

TECNOTION[®]

THE LINEAR MOTOR COMPANY

Torque motor manual



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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.

1.1 About this manual

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

1.2 Intended use

A torque motor system is a permanent-magnet direct drive motor that rotates along an axis. It is intended to be used wherever a rotary movement is required. Only use this torque motor system as intended, every other use is not-intended use and therefore not warranted.

1.3 Use of symbols



This symbol describes a tip to inform the user.



This symbol is a non-safety related important notice that the user should be aware of.



These symbols warn about safety information that should be respected.

1.4 Important notice



Tecnotion declines all responsibility in case of accident or damage due to negligence or lack of observance of the instructions described in this manual. Tecnotion 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 motor.



Handle the components of the motor with care, packed as well as unpacked.



Do not expose the magnets to temperatures higher than 70° C. The magnets may be demagnetized at higher temperatures.



Do not expose the stator to temperatures above 110° C. The filler material or wiring may be damaged.



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

1.5 Safety warnings

Use of magnets



The used magnets show large attraction forces on all ferromagnetic objects such as iron. These forces cannot be controlled by hand. They may cause serious jamming danger. Do not bring any soft magnetic objects (iron) nearer than 25 cm of the magnetic side of the magnets of the rotor.



Provide sufficient radial and axial centering and guidance to prevent collision during installation.



Be sure that the stator and rotor are fixed into your machine before removing the magnetic field protection plates. The stator and rotor will attract each other during installation. These forces cannot be controlled by hand. Put the magnetic field protection plates on again before dismantling them.



Magnetic sensitive objects like banking cards, pacemakers or other magnetic information carriers may be damaged if they are brought within 1 m of the magnets (plates or rotor).



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

Mechanical safety



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



The 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.



The magnets can detach from the rotor when the motor is operated above its allowed maximum rotational speed. This can cause personal injury or damage to the motor and the entire application. This speed varies per motor type. Please set the correct maximum speed for the installed torque motor. Refer to appendix G for maximum mechanical speed.

Earthing



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. 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.

Maintenance



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



The components can be damaged when cleaned with a non-prescribed cleaning agent. Use only isopropanol as a cleaning agent.



Adhesives and activators can damage the stator and rotor.



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 motor contains permanent magnets that produce a magnetic stray field. For transport safety please check chapter 6 for information on transport.

1.6 Certification

All information about certifications can be found in this chapter. The declaration of conformity or compliance can be found in appendix F.

1.6.1 CE Certification

Tecnotion B.V. declares that all torque motors mentioned in this installation manual are manufactured in accordance with European directive 2006/95/EC and in conformity with the following standards, see Table 1.

Table 1: Applicable standards

Standard	Name of standard
EN 60034-1: 2010	Rotating Electrical Machines, Part 1: Rating and performance.
EN 60204-1: 2010	Safety of machinery - Electrical equipment of machines, Part 1: General requirements

1.6.2 Restriction of Hazardous Substances (RoHS)

Tecnotion B.V. declares to be compliant with the RoHS-guideline. Therefore Tecnotion ensures that all products are free from lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyls or polybrominated diphenyl ethers.

1.7 Overview applicable standards

The table below gives an overview of applicable standards per motor type.

Table 2: Applicable standards per motortype

Series	CE	RoHS
QTR 65	Yes	Yes
QTR 78	Yes	Yes
QTR 105	Yes	Yes
QTR 133	Yes	Yes
QTR 160	Yes	Yes
QTR digital Hall module	Yes	Yes

2. OVERVIEW & SPECIFICATIONS

This chapter gives an overview of the motor and its components and specifications.

2.1 Introduction of the motor

Tecnotion QTR torque motors are so called frameless torque motors. They can be applied in numerous application devices. For a fully functional torque motor system the user needs to provide additional components like an:

- axis,
- bearing system,
- encoder and controller system.

In paragraph 2.4 & 2.5 more information can be found on the basic and additional components.

2.2 Motor family and series

Tecnotion's QTR torque motor family currently consist of five diameter types and four heights. This covers a continuous torque range of 0.29Nm up to 36.3Nm. The figure on the right gives an overview of the torque range.

■ Peak torque ■ Continuous torque

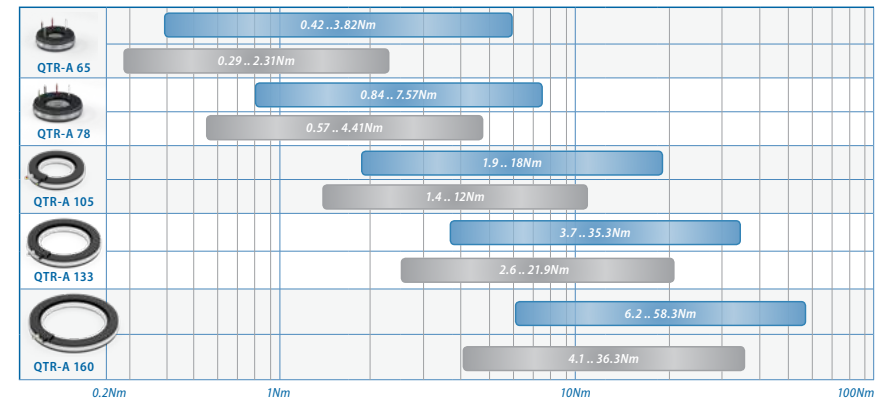
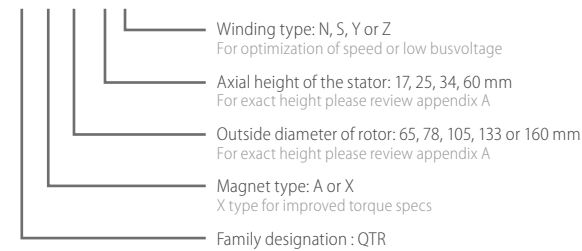


Figure 1: Torque range

Naming of the motors is done through the convention below:

QTR-X-XXX-XX-X



2.3 Specifications

The five types of torque motors have their own extensive spec sheets that can be found in appendix A.

2.4 Basic components

A Tecnotion QTR torque motor kit consists of a rotor containing the magnets and a stator containing the coils. The bigger torque motors are provided with a temperature sensor.



2.4.1 Rotor

The rotor, containing the magnets, is usually the moving part of the torque motor. The rotor can be fastened into an application by means of bonding and clamping.

Magnetic field protection ring

The rotor is always supplied with a magnetic field neutralizing protection ring (QTR-65 & QTR-78 don't need a protection ring), see Figure 2. It functions as a shield for the magnetic forces. With the ring installed the rotor can be handled safely.

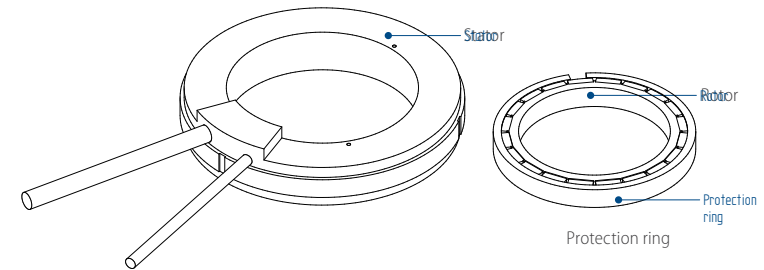
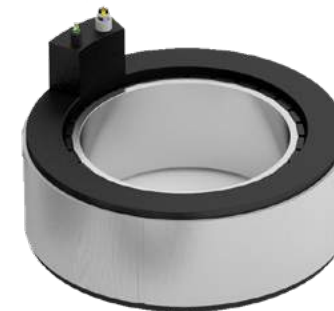


Figure 2: Protection ring

2.4.2 Stator

The stator comes in different diameters and heights. It has a separate power and temperature sensor cable both with a length of 0.5 m. The cable exit can, depending on the motor type, be in axial or radial direction.



The voltage rating of 300 or 600Vdc varies per torque motor. Should another cable exit type or voltage rating be required please contact your local Tecnotion representative to explore the possibilities. Common methods of construction of the stator into an application are clamping or bonding. The Tecnotion torque motor lamination stack surface is made of bare steel and is prone to corrosion. When the lamination stack surface is not protected it will show corrosion, this however will not affect performance.

2.5 Additional components

To construct a complete motion system, additional components are required. These components are not included when buying a Tecnotion QTR motor. Please review the following minimum required components for setting up a complete motion system:

- Power supply with sufficient power and voltage rating.
- Cables and connectors for connecting the torque motor to the drive system.
- Amplifier and servo drive system.
- Bearing system, with sufficient stiffness and appropriate friction force.
- Mechanical infrastructure for containing the rotor and stator and to accommodate heat transfer.

Optional:

- Ruler disc and/or encoder system and/or Tecnotion digital Hall module.

Tecnotion QTR digital Hall module

The Tecnotion QTR digital Hall module can be used to determine the electrical position of the rotor. The module is a replacement for a 'wake-and-shake' of the motor. It means that the module only functions when the QTR stator is not powered. This module cannot commute over the entire speed- and load bandwidth.



3. MOTOR CONFIGURATION

This chapter gives information for designing an application driven by a Tecnotion torque motor. Please take notice of the advice, tips and warnings in this chapter to make sure the torque motor performs in the best possible way.

3.1 Safety

Use of magnets



The used magnets show large attraction forces on all ferromagnetic objects such as iron. These forces cannot be controlled by hand. They may cause serious jamming danger. Do not bring any soft magnetic objects (iron) nearer than 25 cm of the magnetic side of the magnets of the rotor.



Provide sufficient radial and axial centering and guidance to prevent collision during installation.



Be sure that the stator and rotor are fixed into your machine before removing the magnetic field protection plates. The stator and rotor will attract each other during installation. These forces cannot be controlled by hand. Put the magnetic field protection plates on again before dismounting them.



Magnetic sensitive objects like banking cards, pacemakers or other magnetic information carriers may be damaged if they are brought within 1 m of the magnets (plates or rotor).



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

Mechanical safety



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



Be sure your machine as a whole meets the requirements of all applicable electrical standards, such as the EN 60204 standard.



The 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.



The magnets can detach from the rotor when the motor is operated above its allowed maximum rotational speed. This can cause personal injury or damage to the motor and the entire application. This speed varies per motor type. Please set the correct maximum speed for the installed torque motor. Refer to appendix G for maximum mechanical speed.

3.2 Properties

The relevant properties concerning configuration of a torque motor are described below.

Corrosion

The Tecnotion torque motor lamination stack surface is made of bare steel and is prone to corrosion. When the lamination stack surface is not protected it will show corrosion, this however will not affect performance.

Cooling

In order to achieve rated performance, the stator needs to be mounted in a cooled housing. The full lamination stack needs to be in contact with a 20°C surface. Insufficient cooling will have an effect on the motor's continuous torque.

Air gap

The correct air gap will be ensured by installing the Tecnotion QTR torque motor according to the instructions in this manual.

Thermal conduction

Tecnotion torque motors dissipate heat through the lamination stack. Most heat dissipates through the larger stack surface, though the lamination stack shoulders also have an important function. Proper clamping of the shoulders helps dissipate the heat. Cooling is needed when the motor is operated at continuous or stall torque.

For smaller motors (17 mm and 25 mm height) shoulder clamping can be sufficient (see Figure 3). For larger motors it is needed for the motor to lose its heat through the lamination stack. This can be done by a cooled housing or heat sink.

For catalogue performance the lamination stack surface needs to be in full contact with a body or heat sink kept at a maximum of 20°C. When only the shoulders of the lamination stack are in contact with a cooling/clamping surface, the available continuous torque is affected. The available continuous torque can be reduced by up to 75%. This reduction is affected by the motor size, clamping force and various changes in the environment.

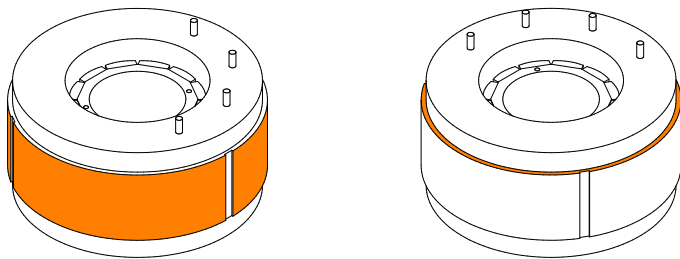


Figure 3: Cooling surface indicated in orange

3.3 Housing requirements

Pay attention to the different housing/connection requirements for Tecnotion 65/78 stators and Tecnotion 105/133/160 stators. When clamping the stator all specifications apply. When a bonding-connection is used, the angularity does not apply. Always use the correct concentricity and centering of the rotor in the stator. Centering of the stator is done on the lamination stack. Rotor centering can be done on the inside of the rotor.

3.4 Mounting

There are a number of factors to consider when mounting a Tecnotion QTR torque motor. Most importantly the method of mounting of the stator can affect performance. A tradeoff has to be made between thermal conduction, cost of infrastructure (housing) and ease of (de)installation.

When designing a mounting/housing for the QTR motor these questions can help:

- Does the application use a high continuous load (that requires good thermal conductivity) or short peak loads (with sufficient downtime for cooling)?
- What clamping force or sheer strength is to be expected to keep the stator in place?
- Is a quick (de)installation of the motor required?

3.4.1 Stator



Do not clamp the stator on the black polyurethane casting, this can damage the coils.



Do not center the stator on the black polyurethane casting.

To ensure a good connection, when mounting a Tecnotion QTR stator, pay attention to the proper alignment, sufficient clamping force and heatextraction. Thermal properties are affected by the mounting method, either by variation in the contact surface or by additional thermal resistances (adhesives).

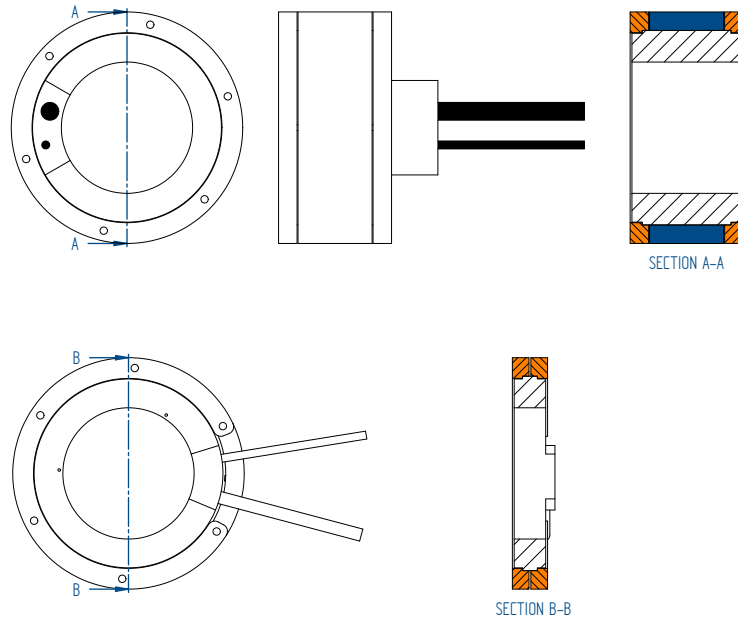


Figure 4: Heat extraction in orange

3.4.2 Rotor

The main objective when mounting the rotor is proper positioning – axial and radial – of the motor. Other than positioning the rotor, the proper clamping or bonding force needs to be considered. The steel of the rotor compared to the stator lamination stack allows for higher clamp forces.

Mounting a rotor requires a strong and rigid axle. Take into consideration that heat dissipation trough the axle will be minimal. Tecnotion recommends two options when mounting a QTR rotor. The rotor can either be mounted by clamping it axially or by bonding, see Figure 5.

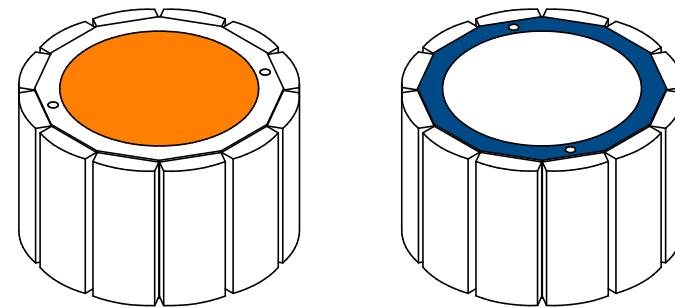


Figure 5: Bonding surface (left), clamping surface (right)

QTR 65 and QTR 78 housing specification

The following specifications apply when designing a housing for a Tecnotion QTR 65 or QTR 78 stator. The stator's main contact area is the lamination stack. The lamination stack is used both for cooling and clamping/bonding purposes. The stator requires a housing with specifications according to Figure 6 and Table 3.

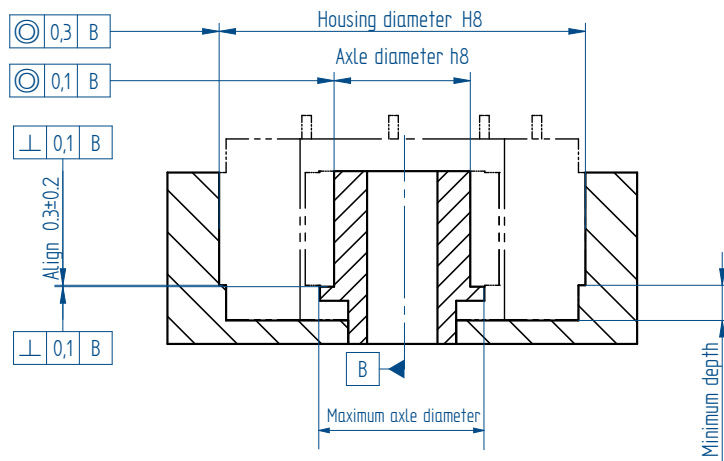


Figure 6: QTR 65 and QTR 78 housing requirement tolerances for mounting/centering purposes



Pay attention to the angularity and parallelism when installing a Tecnotion QTR stator.

Table 3: Housing specification QTR 65 and QTR 78

Motor	QTR 65-17/25 series	QTR 65-34/60 series	QTR 78-17/25 series	QTR 78-34/60 series
Alignment	Axial alignment of the rotor in stator must be within 0,3 mm +/- 0,2 mm			
Minimum depth	5.5 mm	7.5 mm	5.5 mm	7.5 mm
Housing diameter	65 mm H8		78 mm H8	
Axle diameter	17 mm h8		29 mm h8	
Max. axle diameter	23 mm		35 mm	

QTR 1xx housing specification

When mounting a Tecnotion QTR 105, QTR 133 or QTR 160 stator different tolerances apply. See the specifications according to Figure 7 and Table 4. When the housing meets the tolerances described, the Tecnotion QTR motor will perform best.

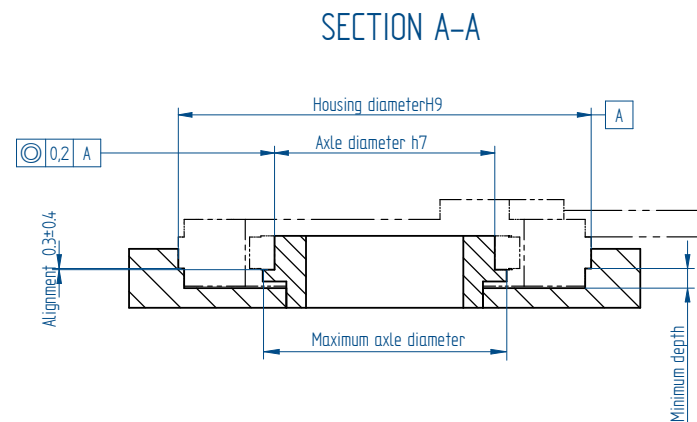


Figure 7: QTR 1xx housing requirement tolerances for mounting/centering purposes



When using a digital Hall module: Tecnotion advises to bond rather than clamp the stator.

Table 4: Housing specification QTR 105, QTR 133 and QTR 160

Motor	QTR 105-17/25	QTR 105-34	QTR 105-60	QTR 133-17/25	QTR 133-34	QTR 133-60	QTR 160-17/25	QTR 160-34	QTR 160-60
Alignment	Axial alignment of the rotor in stator must be within 0.3 mm +/- 0.4 mm								
Minimum depth	4.5 mm	5.0 mm	5.5 mm	4.5 mm	5.0 mm	5.5 mm	4.5 mm	5.0 mm	5.5 mm
Housing diameter	105 mm H9			133 mm H9			160 mm H9		
Axle diameter	56 mm h7			84 mm h7			111 mm h7		
Max. axle diameter	62 mm			91 mm			118 mm		



Beware of the maximum temperature when curing the bonding material. For the stator, no curing above 110°C. Risk of damaging the stator. For the rotor, no curing above 70°C. Above 70°C, Risk of demagnetizing the magnets.

3.5 Electrical interface

Tecnotion torque motors come with various cable configurations. The main difference can be seen by:

- QTR 65 and QTR 78 motors use 4 'flying leads' for powering the motor.
- QTR 105, QTR 133 and QTR 160 motors have two cables, the larger one being the power cable, the smaller being the temperature sensor cable. Both cables being shielded with braided metal.



The temperature sensor cable can be cut off if the sensor is not used.



QTR 65 and QTR 78 have no strain relief, provide proper strain relief in construction.

The cable exit differs for various Tecnotion torque motors (see Figure 8).

- The 65 mm and 78 mm Tecnotion torque motors use flying lead power cables. These motors do not have a temperature sensor (cable).
- Tecnotion torque motors of 105, 133 and 160 diameters with a 17, 25 or 34 mm height use a radial cable exit.
- Tecnotion torque motors of 105, 133 and 160 diameters with a 60 mm height use an axial cable exit.



QTR 1xx Y and Z have different cable exit dimensions.

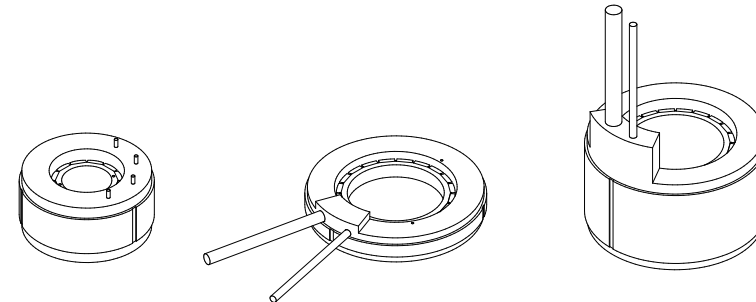


Figure 8: Axial flying lead (left), radial shielded cables (middle), axial shielded cables (right)

3.5.1 Cable specifications & protective earth

See Table 5 below for cable specifications and identification. If desired you can shorten these cables and provide them with appropriate connectors.

Table 5: Cable specification and identification

Motor	QTR 65 QTR 78		QTR 105N QTR 133N QTR 160N		QTR 105 Y/Z QTR 133 Y/Z QTR 160 Y/Z	
	Motor height	All	17-25-34	60	All	17-25-34
Type	4 flying leads (3 phases, 1 ground)	Shielded power cable		Shielded sensor cable	Shielded power cable	Shielded sensor cable
Length	500 mm					
Cable diameter (AWG)	1.5 mm (16)	6.5 mm (20)	9.5 mm (18)	4.3 mm (26)	6.7 mm (14)	4.3 mm (26)
Bending radius	8 mm	32.5 mm	38.4 mm	27.6 mm	67 mm	27.6 mm
Rated voltage	600Vdc	320Vdc	600Vdc	n/s	320Vdc	n/s

Internally the motor's protective earth wire is galvanically connected to the lamination stack. This wire must be connected to the protective earth connector of the servo amplifier.



Provide the motor system with protective earth lines to the amplifier that are as short as possible..

The details about the QTR 1xx sensor cable wire identification are shown in Table 6.

Table 6: Sensor cable wire identification QTR 1xx

Sensor cable (color)	Connection to servo controller
PTC (white)	PTC
PTC (brown)	PTC
KTY21 (green)	KTY83-122
KTY21 (yellow)	KTY83-122
Shield	Protective earth

3.5.2 Wiring schemes

Below are the wiring schemes for the different torque motors.

QTR65 & QTR78

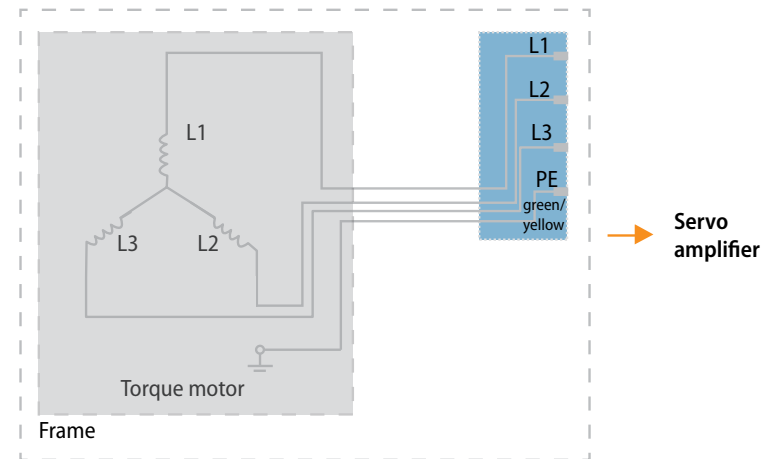


Figure 9: Wiring scheme for QTR65 and QTR78

Table 7: Power cables wire identification QTR 65 and QTR 78

Powercable		Sensor color code	Connection to servo controller
		17/25/34/60	
3-phases	L1	black	3-phases
	L2	red	
	L3	white	
Protective earth		green/yellow	Protective earth

QTR 1xx N+Y

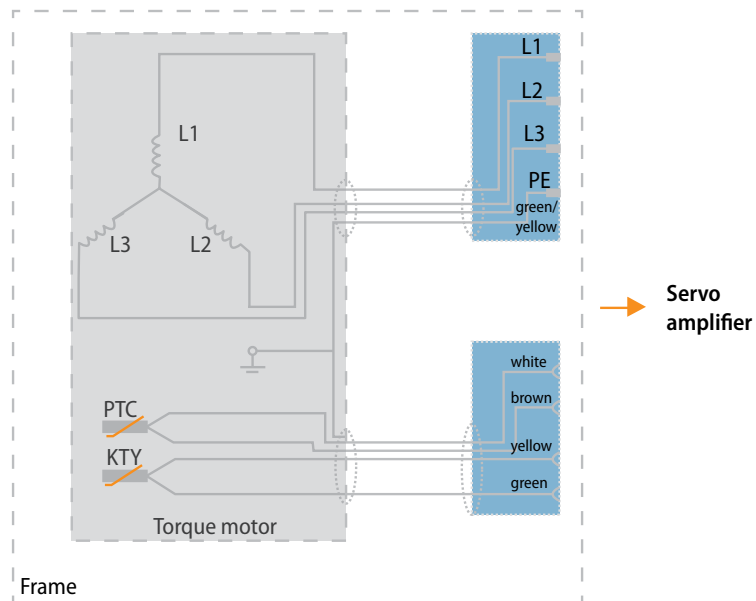


Figure 10: Wiring scheme for QTR 105, QTR 133 and QTR 160

Table 8: Power cables wire identification QTR 1xx N+Y

Powercable		Sensor color code		Connection to servo controller
		17/25/34	60	
3-phases	L1	black	black '1'	3-phases
	L2	red	black '2'	
	L3	white	black '3'	
Protective earth		green/yellow		Protective earth
Shield		Protective earth		

QTR 1xx Z

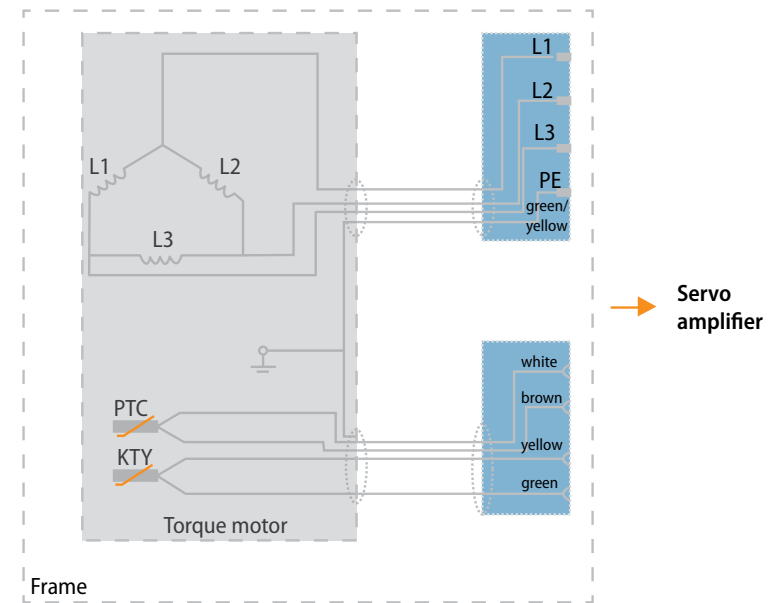


Figure 11: Wiring scheme for torque Z series

3.6 Temperature sensors

Tecnotion can supply two types of temperature sensors with its torque motors:

- PTC-sensors
- KTY-sensors

The PTC-sensor can be used as a cut-off sensor when the maximum temperature is exceeded. The KTY-sensor can be used for monitoring purposes as well.



Tecnotion QTR 65 and QTR 78 torque motors do not use any temperature sensors.



Tecnotion QTR 105, QTR 133 and QTR 160 stators are equipped with two temperature sensors, one PTC-1k-type and one KTY83-122 type.

In cases where long peak currents are demanded, the thermal response time of the stator is too long to ensure a proper overheating protection by the sensors. The temperature sensors can ensure a proper protection up to an I_{rms} of 45% of the ultimate current of the motor. This corresponds with a temperature increase of 4.5°C/s. 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 stator from overheating. In almost all controllers an I_{2t} protection can be set in the software.

3.6.1 PTC characteristic

The PTC-1k type is a sensor which has a very sudden resistance rise near the critical temperature of the stator of 110°C. The PTC-1k type is almost a digital indicator: temperature below vs. above critical temperature. Therefore it is very useful for signaling over temperature without requiring sensitive electronics.

It is not possible to obtain a direct temperature signal from this sensor. At room temperature the PTC has an electrical resistance <100 Ω. When the temperature rises to the critical temperature the resistance will increase rather uniformly up to 1000 Ω. Above this temperature the resistance increases exponentially. 1000 Ω is the switching resistance. The amplifier should immediately stop the power supply when this resistance is exceeded. In this way overheating and motor damage can be prevented.

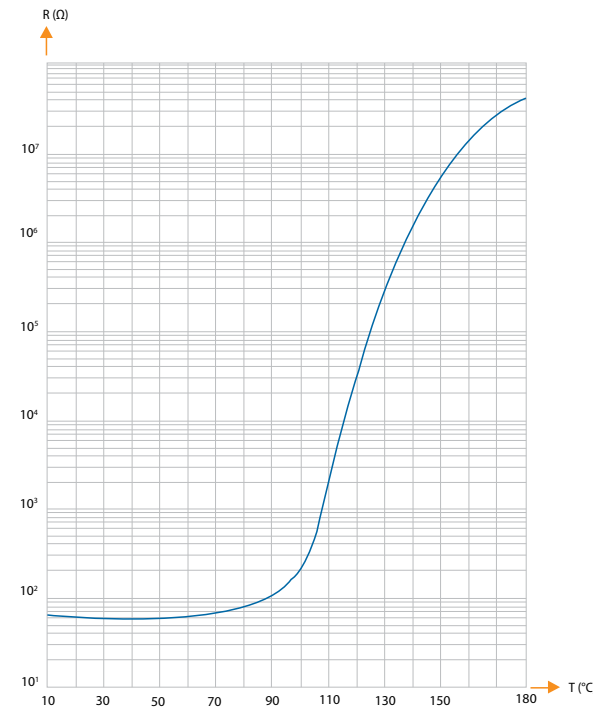


Figure 12: Temperature dependence of the PTC-1k sensor

3.6.2 KTY characteristic

The KTY 83-122 sensor has a rather stable and slow temperature coefficient as shown in Figure 13. The sensor can supply a temperature reading in the whole range. Therefore it is useful to monitor the coil temperature during tests and to decide whether the thermal margins are enough to guarantee error-free running of the machine under certain conditions.

Disadvantage of the sensor is that it requires sensitive and accurate electronics to obtain a reliable reading. Please configure the sensor according to the wiring scheme in Figure 14 to attain a correct read out.

Table 9: KTY 83-122 characteristic values

T (°C)	20	25	30	40	50	60	70	80	90	100	110	120	130
RNOM (Ω)	972	1010	1049	1130	1214	1301	1392	1487	1585	1687	1792	1900	2012

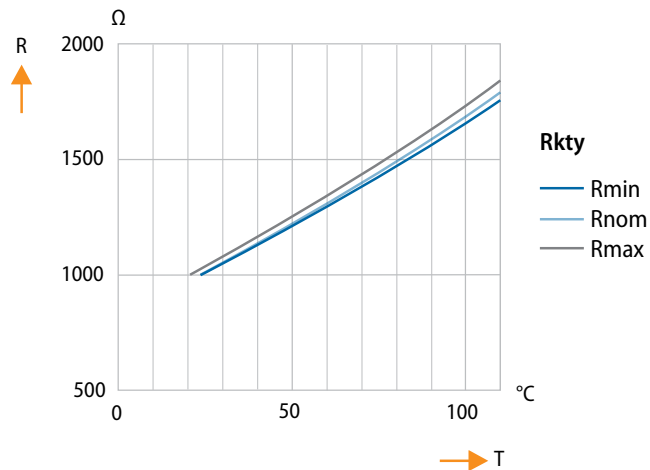


Figure 13: Temperature dependence of the KTY 83-122 sensor

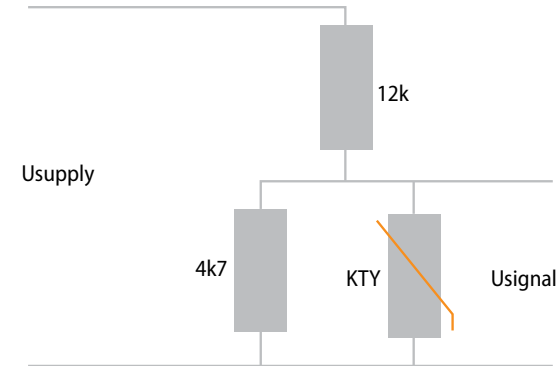


Figure 14: Wiring scheme for KTY 83-122 sensor

3.7 Accessories

3.7.1 Digital Hall module

Tecnotion QTR motors can be equipped with a digital Hall module for 'wake and-shake' functionality. Before the motor is switched on this digital Hall module can determine the position and direction of rotation of the rotor.

The QTR digital Hall modules can only be used as a wake-and-shake replacement. This means that the module only functions when the torque stator is not powered.

3.7.2 Configuration



A filter needs to be placed on the output following scheme in Figure 15. Values for R and C may deviate as long as $R \cdot C$ (time constant) equals $47 \mu\text{s}$.



When considering EMC it is best to use connectors with a metal (conducting) housing. The cable shield has to be connected to the connector housing.



Connecting the Hall module to the connector has to be done with ESD protection.

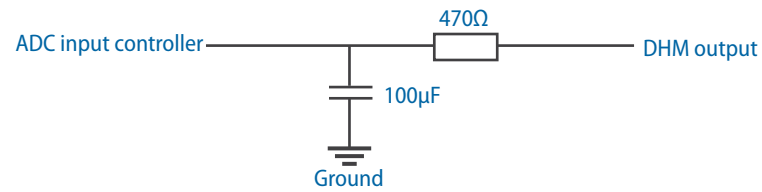


Figure 15: Output filter

Tecnotion digital Hall modules are shipped with the screws used to install them. A Philips ph0 screwdriver is used to mount the module on the QTR stator. The digital Hall module requires a QTR stator with prepared mounting holes for the digital Hall module.



When the sensor is mounted it is not possible to insert or extract the rotor from the sensor side.

Table 10: General specifications

Type	Value
Input voltage	+6 ... 15 Vdc
Output signal	Source type TTL, max 2.5mA, $5 \pm 0.5\text{Vdc}$ (3 signals) AquadB, max 2.5mA, $5 \pm 0.5\text{Vdc}$ (2 signals)
Cable	Shielded 0.5m length
Cable diameter	4.7
EMC	Conform EN61000-6-2 (Immunity)
RoHS	Conform
Reach	Conform

Table 11: Electrical interface

Color	Function
White	0V
Brown	+6 ... 15V
Blue	Hall A1
Yellow	Hall A2
Green	Hall B
Red	Hall C

QTR Digital Hall timing and alignment

The timing diagrams are applicable when the rotor moves clockwise	Legend for TTL diagrams	Legend for AquadB diagrams
	— L12	— L12
	— L23	— L23
	— L13	— L13
	— Hall A1	— Hall A1
	— Hall B	— Hall A2
	— Hall C	

4. INSTALLATION

Please follow the installation order in this manual. A different order may cause dangerous situations and damage due to uncontrolled magnetic attraction forces.

4.1 Safety



The rotor with the installed magnets show large attraction forces on all ferromagnetic objects such as iron. These forces cannot be controlled by hand. They may cause serious jamming danger. Do not bring any soft magnetic objects (iron) nearer than 25 cm of the magnetic side of the rotor.



Put the magnetic field neutralizing protection cover on the rotor again when dismantling them. This does not apply to QTR 65 and QTR 78 motors (are supplied without protection rings.)



The stator and rotor will attract each other during installation. These forces cannot be controlled by hand. Provide sufficient radial and axial centering and guidance to prevent collision during installation.



Magnetic sensitive objects like banking cards, pacemakers or other magnetic information carriers may be damaged if they are brought within 1 m of the rotor.



A torque 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 on the motor or your machine to prevent damage or personal injury in case of such an event.



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.



QTR 65 and QTR 78 have no strain relief, provide proper strain relief in construction.



Beware of the maximum temperature when curing the bonding material.

- For the stator, no curing above 110°C. Risk of damaging the stator.
- For the rotor, no curing above 70°C. Above 70°C, risk of demagnetizing the magnets.

4.2 Introduction

QTR 65 and QTR 78 motors come pre-assembled. The rotor is shipped inside the stator in the motor's packaging. The rotor and stator are separated by a 1 mm thick non-ferromagnetic shim. This package can be installed in the application directly or it can be disassembled before final installation.



Do not switch on the motor before proper installation and removal of the shim!

For QTR 105, QTR 133 and QTR 160 motors the rotor and stator are separated in the packaging. Installation requires the removal of the magnetic protection ring and insertion of the rotor in the stator. Because there is a considerable amount of attraction force between rotor and stator special tooling and/or non-ferromagnetic shims are required.

4.3 Before you start

The magnets on the rotor are attracted by the ferromagnetic material in the lamination stack of the stator. This attraction is present in two directions, axial and radial. During installation specific tooling or system design is required to enable controlled and safe insertion of the rotor into the stator. Perform the installation checks below before installing the components.

- Check axial attraction force and radial attraction force and size tooling accordingly.
- Always use non-ferromagnetic tooling for the QTR rotor assembly.
- Specific tooling is required for mounting the connectors to the power and sensor cables. Please verify with your connector supplier what tooling is required.



Check the installation video on the download section of the website or on our youtube channel.

4.3.1 Cleaning



The stator and rotor can be damaged when cleaned with a non-prescribed cleaning agent. Use only isopropanol as a cleaning agent.



Oxidation on the lamination stack surface can be removed with Scotchbrite.

For general, non-cleanroom applications, the rotor and stator do not need to be cleaned before installation or commissioning. For cleaning purposes Tecnotion prescribes isopropanol as cleaning agent for the stator and rotor.

4.3.2 Axial attraction

The rotor is attracted by the stator in axial direction. The forces are the largest when the rotor starts to enter the stator, see Figure 16. It is in equilibrium when the rotor is symmetrical between the lamination stacks. The axial forces for the different series are shown in Figure 17 through Figure 21.

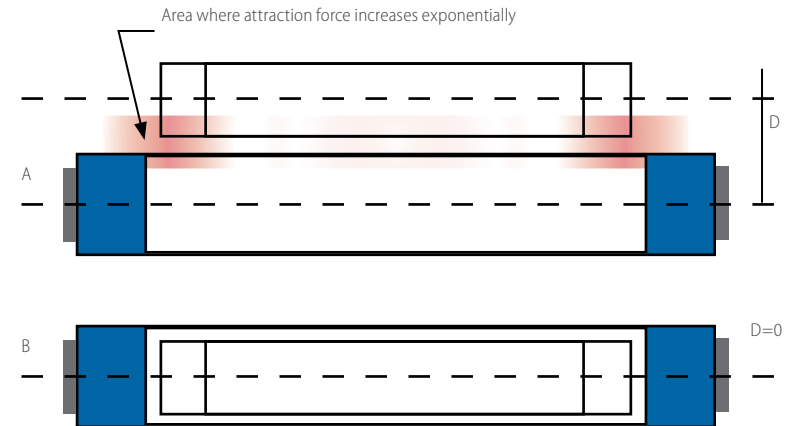


Figure 16: Behaviour of axial attraction forces

A - Attraction force increases exponential

B - Attraction forces are in equilibrium

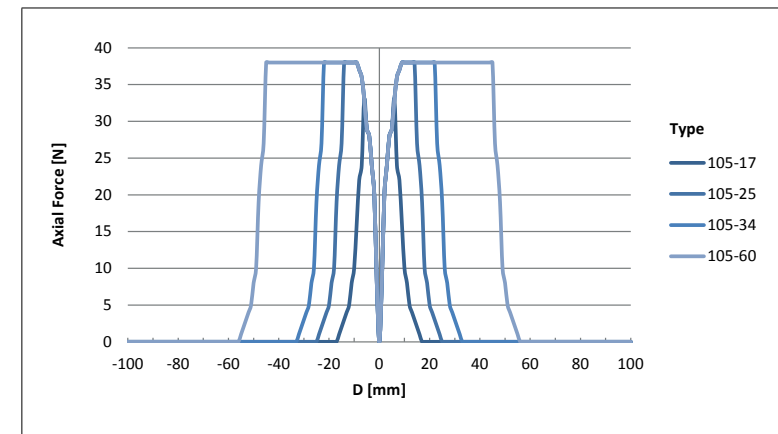


Figure 17: Axial forces QTR105 series

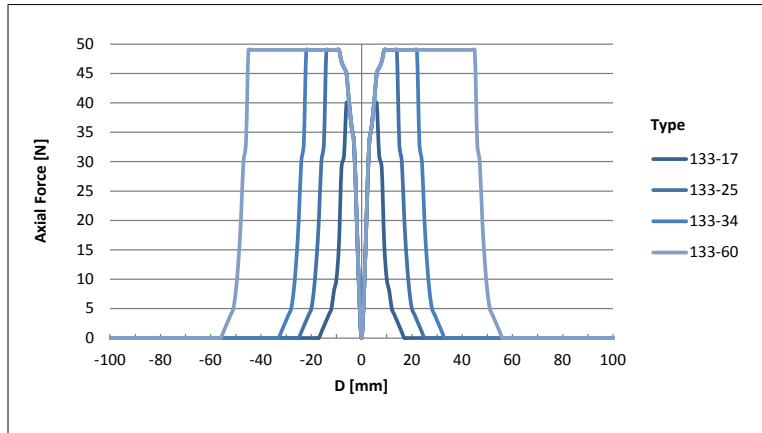


Figure 18: Axial forces QTR133 series

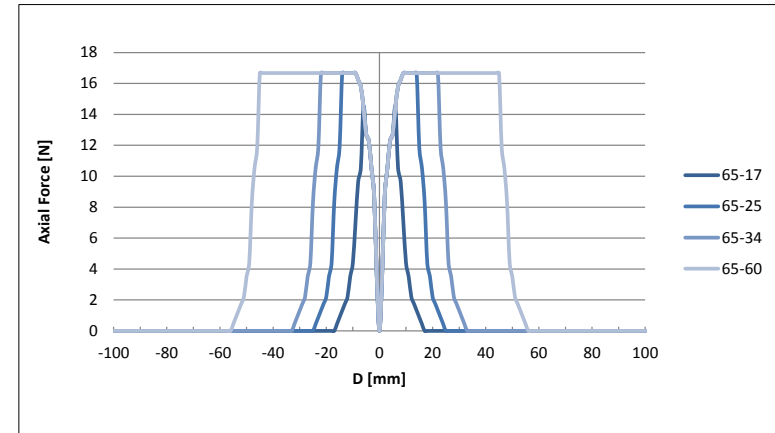


Figure 20: Axial forces QTR65 series

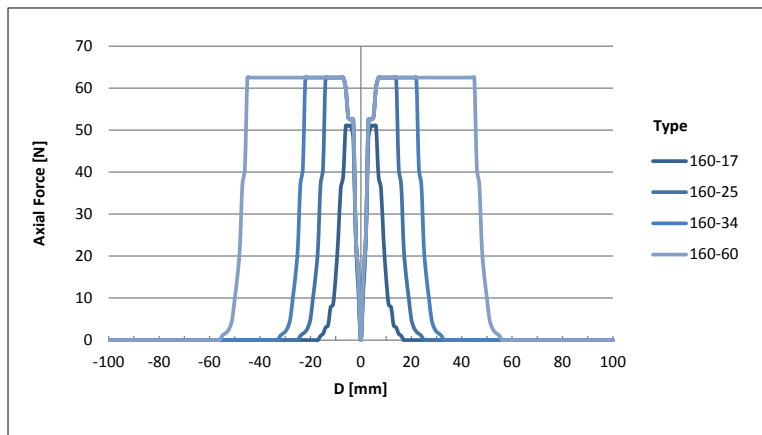


Figure 19: Axial forces QTR160 series

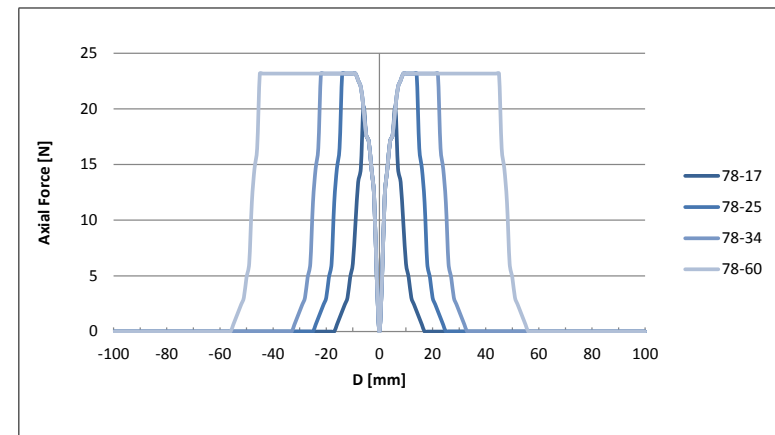


Figure 21: Axial forces QTR78 series

4.3.3 Radial attraction

The rotor is attracted by the stator in radial direction. The attraction force is zero when the rotor is exactly concentrically mounted with respect to the stator. It is at its maximum when the rotor and stator are in contact with each other. Please review Figure 23 & Figure 24 for the radial attraction forces when axially positioned like Figure 22.

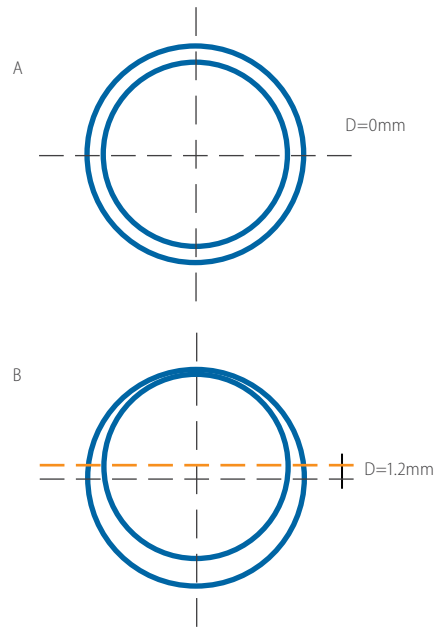


Figure 22: Behaviour of radial attraction forces

A - Radial forces in equilibrium

B - Radial forces are maximal

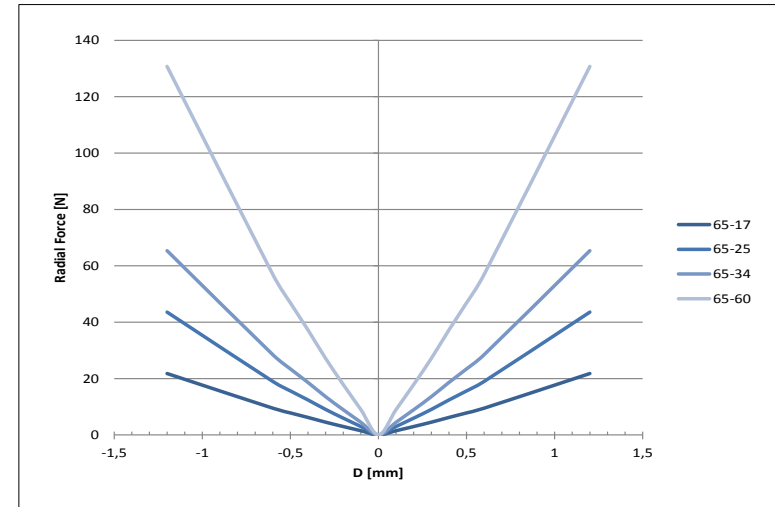


Figure 23: Radial forces QTR65 series

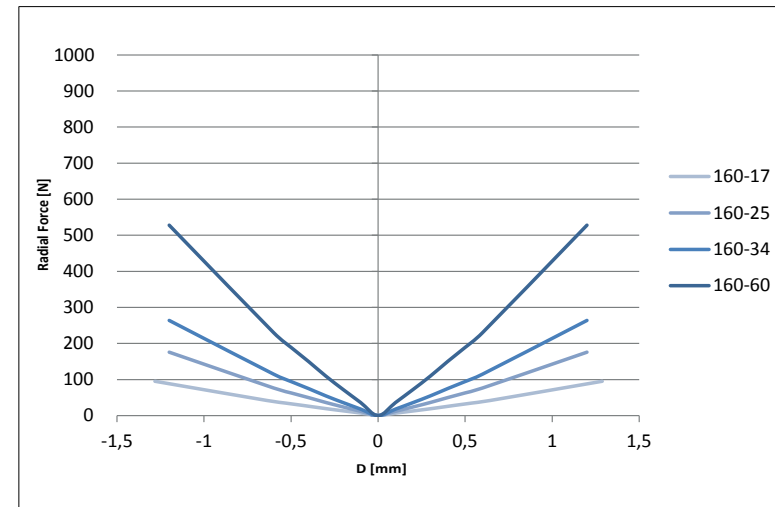


Figure 24: Radial forces QTR160 series

4.4 Mounting options

Successfully mounting a Tecnotion QTR motor requires the proper tooling. When mounted, the motor needs to be cooled and fixed in position properly. Cooling is needed especially in applications with high (continuous) workload.

Tecnotion QTR stators are centered and aligned via the lamination stack. Tecnotion QTR rotors are centered and aligned on the inner diameter.

Rotors and stators can be clamped or bonded to the application following the procedures described in this chapter.

4.4.1 Stator clamping

The required clamping force is determined by the stator's outer diameter. The stators are calculated so that they keep the motor in place and optimize cooling. Some compressing effect can be expected for larger stack heights. This clamping force maximizes the contact area between motor and housing, see Figure 25 and Table 12.

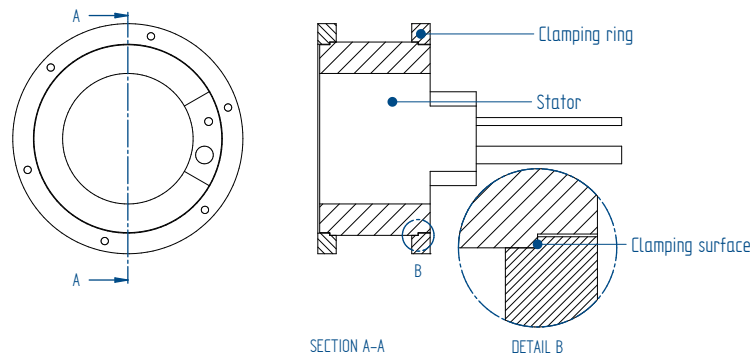


Figure 25: Example clamping ring

Clamping surface area and force are shown in Table 12.

Table 12: Stator clamping force requirement

Motor	QTR 65	QTR 78	QTR 105	QTR 133	QTR 160
Clamping OD	65	78	105	133	160
Clamping ID	62	75	102	130	157
Clamping surface (mm ²)	250	301	407	517	623
Clamping Force (N)	7000	7000	14000	14000	21000

These clamping forces are a recommendation when the motor is used to its ultimate torque. At low loads, the clamping force can be reduced. It is however not recommended to install the motor with less than the required clamping force. The clamping force ensures good contact of the lamination stack and housing.

4.4.2 Stator bonding



Adhesives and activators can damage the stator and rotor. Only use adhesives that do not react with the motor materials. See Appendix D (material properties).

When using a digital Hall module it's better to bond a stator to the housing. Please consider that the adhesive used will have an effect on heat dissipation. Any adhesive will add an extra temperature resistance. This will influence cooling during operation, especially continuous performance is affected.

When using an adhesive to connect a Tecnotion QTR stator to a housing, keep in mind the following variables:

- Heat dissipation of the stator.
- Thermal conductivity of bonding material.
- Thickness of the bonding material.
- Sheer strength of the bonding material.
- Centering of the rotor in the stator.
- No reactivity with polyetherane casting.

Ideally a bonding material with a minimal thickness and high thermal conductivity is used. Table 13 below shows the influence of typical bonding material thickness and thermal conductivity on the performance of the Tecnotion QTR motor.

Table 13: Adhesive conductivity

Motor	QTR 65	QTR 78	QTR 105	QTR 133	QTR 160
Adhesive thickness (mm)	0.2				
Low resistance adhesive (T_c % @ 0,6 W/(m*K))	95%	90%	85%	80%	80%
High resistance (T_c % @ 0,1 W/(m*K))	75%	70%	70%	70%	70%

4.4.3 Rotor clamping



Do not clamp the rotor radially on its inner diameter or on the rotor magnets

If the rotor is to be clamped, the side surfaces of the rotor can be used. An example of a clamped rotor can be seen in Figure 26. The rotor is only designed to withstand axial clamping forces, not radial clamping forces.

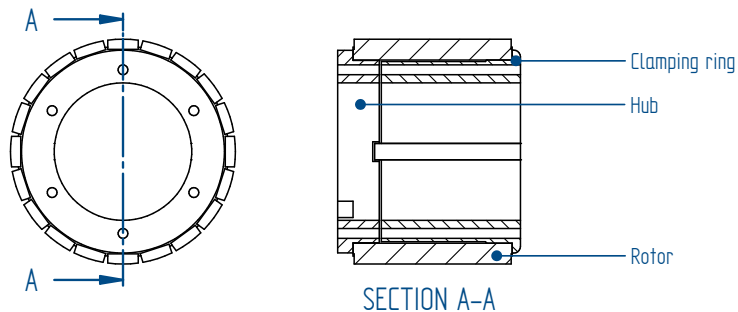


Figure 26: Example clamping ring

The sides of the rotor are described by the maximum clamping diameter and inner diameter of the steel rotor. Table 14 below describes the size and surface per motor diameter.

Table 14: Rotor clamping requirement

Motor	QTR 65	QTR 78	QTR 105	QTR 133	QTR 160
Rotor ID (mm)	17	35	62	84	111
Rotor OD (mm)	23	27	65	91	118
Surface area (mm ²)	188	302	556	962	1259
Rotor clamp force (N)	5000	5000	10000	10000	20000

4.4.4 Rotor bonding

When bonding the rotor using an adhesive, this is best done using the inside surface of the rotor. The bonding surface for a Tecnotion QTR rotor is defined by the width and inner diameter of the rotor. Find the width and diameter in Table 15 below.

Table 15: Rotor bonding specifications

Motor	QTR 65	QTR 78	QTR 105	QTR 133	QTR 160	
Rotor ID (mm)	17	35	62	84	111	
Stack Height (mm)	Rotor width (mm)	Surface area (mm ²)				
17	8,6	459.3	783.5	1513.0	2269.5	2999.0
25	16,6	886.6	1512.4	2920.4	4380.6	5788.7
34	24,6	1313.8	2241.2	4327.9	6491.8	8578.4
60	84,6	2595.6	4427.8	8550.2	12825.2	16947.6
Minimum shear force @ T_u (N/mm ²)						
17	8,6	0.164	0.115	0.068	0.059	0.056
25	16,6	0.169	0.119	0.075	0.065	0.061
34	24,6	0.198	0.139	0.087	0.076	0.072
60	84,6	0.271	0.19	0.119	0.103	0.097

4.5 Installation of stator and rotor

Installation of stator and rotor is the process of bringing together the rotor and stator of a QTR motor. When bringing the rotor and stator together, the rotor magnets will start attracting the stator strongly. Installation should be done in compliance with the radial and axial attraction forces, see paragraphs "4.3.2 Axial attraction" & "4.3.3 Radial attraction"

All QTR 105, QTR 133 and QTR 160 motors require installation (or assembly) of the rotor and stator. These motors are shipped separately in one package/box, see Figure 27. The rotor is covered by a protection ring.

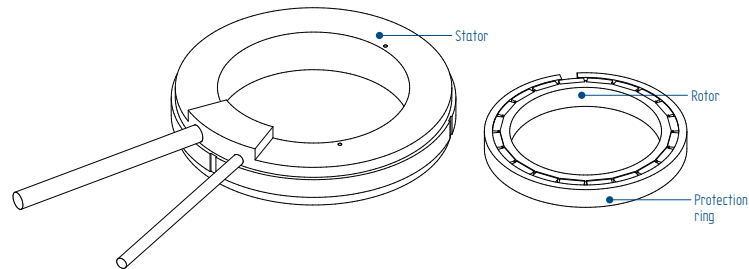


Figure 27: Rotor and stator packaging of QTR 1xx

QTR 65 and QTR 78 motors are shipped with the rotor inside the stator, the two being separated by a plastic shim, see Figure 28.

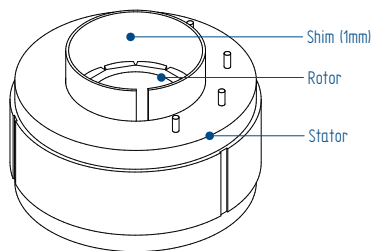


Figure 28: Rotor and stator packaging of QTR65 and QTR78

These motors can be built in the application as they are. If required, the rotors can be pushed out of the stator. The required force can be found in paragraph "4.3.2 Axial attraction". After disassembly the rotor and stator can be put together using the descriptions in this chapter.

4.5.1 Rotor in stator installation

Installing a rotor inside a stator can be done using a custom installation tool and optionally a 1 mm thick shim. It is advised to properly fix the stator in its housing and fix the rotor to a hub. The hub should connect to a custom alignment tool stiff enough to withstand the axial and radial alignment forces. Follow the steps below for installation:

1. Mount the stator.
2. Mount the rotor, by bonding or clamping it to a hub.
3. Install an installation tool to the rotor hub and/or line the stator inner surface with a shim.
4. Carefully insert the rotor in the stator.
5. Fixate the rotor to the axle/application.
6. Remove any shim or tooling used during installation.

4.5.2 Stator over rotor installation

Installing a stator over a rotor can be done using a centering cone or an a 1 mm thick shim. Follow the steps below for installation:

1. Mount the rotor.
2. Mount the centering cone or the shim
3. Carefully pull the stator over the rotor.
4. Fixate the stator to the application.
5. Remove any cone or shim used during installation.

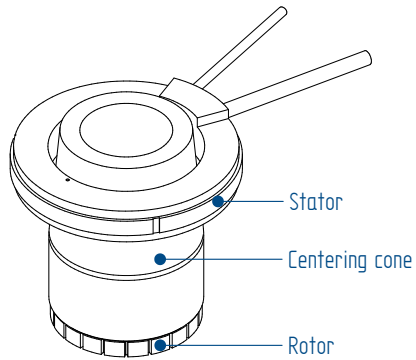


Figure 29: Cone

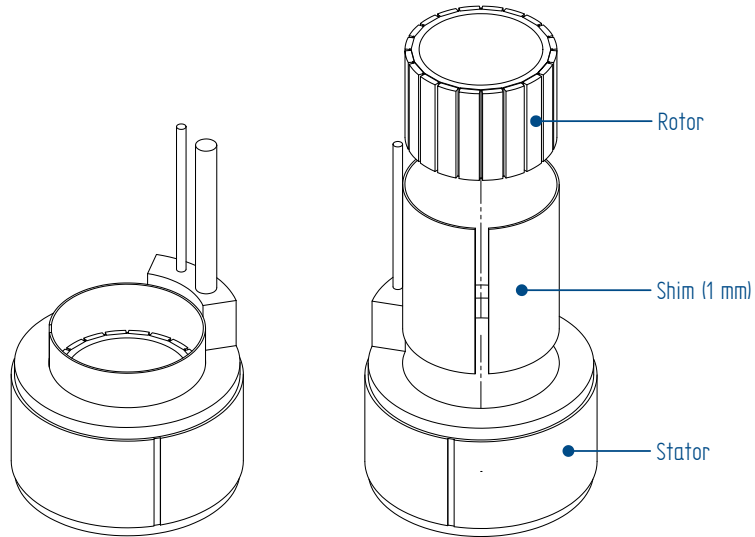


Figure 30: Shim

4.5.3 Final check

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.

4.6 Electrical connections

4.6.1 General remarks

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

4.6.2 Powerlines

The power cable can be confectioned by the user to fit the servo drive.

4.6.3 Protective earth

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

4.6.4 Polarization test

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

4.6.5 Temperature sensor cable wiring

Details about the wire identification are shown in Table 16.

Table 16: Sensor cable wire identification QTR 1xx

Sensor cable (color)	Connection to servo controller
PTC (white)	PTC
PTC (brown)	PTC
KTY21 (green)	KTY83-122
KTY21 (yellow)	KTY83-122
Shield	Protective earth
Red	Hall C

4.6.6 EMC performance

The combination of a torque motor with a servo drive needs a proper shielded connection for optimal EMC performance. Therefore it is very important to connect the shielding of the shielded (EMC) motor cable correctly to the shielding point of the servo drive.

For optimal EMC performance place the metal (conducting) rotor bearings as close as possible near the rotor, to make high frequency electrical contact with the torque stator.

If the cable is not directly connected with the drive, proper connectors must be used to pass the EMC field well.

4.7 De installation



Reposition the magnetic field neutralizing protection cover on the rotor again when dismantling them



If deinstallation is to be expected, save the magnetic protection ring and/or shims supplied with your Tecnotion QTR motor.

In general the de installation order follows the reverse installation sequence as described in the installation order. This can vary however for each application design. Reposition the magnetic field neutralizing cover as soon as the rotor is removed from the stator.

4.8 Additional components

4.8.1 Digital Hall Module

See paragraph "3.7 Accessories" for information on the digital Hall module. See appendices B and C for specifications of the digital Hall module

4.9 Coupling torque motors

Two or more torque motors can be coupled to operate together. Then the torques generated can be added together. Coupled torque motors can in principle be operated by one amplifier, provided that the maximum driver power output, is not reached. The torque motors are connected in parallel and the currents of both motors add up. It is not possible to mount motors in series with voltages adding up, because their wiring is not suitable.

Two or more motors of the same type can always be coupled. For example QTR-A-105-17N with QTR-A-105-17N. Motors of different types can only be coupled if their motor torque constants are equal.

For more information contact your Tecnotion representative. Tel: +31 546 536 300

5. OPERATION

When you are convinced that your application's torque motor system is installed in a proper way, both mechanically and electrically, you can put your motor system into operation.

5.1 Pre-QTRXcommissioning

Before powering the system, please perform a final check on the items below:

1. Does the axis rotate free over the whole turn, without touching small mechanical parts like bolts or contaminations?
2. Does your system have an emergency stop?
3. Is the temperature cable properly connected?
4. Does the motor ruler combination have the right polarization?
5. Has the power cable been connected properly?
6. Operational conditions according to IEC 60721-3. For reference check paragraph logistics.

5.2 Configuring

Some input and output signals need to be configured by following the steps below:

1. The following motor items should be configured as parameter settings of the servo amplifier:
 - Maximum continuous current.
 - Maximum peak current.
 - Value of the coil self-inductance.
 - Maximum speed (rpm).
 - Presence/absence of an electromechanical motor brake.

- Number of pole pairs.
- Switching resistance of PTC.

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

- Type of interface of the ruler system.
- Resolution or period of the encoder.

3. These are the I/O parameters to be configured:

- Settings of the available digital inputs and outputs. For instance, pay attention to the type of end switches if present.
- Settings of the available analog inputs and outputs.

4. Finally the controlling parameters must be configured.

- Current control settings. These settings depend on both motor and amplifier.
- Speed control settings.
- Position control settings.

5.3 Testing

After the amplifier is powered up some input and output signals need to be examined by following the steps below:

1. Check the end switches, if present, by rotating the axis manually to the switch position. Simultaneously check whether the signal is detected by the amplifier.
2. Check the presence of the PTC signal.

5.4 Operational conditions

The mentioned ambient conditions are for the primary product package contained in a secondary cardboard package. The primary package is intended for storage in warehouse and efficient packing in a secondary or tertiary package. The primary packaging itself is not suited as a transportation package. See Table 17 for the operational conditions.

Table 17: Operational conditions

Climatic conditions	
Operation	3K3
Low air pressure	99kPa (different from 3K3). Derating will occur
High air pressure	101kPa (different from 3K3)

Biological conditions	
Operation	3B1

Chemically active substances	
Operation	3C1

Mechanically active substances	
Operation	3S1

Mechanical conditions	
Operation	3M7

6. TRANSPORT, STORAGE & DISMANTLING

This chapter describes the requirements for transportation, storage and dismantling of the torque motors.

6.1 General safety rules for transport, storage & dismantling

- Only handle the rotor with the magnetic field neutralizing protection ring in place (QTR-65 & QTR-78 don't need a protection ring).
- Only transport rotors and magnets in their original packaging. This ensures the magnetic stray field is within safe limits and that no uncontrolled attraction of ferromagnetic materials can occur.
- Magnetic sensitive objects like banking cards, pacemakers or other magnetic information carriers may be damaged if they are brought within 1 m of the magnets (plates or rotor).
- The storage area for motor components needs to be clearly delimited with a warning sign: 'Caution Powerful magnets!'.
- Only store motors in their original packaging.

6.2 Transport & packaging

The rotor of the torque motor contains permanent magnets that produce a magnetic strayfield. For transport safety the following needs to be taken into account when transporting magnetized materials by air.

Airfreight

When magnetic material is transported by air, the IATA airfreight packaging instruction 953 applies. Above a certain threshold value the relevant authority needs to be informed prior to shipping, see Table 18.

Table 18: Magnetic strayfield threshold value

Threshold	Field strength	Action
1	<5.25mG @2.1m of package	No action required
2	>5.25mG @2.1m of package	Notify relevant authority and label products / packages
3	>5.25mG @4.6 m of package	Relevant authority needs to authorize the shipment. Special measures need to be taken, e.g. extra packaging material / higher shipment cost.

Magnetic materials can, when transported in close proximity to each other, amplify their individual magnetic stray field strength. A single rotor can therefore have a stray field well below the safe field strength threshold, multiple rotors could surpass this threshold. All QTR 1xx type motors with protection ring require no action when packed in their original packaging. (QTR-65 & QTR-78 don't need a protection ring).

Other means of transportation

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.

Packaging

Tecnotion products have a primary package that sits directly around the product. Tecnotion primary product package is intended only as product packaging. It's 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 a 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.

6.3 Storage

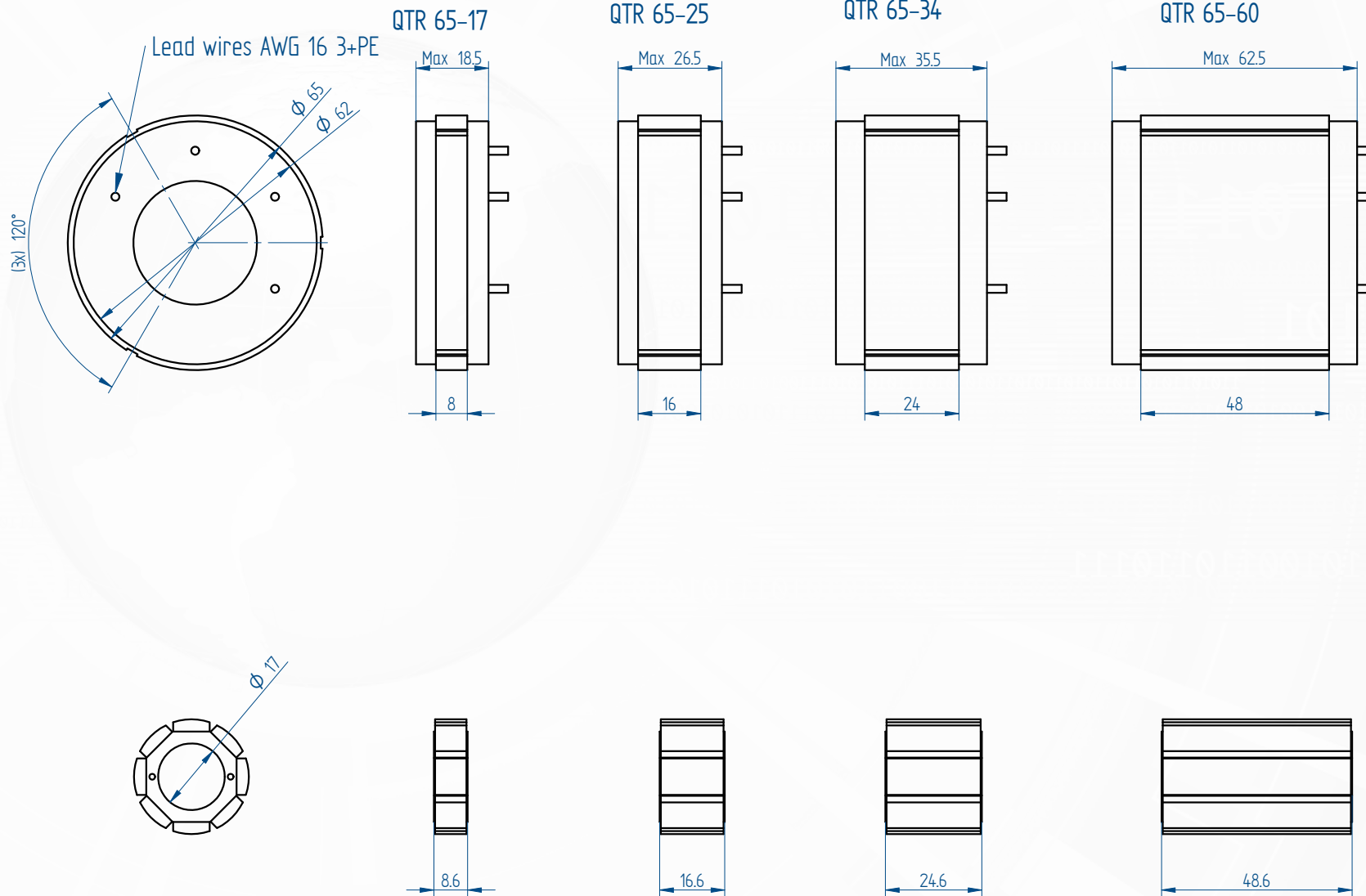
To ensure the product quality Tecnotion advises the following storage conditions: according to IEC 60721-3-1 Storage, 60721-3-2 Transportation.

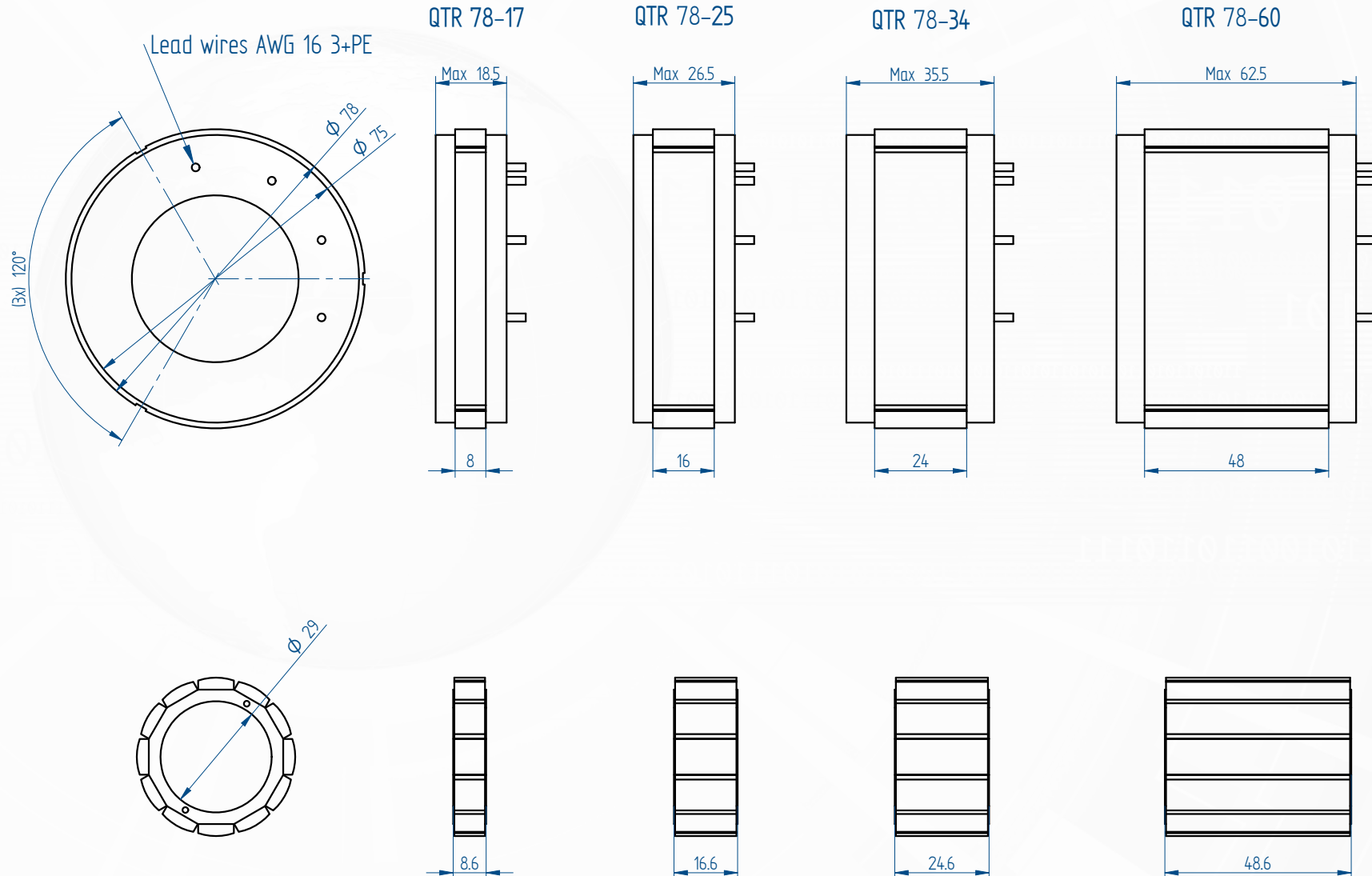
The primary package is intended for storage in a warehouse and efficient packing in a secondary or tertiary package. The primary packaging itself is not suited as a transportation package.

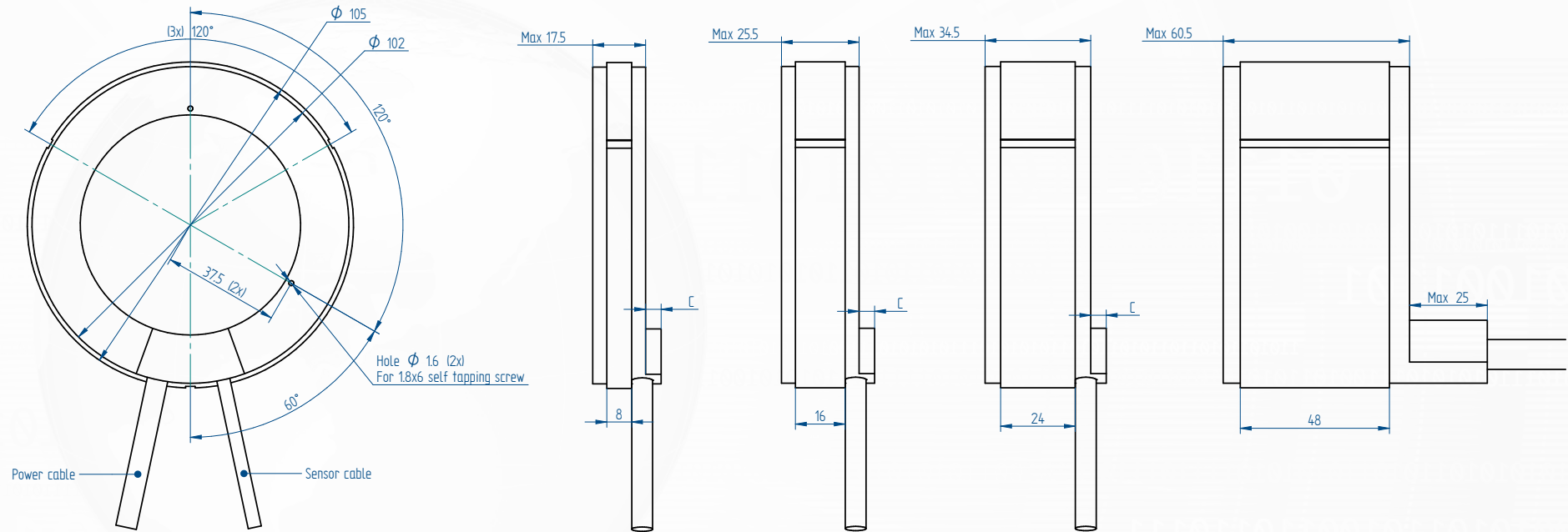
The mentioned ambient transportation conditions in Table 19 below are for the primary product package contained in a secondary cardboard package.

Table 19: Storage conditions

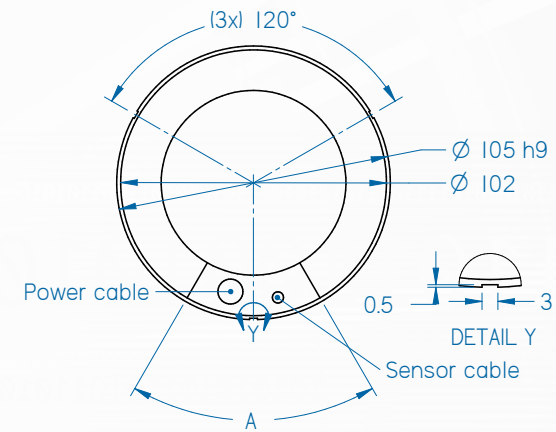
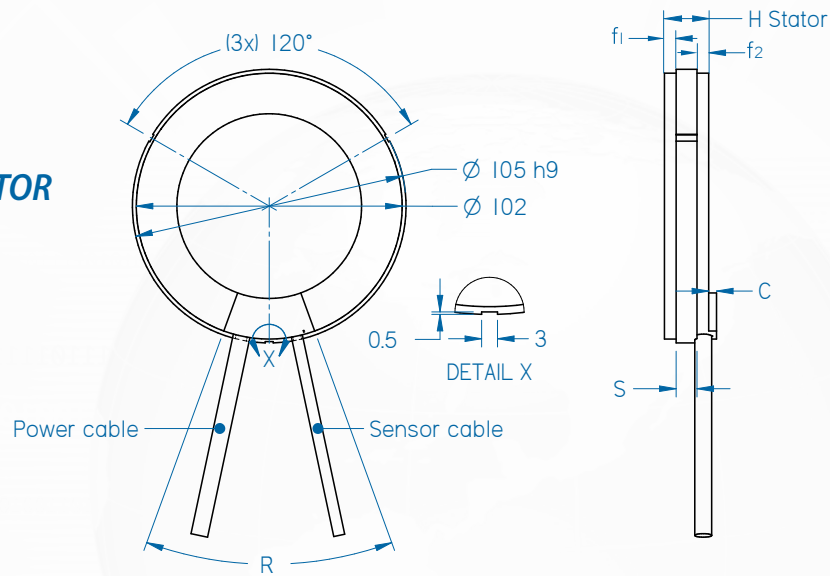
Climatic conditions	
Long term storage	1K3
Storage temperature:	25°C to +55°C (different from 1K3)
Rate of change:	20°C/hour (different from 1K3)
Condensation	None (different from 1K3)
Storage duration	No limitation
Transportation	2K2
Biological conditions	
Long term storage	1B1
Transportation	2B1
Chemically active substances	
Long term storage	1C2
Transportation	2C1
Mechanical conditions	
Long term storage	1M1
Transportation	2M2



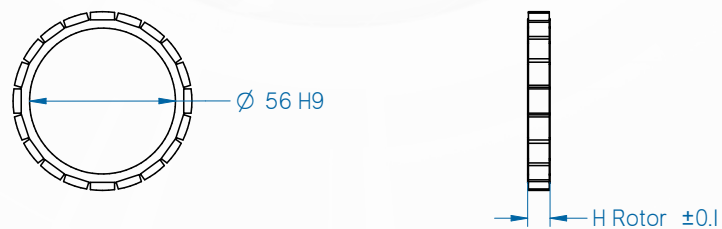




STATOR

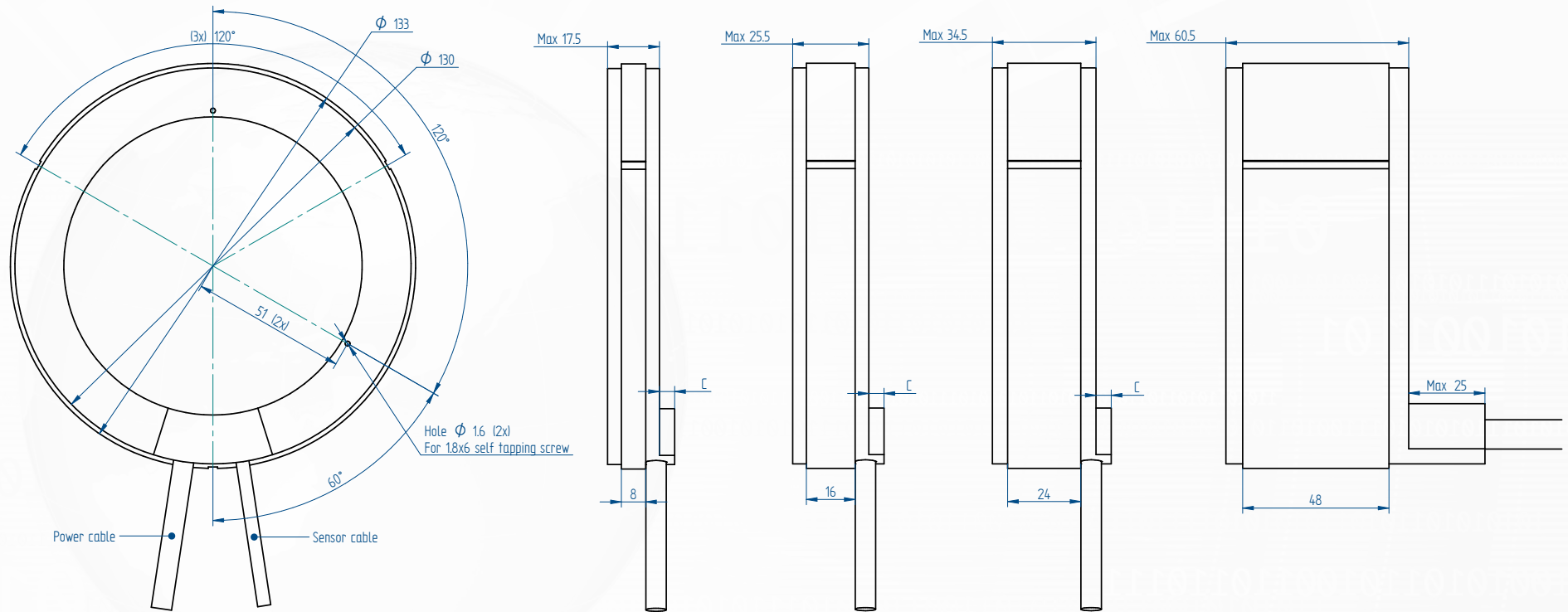


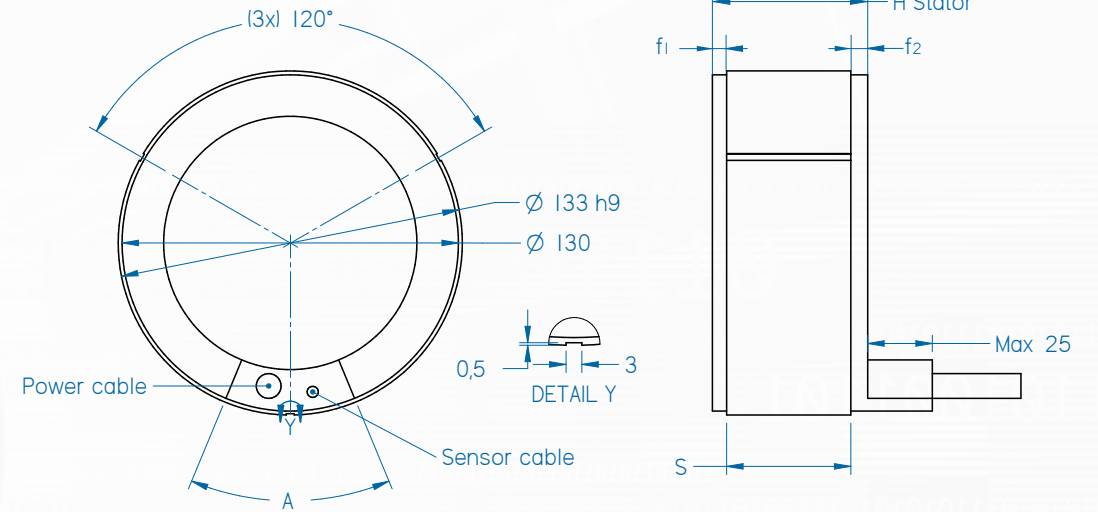
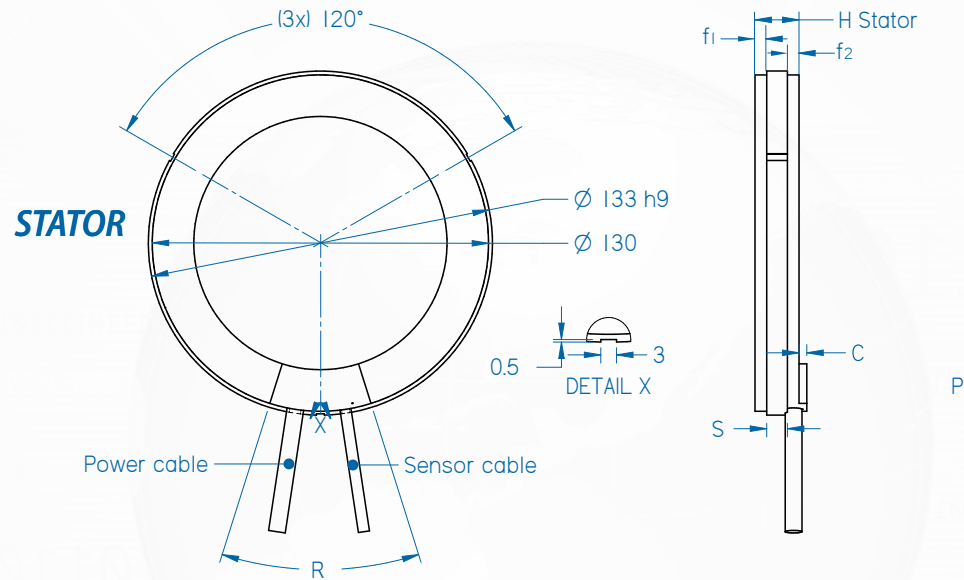
ROTOR



winding	C
N	3.5
Y+Z	5.5

QTR105	R	H stator	S	f1	f2	H rotor
17	40	17.5	8	4.5	4.5	8.6
25	40	25.5	16	4.5	4.5	16.6
34	40	34.5	24	5	5	24.6
60	60	60.5	48	5.5	6.5	48.6

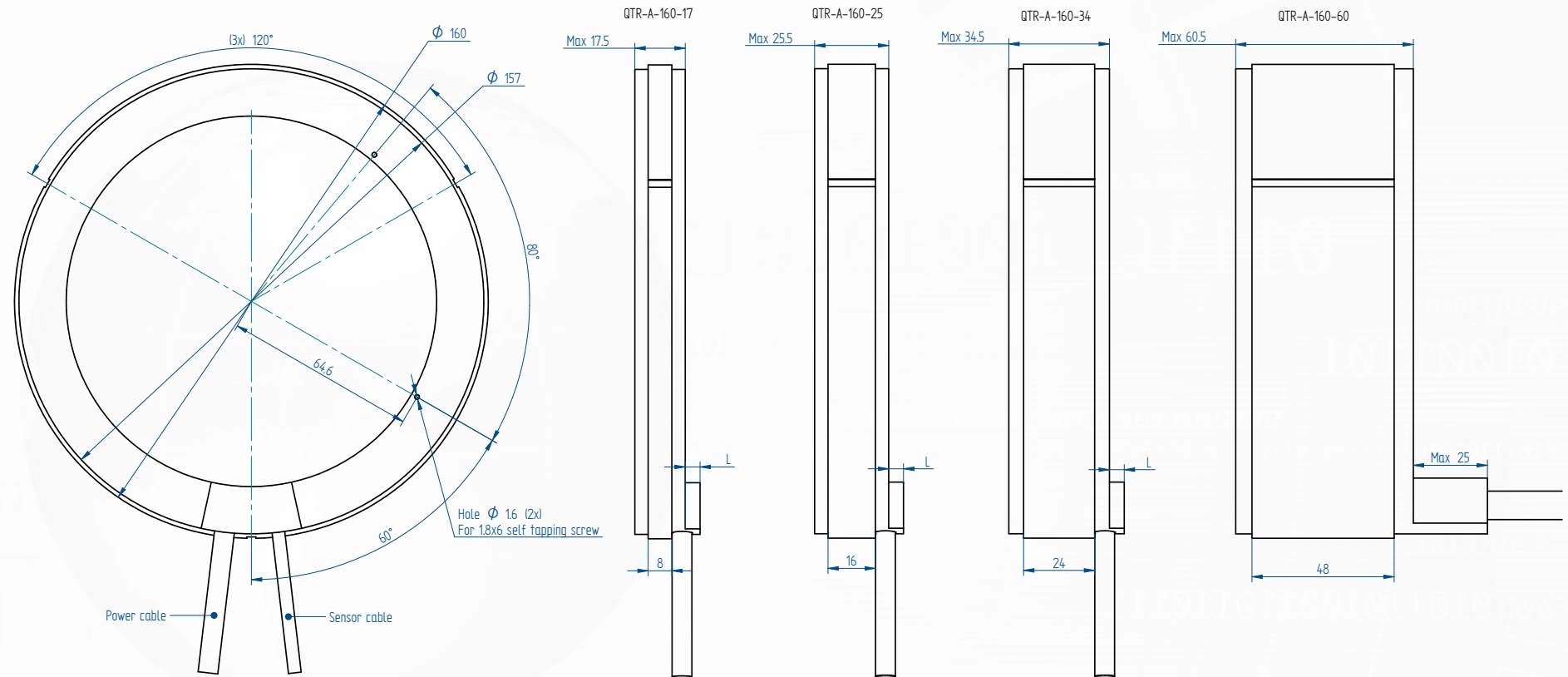


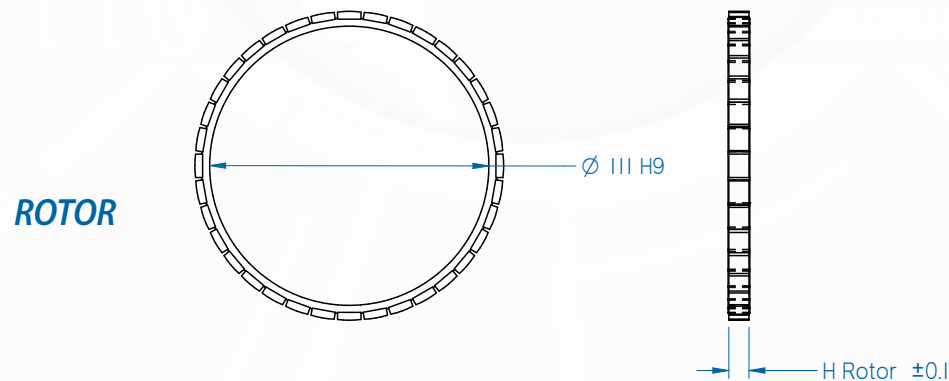
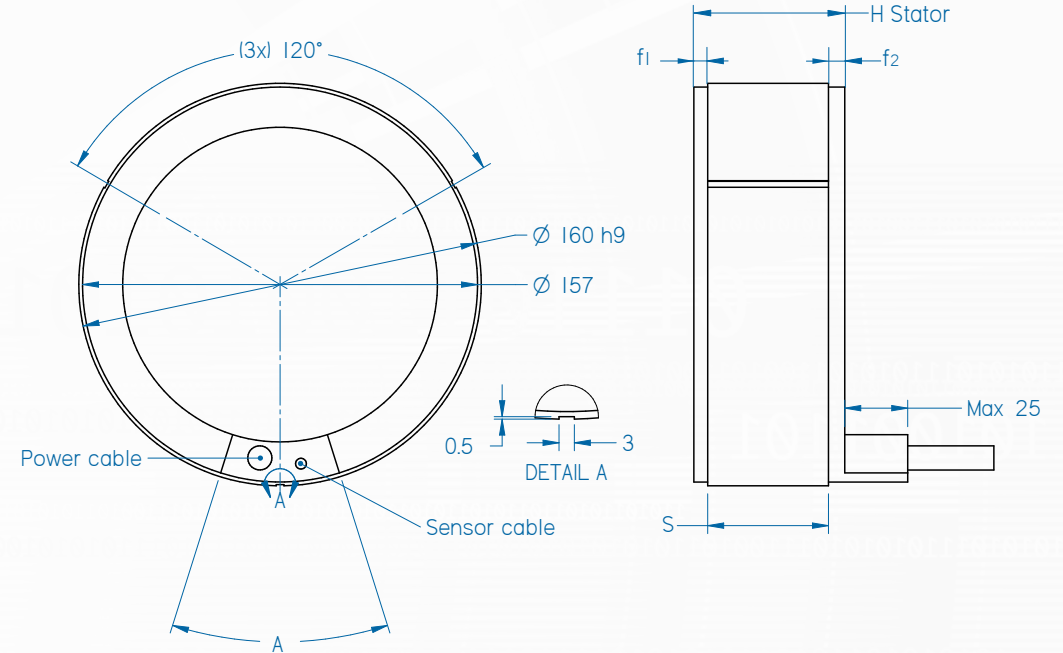
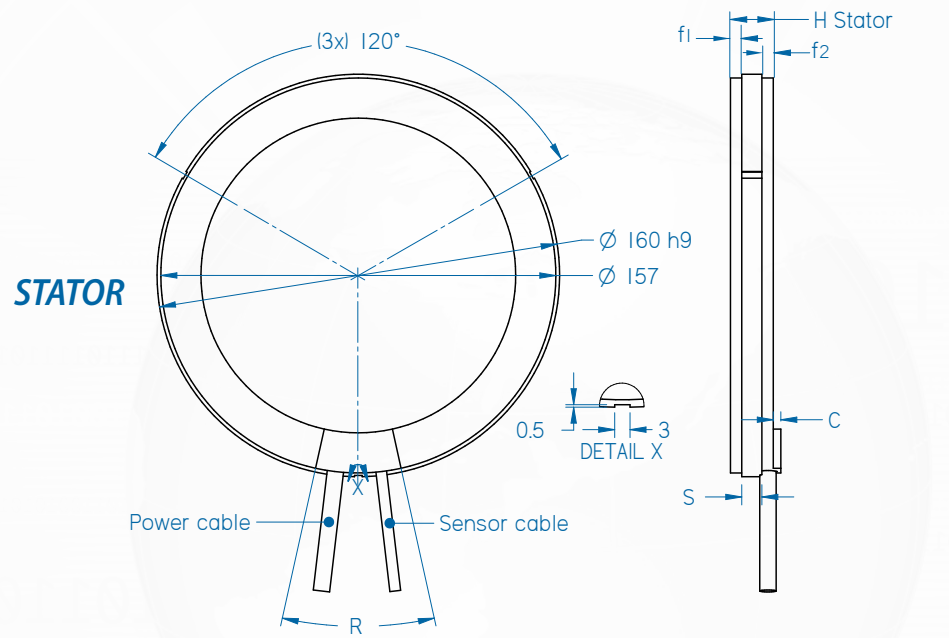


winding	C
N	3.5
Y+Z	5.5

QTR133	R	H stator	S	f1	f2	H rotor
17	35	17.5	8	4.5	4.5	8.6
25	35	25.5	16	4.5	4.5	16.6
34	35	34.5	24	5	5	24.6
60	45	60.5	48	5.5	6.5	48.6

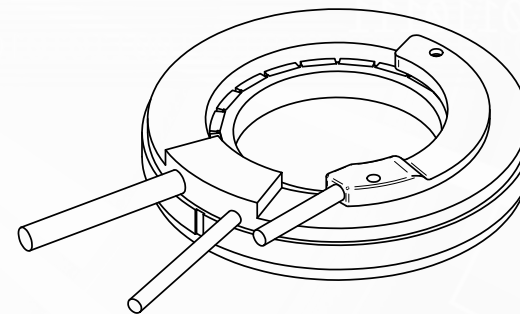
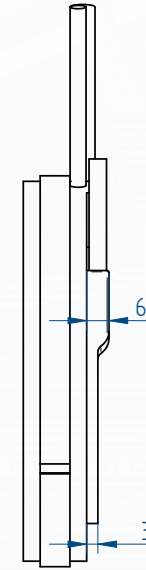
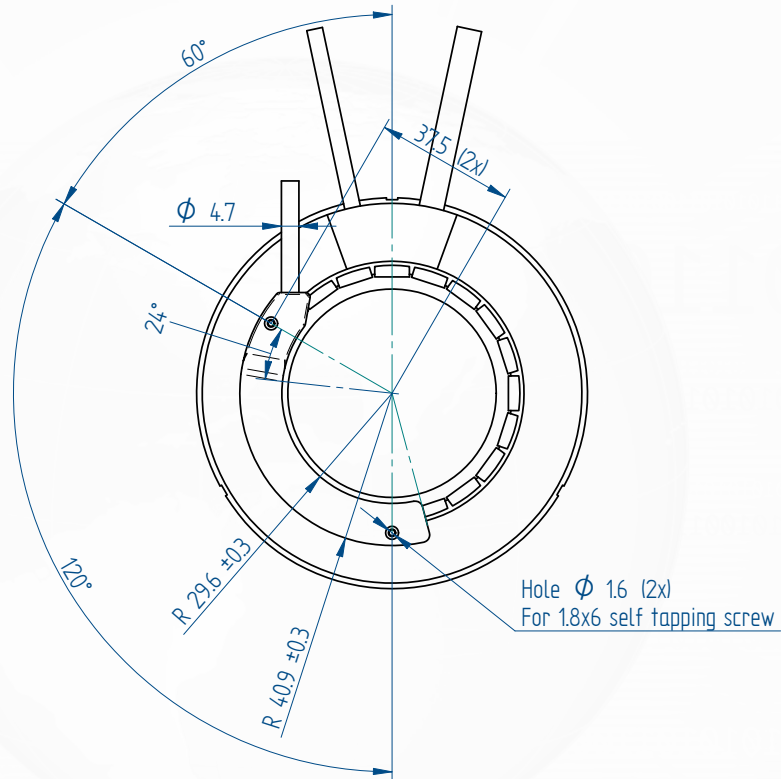
Overview - QTR160 - 17/25/34/60

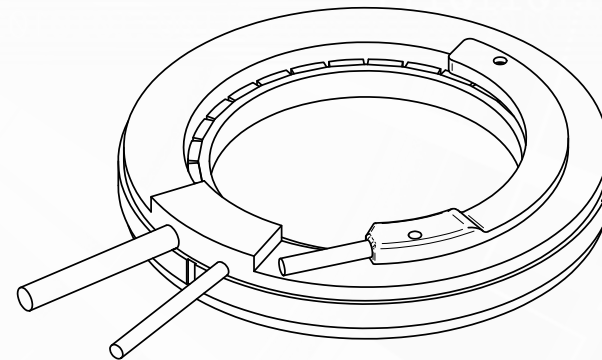
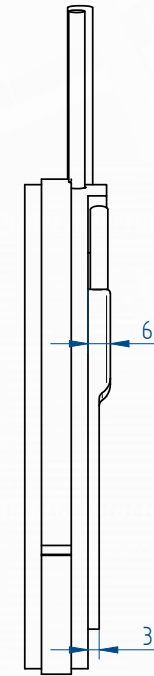
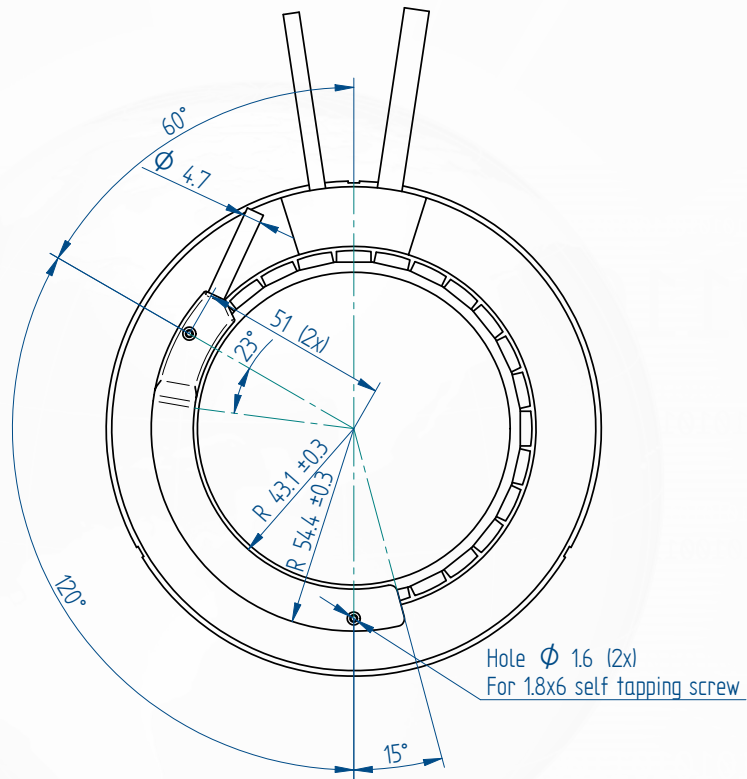


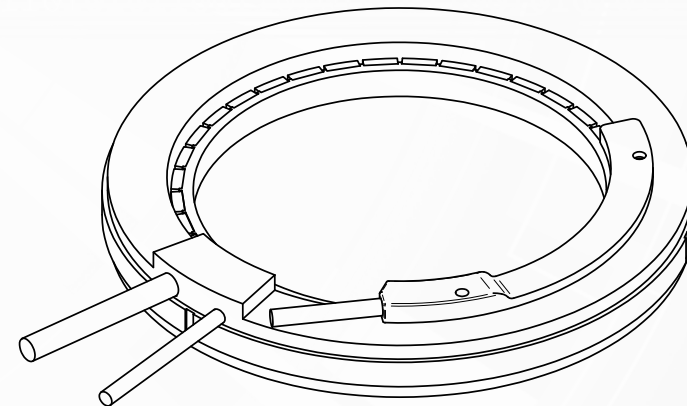
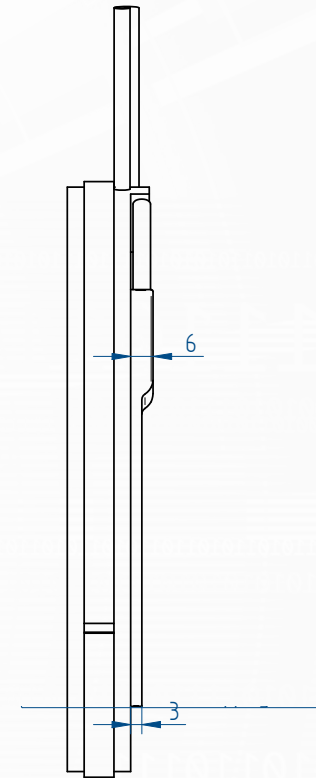
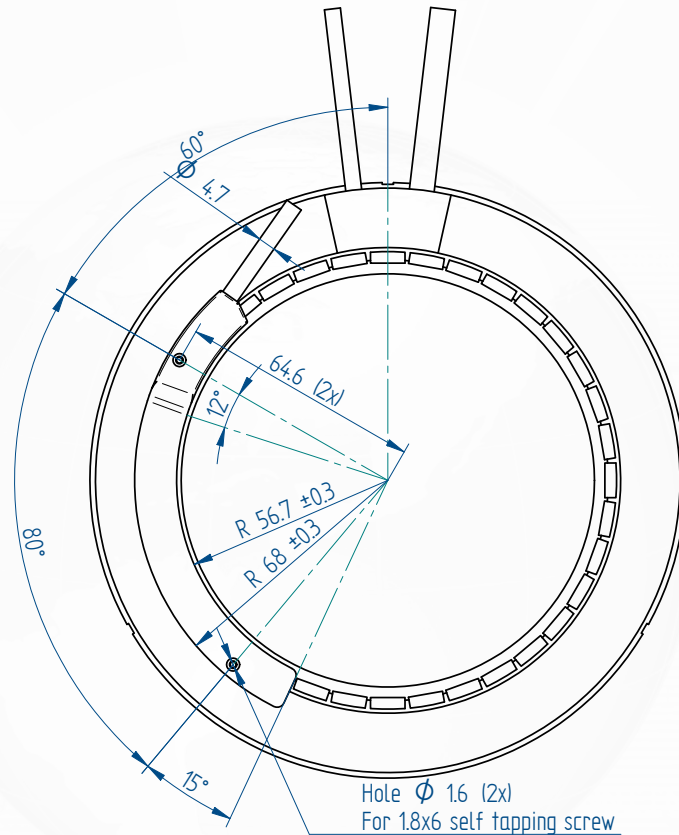


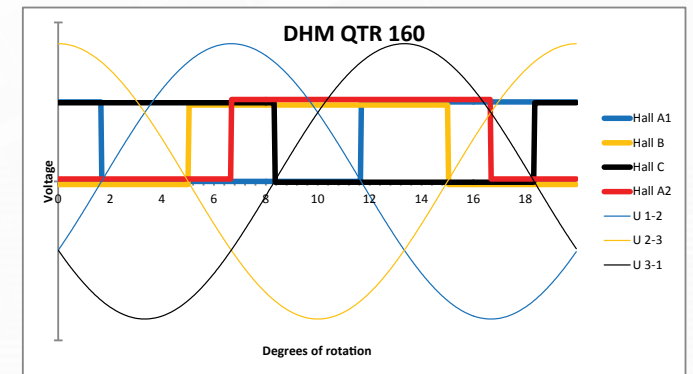
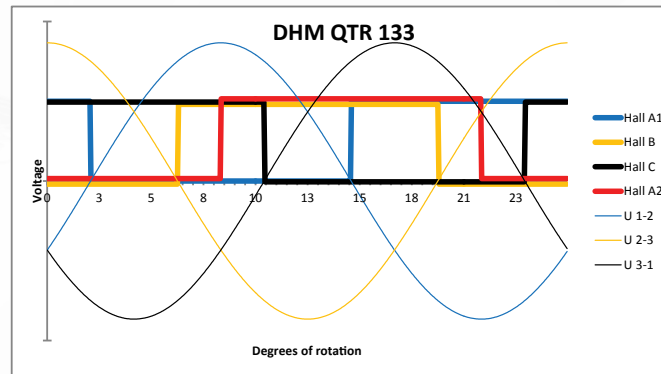
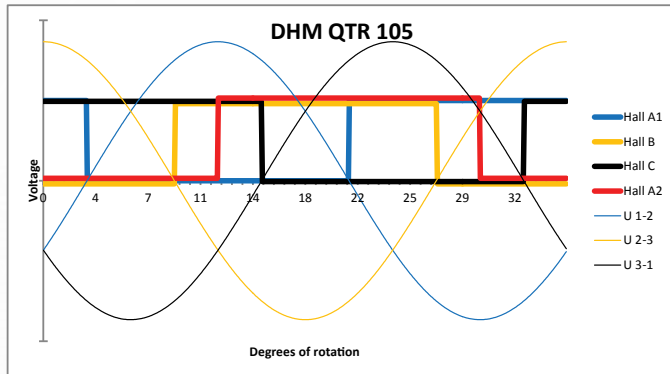
winding	C
N	3.5
Y+Z	5.5

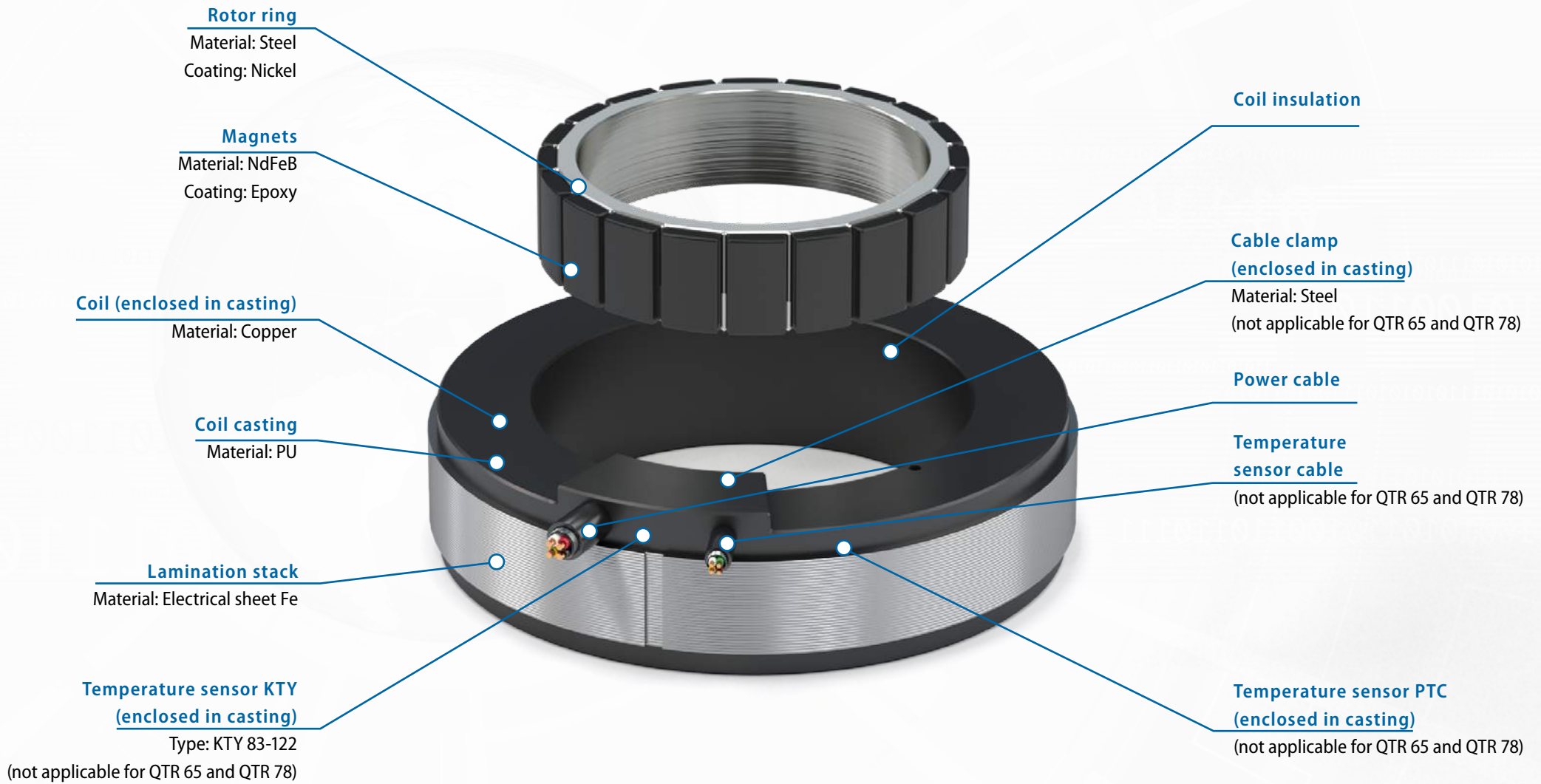
QTR160	R	H stator	S	f1	f2	H rotor
17	25	17.5	8	4.5	4.5	8.6
25	25	25.5	16	4.5	4.5	16.6
34	25	34.5	24	5	5	24.6
60	35	60.5	48	5.5	6.5	48.6







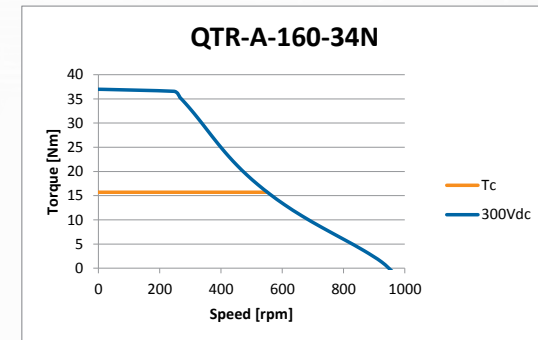
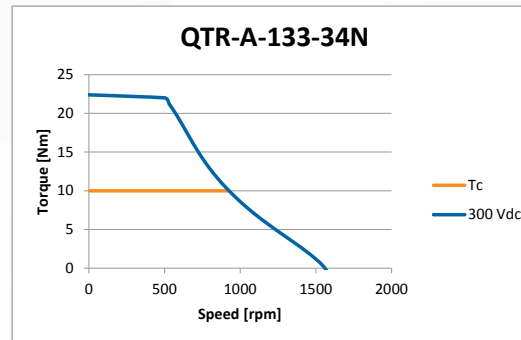
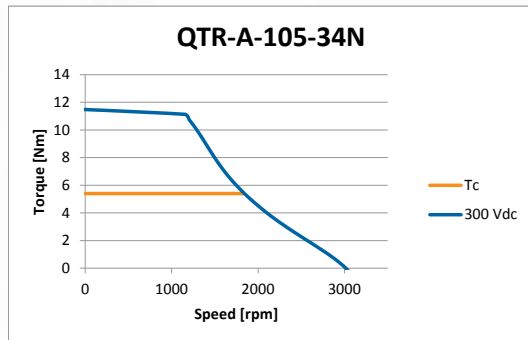
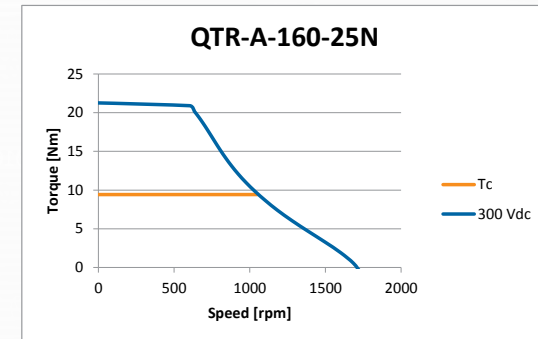
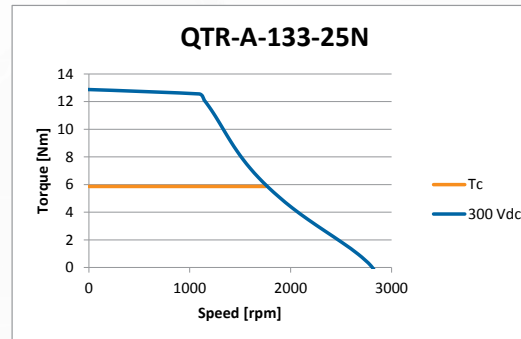
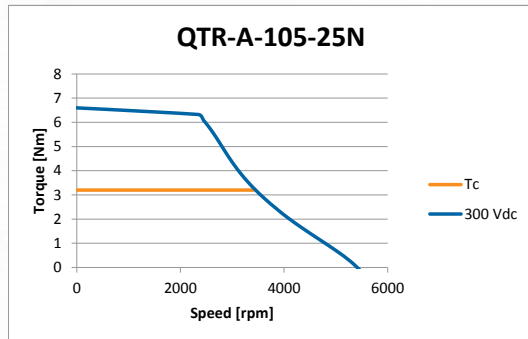
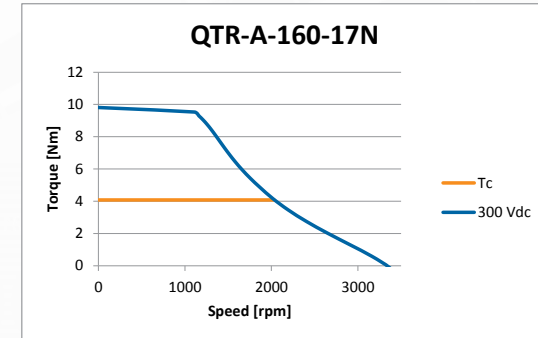
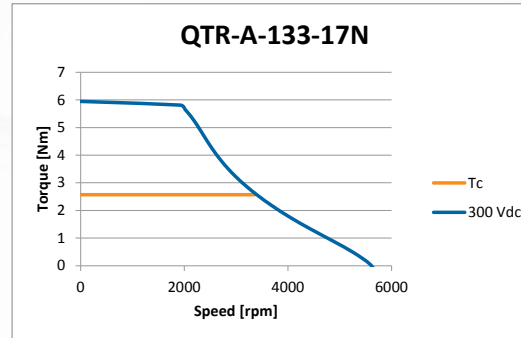
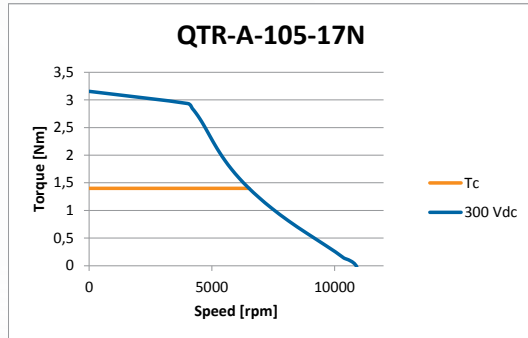


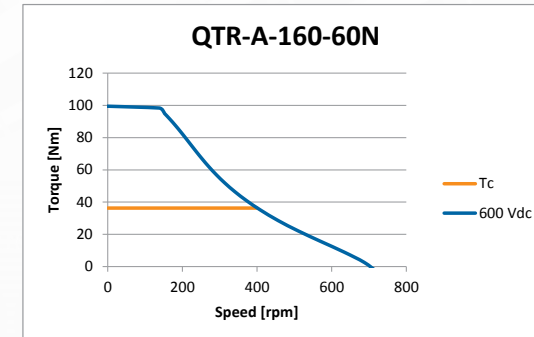
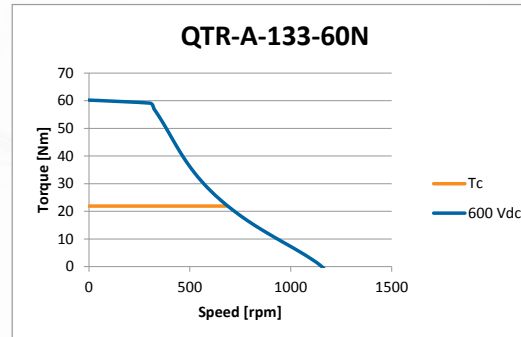
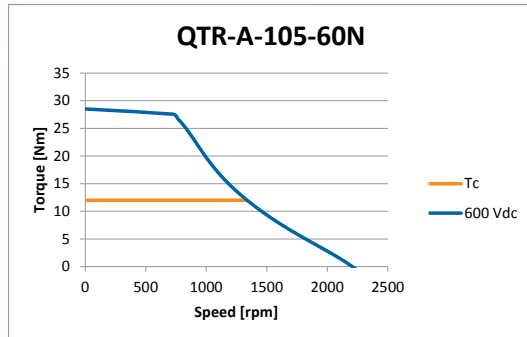


Product	Product configuration	Action		
		No action	Notify relevant authority	Authorisation by relevant authority required
QTR 65-xx	Single kit in original packaging	x		
	Completely filled Euro pallet of kits in original packaging (1200*800*1000mm)	x		
	Individual rotor	x		
QTR 78-xx	Single kit in original packaging	x		
	Completely filled Euro pallet of kit in original packaging (1200*800*1000mm)	x		
	Individual rotor	x		
QTR 1xx	Single kit in original packaging	x		
	Completely filled Euro pallet of kit in original packaging (1200*800*1000mm)	x		
	Rotor with protection ring	x		
	Rotor without protection ring	x		



For most recent version see our website: <http://www.tecnotion.com/certifications.html>



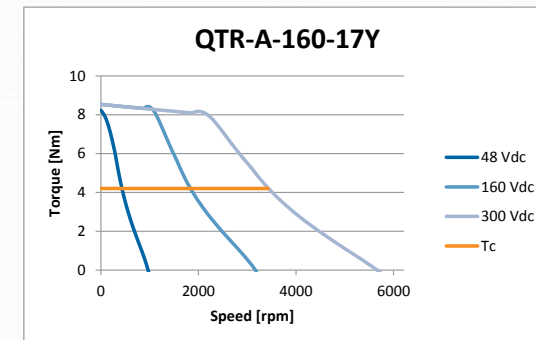
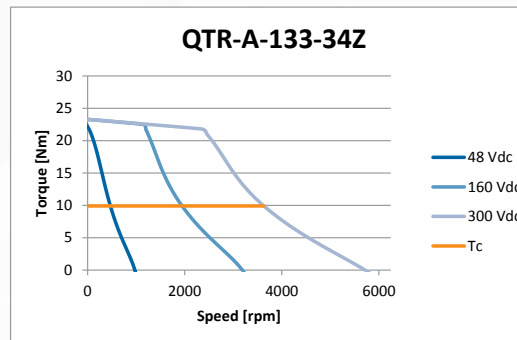
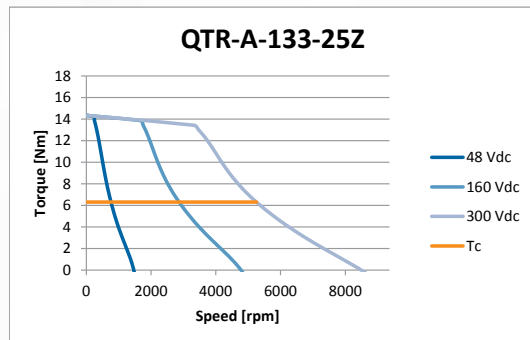
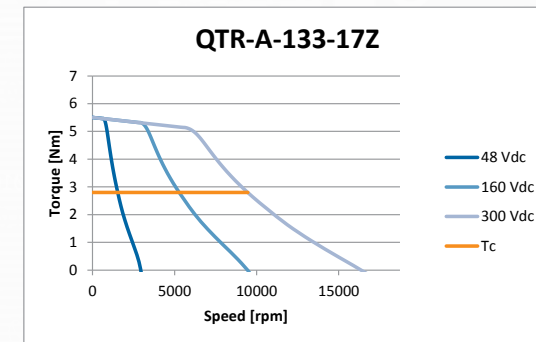
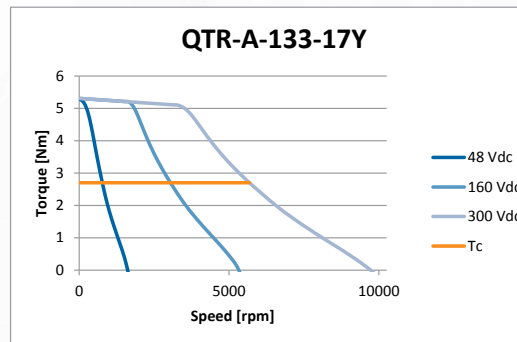
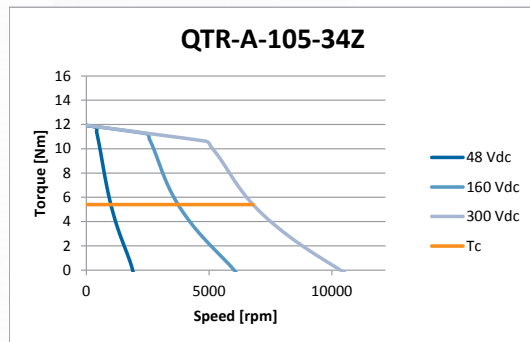
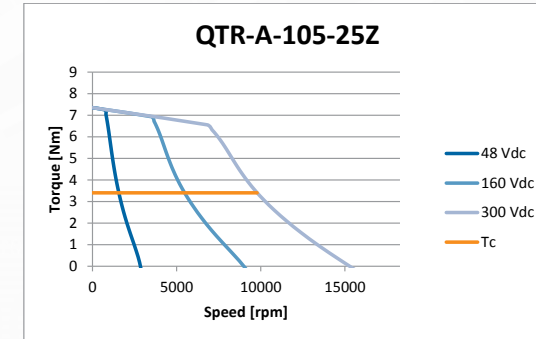
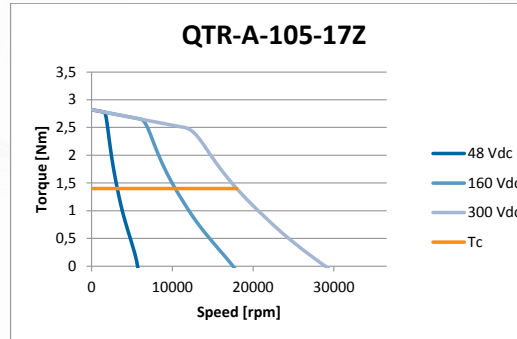
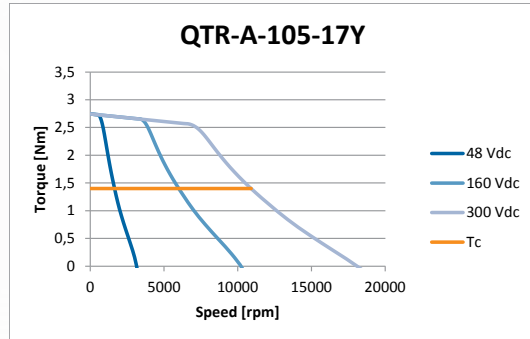


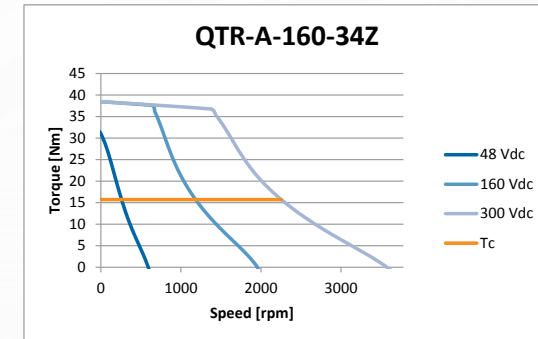
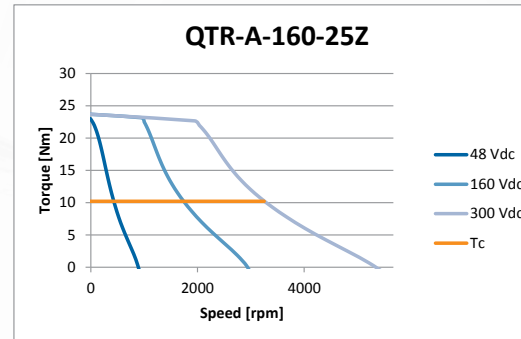
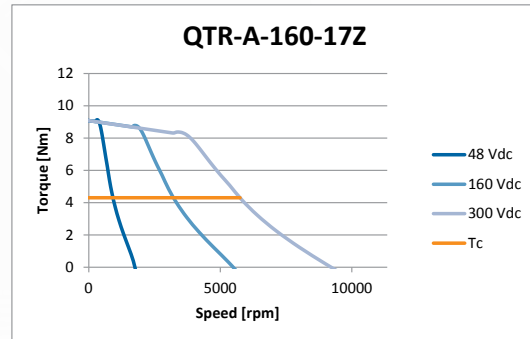
MAXIMUM allowable speed for QTR-A 105 Series motors is 16.500 rpm.

MAXIMUM allowable speed for QTR-A 133 Series motors is 14.000 rpm.

MAXIMUM allowable speed for QTR-A 160 Series motors is 12.000 rpm.

If you plan a high speed application, please contact Tecnotion.



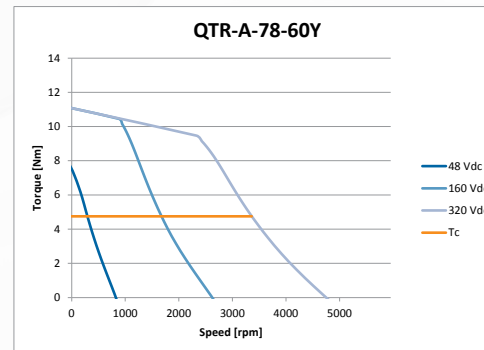
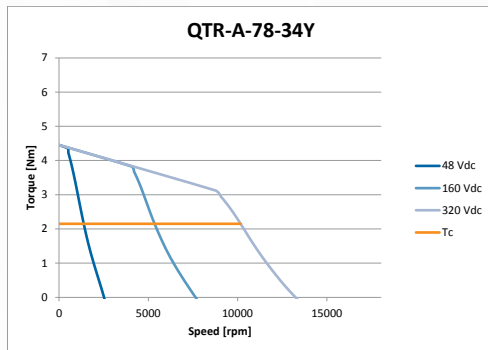
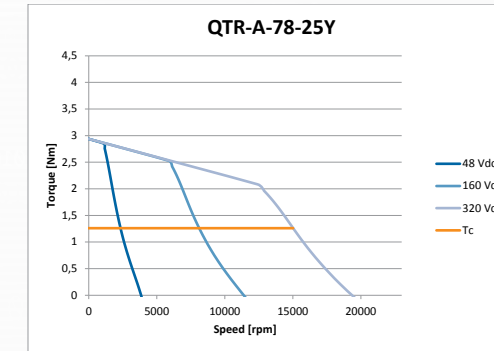
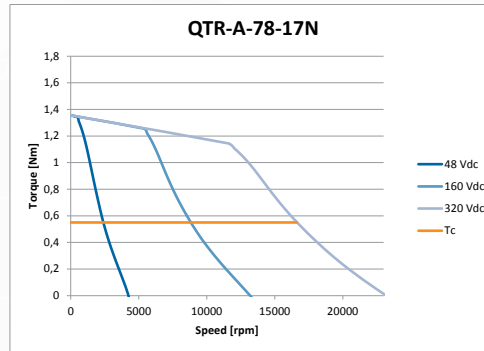
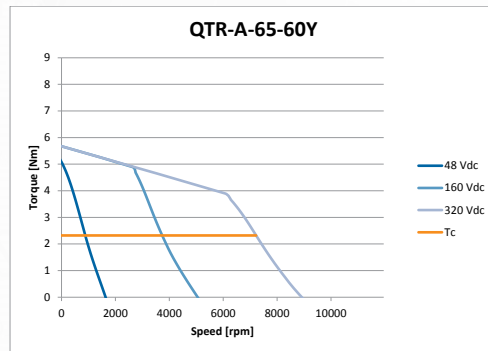
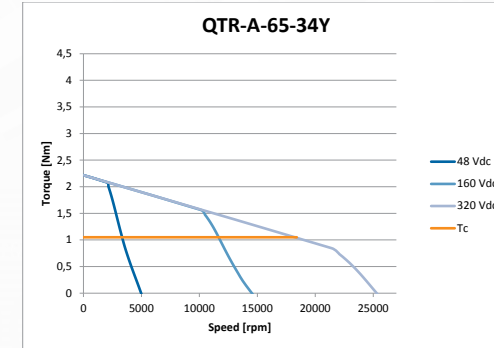
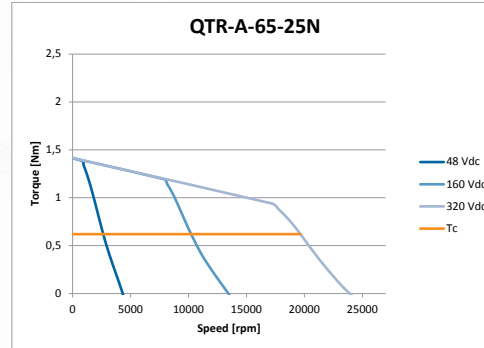
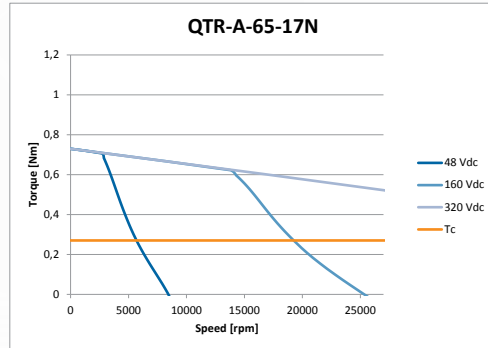


MAXIMUM allowable speed for QTR-A 105 Series motors is 16.500 rpm.

MAXIMUM allowable speed for QTR-A 133 Series motors is 14.000 rpm.

MAXIMUM allowable speed for QTR-A 160 Series motors is 12.000 rpm.

If you plan a high speed application, please contact Tecnotion.



MAXIMUM allowable speed for QTR-A 65 Series motors is 28.000 rpm.

MAXIMUM allowable speed for QTR-A 78 Series motors is 23.000 rpm.

If you plan a high speed application, please contact Tecnotion.

Parameter	Remark	Symbol	Unit	Definition
AWG				American Wire Gauge is a standard for wire thickness specification. The diameter "d" can be calculated with the AWG value "n". $d[\text{mm}] = 0.127[\text{mm}] \times 92^{\wedge}((36-n)/39)$.
Back EMF Phase-Phase _{rms}		K_e	V/krpm	Back electromotive force. A torque 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/krpm]. When the generated voltage is nearly equal to the bus voltage of the system the motor cannot run any faster.
Back EMF Phase-Phase _{peak}		K_e	V/krpm	This value represents the maximum value of the Back EMF that is generated between the phases of the motor. It is obtained by multiplying the effective value of the Back EMF with $\sqrt{2}$
Bending radius	minimum			Minimum bending radius for the cable when used in static configuration.
Cable mass	all cables	m	g	Mass of all cables for a length of 0.5m.
Coil Induction per Phase	$l < 0.6 \text{ lp}$	L	mH	The induction value in [millihenry] of one phase of the motor. This value can be verified via the motor cables. But the double value will be measured because of the star point configuration of the motor, if applicable.
Coil Resistance per Phase	coils @ 25°C ex. cable	R	Ohm	The resistance value in [Ohm] of one phase of the motor. This value can be verified via the motor cables. But the double value will be measured because of the star point configuration of the motor, if applicable.
Continuous power loss	coils @ 100°C	P_c	W	The maximum amount of power in [Watt] that is dissipated when the motor is operated at continuous force. The actual value can be lower as a result of variations in thermal resistance, coil temperature and winding resistance. The resistance per phase increases with the temperature according to $R_{ph_DT} = R_{ph} \cdot (1 + \alpha \times \Delta T)$. With α being the temperature coefficient for copper [1/K] and ΔT the temperature increase in [K].
Continuous torque	coils @ 100°C	T_c	Nm	At continuous torque the heat generated and the heat flowing to the environment are equal. Dissipation occurs purely via conduction, convection and radiation. The continuous torque is specified for a aluminium mounting surface which is kept at 20°C and a thermal resistance of 0.05 K/W.
Electrical time constant	coils @ 25°C	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.
KTY temperature sensor			Ohm/K	The temperature measurement sensor for the torque series, has a positive coefficient between temperature and resistance.
Lamination Stack Height		H_{arm}	mm	Height of the lamination stack.
Magnets @ 25°C				Temperature at which the specified force is rated. Permanent magnets have a negative temperature coefficient. At higher magnet temperatures the achievable force will be lower. Permanent magnets will demagnetise at a specific temperature and applied external magnetic loads. For Tecnotion torque motors this will occur around and above 60°C. At the specified 25°C this demagnetisation will not occur.
Maximum continuous current	coils @ 100°C	I_c	A_{rms}	The maximum continuous current [A] the motor can be run at to achieve the continuous torque. When cooled by means of radiation, convection and conduction through a 20°C aluminium surface and a thermal resistance of 0.05 [K/W].

Parameter	Remark	Symbol	Unit	Definition
Maximum speed	@Tc	N_{max}	rpm	The maximum speed the torque motor can achieve at continuous torque. The actual value depends on the bus voltage and required force. Please check the T/n diagrams in the Tecnotion simulation tool.
Maximum mechanical speed	@Tc	N_{max}	rpm	The maximum mechanical speed is the speed at which the rotor will start to break down, which means that the magnets will detach from the rotor ring. This speed is much higher than the maximum speed that can be obtained by powering the motor.
Motor Constant	coils @25°C	K_m	(Nm) ² /W	Ratio between torque in newton meter and dissipated heat in Watts [(Nm) ² /W]. 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.
Motor Height		H_{motor}	mm	Height of the stator excluding the cable exit.
Motor Torque constant	Up to Ic	K_t	Nm/A	Ratio between torque in newton meter and RMS current [A].
Peak current	magnet @ 25°C	I_p	Arms	The peak current [A] the motor can be run at to achieve the specified peak torque.
Peak Torque	coils @100°C	T_p	Nm	The peak torque is the force generated by the motor just beyond the saturation point of the motor force constant. The coils will heat up with 6°C/s. The peak torque is determined by the tolerated material expansion due to an increased temperature of the coil. For torque motors this increase is at 20°C/s.
Poles		N_{mgn}	nr	Number of poles.
PTC temperature sensor			Ohm/K	The temperature sensor for the Torque series. This PTC-1k type sensor has a very sudden resistance rise near the critical stator temperature and can be used as a cut off sensor for protection against overheating of the stator. The PTC sensor has a positive coefficient between temperature and resistance.
Rotor ID		ID_R	mm	The inner diameter of the rotor.
Rotor Inertia		J_R	Kg*m ²	Moment of inertia of the rotor.
Rotor Mass		M_R	g	Mass of the rotor.
Stator Mass	ex. cables	M_s	g	Mass of the stator excluding cable mass.
Stator OD		Od_s	mm	The outer diameter of the stator.
Synchronous motor				An electric motor that runs at a speed directly proportional to the frequency of the current used to operate it.
Temperature cut-off sensor				A cut-off sensor is used to protect the motor from damage due to overheating. The sensor has a positive coefficient between temperature and resistance. Near 110°C the resistance increases exponentially. The sensor output can be used as input for the controller to shut off the current to prevent damage to the coils.
Temperature sensor			Ohm/K	A temperature sensor can be used for monitoring the coil temperature. Torque motors are fitted with KTY sensors.
Thermal resistance	coils to mounting surface	R_{th}	K/W	Defines how warm the coil unit will become as a result of the dissipation of power to the surface. $R_{therm} \times \text{dissipated power} = [^{\circ}\text{C}/\text{W}] \times [\text{Watt}] = [^{\circ}\text{C}]$ Temperature of the coil unit.

Parameter	Remark	Symbol	Unit	Definition
Thermal Time Constant	to maximum coil temperature	τ_{th}	s	Time [sec] required for the coil windings to reach $[1-1/e=63\%]$ of their maximum temperature during continuous force.
Total Mass	ex. cables	M_T	g	The total mass of the rotor and stator excluding cables.
Ultimate current	magnet @ 70°C	I_u	Arms	The ultimate current [A] the motor can be run at to achieve the specified ultimate force. Do not exceed this current.
Ultimate Torque @ 20°C/s increase	magnet @ 25°C	T_u	Nm	The torque generated by the motor beyond the saturation point in the non linear area of the motor torque constant. The value of the motor torque constant at ultimate torque is 26% less than the linear value. efficiency of transfer of current to force is lower and causes the coils to heat up faster. For ultimate torque the temperature increase is 20°C/s.
V ac RMS				The effective value of a sine shaped alternating current voltage.
V dc				The direct current bus voltage can be calculated from the AC supply voltage by multiplication $V_{dc}=V_{ac\ rms} \times (\sqrt{2})$.
Winding type				The winding type determines balance between maximum speed, force, required current and bus voltage of the coil. N-type windings are optimised for normal currents and regular bus voltages.

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