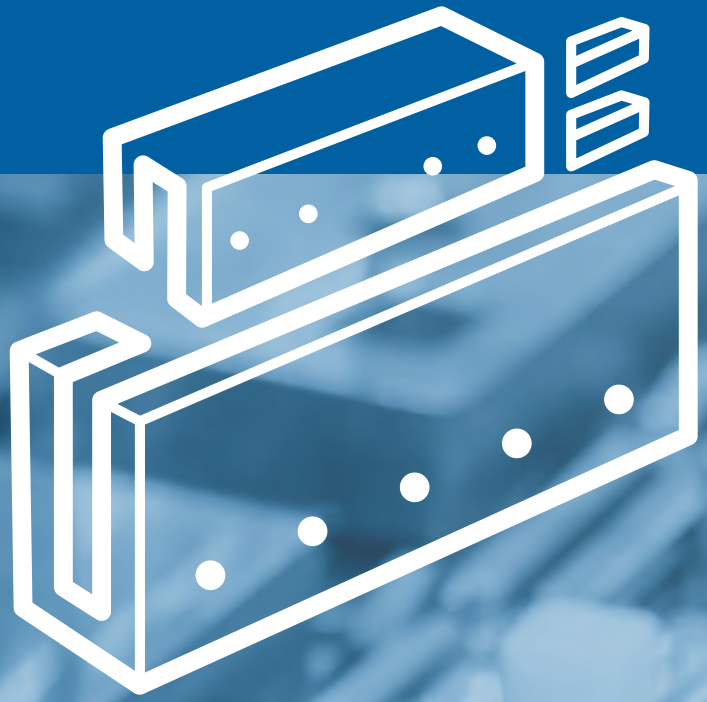
Ironless linear motor manual

version 2.0



TECNOTION®

direct drive in motion

INTRODUCTION

A linear motor system is part of a specific machine. Tecnotion's ironless 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 ironless 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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1. BEFORE YOU START

This is the manual for your Tecnotion 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 ironless 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 ironless linear motor. It will give insight what aspects to consider for the design and installation of a linear motor.

Intended use

An ironless 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 ironless 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 yokes are sensitive to mechanical shocks. Never drop a magnet yoke 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 yokes 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 yoke.

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 yokes.

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

UV blacklight can cause irreversible damage to the eyes and other tissue when exposed. When using a UV blacklight installation wear appropriate protective clothing and glasses.

The magnet yokes do attract each other while mounting. Take care that the closing plates of one yoke do not damage the magnets of the neighboring magnet yoke 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 certificates can be found online at www.tecnotion.com/certificates.

1.3.1 CE certification

Tecnotion B.V. declares that the UM, UL, UXA and UXX series linear ironless motors mentioned in this installation manual are manufactured in accordance with the relevant Union harmonization legislation when installed according the installation manual. These 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 for UM, UL, UXA and UXX series motors.

Tecnotion B.V. furthermore declares that the UC and UF series linear ironless motors mentioned in this installation manual are not entirely manufactured in accordance with the relevant Union harmonization legislation. They are destined to be incorporated in other machines or to be combined with other machines. These linear motors are in conformity with the following standards, see table 1.2.

Standard	Name
ISO 12100:2010	RI&E
EN 61000-6 1 to 4	EMC

Table 1.2: Applicable standards for UC and UF series motors.

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 ironless linear motors from the UM, UL, UXA and UXX series have the CSA compliance, UC and UF linear motors do not have this.

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 ironless linear motor of Tecnotion consists out of a coil unit and one or more magnet yokes. Together with a slide, mounting frame, rails and bearing system, dampers, encoder, controller and amplifier, the linear motor forms a complete machine concept. In figures 2.1 and 2.2, 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 yokes will be obtained.

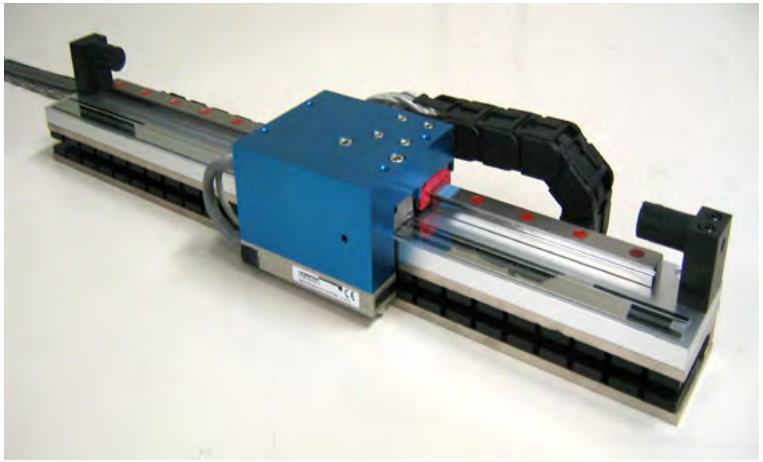

Figure 2.1: A complete axis system with Tecnotion coil unit and magnet yokes installed.

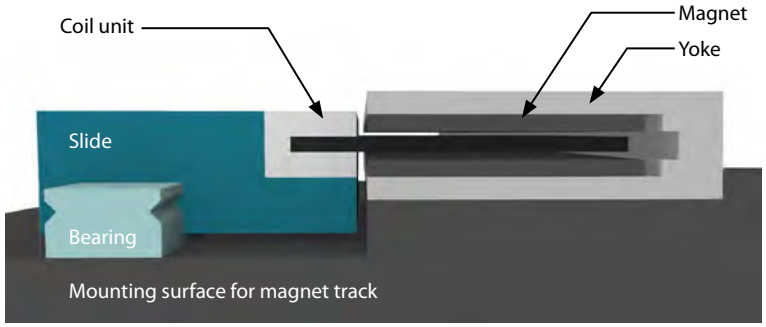

Figure 2.2: Schematic overview of the installed ironless motor.

2.1 Basic components

Tecnotion only supplies coil units, one or multiple magnet yokes and offers a few additional components like Hall modules. 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 yoke. This part is available in different lengths.

The Tecnotion online simulation tool, is the best tool to determine which motor and yoke 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 yoke is the stationary part. It is also possible to do this vice

versa. When the coil is stationary, the cables are not moving and cooling of the coil is easier. The moving mass however is significantly higher in this case, and because of this 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 UC being the smallest coil unit, and UX being the largest coil unit. There are intermediate sizes called UF, UM and UL. The number in the product name indicates the number of coils 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. Coil units in the UC or UF series only have one standard winding option, therefore they do not have this designation. Furthermore, the UC3 coil unit comes in two different designs in terms of cable exit, one of them is inline with the coil unit (called UC3 inline), the other one is to the side (called UC3).

An example of a Tecnotion ironless coil unit is given in figure 2.3. All available winding types per coil unit of the ironless series are given in table 2.1.

Figure 2.3: Example of an ironless coil unit (UM3).

Series	UC		UF		UM				UL					UX				
Number of coils	3	6	3	6	3	6	9	12	3	6	9	12	15	3	6	9	12	18
No designation	x	x	x	x														
N					x	x	x	x	x	x	x	x	x	x	x	x	x	x
S					x	x	x	x	x	x	x	x	x	x	x	x	x	

Table 2.1: Available winding types for all coil units.

2.1.2 Magnet yokes

The coil units require magnet yokes in order to move. The first letters of the magnet yoke indicate the coil unit series where the yoke belongs to, the number indicates the yoke length in millimeter. Table 2.2 shows an overview of the magnet yoke options belonging to the coil units. Note that the UX series coil unit can be used in both the UXA and UXX series yokes. Also the magnet pitch, which indicates the distance between two consecutive magnets of the same polarity, can be seen.

Series	Magnet pitch	Magnet yokes			
UC	16.5 mm	UC66	UC99	UC264	
UF	24 mm	UF72		UF120	
UM	30 mm	UM90	UM120	UM150	UM390
UL	42 mm	UL126	UL168	UL210	UL546
UXA	57 mm	UXA114	UXA171	UXA456	
UXX	57 mm	UXX114	UXX171	UXX456	

Table 2.2: Available magnet yokes belonging to the coil units and the magnet pitch.

Figure 2.4 shows the magnet yoke UM120.

Figure 2.4: Example of an ironless magnet yoke (UM120).

2.2 Additional parts

For a proper installation of your linear motor system you 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-ferro magnetic tools to prevent damaging the magnet yokes.

A digital Hall module for commutation can be used as cost effective alternative 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. Analog Hall modules are not available for ironless motors.

In order to mount the coil units and magnet yokes, 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 yoke. It shows how to calculate the desired magnet track length, and how to couple two or more coil units with each other.

3.1.1 Magnet track length

This paragraph describes how to determine the required amount of magnet yokes for an application. There are two ways to determine the required amount. The easiest way to determine the required number of magnet yokes is to add up the necessary stroke for the application and the length of the coil unit. Please review the example at the end of the paragraph for further information. This will provide the minimum magnet track length that needs to be constructed with the available magnet yoke sizes. Please refer to table 2.2 for an overview of the available lengths per series.

It can be cost effective to determine the required magnet track length by means of the effective length instead of the coil unit length. This is especially interesting when an extra magnet yoke 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 yoke. The effective length of a coil unit is the area where the actual coils are situated in the coil unit, 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 unit can overrun the end of the magnet yoke without any loss of force. Table 3.1 states where the effective length of a coil unit starts and ends.

In order to function properly the effective area of the coil unit should remain inside 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

Suppose we want to move 205 mm using a UL12 coil unit. This coil unit has a length of 358 mm, although the lower part of the coil unit where the coils are located is only 346 mm. The effective length is 336 mm. The available UL magnet yokes are 126, 168, 210 and 546 mm in length.

Magnet length calculation using the coil unit length

The total magnet track length is the sum of the coil unit length (346 mm) and the desired stroke (205 mm). That gives 551 mm. You would need 2 UL210 and 1 UL168 yokes in order to cover the distance. In this example the coil unit will stay inside the magnet yokes.

Magnet length calculation using the effective length

The total magnet track length is the sum of the effective length of the coil unit (336 mm) and the desired stroke (205 mm). That gives 541 mm. You would need only one UL546 yoke to cover the distance. In this example the coil unit will partly run out of the magnet yoke but because the coils are still located inside the magnet yoke, there is no force loss.

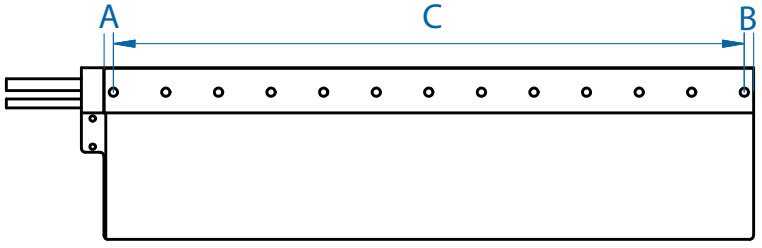

Figure 3.1: Location of effective length of an ironless coil unit.

Parameter	UC3	UC6	UF3	UF6
Cable side A (mm)	0	0	0	0
End B (mm)	1	1	1	1
Effective length C (mm)	33	66	48	96

Parameter	UM3	UM6	UM9	UM12
Cable side A (mm)	2.5	2.5	2.5	2.5
End B (mm)	3.5	3.5	3.5	3.5
Effective length C (mm)	60	120	180	240

Parameter	UL3	UL6	UL9	UL12	UL15
Cable side A (mm)	5	5	5	5	5
End B (mm)	5	5	5	5	5
Effective length C (mm)	84	168	252	336	420

Parameter	UX3	UX6	UX9	UX12	UX18
Cable side A (mm)	3	3	3	3	3
End B (mm)	5	5	5	5	5
Effective length C (mm)	114	228	342	456	684

Table 3.1: Dimensions of the effective length per coil unit type.

3.1.2 Coupling of motors

Individual ironless coil units can be coupled. This can be done using two separate magnet tracks for gantry type applications or on a single track to yield more force. This last option is especially interesting for cost reduction in long stroke applications. By coupling two coil units a smaller series coil and magnet yoke can be used. This will reduce the magnet yoke cost. Different type of coil units 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. Coil units must always be connected to the drive in parallel, connection 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 then 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 yokes, see figure 3.2. In this case there are three possible orientations: with the cable sides pointing to 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 coil units, it is sufficient to use the temperature sensors of only one of the coil units. Make sure that the cables of the coil unit have approximately the same length so that the resistances of the coil units will not differ too much.

Some coil units in the UC and UF series do have lateral cable exits. There are still three possible configurations, although the cable orientations are different then mentioned above.

The UC series coil units have no temperature sensors.

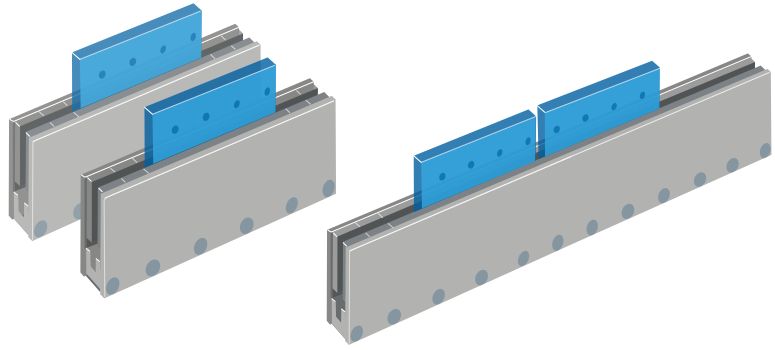

Figure 3.2: Coupling on two magnet tracks (left) versus coupling on one magnet track (right).

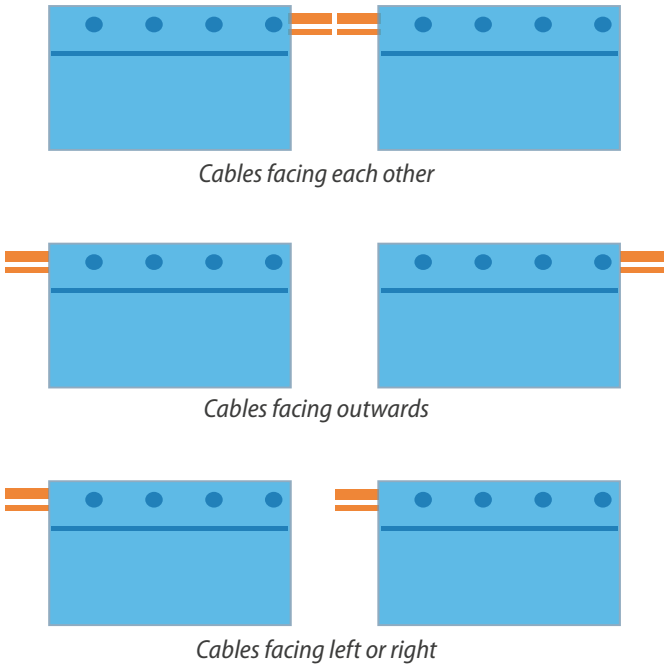

Figure 3.3: The three orientations when coupling two coil units on the same magnet track.

3.2 Heat transfer

The limiting factor of the performance of the linear motor is the maximum temperature (80°C or 110°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 side of the coil unit is completely mounted to the slide.

4. INSTALLATION

The magnet yokes 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 cm of the magnetic side of the magnet yoke.

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 yokes.

The magnet yoke 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 yokes 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 yokes and ironless coil units.

4.1.1 Cleanroom cleaning

For cleanroom applications, Tecnotion products need to be cleaned additionally to remove dust particles. In this process you will need:

- isopropanol cleaning wipes;
- a filtered compressed air installation;
- a blacklight installation;
- UV glasses;
- a cleanroom compatible vacuum cleaner;
- a cotton swab.

Only the cleaning of the magnet yokes is described, the same method can be used to clean the coil unit and the cables. The following steps should be followed:

1. Clean the working station with the isopropanol cleaning wipes.
2. Blow filtered compressed air into the gap between each pair of magnets.
3. Inspect the yoke with the blacklight installation for dust particles.

UV blacklight can cause irreversible damage to the eyes and other tissue when exposed. When using a UV blacklight installation wear appropriate protective clothing and glasses.

If there is a need for intensive cleaning, then steps 4 to 6 should be followed, if not these steps can be ignored and you can move on to step 7.

4. Clean the working station again with isopropanol wipes.
5. Place the magnet yoke on the cleaned working station.
6. Blow filtered compressed air into the side of the yoke. Repeat for the other side.
7. Clean the yoke with a cleanroom compatible vacuum cleaner. Repeat for the other side.
8. Clean all sides of the magnet yoke with isopropanol cleaning wipes.

Only move the isopropanol cleaning wipes in one direction, do not move back and forth.

9. Clean the inside of the magnet yoke with an isopropanol cleaning wipe and a cotton swab.
10. Inspect the magnet yoke with the blacklight installation for remaining dust particles.

Figure 4.1: Cleaning steps of an ironless motor.

If there are still dust particles visible, they can be removed with an isopropanol wipe and a cotton swab until the surface is cleaned to an acceptable level. An indication of some of the cleaning steps can be seen in figure 4.1.

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 magnet yokes to the mounting surface of the machine. After this the coil unit can be mounted to the slide, and the coil unit can be connected. In the next paragraphs these steps are shown in more detail. From a magnetic point of view the installation order of the mechanics is not critical, because there is no attraction present between the coil unit and magnet yokes. Before mounting the coil unit and the magnet yokes, special attention must be paid to the mounting surface of the motor, this is described in paragraph 4.2.1.

4.2.1 Requirements for the mounting surface

The magnet yokes and coil unit have to be aligned with respect to each other. This is accomplished by the machine's construction. For the slide and the mounting frame, we prescribe flatness (R), parallelism (S) and the separation between the two mounting faces (V) according to figure 4.2 and table 4.1. Also the recommended total height (H) is listed in this table, it is also possible to use a larger height, but then you will experience force loss of the motor.

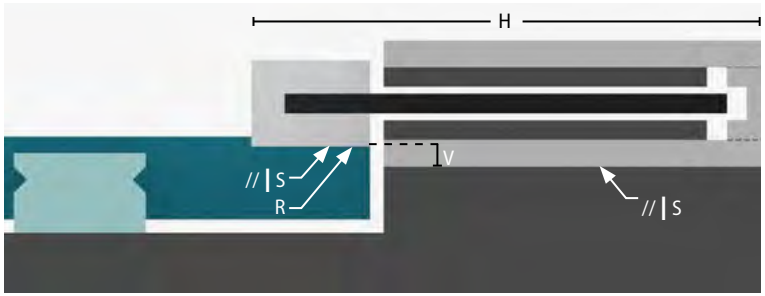

Figure 4.2: Installation dimensions.

Series	Flatness	Parallelism	Height	Separation
	R (mm)	S (mm)	H (mm)	V (mm)
UC	0.02	0.02	51 ±0.2	0.375 ±0.05
UF	0.05	0.02	53 ±0.2	0.625 ±0.05
UM	0.05	0.05	68 ±0.2	5.55 ±0.1
UL	0.1	0.05	105 ±0.2	8.2 ±0.1
UXA	0.1	0.05	124.8 ±0.2	11.5 ±0.1
UXX	0.1	0.05	124.8 ±0.2	16.5 ±0.1

Table 4.1: Installation tolerances.

Both sides of the UM, UL and UX coil unit can be used for mounting to the slide, as long as the values from table 4.1 are followed. For the UC and UF series, the top of the coil unit can also be used for mounting. For these motors it is however not allowed to use the side where the cable exits the motor for mounting.

It can be helpful to use milled reference surfaces at the top of the coil unit and the bottom of the magnet yoke to guarantee the correct height H. If this is done, it is important to keep the height of this milled reference small and to make sure that the edge does not force the parts out of alignment. The references are meant to ensure the position of the parts, not to tighten the parts there. The magnet yokes also have dowel pin holes which can be used optionally.

4.2.2 Magnet yoke mounting

Handle the components of the linear motor with care, packed as well as unpacked. Especially the magnet yokes are sensitive to mechanical shocks. Never drop a magnet yoke or release it in an uncontrolled way.

The magnet yokes 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 cm of the magnetic side of the magnet yoke.

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 yokes.

The magnet yokes do attract each other while mounting. Take care that the closing plate of one magnet yoke do not damage the magnets of the neighboring magnet yoke while mounting.

It is recommended to start the mounting of the magnet track with the middle (and preferably the longest) magnet yoke. This magnet yoke can be aligned using the dowel pins or a milled reference. Fix the magnet yoke on the mounting surface with bolts using the prescribed tightening torque from table 4.2. These parts are necessary to fix the coil unit to the slide and the magnet yokes to the mounting frame. The bolts should be made out of steel, dowel pins should be made out of stainless steel and maximum 3 mm deep. All mounting holes must be used.

The next yokes can be mounted with mechanical contact using the mutual attraction force of the magnet yokes, they should not be

aligned on the dowel pins. Using a track of pins has the disadvantage that rotational mounting is difficult and that mounting can become impossible because of the tolerances. The yokes are designed for a contact mounting without guaranteed gap between them. There is no danger of mounting the magnet yokes with an incorrect orientation, the magnet yokes are "Murphy-safe". A 180° rotated magnet yoke does not have any effect on the motor function.

Features	UC	UF	UM	UL	UXA	UXX
Bolts	M4, DIN912			M5, DIN912	M6, DIN912	
Tightening torque	1.0-2.0 Nm			2.0-3.0 mm	3.0-5.0 mm	
Dowel pins (optional)	3h8, DIN7					

Table 4.2: Bolt and dowel pin characteristics for the magnet yokes.

Apply the principle of controlled rotational mounting, see figure 4.3. A straight directing and placing of the magnet yokes implies the risk of striking due to magnetic forces. Uncontrolled approach may cause damage to the magnets.

Figure 4.3: Principle of controlled rotational mounting.

4.2.3 Coil unit mounting

The mounting of the coil unit on appropriate and clean mounting surfaces is straightforward because no attraction forces are present between the coil unit and the magnet yokes. The coil unit can be placed into the machine by hand carefully, pushed to the axial reference (if used) and fixed with steel bolts. The bolt characteristics can be found in table 4.3, the coil units do not have dowel pins.

Features	UC	UF	UM	UL	UX
Bolts	M3, DIN912			M4, DIN912	M5, DIN912
Tightening torque	1.0-2.0 Nm			2.0-3.0 mm	3.0-5.0 mm
Depth bolt in thread hole	Top: through coil unit; side: 1.5-2.8 mm		Not applicable		

Table 4.2: Bolt characteristics for the coil units.

For applications which are susceptible to vibrations, the bolts have to be secured against loosening by means of rings or (Loctite) threadlocker.

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 UM, UL and UX linear motors 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 UX3S has a 3 meter long flex power cable, which is suitable for a cable chain, and a 1

meter long non-flex sensor cable. The UC and UF series coil units have a 1 meter flex cable. The UC series coil units do not have temperature sensors inside, and two of the 5 wires of its cable do not have a function. All other coil units have 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 ironless coil units can be seen in figures 4.4, 4.5 and 4.6.

Only the UX3S 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.

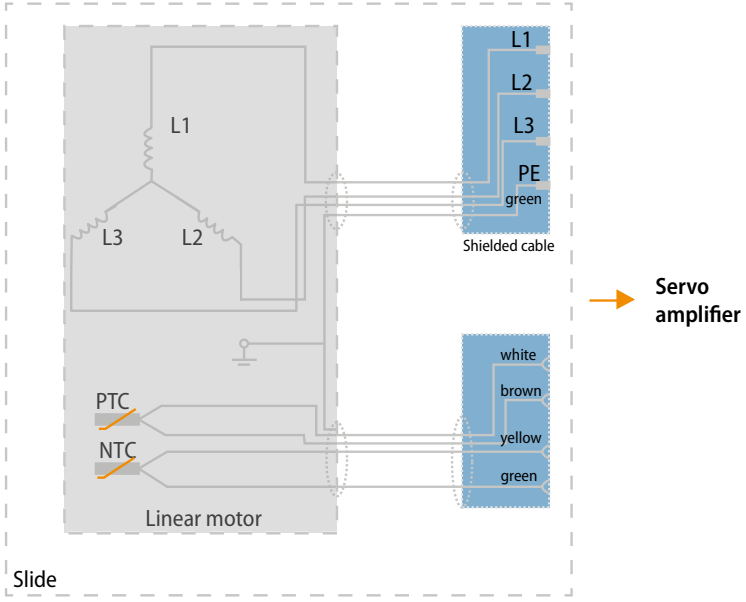

Figure 4.4: Wiring scheme of UM, UL and UX series coil units.

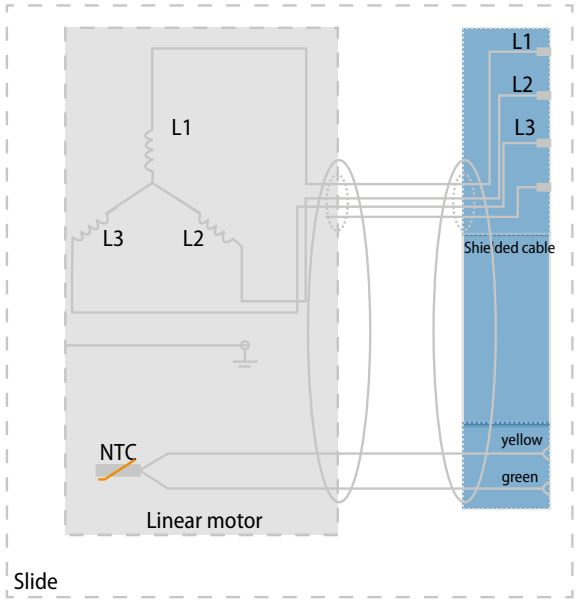

Figure 4.5: Wiring scheme of UF series coil units.

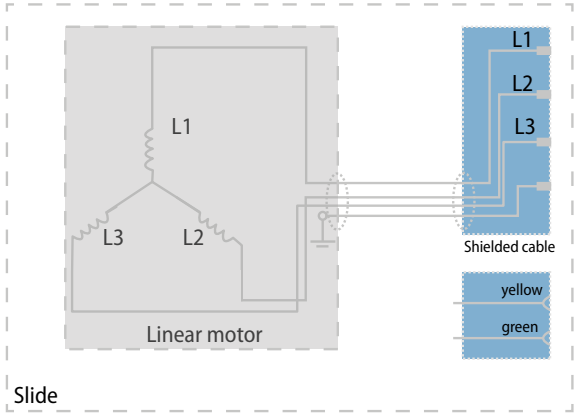

Figure 4.6: Wiring scheme of UC series coil units.

4.3.2 Power wires

Table 4.4 indicates the function of the power cable. The details of the power cable can be seen in Appendix C. The UC and UF series only have one cable, for this cable there is no green protective earth wire. 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 4.3.9 Polarization test.

Power cable		Color code	Connection to servo controller
3 phases	L1	Black	3 phases
	L2	Red	
	L3	White	
Protective earth		Green	Protective earth
Shield			Protective earth

Table 4.4: 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. 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 a short as possible cable length, at all times below the critical length;
- using a sine filter;
- sing a multiple step drive.

4.3.4 Protective earth and EMC

Internally the motor's PE wire (green) 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 UM, UL and UX coil units have two temperature sensors, one PTC and one NTC sensor. The UF coil units have an NTC sensor, the UC coil units do not have temperature sensors. Table 4.5 indicates the function of the four sensor wires. The details of the sensor wires can be seen in Appendix C. The temperature sensor wires can be cut off if the temperature sensors are not being used.

Sensor cable	Color	Connection to servo controller
PTC (if present)	Brown	PTC
PTC (if present)	White	PTC
NTC (if present)	Green	NTC
NTC (if present)	Yellow	NTC
Shield		Protective earth

Table 4.5: Sensor wires identification.

4.3.6 Temperature protection

The temperature sensors are normally used for overheating protection of the coil unit. The NTC sensor can be used for monitoring temperature, the PTC can be used as cut-off sensor when the maximal temperature is exceeded. The two temperature sensors are located between two coils. The maximum coil temperature of UC coil units is 80°C, for all other coil units it is 110°C.

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 maximum. 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 110°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 4.6 and figure 4.7 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 4.6: Characteristic PTC values.

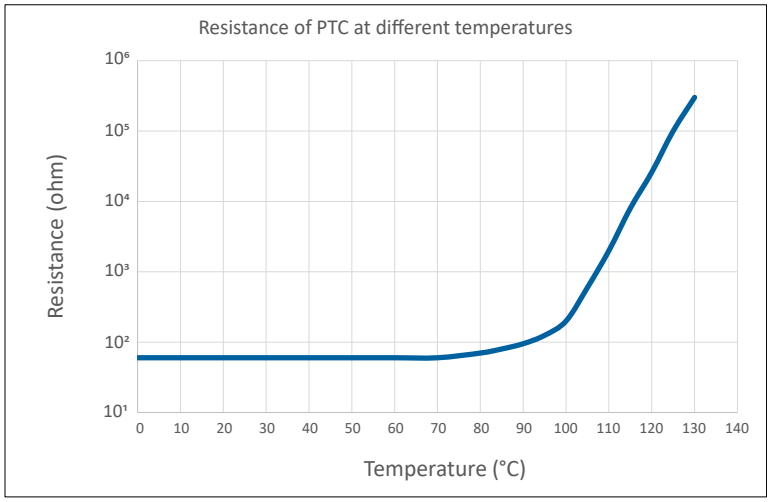

Figure 4.7: Temperature dependence of the PTC-1k sensor.

4.3.8 NTC specification

Most coil units have an NTC temperature sensor for monitoring the temperature. Because of the well-defined and smooth resistance curve, this sensor type is optimal for monitoring. In table 4.7 and figure 4.8 the temperature dependence of the NTC sensor used in the coil units can be seen. Table 4.8 shows other specifications of the sensor.

T (°C)	0	10	20	30	40	50	60
R (ohm)	32650	19990	12490	8057	5327	3603	2488

T (°C)	70	80	90	100	110	120	130
R (ohm)	1752	1258	918	680	511	389	301

Table 4.7: Temperature dependence of the NTC sensor.

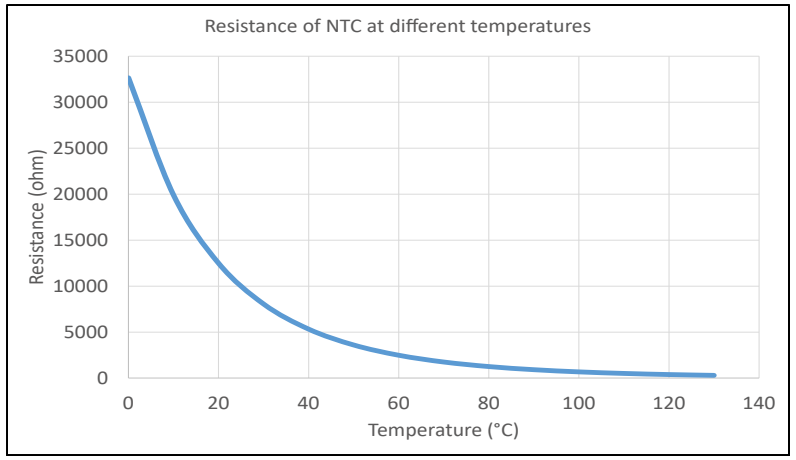

Figure 4.8: Temperature dependence of the NTC sensor.

Tolerance (ΔR/R)	5%
Maximum power	60 mW

Table 4.8: Specifications of the NTC 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 ironless 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

From a magnetic point of view the installation order of the mechanics is not critical, because no attraction is present between the coil unit and the magnet yokes. The de-installation order is as follows:

1. Disconnect the wiring from the coil unit.
2. Dismount the coil unit from the machine parts.
3. Dismount the magnet yokes from the machine's mounting surface.

5. ADDITIONAL INSTALLATIONS

Ironless motors from Tecnotion can be equipped with a digital Hall module for commutation. There is no analog Hall module available for this motor series. The module uses the magnet yoke as a linear scale, a separate scale is not required in this case. All information regarding these modules can be found in paragraphs below.

5.1 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. There are five different digital Hall modules for ironless motors, there is a different one for every motor series. Figure 5.1 shows an example of a digital Hall module.

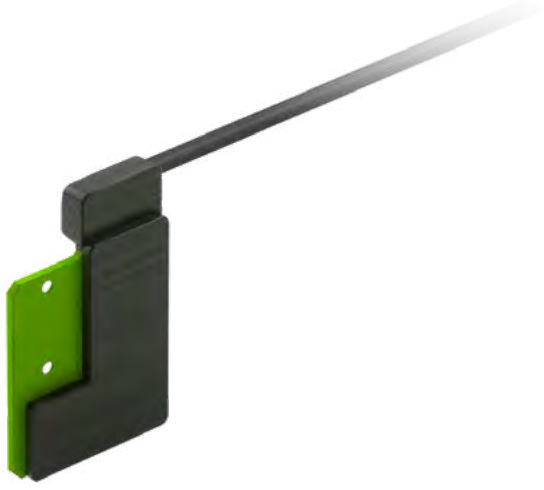

Figure 5.1: Digital Hall module for ironless motors.

The specifications of the digital 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.

Parameter	Specifications
Signal	Sink type 20mA max, 5 volt DC (3 signals)
Signal period	Equals magnet pitch of the motor series (see table 2.2)
Accuracy	Signal period divided by 6
Power supply	4.5-24 volt DC, 40 mA
Mass	Around 10 grams

Table 5.1: Digital Hall module specifications.

5.1.1 Mechanical interface

The coil units in the UM, UL and UX series contain two small holes on the cable side of the coil unit. These two holes should be used for mounting the Hall module. The module should be mounted with two M2x3 countersink screws. This can be seen in Appendix C.

The coil units in the UC and UF series do not have holes for mounting the Hall module. For these motors the PCB is sticking out of the Hall module, and this PCB should be put directly to the casting of the coil unit at the cable side. Only for the UC3 inline coil unit, the Hall module should be mounted at the non-cable side. This can also be seen in Appendix C.

5.1.2 Electrical interface

The cable of the digital Hall module should be connected to the controller according to table 5.2. Only one ground wire needs to be connected for proper grounding. 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
White	0 volt
Brown	4.5-24 volt
Grey	Hall A
Yellow	Hall B
Red	Hall C
Green	Ground
Pink	Ground
Blue	Ground
Shield	Ground

Table 5.2: Digital Hall module electrical connections.

Figures 5.1, 5.2 and 5.3 show the signals from the digital Hall module over one full magnet pitch. There are three different graphs depending on the motor series. The figures indicate 1 full magnet pitch with a normalized x-axis. The magnet pitches of all motor series can be seen in table 2.2.

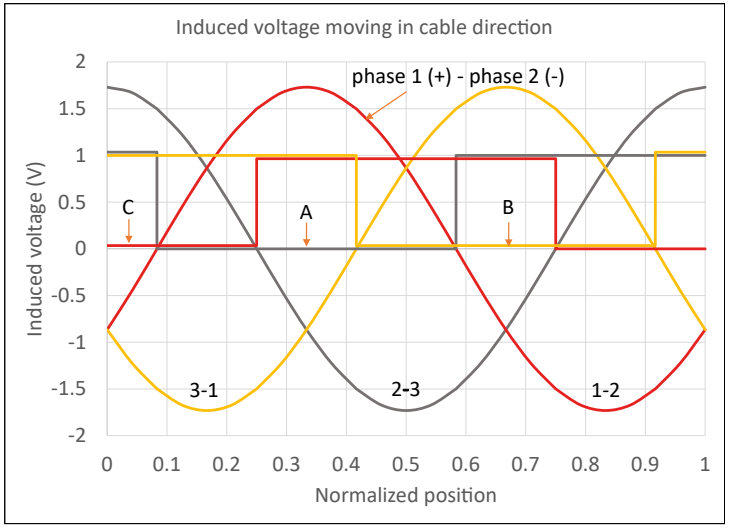

Figure 5.1: Digital Hall signal of the UC3 inline coil unit.

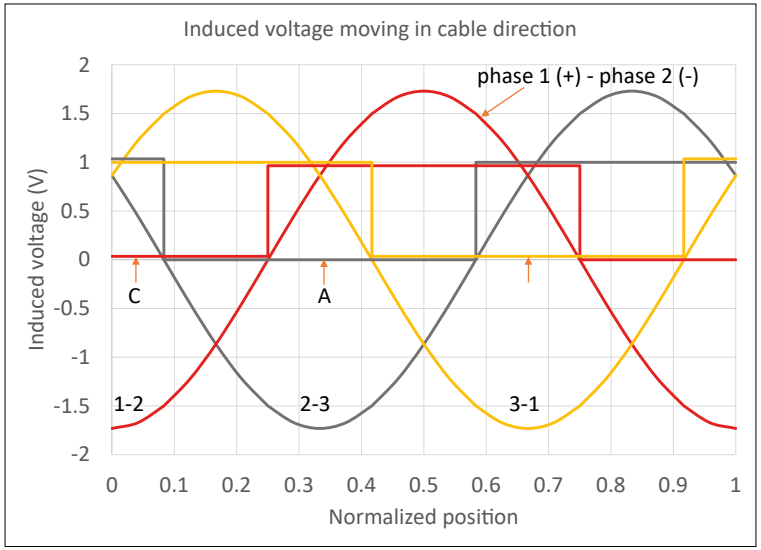

Figure 5.2: Digital Hall signal of the UC and UF coil units (except the UC3 inline).

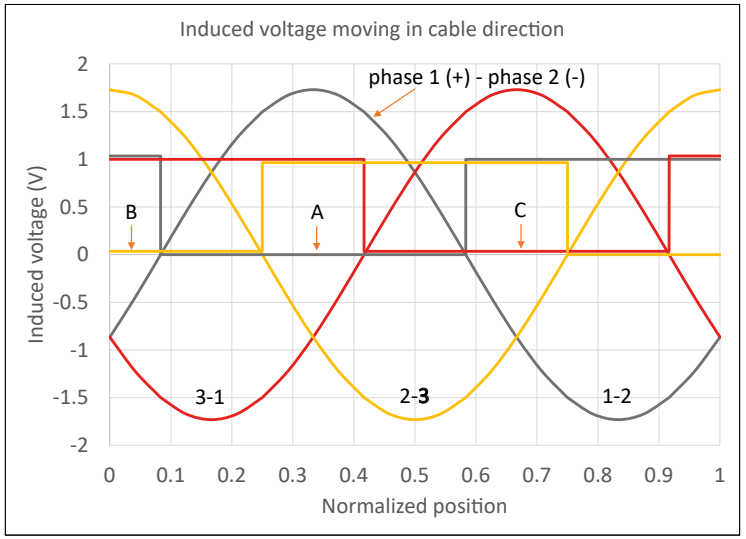

Figure 5.3: Digital Hall signal of the UM, UL and UX coil units.

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. For UM, UL and UX coil units, 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;
- peak current;
- maximum speed;
- resistance;
- induction;
- switching resistance of PTC (if available);
- 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.
  - -25 – 55°C, with a maximum rate of change of 20 K per hour (different from norm).
  - 5 – 95% relative humidity (different from norm).
  - No condensation.
- 1B1
  - Applies to storage locations with environmental controls in place to prevent the growth of mould and physical control to prevent attack by animals.
- 1C2
  - Applies to locations in the immediate vicinity of industrial sources, with chemical emissions and/or with heavy traffic. 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 ICAO (International Civil Aviation Organization) 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 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 × 1200 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 secondary and tertiary 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 in below are for the primary product package 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 mould growth and attack by animals, or in compartments with environmental controls in place to prevent mould 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 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 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 mould 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.
- 3M11
  - Applies to locations experiencing low levels of vibration and insignificant levels of shock, such as those transmitted from air conditioning, machines or passing vehicles in the vicinity.

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direct drive in motion

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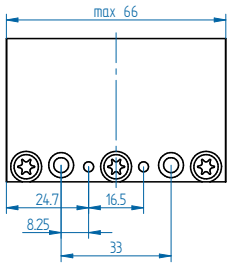
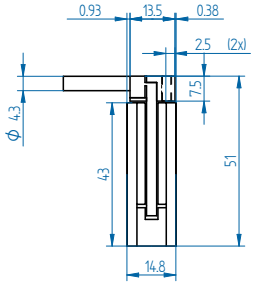
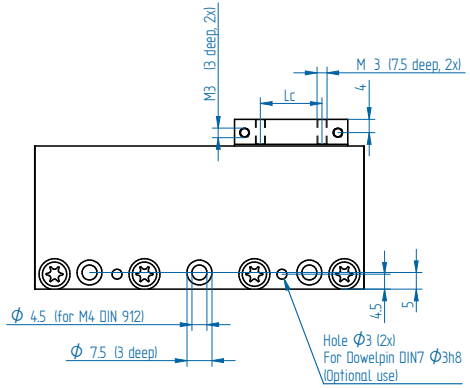
APPENDIX A | Dimensions - UC

UC 66mm

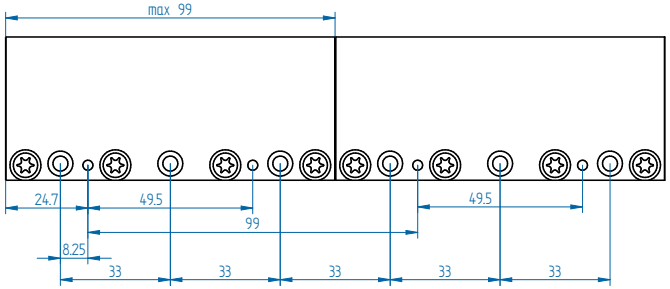


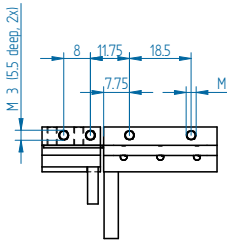




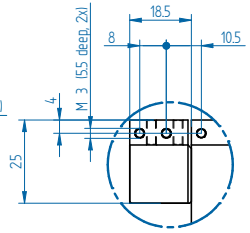
	Lc (mm)
UC3	18.5
UC6	51.5

2x UC 99mm



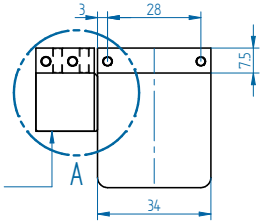


Bottom view



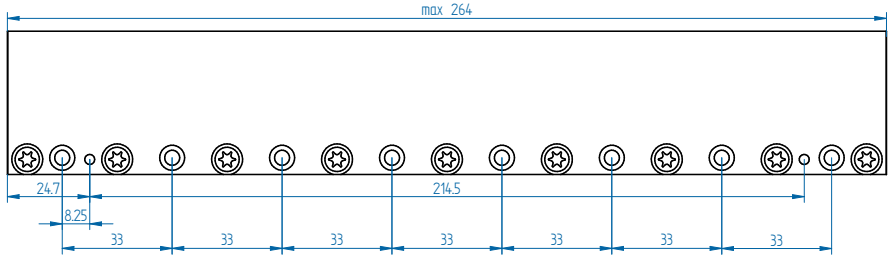
DETAIL A

UC 3

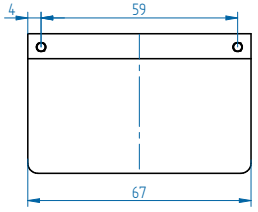


Optional: Digital Hall Module

UC 264mm



UC 6



** All sizes are in mm*

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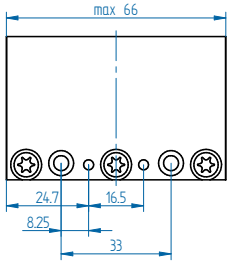
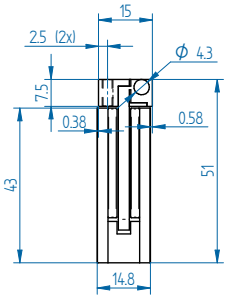
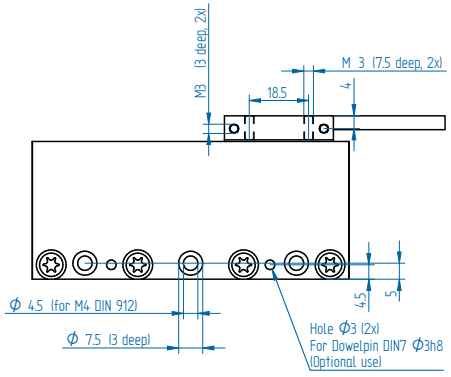
APPENDIX A | Dimensions - UC3 inline

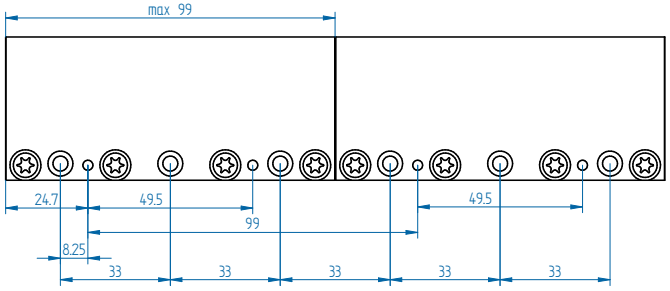
UC 66mm

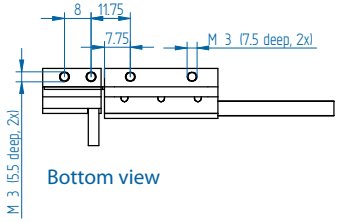




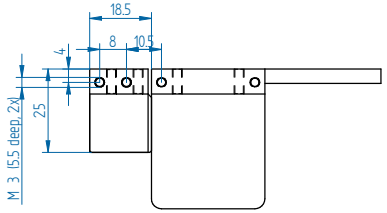


2x UC 99mm

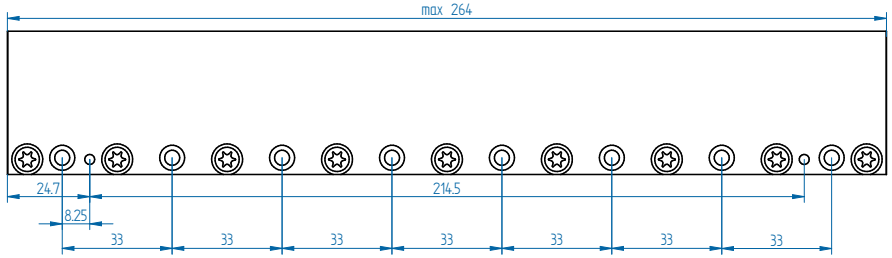




Bottom view



UC 264mm



** All sizes are in mm*

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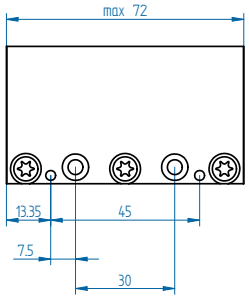
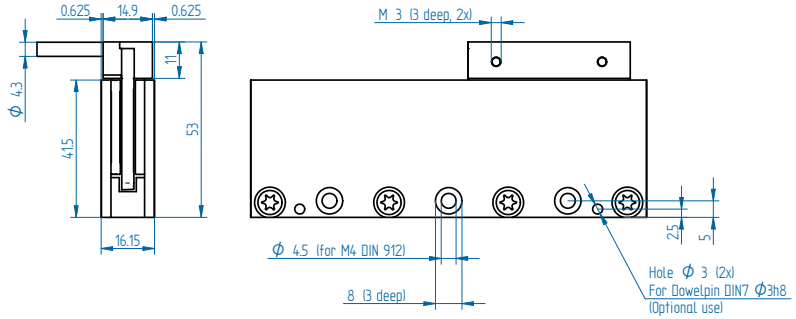
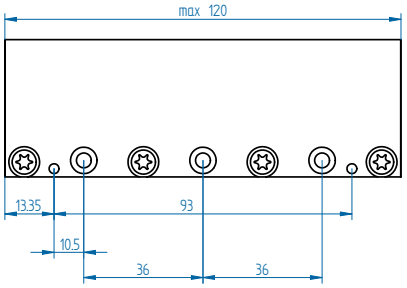
APPENDIX A | Dimensions - UF

UF 72mm

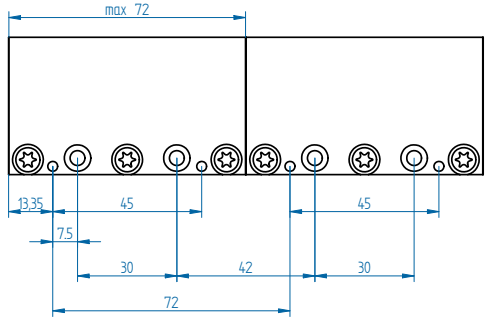


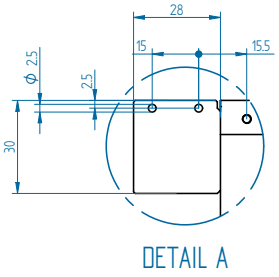


UF 120mm

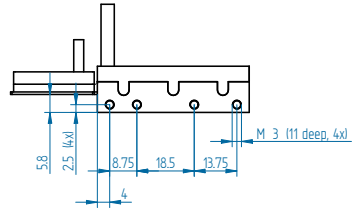


2x UF 72mm

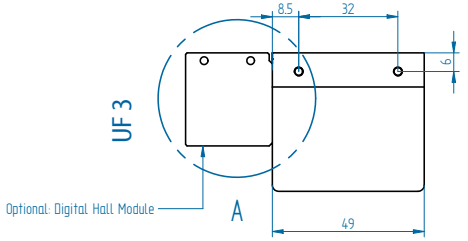




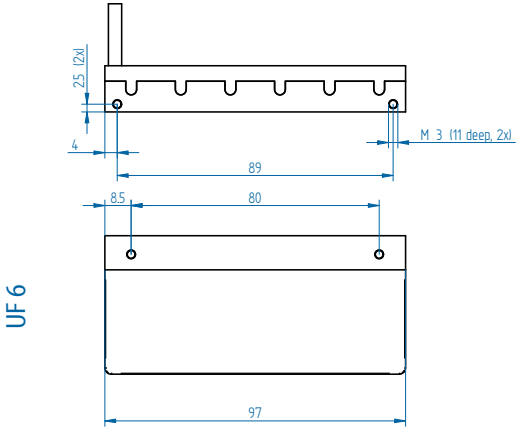
DETAIL A



UF 3



UF 6



** All sizes are in mm*

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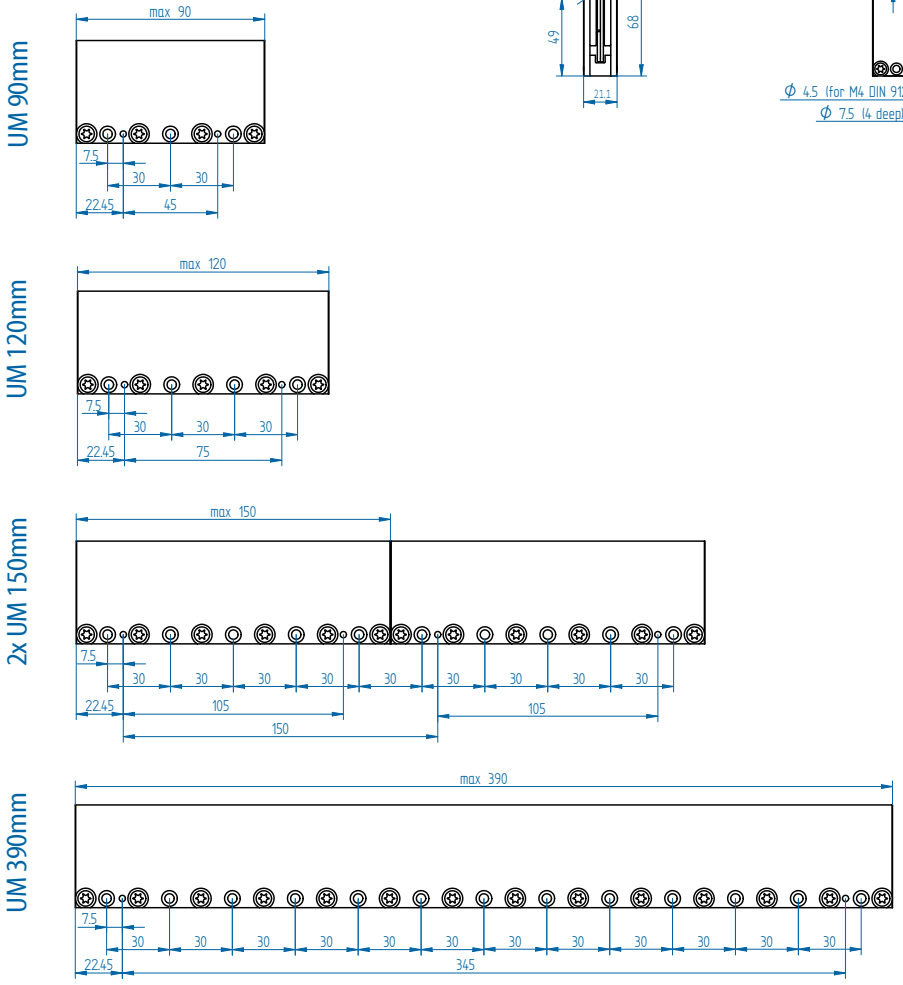
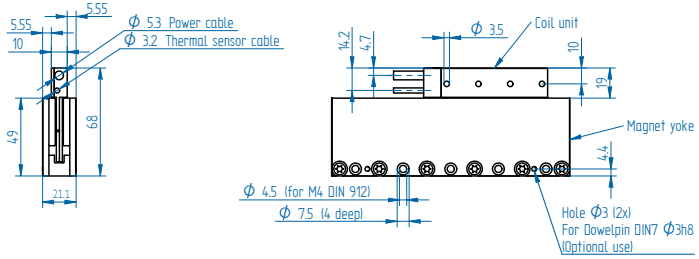
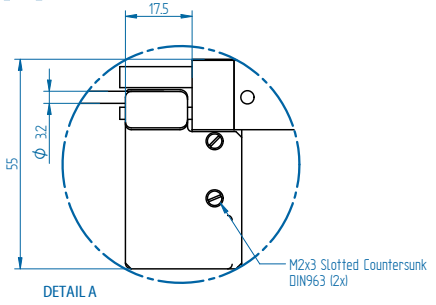
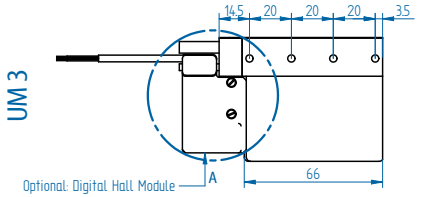
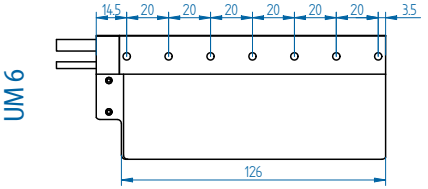
APPENDIX A | Dimensions - UM

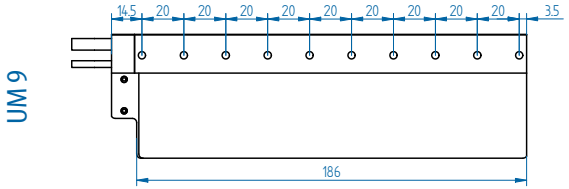


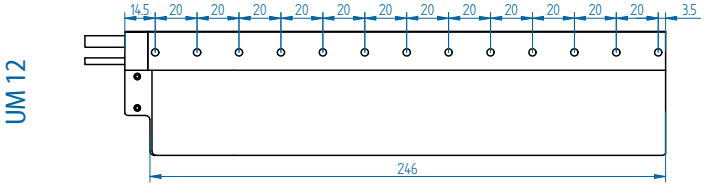












*All sizes are in mm

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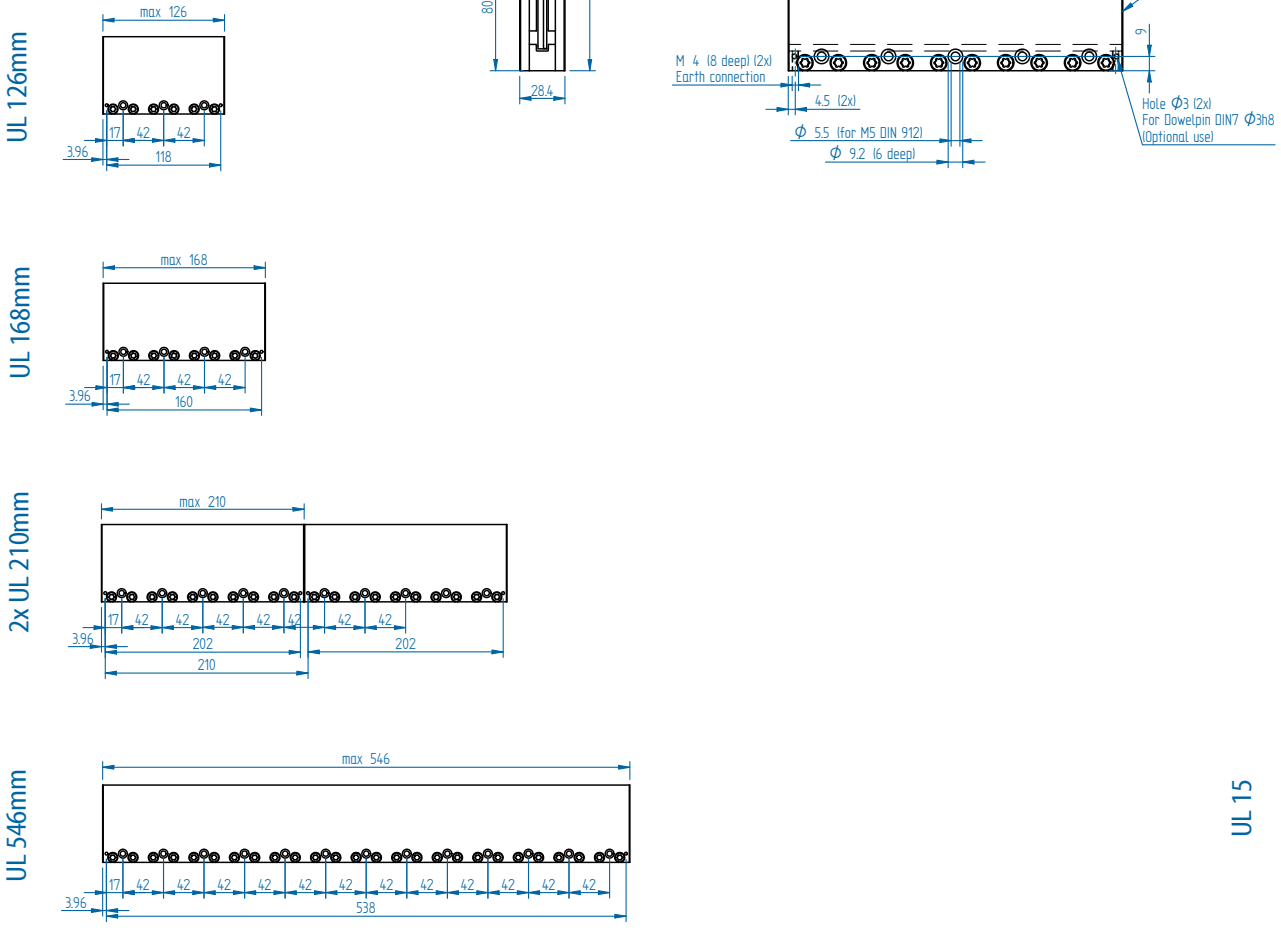
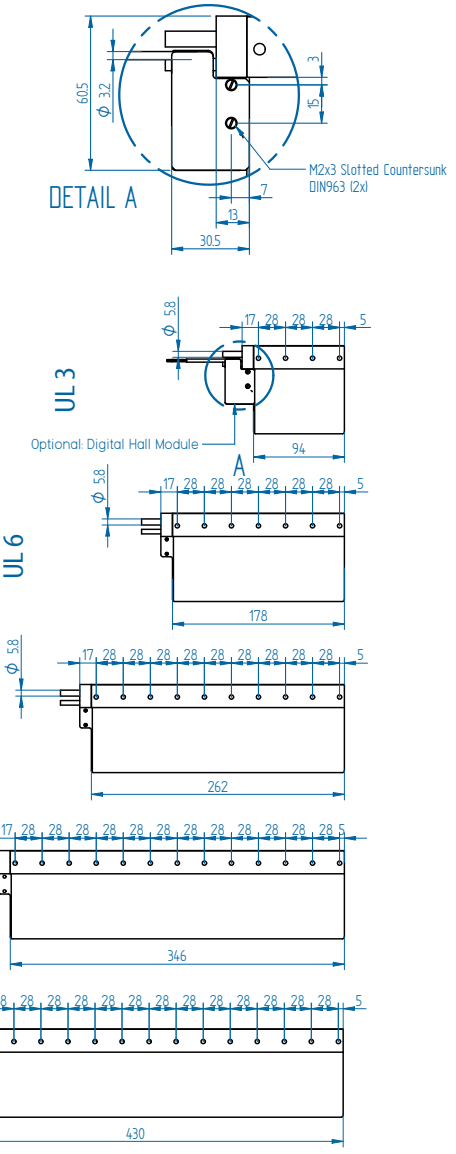
APPENDIX A | Dimensions - UL





** All sizes are in mm*

3D CAD files can be downloaded from our website.

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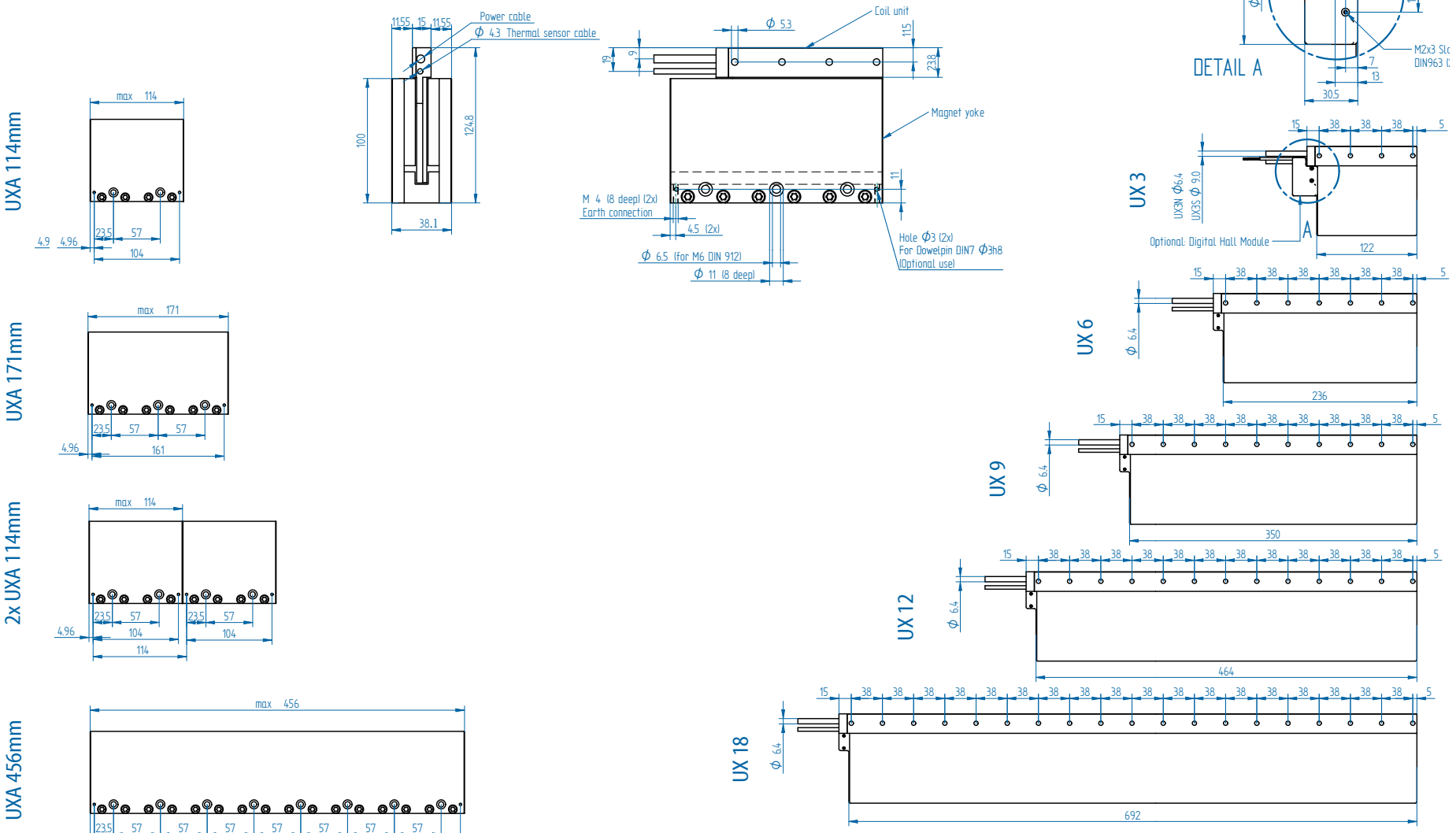
APPENDIX A | Dimensions - UXA



** All sizes are in mm*

3D CAD files can be downloaded from our website.

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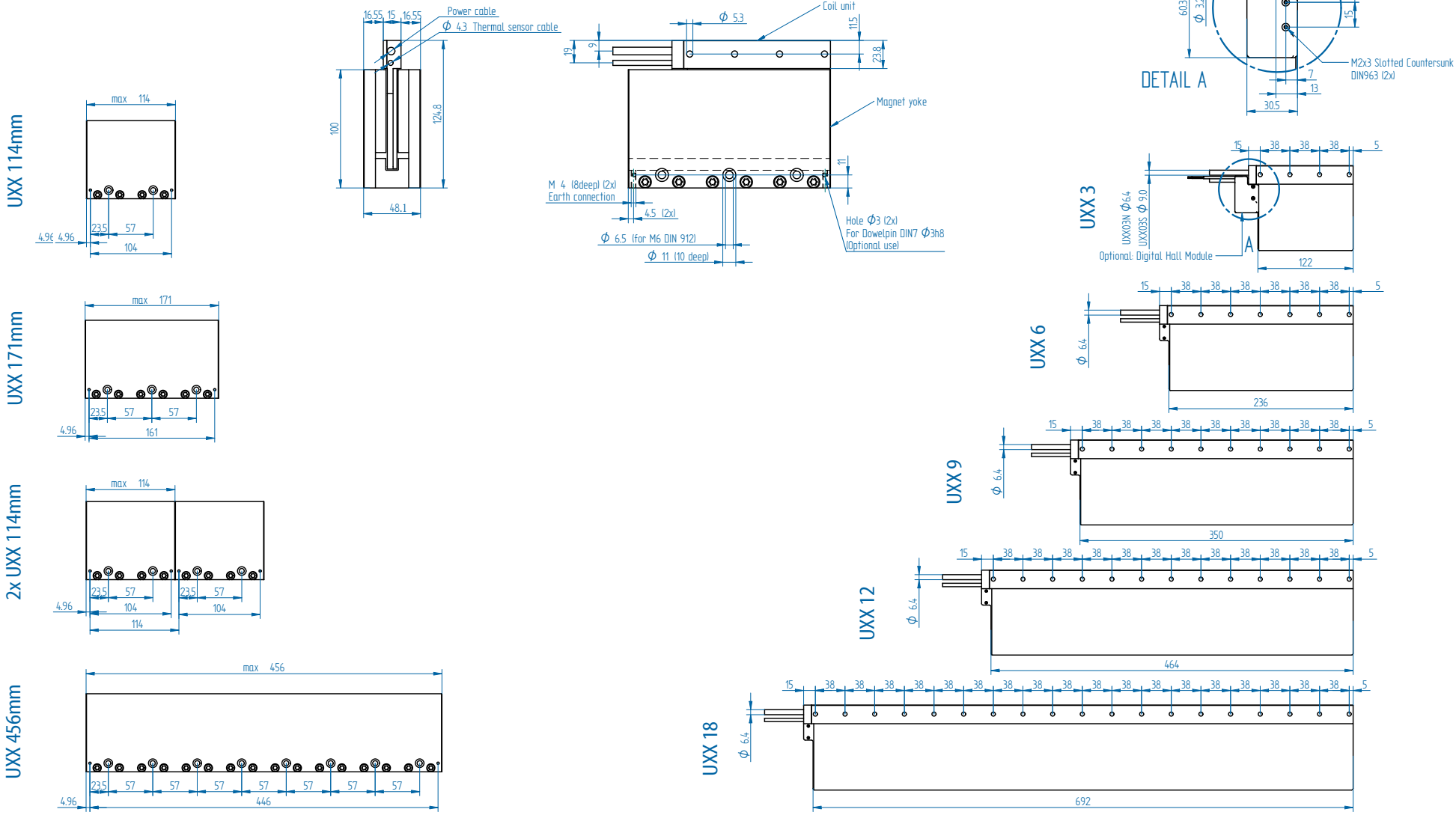
APPENDIX A | Dimensions - UXX



** All sizes are in mm*

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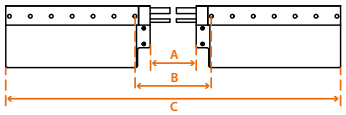
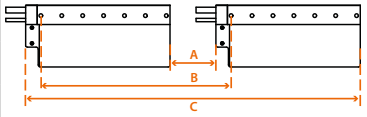
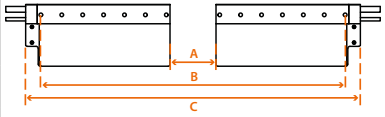
APPENDIX B | Coupling - UC - UF - UM series

Coupling possibilities	Combination	N	S	Distance coil units (A)	Distance mount hole (B)	Total length coil units (C)	L1	L2	L3
	UC3 + UC6	N/A		23.75	30.75	124.75	L3	L2	L1
	UC6 + UC6	N/A		23.75	31.75	157.75	L3	L2	L1
	UF3 + UF6	N/A		27	44	173	L2	L1	L3
	UF6 + UF6	N/A		27	44	221	L2	L1	L3
	UM6 + UM9	X	X	56	85	392	L1	L3	L2
	UM9 + UM9	X	X	56	85	452	L1	L3	L2
	UM9 + UM12	X	X	56	85	512	L1	L3	L2
	UM12 + UM12	X	X	56	85	572	L1	L3	L2
	UC3 + UC6*	N/A		26.5	92.5	127.5	L2	L3	L1
	UC6 + UC6	N/A		26.5	93.5	160.5	L2	L3	L1
	UF3 + UF6*	N/A		23	120	169	L1	L2	L3
	UF6 + UF6	N/A		23	120	217	L1	L2	L3
	UM6 + UM9*	X	X	62	260	398	L2	L3	L1
	UM9 + UM9	X	X	62	260	458	L2	L3	L1
	UM9 + UM12*	X	X	62	320	518	L2	L3	L1
	UM12 + UM12	X	X	62	320	578	L2	L3	L1
	UC3 + UC6	N/A		1.75	95.75	102.75	L1	L3	L2
	UC6 + UC6	N/A		1.75	127.75	135.75	L1	L3	L2
	UF3 + UF6	N/A		3	132	149	L1	L3	L2
	UF6 + UF6	N/A		3	180	197	L1	L3	L2
	UM6 + UM9	X	X	8	315	344	L3	L2	L1
	UM9 + UM9	X	X	8	375	404	L3	L2	L1
	UM9 + UM12	X	X	8	435	464	L3	L2	L1
	UM12 + UM12	X	X	8	495	524	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. All sizes are in mm.

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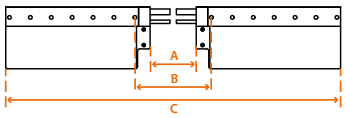
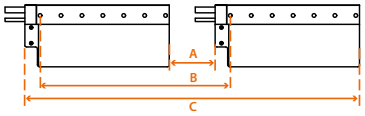
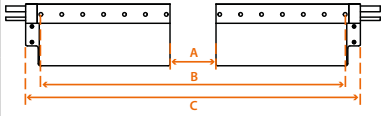
APPENDIX B | Coupling - UL series

Coupling possibilities	Combination	N	S	Distance coil units (A)	Distance mount hole (B)	Total length coil units (C)	L1	L2	L3
	UL9 + UL9	X	X	70	104	618	L3	L2	L1
	UL9 + UL12	X	X	70	104	702	L3	L2	L1
	UL12 + UL12	X	X	70	104	786	L3	L2	L1
	UL12 + UL15	X	X	70	104	870	L3	L2	L1
	UL15 + UL15	X	X	70	104	954	L3	L2	L1
	UL9 + UL9	X	X	62	336	610	L1	L2	L3
	UL9 + UL12*	X	X	76	434	708	L3	L1	L2
	UL12 + UL12	X	X	76	434	792	L3	L1	L2
	UL12 + UL15*	X	X	76	518	876	L3	L1	L2
	UL15 + UL15	X	X	76	518	960	L3	L1	L2
	UL9 + UL9	X	X	12	526	560	L3	L2	L1
	UL9 + UL12	X	X	12	610	644	L3	L2	L1
	UL12 + UL12	X	X	12	694	728	L3	L2	L1
	UL12 + UL15	X	X	12	778	812	L3	L2	L1
	UL15 + UL15	X	X	12	862	896	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. All sizes are in mm.

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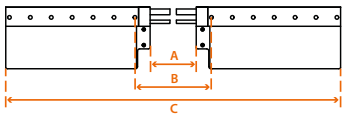
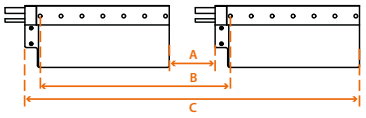
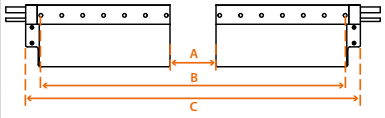
APPENDIX B | Coupling - UX series

Coupling possibilities	Combination	N	S	Distance coil units (A)	Distance mount hole (B)	Total length coil units (C)	L1	L2	L3
	UX6 + UX9	X	X	74.5	104.5	456.5	L1	L3	L2
	UX9 + UX12	X	X	74.5	104.5	912.5	L1	L3	L2
	UX9 + UX18	X		74.5	104.5	1140.5	L1	L3	L2
	UX12 + UX12	X	X	74.5	104.5	1026.5	L1	L3	L2
	UX12 + UX18	X		74.5	104.5	1254.5	L1	L3	L2
	UX18 + UX18	X		74.5	104.5	1482.5	L1	L3	L2
	UX6 + UX9*	X	X	75	323	457	L2	L3	L1
	UX9 + UX12*	X	X	75	551	913	L2	L3	L1
	UX9 + UX18*	X		75	779	1141	L2	L3	L1
	UX12 + UX12	X	X	75	551	1027	L2	L3	L1
	UX12 + UX18*	X		75	779	1255	L2	L3	L1
	UX18 + UX18	X		75	779	1483	L2	L3	L1
	UX6 + UX9	X	X	18.5	598.5	628.5	L3	L2	L1
	UX9 + UX12	X	X	18.5	826.5	856.5	L3	L2	L1
	UX9 + UX18	X		18.5	1054.5	1084.5	L3	L2	L1
	UX12 + UX12	X	X	18.5	940.5	970.5	L3	L2	L1
	UX12 + UX18	X		18.5	1168.5	1198.5	L3	L2	L1
	UX18 + UX18	X		18.5	1396.5	1426.5	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. All sizes are in mm.

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APPENDIX C | Motor cable configuration

Power + sensor cable

Series	Length	Diameter	Configuration	Static bending radius	Dynamic bending radius	Mass
UF	1 meter	4.3 mm	3 x 0.25 mm^2 (AWG24) + 2 x 0.04 mm^2 (AWG32)	5x diameter	8x diameter	0.03 kg/m

The cable on the UF series is a flex cable with a maximum number of bending cycles of 15 million.

Power cable

Series	Length	Diameter	Configuration	Static bending radius	Dynamic bending radius	Mass
UC	1 meter	4.3 mm	3 x 0.25 mm^2 (AWG24)	5 x diameter	8 x diameter	0.03 kg/m
UM	1 meter	5.5 mm	4 x 0.36 mm^2 (AWG22)	10 x diameter	Not allowed	0.06 kg/m
UL3/6/9	1 meter	5.9 mm	4 x 0.56 mm^2 (AWG20)	10 x diameter	Not allowed	0.06 kg/m
UL12/15	1 meter	6.5 mm	4 x 0.82 mm^2 (AWG18)	10 x diameter	Not allowed	0.075 kg/m
UX3S	3 meter	8.5 mm	4 x 0.5 mm^2 (AWG21)	4 x diameter	10x diameter	0.10 kg/m
Other UX	1 meter	6.5 mm	4 x 0.82 mm^2 (AWG18)	10 x diameter	Not allowed	0.075 kg/m

The cable on the UC series is a flex cable with a maximum number of bending cycles of 15 million, the cable on the UX3S 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
UM	1 meter	3.4 mm	4 x 0.14 mm^2 (AWG26)	13 x diameter	Not allowed	0.02 kg/m
UL/UX	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
Digital	1.5 meter	3.2 mm	4 x 2 x 0.05 mm^2 (AWG30)	6 x diameter	13 x diameter	0.02 kg/m

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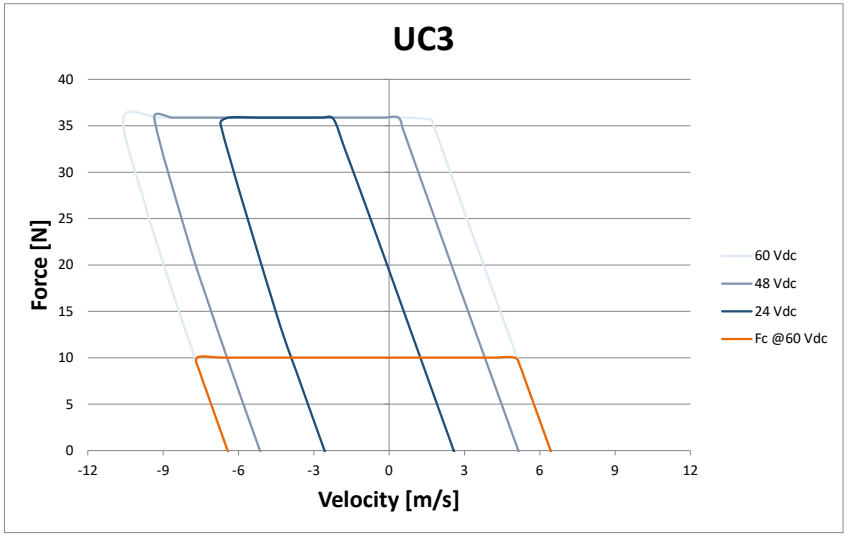
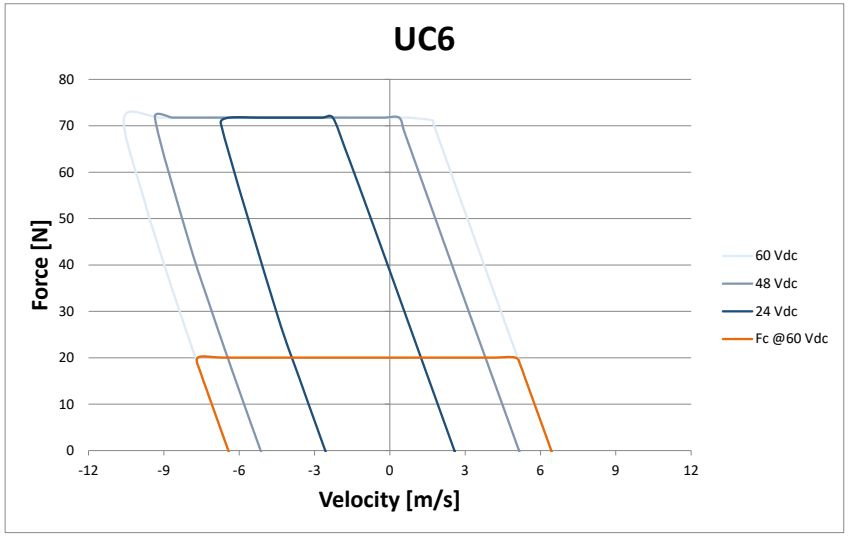
APPENDIX D | F/v graphs - UC series





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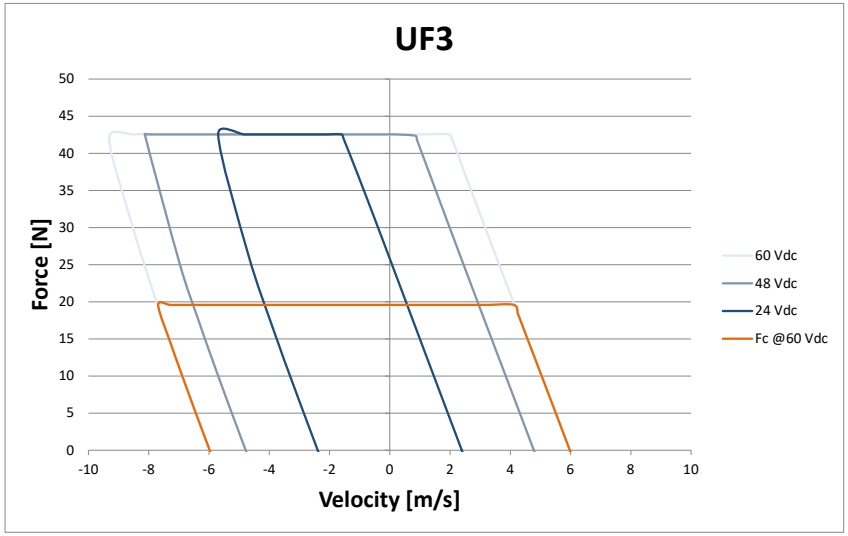
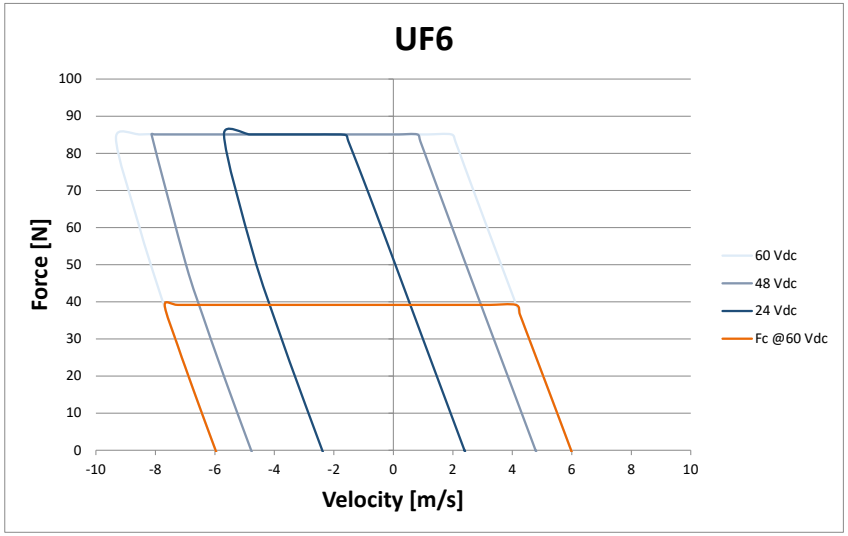
APPENDIX D | F/v graphs - UF series





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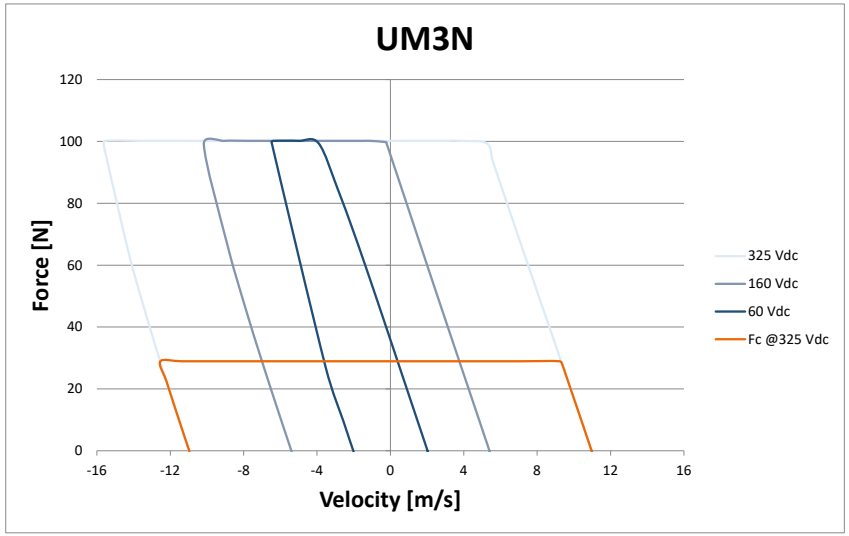
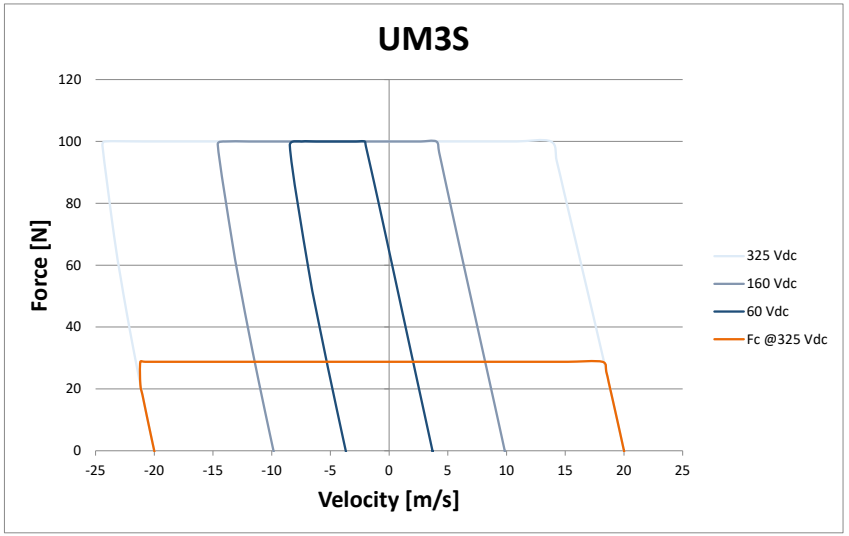
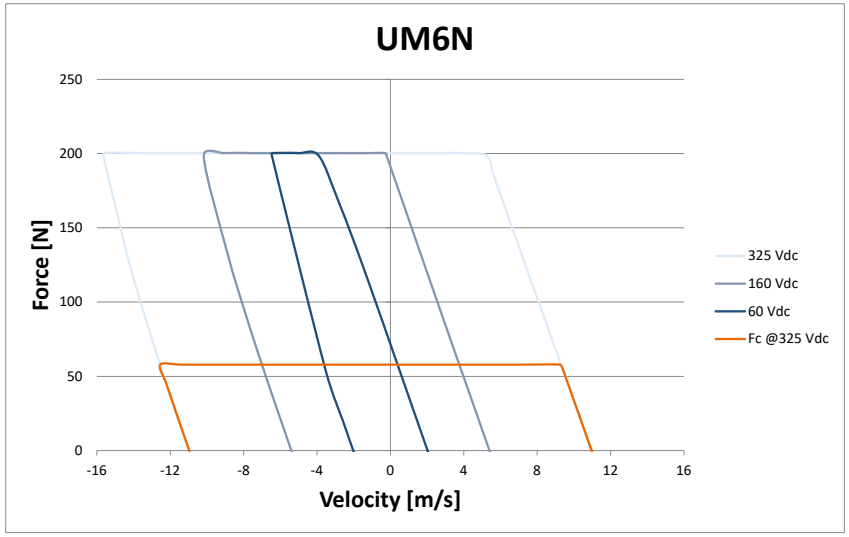
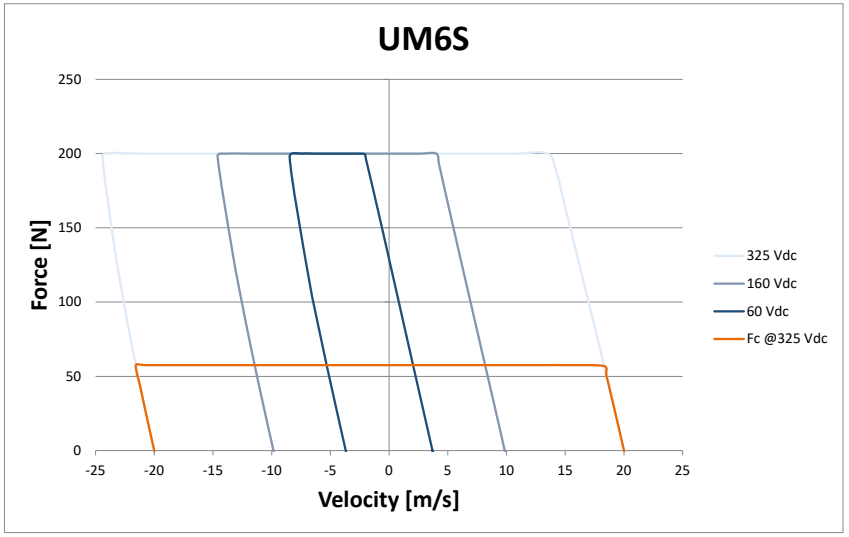
APPENDIX D | F/v graphs - UM series









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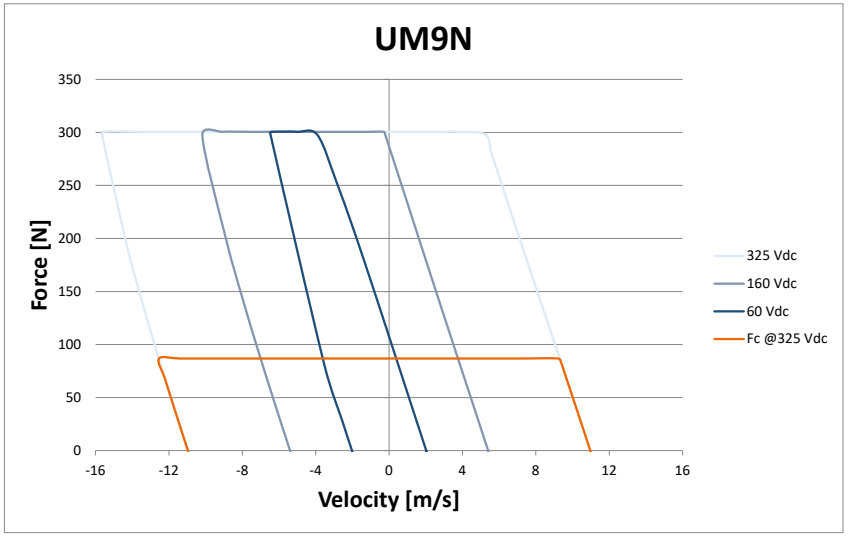
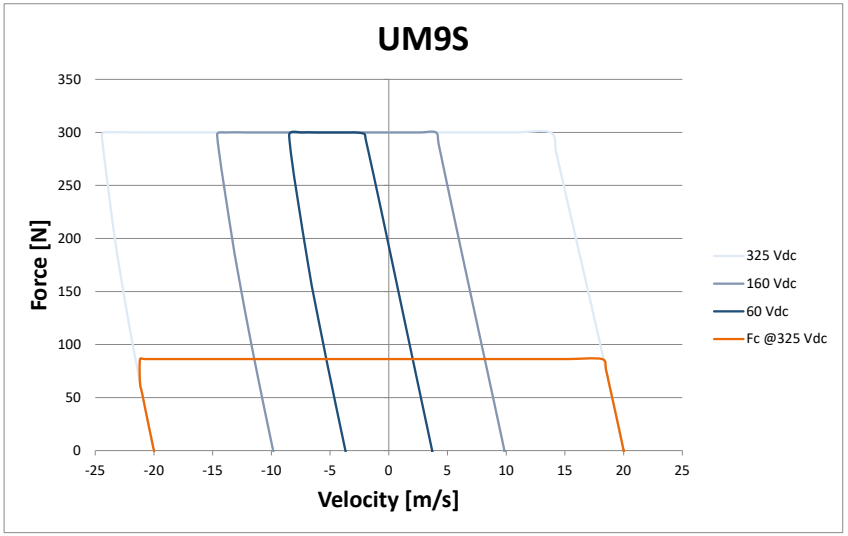
APPENDIX D | F/v graphs - UM series

UM9N



UM9S



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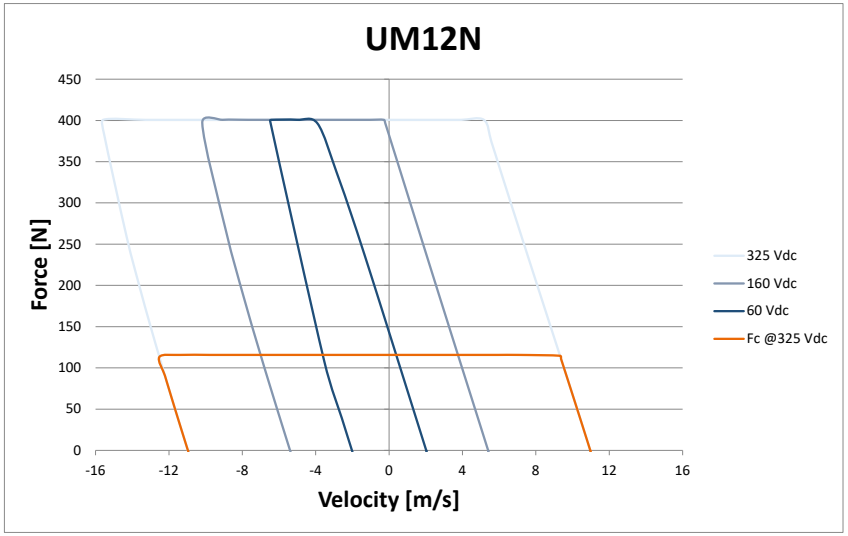

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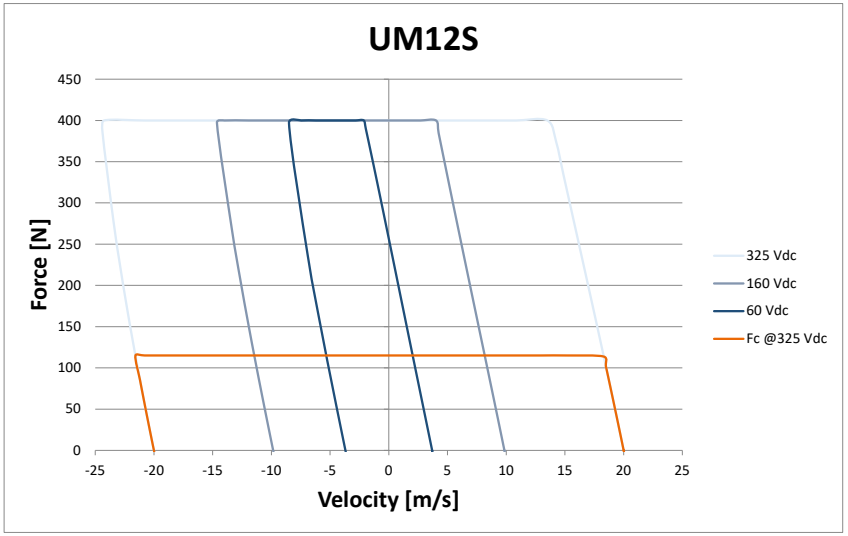

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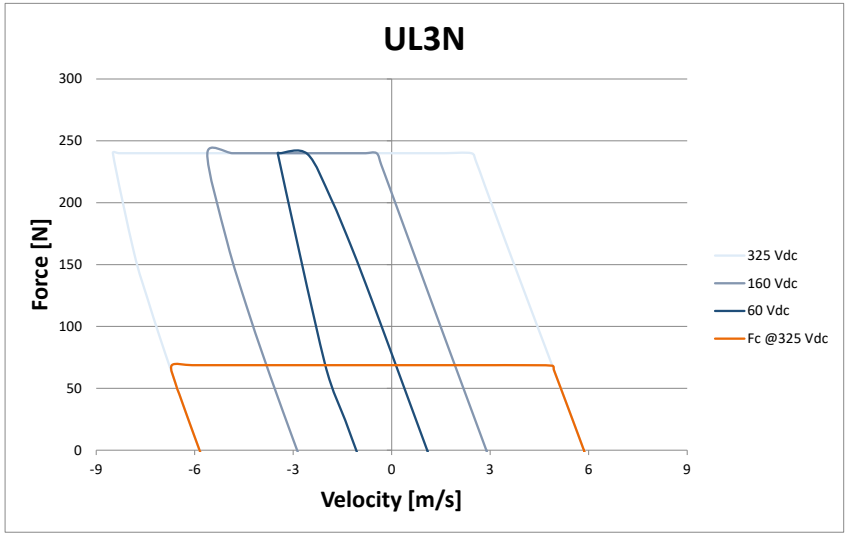
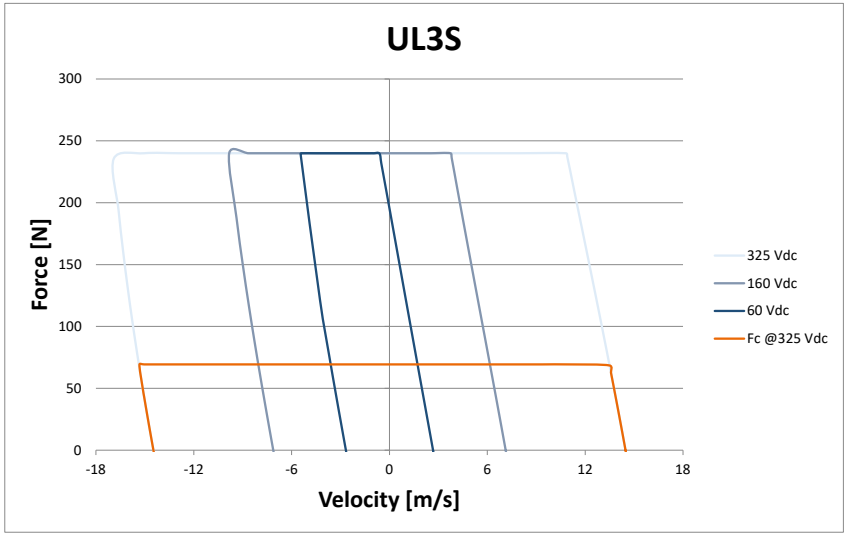
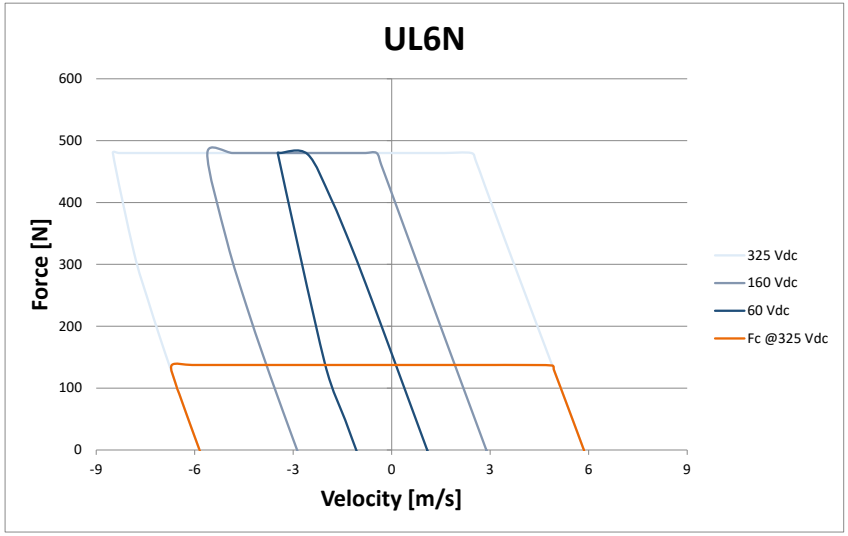
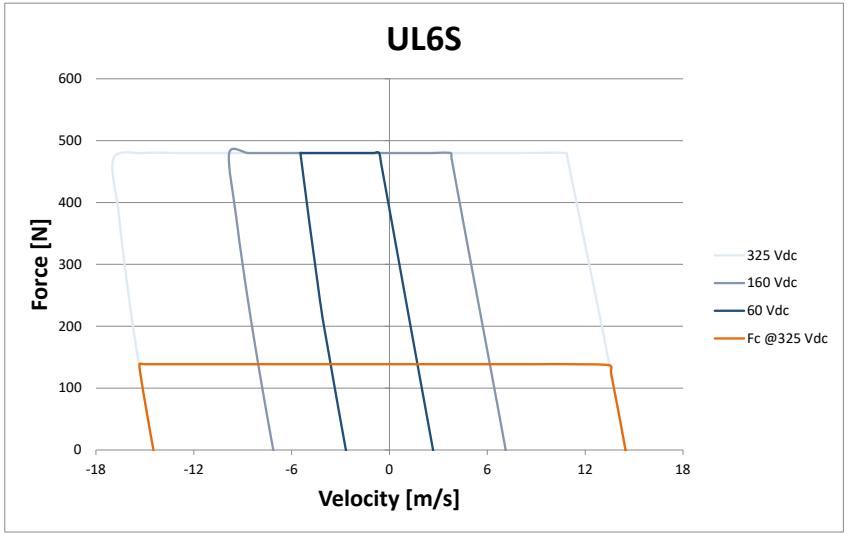
APPENDIX D | F/v graphs - UL series









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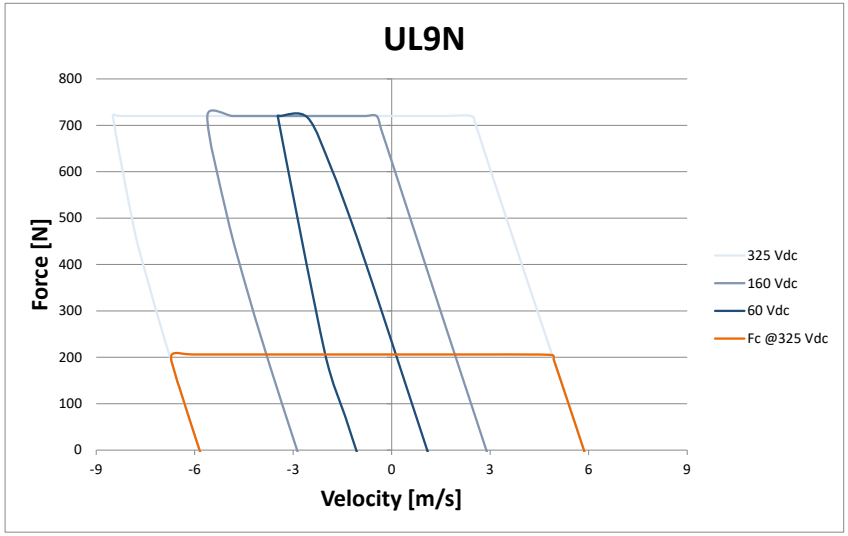
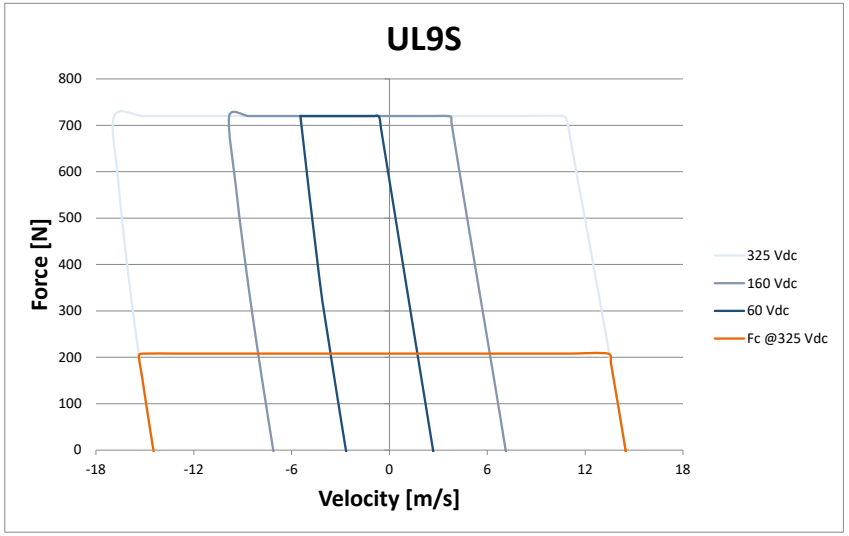
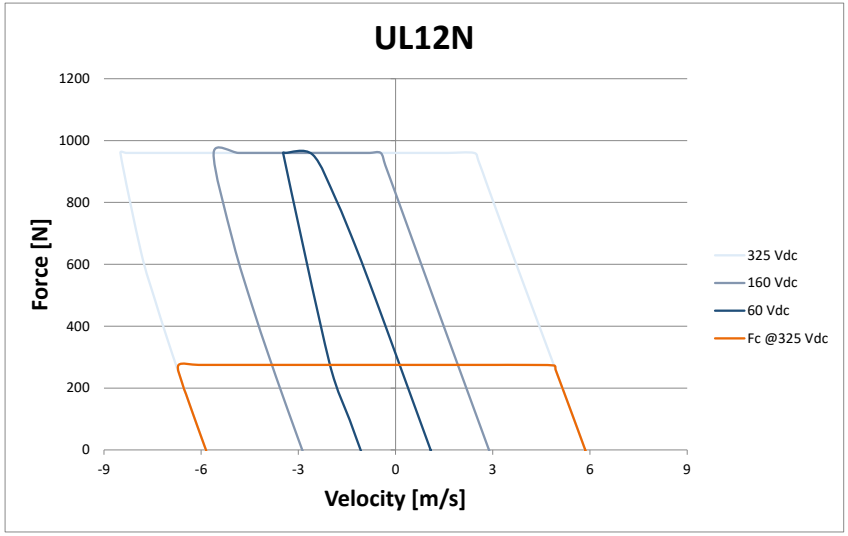
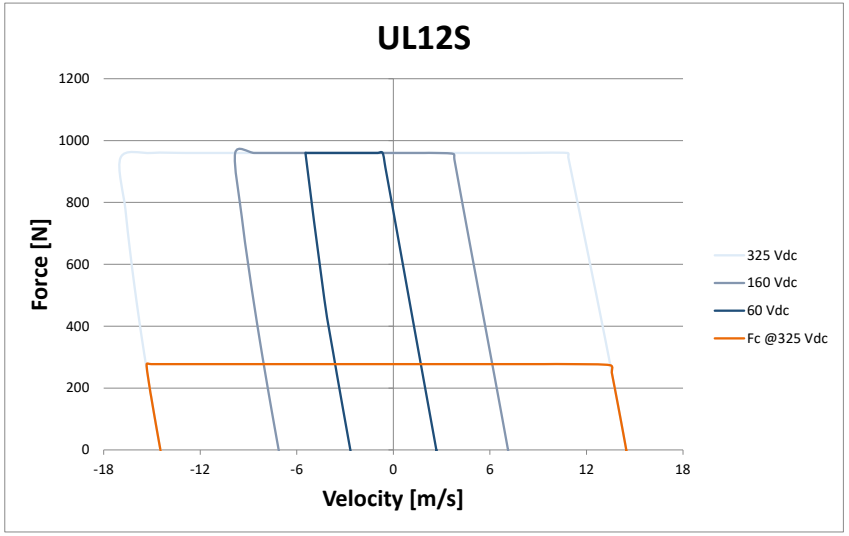
APPENDIX D | F/v graphs - UL series









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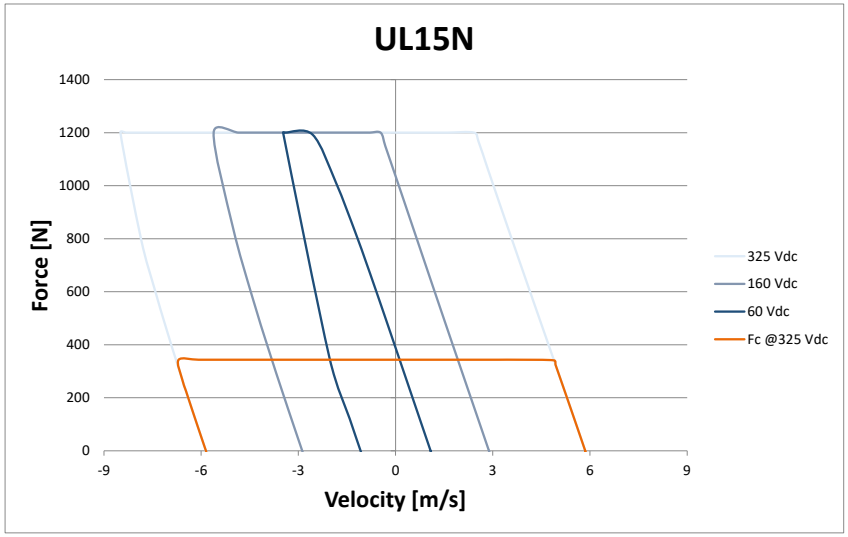
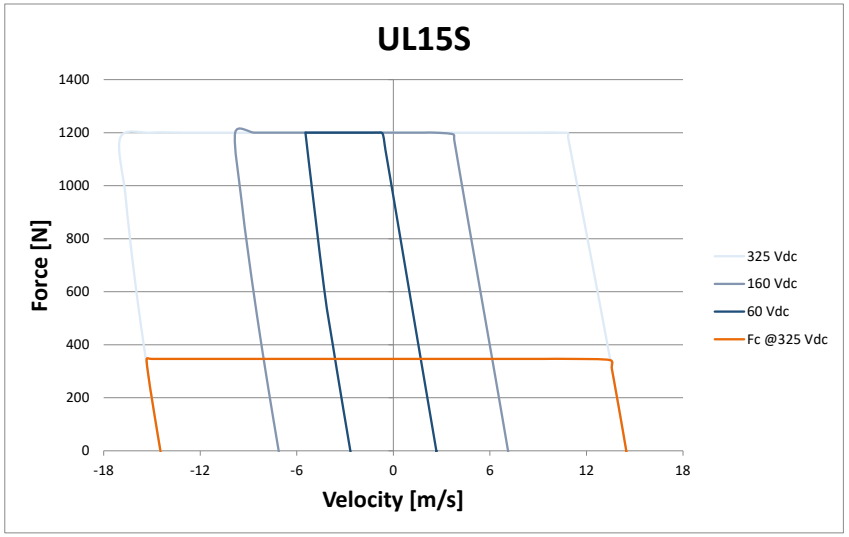
APPENDIX D | F/v graphs - UL series





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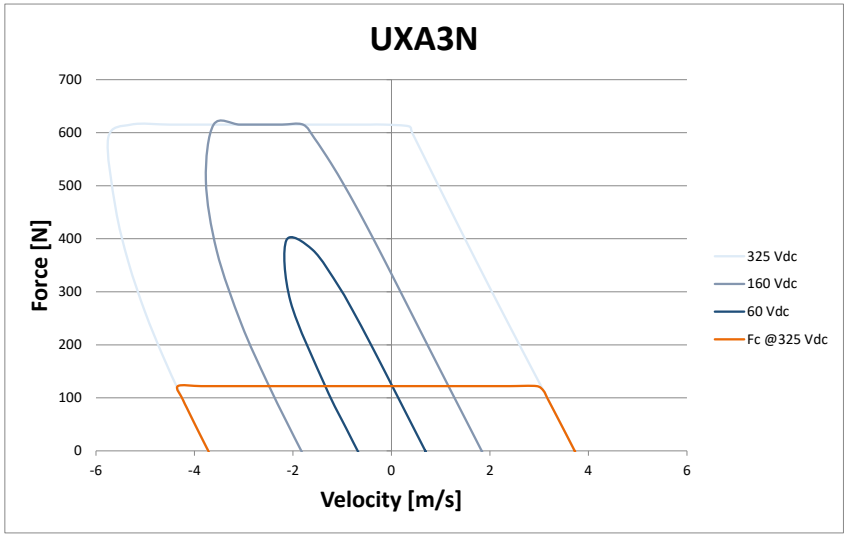
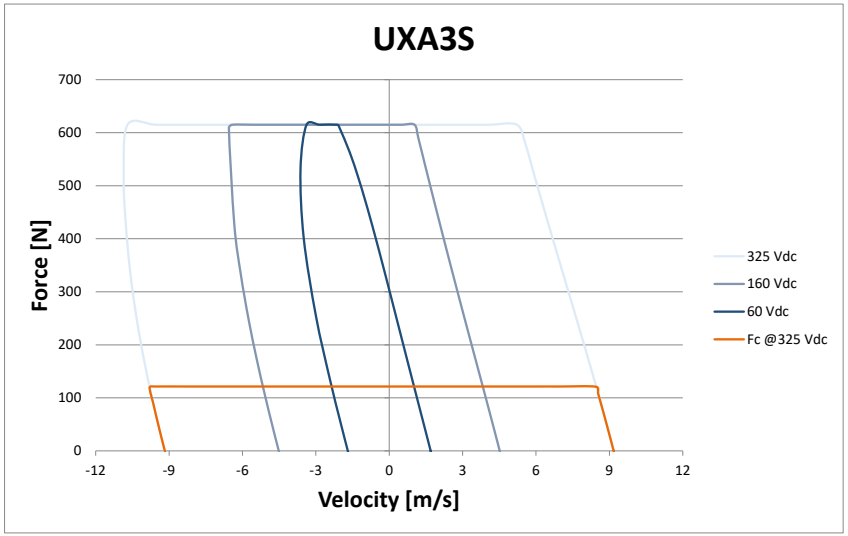
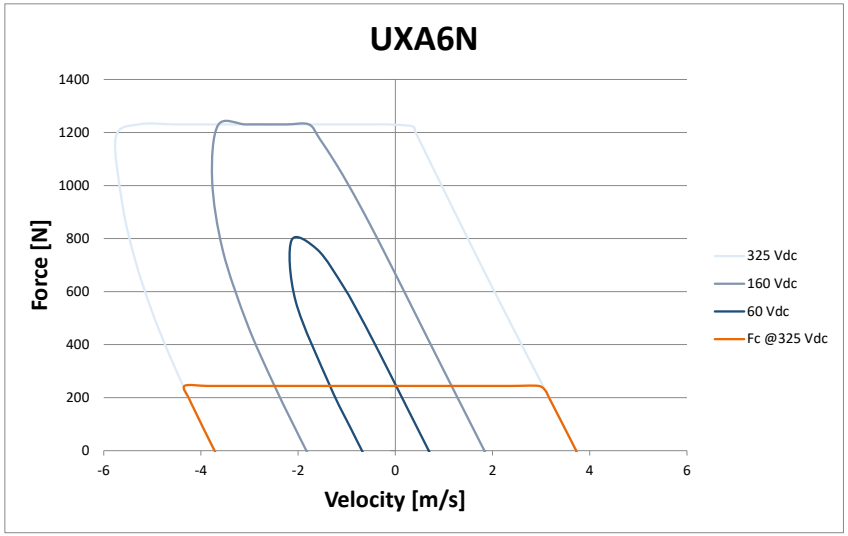
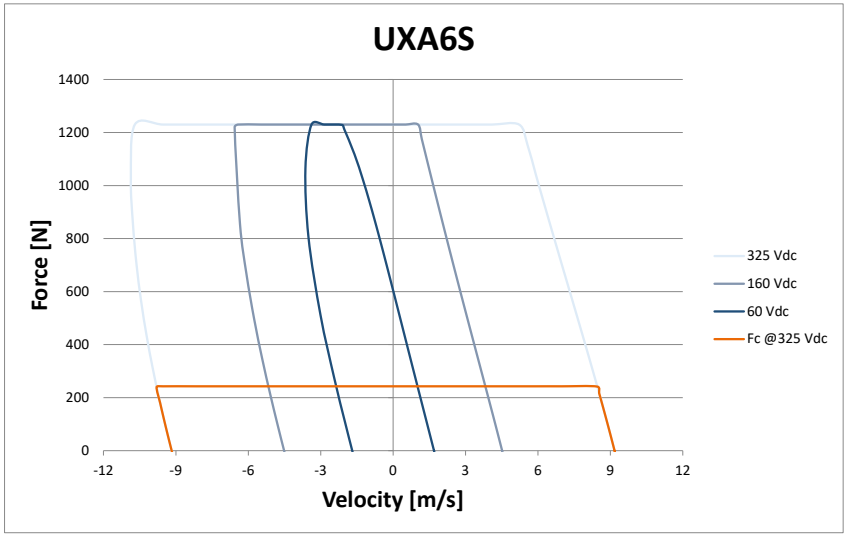
APPENDIX D | F/v graphs - UXA series









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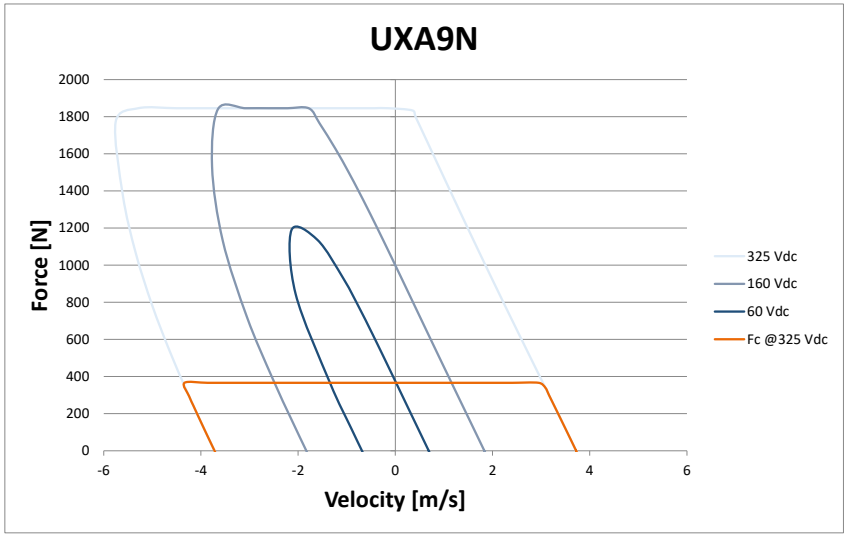
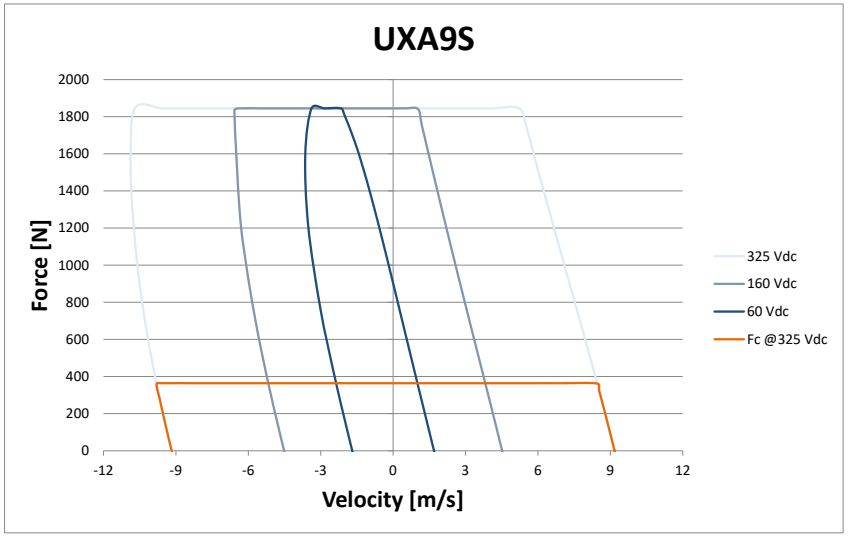
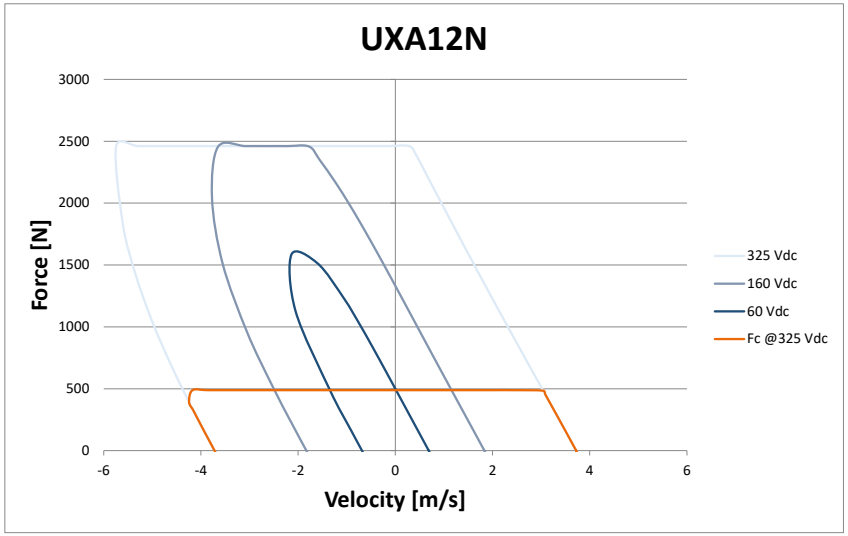
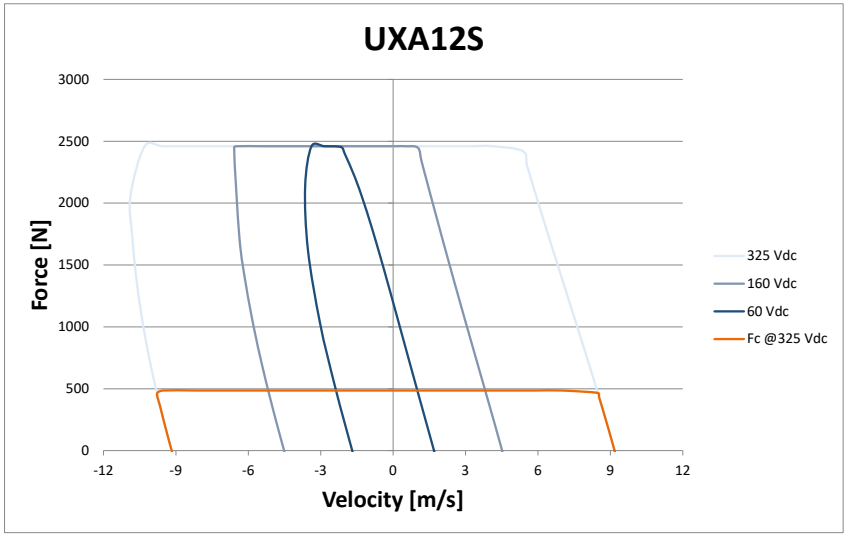
APPENDIX D | F/v graphs - UXA series









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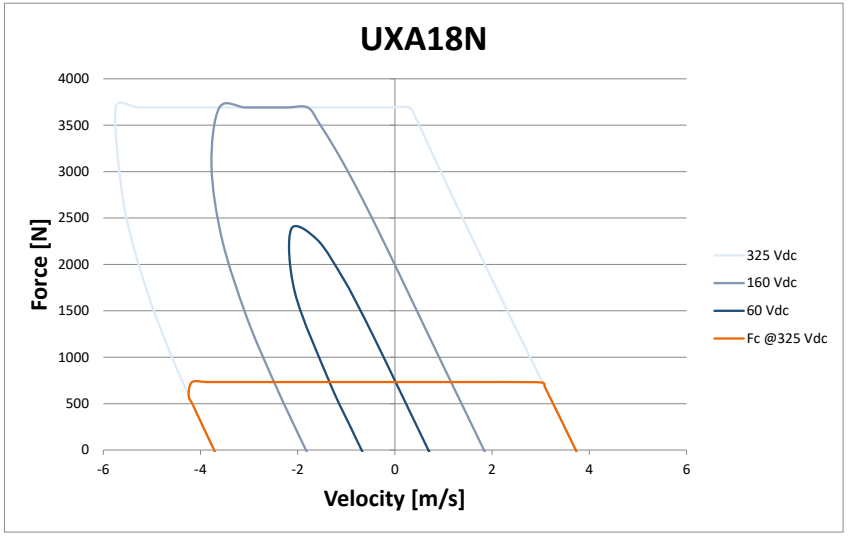
APPENDIX D | F/v graphs - UXA series



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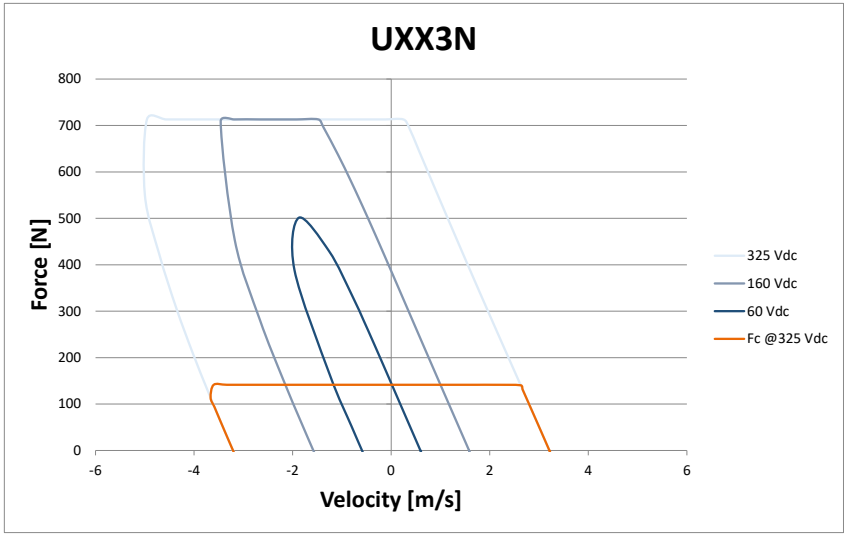
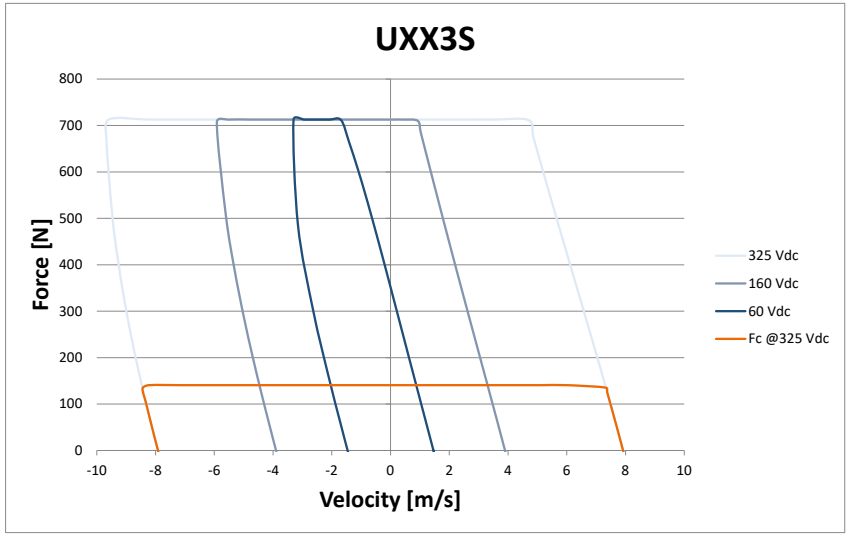
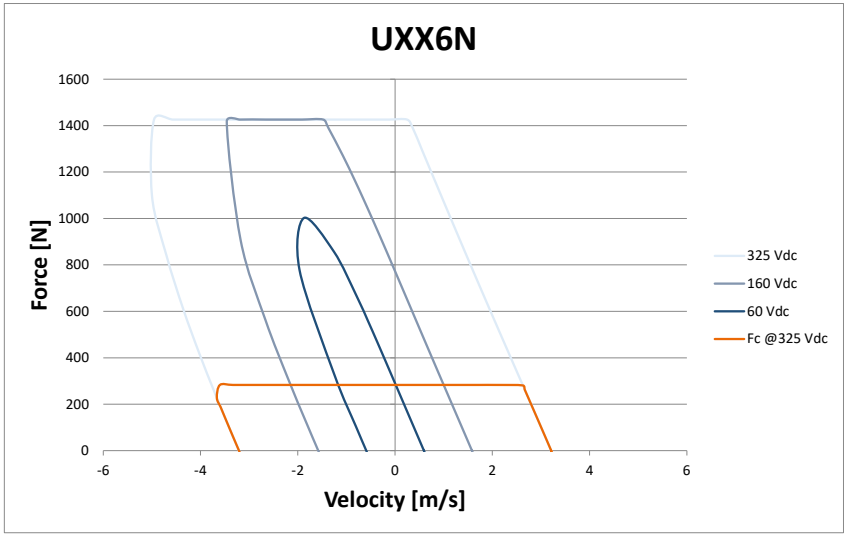
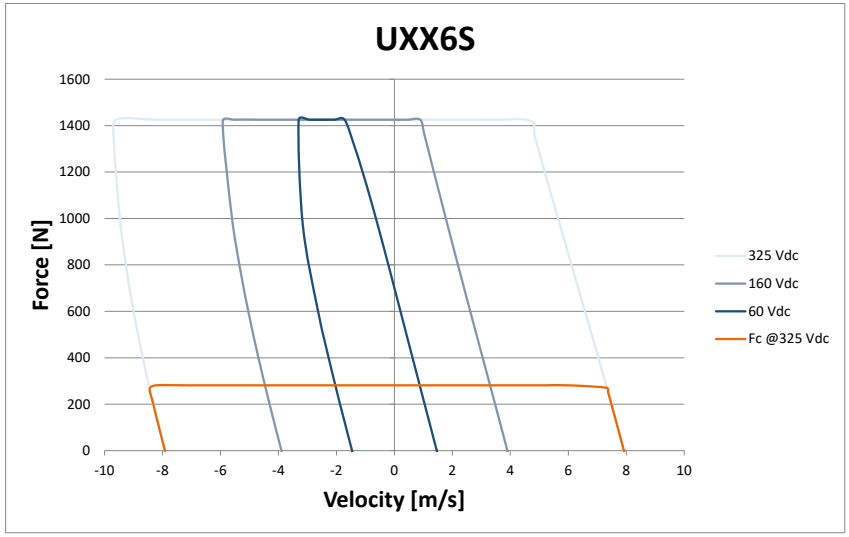
APPENDIX D | F/v graphs - UXX series









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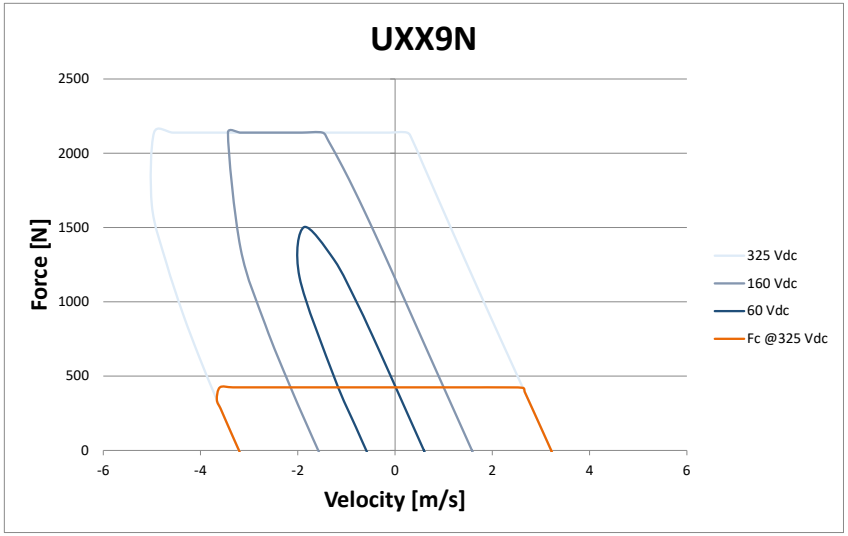
APPENDIX D | F/v graphs - UXX series

UXX9N



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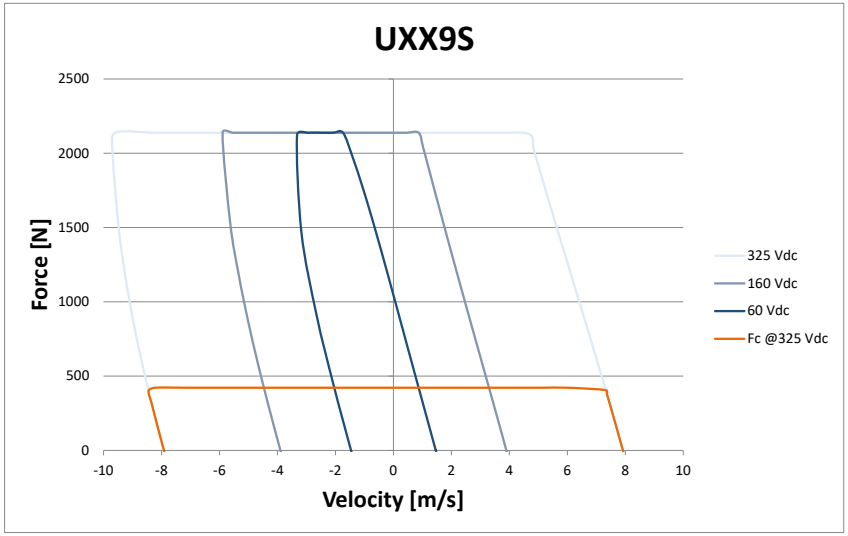

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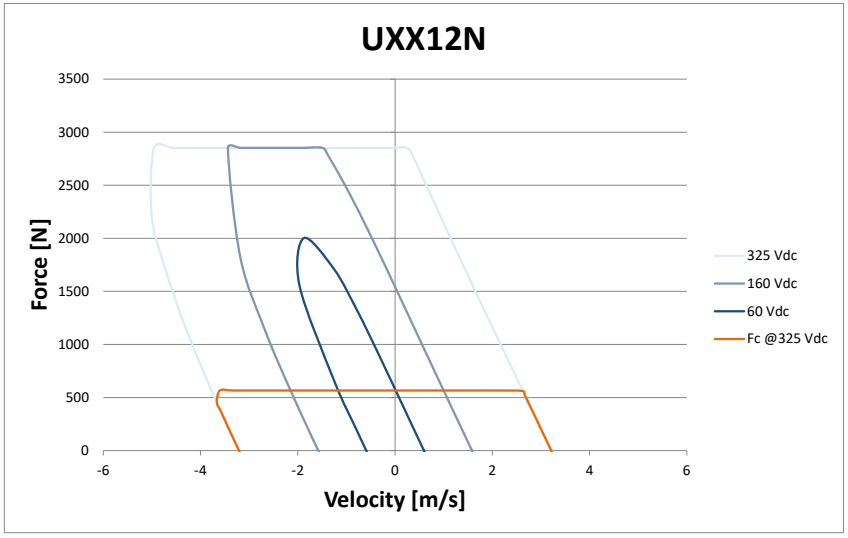

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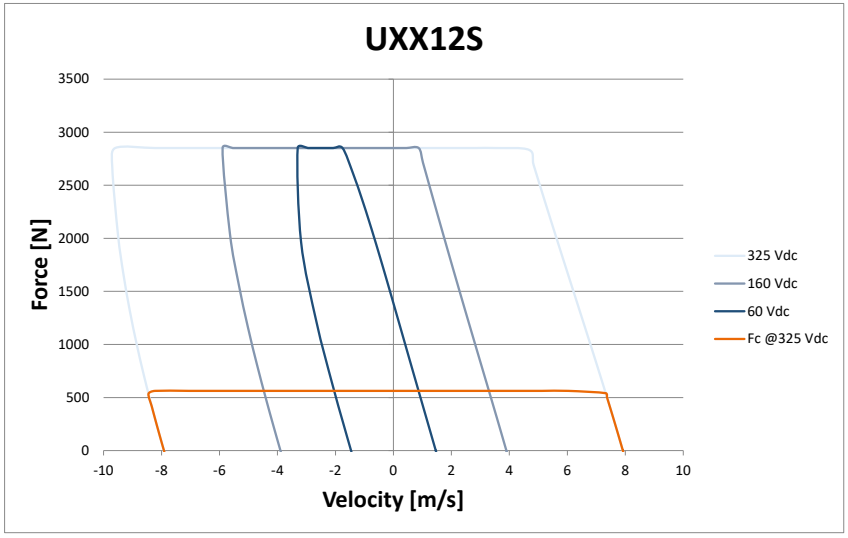

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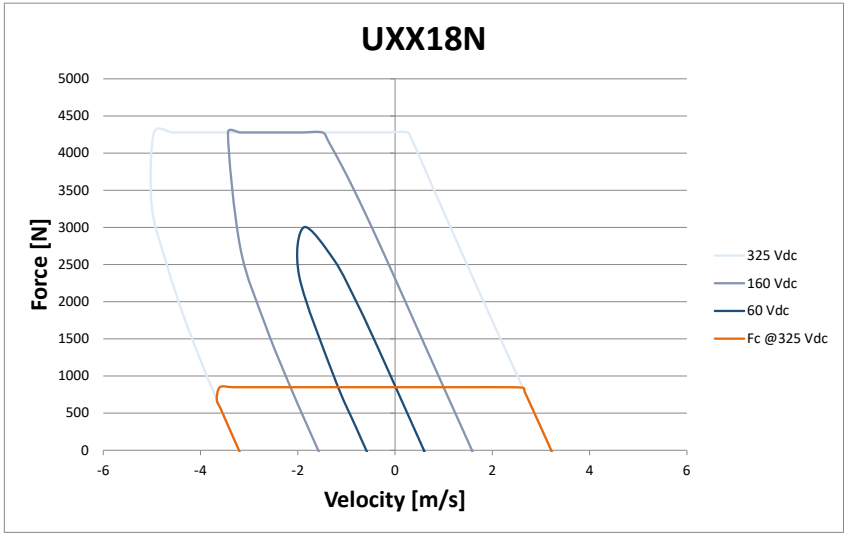
APPENDIX D | F/v graphs - UXX series



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Glossary

Parameter	Remark	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.
Peak force @ 20 K/s increase	magnets @ 25°C	F_p	N	The force of the motor belonging to the peak current.
Continuous force[1]	coils @ 80°C/110°C	F_{cw}	N	The continuous force with a 100% duty cycle. For this value the motor should be moving and its phases should be energized equally.
Continuous force[1]	coils @ 105°C	F_c	N	The continuous force at a maximum coil temperature of 105°C. This is listed because of CSA regulations, and is only applicable for the UM, UL, UXA and UXX series. 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 $K_f^2/3R_{ph}$.
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 20 K/s.
Continuous current[1]	coils @ 80°C/110°C	I_c	A_{rms}	The continuous current with a 100% duty cycle.
Continuous current[1,3]	coils @ 105°C	I_c	A_{rms}	The continuous force at 105°C coil temperature with a 100% duty cycle.
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. The resistance increases with 0.4% for every degree Celsius.
Induction per phase		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. L_{ph} is equal to the values of L_{sd} and L_{sq}.
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 @ 80°C/110°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 coil resistance.
Continuous power loss	coils @ 105°C	P_c	W	The maximum amount of power in watt that is dissipated when the motor is operated at continuous force @105°C. The actual value can be lower as a result of variations in thermal resistance, coil temperature and coil resistance.
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.

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Glossary

Parameter	Remark	Symbol	Unit	Definition
Thermal time constant		τ_{th}	s	Time required for the coil windings to reach 63% (1-(1/e)) of their maximum temperature during continuous force.
Temperature sensor				See 4.3.6 Temperature protection, 4.3.7 PTC specification and 4.3.8 NTC 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 yoke.
Magnet pitch NN		τ	mm	The distance between two consecutive poles of the same polarity.
Cable mass	all cables		kg/m	Mass of both cables.
Cable type (power)	length 1 m	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)	length 1 m	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 UC/UF series or UX3S can do.
Bending radius static (FLEX)	minimum			Minimum bending radius for the cable when used in a static configuration.
Bending radius dynamic (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.*

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Tecnotion Headquarters
Newton 10
7609 RR Almelo
The Netherlands

Tel. +31 (0)546 536 300
Fax +31 (0)546 536 380
sales@tecnotion.com

Tecnotion West Europe
High Tech Systems Park
Building N
Haaksbergerstraat 67
7554 PA Hengelo
P.O. Box 23, 7600 AA Almelo
The Netherlands
Tel. +31 (0)546 536 300
sales@tecnotion.com

Tecnotion D-A-CH
Elsenheimerstraße 59
80687 Munich
Germany

Tel. +49 89 381537-400
Fax +49 89 381537-409
info@tecnotion.de

Tecnotion East Europe
Ul. Ryżowa 49
02-495 Warsaw
Poland

Tel. +48 606 544 046
info@tecnotion.pl

Tecnotion Rep. of Korea
Room #909,
DongJin IT Tower,
30, Sangwon 12-gil
Seongdong-gu
Seoul South Korea

Tel. +82 (0)10 4540 5599
korea@tecnotion.com

Tecnotion USA
200 Broadhollow Rd -
Suite 207
Melville, NY, 11747
United States

Tel.+01 (631) 983-2833
salesusa@tecnotion.com

Tecnotion China
Building 15
369 Lushan Road
SND NEP, Suzhou
China

Tel: +86-512-68760183
sales@tecnotion.com.cn

www.tecnotion.com

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