Iron core linear motor manual

version 2.0

TECNOTION®

direct drive in motion

INTRODUCTION

A linear motor system is part of a specific machine. Tecnotion's iron core linear motors are components that can be combined with numerous application devices. This manual is intended for technicians who want to construct a machine that includes a linear motor system. It gives insight in the basic components of a Tecnotion iron core linear motor and additional components to complete the whole motion system. The manual further informs about important design and installation aspects of the linear motors, the important dimensions for designing the construction that will hold the linear motor, the required settings before starting up, and other aspects. Also, it will give insight in the definition of all specifications of a Tecnotion linear motor.

When installing a linear motor system, one should be familiar with some important safety remarks. In the first chapter these remarks are made. Please read them carefully. For technical questions you can contact the Application Engineering department at support@tecnotion.com or at +31 546 898 475.

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APPENDIX

1. BEFORE YOU START

This is the manual for your Tecnotion iron core motor. Please read this manual very carefully. The information provided is important for a safe and warranted installation and operation of the motor. Be sure to have this manual at hand when installing or working with the motor.

About this manual

This manual describes the use of a Tecnotion iron core linear motor system. These motors can be applied in numerous application devices. This manual is intended for technicians who construct a machine that includes an iron core linear motor. It will give insight what aspects to consider for the design and installation of a linear motor.

Intended use

An iron core linear motor system is a permanent magnet direct drive motor that moves along an axis. It is intended to be used wherever a linear movement is required. Only use this iron core linear motor system as intended, every other use is not-intended use and therefore not warranted.

Safety and information symbols

The lightbulb describes a 'tip'.

The exclamation mark is a, non-safety related, important notice that the user should be aware of.

The warning signs inform about safety information that the user should respect.

1.1 Important notices

Before installing and using the linear motor, read this instruction manual carefully. The manufacturer declines all responsibility in case of accident or damage due to negligence or lack of observance of the instructions described in this manual. The manufacturer also declines all responsibility in case of accident or damage in conditions that differ from those indicated in the manual; Tecnotion also declines all responsibility for damage caused by improper use of the linear motor.

Handle the components of the linear motor with care, packed as well as unpacked. Especially the magnet plates are sensitive to mechanical shocks. Never drop a magnet plate or release it in an uncontrolled way. Do not expose the magnets to temperatures higher than 70°C. The magnets may be demagnetized at higher temperatures.

Unpack the linear motor and check its integrity. If there is any irregularity contact the dealer or manufacturer, signaling the nature of the defects. Make a note of the serial number. This facilitates the correspondence with the supplier.

1.2 Safety warnings

The linear motor is used as a part of a machine. The machine manufacturer or representative has to take care that the machine as a whole fulfils all CE requirements.

The magnet plates show large attraction forces on all soft magnetic objects such as iron. These forces cannot be controlled by hand. They may cause serious jamming danger. Do not bring any soft magnetic objects like iron nearer than 25 centimeter of the magnetic side of the magnet plate. Be sure that the magnet plates are fixed into your machine before removing the magnetic field protection plates. Put the protection plates on the magnet plates again before dismounting them.

Magnetic sensitive objects like payment cards, pacemakers or other magnetic information carriers may be damaged if they are brought within 1 meter of the magnet plates.

The magnet plate and coil unit can be damaged when cleaned with a non-prescribed cleaning agent. Use only isopropanol as a cleaning agent.

The magnet plates attract each other while mounting. This may cause serious jamming danger. Take care that one magnet plate doesn't damage the magnets of the neighboring magnet plate while mounting.

If at any time and in any situation there is any doubt about the safety of the linear motor, do not use it and contact your supplier.

The linear motor is powered by a servo amplifier. In case of a power disruption or fatal error this may automatically result in a free run out of the motor. Make mechanical precautions to prevent damage on the motor or your machine in the case of such an event.

Before installing the motor, make sure that the supply mains are grounded and operate in conformity with the regulations in force.

Make sure that there is an effective protective earth. Also make sure that there is no voltage at the wire terminals before connecting.

An earth connection does not work on non-conducting mounting surfaces like granite. In these cases the protective earth must be established by an earthing wire.

Before performing or doing any maintenance, clear the system by disconnecting the voltage. Be sure that there is no possibility of accidental connections.

Be aware of electric danger if any fluid comes in contact with electrical connections.

1.3 Certification

All information about certifications can be found in this chapter. The certifications can be found online at www.tecnotion.com/certificates.

1.3.1 CE certification

Tecnotion B.V. declares that the linear iron core motors mentioned in this installation manual are manufactured in accordance with the relevant Union harmonization legislation when installed according the installation manual. The iron core linear motors are in conformity with the following standards, see table 1.1.

Standard	Name
EN 60034-1:2010	Rotating electrical machines, Part 1: Rating and performance
ISO 12100:2010	RI&E
EN 61000-6 1 to 4	EMC

Table 1.1: Applicable standards.

The CE marking indicates that the product may be traded freely in any European economic area. All products of Tecnotion have the CE marking.

1.3.2 RoHS certification

RoHS (Restriction of Hazardous Substances) took effect by the European Union on 1 July 2006 to limit the hazardous substances in electrical and electronic equipment. All products supplied by Tecnotion meet the requirements of EU RoHS Directive 2011/65/EU and 2015/863/EU. Therefore, Tecnotion ensures that all products are free from lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyls or polybrominated diphenyl ethers.

1.3.3 ISO certification

The harmonized standard of ISO was updated. Including the implementation meets the requirements of the standard ISO 9001:2015.

1.3.4 CSA certification

CSA compliance shows that a product has been independently tested and certified to meet recognized standards for safety/performance for Canada and US. Tecnotion iron core linear motors have the CSA compliance.

1.3.5 REACH certification

REACH is a system to manage the risks of chemical substances and their potential impacts on human health and the environment. Tecnotion products are evaluated against regulation (EC) 1907/2006 of the European Parliament, "Registration, Evaluation, and Authorization of Chemicals (REACH)".

1.3.6 TSCA certification

TSCA is required if a company imports chemical substances, mixtures or articles and generally must meet the same requirements under TSCA as a chemical manufacturer in the United States. This TSCA compliance declaration applies to all products sold by Tecnotion BV according to the definitions and restrictions given for the persistent, bio accumulative, and toxic chemicals under TSCA section 6(h) by the EPA.

1.3.7 UKCA certification

For goods sold within Great Britain the CE mark will be replaced by the UKCA mark. The deadline is at the moment of writing December 2024. Tecnotion is prepared for this transition and all catalog products have UKCA marking.

1.3.8 Conflict mineral regulation

In politically unstable areas some groups can force labor in mines for the so-called 3TG (tantalum, tin, tungsten, gold and derivates) minerals, therefore in May 2017 the new EU law passed a new regulation.

1.3.9 China compulsory certificate

The China compulsory certificate (abbreviated as CCC or 3C certificate) was established in 2001 and implemented on May 1, 2002 and became fully effective on August 1, 2003. All Tecnotion products are deemed not to require CCC certification.

2. MOTOR COMPONENTS

An iron core linear motor of Tecnotion consists out of a coil unit and one or more magnet plates. Together with a slide, mounting frame, rails and bearing system, dampers, encoder, controller and amplifier, the linear motor forms a complete machine concept. In figure 2.1, an example of such a system is given. The size and the shape of the mounting frame, the design of the slide, the type of bearings or the kind of dampers depend on the required application. For instance, the mounting frame and the slide should be designed in such a way that a correct air gap between coil unit and magnet plates will be obtained.

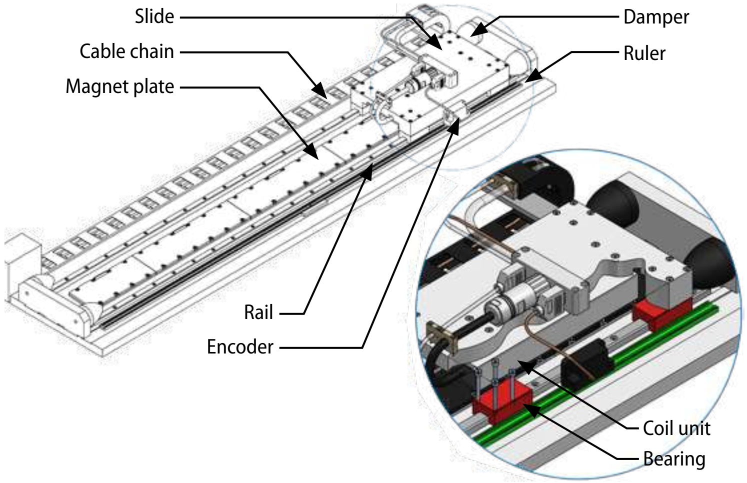

Figure 2.1: A complete axis system with Tecnotion coil unit and magnet plates installed.

2.1 Basic components

Tecnotion only supplies coil units, multiple magnet plates and offers a few additional components like Hall modules and stainless steel covers. All other components need to be sourced from other suppliers.

The basic linear motor components supplied by Tecnotion are:

- the coil unit. This part is available in different sizes and can have different winding options which makes it easier to find a solution which fits your voltage and current requirements;
- the magnet plate. This part is available in different lengths. Every magnet plate has a protection plate.

The Tecnotion online simulation tool, is the best tool to determine which motor and plate would be the best solution for your application. In this tool you can enter your application data, add movement profiles, and observe how this affects current, voltage, power dissipation, et cetera.

Typically, the coil unit is the moving part of the system, and the magnet plate is the stationary part. It is also possible to do this vice versa. When the coil unit is stationary, the cables are not moving and cooling of the coil unit is easier. The moving mass however is significantly higher in this case, therefore the motor that is needed for the application will be larger. Our team of application engineers can support you in making this decision, you can contact them at support@tecnotion.com or at +31 546 898 475.

2.1.1 Coil unit

Tecnotion offers coil units in different series and different lengths. The first letters in the product name are indicating the series, with TM being the narrowest coil unit, TB being the widest coil unit and TL being an intermediate size. The TBW coil unit is equivalent to the TB series but has additional water cooling channels available. The number in the product name indicates the number of windings inside the coil unit.

The letter at the end of the product name is the winding type of the motor, Tecnotion offers most of the coil units as an N- or S-winding version. What type is required depends on the voltage, current and speed requirements of the application. The N-winding type is optimized for low current, enabling the use of a smaller less costly amplifier. The S-winding type is optimized for higher speeds or lower voltages, however it can require a larger amplifier. Some coil units in the TM series are available as Z-winding, they are optimized for even higher speeds or lower voltages. The TL48 is only available in a Q-winding, this winding will cause the maximum speed of the motor to be low but the current consumption as well.

An example of a Tecnotion iron core coil unit is given in figure 2.2. All available winding types per coil unit of the iron core series are given in table 2.1.

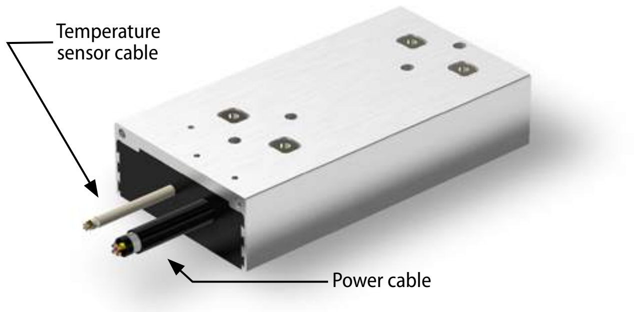

Figure 2.2: Example of a TL6 coil unit.

Series	TM				TL						
Number of coils	3	6	12	18	6	9	12	15	18	24	48
N				x	x	x	x	x	x	x	
S	x	x	x	x	x	x	x	x	x	x	
Z	x	x									
Q											x

Series	TB					TBW		
Number of coils	12	15	18	24	30	18	30	45
N	x	x	x	x	x	x	x	x
S	x	x			x	x	x	x

Table 2.1: Available winding types for all coil units.

2.1.2 Magnet plates

To prevent serious jamming danger only handle the magnet plates covered with the magnetic field protection plates.

The coil units require magnet plates in order to move. The first letters of the magnet plate indicate the coil unit series where the plate belongs to, the number indicates the plate length in millimeter. Table 2.2 shows an overview of the magnet plate options belonging to the coil units. Note that the TBW series uses the same magnet plate as the TB series, there is no TBW magnet plate. Figure 2.3 shows the magnet plate TL192.

Series	Magnet plates		
TM	TM96	TM144	TM384
TL	TL192	TL288	
TB(W)	TB192	TB288	

Table 2.2: Available magnet plates belonging to the coil units.

Figure 2.3: Example of a Tecnotion magnet plate (TL192).

Figure 2.4: Example of a Tecnotion protection plate on a TL192 magnet plate.

2.1.3 Magnetic field protection plates

Magnet plates produce very high attraction forces. These forces are unpredictable and cannot be controlled by hand. Tecnotion iron core magnet plates are always delivered with protection plates. These plates function as a shield for the magnetic fields. With the protection plates the magnet plates can be handled safely. In figure 2.4 a protection plate of a TL plate is shown.

> **!** The protection plates need to be used during assembly and disassembly as described in chapter 4. It is important not to throw them away.

2.2 Additional parts

For a proper installation of your linear motor system besides the motor you will also need:

- an appropriate servo controller/amplifier to drive the motor;
- a ruler and a linear encoder to determine the motor position with high accuracy;
- power supply, cabling and connectors;
- an Allen key set to install the products;
- fixing components like bolts and dowel pins;
- a bearing system.

Occasionally useful are:

- dampers to prevent uncontrolled runout from the track;
- a mechanical brake, especially in vertical applications;
- heat sink compound for better heat transfer from the motor to the heat sink;

- isopropanol wipes to clean mounting surfaces.

All these features are not a part of Tecnotion's standard delivery.

> For installation, use non-ferromagnetic tools to prevent damaging the magnet plates.

A digital Hall module for commutation and analog Hall module for positioning can be used as cost effective alternatives to a separate encoder system when positioning requirements are not too strict. These products can be supplied by Tecnotion, information on these products can be found in chapter 5. Tecnotion can also deliver an optional stainless steel cover to protect the magnet plates during operation, this can be convenient when small magnetic objects are in proximity of the magnet plates.

In order to mount the coil units and magnet plates, bolts and (optionally) dowel pins are required. Information regarding these parts can be found in chapter 4.

3. MOTOR CONFIGURATION

3.1 Configuration options

The following paragraphs give information regarding the configuration of the coil unit and magnet track. It shows how to calculate the desired magnet track length, how to couple two or more coil units with each other, and how the air gap between coil unit and magnet track can be changed and what the influence is on the remaining forces.

3.1.1 Magnet track length

There are two ways to determine the required magnet track length. The easiest way is to add up the necessary stroke for the application and the length of the coil unit. Please review example 3.1 at the end of the paragraph for further information. This will provide the minimum magnet plate length that needs to be constructed with the available magnet plate sizes. In appendix A an overview of the available lengths per series can be found.

It can be cost effective to determine the required magnet plate length by means of the effective length instead of the coil unit length. This is especially interesting when an extra magnet plate is required to attain the minimum stroke length when, according to the coil length, it falls short by a few centimeters. This method will save the need for one magnet plate. The effective length of a coil unit is the area where the actual windings are situated in the coil, see figure 3.1. In this area the force is created that propels a linear motor. The remaining space accommodates for example the wiring, the PCB or filler material. This non-effective length of the coil can overrun the end of the magnet plate without any loss of force. Table 3.1 states where the effective length of a coil starts and ends.

In order to function properly the effective area of the motor should remain on the magnet track. It is possible to use a configuration in which the effective area runs off the magnet track, but that will introduce force losses, difficulties in driving the motor correctly, more and uncontrolled heat generation and more undesirable effects.

Example 3.1

Suppose we want to move 260 mm using a TL12 motor. This coil has a length of 244 mm, and an effective length of 216 mm. The available TL magnet plates are 192 and 288 mm in length.

Magnet length calculation using the coil unit length

The total magnet plate length is the sum of the coil length (244 mm) and the desired stroke (260 mm). That gives 504 mm. You would need 2 TL288 plates in order to cover the distance. In this example the motor will stay on the magnet plates.

Magnet length calculation using the effective length

The total magnet plate length is the sum of the effective length of the coil (216 mm) and the desired stroke (260 mm). That gives 476 mm. You would need only one TL288 and one TL192 plate to cover the distance. In this example the motor will partly run off the magnet track but because the coils are still located above the magnet track, there is no force loss.

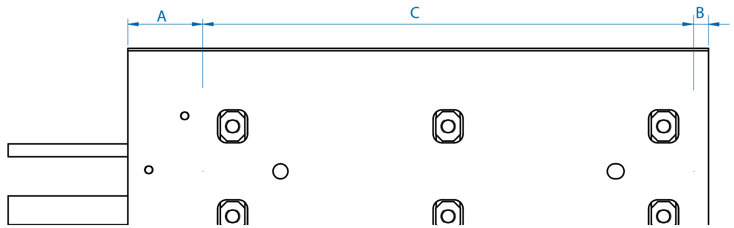

Figure 3.1: Location of effective length of an iron core coil unit.

Parameter	TM3	TM6	TM12	TM18
Cable side A (mm)	19	23	23	26.7
End B (mm)	8	6	2	3.7
Effective length C (mm)	66	114	216	305.6

Parameter	TL6	TL9	TL12	TL15	TL18	TL24	TL48
Cable side A (mm)	26	25	26	26.2	26.7	26	32.2
End B (mm)	6	5	2	6.2	3.7	2	5.2
Effective length C (mm)	114	164	216	257.6	305.6	440	817.6

Parameter	TB12	TB15	TB18	TB24	TB30
Cable side A (mm)	26	26.2	26.3	29.2	26.2
End B (mm)	2	6.2	4.1	3.2	6.2
Effective length C (mm)	216	257.6	305.6	401.6	529.6

Parameter	TBW18	TBW30	TBW45
Cable side A (mm)	34.7	39.2	39.2
End B (mm)	3.7	11.2	11.2
Effective length C (mm)	305.6	529.6	801.6

Table 3.1: Dimensions of the effective length per motor type.

3.1.2 Coupling of motors

Individual iron core coil units can be coupled. This can be done using two separate magnet tracks for gantry type applications, parallel coupling, or inline coupling on a single track to yield more force, see figure 3.2. This last option is especially interesting for cost reduction in long stroke applications. By coupling two coil units a smaller series coil and magnet plate can be used. This will reduce the magnet plate costs. Different type of motors within one series can be coupled as long as they have the same motor force constant. The forces of both coil units can be added up. Motors must always be connected to the drive in parallel. Coupling in series is not possible because of voltage limitations of the cables. Refer to appendix B for details about phase connections.

Mechanically the coupling can be performed in two different ways. The first method is parallel coupling, in which there are two (or more) rows of magnets with coil units. If the coil units face the same direction, they can simply be placed at the same position on each individual magnet track parallel to each other. The second method is in-line coupling, where several coil units are placed in the same row of magnet plates, see figure 3.2. In this case there are three possible orientations: with the cable sides pointing towards each other, away from each other, or in the same direction, see figure 3.3. Details about minimum mounting distances between both coil units can be found in appendix B. When coupling motors, it is sufficient to use the temperature sensors of only one of the motors. Make sure that the cables of the motors have approximately the same length so that the resistances of the motors will not differ too much.

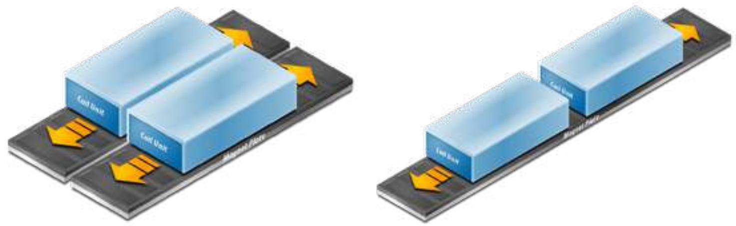

Figure 3.2: Coupling on two magnet tracks (left) versus coupling on one magnet track (right).

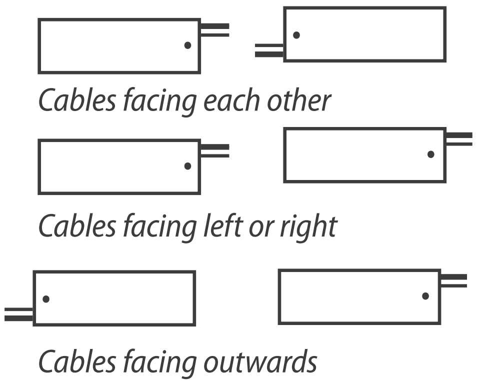

Figure 3.3: The three orientations when coupling two coil units on the same magnet track.

3.1.3 Air gap and mounting height

When the coil unit and magnet plates are installed, there will be a small gap between the two. This is what is called the air gap. Tecnotion does not specify nominal values for the air gap, instead the mounting height is specified. The mounting height is the distance from the top of the coil unit to the bottom of the magnet plates. The nominal air gap is not specified because of the casted finish of the coil unit and magnet plates. This makes it impossible to get an accurate reading of the air gap using a feeler gauge. Therefore Tecnotion always recommends using the mounting height instead of measuring the air gap. When the mounting height is followed, the air gap will automatically be correct. The prescribed mounting height for every series can be seen in table 3.2. When the stainless steel cover is used to protect the magnet plates, Tecnotion recommends to add 0.1 mm to the nominal mounting height.

Series	Mounting height (mm)
TM series	40.0 ± 0.1
TL series	40.0 ± 0.1
TB series	45.0 ± 0.1
TBW series	47.0 ± 0.1

Table 3.2: Mounting height of iron core motors.

The mounting height of an iron core motor can be increased to overcome tolerance issues in clearance or deviations in parallelism or flatness. Especially for large configurations this can be helpful. When a larger mounting height is taken than prescribed in table 3.2, the continuous force and attraction force will become lower. What percentage of force remains when a mounting height larger than indicated in table 3.2 is taken, is shown in figure 3.4. Using a mounting height smaller than described in this table is not recommended.

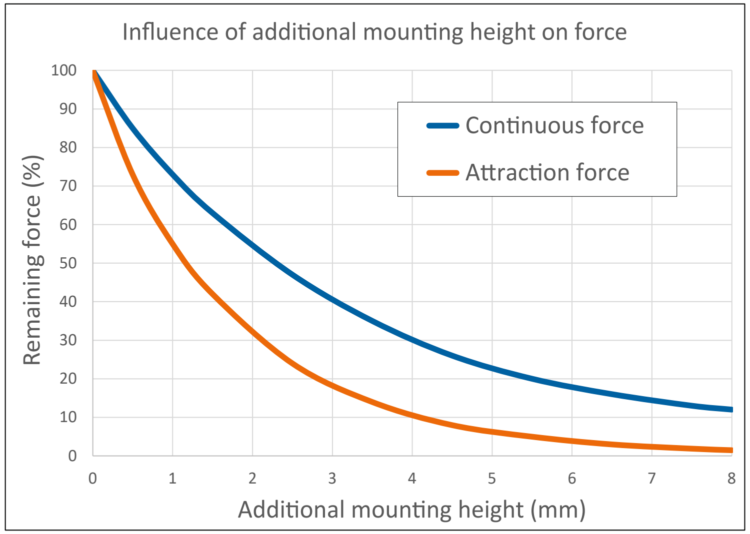

Figure 3.4: Force decrease with increasing mounting height.

3.2 Heat transfer

The limiting factor of the performance of the linear motor is the maximum temperature (100°C) of the coils. In order to reach the highest possible performance, it is crucial to ensure that the heat transfer from the coils to the outside world is as good as it can be. The heat is generated in the copper coils, and transferred to the aluminum housing of the coil unit. The efficiency of the heat transfer from the coil unit to the slide is determined by the contact surface area, the thermal conductivity of the slide material and temperature difference between the slide and the coil unit. When the slide is relatively small, also the heat transfer coefficient of the cooling fluid plays a major role. The following criteria can best be met in order to reach the highest motor performance:

- keep the slide cool using water cooling;
- use aluminum as slide material when there is no active cooling present;
- make sure that the top of the coil unit is completely mounted to the slide.

The TL and TBW series coil units have integrated cooling channels. When these channels are being used the heat transfer from coil unit to the slide is very small because the majority of the heat will leave the motor with the water. The coil units also function without use of the cooling channels, in that case please follow the criteria listed above.

4. INSTALLATION

The installation order of this instruction manual must be followed. A different order may cause dangerous situations and damage due to uncontrolled magnetic attraction forces.

The magnet plates show large attraction forces on all soft magnetic objects such as iron. These forces cannot be controlled by hand. They may cause serious jamming danger. Do not bring any soft magnetic objects like iron nearer than 25 centimeter of the magnetic side of the magnet plate. Be sure that the magnet plates are fixed into your machine before removing the magnetic field protection plates. Put the protection plates on the magnet plates again before dismounting them.

Magnetic sensitive objects like payment cards, pacemakers or other magnetic information carriers may be damaged if they are brought within 1 meter of the magnet plates.

The magnet plate and coil unit can be damaged when cleaned with a non-prescribed cleaning agent. Use only isopropanol as a cleaning agent.

4.1 Cleaning

For general, non-cleanroom applications, the magnet plates and coil units do not need to be cleaned intensively before installation and commissioning. For cleaning purposes Tecnotion prescribes isopropanol as cleaning agent for magnet plates. Isopropanol can also be used for coil units, but only occasionally.

4.2 Installation

!

Before starting the installation, check the presence of the right number and type of the delivered components. In case of doubt, please contact Tecnotion immediately.

Before installing the linear motor components, the installation of the mounting frame should be completed. The rails should be properly positioned and mounted on the frame, as well as the ruler. The slide should be provided with bearings, dampers, linear probe and required cabling in such a way that a smooth, save and well positioned transport of the slide over the stroke is established. The ruler should be properly positioned and fixed to the frame. The operation of bearings and dampers should be tested as well as the guidance of the moving cables. The correct installation order for electrical safety reasons is as follows.

First, mount the coil unit to the slide. Then move the slide to the end of the track and mount the magnet plates on the exposed part of the track. After this, the slide can be moved back over the mounted plates after which the remaining plates can be mounted. Finally, the optional stainless steel cover and water cooling can be installed and the wiring can be connected. In the next paragraphs these steps are shown in more detail. Before mounting the linear motor and the magnet plates, special attention must be paid to the mounting surface of the motor, this is described in the next paragraph 4.2.1.

4.2.1 Requirements for the mounting surface

For the slide and the mounting frame, we recommend flatness and parallelism according to figure 4.1. When these values cannot be met, it is necessary to increase the mounting height (H). The nominal mounting height can be seen in table 3.2.

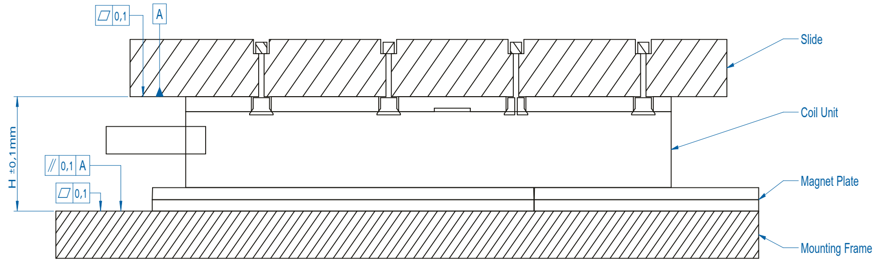

Figure 4.1: Flatness and parallelism requirements for slide and mounting frame.

Do not construct the the coil unit symmetrically over the magnet track. This is due to the fact that the copper windings are not situated in the middle of the coil unit. Please construct according to the specified dimension in drawing 0 in appendix A. When the coil unit alignment over the magnet track is different than in this drawing from appendix A, you will experience force loss of the linear motor.

The dowel pin holes of the coil unit will exactly line up over the length axis of the magnet plate when properly constructed, see figure 4.2.

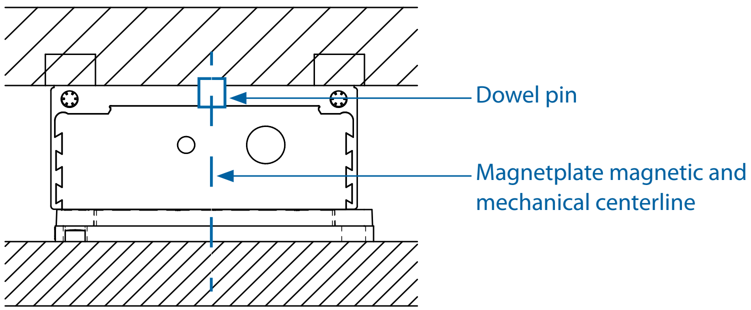

Figure 4.2: Non-symmetrical positioning of the coil unit over the magnet track.

4.2.2 Coil unit mounting

Applying bolts that are too long for the coil unit may inconspicuously cause damage and dangerous situations. Please check the bolt length before and after mounting.

Only use the specified type of flat head fasteners with the correct length. The coil and magnet plate can be damaged by head bolts.

Before mounting the coil unit to the slide, please verify if the mounting height from table 3.2 and the flatness and parallelism from figure 4.1 are met. The bolts and dowel pins that should be used are listed in table 4.1. When this is done, the coil unit can be bolted to the slide using all of the bolting holes, as can be seen in figure 4.3. Apply crosswise tightening of the bolts in order to obtain an equal distribution of the fixing force.

Features	TM	TL	TB(W)
Bolts	M4, DIN912	M5, DIN912	
Depth bolt in thread hole	4-5 mm		4.5-6 mm
Tightening torque	2.0-3.0 Nm	3.0-5.0 Nm	
Dowel pins (optional)	5h8 M3		

Table 4.1: Bolt and dowel pin characteristics for coil units.

Use dowel pins with M3 internal thread to facilitate dismantlement afterwards.

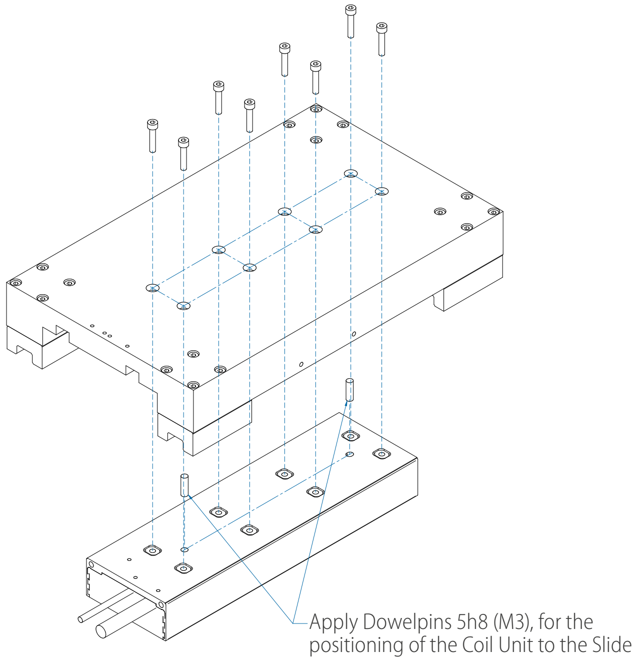

Figure 4.3: Mount the coil unit to the slide.

4.2.3 Magnet plate mounting

Make sure the dowel pins do not extend further than the specified height. The magnet plate can be damaged by dowel pins that are too long.

The magnet plates must be handled with care. They are sensitive to mechanical shocks. Never drop a magnet plate or release it in an uncontrolled way!

The magnet plates show large attraction forces on all soft magnetic objects such as iron. These forces cannot be controlled by hand. They may cause serious jamming danger. Do not bring any soft magnetic objects like iron nearer than 25 centimeter of the magnetic side of the magnet plate. Be sure that the magnet plates are fixed into your machine before removing the magnetic field protection plates. Put the protection plates on the magnet plates again before dismounting them.

Magnetic sensitive objects like payment cards, pacemakers or other magnetic information carriers may be damaged if they are brought within 1 meter of the magnet plates.

The magnet plates attract each other while mounting. This may cause serious jamming danger. Take care that one magnet plate doesn't damage the magnets of the neighboring magnet plate while mounting.

For a short stroke application, the magnet plates can be butted directly together. For a magnet track length of over 2 meter or when the analog Hall module is being used it is recommended to use the dowel pins. The location of the mounting holes and dowel pins can be seen in figure 4.4, and appendix A.

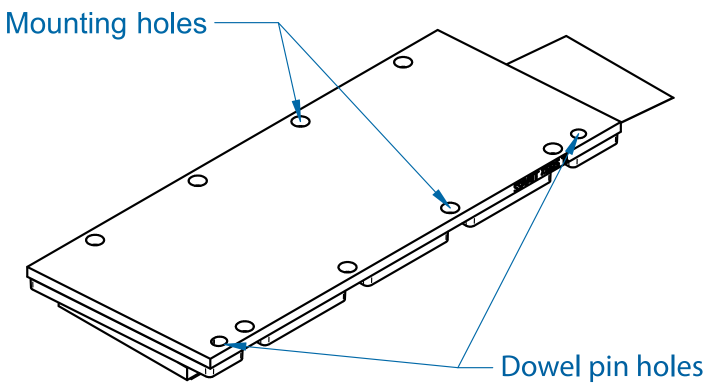

Figure 4.4: Location of the mounting holes and dowel pin holes.

The magnet plates have a magnetic north pole and a south pole. Therefore, two adjacent plates need to be placed correctly. This can be verified using the reference marker, they should all be aligned at the same side. The reference marker is the location in the epoxy which is somewhat lower, see figure 4.5. Also, adjacent magnet plates, regardless of type or series, should always attract and not repel each other.

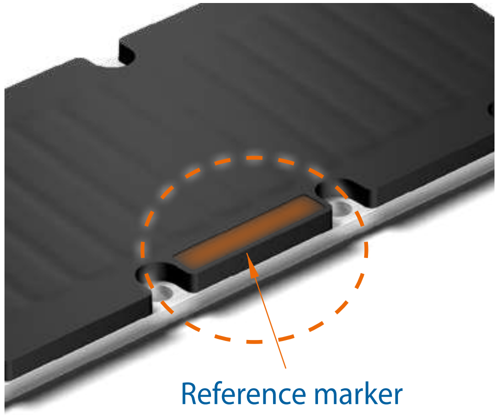

Figure 4.5: Location of the reference marker.

Features	TM, TL	TB
Bolts	M5, DIN7984	M5, DIN912
Depth bolt in thread hole	min. 6.5 mm	
Tightening torque	2.0-3.5 Nm	
Dowel pins (optional)	5h8 M3	

Table 4.2: Bolt and dowel pin characteristics for magnet plates.

The bolts and dowel pins that should be used are listed in table 4.2. For mounting the magnet plates the following steps should be followed:

1. Move the slide to the end of the stroke (1). The first magnet plate will be mounted against the other end of the stroke with the protection plate still on top of the magnet plate (2). Secure the slide against unwanted movements. Make sure the mounting surface is free of dust and small particles. See figure 4.6.

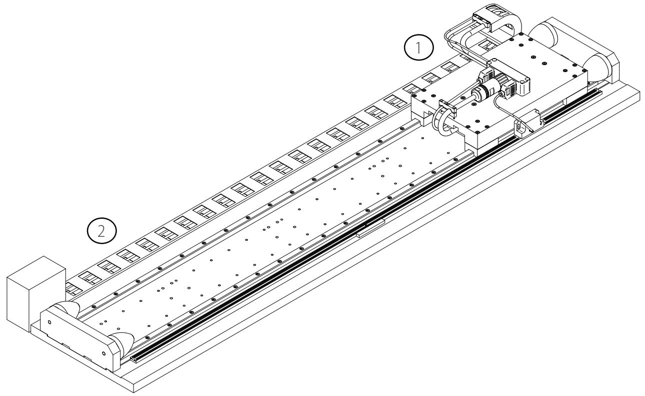

Figure 4.6: Move slide to the end of the stroke.

2. Apply the dowel pins in the mounting frame, see figure 4.7 for the correct position. The total height of the dowel pins above the mounting surface should be maximum 3 mm.

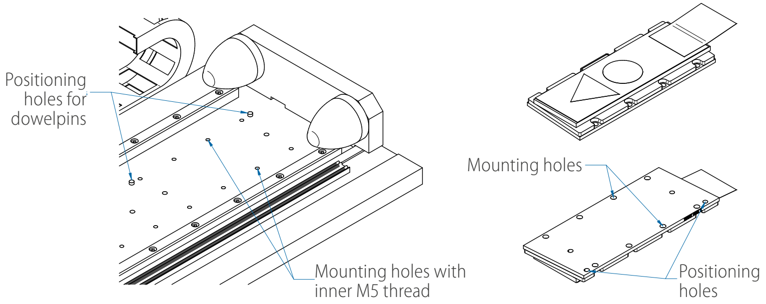

Figure 4.7: Positioning and mounting holes in magnet plates and axis.

Use dowel pins with M3 internal thread to facilitate dismantlement afterwards.

3. Take care that the magnet plate is oriented correctly and fix the magnet plate to the mounting frame using all mounting holes. See figure 4.8.

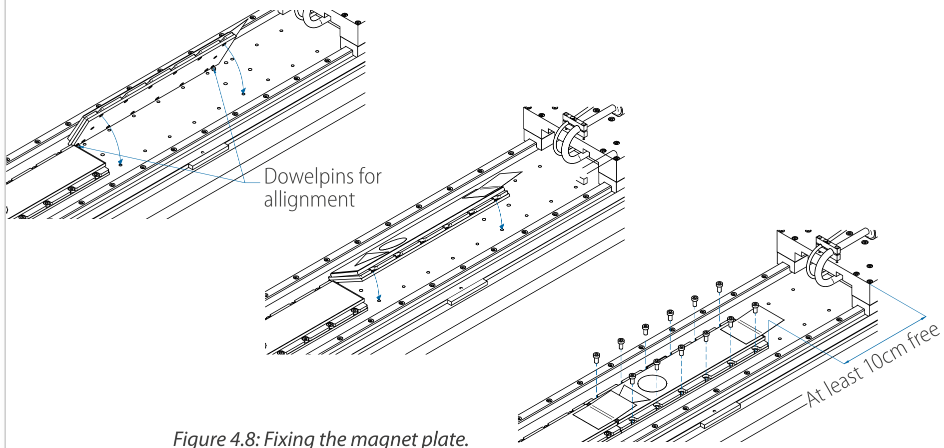

Figure 4.8: Fixing the magnet plate.

4. Remove the protection plate from the mounted magnet plate and move the slide to the other end of the stroke. Secure the slide against unwanted movements. See figure 4.9.

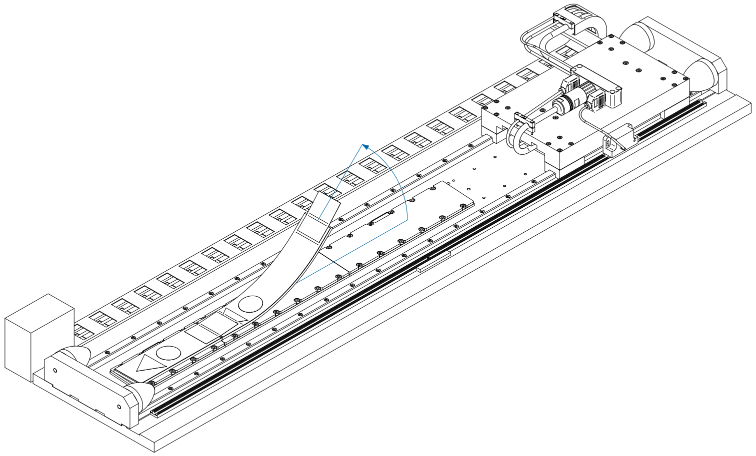

Figure 4.9: Removal of the protection plate.

The slide can be secured against unwanted movement by repositioning a protection plate in front of the slide. See figure 4.10.

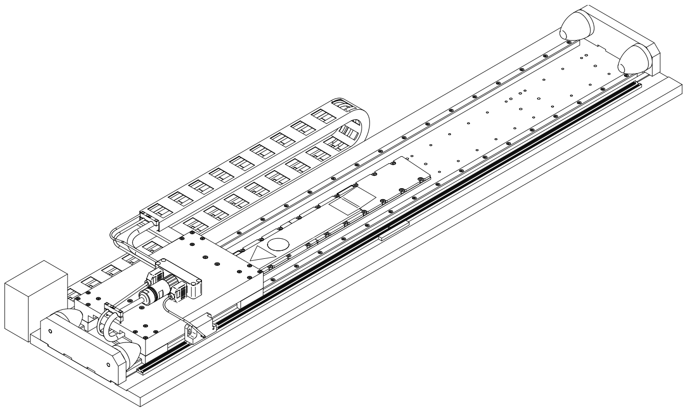

Figure 4.10: Securing the slide.

5. The other magnet plates can be mounted as well, by repeating steps 2 to 4. See figure 4.11.

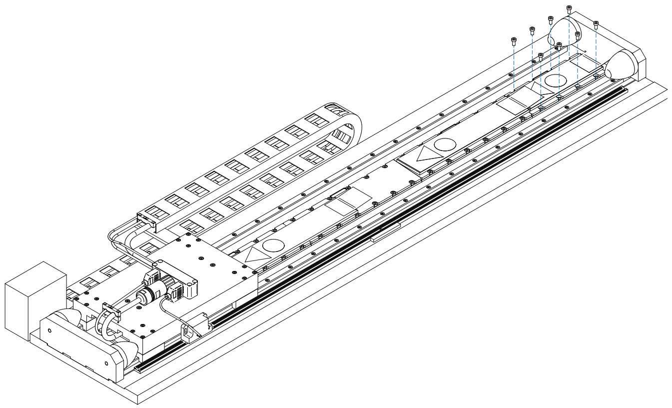

Figure 4.11: Mounting the remaining plates.

6. Finally, remove all protection plates and check whether the slide can move freely and smoothly over the magnet plates. When there is a strong force ripple at the edges of the magnet plates, please check the orientation of the plates.

If the stainless steel cover is used, it can now be mounted and grounded. Then the optional water cooling can be installed according to paragraph 4.2.4, and after this the wiring should be configured according to paragraph 4.3.

> When the setup consists of only one magnet plate or when the stroke is very short, the described steps might not be possible. In this case it is recommended to design the slide in such a way that it can move further than the stroke in order to be able to mount the magnet plates.

4.2.4 Water cooling installation

The TL and TBW series come equipped with integrated water cooling channels. These can be used when water cooling is required to attain a higher continuous force. The TL series coil units come equipped with two channels that run completely through the coil unit, see figure 4.12.

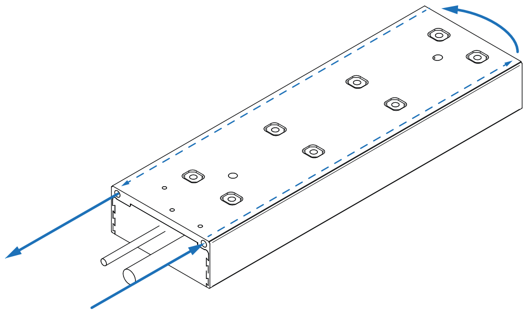

Figure 4.12: Water cooling channels in a TL series motor.

The cooling channels can be installed in parallel or in series. When it is done in series the circuit needs to be closed by means of a tube. When the installation is done in parallel, then the pressure drop of the water can be decreased. For the TL series the nipples will extend above the top mounting surface of the coil unit, see figure 4.13. The slide needs to accommodate space for this.

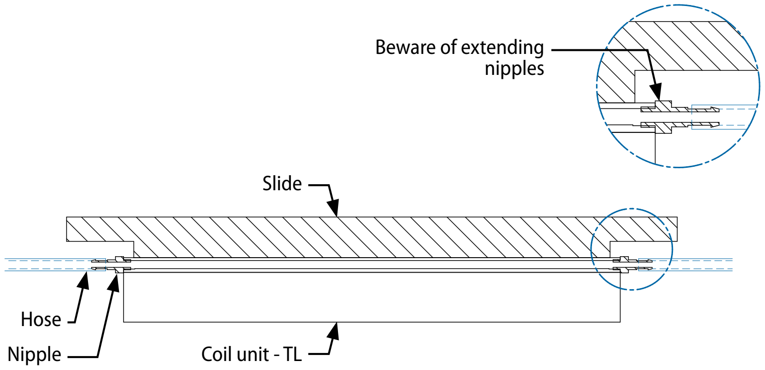

Figure 4.13: Nipples of TL series coil units extending above the mounting surface.

The water cooling channels for the TBW series form a closed loop within the coil unit, as can be seen in figure 4.14. The entrance and the exit are located on one side of the coil unit.

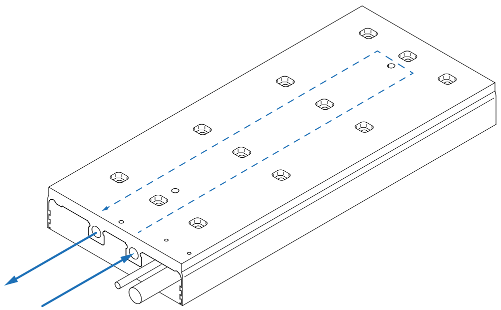

Figure 4.14: Water cooling channels in a TBW series motor.

For connecting the water cooling channels to the coil unit the following parts are necessary:

- hoses;
- hose connections (nipple or fitting);
- sealings or sealant.

Recommended hose connections characteristics can be found in table 4.3.

Specifications	TL series	TBW series
Thread holes	4x M5	2x G 1/8” NPT
Recommended nipple/fitting	QSM-M5-6	Push-in fitting; Festo QS-1/8-8-I
Sealings	M5 rubber sealings and Loctite 638/648 glue	Teflon tape
Tightening torque	0.2-0.3 Nm	4.0 Nm

Table 4.3: Recommended hose connections.

Recommended hose characteristics can be found in table 4.4. Other hoses can also be applied, but the outer diameter should properly fit on the nipple or fitting.

Specifications	TL series	TBW series
Hose diameter	4 mm inner diameter	8 mm outer diameter
Minimum flow diameter	2.5 mm	5 mm
Hose example	Festo PU-4 or Rehau RAUCLAIR-E 4/1	Festo PUN-H-8x1,25

Table 4.4: Recommended hose characteristics.

For installing the water cooling of the TL series, the following steps should be performed:

1. Degrease the connections and thread holes. Before continuing make sure that the degreasing agent has vaporized completely.
2. Place the plastic sealing ring on the connection.
3. Put one drop of Loctite 638/648 glue on the thread and distribute it.
4. Mount the connection and turn until the sealing ring is deformed visibly. This only requires around 0.2 to 0.3 Nm of torque.
5. Remove any glue surplus.
6. Let the glue harden for 4 hours before applying loads.
7. Let the glue harden for 12 hours before applying pressure
8. Connect the hoses.

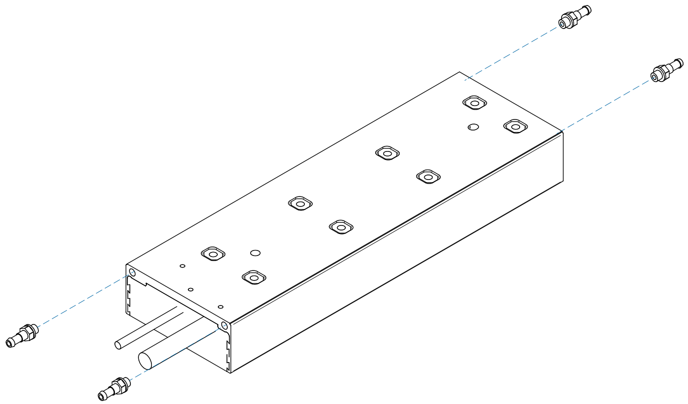

Figure 4.15: Mounting connection to a TL series coil unit.

For installing the water cooling of the TBW series the following steps should be performed:

1. Degrease the connections and thread holes. Before continuing make sure that the degreasing agent has vaporized completely.
2. Use Teflon tape on the thread of the fitting if the thread does not have a standard sealant.
3. Mount the connection and fix the fitting with 4.0 Nm of torque.
4. Connect the hoses.

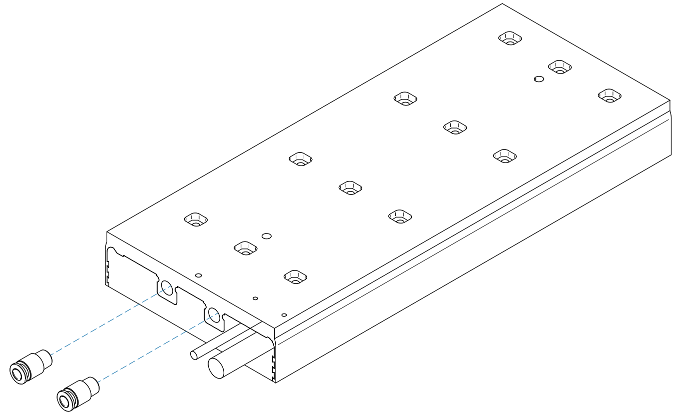

Figure 4.16: Mounting connection to a TBW series coil unit.

The motor housing and cooling channels are made out of aluminum. Please only use compatible cooling connections and fluids. It is recommended to add an anti-corrosion additive to the water. Recommendations for the fluid flow and pressure drop can be found in table 4.5. The use of other connections with a different diameter than prescribed may cause higher pressure drops than indicated due to smaller water throughput. With the given values you will experience a water temperature difference between the outlet and inlet of around 3°C. The values for the TL series assume installation in series.

	TL6	TL9	TL12	TL15	TL18	TL24	TL48
Minimum flow (l/min)	0.7	1.1	1.4	1.8	2.2	2.9	5.7
Pressure drop (bar)	1	1	2	2	2	3	7

	TBW18	TBW30	TBW45
Minimum flow (l/min)	3.1	5.2	7.8
Pressure drop (bar)	1	1.5	2.5

Table 4.5: Water cooling properties.

4.3 Electrical connections

Before starting any activity on the wiring, make sure that the mains are disconnected. Work carefully according the instructions belonging to the applied servo controller. Be sure your machine as a whole meets the requirements of all applicable electrical standards, such as the EN 60204 standard.

With the mechanical installation performed, now the electrical connections can be installed. This is shown in the following paragraphs.

4.3.1 General remarks

The electrical wiring of the linear motor is externally configured with a power cable and a temperature sensor cable. The cable with the largest diameter is the power cable. Both cables are shielded with a braided metal cable shield. The TM series coil units have a 3 meter long flex power cable, which is suitable for a cable chain, and a 1 meter long non-flex sensor cable. All other series have 2 non-flex cables of 1 meter length. If desired you can shorten the cables and provide appropriate connectors. More details on the cable configuration can be found in appendix C. The wiring scheme of all iron core coil units can be seen in figure 4.17.

!

Only the TM series power cable is a flex cable and can be used in a cable chain. Other cables should not be used in a cable chain. It is possible to connect the motor cable to your own cable and use that one in the cable chain, as long as that cable is suitable for cable chains.

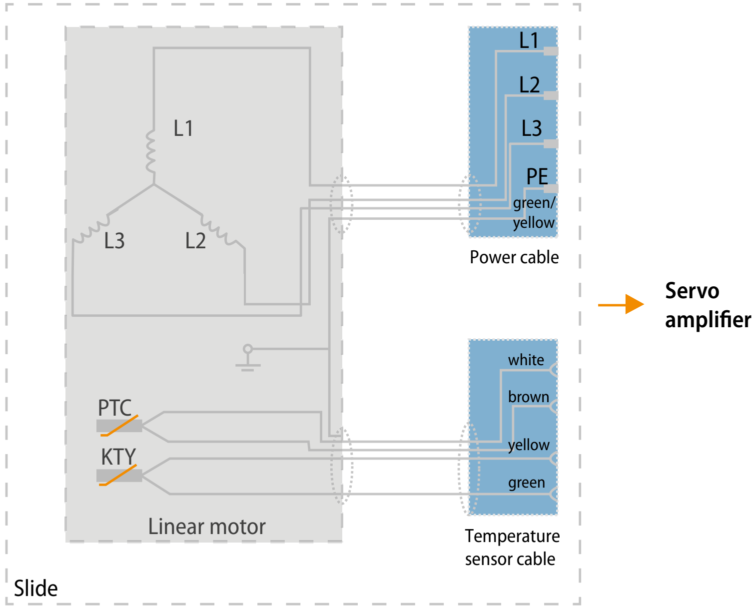

Figure 4.17: Wiring scheme of the power cable and sensor cable.

4.3.2 Power wires

Table 4.6 indicates the function of the power cable. The details of the power cable can be seen in appendix C. The three phases of the cable have to be connected to the servo amplifier in such a way that the positive three phase direction of the motor conforms the positive direction of the linear encoder. This polarization has to be tested, it cannot be seen at first sight. This procedure is described in paragraph 4.3.9.

Power cable		Color code	Connection to servo controller
3 phases	L1	Black '1'	3 phases
	L2	Black '2'	
	L3	Black '3'	
Protective earth		Green/yellow	Protective earth
Shield			Protective earth

Table 4.6: Power wires identification.

4.3.3 Voltage spikes

When a Tecnotion motor is used in an application it might be necessary to either use a connector or a longer cable provided by the customer itself. Adding extra length to the cable can create some challenges with regards to voltage spikes. This text is not intended to be used as an all-encompassing guide. For example, effects of electrical oscillations of the LC network have not been considered. It is the responsibility of the customer to ensure all relevant subjects regarding the application design are considered. The main factor that causes the voltage spikes is the mismatch of the impedance of the motor and the cable. Other factors that influence high voltages are

- motor and cable surge impedance;
- motor load;
- cable length;
- amplitude of the inverter pulse;
- rise time of the inverter pulse;
- width of the inverter pulse.

The voltage spike can be high enough to exceed the partial discharge voltage level of the motor. Partial discharges cause progressive damage to the insulation system ultimately leading to the breakdown of the motor. Some options to mitigate the high voltage spikes are:

- using the shortest possible cable length, at all times below the critical length;
- using a sine filter;
- using a multiple step drive.

4.3.4 Protective earth and EMC

Internally the motor's PE wire (green/yellow) is galvanically connected to the motor housing. This wire must be connected to the PE connector of the servo amplifier. Provide the motor system with PE lines to the amplifier that are as short as possible. Also provide the magnet track with an effective PE connection. Most linear motors are driven on the principle of pulse width modulation. This involves large electrical impulses and causes a significant risk of electromagnetic interference (EMI).

Ensuring electromagnetic compatibility (EMC) is highly dependent on the specific application the motors are used in. Our products are used in a wide range of different application types. Therefore, it is very difficult, if not impossible, to provide information regarding EMC that is applicable to all applications. However, it can be said that the main source of electromagnetic interference is the drive that is used. Especially when the motors are powered by a pulse width modulation (PWM) signal. It is always recommended to keep the current loops as small as possible. It is the responsibility of the customer to ensure all relevant subjects regarding the application design are considered.

4.3.5 Temperature sensor wires

The coil units have two temperature sensors, one PTC and one KTY sensor. Table 4.7 indicates the function of the four sensor wires. The details of the sensor wires can be seen in appendix C. The temperature sensor can be cut off if the temperature sensors are not being used.

Sensor cable	Color	Connection to servo controller
PTC	Brown	PTC
PTC	White	PTC
KTY	Green	KTY
KTY	Yellow	KTY
Shield		Protective earth

Table 4.7: Sensor wires identification.

4.3.6 Temperature protection

The temperature sensors are normally used for overheating protection of the coil unit. The KTY sensor can be used for monitoring temperature, the PTC can be used as cut-off sensor when the maximum temperature is exceeded. The two temperature sensors are located between two coils. The exact location of the sensors can be found in appendix D.

In cases where long peak currents are demanded, the thermal response time of the coil unit is too long to ensure a proper overheating protection by the sensors. These long peak current conditions can occur for example during an accidental run or by taking a new axis in control. In this case I^2t-protection is essential to prevent the coil unit from overheating. In almost all controllers an I^2t-protection can be set in the software.

Tecnotion motors are three-phase motors, but there is only one PTC. In some cases, for example when the coil units are stationary but still powered, you will find different temperatures in every of the three phases. In this case the PTC might not detect the overheating!

4.3.7 PTC specification

The PTC-1k type sensor is a device which has a very sudden resistance rise near the critical temperature of the coils. Therefore, it is very useful for signalizing over temperature without requiring sensitive electronics. At room temperature the PTC has an electrical resistance of less than 100 ohm. When the temperature rises to the maximum coil temperature of 100°C, the resistance will increase rather uniformly up to 1000 ohm. Above this temperature the resistance increases exponentially. 1000 ohm should be the switching resistance that is used. The amplifier should immediately stop the power supply when this resistance is exceeded. In this way overheating and motor damage can be prevented. In table 4.8 and figure 4.18 the temperature dependence of the PTC sensor used in the coil units can be seen.

Temperature	Resistance
Up to 20°C below critical temperature of 110°C	<250 Ω
Up to 5°C below critical temperature of 110°C	<550 Ω
Up to 5°C above critical temperature of 110°C	>1330 Ω
Up to 15°C above critical temperature of 110°C	>4000 Ω

Table 4.8: Characteristic PTC values.

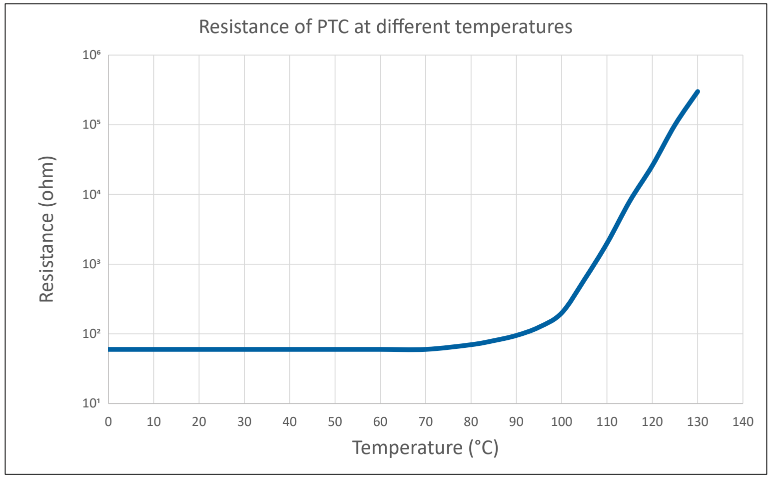

Figure 4.18: Temperature dependence of the PTC-1k sensor.

4.3.8 KTY specification

The coil units have a KTY 83-122 temperature sensor for monitoring the temperature. Because of the well-defined and smooth resistance curve, this sensor type is optimal for monitoring. In table 4.9 and figure 4.19 the temperature dependence of the KTY sensor used in the coil units can be seen.

T (°C)	20	25	30	40	50	60
R (ohm)	972	1010	1049	1130	1214	1301

T (°C)	70	80	90	100	110	120	130
R (ohm)	1392	1487	1585	1687	1792	1900	2012

Table 4.9: Temperature dependence of the KTY 83-122 sensor.

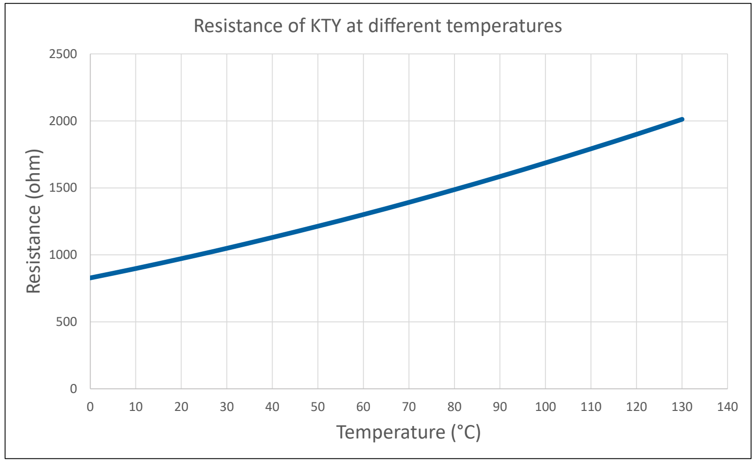

Figure 4.19: Temperature dependence of the KTY 83-122 sensor.

The KTY sensor requires sensitive and accurate electronics to obtain a reliable reading. The sensor can be configured to the wiring scheme in figure 4.20 if a linear voltage signal is required.

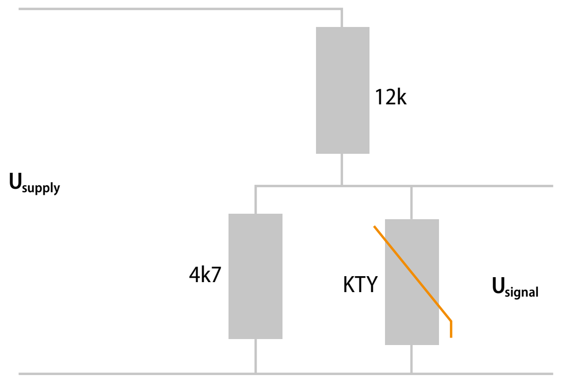

Figure 4.20: Wiring scheme for obtaining a linear voltage signal from the KTY 83-122 sensor.

4.3.9 Polarization test

Testing the polarization is very important, a wrong polarization will result in an uncontrolled run out of the slide.

Before testing, make sure that the electrical and mechanical protection of the linear motor system is well configured!

Make sure that there is an effective protective earth. Also make sure that there is no voltage at the wire terminals before connecting.

There is one regular way of testing the polarization. Some servo amplifiers can operate in an in-moment service mode. By means of regulating an external resolver manually, it can be determined whether the motor's direction of running conforms the resolver's sense of rotation, if so, the motor is well connected. If not, two phases of the power cable – phase 1 and 3 – must be changed.

Internally all iron core linear motors are equally wired and connected, so one test satisfies to find out the polarization of a motor ruler combination. If more axes are constructed in exactly the same way the polarization will be equal.

4.4 De-installation order

The de-installation order of this manual must be followed. A different order may cause dangerous situations and damage or injury due to uncontrolled magnetic attraction forces.

The de-installation order is as follows:

1. Disconnect the wiring (and hoses when water cooling is applied) from the coil unit.
2. Move the slide to one side. Secure the slide against unwanted movements.
3. Dismount the earth connection of the magnet plate (and the stainless steel cover when applied).
4. Adhere the protection plate to each magnet plate that needs to be removed.
5. Remove one or more magnet plates. Keep the magnet plates at least 10 cm away from the coil unit.
6. Move the slide to the other end. Secure the slide against unwanted movements.
7. Remove remaining magnet plates.
8. Remove the coil unit from the slide.

5. ADDITIONAL INSTALLATIONS

Iron core motors from Tecnotion can be equipped with an analog Hall module for positioning or with a digital Hall module for commutation. Both these modules use the magnet track as a linear scale. A separate scale is not required in this case. All information regarding these modules can be found in paragraphs 5.1 and 5.2. Information regarding the stainless steel cover that can be used to protect the magnet plate can be found in paragraph 5.3.

5.1 Analog Hall module

The analog Hall module is a device that can determine the coil unit position with respect to the magnet plate. In this function the module can replace a separate optical or magnetic encoder depending on the demanded resolution. When the accuracy of this module is not sufficient for the application it is recommended to use an external encoder. The module will allow for a wake-and-shake free motor start. The module can be used in combination with all iron core motors. The specifications of the analog Hall module can be found in table 5.1, cable information can be found in appendix C. The cable is not suitable for use in a cable chain.

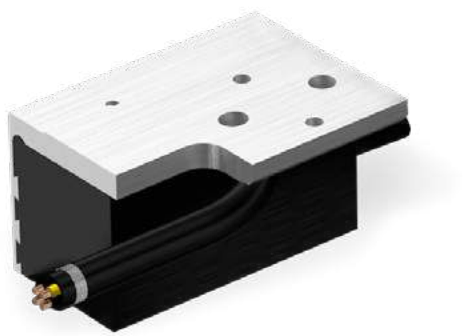

Figure 5.1: Analog Hall module for iron core motors.

For optimal results, the analog signals have to be calibrated on offset and amplitude. This procedure can be performed by most standard servo controllers. When in doubt, please contact your servo supplier.

Parameter	Specifications
Signal	1 volt peak-peak with external 120 ohm terminating resistor
Signal period	24 mm
Repeatability	± 30 µm
Resolution	10 µm
Accuracy	± 100 µm with magnet plate mounting accuracy within ± 20 µm and using offset and amplitude compensation
Power supply	5 volt DC, 100 mA
Mass	80 grams

Table 5.1: Analog Hall module specifications.

5.1.1 Mechanical interface

The module needs to be mounted on the slide in front (on the cable side) of the coil unit. The installation dimensions and requirements of the module can be seen in table 5.2 and figure 5.2. The distance between coil unit and module is arbitrary, you can choose this distance as you want. Furthermore, it is required that the module is aligned with the side of the coil unit within ± 1 mm, and the maximum rotation with respect to the movement axis should be 0.5°. For the installation of the module you require an Allen key set, two bolts with M4 thread and optionally two dowel pins of size ø5 f8. The recommended tightening torque is 0.3-0.4 Nm.

!

For several product combinations, the distance F from figure 5.2 is not equivalent to the coil unit mounting height from table 3.2 in chapter 3. You will need a spacer between the module and slide for proper installation. This spacer is not provided by Tecnotion.

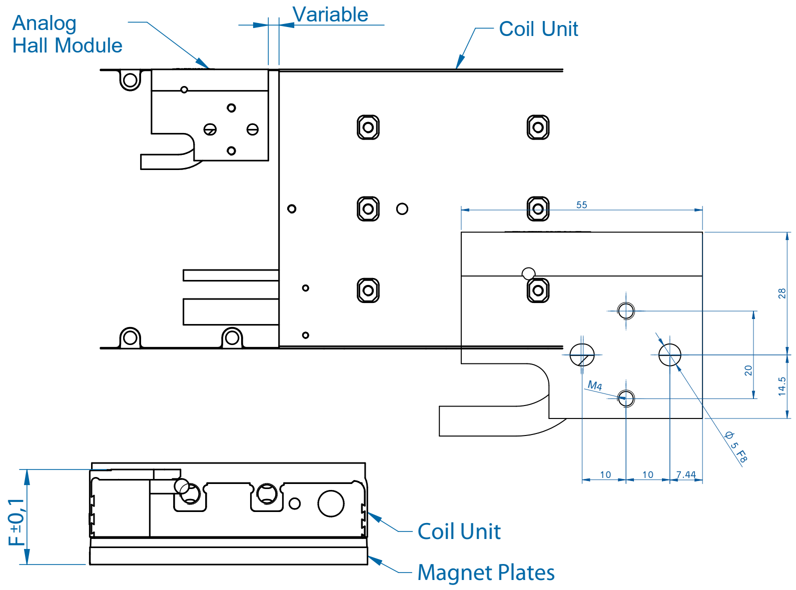

Figure 5.2: Installation dimensions for the analog Hall module.

Series	Distance F (mm)
TM	40.0
TL	40.0
TB	44.0
TBW	44.0

Table 5.2: Analog Hall module installation requirements.

5.1.2 Electrical interface

The cable of the analog Hall module should be connected to the controller according to table 5.3. The pink and grey wires are optional wires, you do not need these. The module itself is delivered without a connector. There is specific tooling required to mount a connector to the cable, please verify with your connector supplier what tooling is required.

Color	Connection
Green	A+ (Cos)
Yellow	A- (Cos)
Blue	B+ (Sin)
Red	B- (Sin)
Brown	+5 volt
White	Ground
Pink	+5 volt (optional)
Grey	Ground (optional)
Shield	Ground (only connected to cable shield)

Table 5.3: Analog Hall module electrical connections.

5.2 Digital Hall module

The digital Hall module is a device that is normally used to perform the commutation, and can replace a wake-and-shake procedure in the drive. If you do not use a controller that allows you to commutate within the servo drive, this module can be a cost effective alternative. The module can be used in combination with all iron core motors. The specifications of the digital Hall module can be found in table 5.4, cable information can be found in appendix C. The cable is not suitable for use in a cable chain.

Figure 5.3: Digital Hall module for iron core motors.

Parameter	Specifications
Signal	TTL, 2mA, 5 volt DC (3 signals)
Signal period	24 mm
Accuracy	4 mm
Power supply	4-28 volt DC, 25 mA
Mass	25 grams

Table 5.4: Digital Hall module specifications.

5.2.1 Mechanical interface

The module needs to be mounted on the slide in front (on the cable side) of the coil unit. The installation dimensions and requirements of the module can be seen in table 5.5 and figure 5.4. Note that for this module the distances D, E and F vary per coil unit type. For the installation of the module you require an Allen key set, two bolts with M3 thread and optionally two dowel pins of size ø5 f8. The recommended tightening torque is 0.2-0.3 Nm.

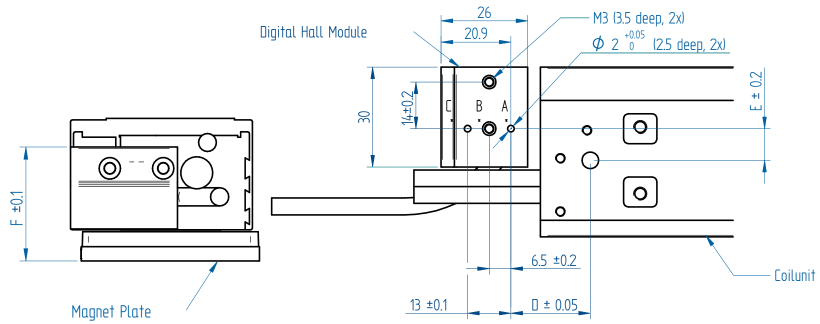

Figure 5.4: Installation dimensions for the digital Hall module.

Coil unit	Distance D (mm)	Distance E (mm)	Distance F (mm)	Hall A signal	Hall B signal	Hall C signal
TM3	23.85	9.5	32.0	S2 inverted	S3 inverted	S1 inverted
TM6	58.85	9.5	32.0	S1	S2	S3
TM12	56.85	9.5	32.0	S1	S2	S3
TM18	73.35	9.5	32.0	S1	S2	S3
TL6	30.80	22.5	32.0	S1	S2	S3
TL9 & TL15	56.80	22.5	32.0	S1	S2	S3
TL12 & TL24	60.80	22.5	32.0	S3 inverted	S1 inverted	S2 inverted
TL18	73.30	22.5	32.0	S1	S2	S3
TL48	66.30	22.5	32.0	S3 inverted	S1 inverted	S2 inverted
TB12	60.85	46.5	36.0	S2	S3	S1
TB15 & TB30	60.80	46.5	36.0	S1	S2	S3
TB18	73.60	46.5	36.0	S1	S2	S3
TB24	60.80	46.5	36.0	S2	S3	S1
TBW18	81.35	46.5	36.0	S2	S3	S1
TBW30 & TBW45	72.85	46.5	36.0	S3	S1	S2

Table 5.5: Digital Hall module installation requirements.

5.2.2 Electrical interface

The cable of the digital Hall module should be connected to the controller according to table 5.6. The module itself is delivered without a connector. There is specific tooling required to mount a connector to the cable, please verify with your connector supplier what tooling is required. Figure 5.5 shows the signals from the digital Hall module over the full magnet pitch of 24 mm.

Color	Connection
Black	Ground
Brown	4-28 volt
Orange	Hall A
Green	Hall B
Yellow	Hall C
Red	Not connected

Table 5.6: Digital Hall module electrical connections.

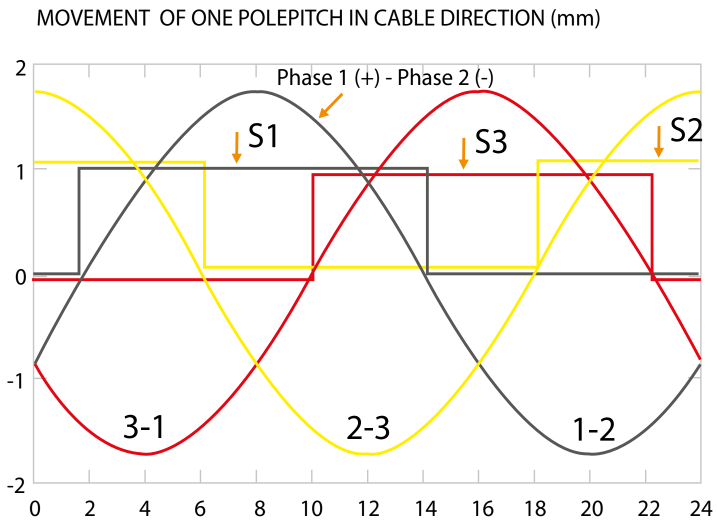

Figure 5.5: Example of a digital Hall signal.

5.3 Stainless steel cover

Be careful! The stainless steel cover could have sharp edges, wear protective gloves while handling the cover.

The magnet track does not provide a physical earth connection to the stainless steel cover. Create an effective protective earth connection according to the machine directives before operation.

The stainless steel cover for the magnet track can be used to avoid contamination of the magnet track by dust particles. For installing this cover, you will need:

- protective gloves for handling the cover;
- cutters for trimming the leftover cover;
- multimeter for checking the protective earth connection.

Because of the high magnetic forces, the cover will adhere firmly to the magnet plates. Placing the cover is easily performed by rolling off the flexible cover. Removing the cover is best performed by rolling it up. These procedures can best be performed by two persons. The following steps are indicating the installation procedure:

1. Move the slide to one end of the stroke to clear the major part of the magnet track (1). Unroll the cover over the cleared magnet track (2), see figure 5.6.

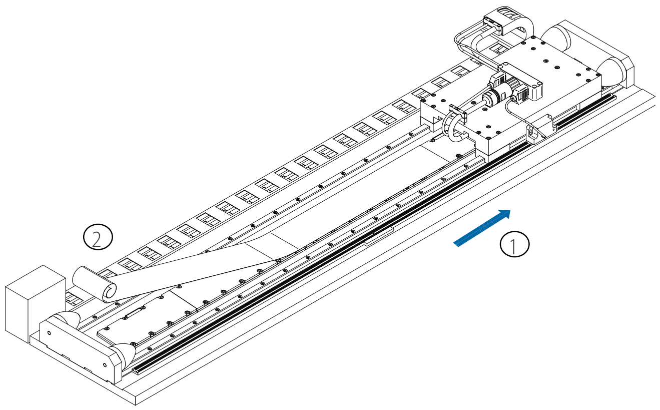

Figure 5.6: Moving the slide and unrolling the cover.

2. Move the slide to the middle of the stroke (3). Now lift up the ends of the cover so that only a small part of the cover underneath the slide sticks to the magnet plate (4), see figure 5.7.

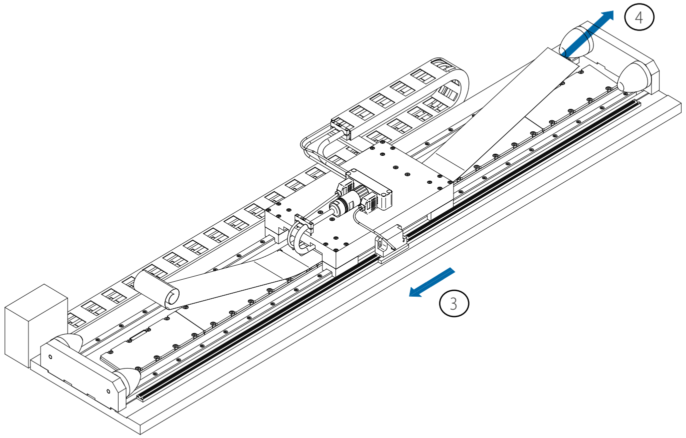

Figure 5.7: Moving the slide and lifting up the cover.

3. The cover can now be slipped over the magnet track. Position the cover so that there is a small overlay at each end of the stroke, see figure 5.8.

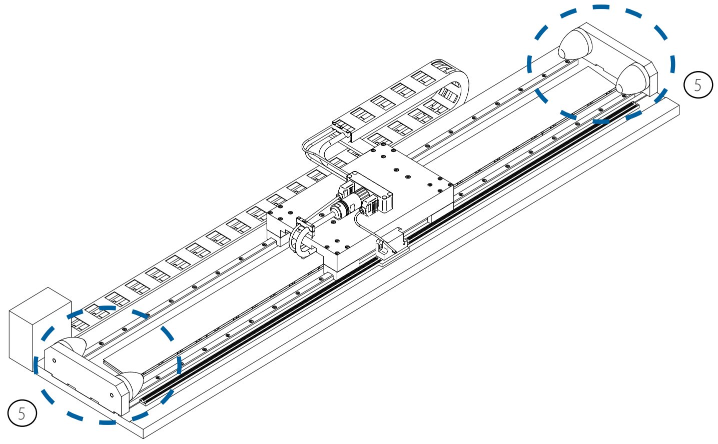

Figure 5.8: Cover in place with small overlay.

4. Cut off the overlay. Note that the magnets are mounted under a slight skewing angle. The cover needs to be cut following this angle for proper alignment with the end of the track. The cover should at the end cover all of the magnet plates.

6. OPERATION

When you are convinced that your application's linear motor system is assembled in a proper way, both mechanically and electrically, you can proceed to the next step. You can put your motor system into operation.

6.1 Pre-commissioning

Before powering the system, please do have a final check. This final check should contain the following actions:

1. Does the slide have a free run over the whole magnet track, without touching small mechanical parts like bolts or contamination?
2. Are the mechanical end stops, end switches and the dampers well dimensioned and properly configured?
3. Does your system have an emergency stop?
4. Is the temperature sensor cable properly connected?
5. Is the power cable properly connected?
6. Does the motor ruler combination have the right polarization?
7. Has the protective earth been connected properly?

6.2 Configuring

After the amplifier is powered up, some input and output signals need to be examined.

1. Check the end switches by pushing the slide manually to the switch position. Simultaneously check whether the signal is detected by the amplifier.
2. Check the presence of the PTC signal.
3. At least the following motor items should be configured as parameter settings of the servo amplifier:

- maximum continuous current;
- ultimate current;
- maximum speed;
- resistance;
- induction;
- switching resistance of PTC;
- presence/absence of an electromechanical motor brake;
- and magnet interval (north-south distance) and/or pole pitch (north-north distance).

> For configuring several types of servo amplifiers Tecnotion can support with completing the parameter files. With these files motor specific settings can be configured. Nevertheless, application specific settings should be configured by yourself.

4. The following settings for the ruler system should be configured as parameters of the servo amplifier:

- type of interface of the ruler system;
- and resolution or period of the linear encoder.

5. The following I/O parameters need to be configured:

- settings of the available digital inputs and outputs (for instance, pay attention to the type of end switches);
- and settings of the available analog inputs and outputs.

6. Finally, the controlling parameters must be configured:

- current control settings, these settings depend on both motor

and amplifier;
- speed control settings;
- and position control settings.

6.3 Testing

Before handing over the control of the linear motor to the closed loop feedback controllers, it is wise to perform some tests. Most important issue for testing are the end switches.

> Before testing, make sure that the electrical and mechanical protection of the linear motor system is well configured!

6.4 Starting up

The first run should start with low speed. If this works fine, the maximum speed can be increased. It is recommended to monitor and log the temperature and current during these tests, because these are the first indicators if the system does not function properly.

6.5 Conditions

The following paragraphs will inform you about storage, transport and operational conditions of the Tecnotion products.

6.5.1 Storage conditions

> The storage area for linear motor components needs to be clearly delimited with a warning sign: "Caution! Powerful magnets".

The maximum stacking height for Tecnotion products is 4 cartons. Furthermore, the following conditions according to IEC 60721-3-1 apply.

- 1K21
  - Applies to an enclosed storage location with limited temperature control and no humidity control.
  - 5 – 40°C.
  - 5 – 85% relative humidity.
  - No condensation.
  -
- 1B1
  - Applies to storage locations with environmental controls in place to prevent the growth of mold and physical control to prevent attack by animals.
- 1C3
  - Applies to locations in the immediate vicinity of industrial sources, with chemical emissions. Salt mist is present in coastal areas.
- 1S12
  - Applies to enclosed storage locations in close proximity to sand or dust sources, including urban area and with no precaution to minimize the ingress of dust or sand. It also applies to exposed storage locations situated in areas not subject to natural dust storms or significant industrial activity.
- 1M11
  - Applies to storage locations experiencing low levels of vibration and shock, such as those transmitted from air conditioning, machines or passing vehicles in the vicinity, et cetera.

6.5.2 Transport conditions

During transport, the Tecnotion packaging should be used. The maximum magnetic field strength is regulated by most airlines and freight carriers. The limits are standardized by the IATA (International Air Transport Association) guidelines. The magnetic field of every Tecnotion package is below the upper limit of 5.25 mG at a distance of 4.6 m. Also stacking of 4 products, which is the maximum stacking height, will not generate a magnetic field larger than that limit. Therefore, no additional measures need to be taken with regards to air freight. For all other means of transportation, no additional measures need to be taken regarding magnetic stray field risks other than those regarding general health and safety.

Tecnotion products have a primary package that sits directly around the product. Tecnotion's primary product package is intended only as product packaging. Its main function is to:

- pack the product and required documentation;
- identify the product type and serial number;
- inform about important safety advice if required;
- inform about important transportation and storage advice;
- safeguard product functionality during transportation and storage.

For transportation the product and primary package will be placed into a secondary package or even a tertiary package (usually an 800 x1200 mm Euro-pallet). The type and size of this package depends on the size of the order to be shipped. Typically, the remaining volume in the packages will be filled with Instapak.

The primary package is intended for storage in a warehouse and efficient packing in a secondary or tertiary package. The primary packaging itself is not suited as a transportation package. The mentioned ambient transportation conditions below are for the primary product packages contained in a secondary cardboard package.

Furthermore, the following conditions according to IEC 60721-3-2 apply.

- 2K11
  - Applies to weather-protected transportation with limited temperature control and no humidity control.
  - 5 – 40°C.
  - 5 – 85% relative humidity.
  - No condensation.
- 2B1
  - Applies to transportation in areas without risks from mold growth and attack by animals, or in compartments with environmental controls in place to prevent mold growth and attack by animals.
- 2C2
  - Applies to transportation and handling in areas with normal levels of contaminants as experienced in urban areas with industrial activity scattered over the whole area, or with heavy traffic. This includes transportation in areas where salt mist is present including maritime transport of containers but not including transport on open decks of ships.
- 2S5
  - Applies to transportation and handling with limited precautions to minimize the presence of dust and sand such as enclosed transport.
- 2M5
  - Applies to handling, transport by rail, river, sea, air (jet aircraft only), road transport using good vehicles on good roads, road transport using poor vehicles on poor roads and handling using trolleys with no suspension. This category includes transport of goods within ISO containers.

6.5.3 Operational conditions

The following operational conditions according to IEC 60721-3-3 apply.

- 3K22
  - Applies to temperature-controlled enclosed locations. Humidity is not controlled. Heating or cooling used to maintain the required conditions, especially where there is a large difference between them and the open-air climate.
  - 5 – 40°C.
  - 5 – 85% relative humidity.
  - No condensation.
- 3B1
  - Applies to locations with environmental controls in place to prevent the growth of mold and physical controls are in place to prevent attack by animals.
- 3S5
  - Applies to locations where precautions have been taken to minimize the presence of dust and sand. Ingress of sand is prevented.
- 3M12
  - Applies to locations experiencing significant levels of vibration and shock, such as those close to heavy machines and conveyor belts.

TECNOTION®
direct drive in motion

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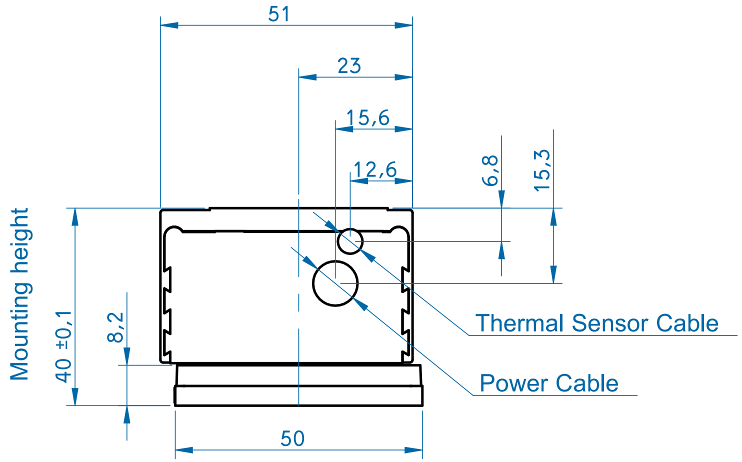
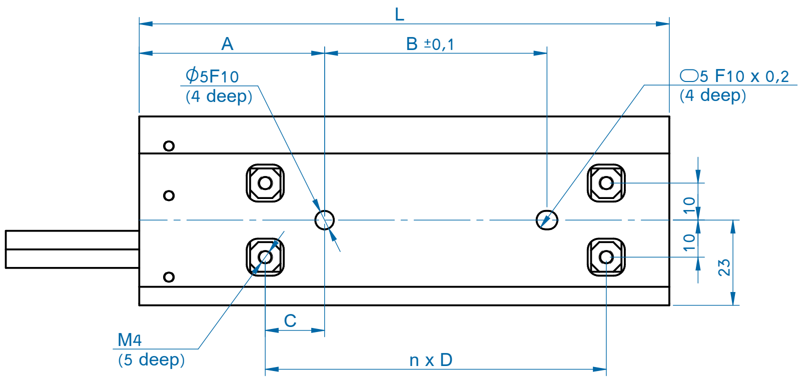
APPENDIX - TABLE OF CONTENTS

TECNOTION® direct drive in motion | APPENDIX A | Dimensions - TM coil

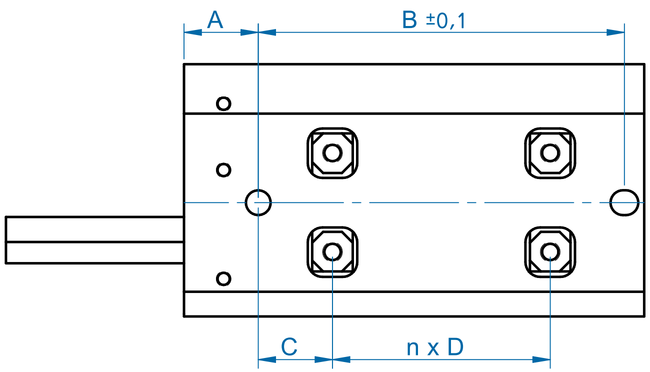
Parameter	Dimension	Unit	TM3	TM6	TM12	TM18
Drawing number			2	1		
Coil unit length	L	mm	93	143	241	336
Coil unit width		mm	51			
Coil unit mounting height		mm	40			
Coil unit mass		kg	0.6	0.9	1.6	2.3
Motor edge to center line		mm	23			
Motor edge to dowel pin	A	mm	15	50	51	68
Dowel pin to slotted dowel pin	B	mm	74	60	160	223
Dowel pin to mounting hole	C	mm	15	16	16	16
Mounting hole to mounting hole	D	mm	44	92	64	85
Number	n		1	1	3	3
Mounting hole to center line		mm	10			
Dowel pin dimensions		mm	Ø5 F10 (4 deep)			
Slotted dowel pin dimensions		mm	5F10 x 0.2 (4 deep)			
Mounting hole dimensions		mm	M4 (5 deep) (4x)		M4 (5 deep) (8x)	



Drawing 0



Drawing 1



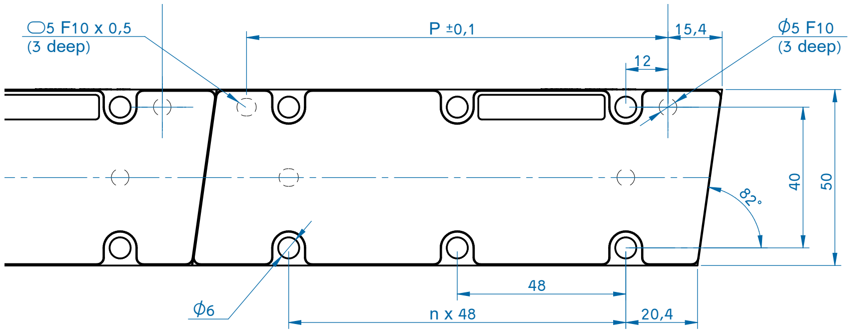
Drawing 2

* All sizes are in mm

TECNOTION® direct drive in motion

APPENDIX A | Dimensions - TM magnet plate

Parameter	Dimension	Unit	TM96	TM144	TM384
Magnet plate length		mm	96	144	384
Magnet plate width		mm	50		
Magnet plate height		mm	8.2		
Magnet plate mass		kg/m	2.2		
Magnet plate edge to center line		mm	25		
Magnet plate edge to dowel pin		mm	15.4		
Dowel pin to slotted dowel pin	P	mm	72	120	360
Dowel pin to dowel pin	M	mm	96	144	384
Dowel pin to mounting hole		mm	12		
Mounting hole to mounting hole		mm	48		
Number	n		1	2	7
Mounting hole to center line		mm	20		
Dowel pin dimensions		mm	Ø5 F10 (3 deep)		
Slotted dowel pin dimensions		mm	5F10 x 0.5 (3 deep)		
Mounting hole dimensions		mm	Ø6 (4x)	Ø6 (6x)	Ø6 (16x)

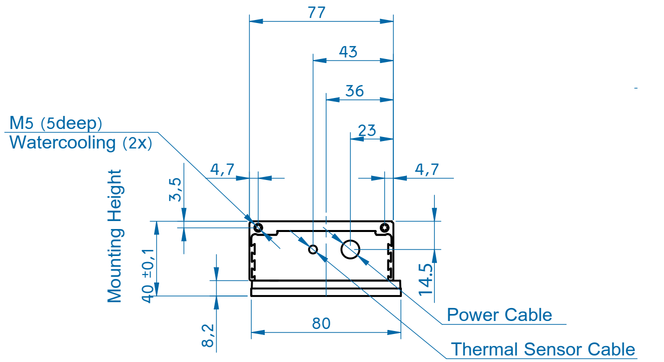


* All sizes are in mm

TECNOTION®
direct drive in motion

APPENDIX A | Dimensions - TL coil

Parameter	Dimension	Unit	TL6	TL9	TL12	TL15	TL18	TL24	TL48
Drawing number			2	1				3	
Coil unit length	L	mm	146	194	244	290	336	468	855
Coil unit width		mm	77						
Coil unit mounting height		mm	40						
Coil unit mass		kg	1.5	2.0	2.6	3.2	3.8	5.2	9.75
Motor edge to center line		mm	36						
Motor edge to dowel pin	A	mm	25	51	54	51	68	54	57
Dowel pin to slotted dowel pin	B	mm	116	112	160	208	223	384	768
Dowel pin to mounting hole	C	mm	12	16	16	16	16	16	16
Mounting hole to mounting hole	D	mm	92	72	64	80	85	64	64
Distance	D2	mm						32	
Number	n		1	2	3	3	3	3 (2x)	6 (2x)
Mounting hole to center line		mm	15						
Dowel pin dimensions		mm	Ø5 F10 (4 deep)						
Slotted dowel pin dimensions		mm	5F10 x 0.6 (4 deep)						
Mounting hole dimensions		mm	M5 (5 deep) 4x	M5 (5 deep) 6x	M5 (5 deep) 8x			M5 (5 deep) 16x	M5 (5 deep) 28x



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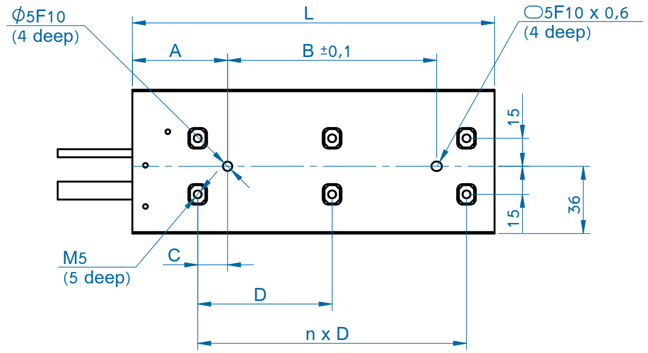
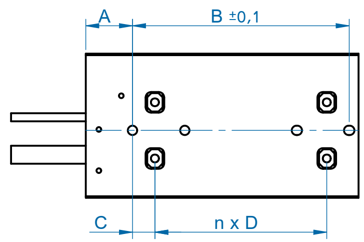
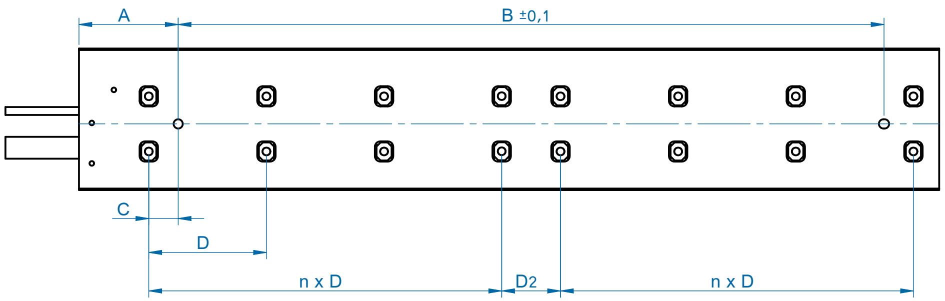


Drawing 1



Drawing 2



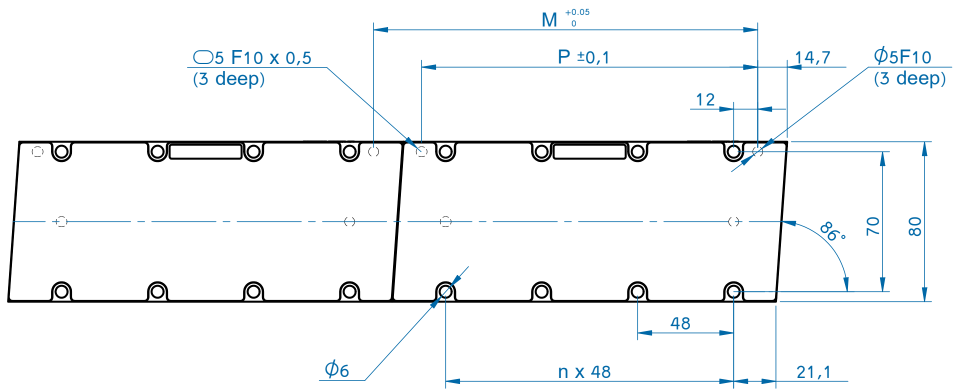
Drawing 3

** All sizes are in mm*

direct drive in motion

APPENDIX A | Dimensions - TL magnet plate

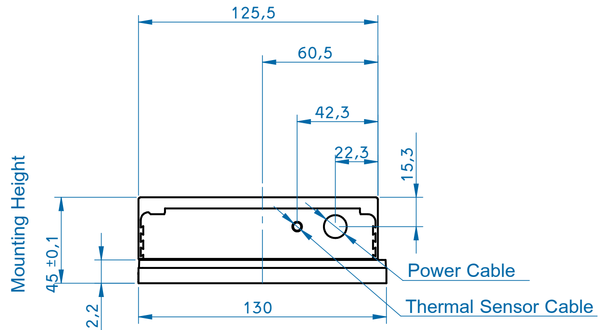
Parameter	Dimension	Unit	TL192	TL288
Magnet plate length		mm	192	288
Magnet plate width		mm	80	
Magnet plate height		mm	8.2	
Magnet plate mass		kg/m	3.8	
Magnet plate edge to center line		mm	40	
Magnet plate edge to dowel pin		mm	14.7	
Dowel pin to slotted dowel pin	P	mm	168	264
Dowel pin to dowel pin	M	mm	192	288
Dowel pin to mounting hole		mm	12	
Mounting hole to mounting hole		mm	48	
Number	n		3	5
Mounting hole to center line		mm	35	
Dowel pin dimensions		mm	Ø5 F10 (3 deep)	
Slotted dowel pin dimensions		mm	5F10 x 0.5 (3 deep)	
Mounting hole dimensions		mm	Ø6 (8x)	Ø6 (12x)



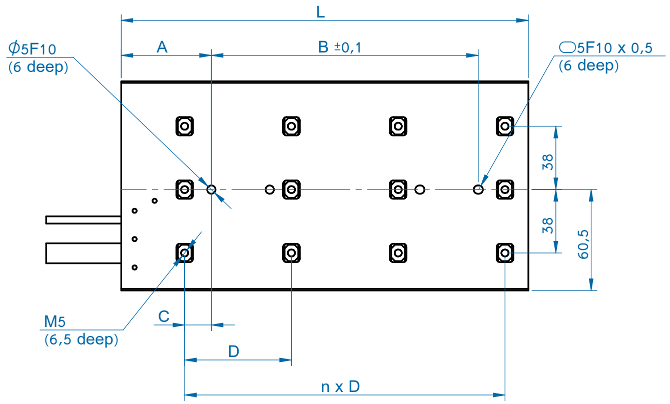
* All sizes are in mm

TECNOTION® direct drive in motion | APPENDIX A | **Dimensions - TB coil**

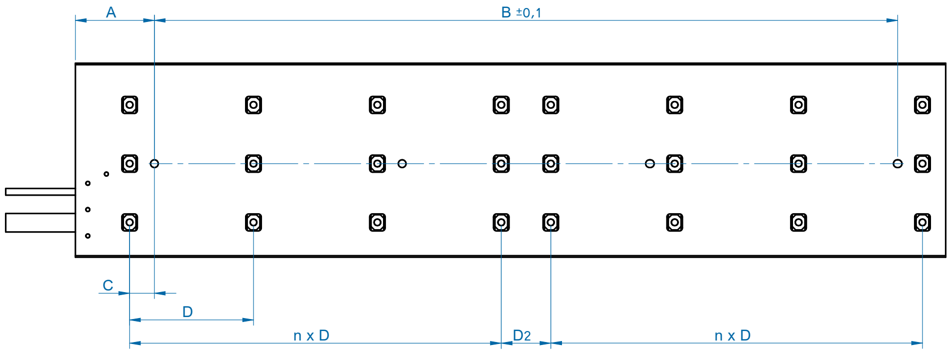
Parameter	Dimension	Unit	TB12	TB15	TB18	TB24	TB30
Drawing number			1				2
Coil unit length	L	mm	244	290	336	434	562
Coil unit width		mm	125.5				
Coil unit mounting height		mm	45				
Coil unit mass		kg	4.9	5.9	6.9	9.4	11.6
Motor edge to center line		mm	60.5				
Motor edge to dowel pin	A	mm	54	51	68	54	51
Dowel pin to slotted dowel pin	B	mm	160	208	223	352	480
Dowel pin to mounting hole	C	mm	16	16	16	16	16
Mounting hole to mounting hole	D	mm	64	80	85	64	80
Distance	D2	mm					32
Number	n		2	3	4	7	3 (2x)
Mounting hole to center line		mm	38				
Dowel pin dimensions		mm	Ø5 F10 (6 deep)				
Slotted dowel pin dimensions		mm	5F10 x 0.5 (6 deep)				
Mounting hole dimensions		mm	M5 (6.5 deep) 12x			M5 (6.5 deep) 21x	M5 (6.5 deep) 24x



Drawing 0



Drawing 1



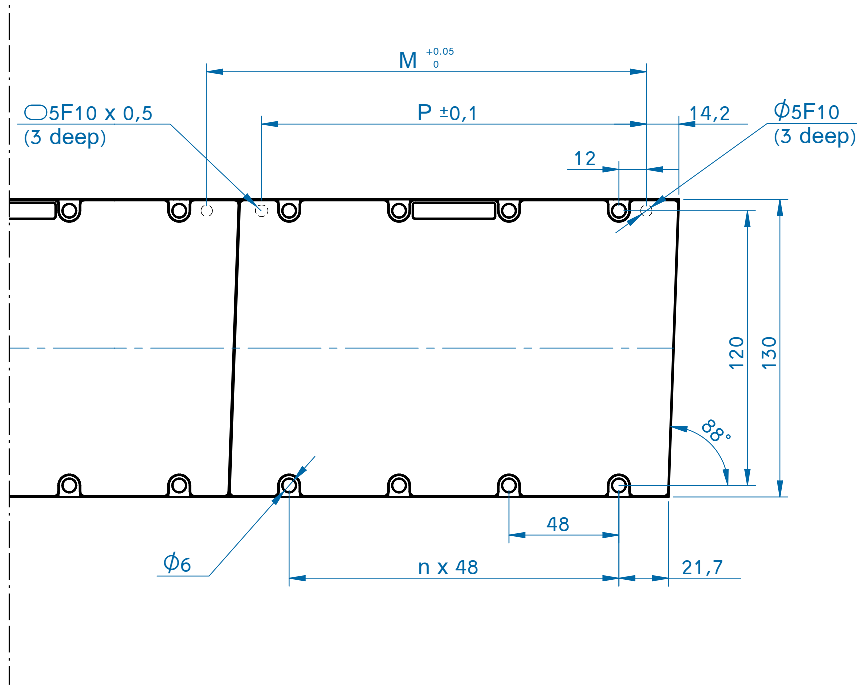
Drawing 2

* All sizes are in mm

TECNOTION® direct drive in motion

APPENDIX A | Dimensions - TB magnet plate

Parameter	Dimension	Unit	TB192	TB288
Magnet plate length		mm	192	288
Magnet plate width		mm	130	
Magnet plate height		mm	12.2	
Magnet plate mass		kg/m	10.5	
Magnet plate edge to center line		mm	65	
Magnet plate edge to dowel pin		mm	14.2	
Dowel pin to slotted dowel pin	P	mm	168	264
Dowel pin to dowel pin	M	mm	192	288
Dowel pin to mounting hole		mm	12	
Mounting hole to mounting hole		mm	48	
Number	n		3	5
Mounting hole to center line		mm	60	
Dowel pin dimensions		mm	Ø5 F10 (3 deep)	
Slotted dowel pin dimensions		mm	5F10 x 0.5 (3 deep)	
Mounting hole dimensions		mm	Ø6 (8x)	Ø6 (12x)

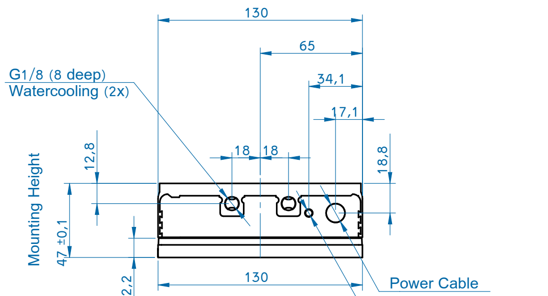


* All sizes are in mm

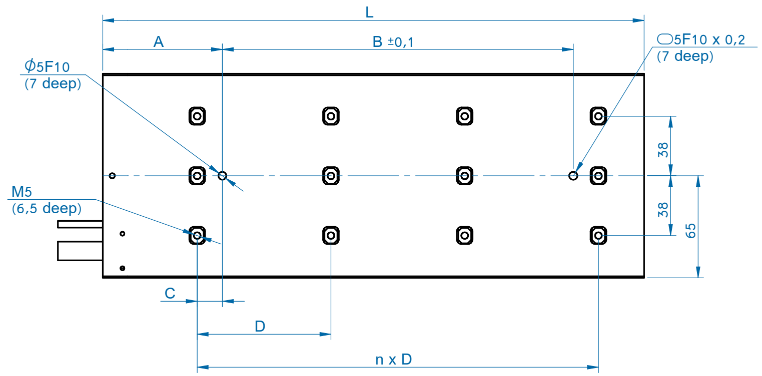
TECNOTION® direct drive in motion | APPENDIX A |

Dimensions - TBW Coil

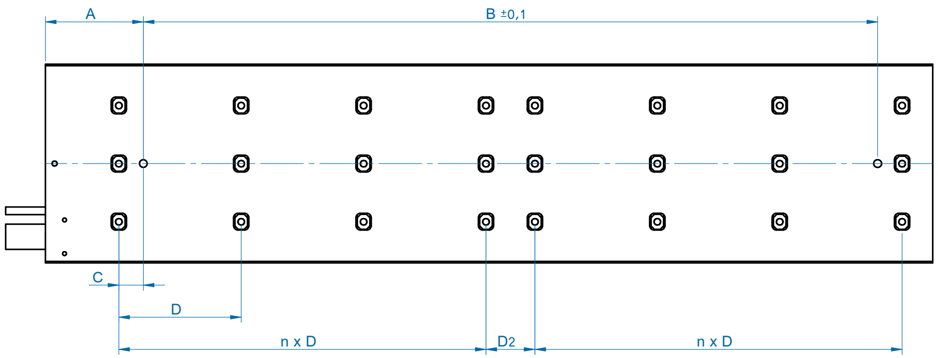
Parameter	Dimension	Unit	TBW18	TBW30	TBW45
Drawing number			1	2	
Coil unit length	L	mm	344	580	852
Coil unit width		mm	130		
Coil unit mounting height		mm	47		
Coil unit mass		kg	7.3	12.3	18.2
Motor edge to center line		mm	65		
Motor edge to dowel pin	A	mm	76	64	64
Dowel pin to slotted dowel pin	B	mm	223	480	752
Dowel pin to mounting hole	C	mm	16	16	16
Mounting hole to mounting hole	D	mm	85	80	80
Distance	D2	mm		32	
Number	n		3	3 (2x)	3 (3x)
Mounting hole to center line		mm	38		
Dowel pin dimensions		mm	Ø5 F10 (7 deep)		
Slotted dowel pin dimensions		mm	5F10 x 0.2 (7 deep)		
Mounting hole dimensions		mm	M5 (6.5 deep) 12x	M5 (6.5 deep) 24x	M5 (6.5 deep) 36x



Drawing 0



Drawing 1

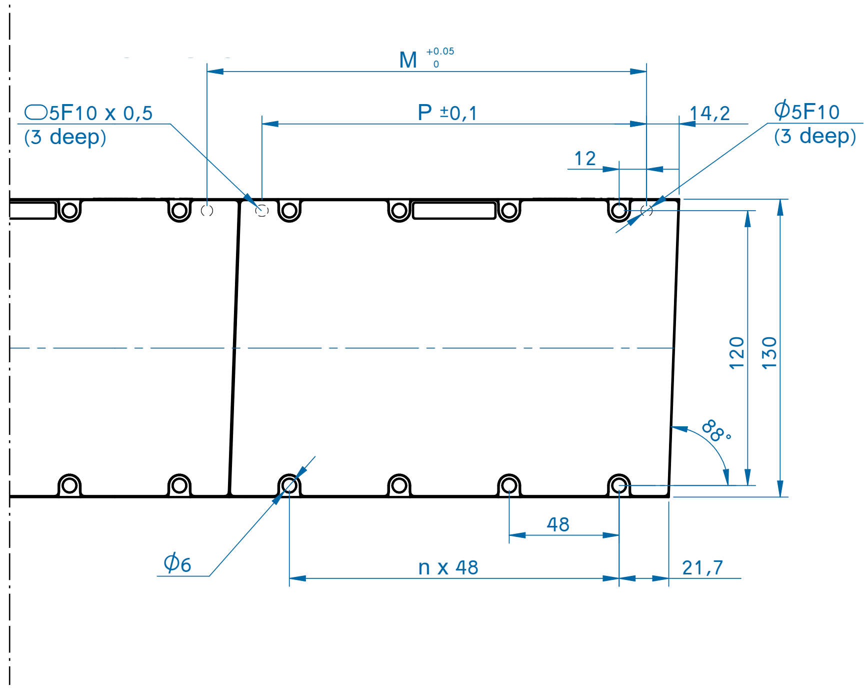


Drawing 2

* All sizes are in mm

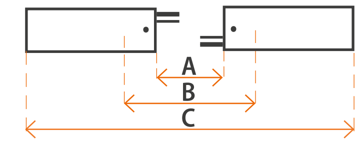
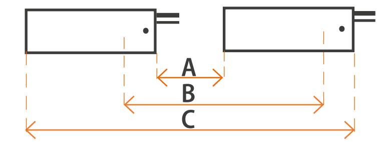
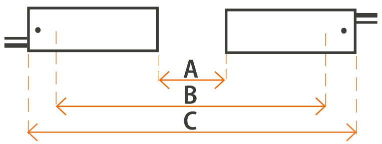
APPENDIX A | Dimensions - TBW magnet plate

Parameter	Dimension	Unit	TB192	TB288
Magnet plate length		mm	192	288
Magnet plate width		mm	130	
Magnet plate height		mm	12.2	
Magnet plate mass		kg/m	10.5	
Magnet plate edge to center line		mm	65	
Magnet plate edge to dowel pin		mm	14.2	
Dowel pin to slotted dowel pin	P	mm	168	264
Dowel pin to dowel pin	M	mm	192	288
Dowel pin to mounting hole		mm	12	
Mounting hole to mounting hole		mm	48	
Number	n		3	5
Mounting hole to center line		mm	60	
Dowel pin dimensions		mm	Ø5 F10 (3 deep)	
Slotted dowel pin dimensions		mm	5F10 x 0.5 (3 deep)	
Mounting hole dimensions		mm	Ø6 (8x)	Ø6 (12x)



** All sizes are in mm*

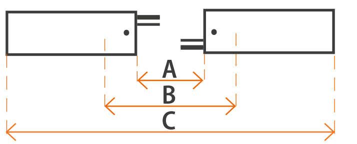
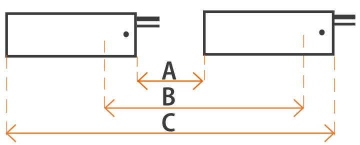
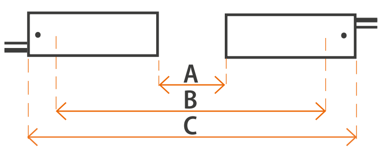
APPENDIX B | Coupling - TM series

Coupling possibilities	Combination	N	S	Z	Distance coil units (A)	Distance dowel pins (B)	Total length coil units (C)	L1	L2	L3
	TM3 + TM6		X	X	36	101	272	L3	L2	L1
	TM3 + TM12		X		49	115	383	L2	L1	L3
	TM3 + TM18		X		48.5	131.5	477.5	L2	L1	L3
	TM12 + TM12		X		42	144	524	L2	L1	L3
	TM12 + TM18		X		41.5	160.5	618.5	L2	L1	L3
	TM18 + TM18	X	X		41	177	713	L2	L1	L3
	TM3 + TM6*		X	X	37	145	273	L3	L1	L2
	TM3 + TM12*		X		38	243	372	L3	L1	L2
	TM3 + TM18*		X		39.5	322.5	468.5	L3	L1	L2
	TM12 + TM12		X		47	288	529	L1	L2	L3
	TM12 + TM18*		X		48.5	367.5	625.5	L1	L2	L3
	TM18 + TM18	X	X		48	384	720	L1	L2	L3
	TM3 + TM6		X	X	16	187	252	L3	L2	L1
	TM3 + TM12		X		1	269	335	L2	L1	L3
	TM3 + TM18		X		2.5	348.5	431.5	L2	L1	L3
	TM12 + TM12		X		4	384	486	L2	L1	L3
	TM12 + TM18		X		5.5	463.5	582.5	L2	L1	L3
	TM18 + TM18	X	X		7	543	679	L2	L1	L3

*In these configurations it is assumed that the first mentioned motor is the left one in the picture. If this is not the case in your application, different distances and connections might apply. Please contact Tecnotion in such a case.

TECNOTION®
direct drive in motion

APPENDIX B | Coupling - TL series

Coupling possibilities	Combination	N	S	Distance coil units (A)	Distance dowel pins (B)	Total length coil units (C)	L1	L2	L3
	TL6 + TL12		X	71	150	461	L3	L2	L1
	TL6 + TL15		X	58	134	494	L1	L3	L2
	TL9 + TL9	X	X	58	160	446	L1	L3	L2
	TL9 + TL12		X	71	176	509	L3	L2	L1
	TL9 + TL24		X	87	192	749	L2	L1	L3
	TL12 + TL15		X	71	176	605	L3	L2	L1
	TL12 + TL18	X		70.5	192.5	650.5	L3	L2	L1
	TL12 + TL24	X		84	192	796	L2	L1	L3
	TL6 + TL12*		X	63	278	453	L2	L3	L1
	TL6 + TL15*		X	62	326	498	L2	L3	L1
	TL9 + TL9	X	X	62	256	450	L2	L3	L1
	TL9 + TL12*		X	63	304	501	L2	L3	L1
	TL9 + TL24*		X	63	528	725	L1	L2	L3
	TL12 + TL15*		X	59	352	593	L2	L3	L1
	TL12 + TL18*	X		61.5	383.5	641.5	L2	L3	L1
	TL12 + TL24*	X		60	528	772	L1	L2	L3
	TL6 + TL12		X	3	314	393	L2	L1	L3
	TL6 + TL15		X	2	362	438	L2	L1	L3
	TL9 + TL9	X	X	2	288	390	L2	L1	L3
	TL9 + TL12		X	3	336	441	L2	L1	L3
	TL9 + TL24		X	3	560	665	L1	L3	L2
	TL12 + TL15		X	3	432	537	L2	L1	L3
	TL12 + TL18	X		5.5	463.5	585.5	L2	L1	L3
	TL12 + TL24	X		4	608	716	L1	L3	L2

*In these configurations it is assumed that the first mentioned motor is the left one in the picture. If this is not the case in your application, different distances and connections might apply. Please contact Tecnotion in such a case.

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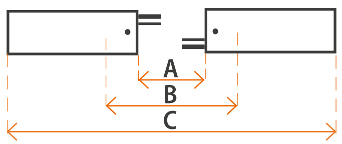
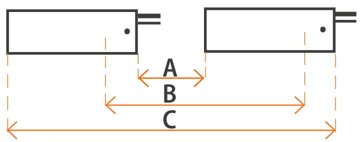
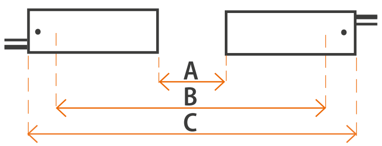
APPENDIX B | Coupling - TL series

Coupling possibilities	Combination	N	S	Q	Distance coil units (A)	Distance dowel pins (B)	Total length coil units (C)	L1	L2	L3
	TL15 + TL15	X	X		58	160	638	L1	L3	L2
	TL15 + TL24		X		87	192	845	L2	L1	L3
	TL18 + TL18	X	X		73	209	745	L3	L2	L1
	TL18 + TL24	X			86.5	208.5	890.5	L2	L1	L3
	TL24 + TL24	X	X		84	192	1020	L2	L1	L3
	TL48 + TL48			X	78	192	1788	L2	L1	L3
	TL15 + TL15	X	X		62	352	642	L2	L3	L1
	TL15 + TL24*		X		63	528	821	L1	L2	L3
	TL18 + TL18	X	X		64	400	736	L2	L3	L1
	TL18 + TL24*	X			62.5	544.5	866.5	L1	L2	L3
	TL24 + TL24	X	X		76	544	1012	L2	L3	L1
	TL48 + TL48			X	73	928	1783	L2	L3	L1
	TL15 + TL15	X	X		2	480	582	L2	L1	L3
	TL15 + TL24		X		3	656	761	L1	L3	L2
	TL18 + TL18	X	X		7	543	679	L2	L1	L3
	TL18 + TL24	X			5.5	687.5	809.5	L1	L3	L2
	TL24 + TL24	X	X		4	832	940	L3	L2	L1
	TL48 + TL48			X	4	1600	1714	L3	L2	L1

*In these configurations it is assumed that the first mentioned motor is the left one in the picture. If this is not the case in your application, different distances and connections might apply. Please contact Tecnotion in such a case.

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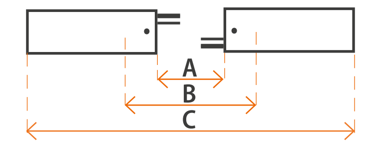
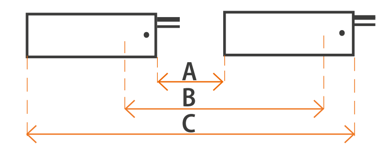
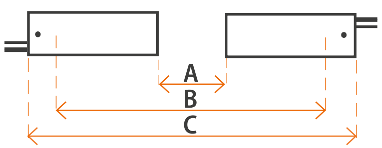
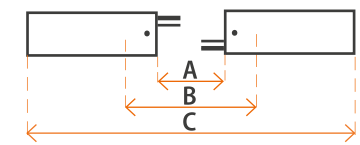
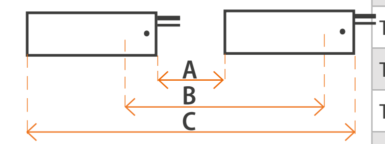
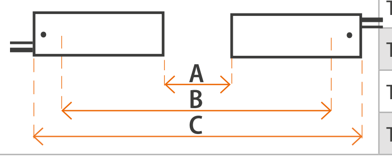
APPENDIX B | Coupling - TB series

Coupling possibilities	Combination	N	S	Distance coil units (A)	Distance dowel pins (B)	Total length coil units (C)	L1	L2	L3
	TB12 + TB12	X	X	84	192	572	L2	L1	L3
	TB12 + TB15		X	87	192	621	L2	L1	L3
	TB12 + TB18	X		86.5	208.5	666.5	L2	L1	L3
	TB12 + TB30		X	87	192	893	L2	L1	L3
	TB15 + TB30	X	X	74	176	926	L3	L2	L1
	TB18 + TB18	X		73	209	745	L3	L2	L1
	TB24 + TB24	X		84	192	952	L2	L1	L3
	TB30 + TB30	X	X	74	176	1198	L3	L2	L1
	TB12 + TB12	X	X	76	320	564	L3	L1	L2
	TB12 + TB15*		X	75	368	609	L3	L1	L2
	TB12 + TB18*	X		77.5	399.5	657.5	L3	L1	L2
	TB12 + TB30*		X	75	640	881	L2	L3	L1
	TB15 + TB30*	X	X	78	640	930	L2	L3	L1
	TB18 + TB18	X		80	416	752	L3	L1	L2
	TB24 + TB24	X		78	512	946	L3	L1	L2
	TB30 + TB30	X	X	78	640	1202	L2	L3	L1
	TB12 + TB12	X	X	4	384	492	L2	L1	L3
	TB12 + TB15		X	3	432	537	L2	L1	L3
	TB12 + TB18	X		5.5	463.5	585.5	L2	L1	L3
	TB12 + TB30		X	3	704	809	L1	L3	L2
	TB15 + TB30	X	X	2	752	854	L1	L3	L2
	TB18 + TB18	X		7	543	679	L2	L1	L3
	TB24 + TB24	X		8	768	876	L2	L1	L3
	TB30 + TB30	X	X	2	1024	1126	L3	L2	L1

*In these configurations it is assumed that the first mentioned motor is the left one in the picture. If this is not the case in your application, different distances and connections might apply. Please contact Tecnotion in such a case.

APPENDIX B | Coupling - TBW series

Coupling possibilities	Combination	N	S	Distance coil units (A)	Distance dowel pins (B)	Total length coil units (C)	L1	L2	L3
	TBW18 + TBW18	X	X	73	225	761	L2	L1	L3
	TBW30 + TBW30	X		80	208	1240	L1	L3	L2
	TBW30 + TBW30		X	112	240	1272	L2	L1	L3
	TBW30 + TBW45	X	X	112	240	1544	L2	L1	L3
	TBW45 + TBW45	X	X	112	240	1816	L2	L1	L3
	TBW18 + TBW18	X	X	72	416	760	L3	L1	L2
	TBW30 + TBW30	X		76	656	1236	L3	L1	L2
	TBW30 + TBW30		X	108	688	1268	L2	L3	L1
	TBW30 + TBW45*	X	X	108	960	1540	L1	L2	L3
	TBW45 + TBW45	X	X	108	960	1812	L1	L2	L3
	TBW18 + TBW18	X	X	7	543	695	L2	L1	L3
	TBW30 + TBW30	X	X	8	1040	1168	L1	L3	L2
	TBW30 + TBW45	X	X	8	1312	1440	L3	L2	L1
	TBW45 + TBW45	X	X	8	1586	1712	L2	L1	L3

*In these configurations it is assumed that the first mentioned motor is the left one in the picture. If this is not the case in your application, different distances and connections might apply. Please contact Tecnotion in such a case.

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APPENDIX C | Motor cable configuration

Power cable

Series	Length	Diameter	Configuration	Static bending radius	Dynamic bending radius	Mass
TM	3 meter	8.3 mm	4 x 0.5 mm^2 (AWG18)	4 x diameter	10 x diameter	0.15 kg/m
TL6/9/12/15/18	1 meter	9.6 mm	4 x 1 mm^2 (AWG18)	6 x diameter	Not allowed	0.15 kg/m
TL24/48	1 meter	11.4 mm	4 x 2.5 mm^2 (AWG14)	6 x diameter	Not allowed	0.27 kg/m
TB	1 meter	11.4 mm	4 x 2.5 mm^2 (AWG14)	6 x diameter	Not allowed	0.27 kg/m
TBW18/TBW30N	1 meter	11.4 mm	4 x 2.5 mm^2 (AWG14)	6 x diameter	Not allowed	0.27 kg/m
TBW30S/TBW45	1 meter	15.8 mm	4 x 6 mm^2 (AWG10)	6 x diameter	Not allowed	0.57 kg/m

The cable on the TM series is a flex cable with a maximum number of bending cycles of 5 million.

Sensor cable

Series	Length	Diameter	Configuration	Static bending radius	Dynamic bending radius	Mass
All	1 meter	4.7 mm	4 x 0.14 mm^2 (AWG26)	6 x diameter	Not allowed	0.03 kg/m

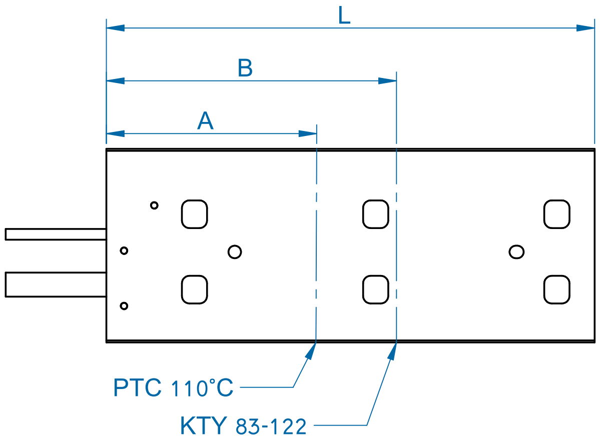
Hall module

Type	Length	Diameter	Configuration	Static bending radius	Dynamic bending radius	Mass
Analog	3 meter	6.2 mm	4 x 2 x 0.14 mm^2 (AWG26)	6 x diameter	Not allowed	0.054 kg/m
Digital	1 meter	5.1 mm	6 x 0.14 mm^2 (AWG26)	7.5 x diameter	Not allowed	0.030 kg/m

TECNOTION® direct drive in motion

APPENDIX D | Temperature sensor location

Coil unit	Location PTC between coils	Location KTY between coils	Motor edge to PTC (A)	Motor edge to KTY (B)
TM3	1-2	2-3	43.85 mm	75.85 mm
TM6	2-3	4-5	63.25 mm	95.25 mm
TM12	4-5	6-7	98.85 mm	130.85 mm
TM18	4-5	6-7	99.45 mm	131.45 mm
TL6	2-3	4-5	67.15 mm	99.15 mm
TL9	2-3	4-5	67.15 mm	99.15 mm
TL12	4-5	6-7	102.15 mm	134.15 mm
TL15	4-5	6-7	99.15 mm	131.15 mm
TL18	4-5	6-7	99.45 mm	131.45 mm
TL24	4-5	6-7	102.15 mm	134.15 mm
TL48	4-5	6-7	105 mm	137 mm
TB12	4-5	6-7	102 mm	134 mm
TB15	4-5	6-7	99 mm	131 mm
TB18	4-5	6-7	99.15 mm	131 mm
TB24	4-5	6-7	102 mm	134 mm
TB30	4-5	6-7	99 mm	131 mm
TBW18	4-5	6-7	107.5 mm	139.5 mm
TBW30	4-5	6-7	112 mm	144 mm
TBW45	4-5	6-7	112 mm	144 mm



The wires should not be bent dynamically and therefore cannot be placed in a cable chain. If this is desired a connector should be used connecting the standard wires to bendable wires.

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direct drive in motion

APPENDIX E | Package weight

Article	Article code	Package weight
Coil unit TM 3S FLEX	4022 368 5075	1.54 kg
Coil unit TM 3Z FLEX	4022 368 5533	1.54 kg
Coil unit TM 6S FLEX	4022 368 5076	1.9 kg
Coil unit TM 6Z FLEX	4022 368 5300	1.9 kg
Coil unit TM 12S FLEX	4022 368 5078	2.6 kg
Coil unit TM 18N FLEX	4022 368 5500	3.5 kg
Coil unit TM 18S FLEX	4022 368 5519	3.5 kg
Magnet plate TM 96 mm	4022 368 5225	0.28 kg
Magnet plate TM 144 mm	4022 368 5226	0.4 kg
Magnet plate TM 384 mm	4022 368 5227	1.08 kg
Coil unit TL 6N	4022 369 7458	2.04 kg
Coil unit TL 6S	4022 368 5032	2.04 kg
Coil unit TL 9N	4022 368 5311	2.62 kg
Coil unit TL 9S	4022 368 5312	2.62 kg
Coil unit TL 12N	4022 369 7459	3.2 kg
Coil unit TL 12S	4022 368 5033	3.2 kg
Coil unit TL 15N	4022 369 7460	3.88 kg
Coil unit TL 15S	4022 368 5034	3.88 kg
Coil unit TL 18N	4022 368 5223	4.5 kg
Coil unit TL 18S	4022 368 5224	4.5 kg
Coil unit TL 24N	4022 368 5014	6.08 kg
Coil unit TL 24S	4022 368 5035	6.08 kg

Article	Article code	Package weight
Coil unit TL 48Q	112547	11.3 kg
Magnet plate TL 192 mm	4022 368 5193	0.94 kg
Magnet plate TL 288 mm	4022 368 5194	1.4 kg
Coil unit TB 12N	4022 368 5155	5.62 kg
Coil unit TB 12S	4022 368 5157	5.62 kg
Coil unit TB 15N	4022 368 5122	6.62 kg
Coil unit TB 15S	4022 368 5120	6.62 kg
Coil unit TB 18N	111026	7.8 kg
Coil unit TB 24N	111027	10.4 kg
Coil unit TB 30N	4022 368 5123	12.66 kg
Coil unit TB 30S	4022 368 5121	12.66 kg
Magnet plate TB 192 mm	4022 368 5221	2.34 kg
Magnet plate TB 288 mm	4022 368 5222	3.52 kg
Coil unit TBW 18N	4022 368 5263	8.02 kg
Coil unit TBW 18S	4022 368 5264	8.02 kg
Coil unit TBW 30N	4022 368 5242	13.28 kg
Coil unit TBW 30S	4022 368 5243	13.28 kg
Coil unit TBW 45N	4022 368 5244	19.12 kg
Coil unit TBW 45S	4022 368 5245	19.12 kg
Analog Hall module	4022 368 5139	0.34 kg
Digital Hall module	4022 368 5418	0.18 kg

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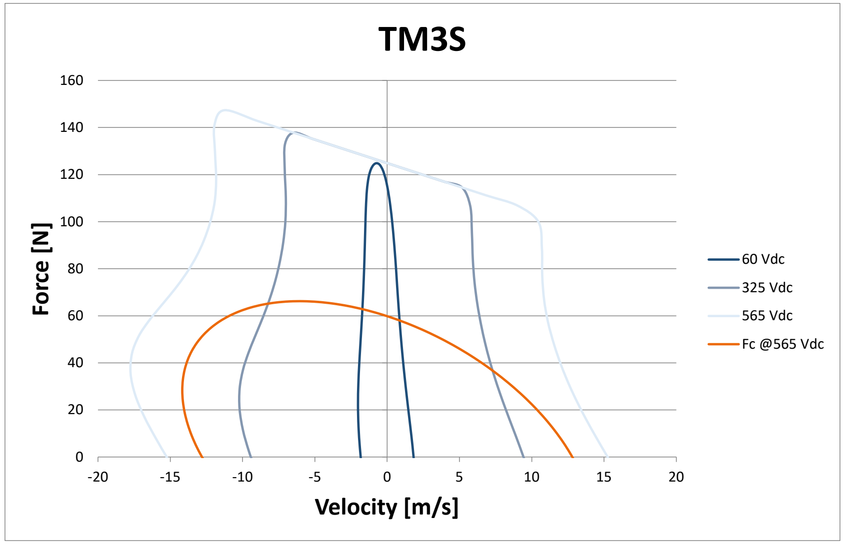
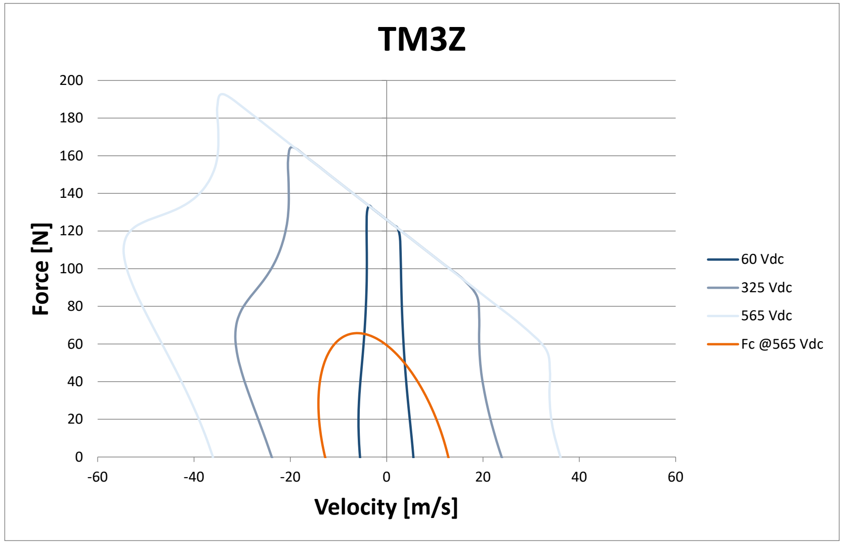
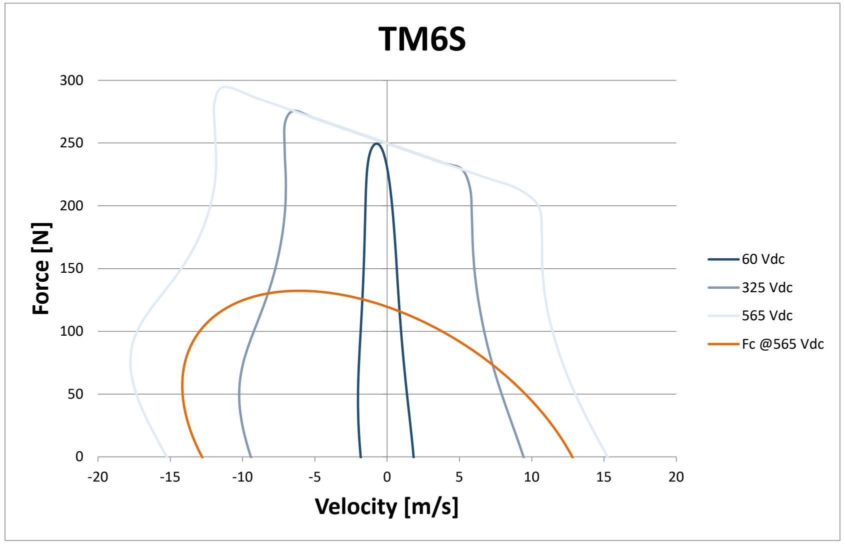
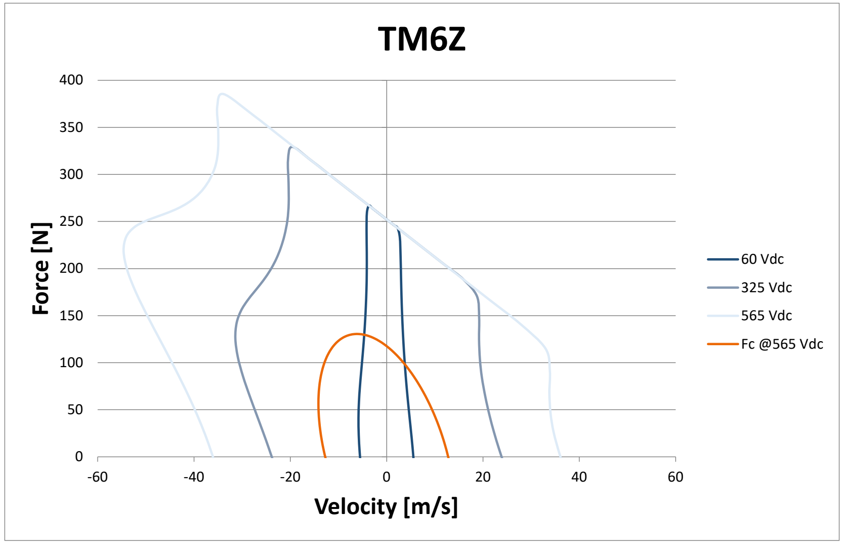
APPENDIX F | F/v graphs - TM series

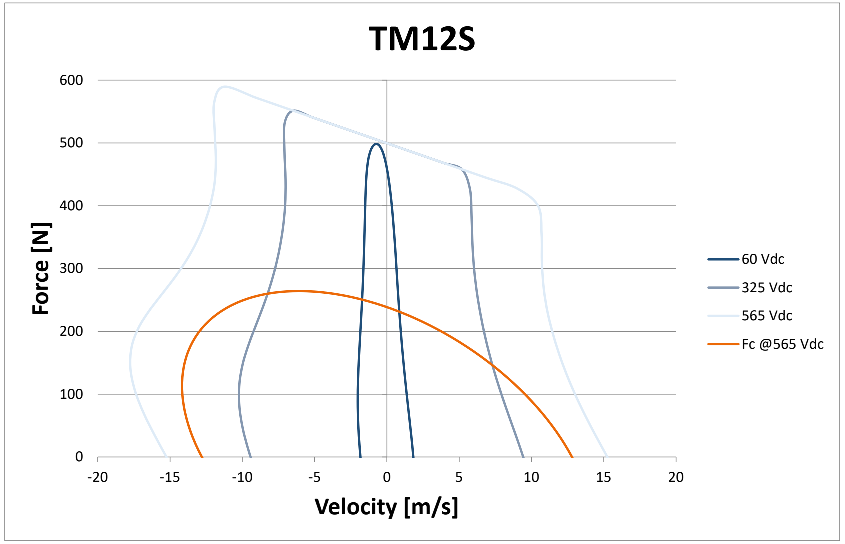


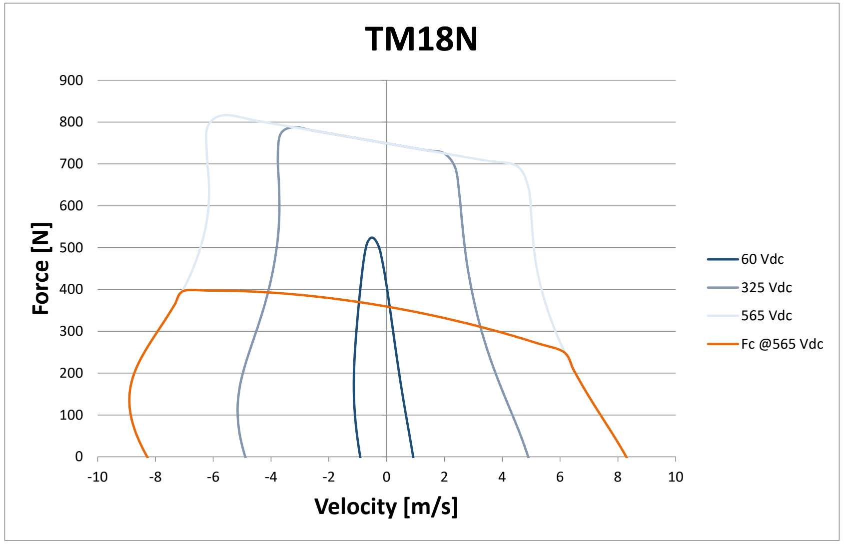


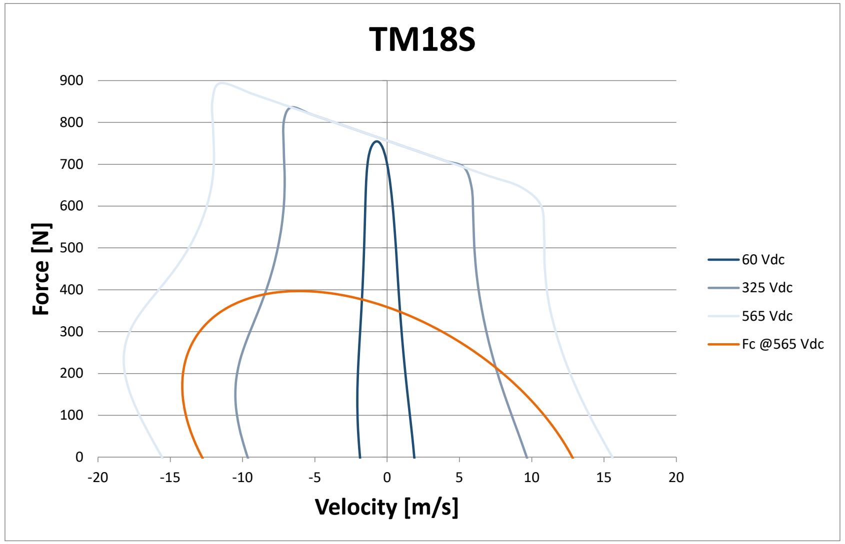




TECNOTION® direct drive in motion | APPENDIX F | F/v graphs - TM series



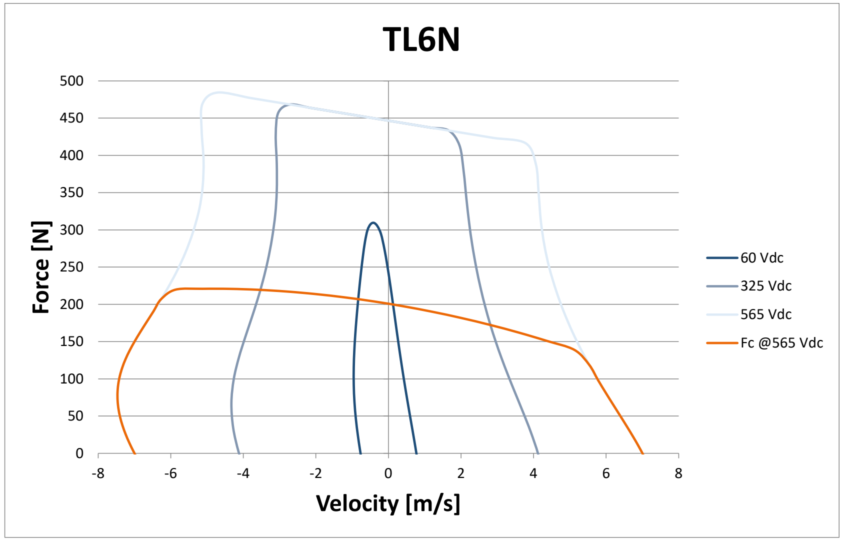


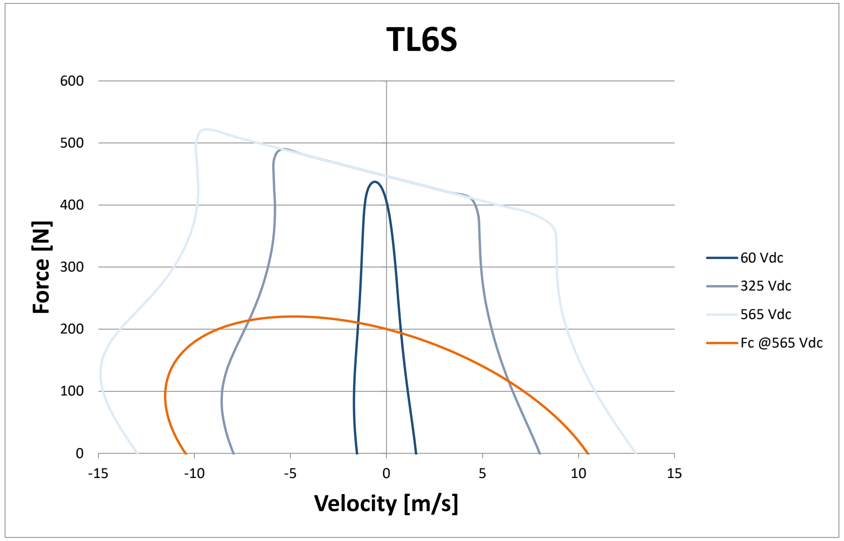


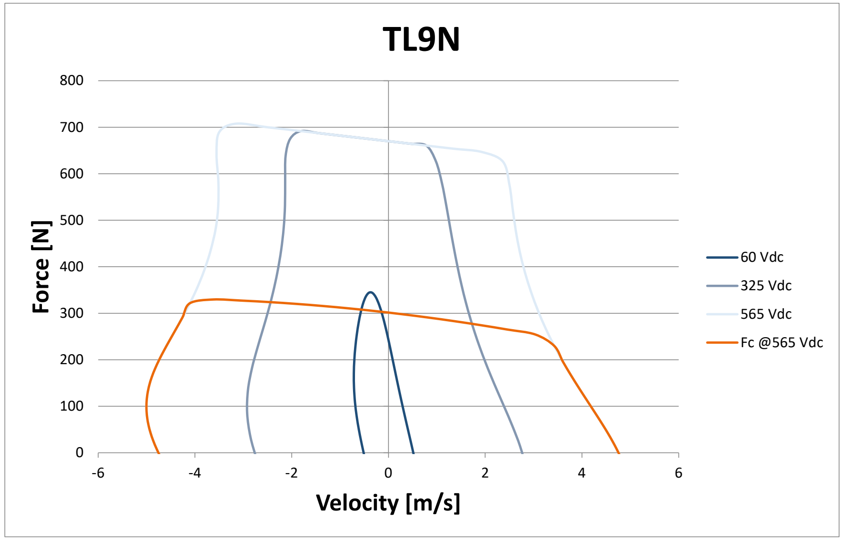
TECNOTION® direct drive in motion | APPENDIX F | F/v graphs - TL series

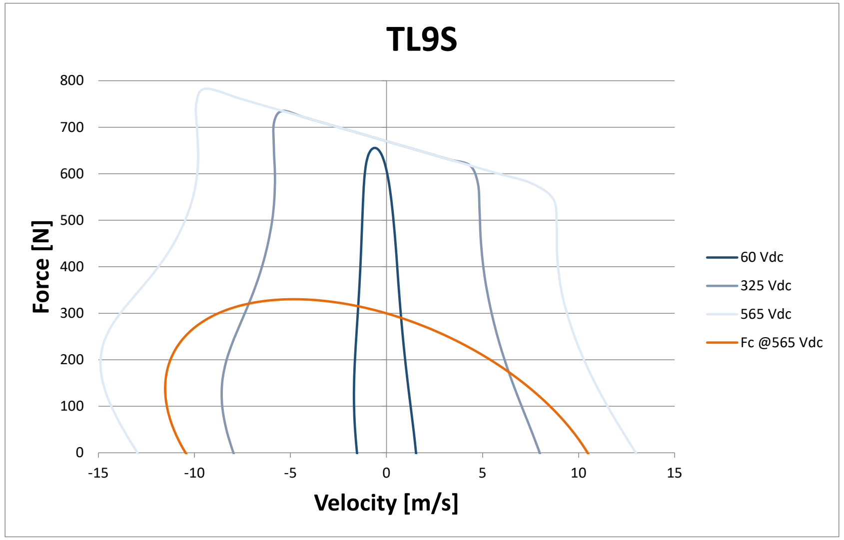
APPENDIX F

F/v graphs - TL series



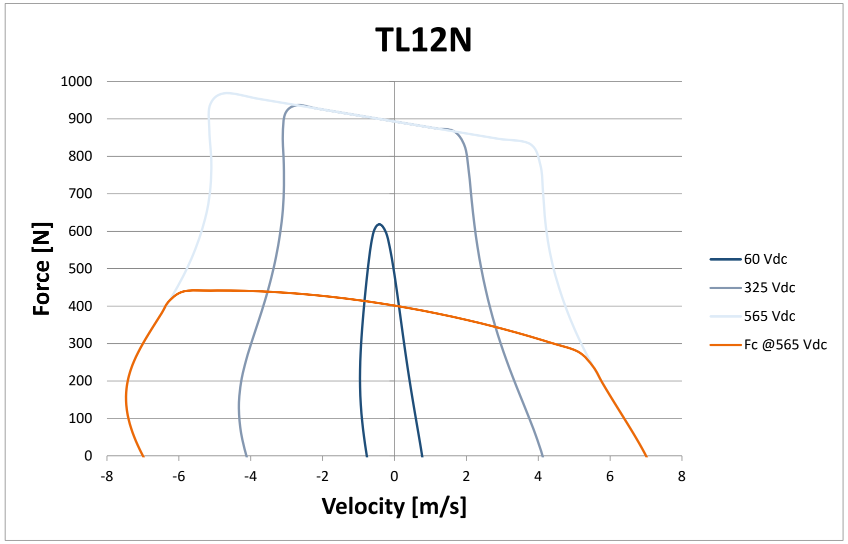


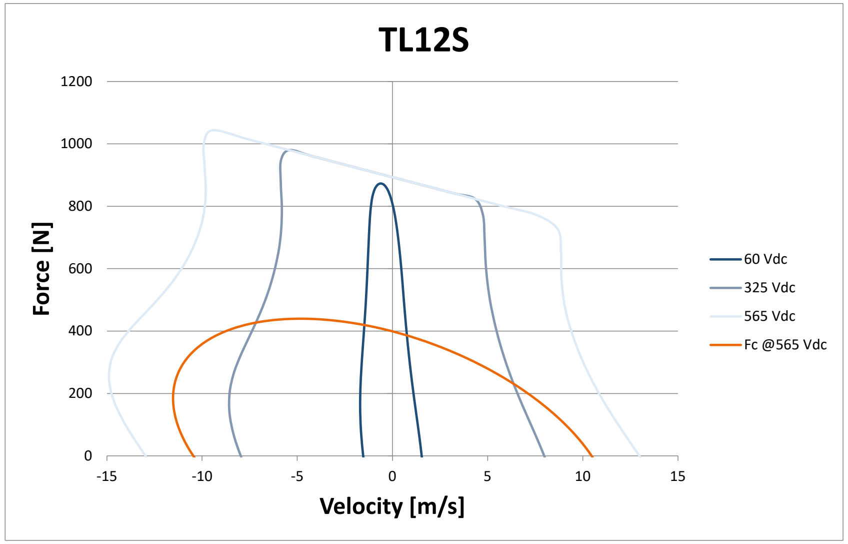


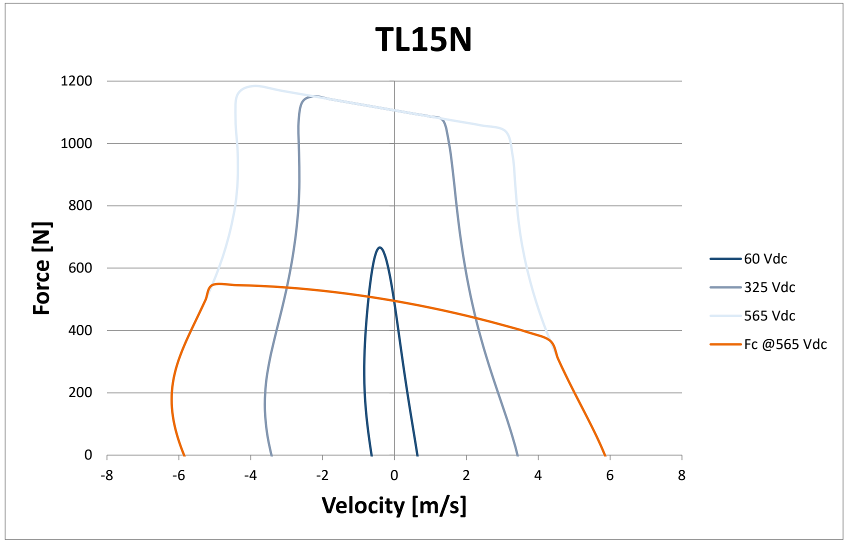


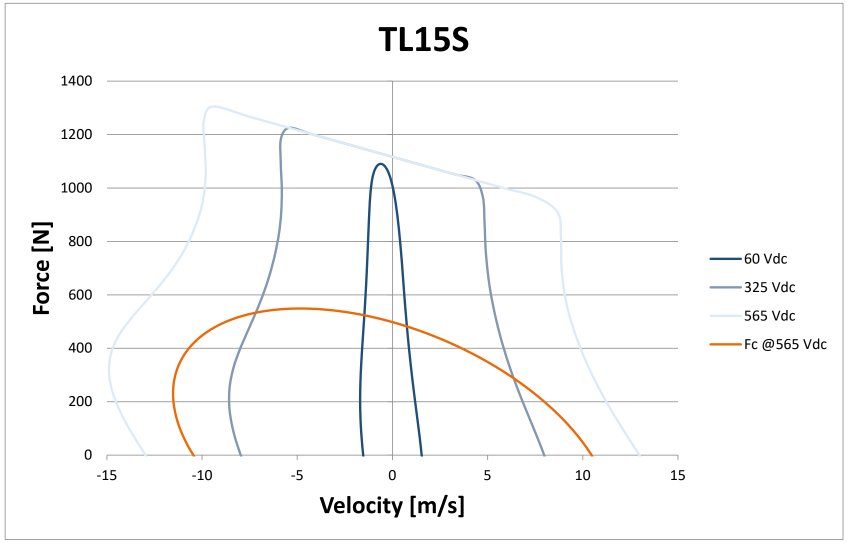
direct drive in motion

APPENDIX F | F/v graphs - TL series



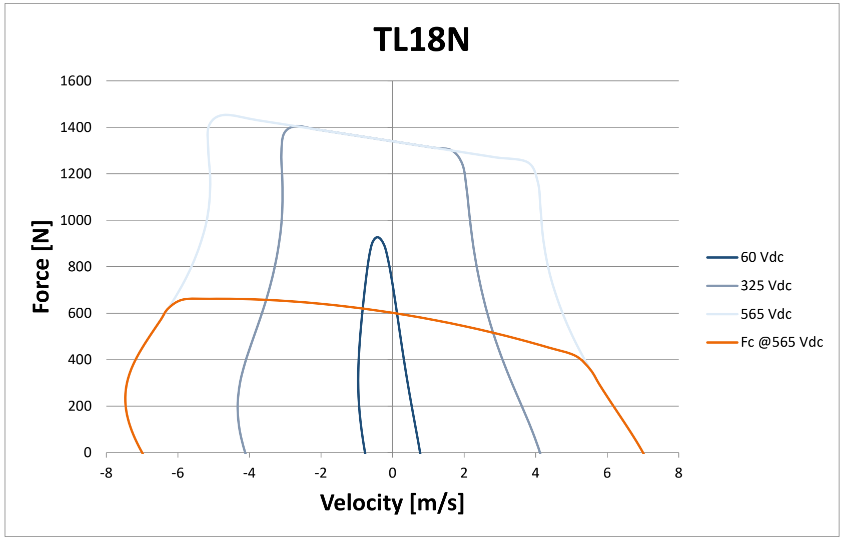


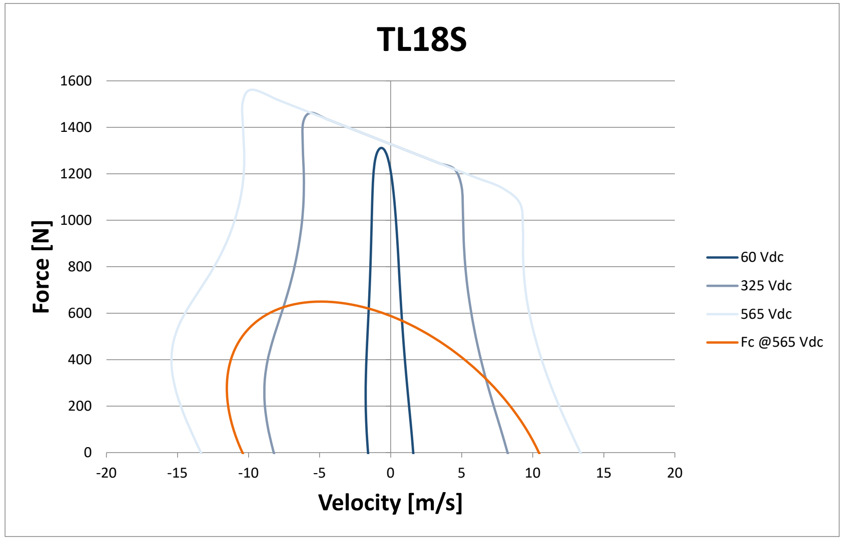


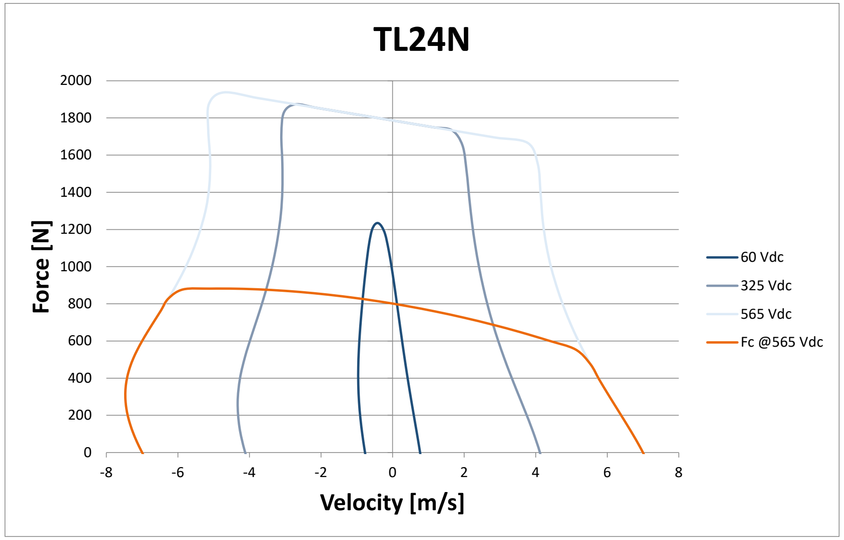


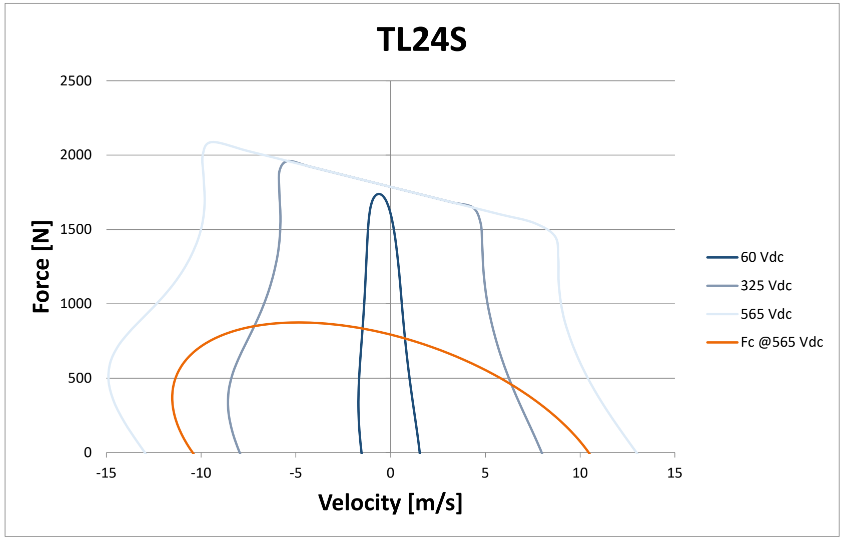
TECNOTION® direct drive in motion | APPENDIX F

F/v graphs - TL series





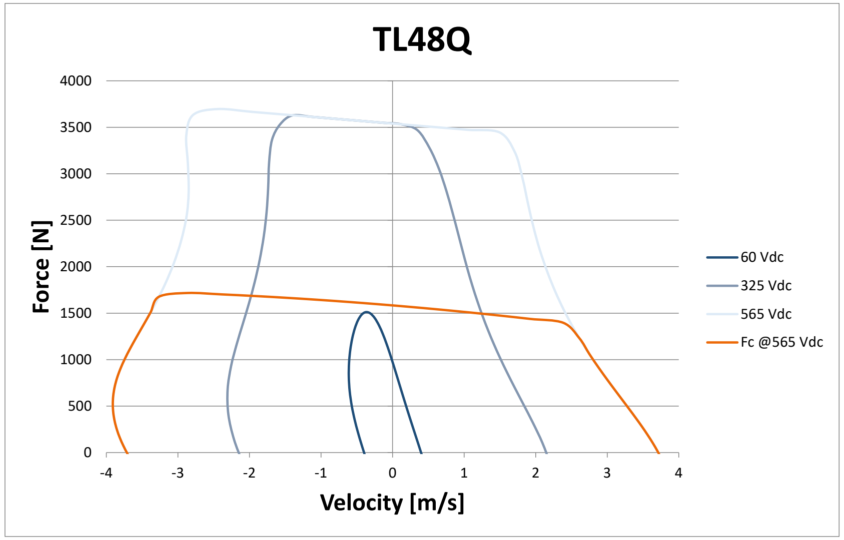




direct drive in motion

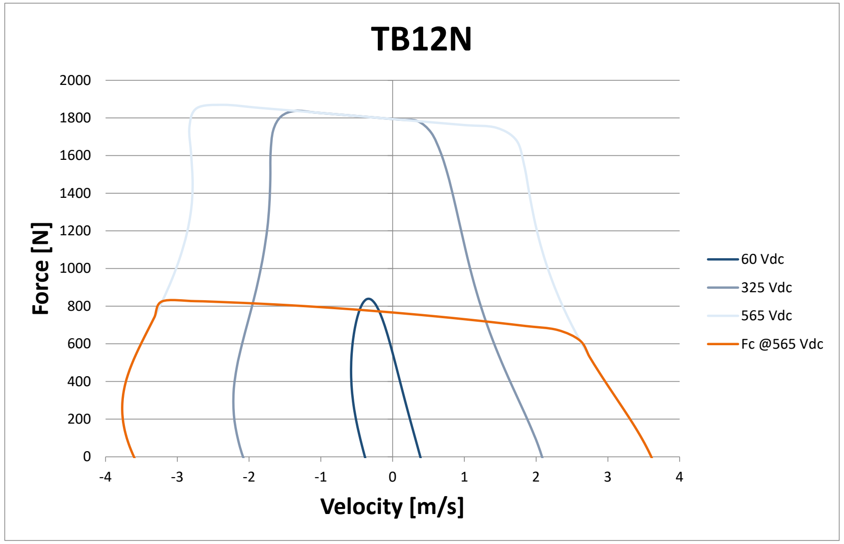
APPENDIX F

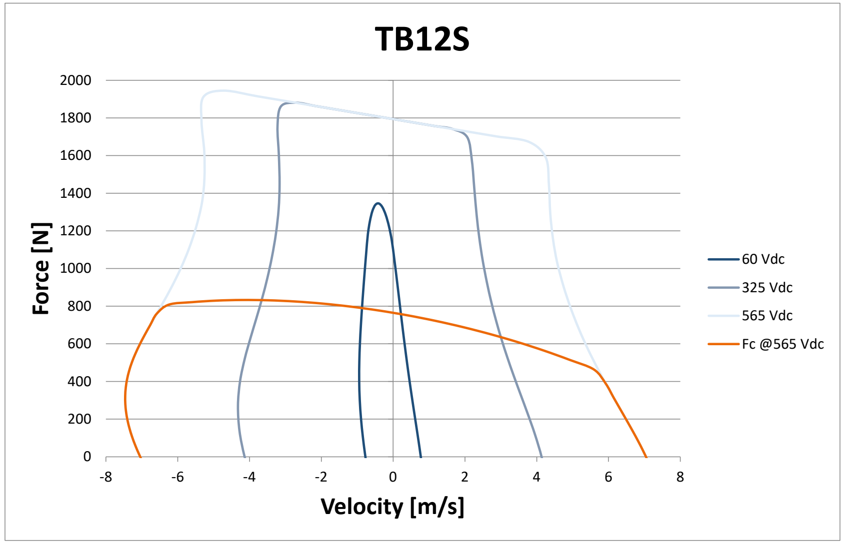
F/v graphs - TL series

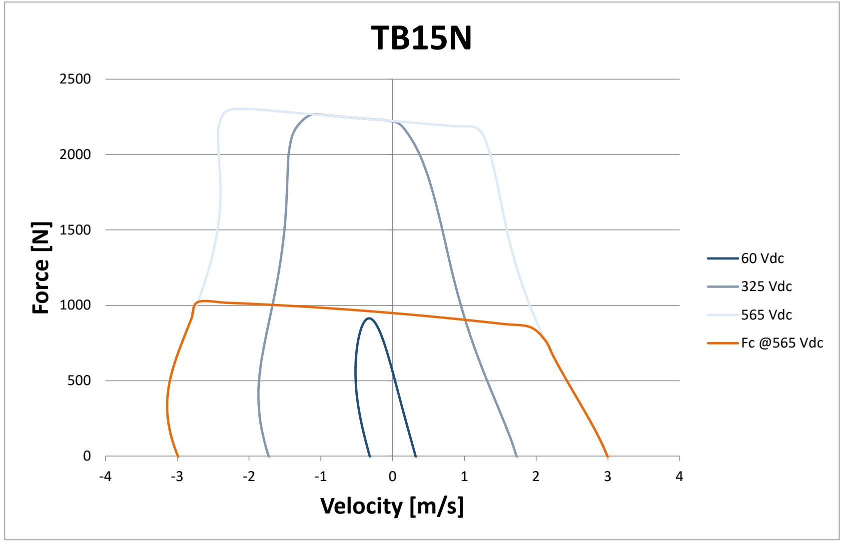


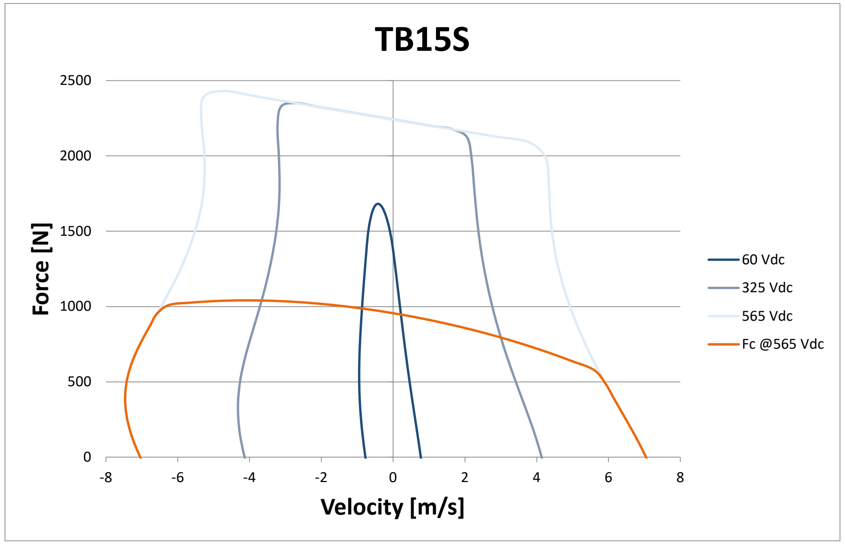
direct drive in motion

APPENDIX F | F/v graphs - TB series

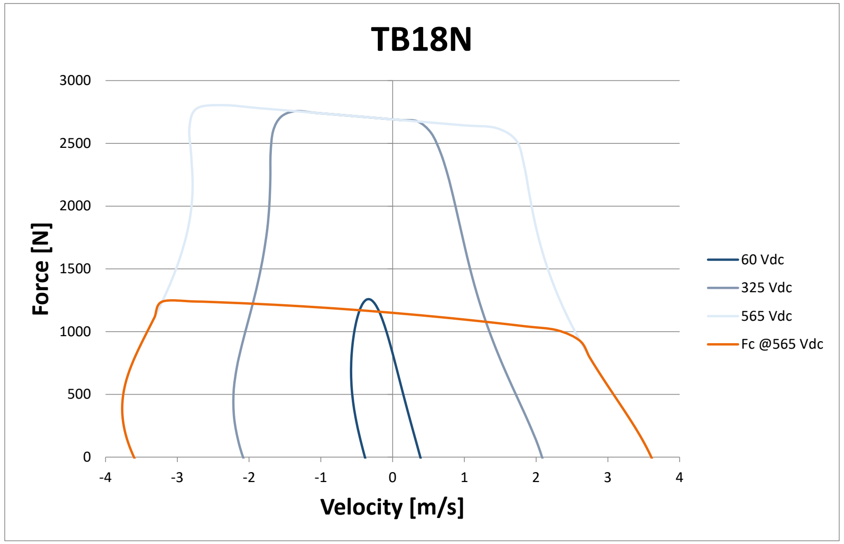


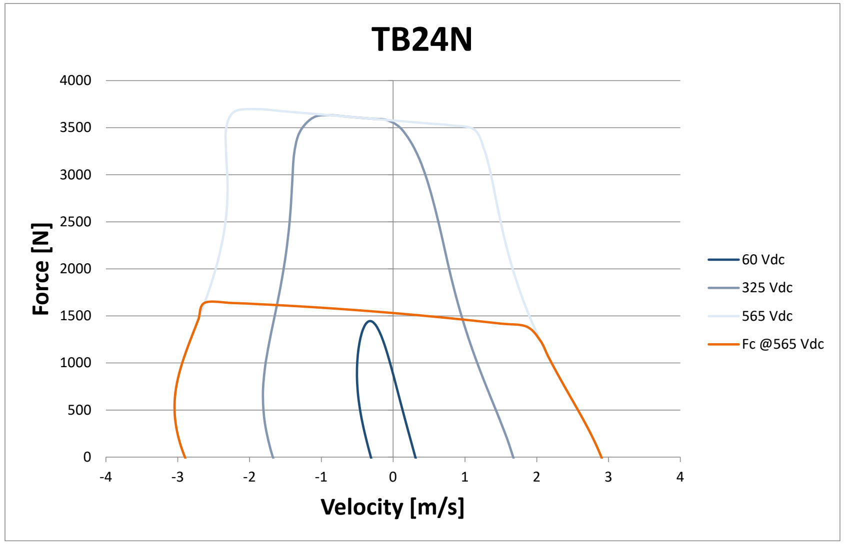


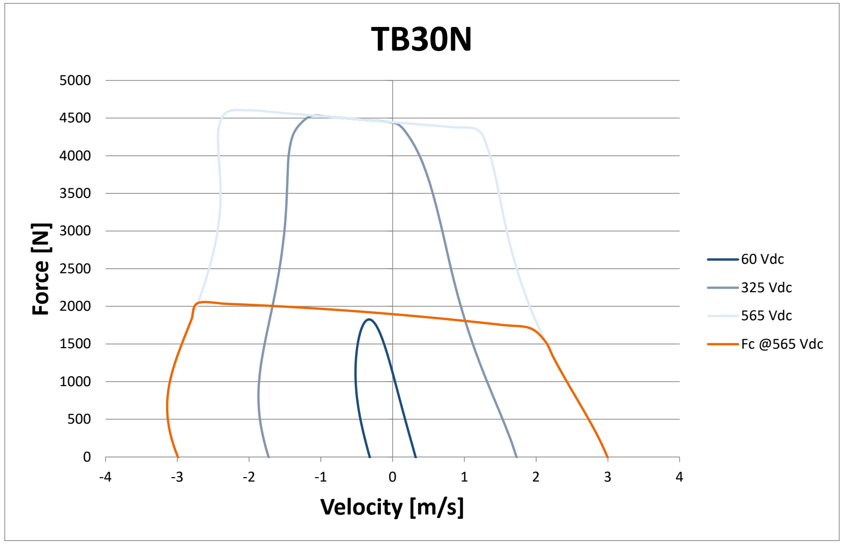


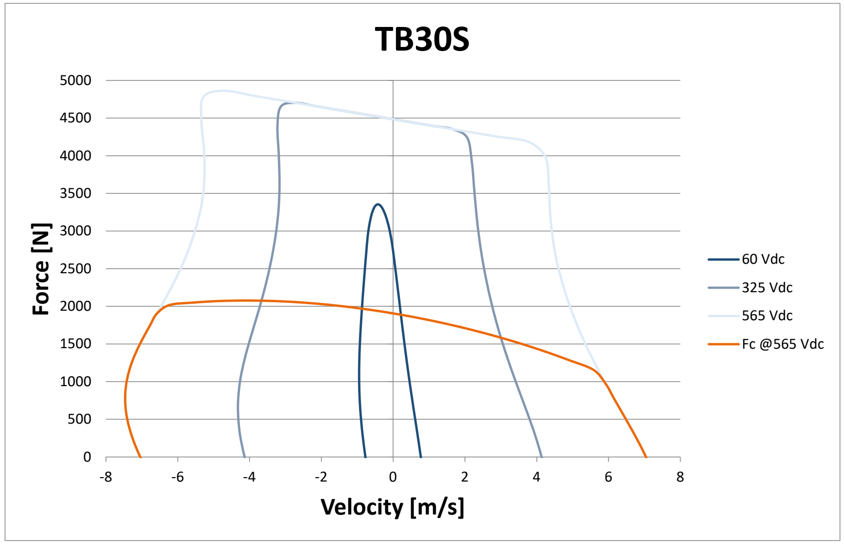


TECNOTION® direct drive in motion | APPENDIX F | F/v graphs - TB series



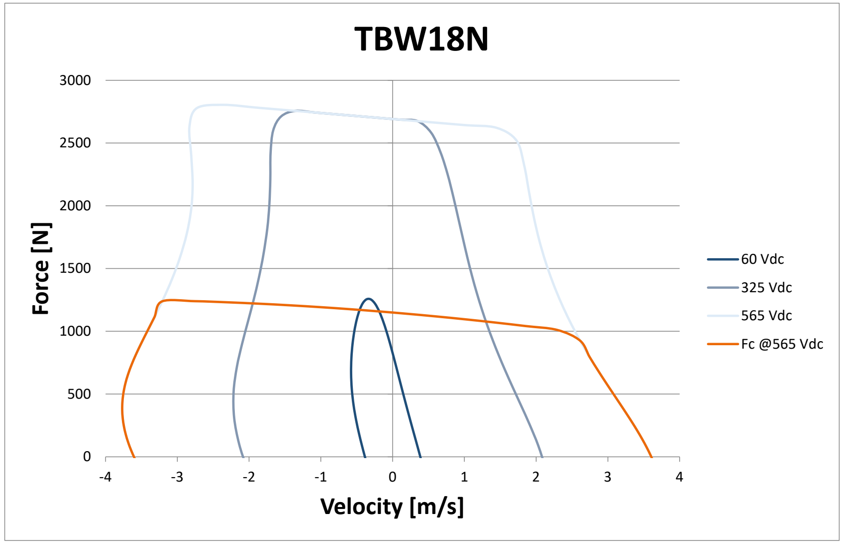


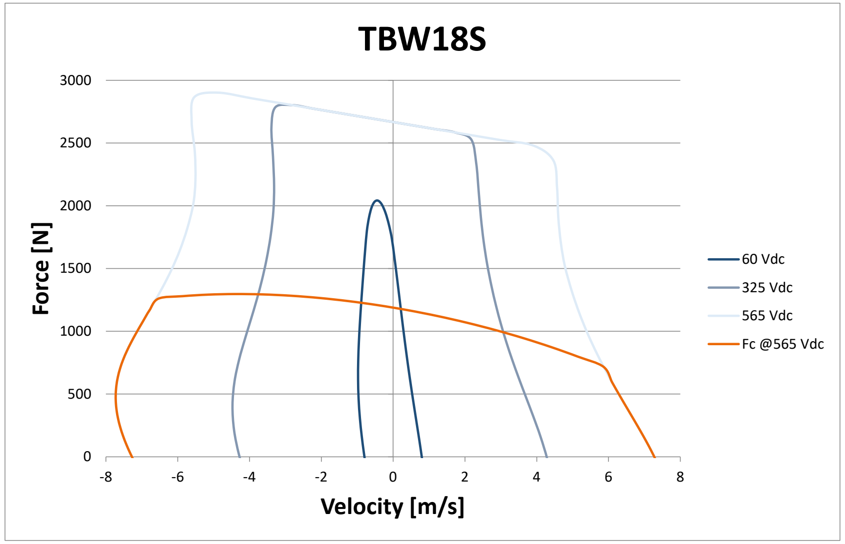


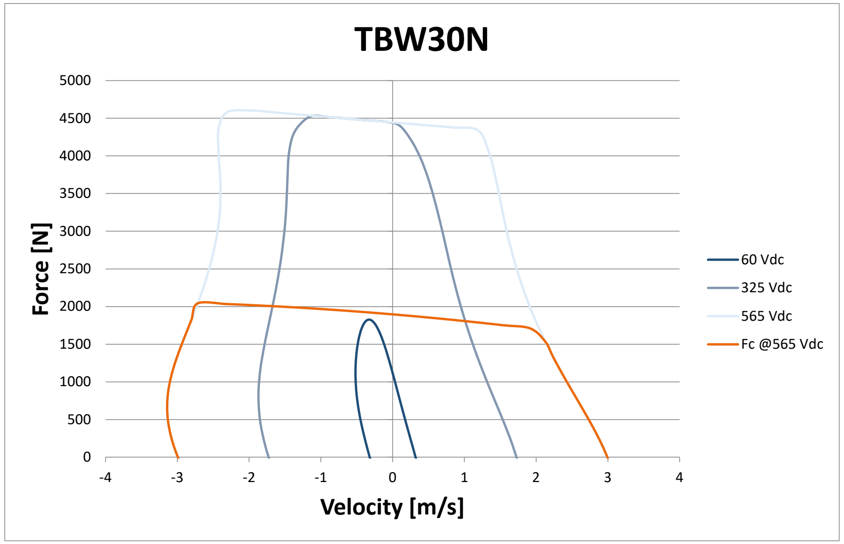


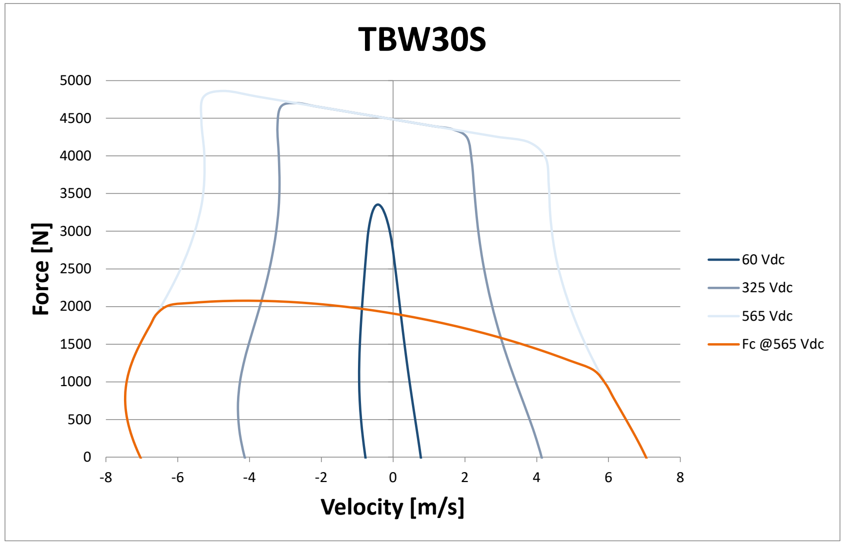
direct drive in motion

APPENDIX F | F/v graphs - TBW series





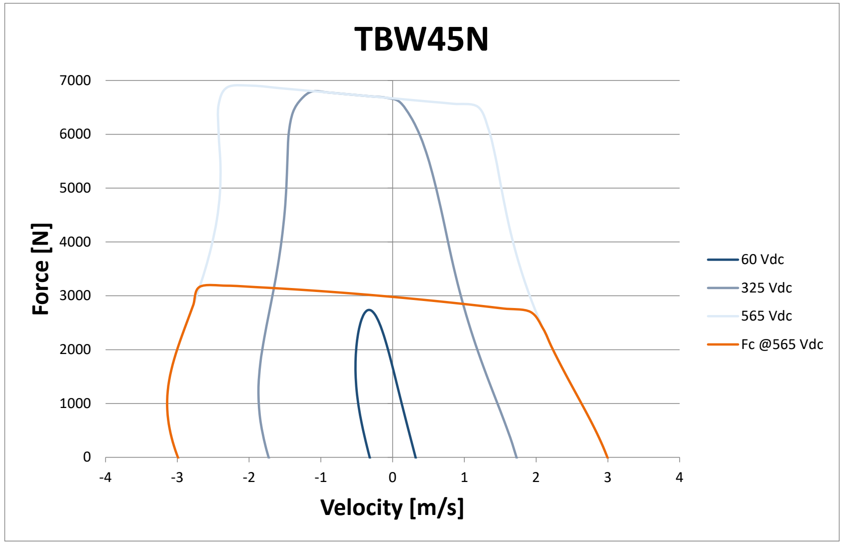


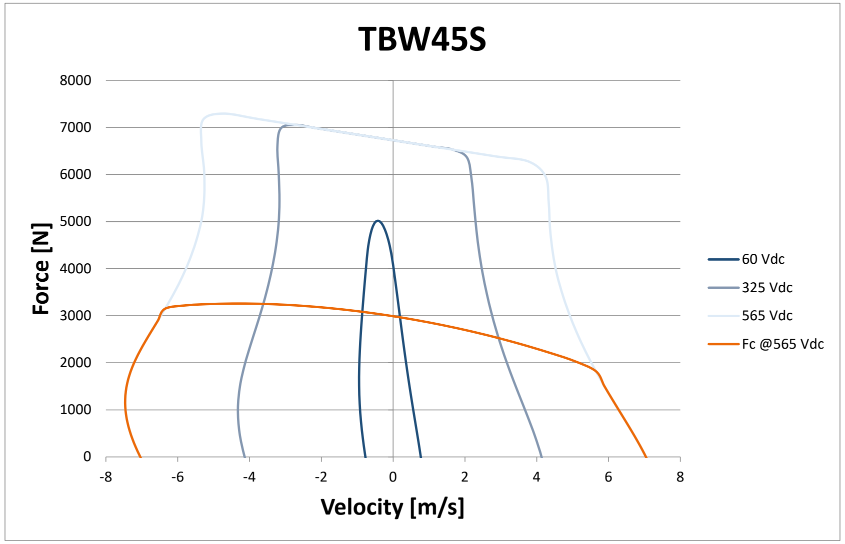


direct drive in motion

APPENDIX F

F/v graphs - TBW series





TECNOTION®
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Glossary

Parameter	Remarks	Symbol	Unit	Definition
Winding type				See paragraph 2.1.1 Coil unit
Motor type, max voltage ph-ph				A synchronous motor system has a linear relation between the current frequency and the movement frequency. Then the effective value of a sine shaped alternating current voltage is indicated, together with the DC value which is square root 2 higher.
Ultimate force @ 10 K/s increase	magnet @ 25°C	F_u	N	The force of the motor belonging to the ultimate current. This is the maximum force that the motor can reach.
Peak force @ 6 K/s increase	magnet @ 25°C	F_p	N	The force of the motor belonging to the peak current. It is possible to deliver more force, this is the ultimate force.
Continuous force water cooled[1]	coils @ 100°C	F_{cw}	N	The continuous force with a 100% duty cycle and using the cooling channels of the motor. For this value the motor should be moving and its phases should be energized equally.
Continuous force[1]	coils @ 100°C	F_c	N	The continuous force with a 100% duty cycle and the motor connected to a heat sink kept at 20°C. For this value the motor should be moving and its phases should be energized equally.
Maximum speed[2]	@ U_{max} @ F_c	v_{max}	m/s	The maximum speed the linear motor can achieve at continuous force. The actual value depends on the bus voltage and required force. Please check the force/velocity diagrams in the Tecnotion simulation tool.
Motor force constant	$I \leq I_c$	K_f	N/A_{rms}	Ratio between generated force in newton and applied RMS current in ampere.
Motor constant	coils @ 25°C	S	N^2/W	Ratio between force in newton and dissipated heat in watt. A higher value of the constant implies that the motor dissipates less heat for the generation of a certain amount of force. The value decreases at higher coil temperatures. This is caused by increased winding resistance at higher temperature. S is defined as $K^2/3R_{ph}$.
Ultimate current	magnets @ 25°C	I_u	A_{rms}	The ultimate current the motor can be run at to achieve the specified ultimate force. The coil temperature will rise with 10 K/s.
Peak current	magnets @ 25°C	I_p	A_{rms}	The peak current the motor can be run at to achieve the specified peak force. The coil temperature will rise with 6 K/s.
Continuous current water cooled[1]	coils @ 100°C	I_{cw}	A_{rms}	The continuous current with a 100% duty cycle and using the cooling channels of the motor.
Continuous current[1]	coils @ 100°C	I_c	A_{rms}	The continuous force with a 100% duty cycle and the motor connected to a heat sink kept at 20°C.
Back EMF ph-ph_{peak}		K_e	$V_{dc}/m/s$	Back electromotive force. A linear motor, when operated, also acts as a generator. The back EMF describes the coefficient between the generated voltage and the speed of the motor [V/m/s]. When the generated voltage is nearly equal to the bus voltage of the system the motor cannot run any faster.
Resistance per phase	coils @ 25°C ex. cable	R_{ph}	Ω	The resistance value of one phase or winding of the coil. This value can be verified via the motor cables, you will measure twice the catalog value because of the star point configuration of the phases/windings.
Induction per phase	$I < 0.6\, I_p$	L_{ph}	mH	The induction value in millihenry of one phase or winding of the coil. This value can be verified via the motor cables, you will measure twice the catalog value because of the star point configuration of the phases/windings. When the applied current is higher than 60% of the peak current, the induction will become lower than the catalog value. L_{ph} is equal to the values of L_{sd} and L_{sq}.

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Parameter	Remarks	Symbol	Unit	Definition
Electrical time constant		τ_e	ms	The time after which the current reaches 63% (1-(1/e)) of the desired magnitude. This metric gives an indication of the reaction time of the motor.
Continuous power loss[1]	coils @ 100°C	P_c	W	The maximum amount of power in watt that is dissipated when the motor is operated at continuous force. The actual value can be lower as a result of variations in thermal resistance, coil temperature and winding resistance. The winding resistance increases with 0.4% for every degree Celsius.
Thermal resistance	coils to mount. sfc.	R_{th}	K/W	Defines how hot the coil unit will become as a result of the dissipation of power to the surface. The thermal resistance in K/W multiplied by the dissipated power in watt will equal the temperature rise of the coil unit in °C.
Thermal time constant	up to 63% max. coil temp.	τ_{th}	s	Time required for the coil windings to reach 63% (1-(1/e)) of their maximum temperature during continuous force.
Water cooling flow	for ΔT=3K	Φ_w	l/min	Volume of water at 20°C per minute that will create a ΔT of 3K between entrance and exit of the coil unit. At a different flow rate the temperature difference will be different.
Water cooling pressure drop		ΔP_w	bar	Drop in pressure over the in- and outlet of the coils caused by friction forces in the water cooling channels. The pressure drop over the hoses and nipples of the entire system are not included.
Temperature sensor				See paragraphs 4.3.6 Temperature protection, 4.3.7 PTC specification and 4.3.8 KTY specification
Coil unit mass	ex. cables	m	kg	Mass of the coil unit without the cables.
Coil unit length	ex. cables	L	mm	Length of the coil unit without the cables.
Motor attraction force	rms @ 0 A	F_a	N	The attraction force between motor and magnet plate.
Magnet pitch NN		τ	mm	The distance between two consecutive poles of the same polarity.
Cable mass			kg/m	Mass of both cables.
Cable type (power)		d	mm (AWG)	American Wire Gauge is a standard for wire thickness specification. The diameter "d" in mm can be calculated with the AWG value "n" using 0.127*92^((36-n)/39).
Cable type (sensor)		d	mm (AWG)	American Wire Gauge is a standard for wire thickness specification. The diameter "d" in mm can be calculated with the AWG value "n" using 0.127*92^((36-n)/39).
Cable life (power FLEX)[3]	minimum		cycles	Number of bending cycles that the flex cable of the TM series can do.
Bending radius static (power FLEX)	minimum			Minimum bending radius for the cable when used in a static configuration.
Bending radius dynamic (power FLEX)	minimum			Minimum bending radius for the cable when used in a dynamic configuration.

1 These values are only applicable when the mounting surface is at 20°C and the motor is driven at continuous current. If these values differ in your application, please check our simulation tool.

2 Actual values depend on bus voltage. Please check the F/v-graph in our simulation tool.

3 Depending on bending radius, velocity and acceleration.

TECNOTION
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version 2.0