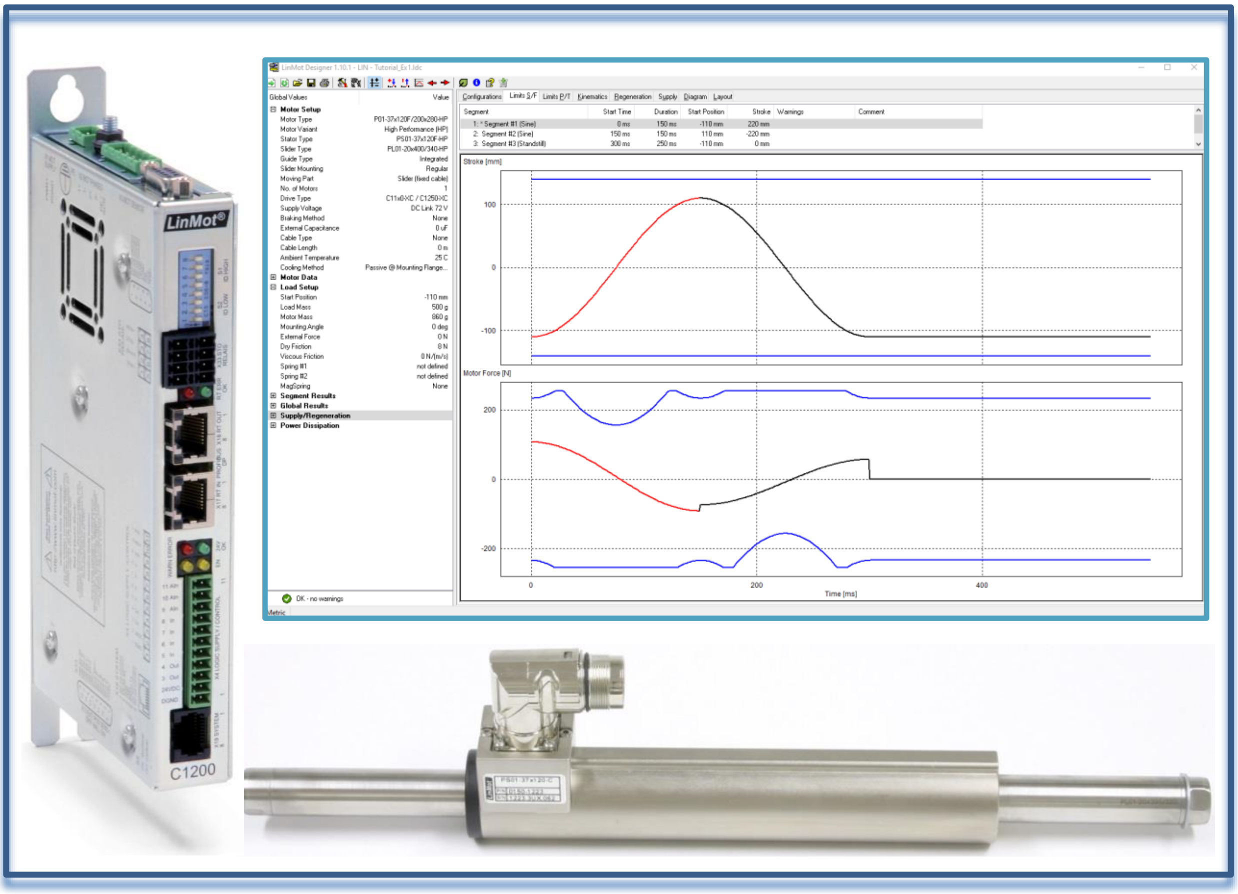

# Tutorial
# LinMot® Designer 1.10.1

NTI AG
LinMot®
Bodenaeckerstr. 2
CH-8957 Spreitenbach

Tel.: +41 56 419 91 91
Fax: +41 56 419 91 92
office@LinMot.com
www.LinMot.com

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# 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**

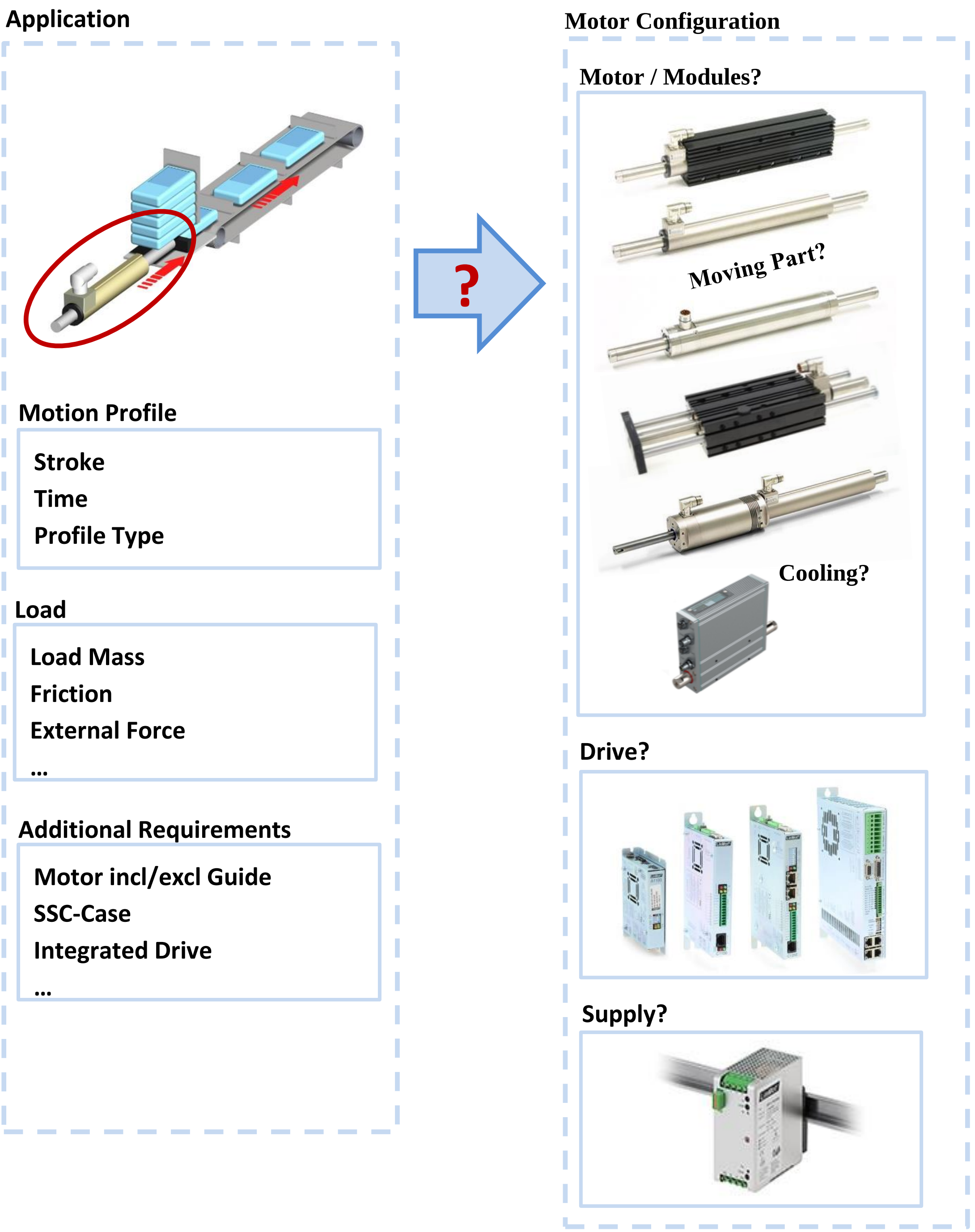
**Important:** LinMot Designer is a sizing program that simulates the behaviour of LinMot linear motors under static and dynamic load conditions. LinMot Designer offers the design engineer quick help in the analysis and optimization of drive technology for a specific task. The simulation and calculation 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.

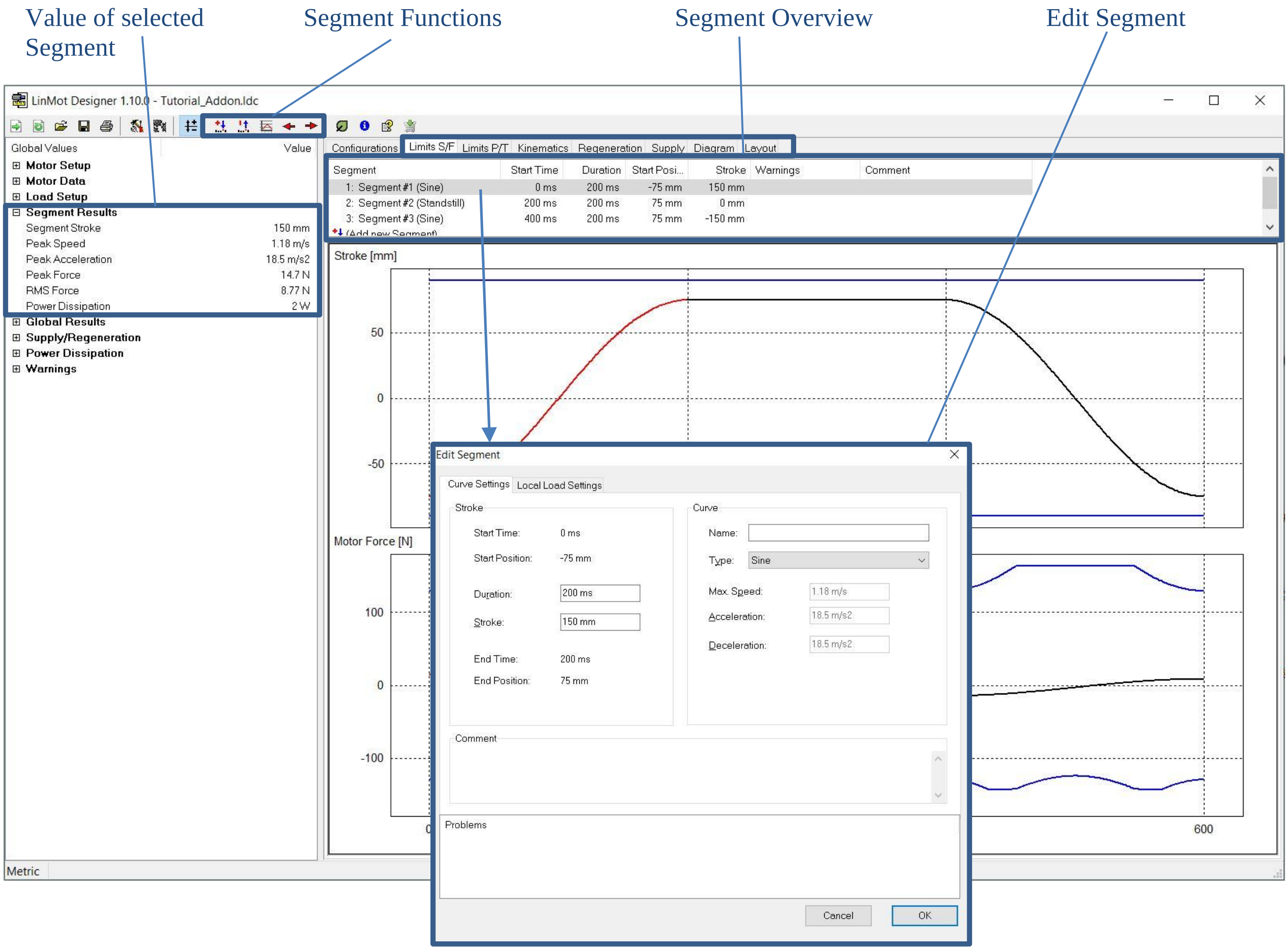
To select motor configurations for a simulation, a powerful motor configuration selection tool with filter functionality is available.

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



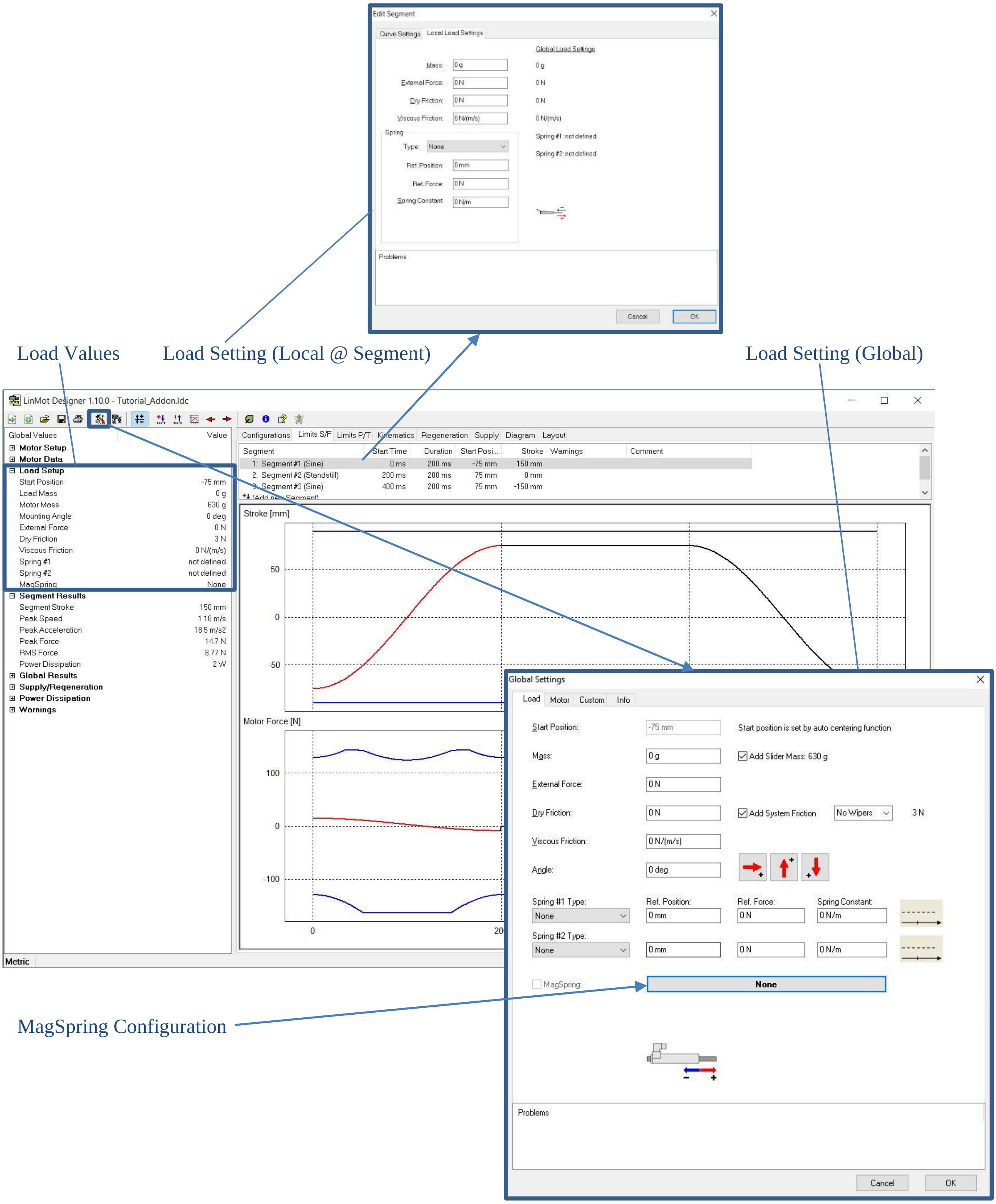
## Motion Profile

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.

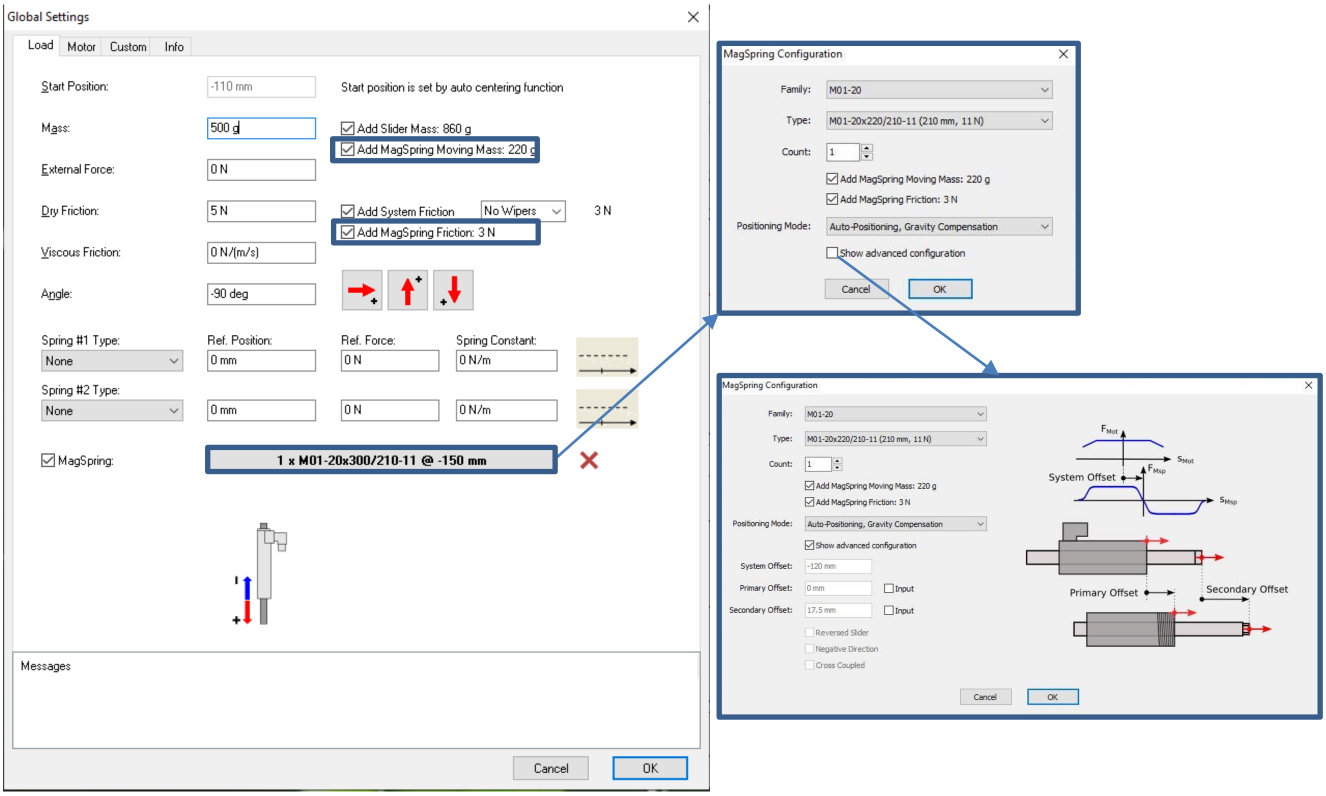


## Load Definition

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.



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 centrically 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 “Messages” 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 1.10.1).

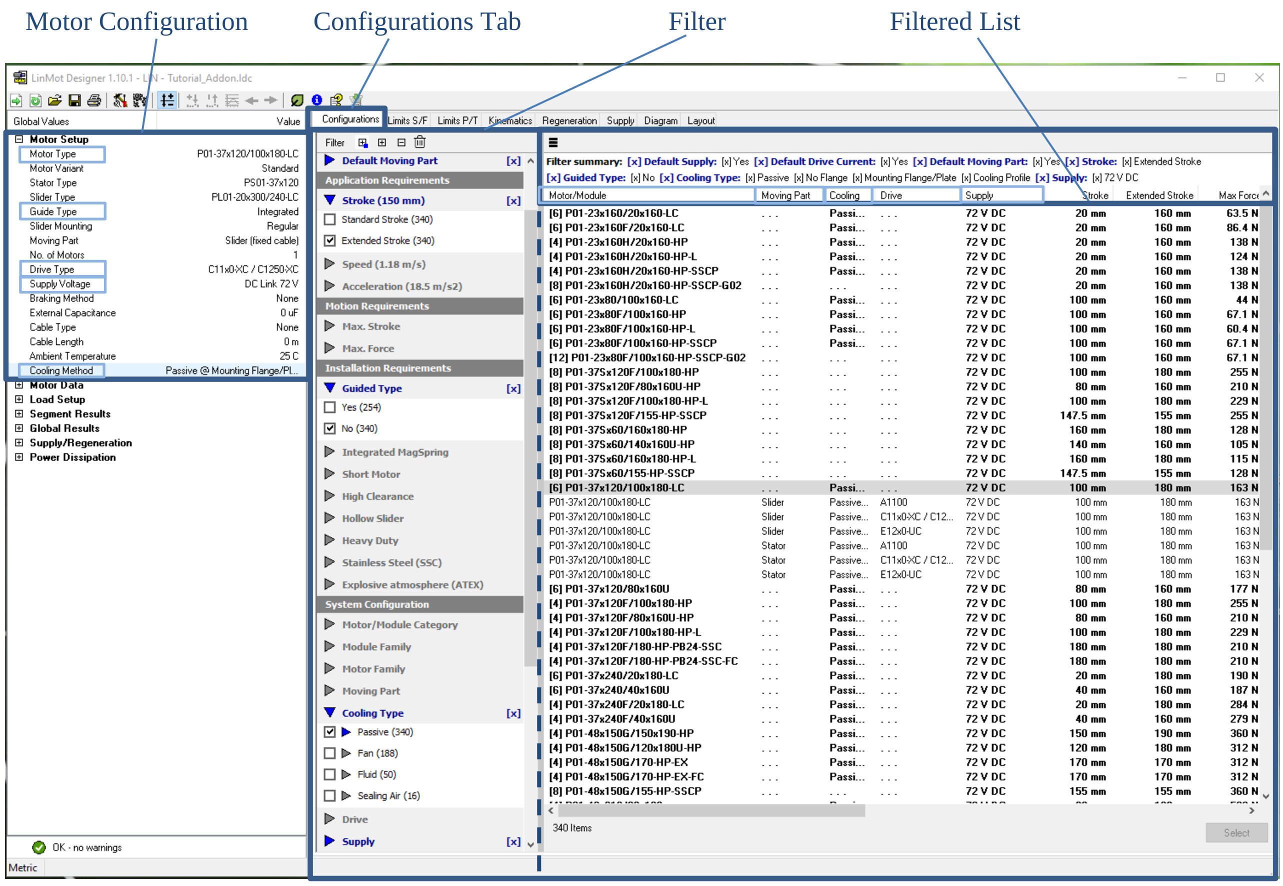
## Motor Configuration & Filter Selection

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.

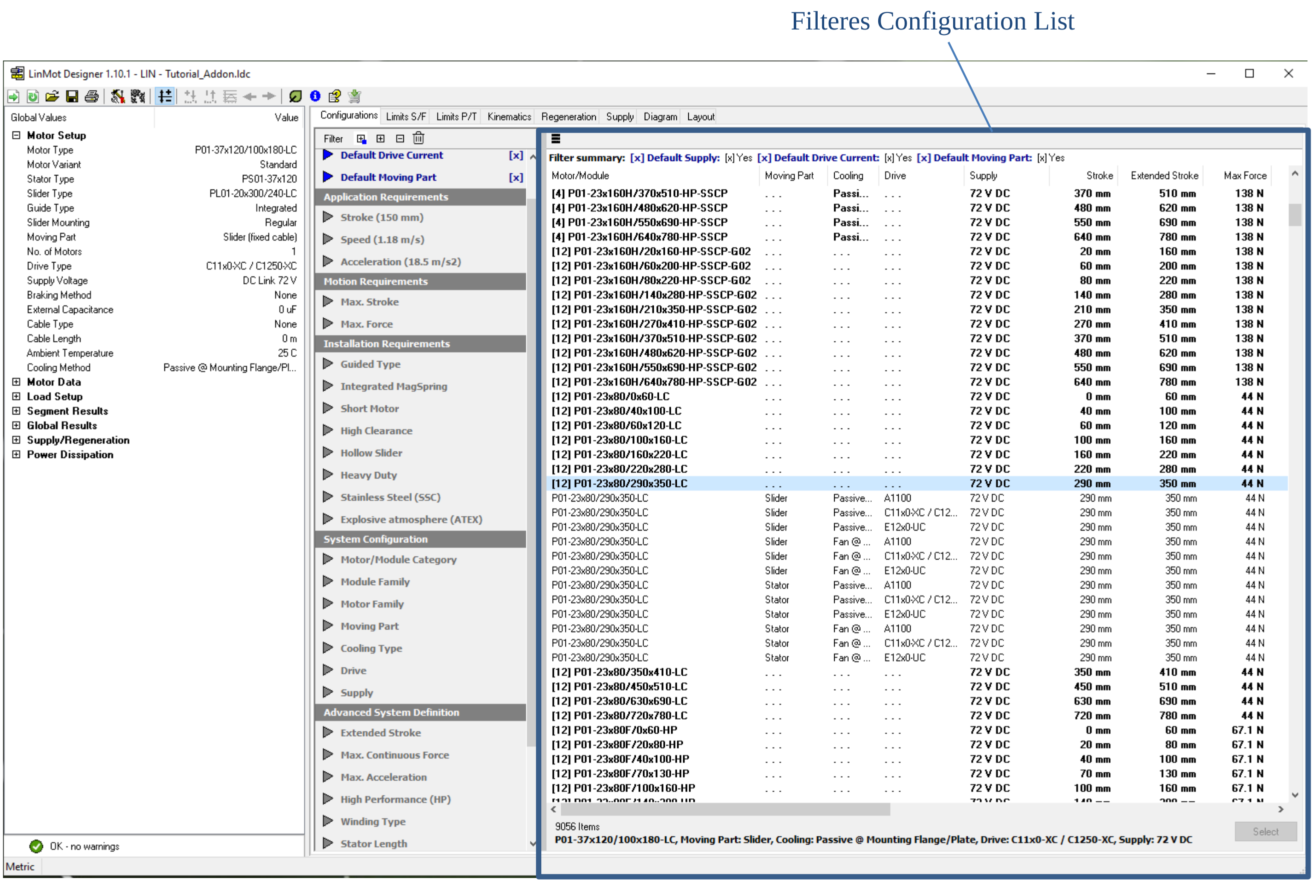
Remark: By selecting a configuration in the "Configurations" tab, all components, "Motor Type", "Moving Part", Cooling", "Drive Type" and "Supply Type" are redefined.



## Filtered List

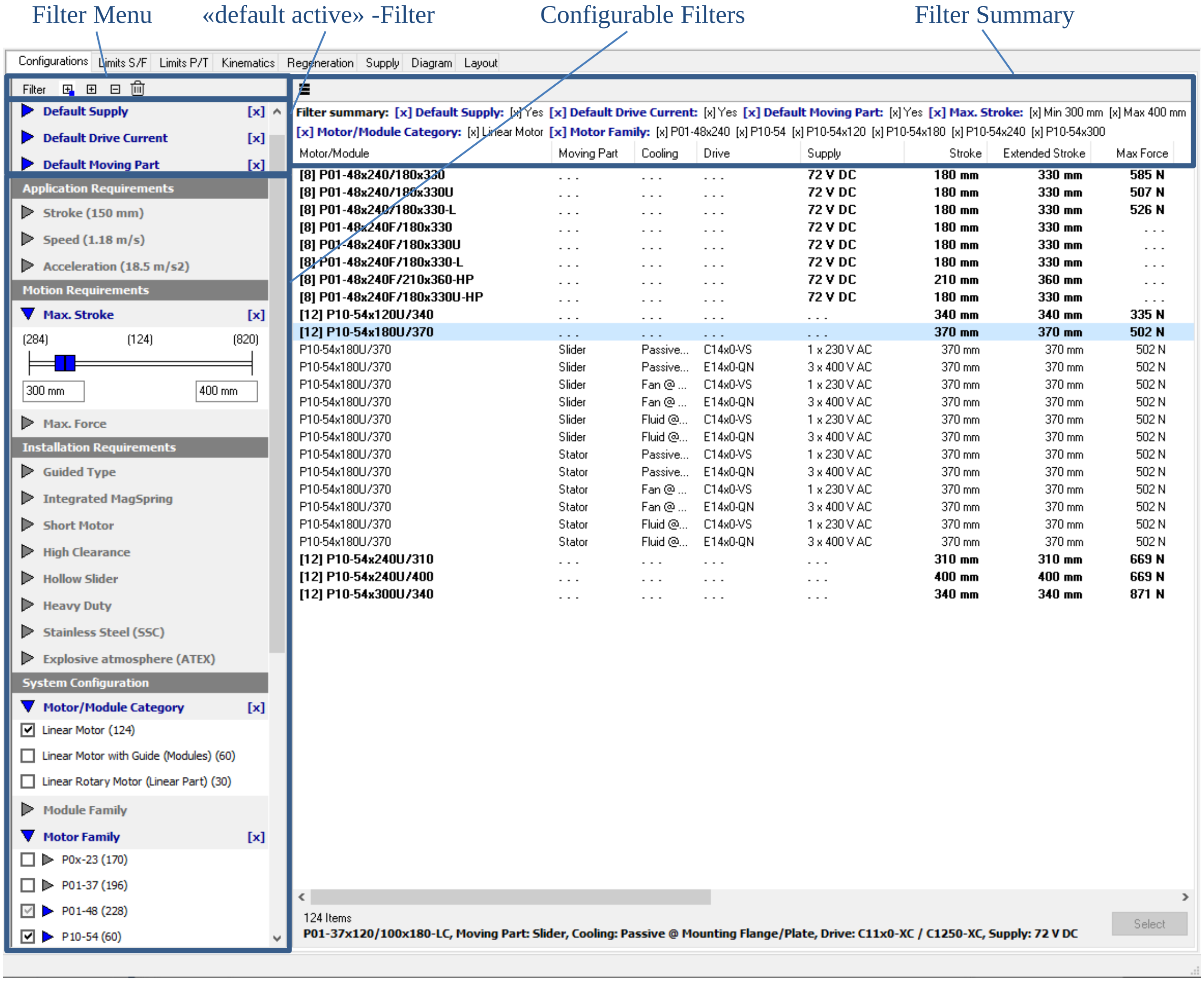
When working with the motor/module configuration list, it is important to know the following:

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.



## 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.




**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.

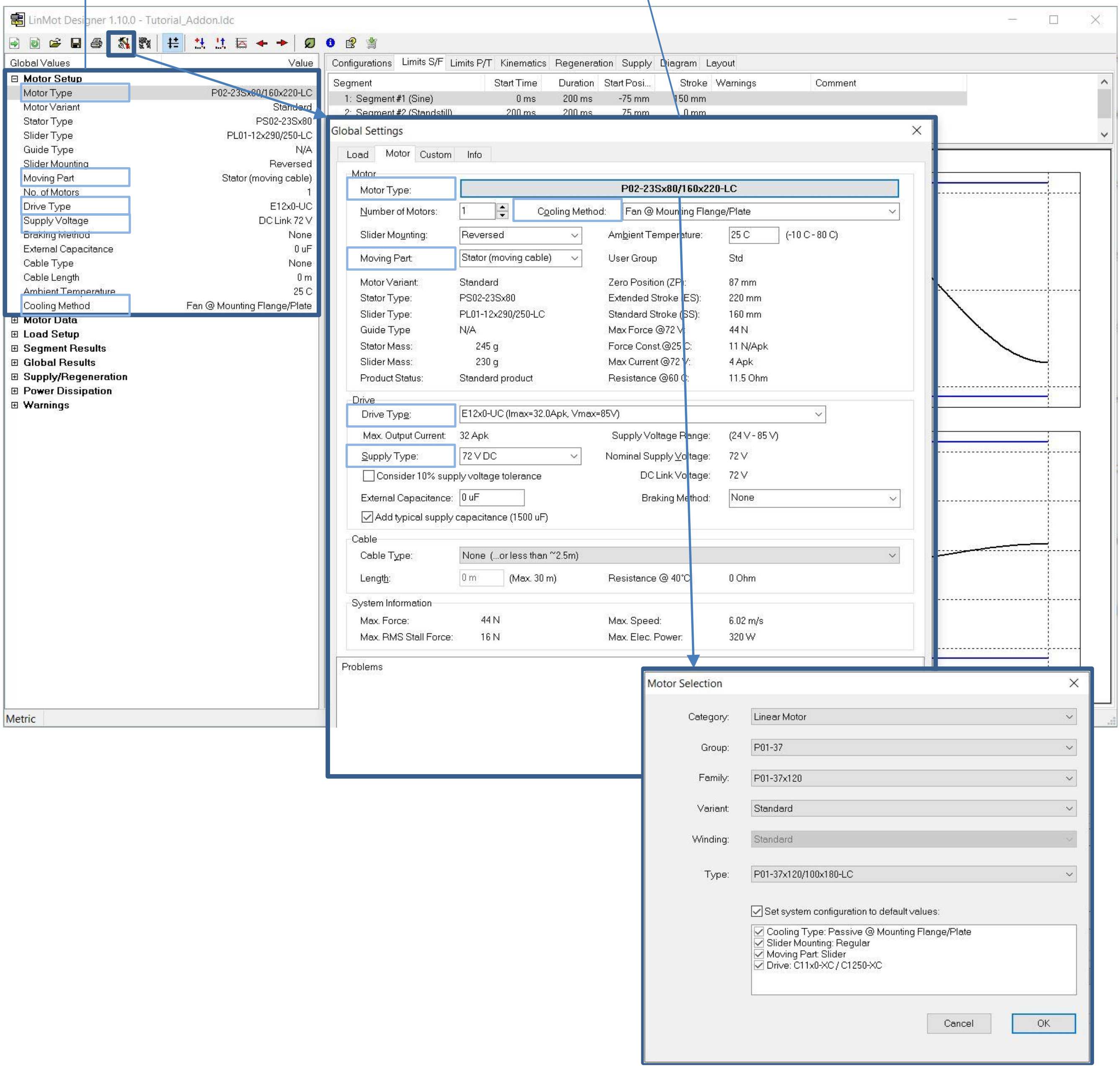
**Number of Configurations**
The number in brackets () shows the number of configurations that matches the criteria at the current overall filter state. If no configuration matches the criteria, the number is (0) and the filter caption is grey.

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.

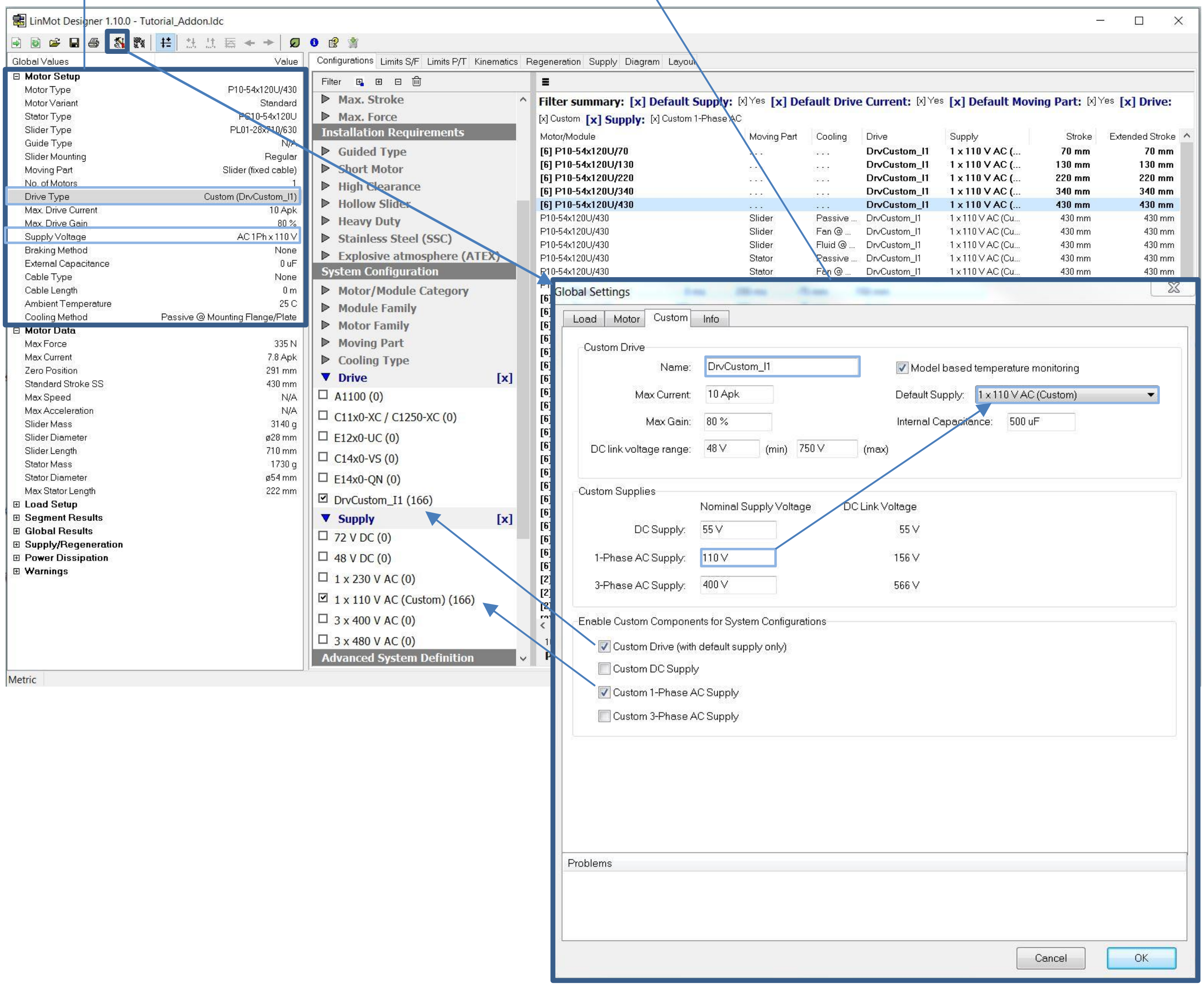
Motor Setup (Values) Motor Configuration (edit dialog)



## 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.

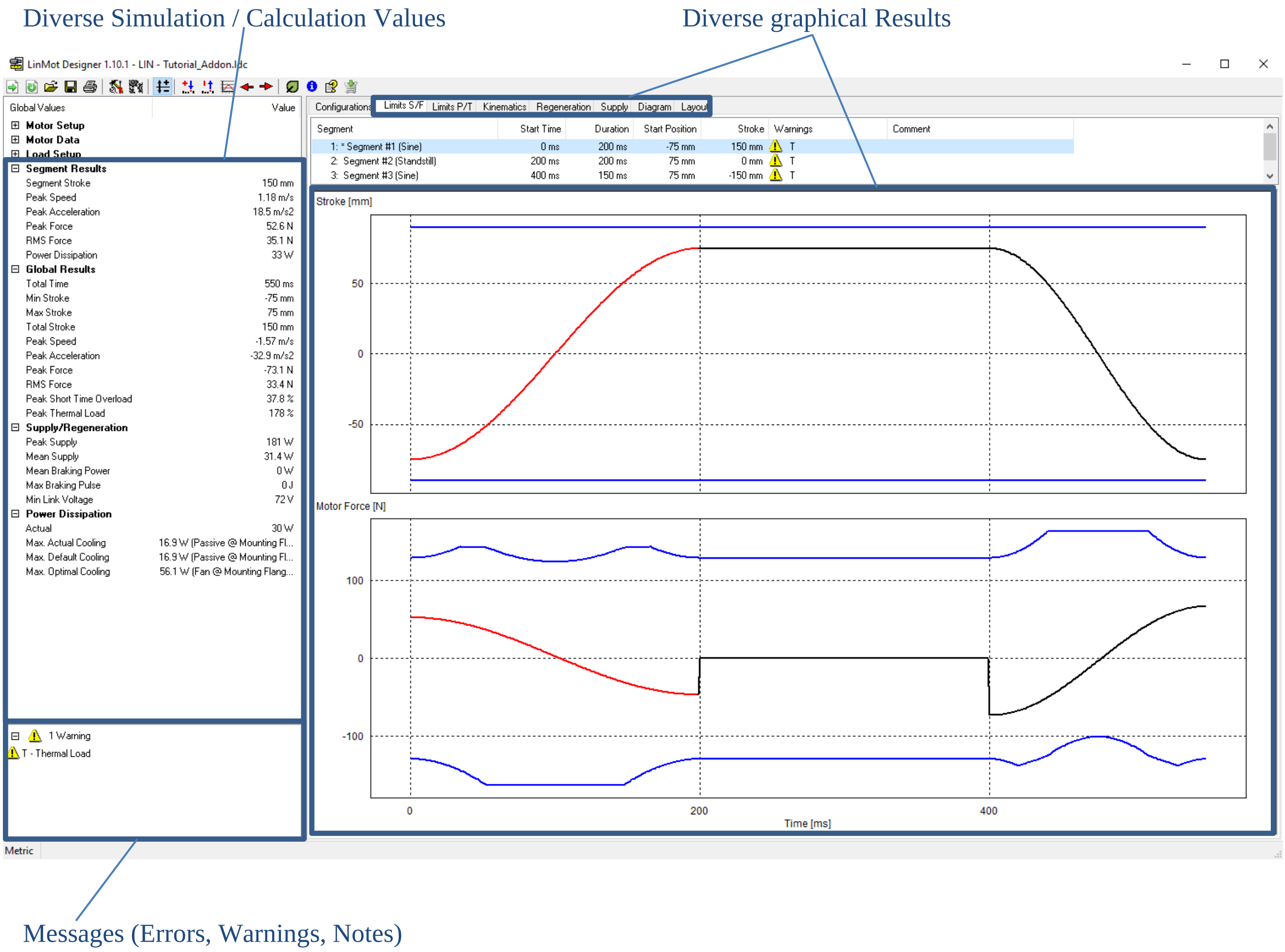
Motor Setup (Values) Custom Components (Drive & Supplies)



## Simulation Results

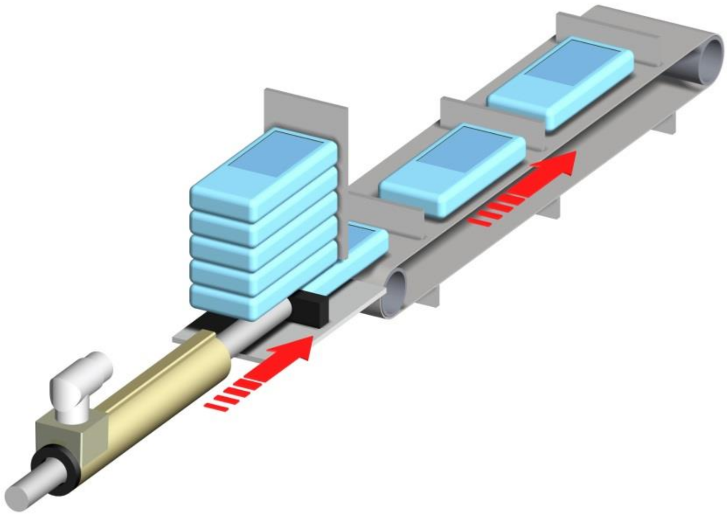
As soon as a new configuration is defined (exit dialog boxes), the simulation results are calculated and updated. If no error or warnings are showed, the current motor configuration with its components can be used for the application.

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.

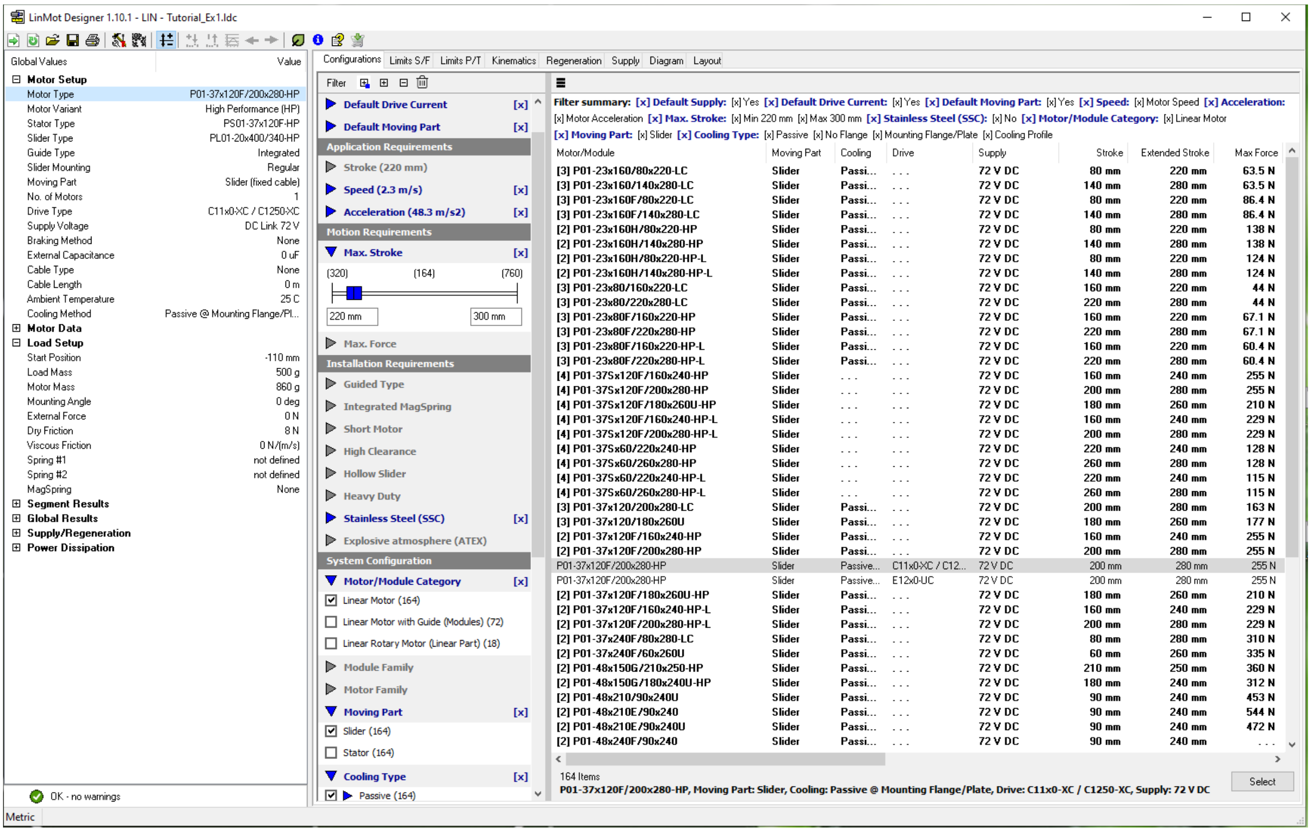
When importing for the first time a project created with an older version of LinMot Designer, you may be asked to select an appropriate replacement drive type, since in the newer Designer version some components (e.g. the drive series E11x0 and B1100 or RS01 motors) are no longer available.

“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”.



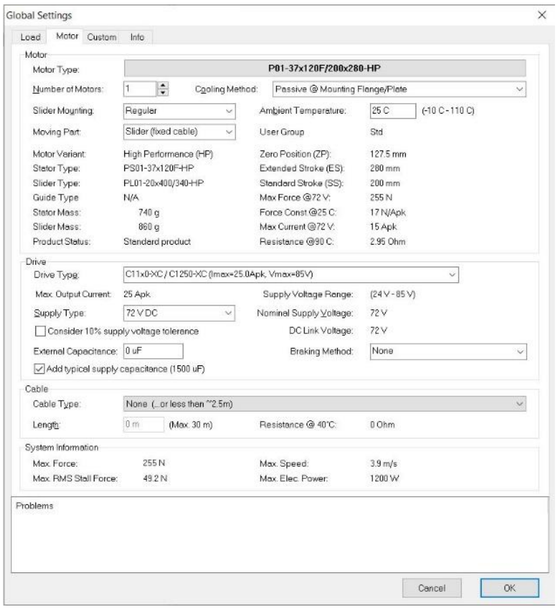

Once the filter criteria have been set, select from the filtered configuration a smaller motor from the 72V-System, for example the P01-37x120F/200x280-HP with a X1xx0 drive (“C11x0-XC / C1250-XC”). A double click on the row copies the components “Motor/Module”, “Moving Part”, “Cooling”, “Drive” and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

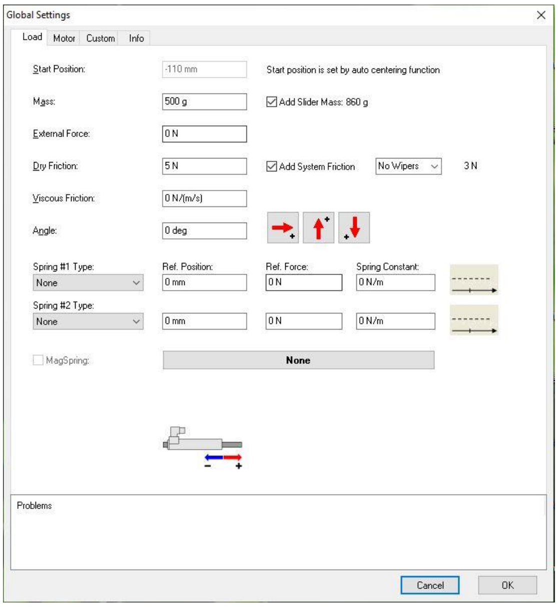
To define the details of the motor configuration, open the “Global Settings” dialog. Open it via the menu button or double clicking a configuration parameter in the Motor Setup (Global Values).

↑

“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.

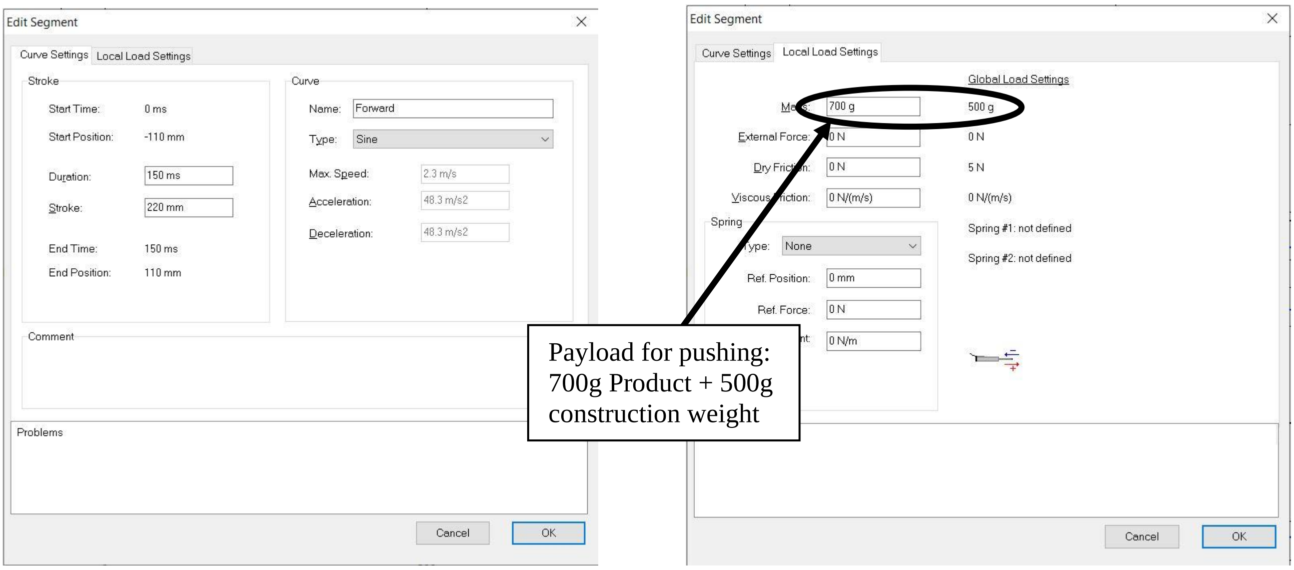
## Step 2: Segmentation of the Motion

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 |

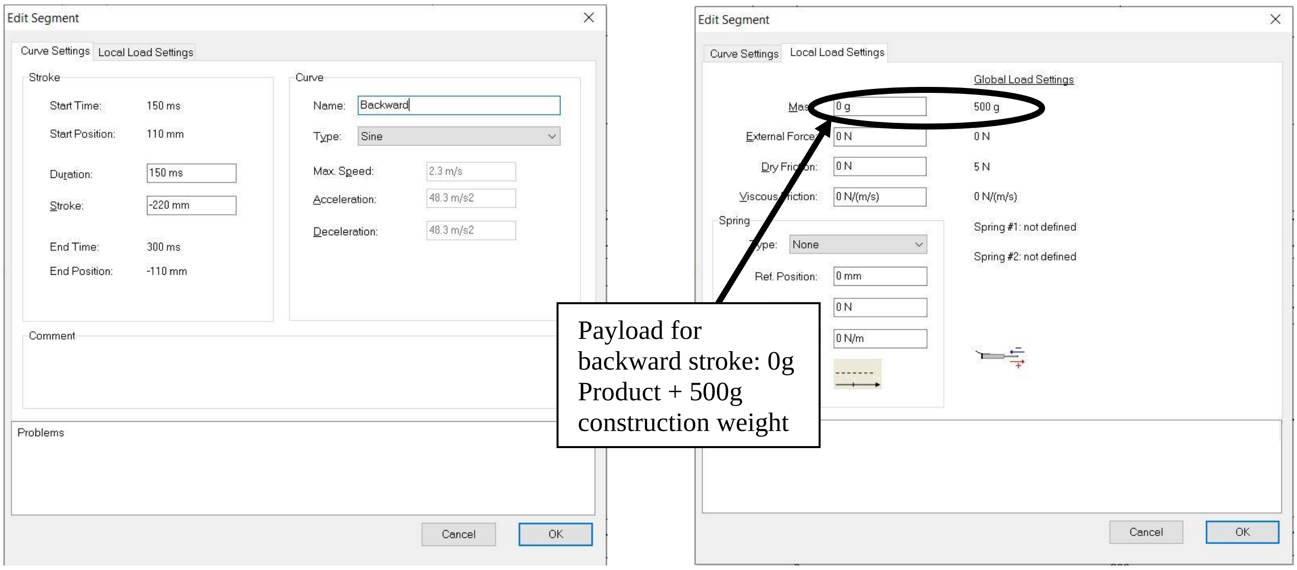
**Define the “Forward” Motion**

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).



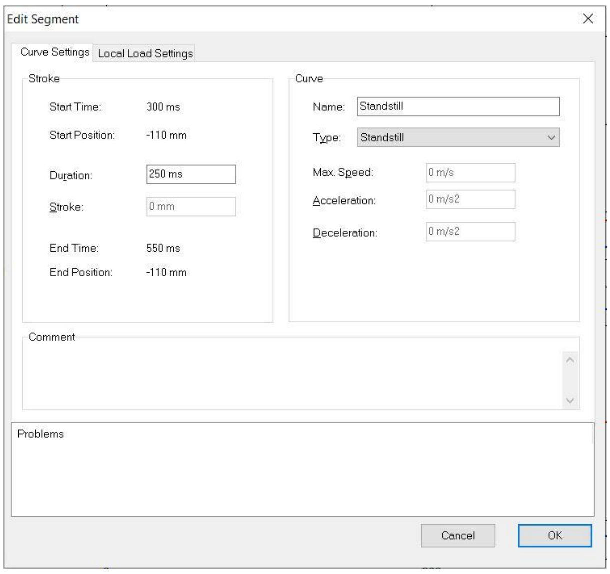

**Define the “Backward” motion**

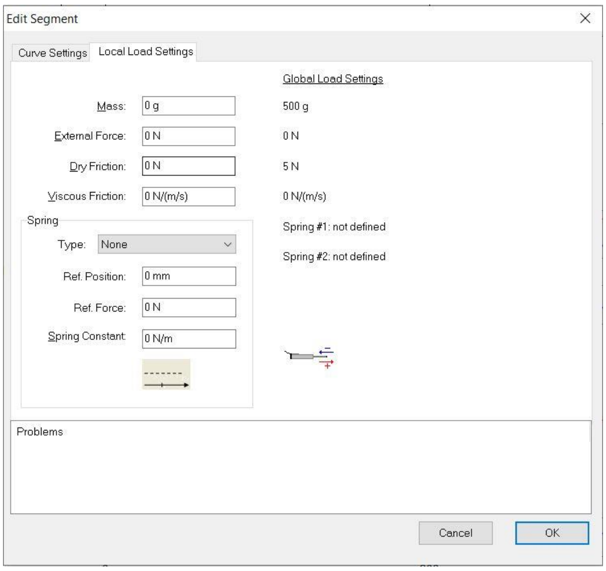
Add a new segment for the backward stroke and open the “Edit Segment” window (double click on text “Add new segment”). In the “Curve Settings” window specify the -220mm of stroke for the backward movement. An additional mass is not added, since for the backward movement there is no additional payload.



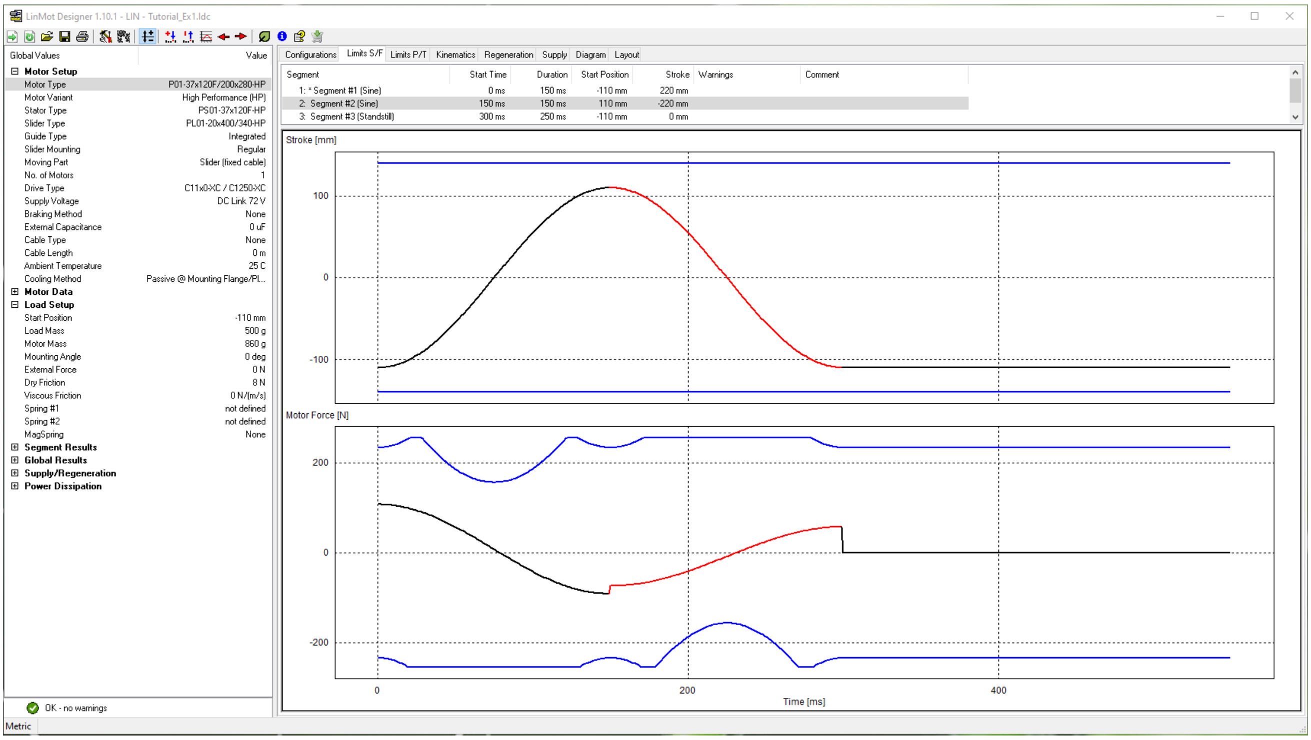
**Define the "Standstill" time**

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 | | 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. |

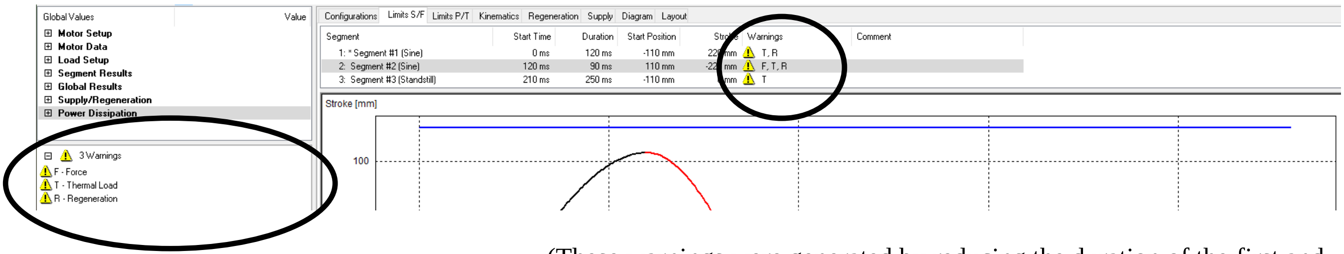
A realisation of the defined application will only be successful, if the dynamic parameters do not exceed their corresponding limits and therefore none of the following errors or warnings are displayed:

| 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 |
| 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.

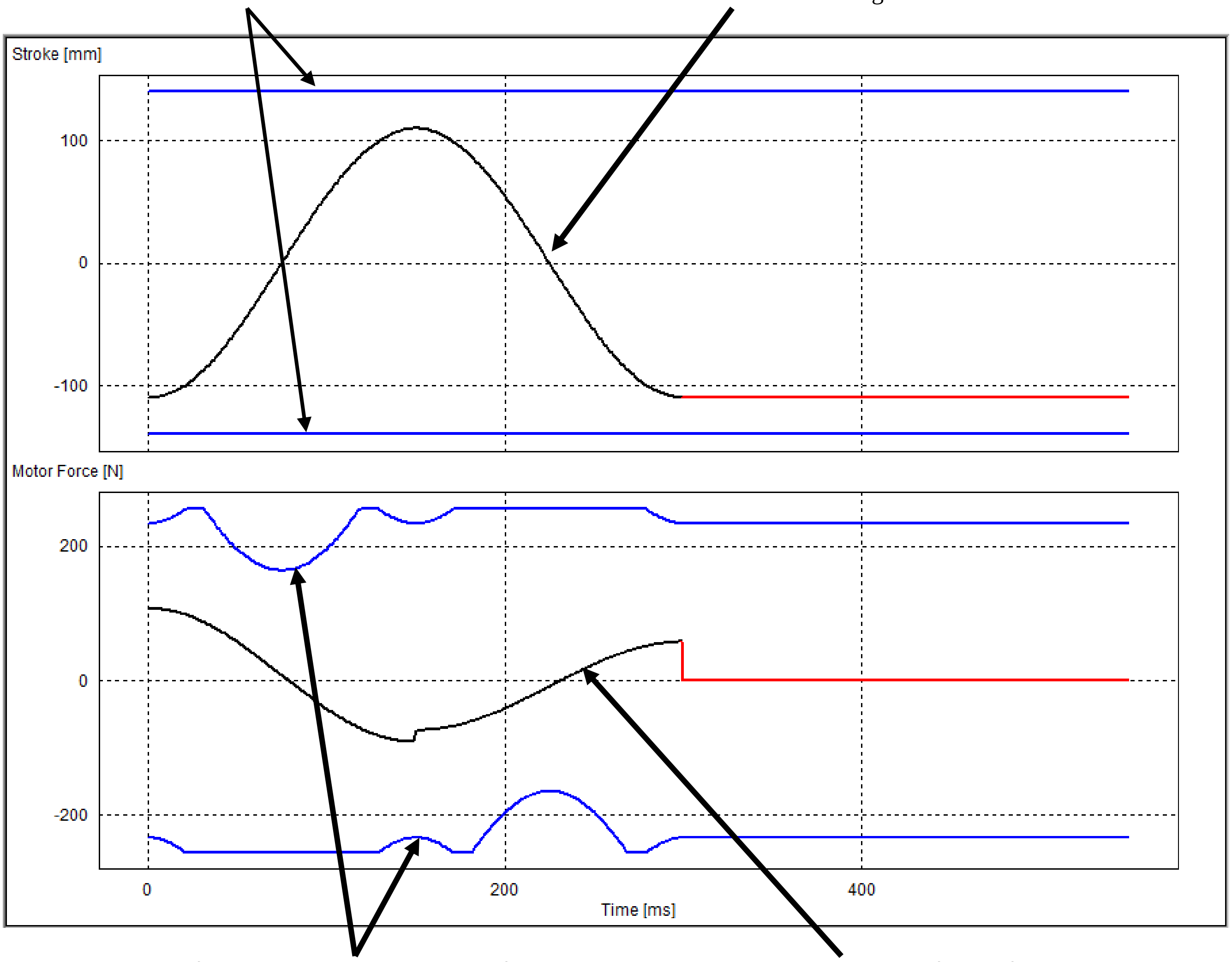
**Stroke Limits**

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.

Stroke limits of the selected linear motor/module        Stroke-Time diagram of the defined motion




Peak Force limits of the current motor/module configuration        Force-Time diagram of the defined motion

**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.

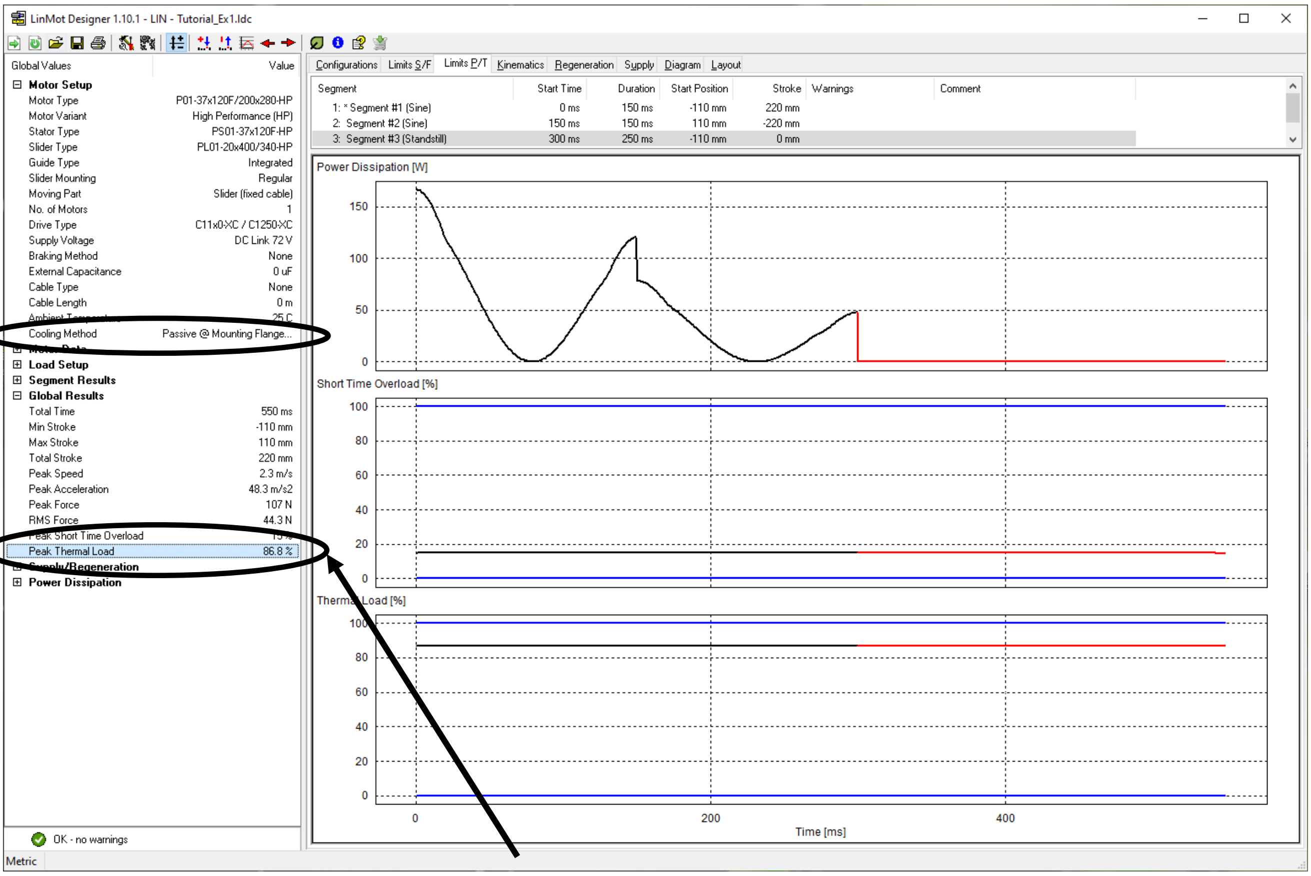
**Short Time Overload**

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.

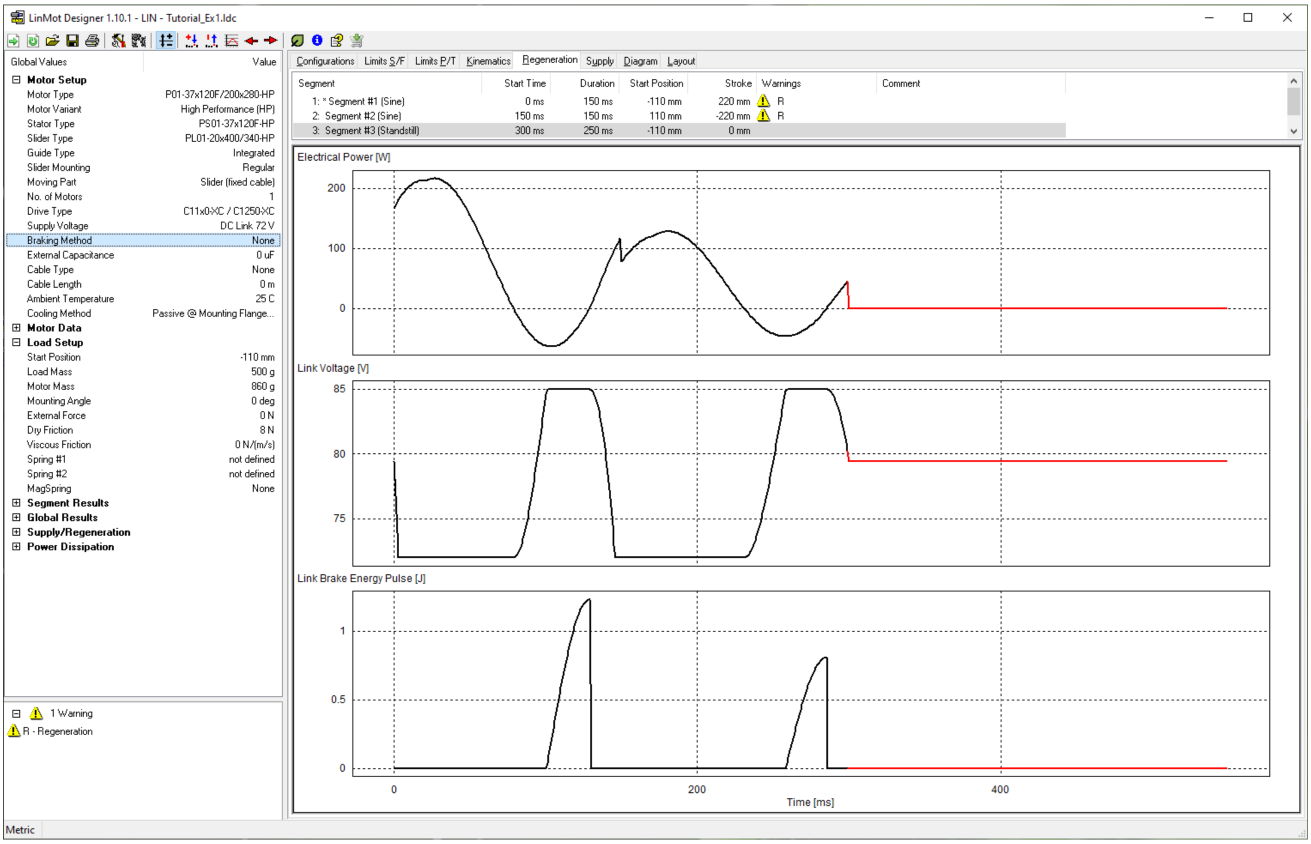
**Acceleration**

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**

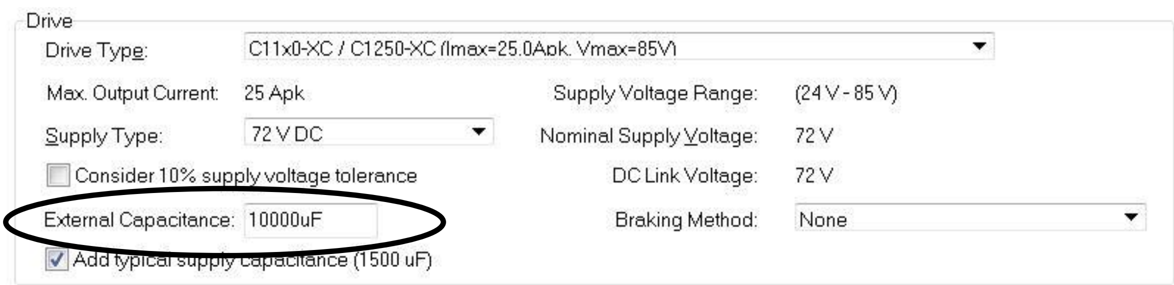
Usually, DC link power supplies have an output capacitance that can be used as an external capacitance of the drive. For a DC Supply Type, LinMot Designer adds by default a typical supply capacitance of 1500uF. If the output capacitance of the supply differs from this value, then the correct value should 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

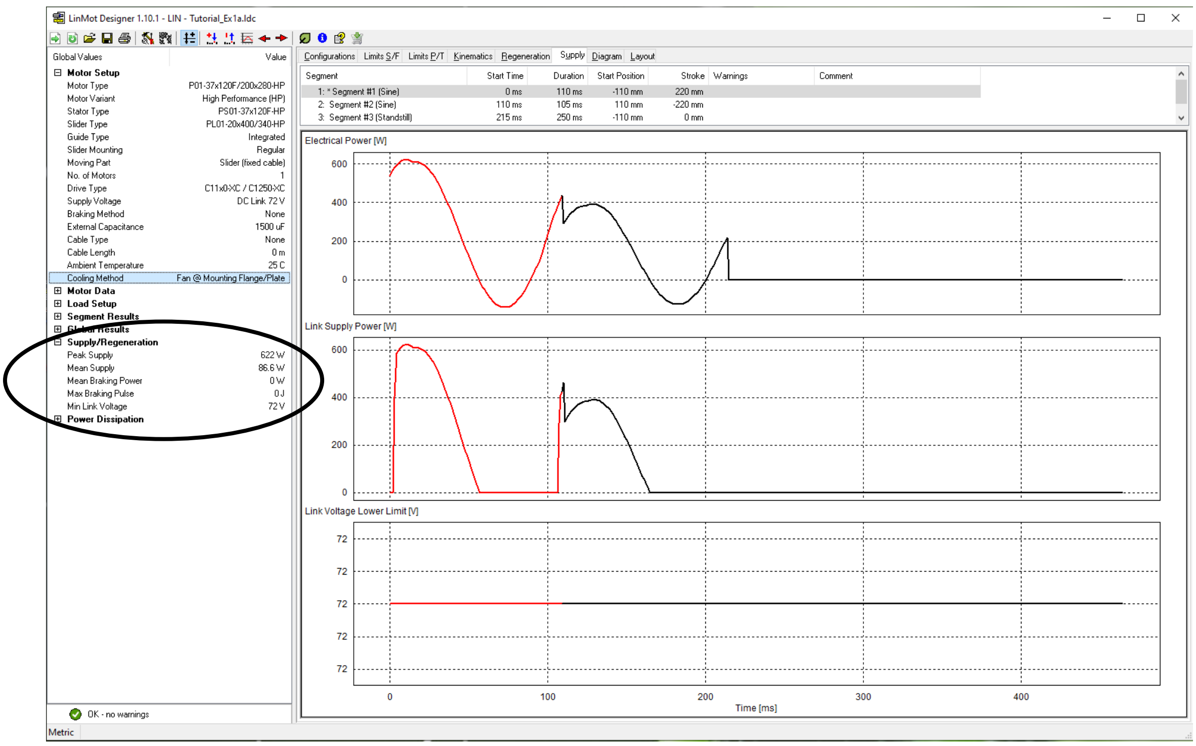
The “Speed Jump” Error is generated when the speed jumps at the motion segment borders. This error can only be generated when the “Speed Change Linear” curve type is used incorrectly and in such a way that it leads to speed discontinuities from one motion segment to another (i.e., the end speed of one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

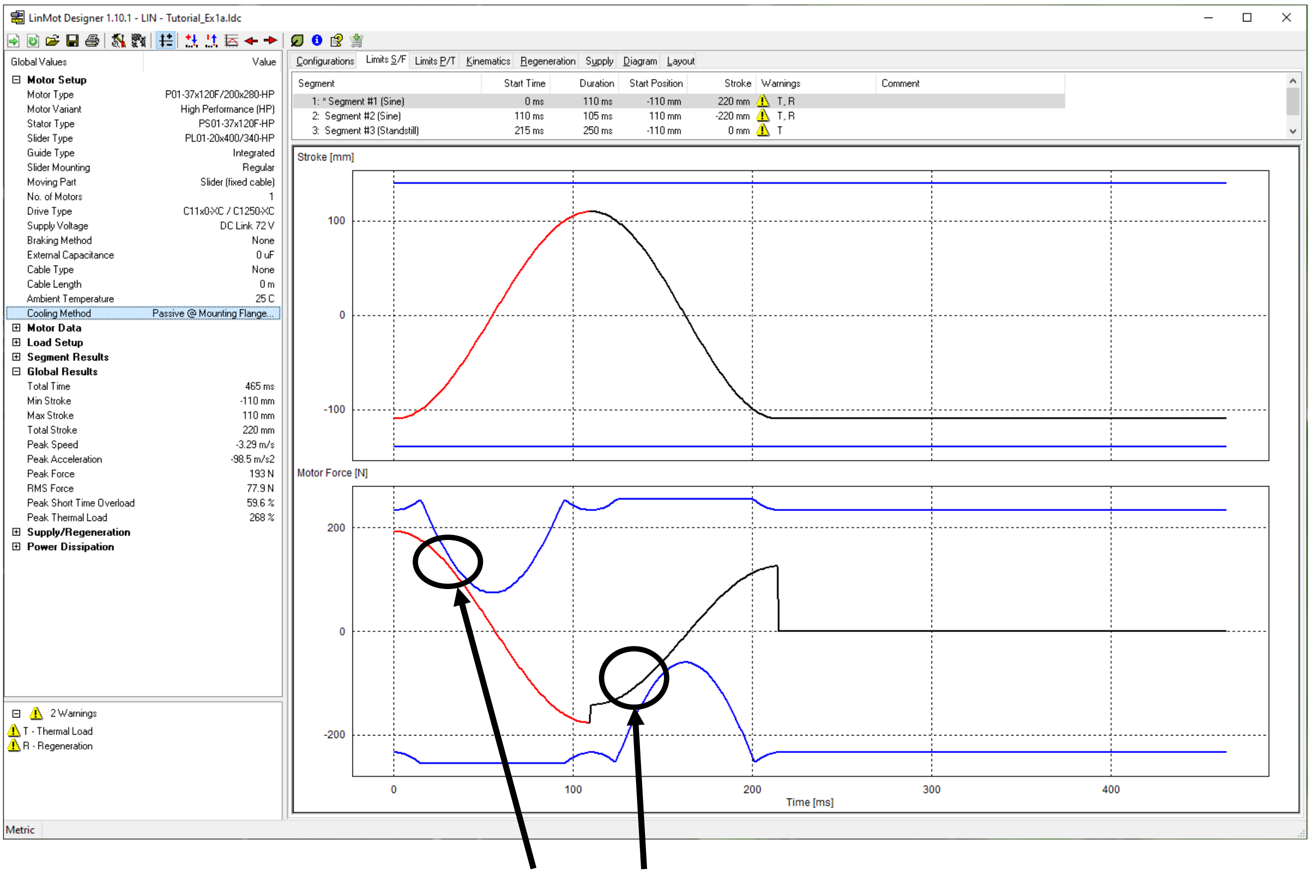
**Motor and Servo Drive**

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.

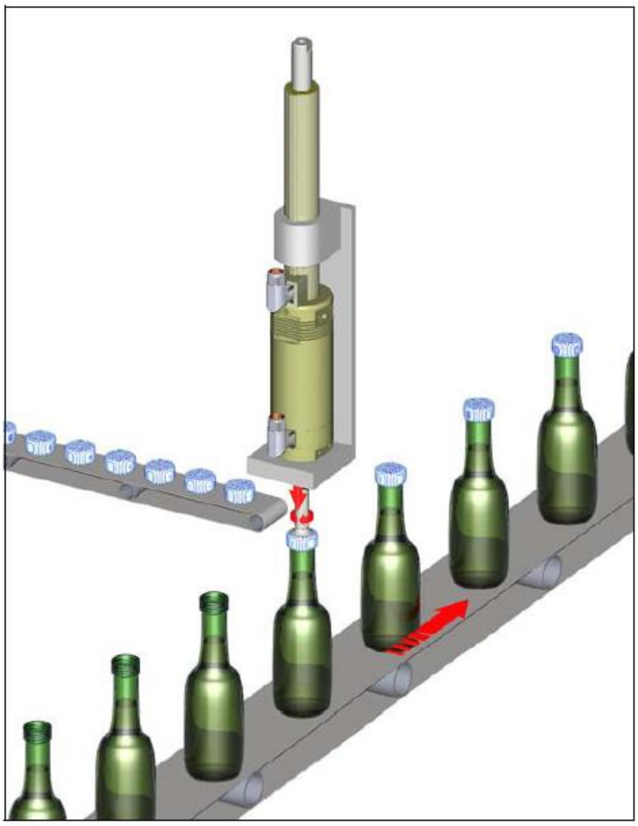
Reducing the time for the forward and backward motion will increase the Peak Thermal Load over the 100%-limit (268% ➔ Thermal Load Warning) if the motor is mounted with the standard flange (Cooling Method: Passive). With a change of the Cooling Method to “Fan”, the Peak Thermal Load decreases under its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

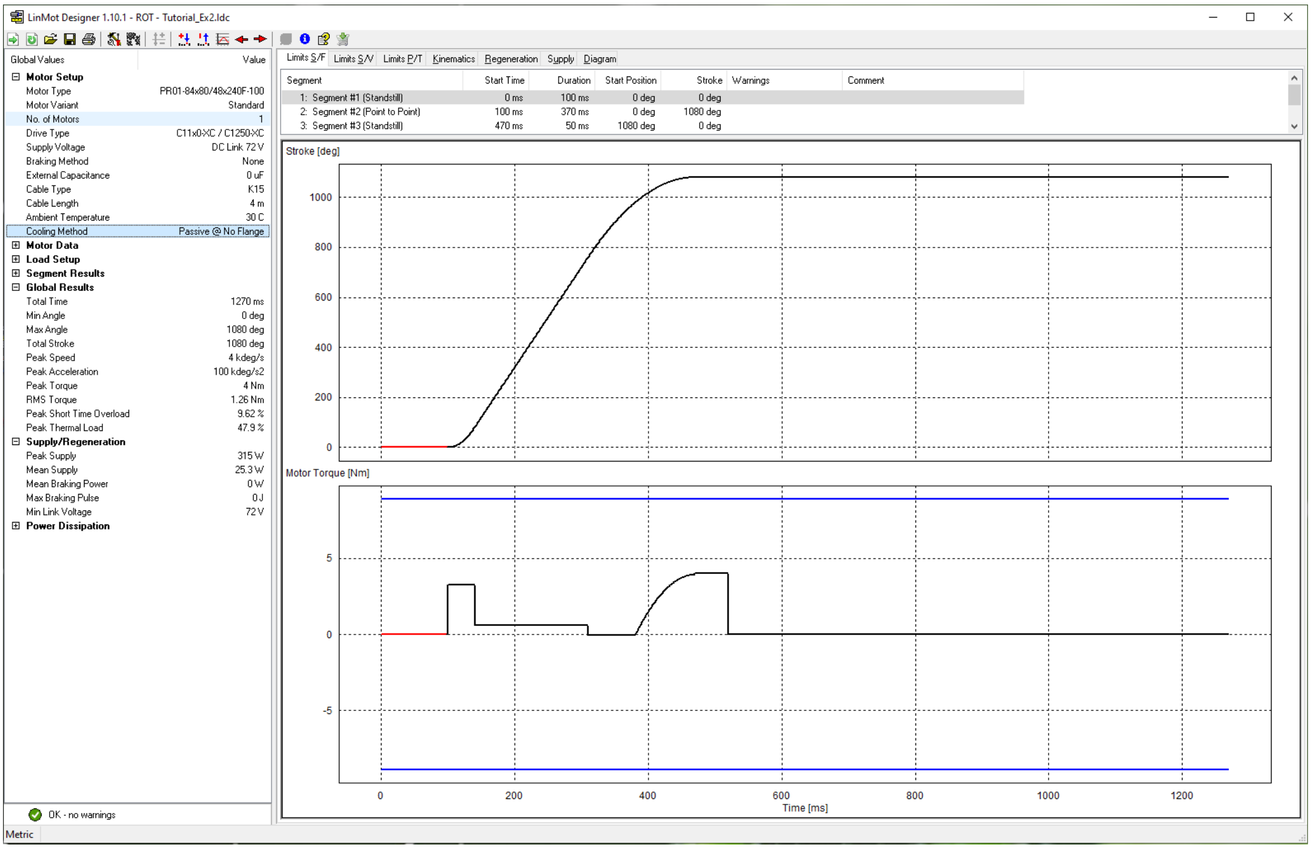


Cycle of the application:

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:

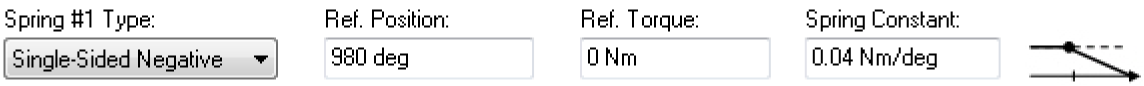
T_Cycle: **1.3s (2'770 bottles/hour)**
T_Screw&Tigthen: **< 0.5s**
Stroke Screw&Tighten: **1080deg (3 turns)**
Stroke Tighten: **100deg (ca. 1/4 turn)**
J_CappingHead: **13.1 kg/cm2**
J_Cap: **negligible**
Friction torque: **0.6Nm**
Max. tightening Torque: **4Nm**




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



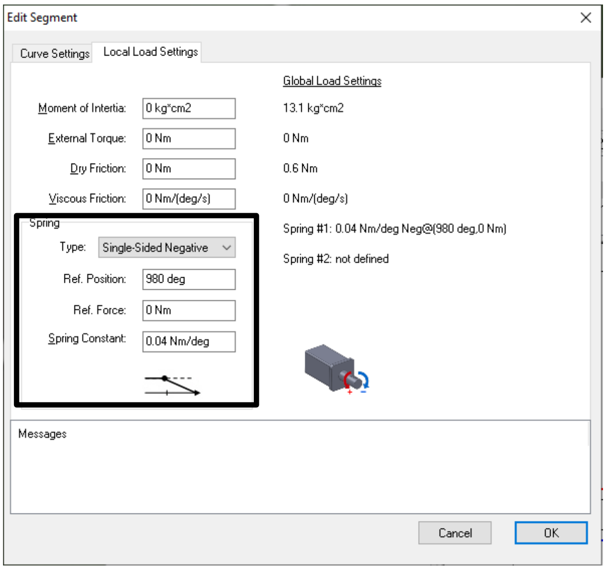

   The Moment of Inertia of the capping head is defined in the Global Load Settings.

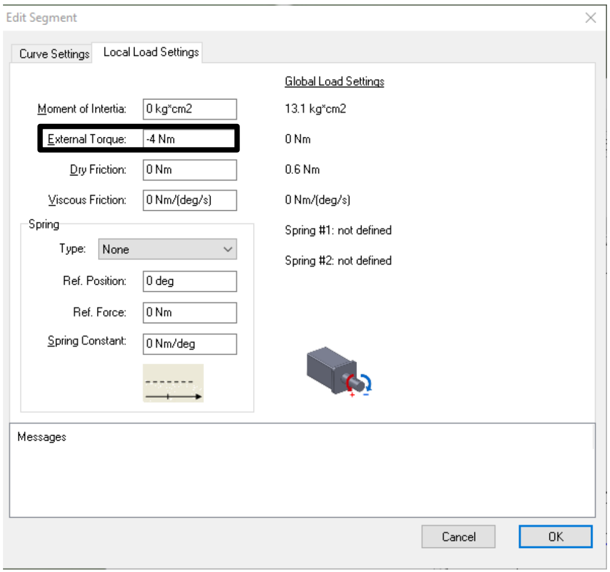
3) **Standstill**
   Keep the limit tightening torque of 4Nm for 50ms.

4) **Standstill**
   Release the tigthening 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 bahaviour 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).

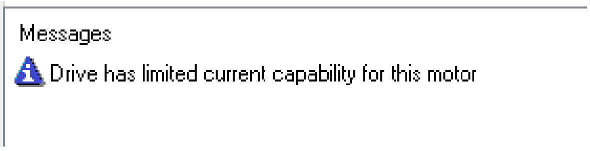


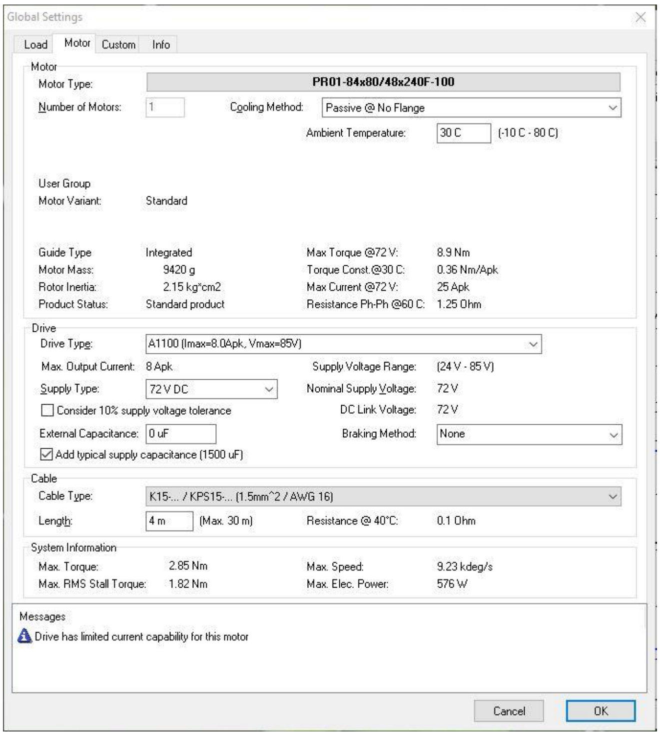




**Definition of the motor system**

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 message is also displayed in the Messgae window of the Global Settings when the drive has insufficient current capability for the motor.



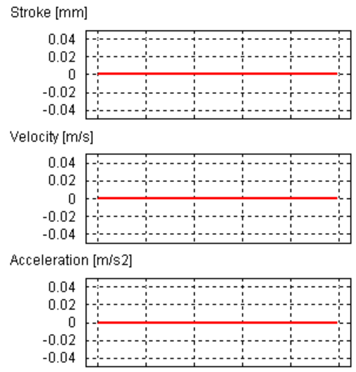
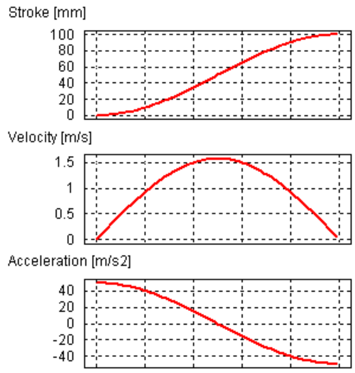
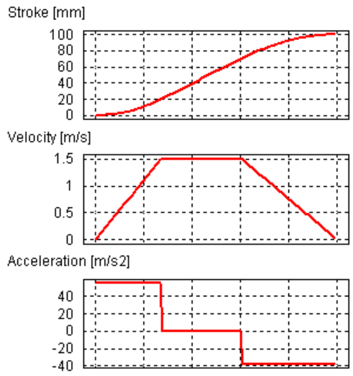

**Results**

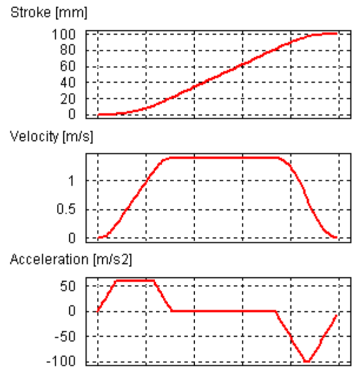
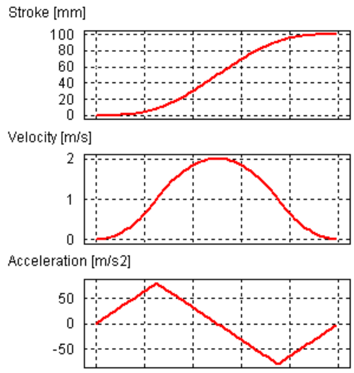
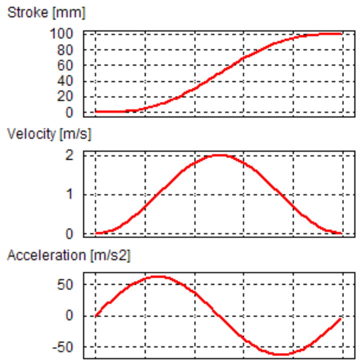
This simulation shows, that the rotary part of the application can be realized with the selected system. With a peak thermal load of less than 50% at an ambient temperature of 30°C, the motor will not be working at its thermal limit. So, there is still potential to increase the speed of the capping process.

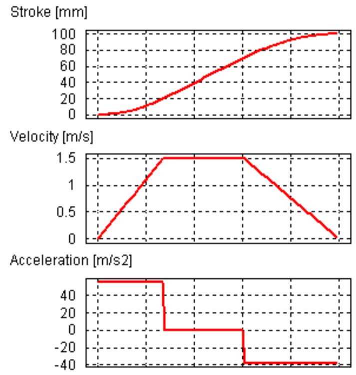
When sizing a rotary project, a warning will be generated if the velocity limit of the motor is exceeded. The velocity and its limits are shown in the lower diagram of the “Limit S/V” window. The graph of the motion (black-red line) has to be within the limits (blue lines) for the selected rotary motor.

## *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: • Time | Parameters: • Time<br>• Stroke | Parameters: • Stroke<br>• Max. velocity<br>• Acceleration<br>• Deceleration |
|  |  |  |

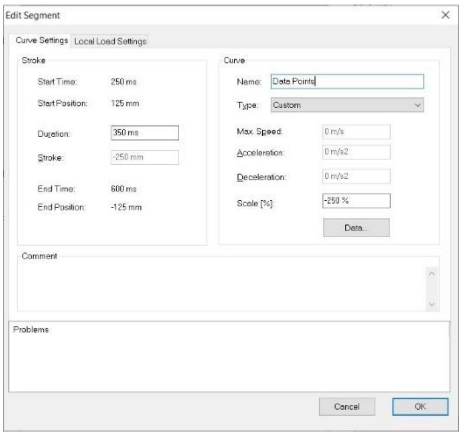
| **Limited Jerk** | **Minimal Jerk** | **Bestehorn** |
|---|---|---|
| Parameters: • Stroke<br>• Max. velocity<br>• Max. acceleration<br>• Max. deceleration<br>• Jerk | Parameters: • Time<br>• Stroke | Parameters: • Time<br>• Stroke |
|  |  |  |

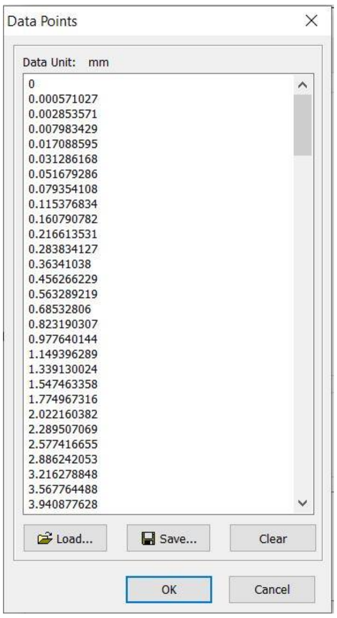
| **Speed Change Linear** |
|---|
| Parameters: • Time<br>• End Velocity |
|  |

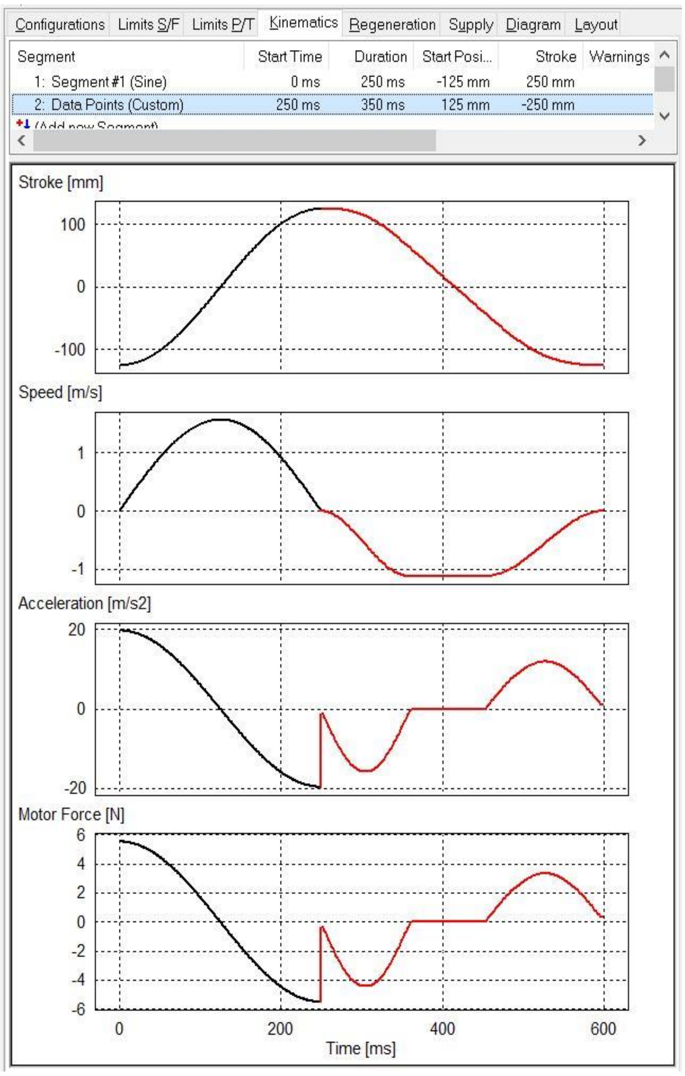
It is also possible to import a custom motion profile or just a segment of it into LinMot Designer. To do that, choose the **“Custom”** curve type. Open the “Data Points” window to define the custom position vector. There are two possibilities to do that:

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.



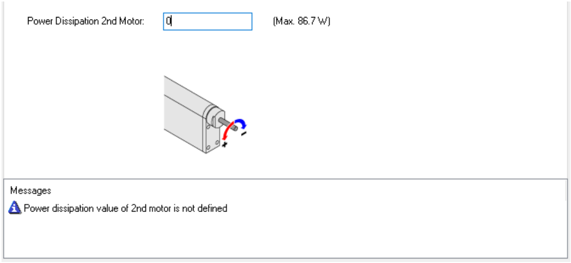



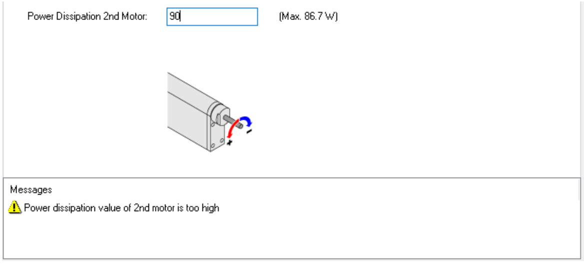

In “Tutorial_Ex3.ldc” a Custom curve (Segment 2) follows on a Sine curve (Segment 1). The data vector of the custom curve was imported (loaded) from the csv-file “Tutorial_Ex3.csv”. With a (negative) Scale value of -250%, the curve data points (forward motion from 0…100mm (in)) are scaled to a backward 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.

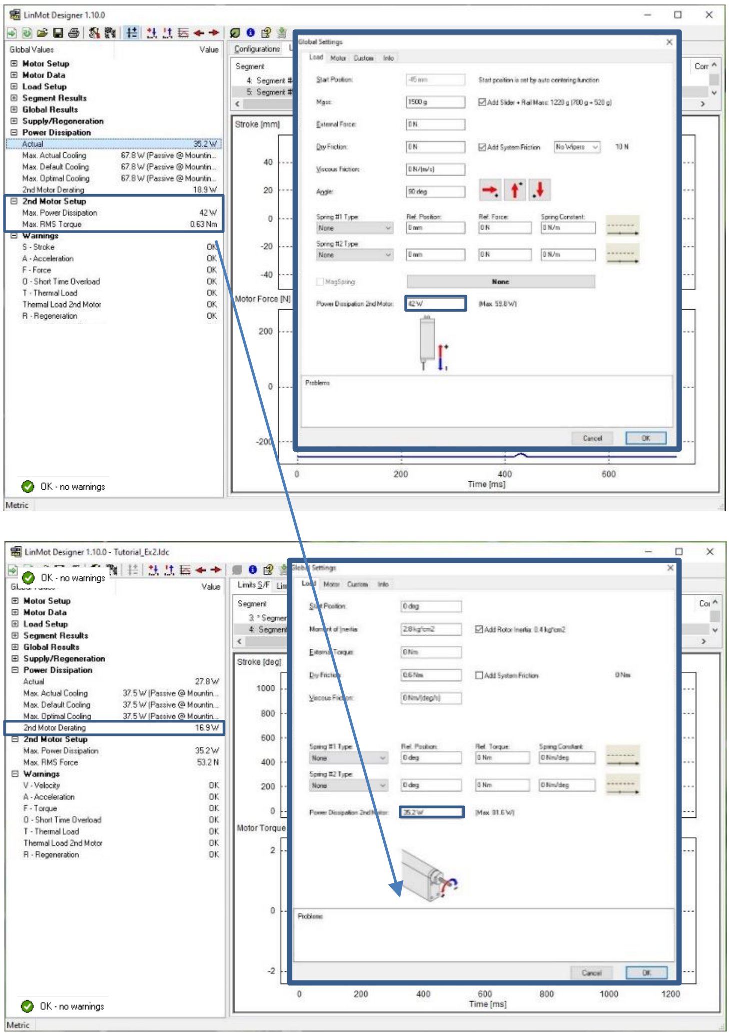



The power dissipation of the 2nd motor together with the corresponding RMS Force / Torque available, are displayed in the “2nd Motor Setup” window of the Global Values. In addition, in the “Power Dissipation” window is calculated and displayed the derating of the maximal cooling caused by the 2nd motor.

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.



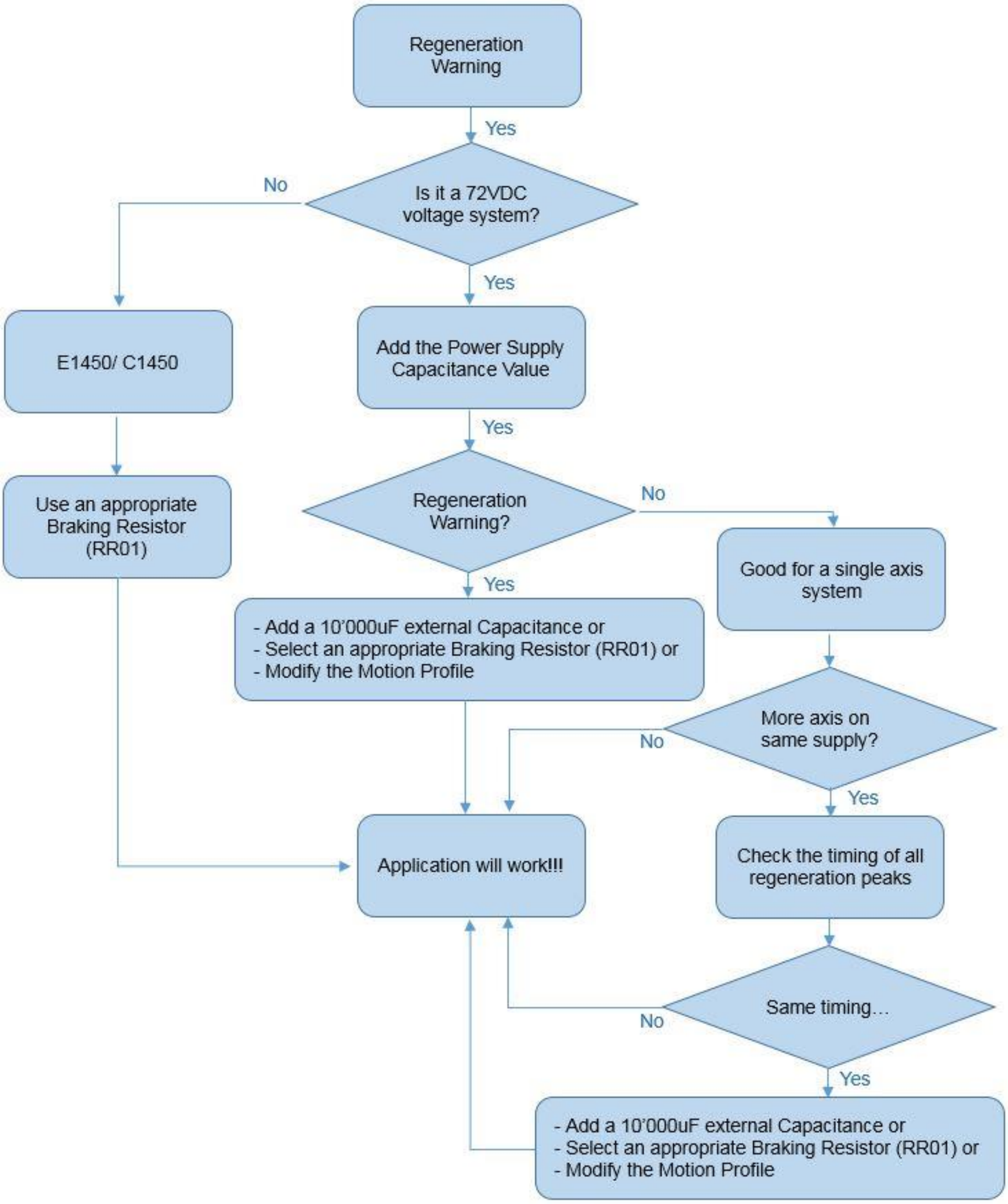
Below is suggested a procedure that could be used when sizing the rotary linear motor.

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] |
|---|---|---|---|
| *Transformer Power Supply* | | | |
| 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 |
| *Switching Power Supply* | | | |
| 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 |

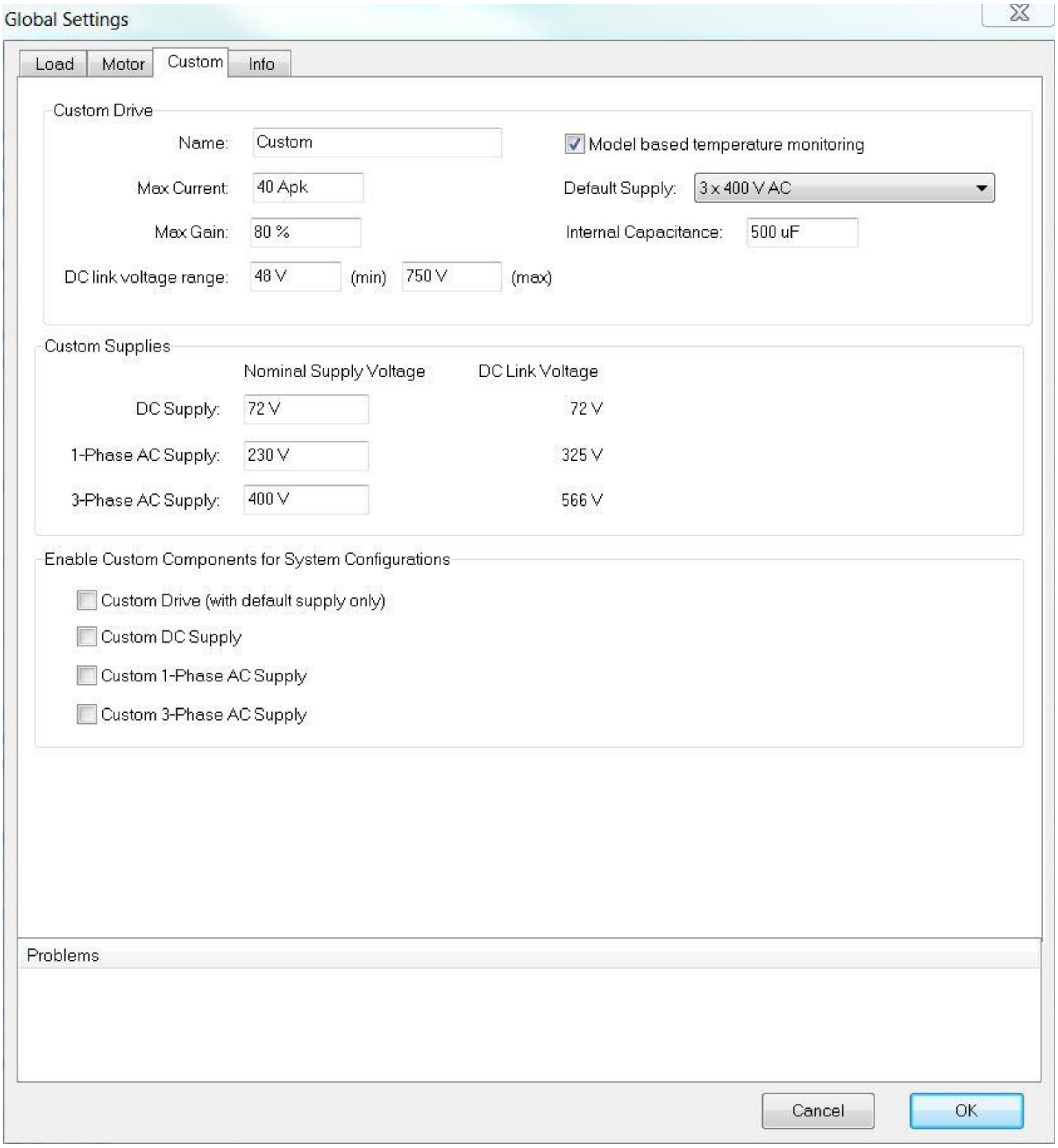
**Regeneration Resistor**
An external Resistor is connected to the servo drive (RR+ and RR-). Only servo drives with the regeneration resistor option can be used with regeneration resistors.

**Capacitor**
Possibility to connect an additional capacitor to the motor power supply. It is recommended to use a capacitor with a capacitance ≥ 10’000 µF.
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.



**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.

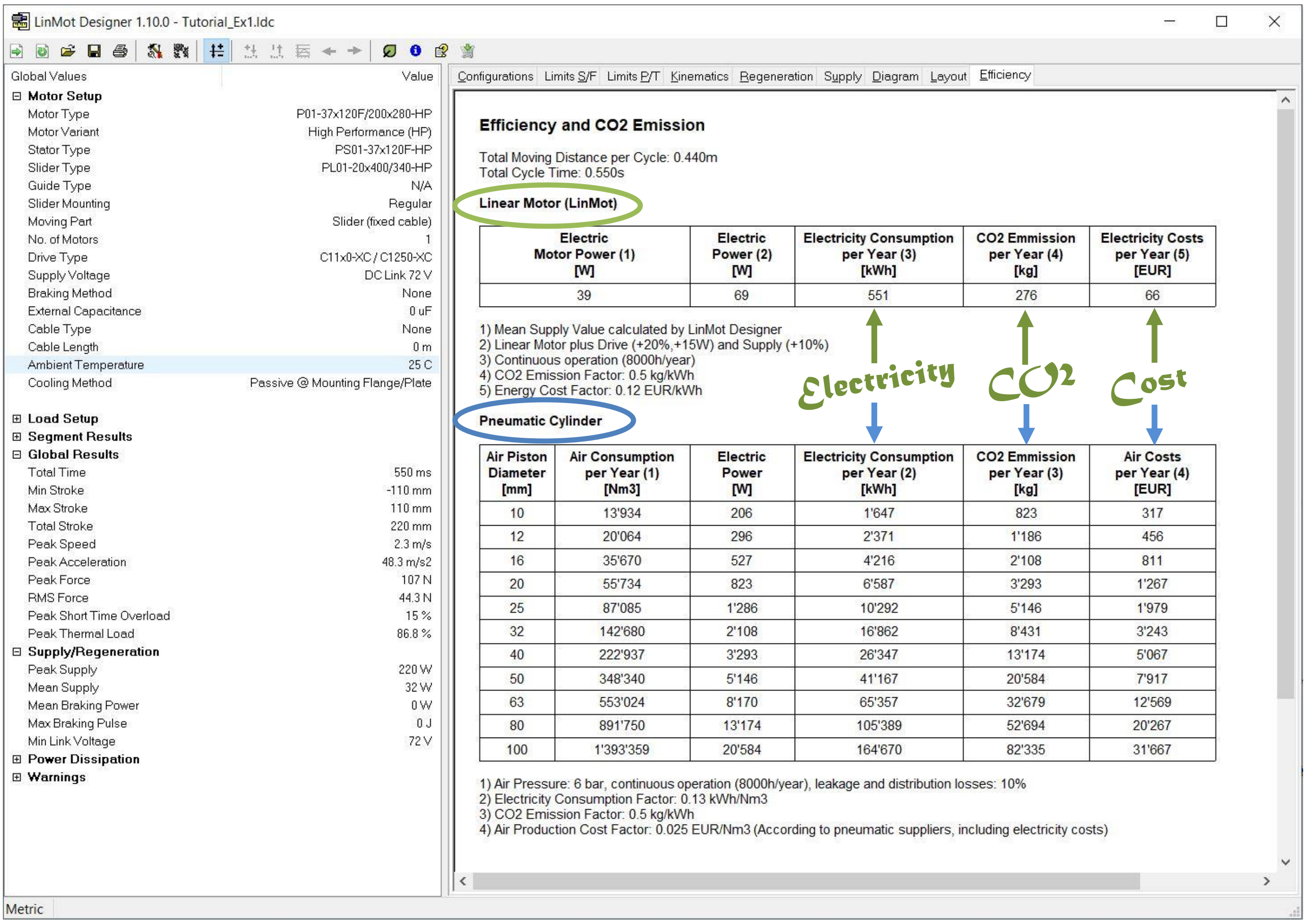
## Efficiency (Linear Motor ↔ Pneumatic Cylinder)

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.

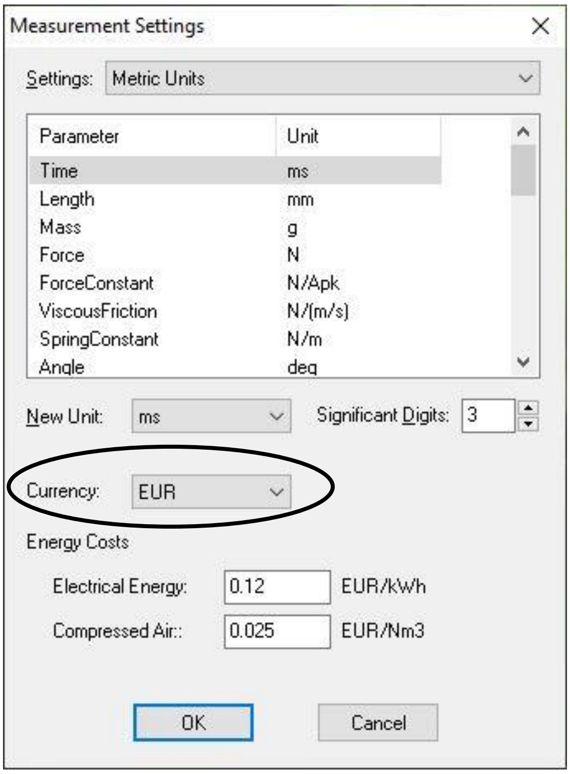
The content of the efficiency tab is only printed, if the tab is activated.



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.

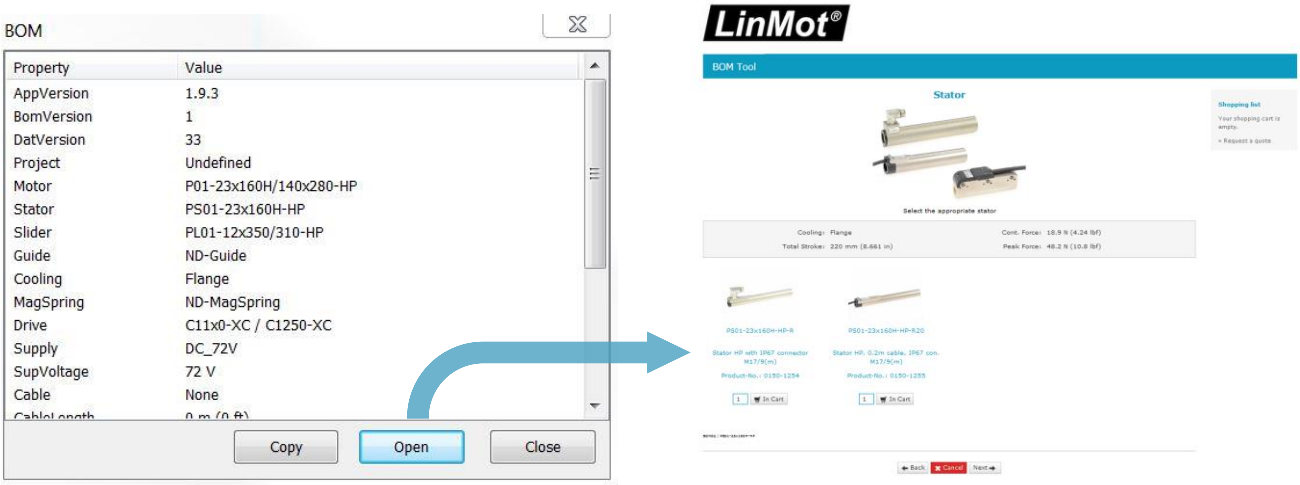


## BOM – Link

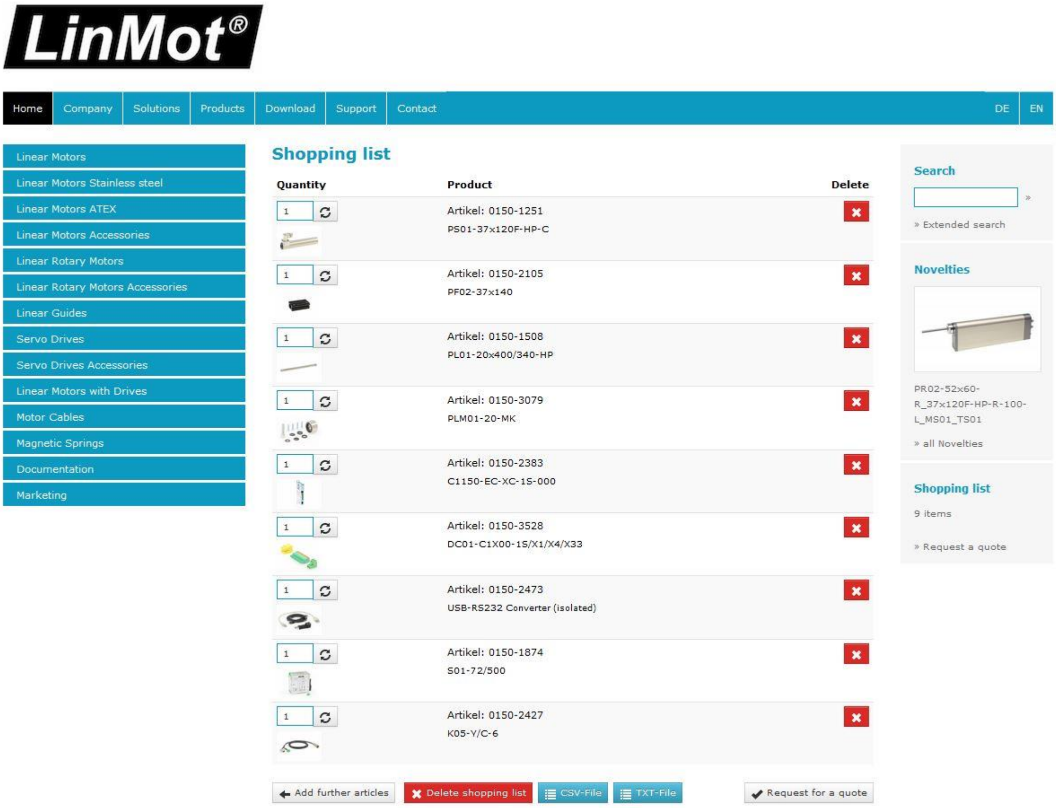
To create a web link to the **Bill of Material** and to show the BOM project data, select the "Show BOM" Button.

"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).

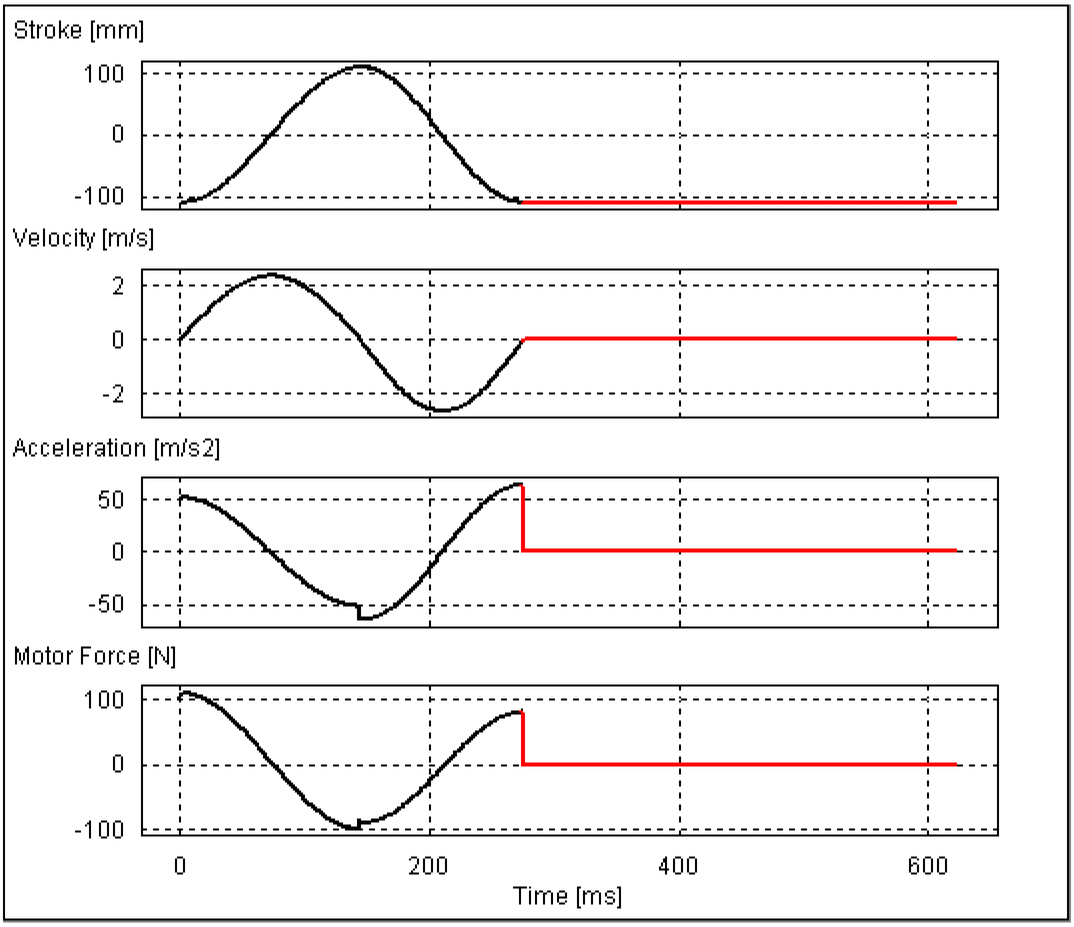



At the end of the BOM wizard the shopping list can be saved as cvs or text file and a quote can also be requested directly.

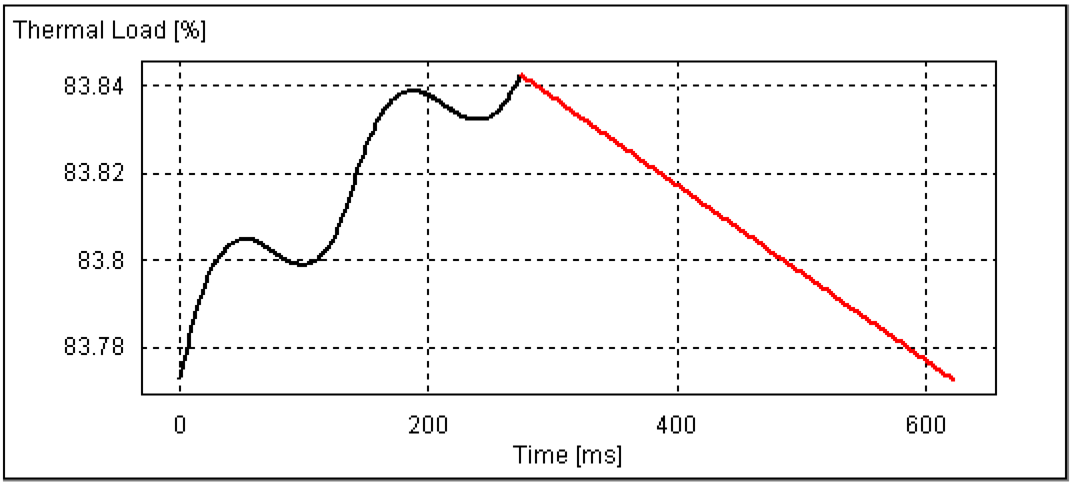


## Time Graphs

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".