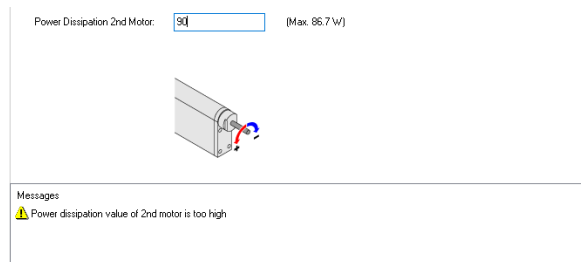
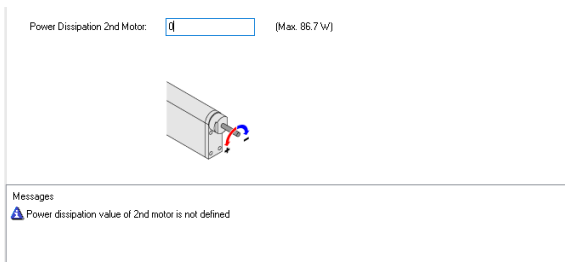


In **“Tutorial_ Ex3.ldc”** a Custom curve (Segment 2) follows on a Sine curve (Segment 1). The data vector of the custom curve was imported (loaded) from the csv-file **“Tutorial_ Ex3.csv”**. With a (negative) Scale value of **-250%**, the curve data points (forward motion from 0...100mm (in)) are scaled to a backward motion from 0...-250mm, starting at the end of Segment 1.

Additional Information

Power Dissipation of PR02 Motors

For a PR02 linear rotary motor, the dependency of the two axes with respect to the thermal limits and thus to the power loss of both motors has to be considered. The higher the power loss of one motor, the lower the permissible power loss of the other motor. Therefore, in addition to the usual load parameters, the user must also define the power dissipation of the 2nd motor in the “Load” window of the “Global Settings” dialog. If this value is 0 (inactive 2nd motor) a Note will be displayed. This is a Note and not a Warning, as it is not impossible, but very unusual, for the second axis not to be used. If the value is higher than the maximum value (no additional power losses are permitted for the 1st motor), a warning will be generated and displayed in the “Problems” window.



The power dissipation of the 2nd motor together with the corresponding RMS Force / Torque available, are displayed in the “2nd Motor Setup” window of the Global Values. In addition, in the “Power Dissipation” window is calculated and displayed the derating of the maximal cooling caused by the 2nd motor.

In addition to the thermal monitoring of the current axis, the thermal load of the 2nd axis is also monitored and, if the limit is exceeded, an additional warning "Thermal Load 2nd Motor" is displayed.

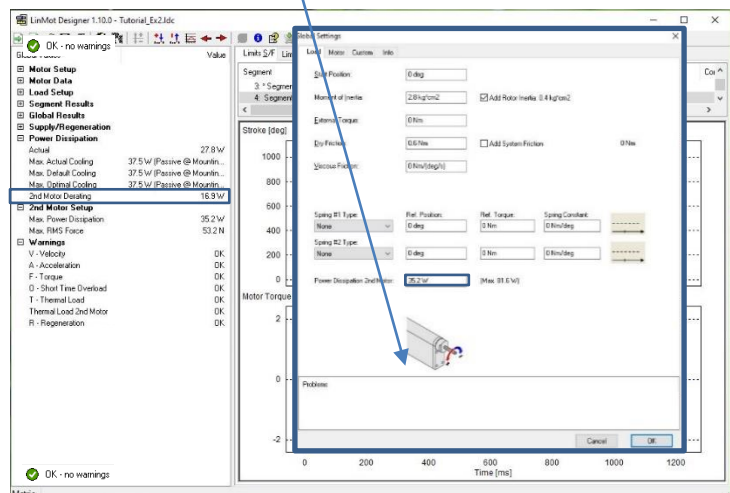
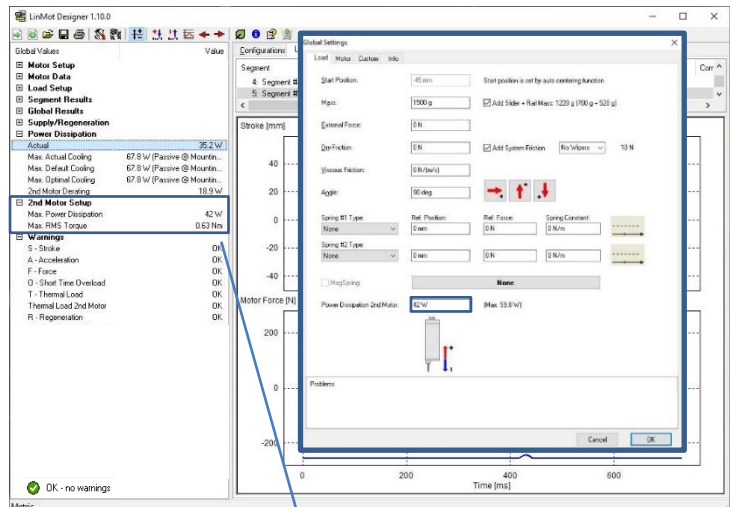
Due to the thermal coupling, both axes must be designed with the correct power dissipation (or with a higher value) of the 2nd axis.

Below is suggested a procedure that could be used when sizing the rotary linear motor.

Start with the linear project. During the load definition enter a value for the power dissipation of the 2nd motor, e.g. 70% of the maximum value. This will ensure high thermal margins for the rotary part, which in this example results in a maximum rms torque of 0.63Nm.

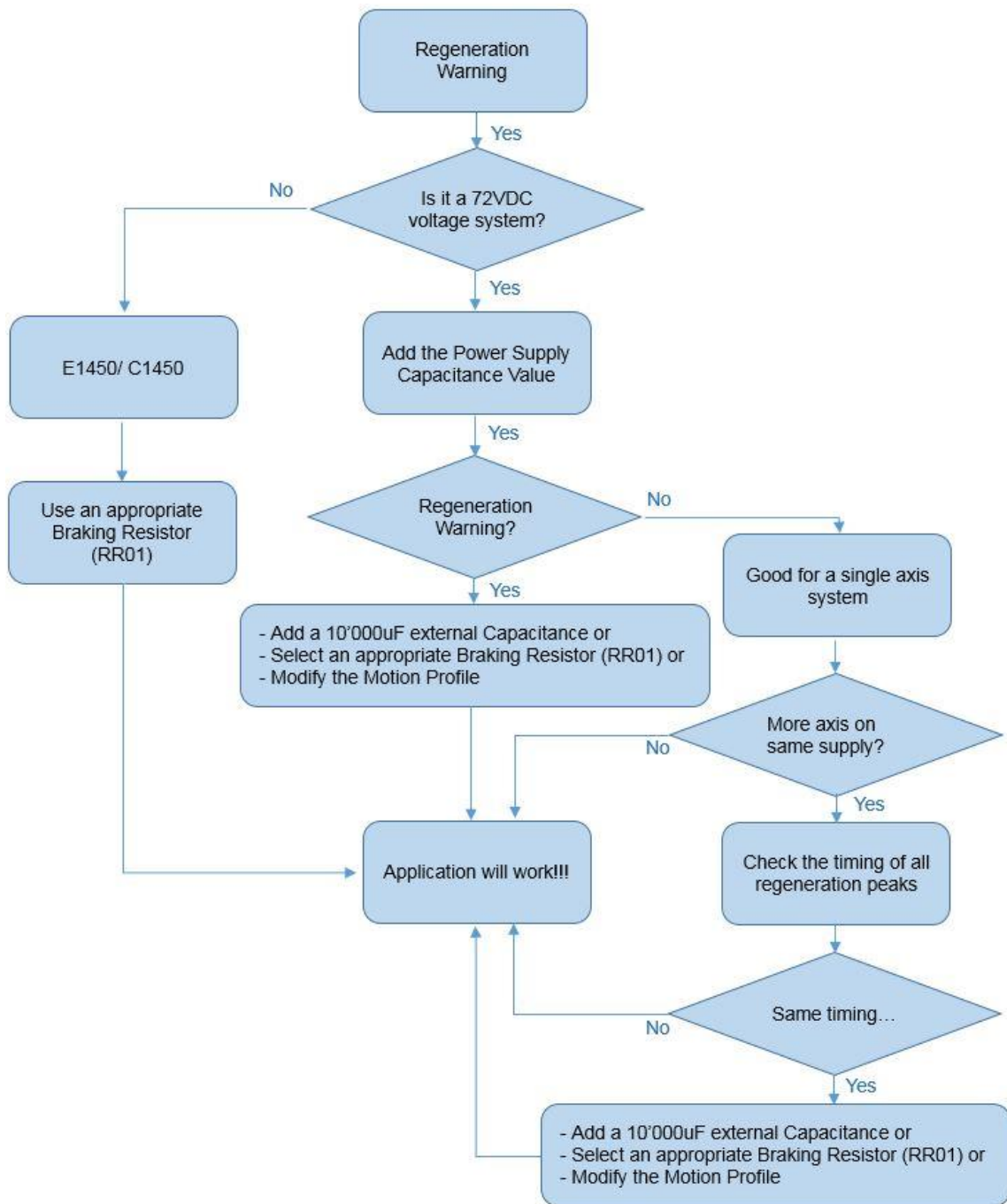
Lowering the dissipation of the second motor will increase the thermal margins of the current (primary) motor and vice versa.

Once the sizing of the linear part is completed, take the Actual Dissipation value, and enter it in the Power Dissipation 2nd Motor field of the rotary project. In the “Power Dissipation” window of the Global Values a 2nd motor derating of 16.9W is displayed. The actual power dissipation of the current project (27.8W) is lower than the maximum actual cooling, and since it is also lower than the initial assumption used during the linear project there is no need to update its value in the linear project. If this were not the case, an iterative process would have been necessary to verify that the thermal load is within the permitted limit for both the linear and the rotary project.



Regeneration

If a Regeneration Warning arises, the steps shown in the block diagram below should be followed.



The output capacitance values for the standard power supplies are given in the following table:

ArticleNumber	Name	Comment	OutputCapacity [uF]
<i>Transformer Power Supply</i>			
0150-1859	T01-72/420 -1ph	Tr-Supply 420VA, 1x208/220/230/240VAC	22'000
0150-1869	T01-72/420-Multi	Tr- Supply 420VA, 3x230/400/480VAC	10'000
0150-1871	T01-72/1500-Multi	Tr- Supply 1500VA, 3x230/400/480VAC	22'000
0150-1870	T01-72/900-Multi	Tr- Supply 900VA, 3x230/400/480 VAC	10'000
<i>Switching Power Supply</i>			
0150-1872	S01-72/1000	Sw- Supply 72V/1000W, 3x340-550VAC	1'500
0150-1874	S01-72/500	Sw- Supply 72V/500W, 1x120/230VAC	390

In the next table is presented a short overview of our drives that can be used in combination with an external capacitor, a regeneration resistor or that can take advantage of the Motor Regeneration Mode.

	Regeneration Resistor	Capacitor	Motor Regeneration
A1100	No	Yes – Nr. 0150-3075	Yes
B1100-xx	No	Yes – Nr. 0150-3075	No
E11x0-xx	Yes – Nr. 0150-3088	Yes – Nr. 0150-3075	No
C11x0-xx	No	Yes – Nr. 0150-3075	Yes
C12x0-xx	No	Yes – Nr. 0150-3075	Yes
E12x0-UC	Yes – Nr. 0150-3088	Yes – Nr. 0150-3075	No
E14x0-QN	Yes – Nr. 0150-3373	No	No
C14x0-VS	Yes – Nr. 0150-3581	No	No
I1100-XC	No	No	Yes

Regeneration Resistor

An external Resistor is connected to the servo drive (RR+ and RR-). Only servo drives with the regeneration resistor option can be used with regeneration resistors.

Capacitor

Possibility to connect an additional capacitor to the motor power supply. It is recommended to use a capacitor with a capacitance $\geq 10'000 \mu\text{F}$.

Install the capacitor close to the power supply!

Motor Regeneration Mode (Drive Configuration)

The Motor Regeneration mode can be activated in the drive configuration. No external equipment is required. In this mode, the additional energy is blasted in the motor (make sure the motor thermal load is below 80% in the LinMot-Designer simulation).

3rd Party Servodrive (P10-70 & P10-54)

Motor type P10-70-Dxx and P10-54-Dxx can be driven by a 3rd party servodrive. If so, a Custom drive type must be selected. This setting can be changed in the Custom tab within the “Global Settings” window. LinMot-Designer will take any limitations into consideration according entered values.

✕
Global Settings

Load
Motor
Custom
Info

Custom Drive

Name: Model based temperature monitoring

Max Current: Default Supply:

Max Gain: Internal Capacitance:

DC link voltage range: (min) (max)

Custom Supplies

	Nominal Supply Voltage	DC Link Voltage
DC Supply:	<input style="width: 60px;" type="text" value="72 V"/>	72 V
1-Phase AC Supply:	<input style="width: 60px;" type="text" value="230 V"/>	325 V
3-Phase AC Supply:	<input style="width: 60px;" type="text" value="400 V"/>	566 V

Enable Custom Components for System Configurations

Custom Drive (with default supply only)

Custom DC Supply

Custom 1-Phase AC Supply

Custom 3-Phase AC Supply

Problems

Cancel
OK

Name: Enter any plain text such as drive manufacturer, type or other. Max. 12 characters are allowed. This text is only used for information purpose.

Max Current: Max. servodrive output current (motor phase current). LinMot-Designer expects a peak value. This value has influence on maximum motor force.

Max Gain: Max. servodrive output voltage based on DC link voltage in percent. This value has influence on maximum motor speed.

DC link voltage range: Enter the minimum and maximum value of the DC link.

Model based temp. monitoring: Unselect this box, if servodrive is unable to calculate a thermal model. In such a case LinMot-Designer will activate a current derating of about -40% (according to the motor specification).

Default Supply: Choose one of the available predefined or custom supplies.

Internal Capacitance: Internal capacitance of the Custom Drive.

Nominal Supply Voltage (Custom Supplies): Define the supply voltage for the supply type/types (DC, 1-phase AC, 3-phase AC). This value has influence on max. motor speed.

Enable Custom Components for System Selection: Enable the custom components to have them available in the motor configuration list and its filters.

Efficiency (Linear Motor ↔ Pneumatic Cylinder)

The “Efficiency” tab can be shown/hidden by pushing the green leaf button in the menu bar and is only available for linear motor designs.



The “Efficiency” tab shows the required electric power as well as the electricity consumption, the CO2 emission and the energy costs per year for the defined application in case of continuous operation. The upper table shows the calculated values for the selected linear motor system. The lower table shows the values, if the defined application is driven by a pneumatic cylinder. The values are calculated for different standard diameters of pneumatic cylinders. The values can help to decide, whether a pneumatic driven application should be substituted by a linear motor.

The “Total Moving Distance per Cycle”, the “Total Cycle Time” and the “Electric Motor Power” of the linear motor are values from the current application. The “Total Moving Distance per Cycle” is calculated from the segment definition, the “Total Cycle Time” and the “Electric Motor Power” are copied from the “Global Values” window. The assumptions for the calculations are shown in the footnotes below the tables.

The content of the efficiency tab is only printed, if the tab is activated.

Global Values

Motor Setup
 Motor Type: P01-37x120F/200x280-HP
 Motor Variant: High Performance (HP)
 Stator Type: PS01-37x120F-HP
 Slider Type: PL01-20x400/340-HP
 Guide Type: N/A
 Slider Mounting: Regular
 Moving Part: Slider (fixed cable)
 No. of Motors: 1
 Drive Type: C11x0-XC / C1250-XC
 Supply Voltage: DC Link 72 V
 Braking Method: None
 External Capacitance: 0 uF
 Cable Type: None
 Cable Length: 0 m
 Ambient Temperature: 25 C
 Cooling Method: Passive @ Mounting Flange/Plate

Segment Results

Global Results
 Total Time: 550 ms
 Min Stroke: -110 mm
 Max Stroke: 110 mm
 Total Stroke: 220 mm
 Peak Speed: 2.3 m/s
 Peak Acceleration: 48.3 m/s²
 Peak Force: 107 N
 RMS Force: 44.3 N
 Peak Short Time Overload: 15 %
 Peak Thermal Load: 86.8 %

Supply/Regeneration
 Peak Supply: 220 W
 Mean Supply: 32 W
 Mean Braking Power: 0 W
 Max Braking Pulse: 0 J
 Min Link Voltage: 72 V

Power Dissipation
Warnings

Efficiency and CO2 Emission

Total Moving Distance per Cycle: 0.440m
 Total Cycle Time: 0.550s

Linear Motor (LinMot)

Electric Motor Power (1) [W]	Electric Power (2) [W]	Electricity Consumption per Year (3) [kWh]	CO2 Emission per Year (4) [kg]	Electricity Costs per Year (5) [EUR]
39	69	551	276	66

1) Mean Supply Value calculated by LinMot Designer
 2) Linear Motor plus Drive (+20%, +15W) and Supply (+10%)
 3) Continuous operation (8000h/year)
 4) CO2 Emission Factor: 0.5 kg/kWh
 5) Energy Cost Factor: 0.12 EUR/kWh

Pneumatic Cylinder

Air Piston Diameter [mm]	Air Consumption per Year (1) [Nm ³]	Electric Power [W]	Electricity Consumption per Year (2) [kWh]	CO2 Emission per Year (3) [kg]	Air Costs per Year (4) [EUR]
10	13'934	206	1'647	823	317
12	20'064	296	2'371	1'186	456
16	35'670	527	4'216	2'108	811
20	55'734	823	6'587	3'293	1'267
25	87'085	1'286	10'292	5'146	1'979
32	142'680	2'108	16'862	8'431	3'243
40	222'937	3'293	26'347	13'174	5'067
50	348'340	5'146	41'167	20'584	7'917
63	553'024	8'170	65'357	32'679	12'569
80	891'750	13'174	105'389	52'694	20'267
100	1'393'359	20'584	164'670	82'335	31'667

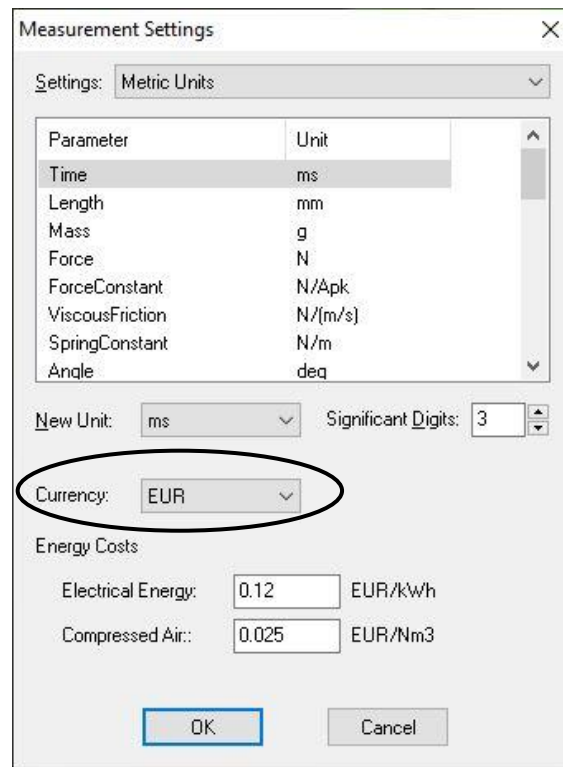
1) Air Pressure: 6 bar, continuous operation (8000h/year), leakage and distribution losses: 10%
 2) Electricity Consumption Factor: 0.13 kWh/Nm³
 3) CO2 Emission Factor: 0.5 kg/kWh
 4) Air Production Cost Factor: 0.025 EUR/Nm³ (According to pneumatic suppliers, including electricity costs)

The currency of the costs shown on the **“Efficiency”** tab can be changed.



For that purpose, select the “Edit measurement Settings” – Button.

In the “Measurement Settings” tab it is also possible to configure the energy costs parameters used to calculate the electricity and compressed air costs per year.



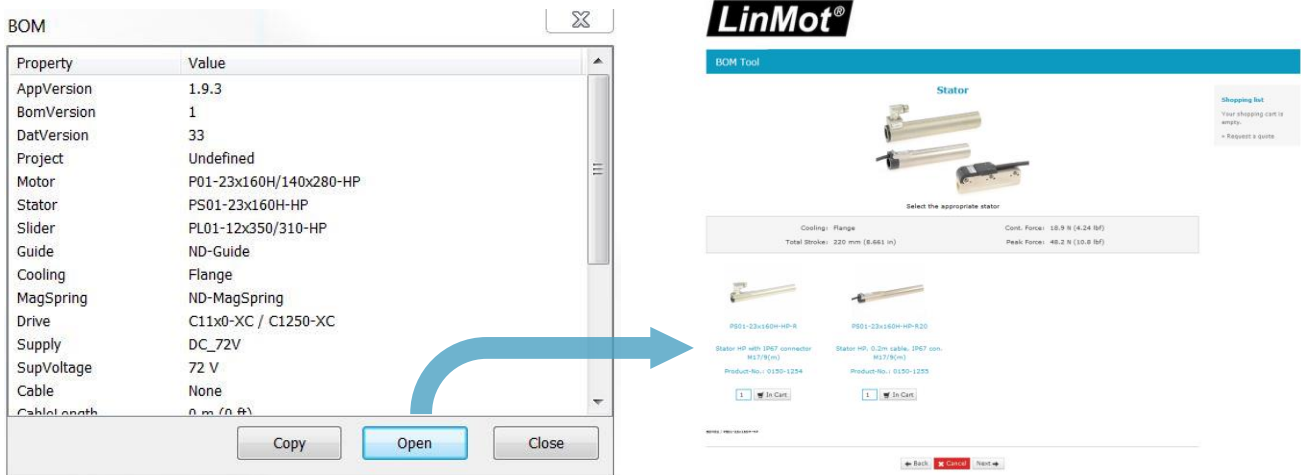
BOM – Link

To create a web link to the **Bill of Material** and to show the BOM project data, select the “Show BOM” Button.

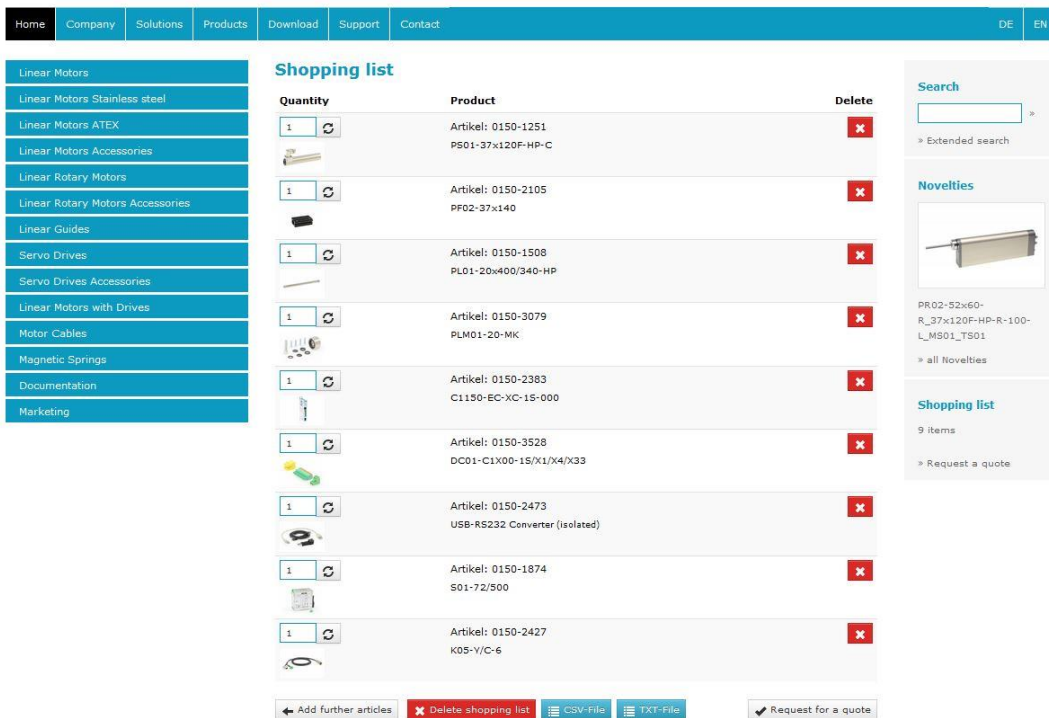


“Show BOM” Button

Click “Open” in the “BOM” window to open the BOM wizard. This will open the browser with the BOM wizard start page, which runs on the LinMot website (e-catalogue).

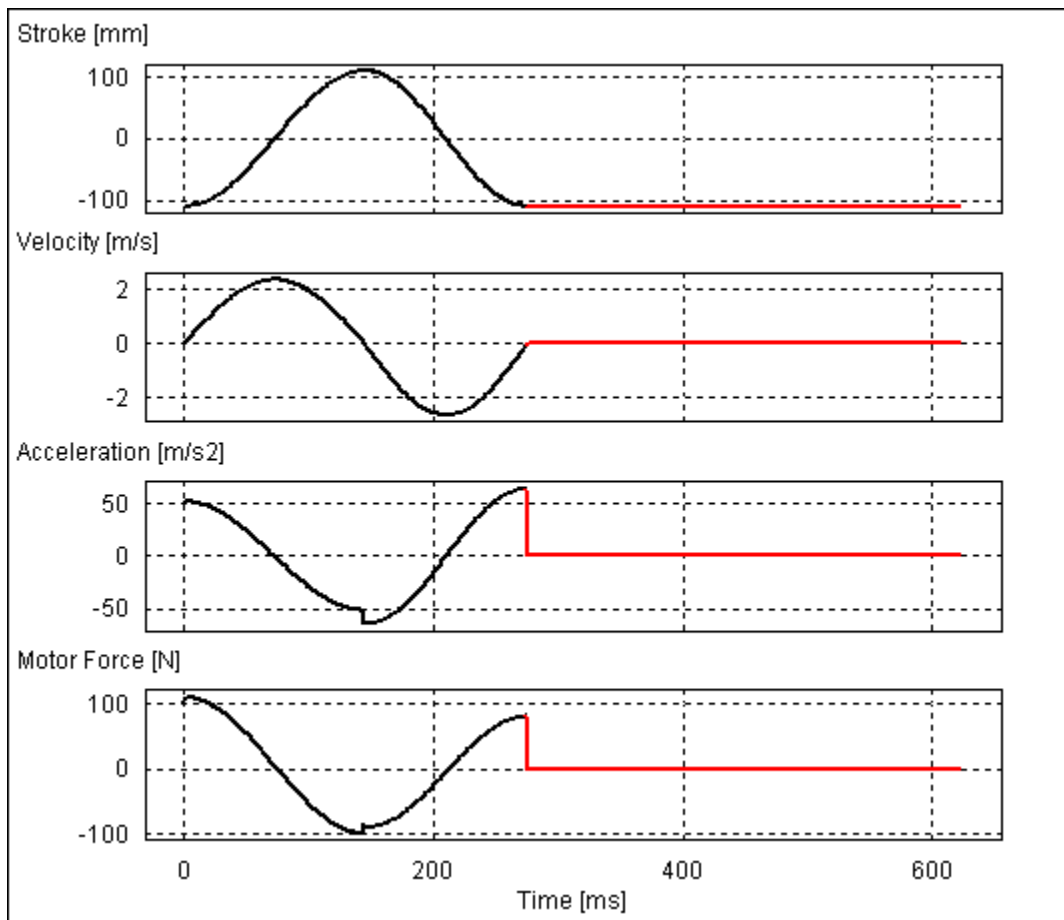


At the end of the BOM wizard the shopping list can be saved as cvs or text file and a quote can also be requested directly.

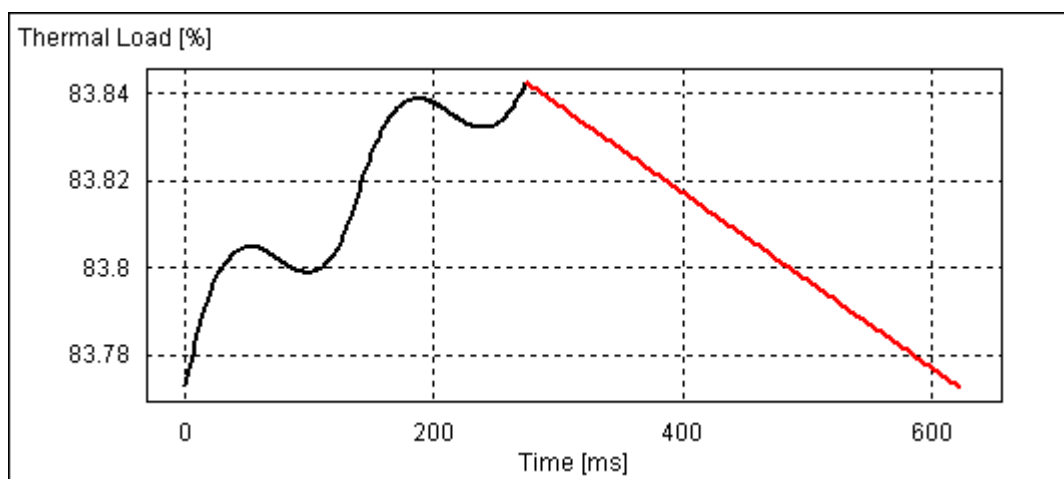


Time Graphs

In the **“Kinematics”** tab, time graphs of the stroke, velocity, acceleration, and motor force give an overview of the motion.

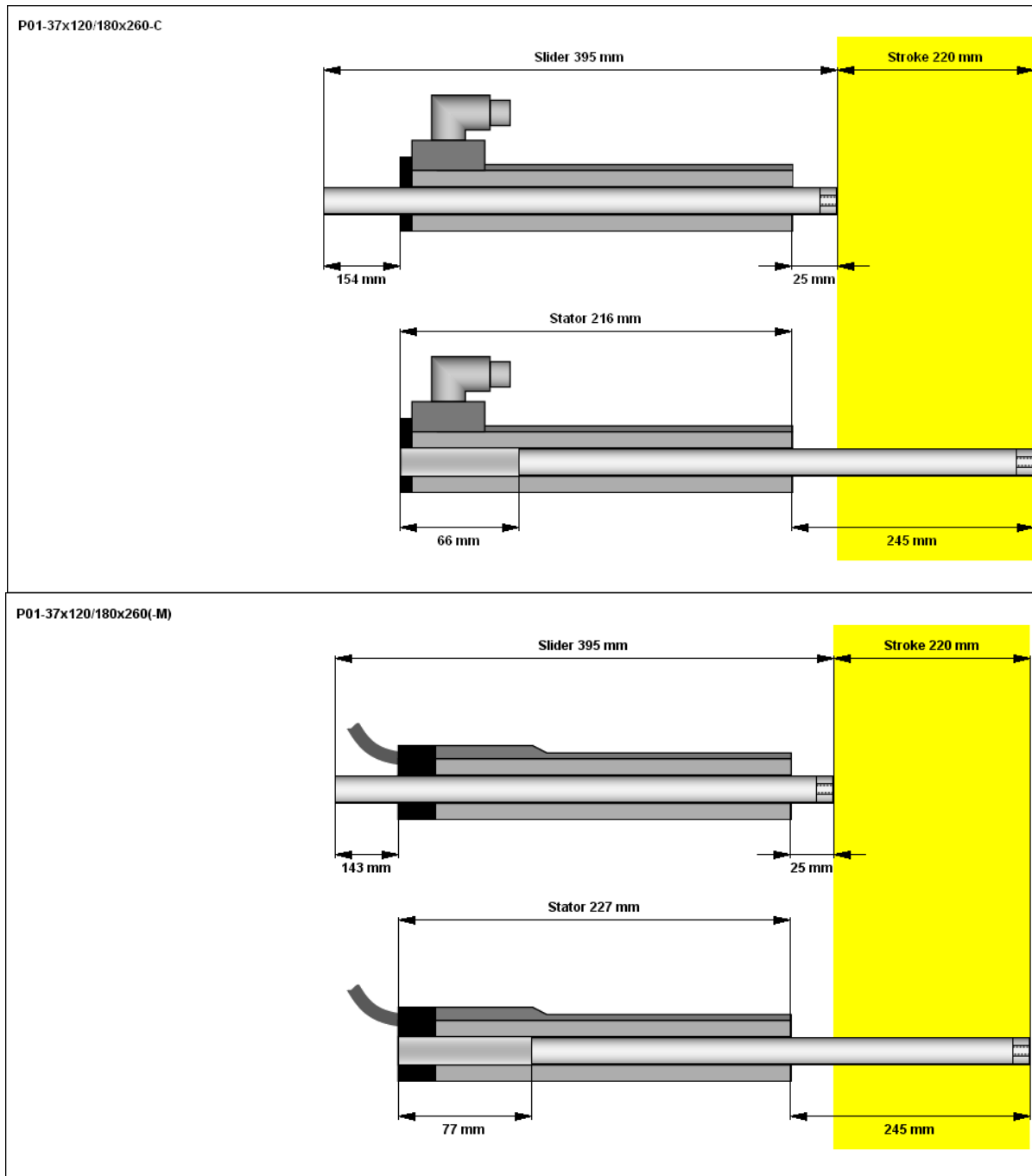


In the **“Diagram”** tab, any calculated parameter can be visualized by double clicking a corresponding characteristic value in the **“Global Values”** window (e.g. Min, Max, Peak, RMS or Mean values).



Layout

The “**Layout**” tab displays the mechanical dimension of the Linear Motor and the end positions for the different types of motors. Complete modules are NOT displayed.
 The Layout is dependent on the “Slider Mounting”-parameter and the “Moving Part”-parameter in “Global Settings”.



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