HIWIN® MIKROSYSTEM

Torque Motor

User Manual

www.hiwinmikro.tw

MW99UE01-2303_V1.4

Related Documents

The figure and table of the documents related to the product are shown below. Refer to these documents as required.

Product		Doc. Name		Doc. No.	Content
Controller	HIMC Motion Controller	HIMC Installation Guide		MH07UE01-□□□□	Provides detailed information on installing and connecting HIMC motion controller.
		HIMC iA Studio User Guide		MH01UE01-□□□□	Provides detailed information on the human machine interface operation of HIMC motion controller.
		HIMC Modbus TCP User Guide		MH02UE01-□□□□	Provides detailed information on the way Modbus TCP communication protocol applied to HIMC motion controller.
		HIMC HMPL User Guide		MH06UE01-□□□□	Provides detailed information on HMPL library of HIMC motion controller.
		HIMC API Reference Guide		MH05UE01-□□□□	Provides detailed information on API library of HIMC motion controller.
		HIOM Installation Guide		MH03UE01-□□□□	Provides detailed information on installing and connecting HIOM (HIWIN mega-ulink IO module).
		ETA3 Installation Guide		MH09UE01-□□□□	Provides detailed information on installing and connecting ETA3 (HIMC remote module).
Servo Drive	E Series Servo Drive	Technical Manuals	E1 Series Servo Drive User Manual	MD09UE01-□□□□	Provides detailed information on selecting, installing, connecting, setting, performing test run for, tuning, and monitoring E1 series servo drive.
			E2 Series Servo Drive User Manual	MD28UE01-□□□□	Provides detailed information on selecting, installing, connecting, setting, performing test run for, tuning, and monitoring E2 series servo drive.
			E Series Servo Drive Thunder Software Operation Manual	MD12UE01-□□□□	Provides detailed information on the human machine interface operation of E series servo drive.
			E Series Servo Drive Gantry Control System User Manual	MD22UE01-□□□□	Provides detailed information on the usage of E series servo drive gantry control system.
			E Series Servo Drive Electronic Cam Control System User Manual	MD27UE01-□□□□	Provides detailed information on the usage of E series servo drive electronic cam control system.
			E Series Servo Drive Multi-Motion Function User Manual	MD32UE01-□□□□	Provides detailed information on the usage of E series servo drive multi-motion function.
			MPI Library Reference Manual	MD19UE01-□□□□	Provides detailed information on MPI library of E series servo drive and D series servo drive.
			MPI Examples	MD18UE01-□□□□	Provides detailed information on MPI examples of E series servo drive and D series servo drive.
			API Library Reference Manual for Servo Drives	MD23UE01-□□□□	Provides detailed information on API library of E series servo drive and D series servo drive.
			PDL Examples for E Series Servo Drive	MD25UE01-□□□□	Provides detailed information on PDL examples of E series servo drive.
		Communication Manuals	E Series Servo Drive EtherCAT(CoE) Communications Command Manual	MD08UE01-□□□□	Provides detailed information on the way EtherCAT communication protocol applied to E series servo drive.
			E1 Series Servo Drive MECHATROLINK-III Communication Command Manual	MD24UE01-□□□□	Provides detailed information on the way MECHATROLINK-III communication protocol applied to E1 series servo drive.
			E1 Series Servo Drive PROFINET Communication Command Manual	MD02UE01-□□□□	Provides detailed information on the way PROFINET communication protocol applied to E1 series servo drive.

Product		Doc. Name		Doc. No.	Content
		Application Manuals	E2 Series Servo Drive Replacement Guide	MD34UE01-□□□□	Provides detailed information on the way of replacing E1 series servo drive and D1 series servo drive with E2 series servo drive.
		Application Manuals	Application Note E1 PROFINET Drive Complete Setup with Siemens TIA Portal	MD30UE01-□□□□	Provides detailed information on the operation of PLC software TIA Portal when E1 PROFINET drive is used with Siemens S7 series PLC.
		Application Manuals	Application Note E1 MECHATROLINK-III Drive Complete Setup with YASKAWA MPE720	MD31UE01-□□□□	Provides detailed information on the operation of machine controller software MPE720 when E1 MECHATROLINK-III drive is used with YASKAWA MP3000 series machine controller.
		Application Manuals	Function Blocks Application Manual E Series EtherCAT Drive with OMRON Sysmac Studio	MD35UE01-□□□□	Provides detailed information on the usage of application function blocks when E series EtherCAT drive is used with OMRON Sysmac Studio.
		Application Manuals	Function Blocks Application Manual E Series EtherCAT Drive with KEYENCE KV STUDIO	MD36UE01-□□□□	Provides detailed information on the usage of application function blocks when E series EtherCAT drive is used with KEYENCE KV STUDIO.
Servo Drive	D Series Servo Drive	D1 Servo Drive User Manual		MD20UE01-□□□□	Provides detailed information on selecting, installing, connecting, setting, performing test run for, tuning, and monitoring D1 servo drive.
Servo Drive	D Series Servo Drive	D2 Series Servo Drive User Manual		MD07UE01-□□□□	Provides detailed information on selecting, installing, connecting, setting, performing test run for, tuning, and monitoring D2T servo drive.
Servo Drive	D Series Servo Drive	D2T-LM Series Servo Drive User Manual		MD11UE01-□□□□	Provides detailed information on selecting, installing, connecting, setting, performing test run for, tuning, and monitoring D2T-LM servo drive.
Servo Drive	D Series Servo Drive	MPI Library Reference Manual		MD19UE01-□□□□	Provides detailed information on MPI library of E series servo drive and D series servo drive.
Servo Drive	D Series Servo Drive	MPI Examples		MD18UE01-□□□□	Provides detailed information on MPI examples of E series servo drive and D series servo drive.
Servo Drive	D Series Servo Drive	API Library Reference Manual for Servo Drives		MD23UE01-□□□□	Provides detailed information on API library of E series servo drive and D series servo drive.
Servo Drive	D Series Servo Drive	PDL Examples for D-series Drives User Manual		MD13UE01-□□□□	Provides detailed information on PDL examples of D series servo drive.
Motor	Linear Motor	Linear Motor User Manual		MP99UE01-□□□□	Provides detailed information on selecting, installing, and connecting linear motor.
Motor	Direct Drive Motor	DMN Series Direct Drive Motor User Manual		MR01UE01-□□□□	Provides detailed information on selecting, installing, and connecting DMN series direct drive motor.
Motor	Direct Drive Motor	DMT Series Direct Drive Motor User Manual		MR03UE01-□□□□	Provides detailed information on selecting, installing, and connecting DMT series direct drive motor.
Motor	Direct Drive Motor	DMY Series Direct Drive Motor User Manual		MR04UE01-□□□□	Provides detailed information on selecting, installing, and connecting DMY series direct drive motor.
Motor	Direct Drive Motor	DMS Series Direct Drive Motor User Manual		MR05UE01-□□□□	Provides detailed information on selecting, installing, and connecting DMS series direct drive motor.
Motor	Direct Drive Motor	DMR Series Direct Drive Motor User Manual		MR06UE01-□□□□	Provides detailed information on selecting, installing, and connecting DMR series direct drive motor.

Product		Doc. Name	Doc. No.	Content
	Torque Motor	Torque Motor User Manual	MW99UE01-□□□□	Provides detailed information on selecting, installing, and connecting torque motor.
	AC Servo Motor	AC Servo Motor User Manual	MC03UE01-□□□□	Provides detailed information on selecting, installing, and connecting AC servo motor.
	IM-1 Series Spindle Motor	IM-1 Series Spindle Motor User Manual	MS01UE01-□□□□	Provides detailed information on selecting and installing IM-1 series spindle motor.
Linear Motor Stage	Standard Single-Axis Linear Motor Stage	Standard Single-Axis Linear Motor Stage User Manual	MM06UE01-□□□□	Provides detailed information on selecting, installing, and connecting standard single-axis linear motor stage.
Actuator	Linear Actuator	Linear Actuator User Manual	MA99UE01-□□□□	Provides detailed information on selecting, installing, and connecting linear actuator.

Approvals

Motor Model	Approvals		
	EU Directives		UL Approvals
	EMC Directive: 2014/30/EU reference standard EN 61000-6-2:2005 EN 61000-6-4:2007+A1:2011	LVD Directive: 2014/35/EU reference standard EN 60034-1:2010	Rotating Electrical Machines reference standard UL 1004-1 UL 1446
TMRW□□	CE		c US

Note:
EN：Europischen Normen = European standard

Motor Model	Approvals		
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	EMC Directive: 2014/30/EU reference standard EN 61000-6-2:2005 EN 61000-6-4:2007+A1:2011	LVD Directive: 2014/35/EU reference standard EN 60034-1:2017	Rotating Electrical Machines reference standard UL 1004-1 UL 1446
TM-2-□□	CE UKCA		c US
IM-2-□□			

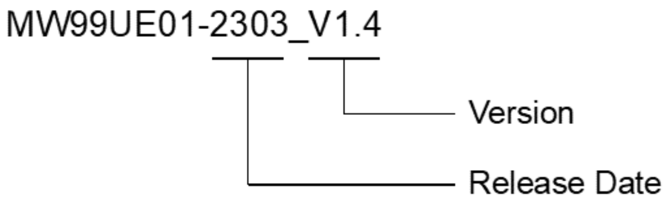
Note:
EN: Europischen Normen = European standard
CE refers to European standards.
(Publication of harmonised standards under Union harmonisation legislation)
IEC: International Electrotechnical Commisiion
UKCA: UK Conformity AssessedThe Certificate and the Declaration of Conformity can be downloaded from the HIWIN MIKROSYSTEM CORP. website. (https://www.hiwinmikro.tw/en/download)

Table of Contents

1. General information

1.1 Revision History

The version of the manual is also indicated on the bottom of the front cover.



Release Date	Version	Applicable Product	Revision Contents
Mar. 14st, 2023	1.4	Torque Motor	1. Typesetting update 2. Update EN 60721-3-1~3-3 classification 3. Modify long-term storage desc. 4. Add voltages reflection in cable desc. 5. Add neutral point oscilation desc. 6. Add bleed out air bubble desc. 7. Add Stall desc. 8. Modify air gap value of TMRW 9. Add TM-2(J0)
Apr. 10st, 2021	1.3	Torque Motor	10. Add TM-2/IM-2 11. Add intended use 12. Add product code and logistics content 13. Edit axial force 14. Add power supply and controller sizing 15. Edit symbols 16. Add Tolerances and Hypotheses 17. Add technical terms 18. Add Maintenance and Troubleshooting form 19. Add Decommissioning and disposal
Apr. 15st, 2019	1.2	Torque Motor	20. Move safety instructions to the first chapter 21. Edit cooling contents 22. Edit motor interface design contents
May. 10st, 2017	1.1	Torque Motor	1. Add motor sizing configurator 2. Add interface design contents 3. Add thermal protection device 4. Add technical terms
Mar. 1st, 2014	1.0	Torque Motor	First edition.

1.2 About this manual

This manual is mainly about HIWIN's standard torque motor series (also referred to as "motors" in the manual) TMRW/TM-2/IM-2. This manual provides users information about how to handle, assemble and operate the motor in a completely safe condition. Unless any specific document is mentioned, this manual is also applicable to customized products.

HIWIN's liability is in any case limited to the function of the torque motor and does not cover customer's entire system or machine. If any failure or technical problem occurs and this product does not provide a solution, please contact HIWIN for technical support. Please do not hesitate to notify us if you find any error or necessary correction in this document. Except for motor replacement, the customer or anyone who owns or operates the system is responsible to evaluate all safety and compatibility issues of the entire system. HIWIN cannot know and will not be responsible for any motor failure or system disfunction caused by any possible reasons.

1.3 General Precautions

Before using the product, please carefully read through this manual. HIWIN MIKROSYSTEM is not responsible for any damage, accident or injury caused by failure in following the installation instructions and operating instructions stated in this manual.

- Before installing or using the product, ensure there is no damage on its appearance. If any damage is found after inspection, please contact HIWIN or local distributors.
- Ensure the wiring is not damaged and can be normally connected.
- Do not disassemble or modify the product. The design of the product has been verified by structural calculation, computer simulation and actual testing. HIWIN is not responsible for any damage, accident or injury caused by disassembly or modification done by users.
- Keep children away from the product.
- People with psychosomatic illness or insufficient experience should not use the product alone. The supervision of managers or product docents is definitely needed.

If the login information does not match your order, please contact HIWIN or local distributors.

HIWIN MIKROSYSTEM offers 1-year warranty for the product. The warranty does not cover damage caused by improper usage (refer to the precautions and instructions stated in this manual) or natural disaster.

1.3.1 Requirements

- Operators have received training on the operation procedures for torque motors, and have fully read and understood this user manual.
- Maintenance personnel perform maintenance and repairs on torque motors to prevent any danger to personnel, property, or the environment.

1.4 Safety instruction

■ Warning notice system

Safety notices are always indicated using a signal word and sometimes also a symbol for the specific risk. Different safety alert symbols refer to different types of dangers. Please be aware of personal safety while handling the goods with warning labels on it.

⚠Danger
Imminent danger! Indicates that death or severe personal injury will result if proper precautions are not taken.

⚠WARNING
Potentially dangerous situation! Indicates that death or severe personal injury may result if proper precautions are not taken.

⚠CAUTION
Potentially dangerous situation! Indicates that property damage or environmental pollution can result if proper precautions are not taken.

Warning Signs

No access for people with active implanted cardiac devices.	Substance hazardous to the environment!
Warning!	Warning of crushing of hands!
Warning of electricity!	Warning of hot surface!
Warning of magnetic field!	

Mandatory Signs

Wear head protection!	Refer to user manual!
Wear protective gloves!	Disconnect before carrying out maintenance or repair.
Wear safety footwear!	Lifting point.

1.5 Copyright

Note:

HIWIN MIKROSYSTEM reserves the right to change the contents of this manual or product specifications without prior notice.

1.6 Manufacturer information

Table 1.6.1 Manufacturer's details

Corp.	HIWIN MIKROSYSTEM CORP.
Address	No.6, Jingke Central Rd., Taichung Precision Machinery Park, Taichung 40852, Taiwan
Tel.	+886-4-23550110
Fax	+886-4-23550123
Sales E-mail	business@hiwinmikro.tw
Customer Service E-mail	service@hiwinmikro.tw
Website	http://www.hiwinmikro.tw

1.7 Product monitoring

Please inform the manufacturer of torque motor, HIWIN MIKROSYSTEM.

- Unexpected incidents.
- Potential hazards of the torque motor.
- Content in this manual that is difficult to understand.

2. Basic safety information

2.1 Overview

Torque motors are components of a rotary drive system for the precise positioning in terms of time and location of fixed mounted loads, e.g. system components, within an automated system.
Torque motors are designed for installation and operation in any position. The loads being moved must be solidly mounted to the rotor.
Torque motor components must not be used outdoors or in potentially explosive atmospheres.
Torque motor components may only be used for the intended purpose as described.

- Torque motors must be operated within their specified performance limits.
- For the safe operation of torque motors, suitable safety precautions must be taken to protect the motor against overload.
- Proper use of the torque motors includes observing the assembly instructions and following the maintenance and repair specifications.
- Use of the torque motor components for any other purpose shall be considered improper use.
- Use only genuine spare parts from HIWIN.

2.2 Basic safety notices

⚠DANGER

Risk of death as a result of strong magnetic fields!

Strong magnetic fields around torque motor systems represents a danger for people with active medical implants, who come close to the motors. This is also the case when the motor is switched off.

- If you are affected, stay a minimum distance of 500 mm from the permanent magnets
  - ■ Trigger threshld for static magnetic fields of 0.5 mT according Directive 2013/35/EU

Also take national and local guidelines or requirements into account.

- For reference DGUV rule 103-013 of the German Social Accident Insurance specifies requirements when working with magnetic fields

⚠CAUTION

Risk of physical damage to watches and magnetic storage media.

Strong magnetic forces may destroy watches and magnetisable data storage media near to the torque motor system!

- Do not bring watches or magnetisable data storage media into the vicinity (<300 mm) of the torque motor systems!

⚠CAUTION

Safety distance to the rotor

- The rotor's magnetic fields is permanent. When you come into direct body contact with the rotor, a static magnetic flux density of 2 T is not exceeded.

◆ When taking or placing the product, do not just pull the cable and drag it.

◆ Do not subject the product to shock.

◆ Ensure the product is used with rated load.

◆ According to IEC 60034-5 standard, all HIWIN torque motors have the following class of protection: IP20 for the stator and IP00 for the rotor.

◆ HIWIN torque motors have a insulation class F (TM-2 / IM-2 series) and class B (TMRW series) according to IEC 60085 standard.

2.3 Reasonably foreseeable misuse

Torque motors must not be operated:

- Outdoors
- In potentially explosive atmospheres.

2.4 Conversions and modifications

- Don’t modify, disassemble, or damage the product without authorization. If you have any requirements, please contact our company's sales department and state your needs.
- Don’t tear off the product label and attached marking cards at will.
- Cardboard boxes with our company's logo should not be used to sell or forward other products.

2.5 Residual risks

If user operates the product normally and follows the instructions and precautions in the user manual, they can effectively control and reduce the risk of incidents. Relevant sections of the manual provide information on maintenance and the potential risks and warnings associated with using the product.

There may still be residual risks associated with using this product. For example, it is important to inform customers and operators to read the user manual, but it is not certain whether they fully understand the product's instructions. If you have any questions regarding the manual, please contact our company's sales department and ask. We will provide professional guidance in response.

2.6 Personnel requirements

Only authorized and competent persons may carry out work on the torque motor components. They must be familiar with the safety equipment and regulations before starting work. (See Table 2.6.1)

Table 2.6.1 Personnel requirements

Activity	Qualification
Commissioning	Trained specialist personnel of the operator or manufacturer
Normal operation	Trained personnel
Cleaning	Trained personnel
Maintenance	Trained specialist personnel of the operator or manufacturer
Repairs	Trained specialist personnel of the operator or manufacturer

2.7 Protective equipment

■ Personal protective equipment

Table 2.7.1 Personal protective equipment

Operating phase	Mandatory Signs	Personal protective equipment
Transport		When moving the product, to avoid the risk of accidental dropping and injury, please wear safety shoes.
Normal operation		When assembling the rotor, due to the strong suction force, it is necessary to use a hanging method and wear a safety helmet for protection.
Cleaning and Maintenance		When lubricating the product surface and wiping with alcohol, please wear latex gloves.
Commissioning		If there is noise, do not expose yourself to the noise for a long time, and wear protective earplugs.

■ Safety equipment

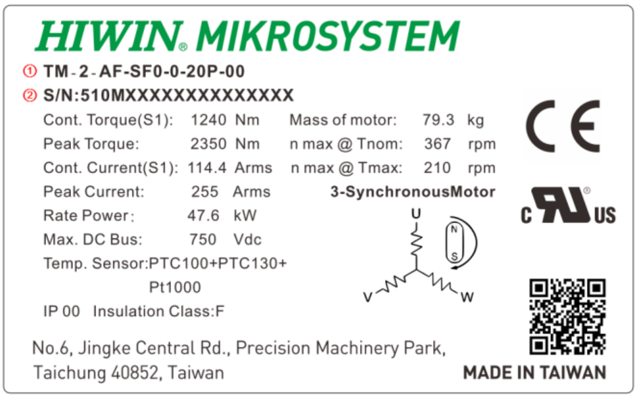
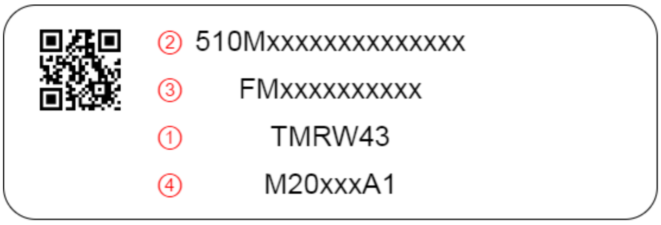
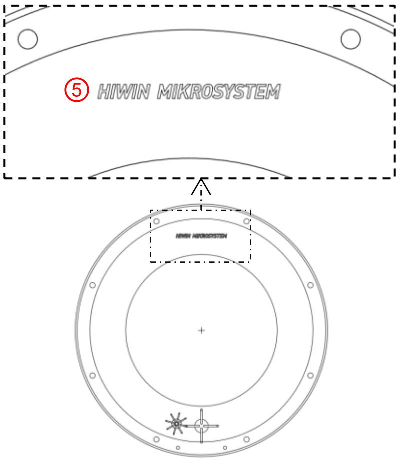
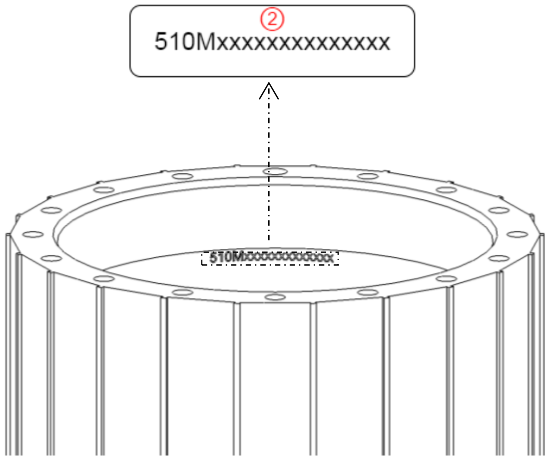
This product comes in different sizes and specifications. If it cannot be manually handled, please use a crane for lifting. When lifting, be sure to wear a safety helmet to protect your head

Table 2.7.2 Safety equipment requirements

Operating phase	Mandatory Signs	Safety equipment
Hanging		Ensure that the lifting rings are securely clamped and the load is within the specified limit.

2.8 Labels on torque motor

Each rotor and stator has the specific mark. 2 name labels and 3 simple labels and 2 O-rings are delivered in the package. And have one magnetic warning sign on the rotor. Here is an example of these labels

Name label	Simple label
	
Stator mark	Rotor label
	

① : Motor type
② : Serial number
③ : Article number
④ : Drawing number
⑤ : Laser engraving trademark

Magnetic warning sign

3. Product description

3.1 Torque motor description

Torque motor adopts Permanent Magnet Synchronous Motor (PMSM) design, which increases the efficiency and generates large torque output. Unlike servo motor with reducer, torque motor can directly connect to the load and output torque. The advantages are listed as follows.

- Easy for design
  - Large hollow shaft – Large hollow shaft rotor reduces the difficulty of design. Cables can be easily organized, and various parts can all be hidden in it.
  - Low parts count – Directly connecting to the load can reduce the number of transition parts and further improve the reliability.
  - Compact – The characteristics of large hollow shaft and direct connection make the mechanism design more compact.



- Reduce the cost
  - Without reducer – Reduce installation difficulties and maintenance cost.
  - Without wear parts – Significantly reduce downtime and maintenance time. Production can be continuously performed.
  - Long life – Without wear and reducer, the life of machine is greatly improved.



- Improve the performance
  - High dynamic characteristics – Without The transmission delay such as elastic connection, backlash and friction, it provides the best motion characteristics.
  - Low cogging torque – Multiple polarities with the optimized motor design of HIWIN reduce the cogging torque during operation.
  - Low moment of inertia – Large hollow shaft rotor reduces the load.
  - High accuracy – Directly connecting to the load makes the position feedback more accurate.



3.2 Main components of torque motor

HIWIN torque motor can get its best performance through water cooling. Bearing, feedback system and other related parts are excluded from shipment. Basic structure of motor is shown in Figure 3.2.1.

- Stator

  Stator in TMRW/TM-2/IM-2 series does contain cooling channel. The stator housing is made of aluminum alloy or steel, and the inner part is composed of iron core, coils, covered with epoxy. There are two cable outlets on one side, motor power cable and temperature sensor cable. Stator should be installed on the fixed part of customer's machine. J□ type has a cooling jacket that is installed outside the stator, shown in Figure 3.2.2.
- Rotor

  The main structure is a steel ring with evenly attached magnets. Rotor should be installed on the rotating part of customer's machine. Due to its strong magnetic attraction, well protection is needed during assembly and handling. To avoid danger, keep it away from magnetic conductors (e.g. iron objects).

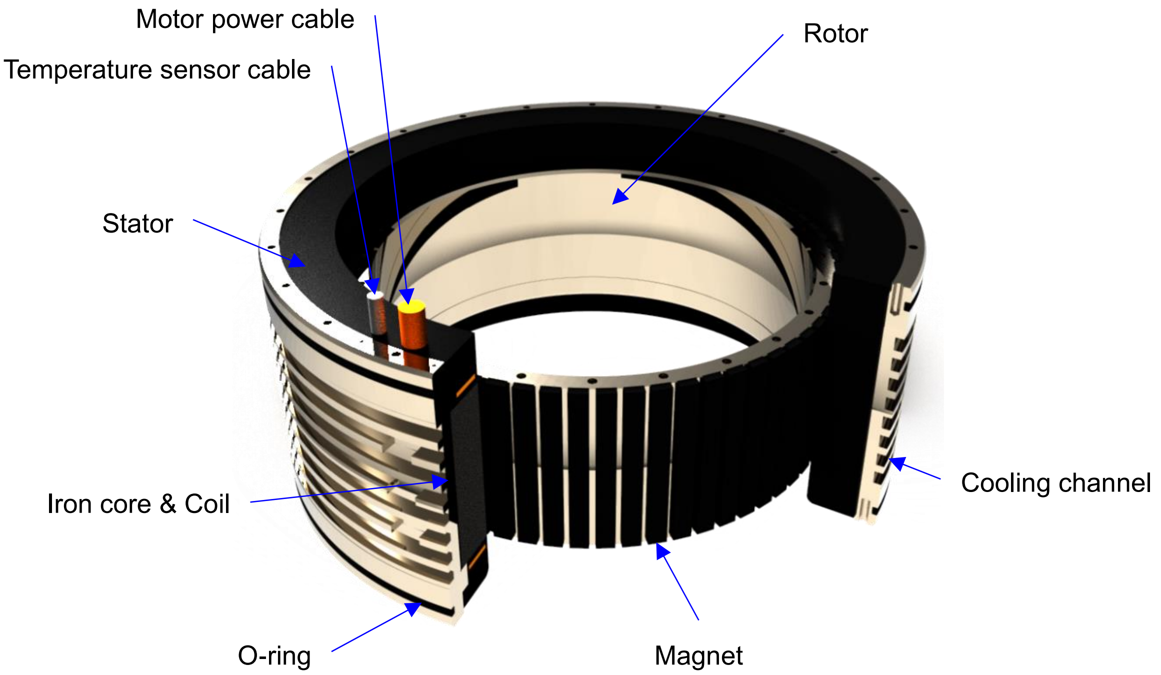


Figure 3.2.1 Basic structure of torque motor TM-2

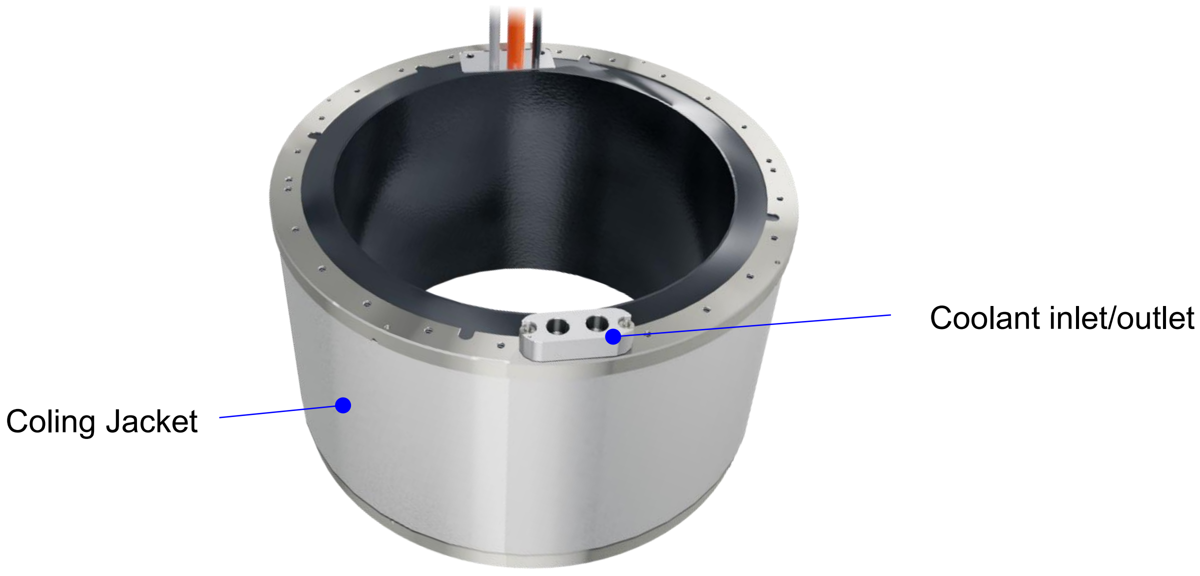


Figure 3.2.2 Basic structure of torque motor TM-2(J□)

3.3 Order code

3.3.1 TMRW series codification

Motor specification			Function			Characteristic	
TMRW	**4**	**7**	**L**	**C**	**-**	**X**	**X**

Code	Description
Type:	
TMRW	Torque Motor
External diameter of the stator:	
1	Ø160mm
2	Ø198mm
4	Ø230mm
7	Ø310mm
A	Ø385mm
D	Ø485mm
G	Ø565mm
Rotor (Magnet) height:	
3	30mm
5	50mm
7	70mm
A	100mm
F	150mm
Winding code:	
	Standard
L	Low Back emf
Optional:	
	Standard
C	Customized
Reserved:	
	Standard
XX	Characteristics Code See motor datasheet

3.3.2 TM-2/IM-2 series codification

Motor specification											Sensor		Cable output			Reserved	
TM	**-**	**2**	**-**	**7**	**5**	**-**	**S**	**D**	**0**	**-**	**0**	**-**	**20**	**V**	**-**	**X**	**X**

Type :
TM-2: Torque motor
IM-2 : IM motor

External diameter of the stator:
1 : Ø160mm
2 : Ø198mm
4 : Ø230mm
7 : Ø310mm
A : Ø385mm
D : Ø485mm
G : Ø565mm

Rotor (Magnet) height:
3 :30mm
5 :50mm
7 :70mm
A :100mm
F :150mm

Torque / Speed Characteristics Code
See motor datasheet

Temperature sensor configuration:
0 :PTC130+PTC100+Pt1000 (Standard)
1 :PTC130+PTC100+Pt1000x3
⋮

Cable length:
20 : 2.0m (Standard)
05 : 0.5m
10 : 1.0m
⋮

Cable output style: Cable output style schematics refer to Figure 3.3.1
S :Straight output
V :Straight output with cable clamp
A :Straight output with cable gland
H :90° output in tangent direction with cable clamp (temp. cable straight output)
P :All cable separate with cable clamp (straight output)
⋮

Reserved:
00 :Standard(without bridge)
03 :Bridge on cable side
⋮

3.3.3 TM-2(J0) series codification

Motor specification											Sensor		Cable output			Reserved	
TM	-	2	-	7	5	-	S	D	0	-	0	-	20	V	-	J	0

Type :
TM-2:Torque motor

External diameter of the stator:
7 : Ø329mm
A : Ø399mm
D : Ø498mm
G : Ø572mm

Rotor (Magnet) height:
4 :40mm
5 :50mm
6 :60mm
7 :70mm
8 :80mm
9 :90mm
B :110mm
C :120mm
G :160mm
H :170mm

Torque / Speed Characteristics Code
See motor datasheet

Temperature sensor configuration:
0 :PTC130+PTC100+Pt1000 (Standard)
1 :PTC130+PTC100+Pt1000x3
⋮

Cable length:
20 : 2.0m (Standard)
05 : 0.5m
10 : 1.0m
⋮

Cable output style: Cable output style schematics refer to Figure 3.3.1
S :Straight output
V :Straight output with cable clamp
A :Straight output with cable gland
H :90° output in tangent direction with cable clamp (temp. cable straight output)
P :All cable separate with cable clamp (straight output)
⋮

Reserved:
J0 :With cooling jacket(without bridge)
J3 :Bridge on cable side
⋮

S :Straight output	V :Straight output with cable clamp
	
A :Straight output with cable gland	H :90° output in tangent direction with cable clamp (temp. cable straight output)
	
P :All cable separate with cable clamp (straight output)	Note: The style shown above is schematic diagram, and the shape may be modified in case of design purpose.
	

Figure 3.3.1 Cable output style

3.3.4 Basic torque motor sizing

The way to select a suitable motor based on speed, moving distance, and loading inertia is described in the following contents. The basic process for sizing a motor is as below.

Requirement

- Operating environment
- Installation (horizontal or vertical)
- Driving method
- Load conditions (loading inertia, friction and cutting force)
- Speed condition (maximum acceleration and velocity)
- Duty cycle

↓

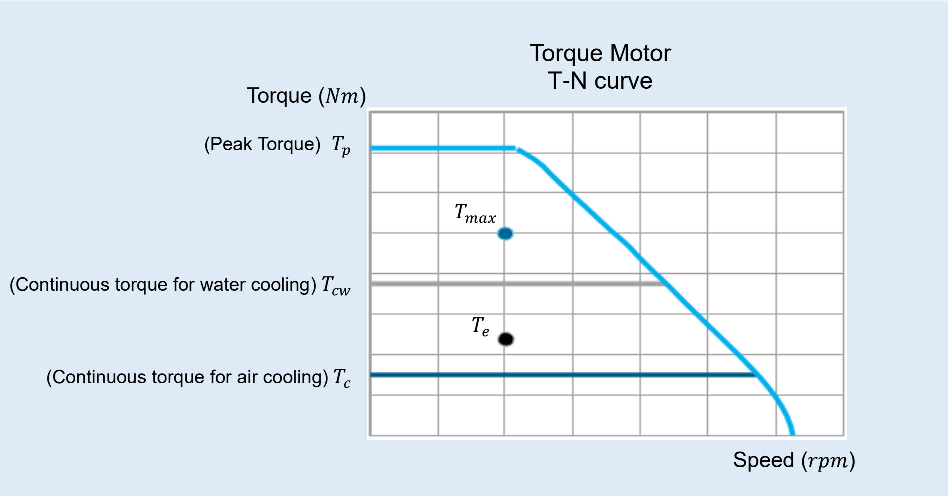
Torque calculation

- Calculate the torque corresponding to the speed under each operation condition
- Calculate equivalent torque

↓

Motor sizing and T-N curve confirmation

- Select the appropriate motor from HIWIN's catalogue in accordance with calculated maximum torque, equivalent torque and speed.
- Ensure the speed and the corresponding torques under all operating conditions is within the range of torque-speed curve of the motor.
- Confirm the equivalent torque is within the continuous torque of the motor.



■ Symbol

φ	Angular displacement (rad)	I_p	Peak current (A_{rms})
t	Moving time (sec)	I_e	Equivalent current (A_{rms})
α	Angular acceleration (rad/s^2)	I_c	Continuous current (A_{rms})
ω	Angular velocity (rad/s)	ω_0	Initial angular velocity (rad/s)
J_L	Load inertia (kgm^2)	m	Loading Mass (kg)
J	Rotor inertia (kgm^2)	R_L	External diameter of loading Mass (m)
T_p	Peak torque (Nm)	r_L	Internal diameter of loading Mass (m)
T_c	Continuous torque (Nm)	a_L、b_L	Side length of loading Mass (m)
T_j	Inertia torque (Nm)	S	Distance from gravity center to rotary center (m)
K_t	Torque constant (Nm/A_{rms})		

STEP 1 Requirement

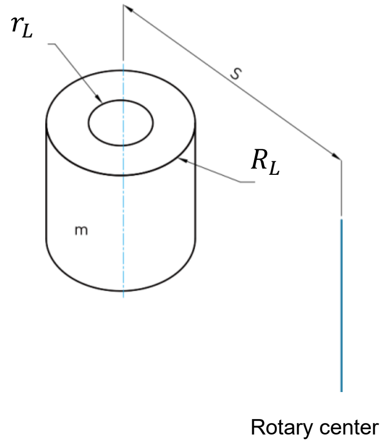
To size a proper motor, the following formula of load inertia and motion must be understood before sizing.

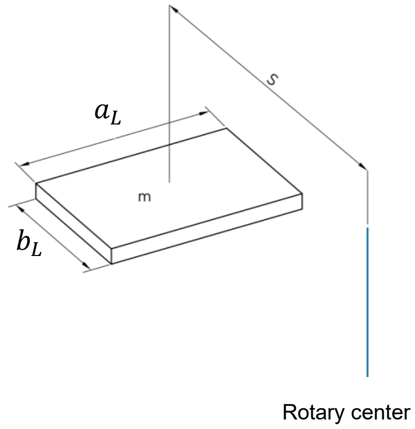
Calculation of load inertia

Load inertia can be determined by 3D drawing software or the formula. Basic formula is as below.

Moment of inertia of a hollow cylinder: $J_L = m\left(\frac{R_L + r_L}{2} + S^2\right)$

Moment of inertia of a rectangular: $J_L = m\left(\frac{a_L + b_L}{12} + S^2\right)$





Determine motion speed and parameters

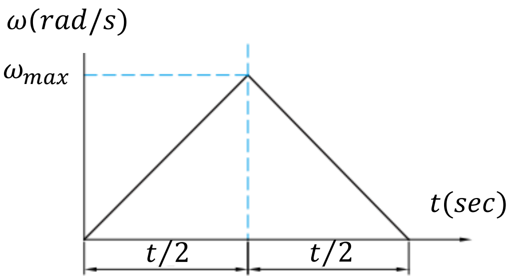
Basic kinematics equations are described as below.

$\omega = \omega_0 + \alpha t \qquad \varphi = \omega_0 t + \frac{1}{2}\alpha t^2$

Where ω_0 is initial angular velocity.
Users can choose two of the four parameters (ω, α, t and φ) as designed parameters. The left two parameters can be calculated by above equations.

※ Motion velocity profile

Motion profiles for torque motor can be classified into “Trapezoidal profile” and “Triangular profile”. Trapezoid profile is usually used in scanning applications. Its motion profile can be divided into acceleration, constant velocity and deceleration. The maximum angular acceleration can be determined by the basic kinematics equations mentioned above. Triangle profile is usually used in point-to-point applications. Its motion profile can be divided into acceleration and deceleration, and its motion profile and formula can be simplified as below.



$\omega_{max} = 2 \times \frac{\varphi}{t}$ or $\omega_{max} = \sqrt{\alpha \times \varphi}$, $\alpha_{max} = \frac{4\varphi}{t^2}$

Other trajectory profiles like “s-curve”, “full-jerk“, “sine“, “modified sine“, will not going to discuss in the manul.

- ◆ “S-curve”, “sine“, “modified sine“ are also computable in HIWIN.
- ■ Different types of trajectory profiles which can provide advantages or disadvantages depending on the application requirements.

The jerk in “Triangular profile” and “Trapezoidal profile” will be ±∞.

STEP 2 Torque calculations

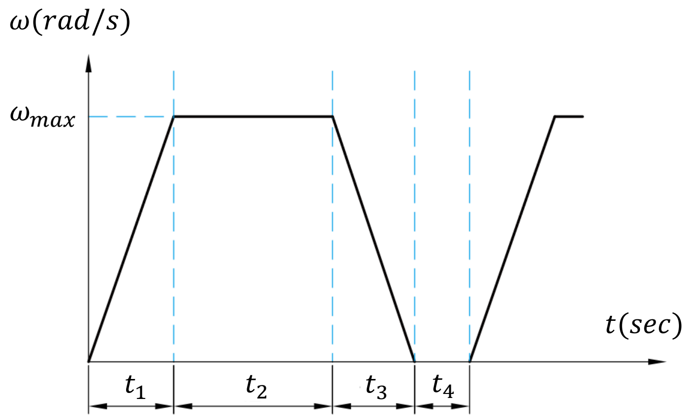
The maximum torque can be calculated by the following equation.

$T_{max} = (J + J_L) \times \alpha_{max} + T_f = T_j + T_f$

Where T_j is inertia torque, T_f is the torque caused by friction torque, cutting force or external force.

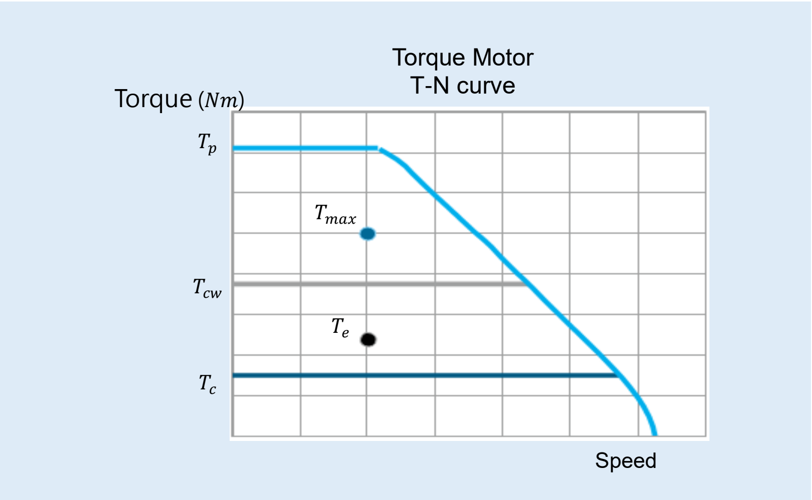
In most cases, the motions are cyclic point-to-point movements. The equivalent torque of a cyclic motion with a dwell time of t_4 second can be calculated as below.

$$T_e = \sqrt{\frac{(T_j+T_f)^2 \times t_1 + T_f^2 \times t_2 + (T_j-T_f)^2 \times t_3}{t_1+t_2+t_3+t_4}}$$



STEP 3 Motor sizing and T-N curve confirmation

With the help of HIWIN's motor specification, users can select the appropriate motor from peak torque and equivalent torque, and ensure speed and torque under all operating conditions is within the range of the motor's T-N curve.



Motor sizing is determined as follows.

$T_{max} < T_p$

$T_e < T_c$

Users need to consider the ratio of equivalent torque and continuous torque. Generally, the ratio (T_e/T_c) is recommended to be within 0.7. Continuous torque for TMRW/TM-2/IM-2 series can be classified into air cooling and water cooling. If the motor is operated with water cooling, the water cooling continuous torque can be taken as the guideline for comparison.

See also Section 3.3.5 for understanding more about thermal calculation.

Note:

The torque-speed curve provided in the specification is for a specific voltage, regardless of the speed limit of the bearing and the position feedback system. The customer should also set the maximum speed limit of the overall mechanism when sizing to avoid bearing life or position feedback system failure result in abnormal operation or damage of the motor.

3.3.5 Thermal calculation

3.3.5.1 Heat loss

When the motor converts electric energy into kinetic energy, copper loss, iron loss and mechanical loss are inevitable. Copper loss is the loss generated by the resistance when the current flows through the stator coil of the motor. Iron loss, which can be classified into hysteresis loss and eddy current loss, is generated by the conversion of the magnetic field between stator iron core and rotor magnet. As for mechanical loss, it is generally much less than copper loss and iron loss; therefore, it can be ignored.
Copper loss under continuous torque is calculated as below.

$$P_c = \frac{3}{2} R_{25}\{1 + [\alpha(\theta_c - 25)]\} I_c^2$$

P_c=copper loss at coil temperature θ_c $[W]$
R_{25}= line-to-line resistance at coil temperature 25℃ $[\Omega]$
α_{25}: temperature coefficient of cooper @ 25℃ (α_{25}≒0.003844)
I_c=continuous current at coil temperature θ_c $[A_{rms}]$
θ_c= coil temperature [℃] (120℃ for TMRW series, 130℃ for TM-2/IM-2 series)
Iron loss is mainly caused by the change of magnetic flux during the operation and is influenced by the frequency a lot. Since rotational speed is directly proportional to frequency, iron loss will be larger at high speed. However, rotational speed for HIWIN torque motor is low, so iron loss is relatively less than copper loss. Rotational speed value indicated by HIWIN drawing and specification is the maximum peak speed that the motor can reach. Under the continuous operation of high speed, iron loss must calculate extra heat given to rotor. At this time, motor loss increases rapidly. To avoid overheating, users need to appropriately adjust operating conditions or apply heat dissipation on rotor.
Iron loss is mainly generated by eddy current and frequency. The faster the speed is, the more the iron loss will be.

$$P_{Fe} \propto f^2$$

P_{Fe}= iron loss $[W]$
f = frequency $[Hz]$
Definition of frequency：

$$f = \frac{n \cdot 2p}{120}$$

n = rotational speed $[rpm]$
$2p$ = Number of poles
Heat loss mainly transmits the loss of coil and iron core to motor outer casing via heat conduction. Take natural air cooling for example. Loss heat source will be transmitted from the surface of outer casing contacted by the air to external environment via heat convection, and from the customer's installation surface via heat radiation and heat conduction. As for water cooling, lost heat source will be transmitted from center of heat source to cooling water via heat conduction. Since the heat-conduction coefficient of cooling water is much higher than that of air, the effect that heat source transmits to the air via convection

can be ignored. TMRW series is available to either water cooling or air cooling while TM-2 and IM-2 series are mainly available to water cooling. Ensure parameters you use fit the specification, and keep coil temperature from exceeding 120℃. (for □M-2 is 130℃). Please contact HIWIN for other applications.

3.3.5.2 Continuous operating temperature

Steady state temperature of motor coil is determined by the proportion of copper loss and iron loss. When rotational speed is low, iron loss may not be considered. Both total loss and rated continuous current (T_c) are defined when coil temperature is 120℃. (for □M-2 is 130℃). When equivalent torque (T_e) is less than rated continuous torque (T_c), steady state temperature of motor coil under various operating conditions can be known by the following formula.

$$\theta_e = \theta_{surr} + \left(\frac{I_e}{I_c}\right)^2 (\theta_{cont.} - 25)$$

$\theta_{cont.}$ = steady state temperature of coil under rated condition (TMRW: 120 / □M-2: 130) [℃]
θ_e= steady state temperature of coil under equivalent torque [℃]
θ_{surr}= ambient temperature [℃] (ambient temperature for air cooling / water temperature for water cooling)

I_e= equivalent current under actual operation [A_{rms}] (when coil temperature is θ_e)

I_c= rated continuous current [A_{rms}] (when coil temperature is θ_(cont.), this is related to heat dissipation conditions. When it is used for air cooling, it means air cooling continuous current. When it is used for water cooling, it means water cooling continuous current.
I_p= peak current [A_{rms}]

T_e= equivalent torque under actual operation [Nm] (when coil temperature is θ_e)

T_c= rated continuous torque [Nm] ((when coil temperature is $\theta_{cont.}$)
T_p= peak torque [Nm]
When the motor is in use, the ratio of the output torque to the current will lead to iron core saturation with the increase of the current. The linear relationship will turn to nonlinear, which makes it difficult to estimate the current. This relationship cannot be directly described by an equation. However, the current can be estimated according to the following conditions in Figure 3.3.2 :

Case A: ($T_e < T_c$) equal to ($I_e < I_c$)

$$I_i = I_{cw} \times \frac{T_i}{T_{cw}}$$

Case B: ($T_c < T_e < T_p$) equal to ($I_c < I_e < I_p$)

$$I_i = I_{cw} + \frac{(T_i - T_{cw})(I_p - I_{cw})}{T_p - T_{cw}}$$

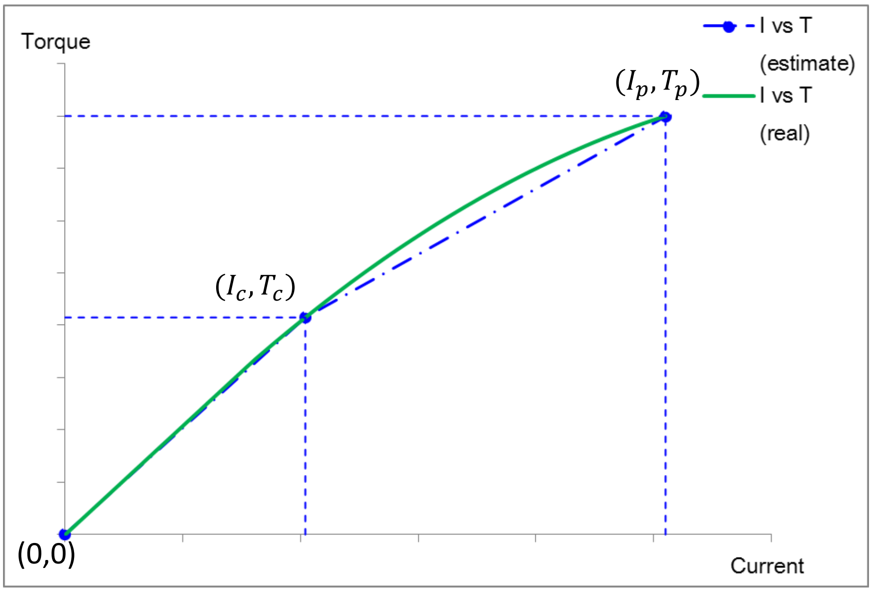


Figure 3.3.2 Curve of Current vs Torque

3.3.5.3 Thermal time constant

The temperature of the coil of the motor is related to the thermal time constant during operation. The thermal time constant is defined as the time required for the temperature difference to reach 63.2% of the difference between the steady-state temperature and the initial temperature (Figure 3.3.3). The time to reach the thermal steady-state is about 5 times the thermal time constant.

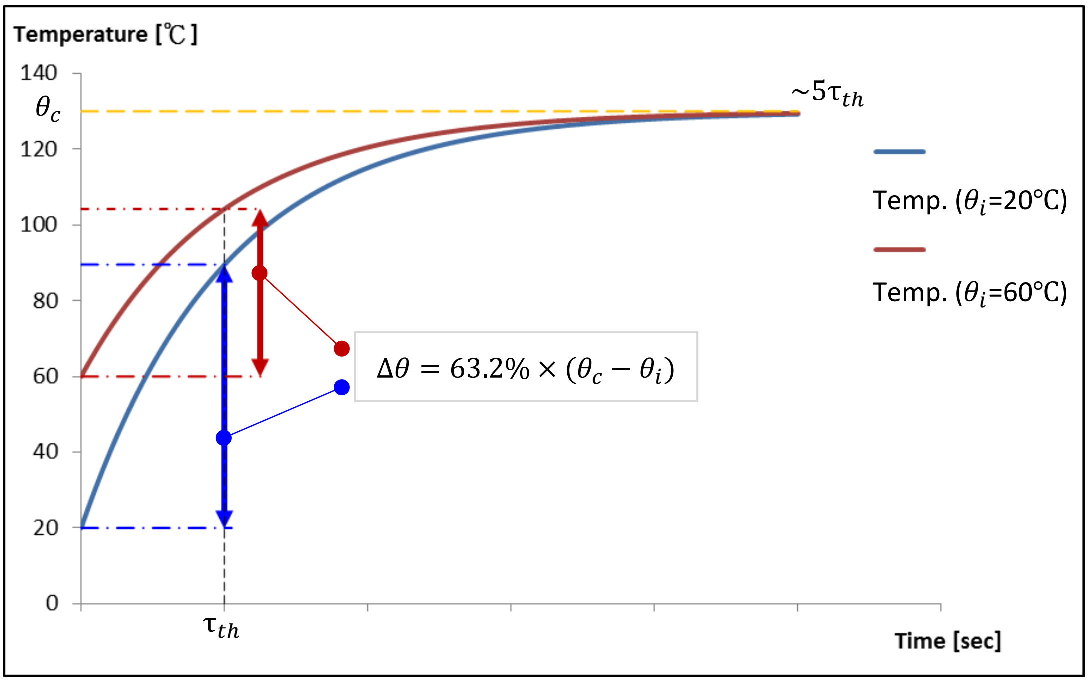


Figure 3.3.3 Curve of temperature rising

The relationship between thermal time constant and temperature is

$$\theta(t) = \theta_i + (\theta_c - \theta_i) \cdot \left(1 - e^{-\left(\frac{t}{\tau_{th}}\right)}\right)$$

$\theta(t)$= coil temperature [°C] (at the operating time t)

θ_i= initial coil temperature [°C]

t= operating time [sec]

τ_{th}= thermal time constant [sec]

When operating current is between rated current and peak current ($I_c < I_e < I_p$), power off time should be set to cool the motor. The thermal time constant mentioned above can be applied to calculate the time for load cycle. Refer to **Section 3.3.5.2** to get steady state temperature of coil under equivalent torque (θ_e) through equivalent torque under actual operation (T_e). Then, get the relative maximum operating time via the following formula.

The relationship between steady state temperature of coil under equivalent torque (θ_e) and maximum operating time is

$$t_0 = -\tau_{th} \cdot ln\left(1 - \frac{\theta_c - \theta_i}{\theta_e - \theta_i}\right)$$

t_0= maximum operating time [sec]

Note: Coil temperature (θ_c) here cannot exceed the specification's upper limit.

(120℃ for TMRW series, 130 ℃ for TM-2/IM-2)

The relationship between coil temperature and power off time is

$$t_b = -\tau_{th} \cdot ln\left(1 - \frac{\theta(t_b) - \theta_c}{\theta_{surr} - \theta_c}\right)$$

$\theta(t_b)$= coil temperature to be cooled [℃] (after power off time t_b)

t_b= power off time [sec]

The time allocation of load cycle during motor operation can be determined by the two formulas above.

3.3.5.4 Stall conditions

When the motor speed is extremely slow (including standstill), the current commutation speed inside the motor is very slow, the current will accumulate in certain sets of coils inside the motor. If continuous current is used at this time, it will eventually lead to insufficient heat dissipation, which will end up the motor overheat.

The concept is as followings, Figure 3.3.4：

a. The arrow is like a water flow around the motor for heat dissipation, and the amount of water that can flow out per unit of time is fixed.

b. When under stall condition, the temperature of the motor will be concentrated on a certain two phases or a certain phase of the motor.

c. The water flow around the motor has not increased, so the heat of the motor will continue to accumulate in some coils.

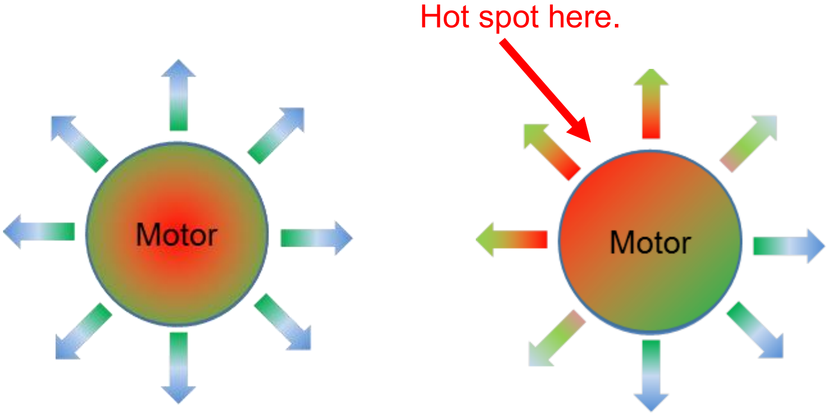


Figure 3.3.4 Normal operation (Left), Stall condition (right)

When the motor operates at a motor frequency lower than 1 Hz, it is regarded as stall condition.

The relationship between motor frequency, motor speed and the number of poles is as follows:

$$\mathrm{n} = \frac{120f}{2p}\ [rpm]$$

n= rotational speed $[rpm]$

f= Electrical frequency $[Hz]$

$2p$= Number of poles

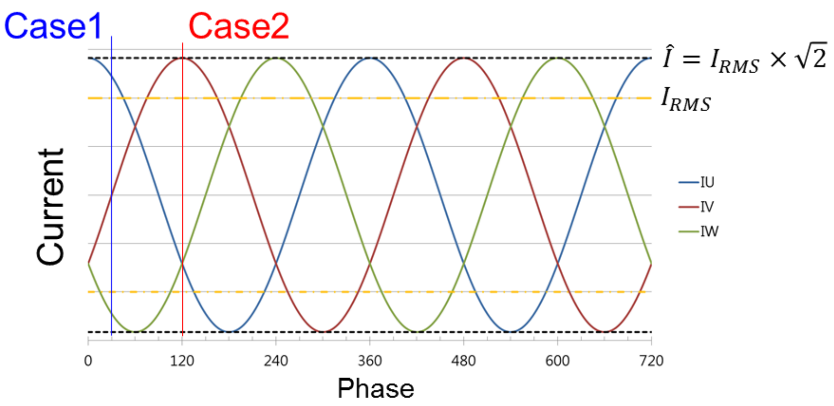


Figure 3.3.5 Current in motor @ different phase

As mentioned earlier, when the motor speed is extremely low and the motor is operating in stall condition, the current will exceed the continuous current that each phase can withstand on two-phase or single-phase as shown in Figure 3.3.5, the operating current must be properly reduced to avoid overheating. There are two boundaries in the stalled condition. At any electrical angle, the current must be between the following two cases:

Case1 Overcurrent on both phases. (Example of U, W phase)

➔ Current down to **81%** continuous current ($\frac{1}{\sqrt{1.5}}$)

➔ Modify Current: $I_{phase\_U} = I_{phase\_W} = \frac{1}{\sqrt{1.5}} I_{c(w)}$

Case2 Overcurrent on single phase. (Example of V phase)

➔ Current down to **70%** continuous current ($\frac{1}{\sqrt{2}}$)

➔ Modify Current: $I_{phase\_V} = \frac{1}{\sqrt{2}} I_{c(w)}$

Stall condition is easily ignored by users in application and calculation. If the motor speed is lower than the speed shown in Table 3.3.1, it must be regarded as a stall condition. The operation conditions must be carefully estimated. Current and temperature must be monitored. This is to prevent the motor from getting damaged by overheating.

Table 3.3.1 Stall Speed of HIWIN torque motor

TMRW	TM-2	IM-2	Speed $[rpm]$
TMRW1x, TMRW2x, TMRW4x	TM-2-1x, TM-2-2x,	IM-2-2x	5.45
-	-	IM-2-4x	3
TMRW7x	TM-2-4x, TM-2-7x	-	2.73
TMRWAx	TM-2-Ax	IM-2-Ax	1.82
TMRWDx, TMRWGx	TM-2-Dx, TM-2-Gx	IM-2-Gx	1.36

3.3.6 Servo drive related

3.3.6.1 Power supply and controller selection

The continuous current, peak current and bus voltage must be considered while selecting a power supply. In addition, the resonance effect which can be induced in motors by some drive systems must be taken into account. Motors are assembled with several individual coils connected in series. Each one of these coils has an inductance in series and a stray capacitance to earth. The LC network obtained possesses a resonant frequency, so when an electrical oscillation is applied to the phase inputs (in particular the PWM modulation frequency), the neutral point of the motor can oscillate with very high amplitudes with respect to earth, and the insulation can be damaged as a consequence of these oscillations. This phenomenon is more pronounced in motors with a large number of poles (such as torque motors).

Under ideal conditions, the 600V_{DC} bus voltage generated by the power supply should be ±300V_{DC} relative to earth. However, in some configurations, the voltage between the bus and earth will have an oscillating voltage, and the peak of the high voltage will be transmitted to the motor. The oscillation voltage between the bus and earth depends on system characteristics. By experience, a system with few axes connected to the bus voltage is less liable to have disturbing oscillations on the bus, but for example in a large machine tool with many axes and several spindles, the oscillations can reach high amplitudes. If the frequency of these oscillations is close to the resonant frequency of the motor, it can lead to over-voltage failures on the neutral point.

The case where the PWM modulation frequency of the controller happens to correspond to the resonant frequency of the motor. In this case, the fundamental harmonic of the PWM modulation frequency is directly exciting the resonant frequency of the motor, and very high voltages are thus obtained on the neutral point. Also, as the PWM voltage is a square wave, it contains odd harmonics (1, 3, 5, 7, etc..) that can also excite the motor resonance. Fortunately, these harmonics have a smaller amplitude that the fundamental.

In another case, it may also lead an over-voltage failure. In this case, the fundamental harmonic of the PWM modulation frequency is directly exciting the resonant frequency of the motor, and very high voltages are thus obtained on the neutral point. In addition, because the PWM voltage is a square wave, it contains odd harmonics (1, 3, 5, 7, etc.) that can also excite motor resonance.

In conclusion, to prevent any failure from occurring, two elements must be considered: the oscillations between the bus voltage and earth and the PWM modulation frequency. If both elements above do not enter into resonance with the motor, then there is no risk for the motor.

When selecting power supply, please check the conditions below:

Peak voltages and dV/dt gradients generated by the power supply must not exceed the values below:

- 300 V_{DC} controllers: 750 V_p(phase to ground), voltage gradient: 8$kV/\mu s$.
- 600 or 750 V_{DC} controllers: 800 V_p maximum (at the PWM frequency) and a voltage gradient: 11 $kV/\mu s$,as shown in Figure 3.3.6, and Table 3.3.2.

The cable between the controller and the motor will generate a reflected wave due to the impedance mismatch between the cable and the motor, and the reflected voltage will be superimposed with the subsequent input voltage, causing the voltage to rise. This phenomenon will be more obvious when the motor cable is longer. If the length of the cable between the controller and the motor is longer than 10 m, it is necessary to measure voltages at the motor terminals to ensure they are lower than specified above. If the measured value is greater, a dV/dt filter must be inserted between the controller and the motor for protection.

Please refer to section 3.3.6.2 and 3.3.6.3 for a detailed description for this voltage oscillation.

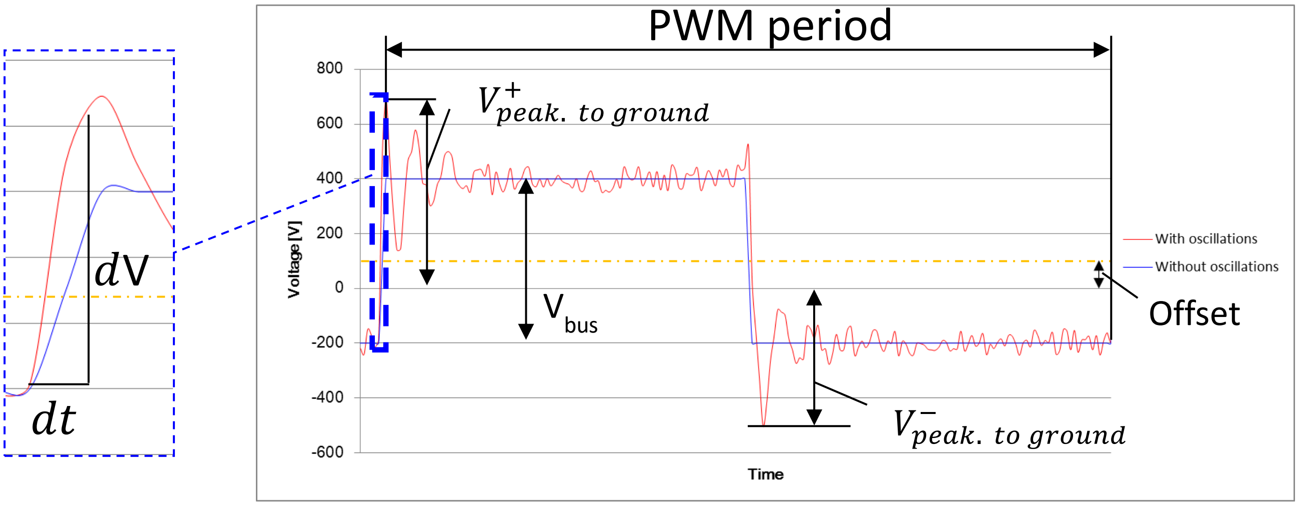


Figure 3.3.6 Voltage oscillation schematic (600/750 V_{DC} controller)

Table 3.3.2 Voltage limitation of power supply and neutral point (TMRW/TM-2/IM-2)

Item	600/750 V_{DC} Controllers
V_{bus}	Max. 750
$\lvert V^{+}_{peak.\ to\ ground}\rvert$	< 800 V_p (phase to ground) @ PWM frequency
$\lvert V^{-}_{peak.\ to\ ground}\rvert$	< 800 V_p (phase to ground) @ PWM frequency
Voltage gradient $\lvert dV/dt\rvert$	< 11$kV/\mu s$ (instantaneous) If it is difficult to obtain instantaneous voltage gradient, the following formula can be used to estimate (Figure 3.3.7)： $\lvert dV/dt\rvert = \lvert(90\%V_{pp} - 10\%V_p)/t_r\rvert$

3.3.6.2 Voltages reflection in cable

When the electromagnetic wave is transmitted in the cable, there will be voltage and current variation along the cable. When the cable length is relatively short to the wavelength, this phenomenon can be ignored and voltage is regarded as the same through the entire cable. However, when the frequency of the electromagnetic wave is high enough, the wavelength will become very short. In this case, obvious voltage distribution can be observed in the cable. The voltage distribution in the cable must be calculated with the transmission line theory. In the transmission line theory, electricity is regarded as electromagnetic waves transmitted in the cable. The impedance mismatch during transmission will result in incident reflection. This phenomenon is more likely to occur when a motor is used. This is because the impedance of the motor is relatively larger than that of the cable. Therefore, a reflected voltage is generated and superimposed on the incident voltage waveform.
This phenomenon will be affected by the rise time of the voltage signal. According to IEC61800-8, the common rise time t_r is 50ns to 1μs(as defined in Figure 3.3.7), After the transmitted wave speed ν is calculated based on characteristic inductance and characteristic capacitance of the cable, the critical length l_{cr} at which the maximum reflected voltage will occur can be estimated.：

$$\nu = \frac{1}{\sqrt{L_0 C_0}} \; (typical\ 50 \sim 300\, m/\mu s)$$

$$l_{cr} = \frac{\nu t_r}{2}$$

ν= The pulses travel along the motor cable with a propagation velocity
L_0= Cable characteristic inductance
C_0= cable characteristic capacitance

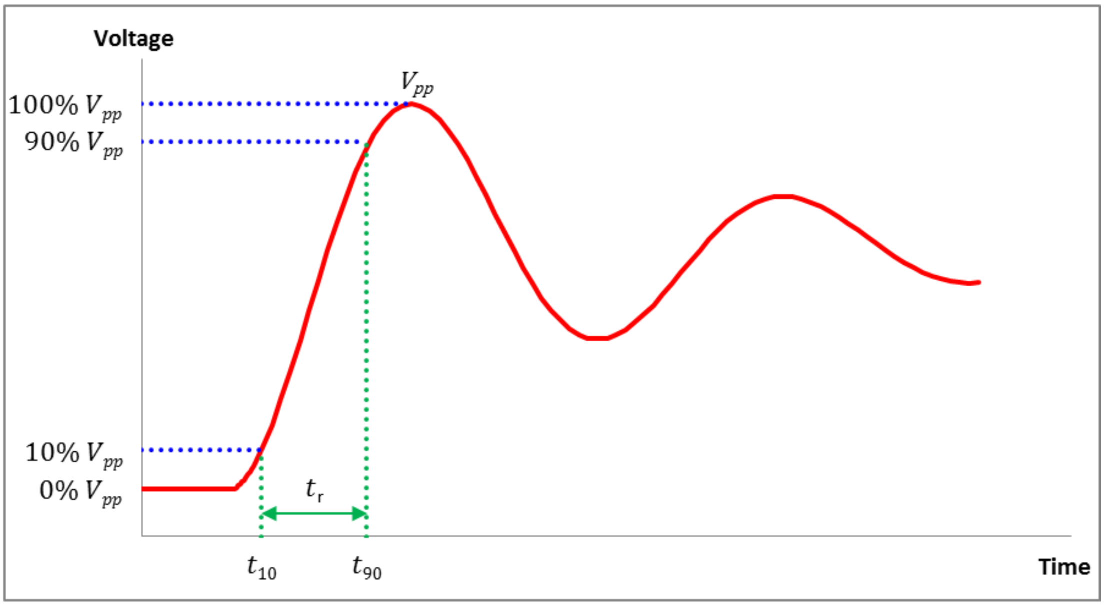


Figure 3.3.7 Rise time t_r

Get l_{cr} first. If the characteristic impedances of the motor Z_m and the cableZ_0 are known, the maximum voltage that will be generated at the motor under conditions below can be estimated:

1. At motor cable length l_c above the critical length l_{cr}:

$$V_{mot} = (1 + \Gamma)V_{inv}$$

2. At motor cable length l_c below the critical length l_{cr}:

$$V_{mot} = \left(1 + \frac{l_c}{l_{cr}}\Gamma\right)V_{inv}$$

V_{mot}= The peak voltage at the motor terminals

V_{inv}= The power converter output voltage

Γ= Reflection coefficient depending on the impedance mismatch between the motor cable and motor:

$$\Gamma = \frac{Z_m - Z_0}{Z_m + Z_0}$$

The characteristic impedance Z_0 of the cable is well defined and related to the parameters of the cable, such as theL_0, C_0 the characteristic impedance R_0 the characteristic admittance G_0, If we assume the cable is no loss cable, Z_0 can be shown as follows:

$$Z_0 \sim \sqrt{\frac{L_0}{C_0}}$$

However, the motor impedance Z_m is not easy to be obtained. It is only known that as the motor power increases, the impedance Z_m gets lower and the reflection coefficient gets lower, too.
When the voltage reflection occurs and the voltage is too large, the worst case is the almost total reflection ($\Gamma \approx 1$) resulting in $V_{mot} \approx 2V_{inv}$, as shown in Figure 3.3.8、Figure 3.3.9。

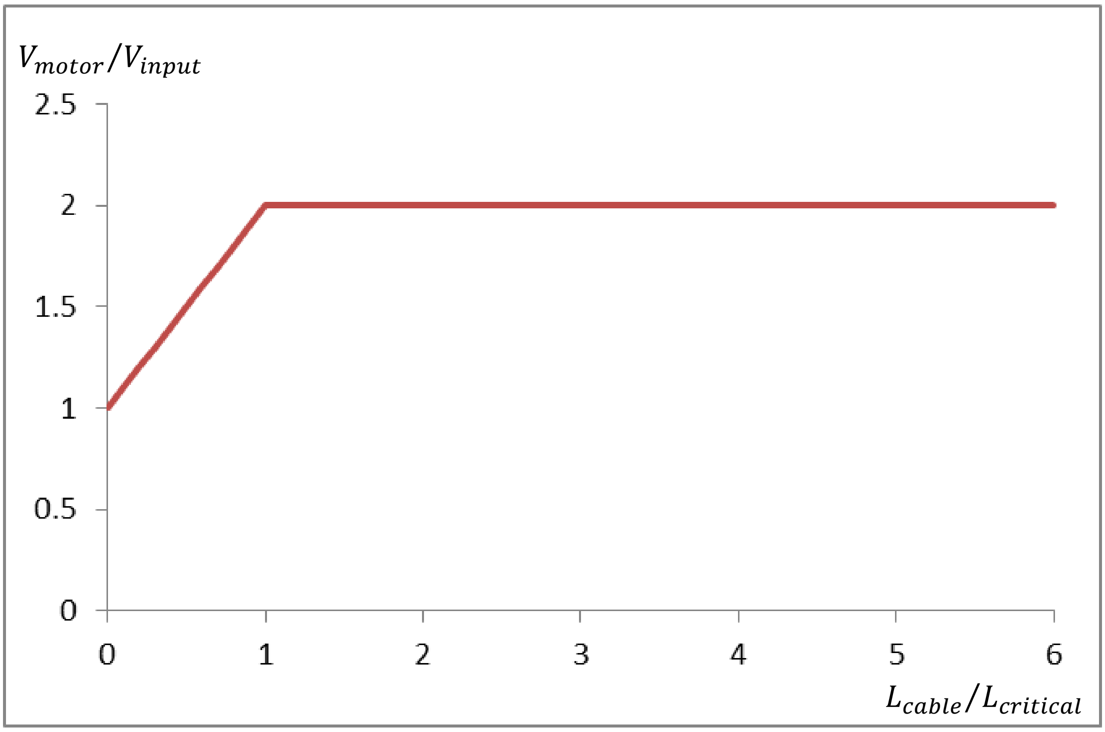


Figure 3.3.8 Voltage ratio as a function of cable length ratio (illustration)

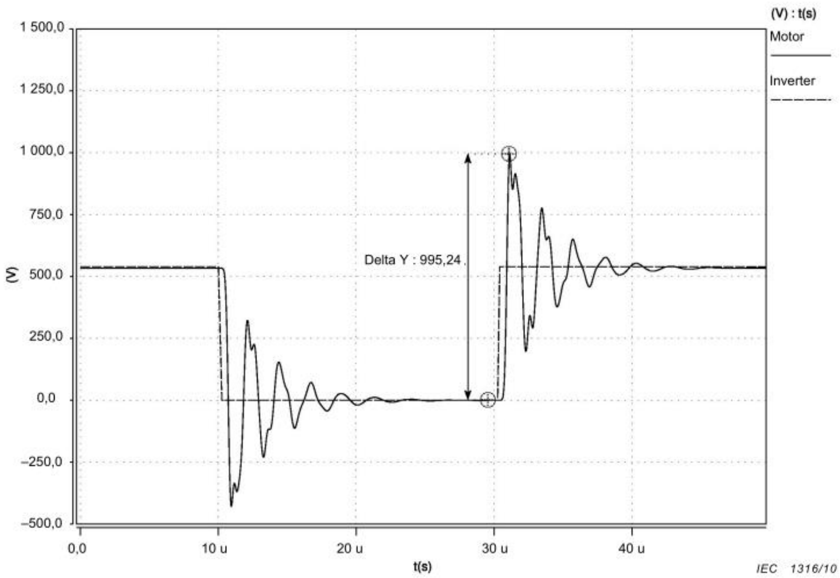


Figure 3.3.9 Example of converter output voltage and motor terminal voltage with 200m motor cable (IEC61800-8:2010)

In addition to increasing the rise time of the input voltage and shortening the motor cable length as much as possible, a filter (dV/dt, sine wave, reactor, etc.) can also be installed between the motor and the controller to reduce the voltage gradient and reduce the risk of motor insulation failure caused by excessive voltage stress (as shown in Figure 3.3.10, Figure 3.3.11). Generally a filter supplier will require the filter to be installed close to the controller, the closer the better.

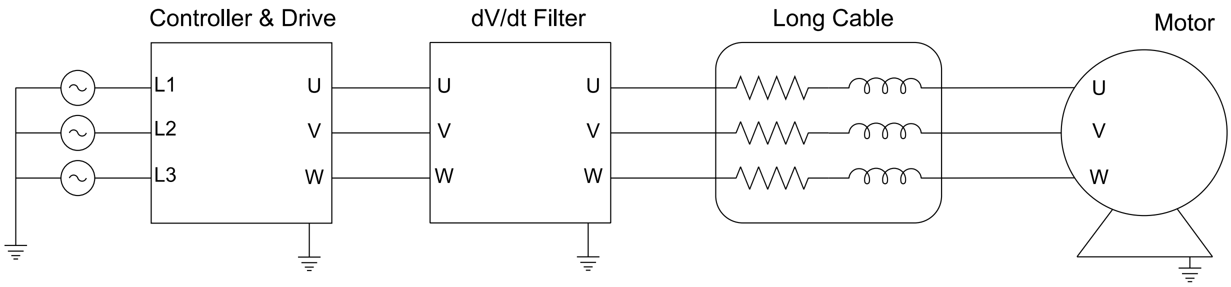
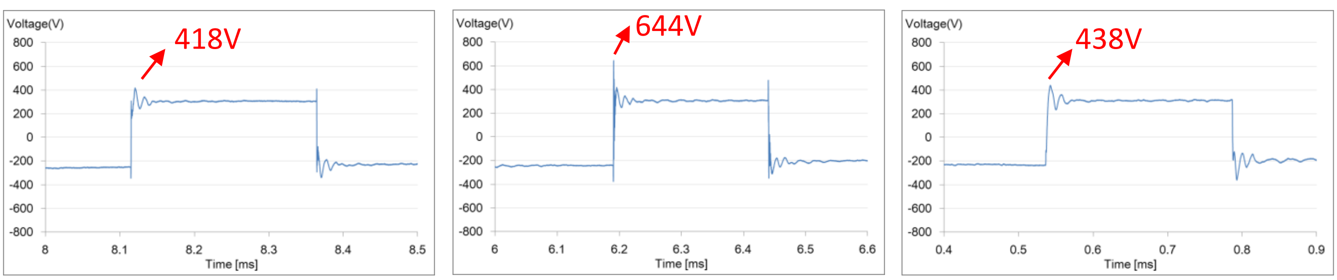


Figure 3.3.10 dV/dt Filter Configuration diagram



(a). Cable length 2m

(b). Cable length 23 m

(c). Cable length 23 m + dV/dt filter

Figure 3.3.11 Example of the relationship between the motor terminal voltage (phase to ground).

3.3.6.3 Neutral-point oscillation phenomenon

When the high switching frequency voltage is input to the motor, the motor can be regarded as an RLC circuit composed of resistance, inductance and stray capacitance. The neutral point is located at the end of the circuit, as shown in Figure 3.3.12 below. At this time, the motor-to-ground voltage will oscillate in the circuit, and the maximum value will be generated at the neutral point as shown in Figure 3.3.13 (a). When the input voltage frequency is close to the resonance frequency, the coil insulation near the neutral point will be destroyed due to the high to-ground voltage which is generated continuously.
Note: This phenomenon will be more obvious when the motor is in standstill.

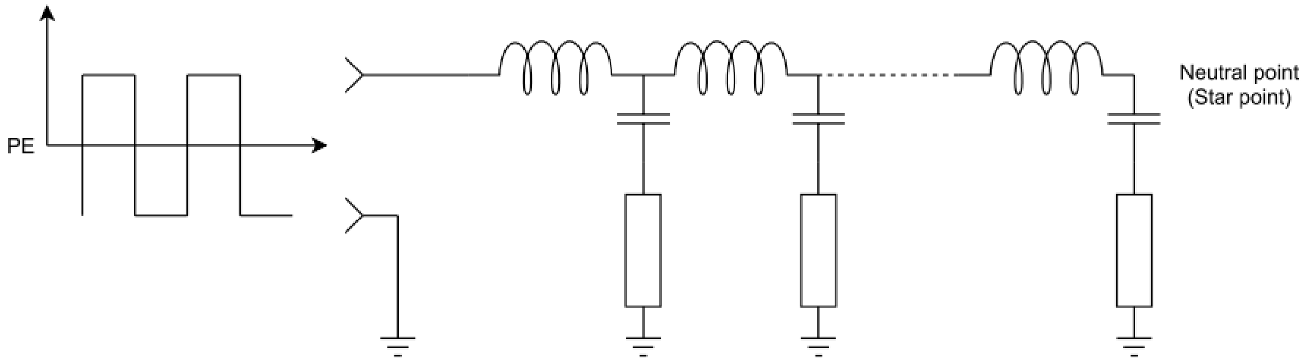
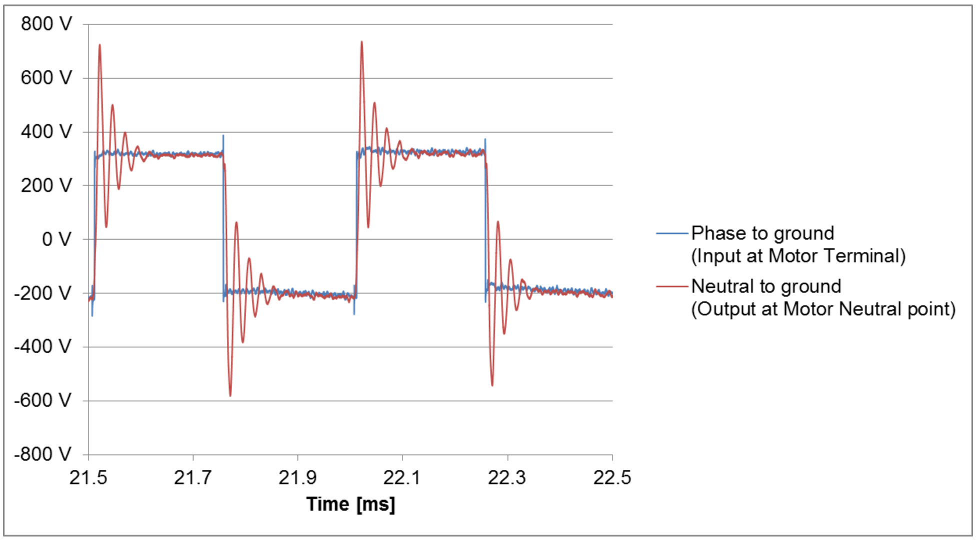


Figure 3.3.12 Equivalent simplified circuit (lattice network)

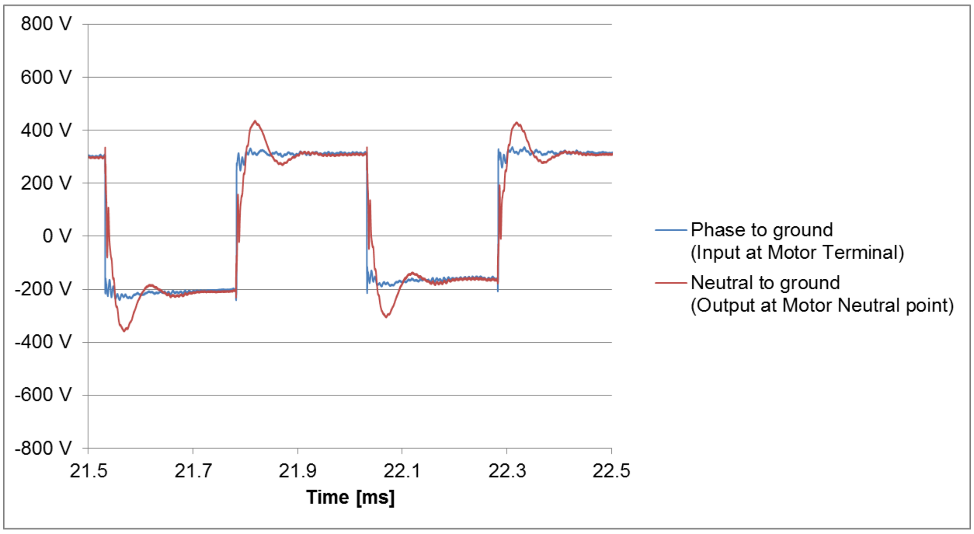
As shown in Figure 3.3.12, it can be simply regarded as low-pass filters from the motor enter point to the neutral point. Its properties are decided by motor type and wiring design. Because of its low pass feature and the fact that generally the cut-off frequency will fall within 20kHz~200kHz, it is impossible to be affected by cable reflection of which voltage is about 1~2MHz. Therefore, the insulation damage near the neutral point should not be caused by cable reflection or voltage gradient.
When the oscillation occurs, there will not be too much voltage amplitude even near the resonance frequency if there is sufficient damping. However, the natural damping inside the motor is usually not enough to avoid the generation of excessive voltage peaks. In this case, the neutral will continue to be impacted by the voltage at the PWM modulation frequency until the insulation breaks down. Generally, if we try to apply different versions of wiring in motors of the same size, we'll see a design with a larger torque constant is usually more likely to result in the resonance frequency. The damping will decrease and the peak value of the neutral point resonance voltage will increase.
It is very difficult to predict whether this resonance will occur in the whole system with the motor. Even if the relatively to ground voltage before entering the motor meets the requirements in 0, in some cases, high voltage difference to ground may still be generated at the neutral point. Therefore, it is recommended to use a motor with a neutral wire for the first device and measure the voltage to ground at the neutral point during motor enabling (such as 3.3.6.4). If the voltage measuring result shows no risk of motor insulation damage, the motor neutral wire can be ignored after insulation or not pulled out.
However, if the situation seems to be risky, a common solution is to pull out a neutral line from the motor and install a "snubber" to suppress this voltage (the effect is shown in Figure 3.3.13 (a)). As to how to use

a "snubber", the configuration will be different according to operation principles developed by different suppliers (Figure 3.3.14) . All details cannot be explained in this manual.

Note: HIWIN can be consulted about voltage risk judgment and possible solutions after measurement.

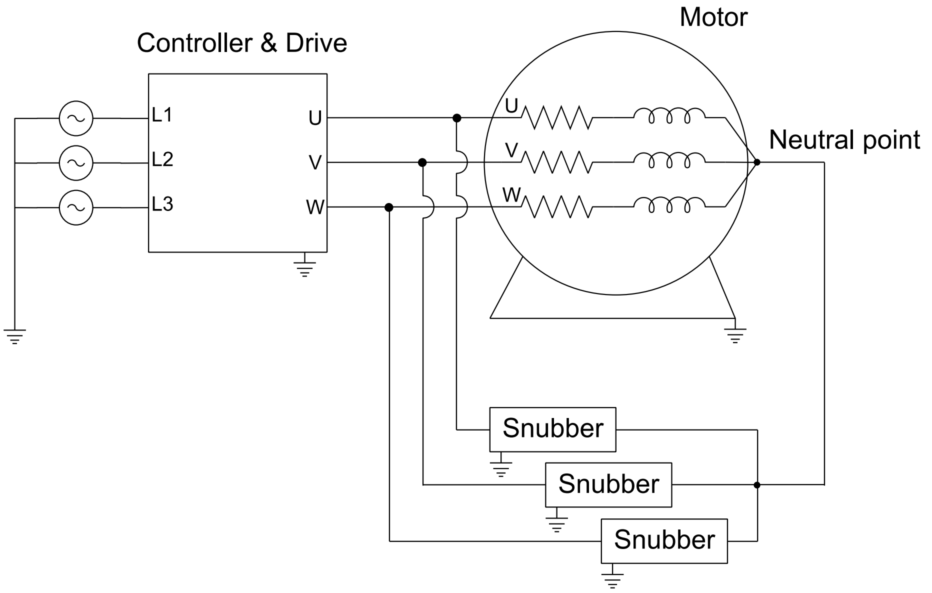


(a). Without snubber

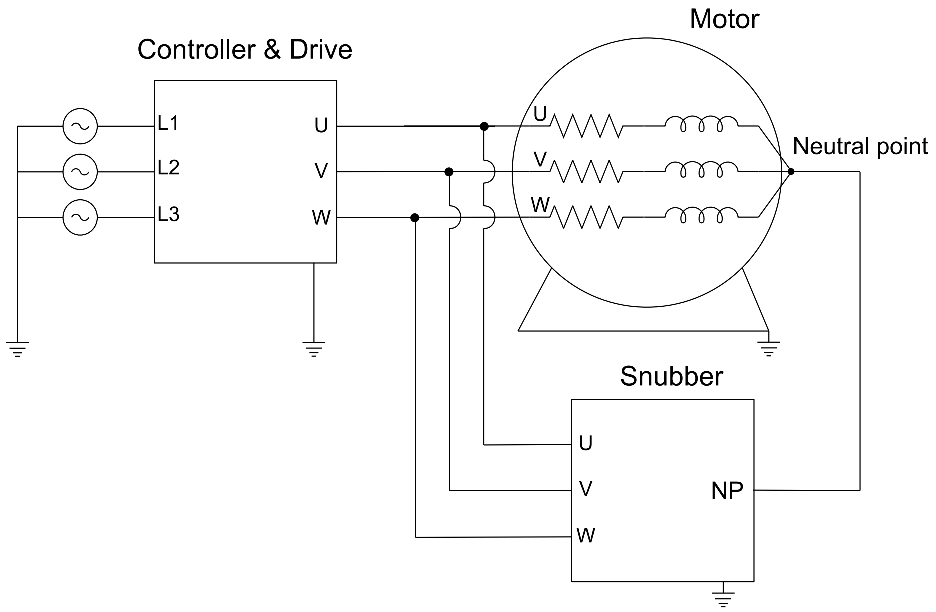


(b). With snubber

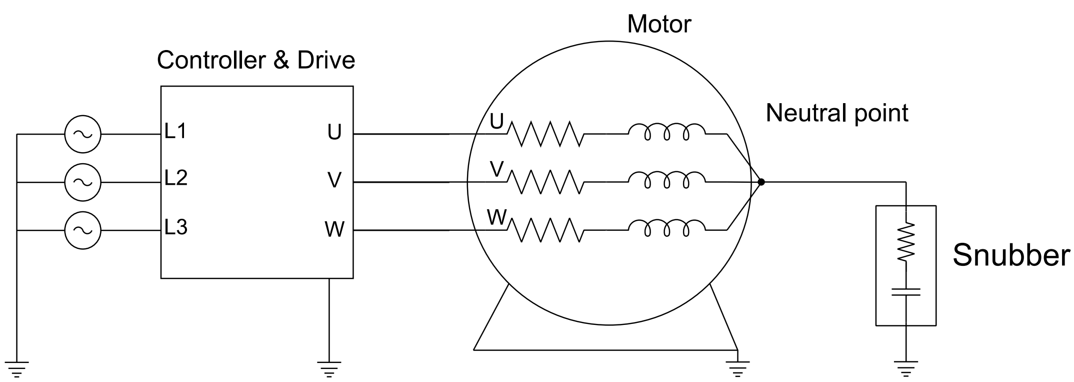
Figure 3.3.13 Neutral point to ground voltage (a). Without snubber (b). With snubber



(a). Schematic A



(b). Schematic B



(c). Schematic C

Figure 3.3.14 Neutral point to ground voltage (a). Without snubber (b). With snubber

3.3.6.4 Neutral-point voltage measurement

⚠DANGER!	
	Danger from electrical voltage! **Before and during connecting or measurement work, dangerous currents may flow.** ◆ Connecting work may only be carried out by a qualified electrician and with the power supply disconnected! ◆ Before carrying out connecting and measurement on the motor system, disconnect the power supply and protect it from being switched back on!

■ Equipment Requirements

(1) Drive
(2) Motor（with neutral point brought out）
(3) Oscilloscope (bandwidth >150MHz)
(4) High Voltage Differential Probes (maximum Voltage：Vpk-pk±1500V, bandwidth > 5MHz)

■ Voltage measurement procedures

(1) Disconnect the power supply and protect it from being switched back on.
(2) Wire according to the wiring diagram (Figure 3.3.16), and use a high-voltage differential probe to connect to the following two points:
   1. Measure the voltage to ground (defined as CH1), at the output of the drive.
   2. Measure the neutral point to ground voltage (defined as CH2).
   ※ The ground measurement points need to be in the same position.
(3) For safety reasons, the lap joints of the probes must be covered with insulating materials, such as insulating paper, electrical tape, etc.
(4) After the connection is completed, power on and enable the motor (no need to rotate).
(5) Use an oscilloscope to observe the voltage waveform. Here is an example of the voltage waveform (as shown in the Figure 3.3.10).
(6) Screenshot of output voltage waveform. It is necessary to capture the peak voltage difference and include at least 5 complete waveforms (as shown in Figure 3.3.10)
(7) Save the voltage waveform data as a CSV file, which needs to include the time and voltage value data based on synchronization of two measurement points.
(8) If the drive motor has different PWM modulation frequencies, the PWM modulation frequency of the drive needs to be changed. The modulation frequencies which may be used should all be measured and recorded individually.
(9) Repeat the above steps to measure the neutral point to ground voltage in sequence.

※When capturing the voltage waveform, it should be noted that the voltage may change periodically (as shown in Figure 3.3.10). Please get the peak voltage.

※The motor will heat up since it’s in stall condition. Please turn on the chiller during measurement.

※The enabling current should be limited and cannot be larger than the stall current.

■ Data interpretation

(1) Record the cable length from the measurement point of the drive output to the motor interface (near the motor mounting surface)

(2) Provide voltage waveform screenshots and data CSV files to HIWIN and HIWIN will assist in judging risks and providing solutions.

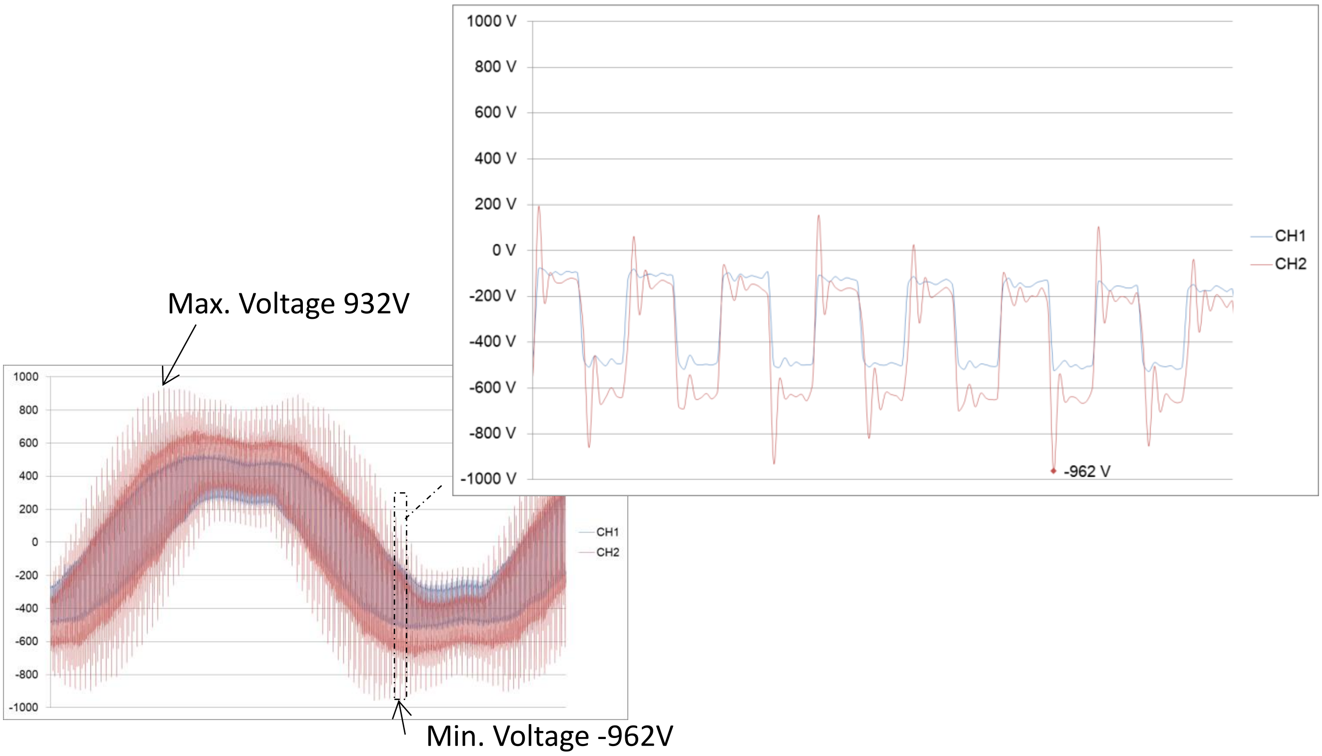


Figure 3.3.15 A captured diagram of voltage waveform.

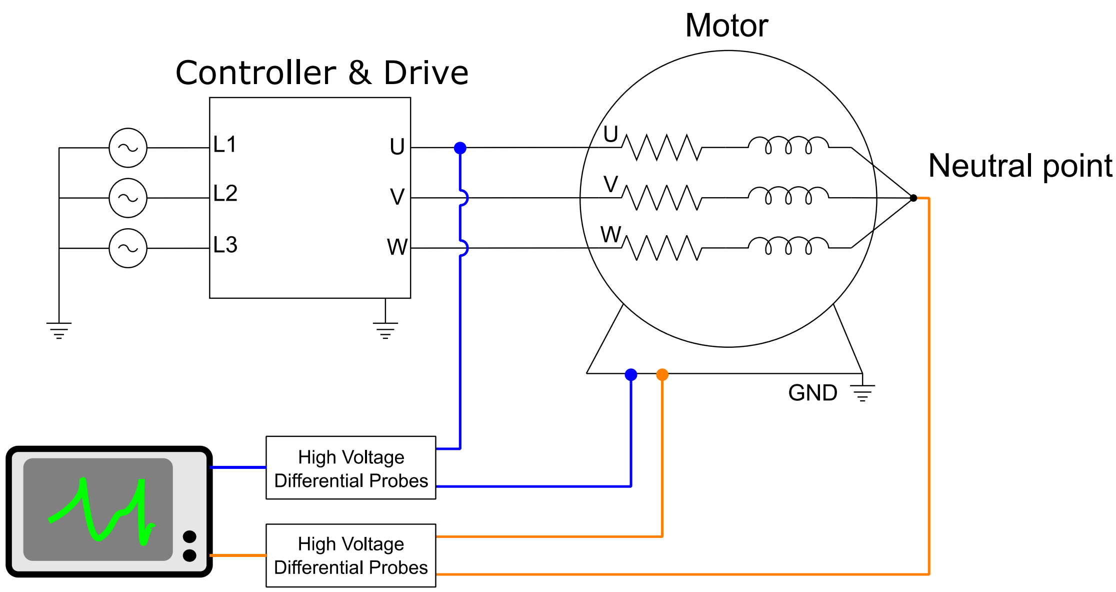


Figure 3.3.16 The wiring diagram of neutral point measurement.

3.3.7 Cooling related

3.3.7.1 Water cooling system calculation

The features of motor indicated in HIWIN torque motor drawing and specification are suitable for water cooling condition, and coolant temperature is 20℃. Taking oil as coolant is also acceptable. Just properly modify the performance of motor based on the features of coolant. The cooling condition indicated in specification: coil temperature should be less than 120℃(130℃ for □M-2) when motor stator continuously operates under continuous torque. If equivalent torque of actual operation is lower than continuous torque indicated in specification, reduce cooling water flow to avoid consuming excess pump. The cooling condition can be properly adjusted based on the following formulas.

Adjust the boundary conditions of water cooling system according to the motor power loss:

When equivalent torque is lower than continuous torque ($T_e < T_c$), get the corresponding coolant flow from the following formulas.

$$P_e = \frac{p_c}{\left(\frac{T_c}{T_e}\right)^2}$$

$$P_e = 69.7 \cdot q_e \cdot \Delta\theta$$

P_e= Total loss of motor under equivalent torque [W]

$\Delta\theta$ = Temperature difference between motor inlet and outlet [℃]

q_e= Coolant flow[l/min] (under equivalent torque)

Pressure difference between inlet and outlet (ΔP_{eff}) is related to coolant flow (q)

$$\Delta P_{eff} = \Delta P \cdot \frac{q_e}{q}$$

ΔP_{eff}= Pressure difference between inlet and outlet [bar] (under equivalent torque)

ΔP = Pressure difference between inlet and outlet [bar] (in datasheet)

q = Coolant flow [l/min] (n datasheet)

- **Example**

In model type TMRWAF's specification, the continuous torque (T_c) water cooling condition is 1290 Nm power loss (P_c) is 8262 W, coolant flow(q) is 23.7 l/min, pressure difference between inlet and outlet(ΔP) is 3 bar. If the used continuous toque is only 600 Nm and the temperature difference between inlet and outlet should be 6℃, what is the coolant flow (q_e) and the pressure difference between inlet and outlet (ΔP_{eff}) in cooling water system? [$v_{water} = 10^{-3}(m^3/kg)$]

$$P_e = \frac{p_c}{\left(\frac{T_c}{T_e}\right)^2} = \frac{8262}{\left(\frac{1290}{600}\right)^2} = 1787(W)$$

$$1787 = 69.7 \times q_e \times 6$$

$$q_e = 4.27(l/min)$$

$$\Delta P_{eff} = \Delta P \cdot \frac{q_e}{q} = 3 \times \frac{4.27}{23.7} = 0.54(bar)$$

The differences between datasheet parameters and user parameters are listed in the following Table 3.3.3

Table 3.3.3 Difference between datasheet parameter and user parameter

Parameter (Under water cooling condition)	Datasheet	User
Torque (T)	1290 Nm	600 Nm
Power loss (P)	8262 W	1787 W
Temperature difference between inlet and outlet $(\Delta\theta)$	5℃	6℃
Coolant flow (q)	22 l/min	4.27 l/min
Pressure difference between inlet and outlet (ΔP)	3 bar	0.54 bar

3.3.7.2 Coolant selection

Coolant needs to be prepared by the user. Anti-corrosion coolant needs to be used for HIWIN torque motor. The design and performance test of HIWIN torque motors are based on pure water. If customers use oil as the coolant, the heat that can be taken away by the same flow rate will be reduced and so will the motor power, otherwise the flow rate should be increased to keep the motor power. Please contact HIWIN for related information.

The coolant must be processed and filtered in advance to avoid blocking the cooling channel. The maximum allowable size of particles in the coolant is 100 microns, and it must not freeze. If untreated water is used, it may cause failure or damage due to deposition, algae growth or formation of slime, and corrosion, such as: reduced thermal conductivity, pressure loss due to cross-sectional area reduction, and blockage of various components. And for water quality, at the least the following requirements must be met:

1. Chloride and sulfate must be less than 100 ppm.
2. The solute of mineral salt must be less than 2000 ppm.
3. 6.5≦pH≦9.5
4. Compatible with the O-ring material (refer to Table 5.1.5)

If an anti-corrosion agent is added (the basic raw material is Ethylene Glycol Monoethyl Ether), it must not react with water and the freezing point must be at least -5℃. The anti-corrosion agent must be compatible with the connectors and the materials in the cooling system including the O-ring of the motor. Please confirm with the supplier of the agent! It is generally recommended that the concentration should not exceed 50%.

Apart from oil, adding various solvents to water will also cause its specific heat capacity (C_p) to decrease (please confirm the features with the supplier). It is necessary to reduce the motor power accordingly. For example, when using Glycol as an additive, please refer to the Table 3.3.4 below:

Table 3.3.4 The specific heat capacity of Ethylene Glycol based water solutions at various temperatures

	Specific heat capacity C_p $(KJ/kg\ K)$			
Concentration of Ethylene Glycol (Weight %)	Temperature			
	0℃	10℃	20℃	30℃
0	4.203	4.195	4.189	4.185
10	4.071	4.079	4.087	4.096
20	3.918	3.935	3.951	3.968
30	3.764	3.807	3.807	3.828
40	3.595	3.647	3.647	3.674
50	3.412	3.473	3.473	3.504

Note: Better to mix the water with an appropriate ion neutralizer instead of Glycol with the additional benefit of limiting corrosion and clogging risk.

- **Example**

Here we can do a calculation based on motor conditions provided in examples above. If we assume that the customer only uses water with 20% Glycol as the coolant, the influence of heat capacity reduction must be considered and the flow rate needs to be increased to maintain the heat removal per unit time.

It can be seen from the table that the heat capacity of pure water below 20℃ is 4.189 $(KJ/kg\ K)$, and the heat capacity of water with Glycol 20% is 3.951 $(KJ/kg\ K)$

$$q_e = \frac{4.189}{3.951} \times 22 = 23.3\ (\ l/min)$$

Table 3.3.5 Difference between datasheet parameter and user parameter

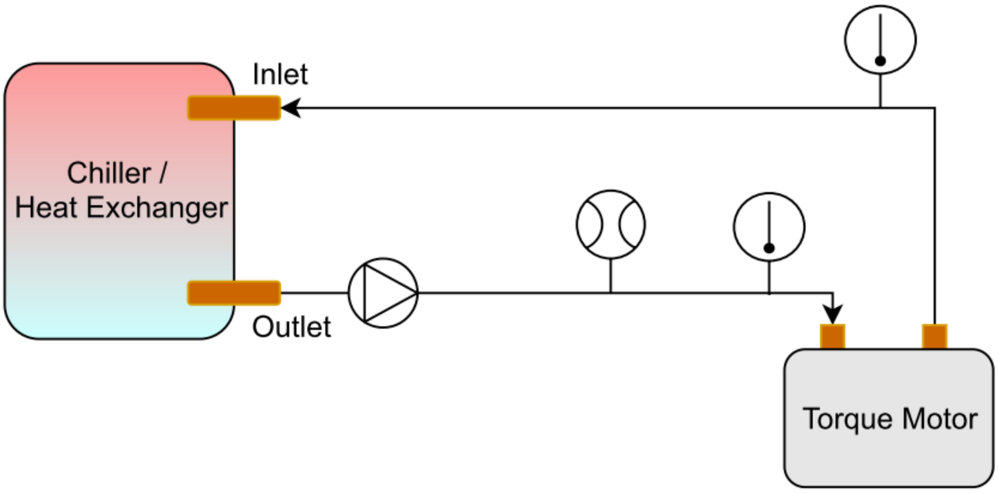
Parameter (under water cooling condition)	Datasheet	User
Torque (T)	1290 Nm	1290 Nm
Power loss (P)	8262 W	8262 W
Temperature difference between inlet and outlet $(\Delta\theta)$	5℃	5℃
Coolant flow (q)	22 l/min	23.3 l/min
Agent	0% Pure Water	Glycol 20% with water

3.3.7.3 Coolant diagram

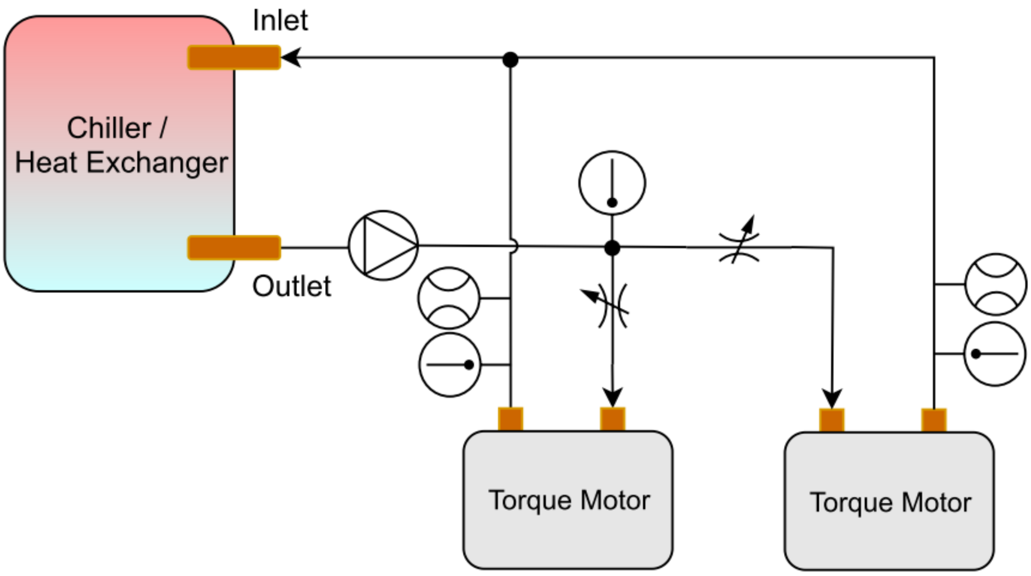
	Pump		Flow Indicator		Thermometer		Flow control (Adjustable)

This section shows simple schematic cooling diagram:

a. Single torque motor

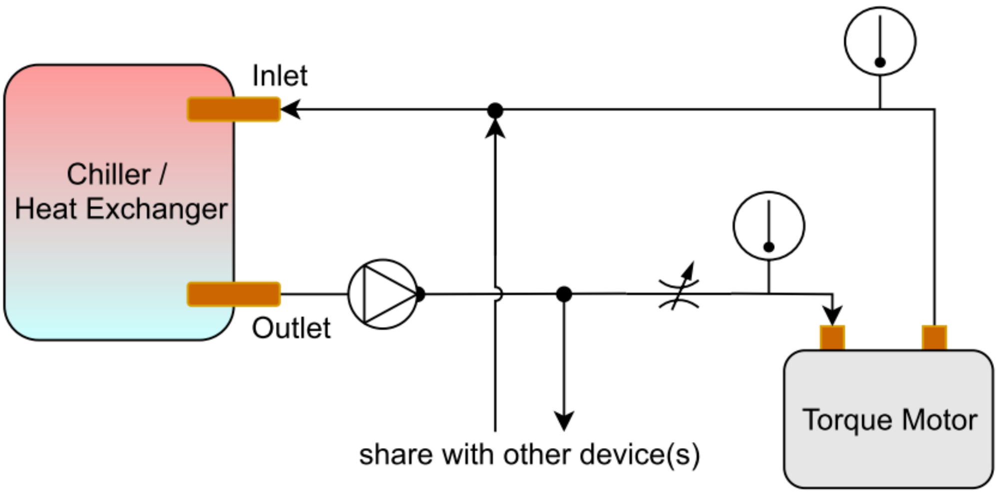


b. Parallel operation



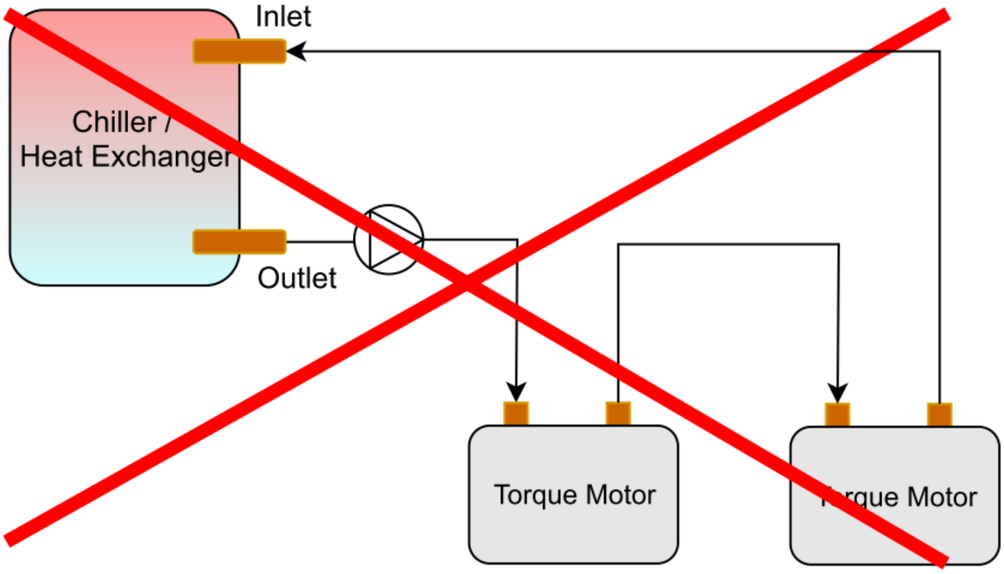
c. Share with other device(s)

In any case, sharing flow with other device should be monitor flow and control it.



d. Serial Circuit

Never do serial circuit!



4. Transport and setup

4.1 Delivery

■ **Transport precautions**

1. Permanent magnets are listed as Dangerous Goods (Magnetized material: UN2807) according to International Air Transport Association (IATA).
2. For products containing permanent magnets, no additional measures on packaging are required to resist the magnetic field in sea freight and inland transportation.
3. When transporting products containing permanent magnets by air, the maximum permissible magnetic field strengths specified by the appropriate IATA Packing Instruction must not be exceeded. Special measures may be required so that these products can be shipped. Above a certain magnetic field strength, such shipments must be labelled in accordance with Packing Instruction 953 from IATA (Please refer below or the latest regulation from IATA.)
   i、 Products whose highest field strength exceeds 0.418 A/m (0.525 μT) or 2° of compass deviation, as determined at a distance of 4.6 m from the product, require shipping authorization from the responsible national body of the country from where the product is being shipped (country of origin) and the country where the airfreight company is based. Special measures need to be taken to enable the product to be shipped.
   ii、 When shipping products whose highest field strength is equal to or greater than 0.418 A/m (0.525 μT) or 2° of compass deviation, as determined at a distance of 2.1 m from the product, shipment is conducted with regulation of Dangerous Goods Transportation.
   iii、 When shipping products whose highest field strength is less than 0.418 A/m (0.525 μT), as determined at a distance of 2.1 m from the product, you do not have to notify the relevant authorities and you do not have to label the product.
4. Shipping originally packed motor components neither has to be disclosed nor marked.
5. Transport conditions must comply with EN 60721-3-2:2018 (refer to Table 4.1.1).

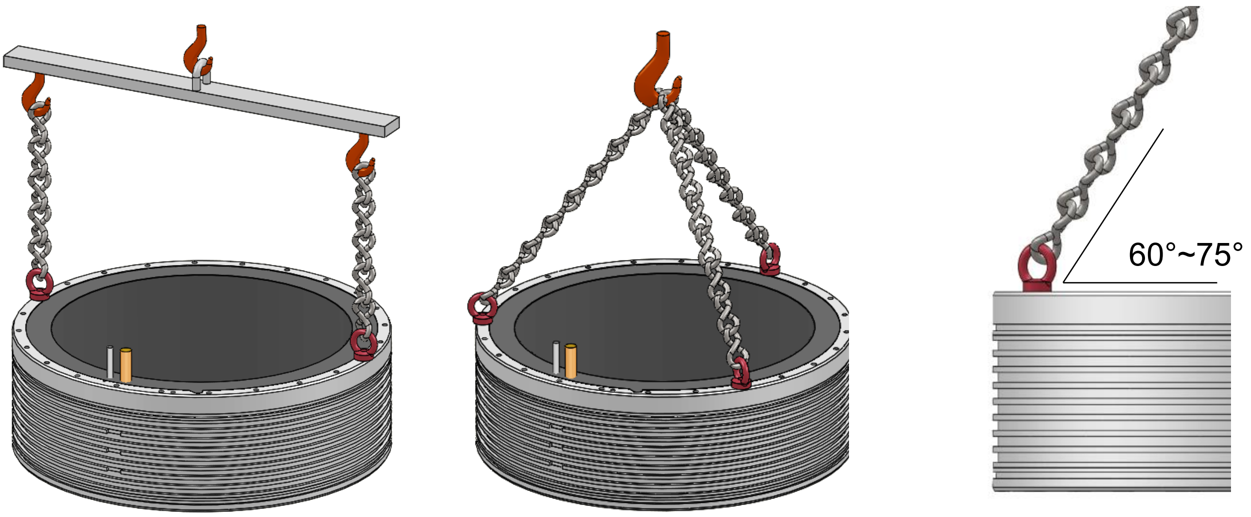
Table 4.1.1 Transport conditions

Environmental parameter	Unit	Value
Air temperature	(℃)	-5~40
Relative humidity	(%)	5~85
Rate of change of temperature	$(℃/min)$	0.5
Condensation		Not allowed
Formation of ice		Not allowed
Transport condition		Class 2K11
Transport the motor in an environment with good weather protection (indoor/factory)		
Biological conditions	Class 2B1	
Chemically active substances	Class 2C1	
Mechanically active substances	Class 2S5	
Mechanical conditions	Class 2M4	

4.2 Transport to the installation site

■ **Handling motor directly with lifting rings**

- If only two rings are used, the rings must be precisely opposed to each other, and a boom should be used.
- If three or more rings are used, the rings must be set with equal distance. The rope length between the motor lifting points must be all the same.

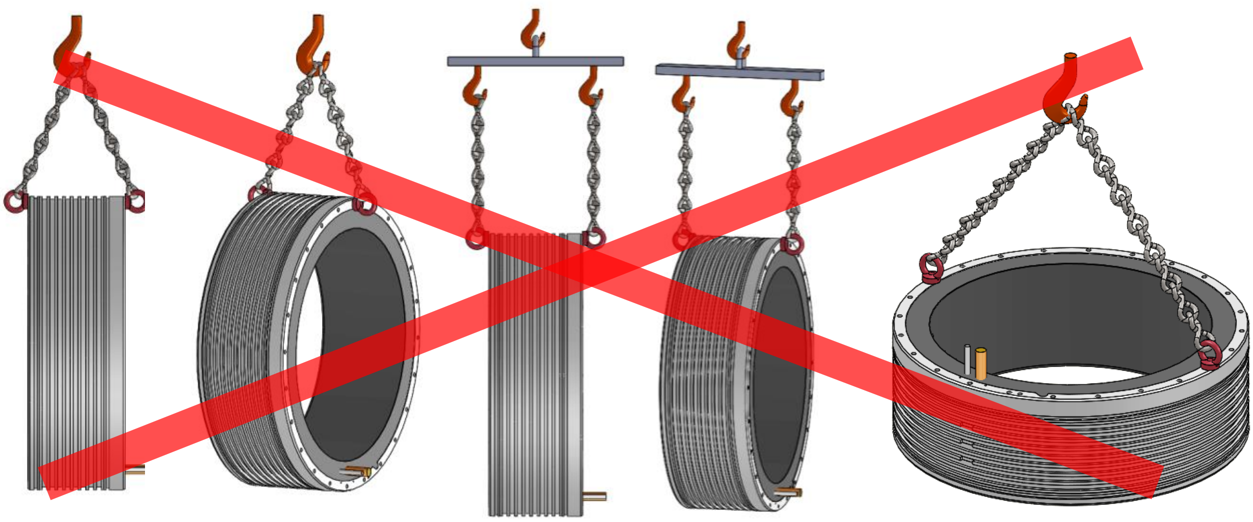


(a) (b) (c)

Figure 4.2.1 Handling motor directly with lifting rings

(a). Use two rings (b). Use more than three rings (c). Ring included angle

- Please avoid hanging motors more than 30kg and motors with frame size larger than D series. This can prevent the motor from being damaged by excessive stress.



(a) (b) (c)

Figure 4.2.2 Please avoid hanging with too heavy or too large objects

◆ Please use the following methods when the motor needs to be moved vertically (stress needs to be estimated) or overturned (preferably on the ground).

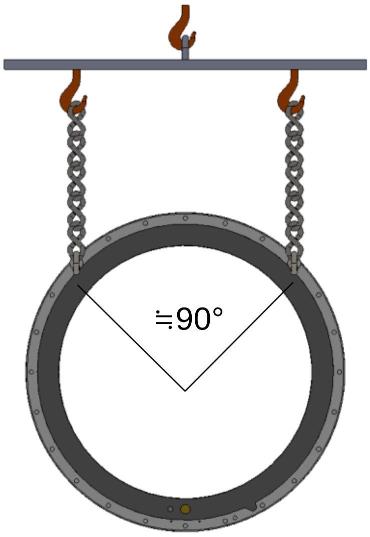


Figure 4.2.3 Vertical or overturning motor hanging method

■ **Handling motor with lifting rings and bridge**

◆ There are mounting holes for lifting rings on the bridge. Please use lifting rings that meet the specifications and set the rings with equal distance. The rope length between the motor lifting points must be all the same.

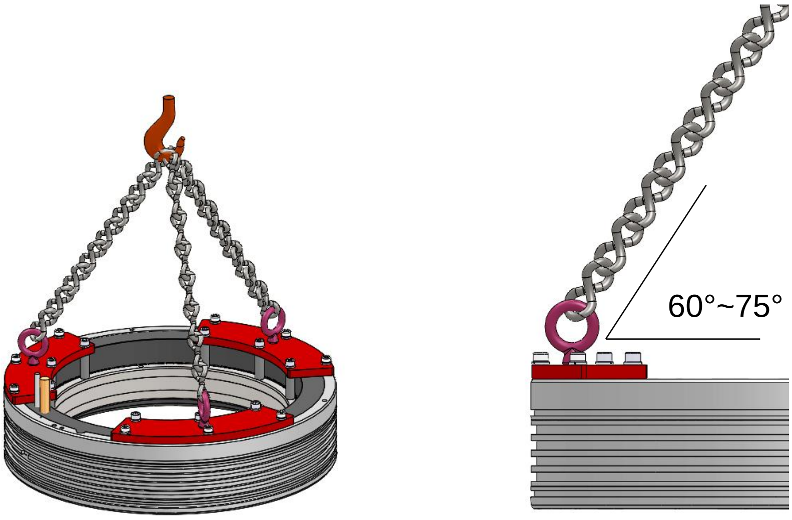


Figure 4.2.4 Handling motor with lifting rings and bridge

Note: Based on motor weight and design considerations, the quantity of bridges will be different from case to case. Please refer to approval drawings for accurate bridge quantity.

4.3 Requirements at the installation site

DANGER!

Danger from electrical voltage!

Before and during assembly, disassembly and repair work, dangerous currents may flow.

- Work may only be carried out by a qualified electrician and with the power supply disconnected!
- Before carrying out work on the linear motor system, disconnect the power supply and protect it from being switched back on!

DANGER!

Risk of death as a result of strong magnetic fields!

Strong magnetic fields around torque motor systems represents a danger for people with active medical implants, who come close to the motors. This is also the case when the motor is switched off.

- If you are affected, stay a minimum distance of 500 mm from the permanent magnets
  - Trigger threshld for static magnetic fields of 0.5 mT according Directive 2013/35/EU

Also take national and local guidelines or requirements into account.

- For reference DGUV rule 103-013 of the German Social Accident Insurance specifies requirements when working with magnetic fields

DANGER!

Risk of crushing from strong forces of attraction!

- Assemble the rotors and stators carefully!
- Do not place fingers or objects between the rotors and stators!
- The rotor and magnetizable objects may accidentally attract each other and collide!
- Two rotors may accidentally attract each other and collide!
- The magnetic force of the rotor acting on the object may be as high as several kN, which may cause a certain part of the body to be clamped.
- Do not underestimate the attraction force and operate carefully.
- Wear safety gloves when necessary.
- At least two people are required to cooperate during operation.
- If the assembly steps have not yet reached the installation of the rotor, please place the rotor in a safe and proper place first.
- Never take multiple rotors at once.
- Never place two rotors directly together without any protection.
- Do not bring any magnetizable materials close to the rotor! If the tool must be magnetized,

please hold it firmly with both hands and slowly approach the rotor!

- ◆ It is recommended to install the rotor immediately after unpacking!
- ◆ When installing the stator and rotor, an installation auxiliary device is required to assemble the stator and rotor individually. Please follow the correct method.
- ◆ Keep the following tools at hand at any time to release body parts (hands, fingers, feet, etc.) clamped by magnetic force.
  - ■ Hammer made of non-magnetized solid material (about 3Kg)
- ◆ Two wedge blocks composed of non-magnetized materials (wedge-shaped sharp angle 10°~15°, minimum height 50mm).

4.4 Storage

■ Maintenance and storage precautions

1. Do not store the product in an inflammable environment or with chemical agents.
2. Store the product in a place without humidity, dust, harmful gases or liquids.
3. Install the product in location with less vibration.
4. The way to clean the product: wipe with alcohol (70%)
5. The way to discard the damaged product: recycle it according to local laws and regulations.
6. Storage conditions must comply with EN 60721-3-1:2018(refer to Table 4.4.1).
7. Motor can be stored for up to two years indoor with the following conditions:
   - i、 Dry
   - ii、 Dust-free
   - iii、 No vibration
   - iv、 Good ventilation
   - v、 Resistance to extreme weather
   - vi、 Indoor air does not contain corrosive gas
   - vii、 Prevent motor vibration and moisture
8. If no dry storage environment is available, the following measures need to be taken:
   - i、 Wrap the motor with moisture-absorbing material, and then seal the motor.
   - ii、 Put desiccant in the sealed package; the desiccant needs to be checked and replaced if necessary.
   - iii、 Check the motor regularly.
9. Motors should be stored in the original packages and laid flat. It can be temporarily stored outside the package if sufficient support and protection is provided. Also, the storage environment needs to meet the requirements. Please make sure that the cables must face upwards in case of pinching, as shown in Figure 4.4.1 below.
10. After long-term storage and removal of the motor, the insulation resistance value may be reduced due to moisture. Before installing the machine, confirm the insulation resistance state of the motor. Use an inspection instrument that meets EN61557. The test must reach $100\mathrm{M\Omega}$ after 60 seconds at $1000V_{DC}$. If it does not meet the specifications, the motor may be damp. If it is used directly, it may cause insulation damage. Please contact HIWIN for assistance.

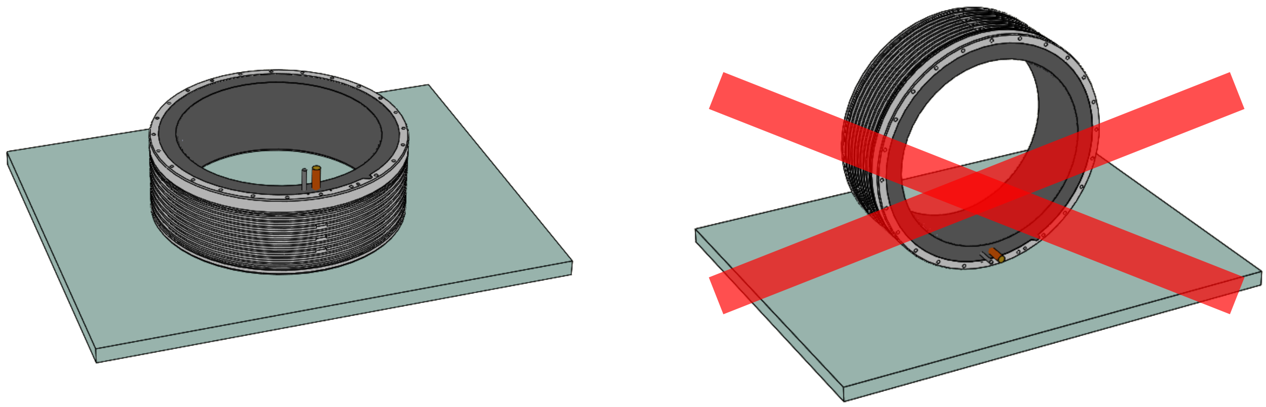


Figure 4.4.1 Schematic diagram of storage outside the package

Table 4.4.1 Storage conditions

Environmental parameter	Unit	Value
Air temperature	(℃)	-5~40
Relative humidity	(%)	5~85
Absolute humidity	(g/m^3)	1~25
Rate of change of temperature	$(℃/min)$	0.5
Air pressure	(kPa)	70~106
Solar radiation	(w/m^2)	700
Condensation		Not allowed
Formation of ice		Not allowed
Long-term storage conditions		Refer Class 1K21
Store the motor in an environment with good weather protection. (indoor/factory)		
Biological conditions	Class 1B1	
Chemically active substances	Class 1C1	
Mechanically active substances	Class 1S11	
Mechanical conditions	Class 1M11	

4.5 Unpacking and setup

WARNING!

Danger from heavy loads!

Lifting heavy loads may damage your health.

- Use a hoist of an appropriate size when positioning heavy loads which are over 20 kg!
- Observe applicable occupational health and safety regulations when handling suspended loads!
- Motors with stator and rotor fixture can be hung with hanging holes. The strength of the components should be considered when hanging under any circumstances.

■ Please disassemble and assemble this product indoors. The precautions for disassembling the product package are as follows:

1. Please confirm that the quantity and the specifications of the label are correct.
2. Please disassemble the carton carefully, and note that the rotor contains magnet.
3. Please save the disassembled carton and send it back if there is any problem later. If there is no problem, please dispose of the packaging in an environmentally friendly manner.
4. Please take out the product carefully, confirm that the appearance is not damaged and the internal product is correct, and you can take pictures for storage.
5. Please carefully move the product to the installation site before assembling. Because the rotor contains magnet, it is necessary to avoid magnetically conductive objects around it.

5. Assembly and connection

5.1 Mechanical installation

5.1.1 Water cooling design

HIWIN torque motor can be cooled by water or air. (TM-2 and IM-2 are default with water cooled) Cooling channel is designed on the outer case of stator. O-ring is installed outside the cooling channel as a leak-proof device. To ensure a good circulation of the coolant for cooling, the design coolant inlet/outlet must be aligned with position on the approved drawing.

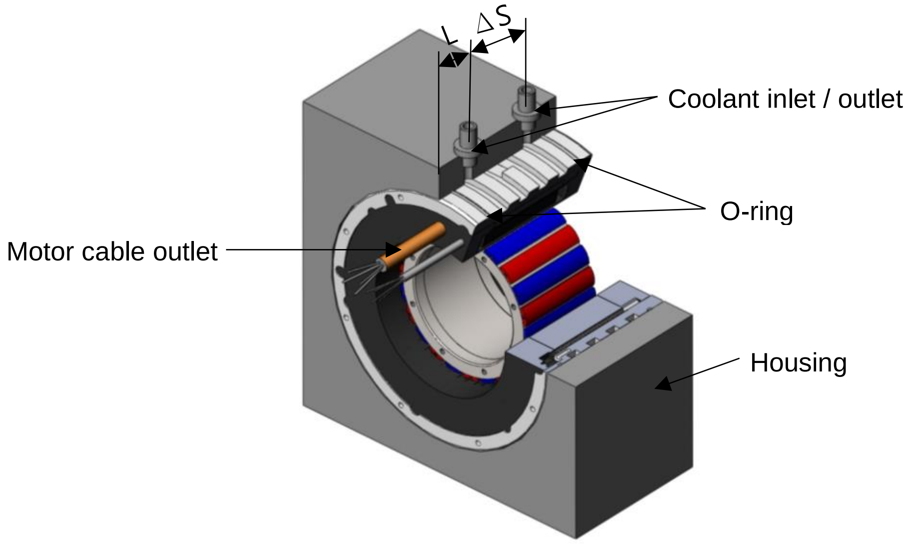
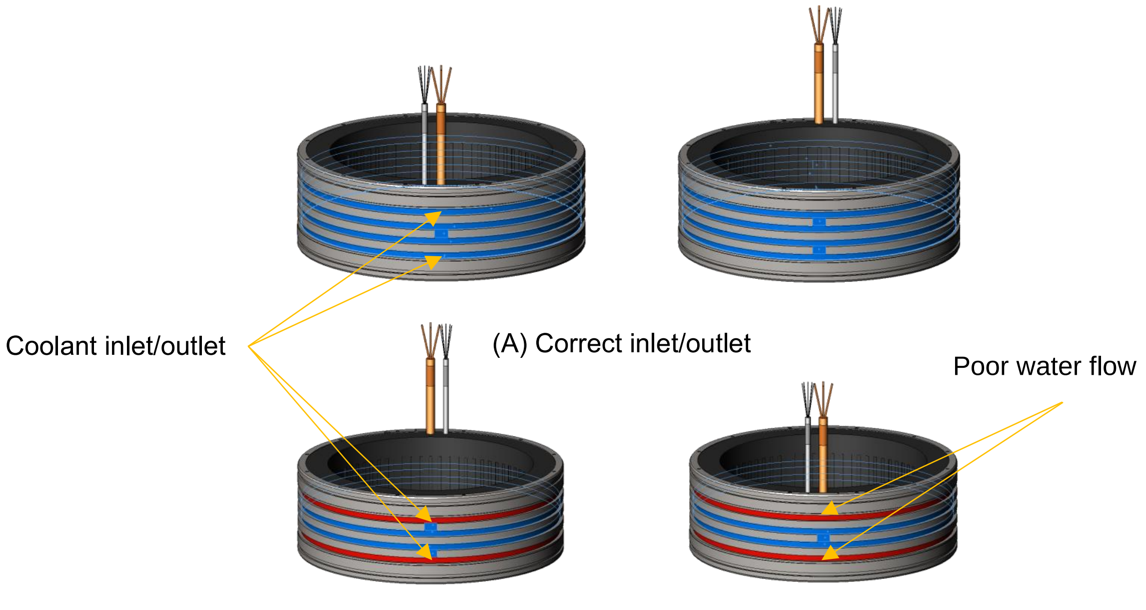


Figure 5.1.1 Basic structure of HIWIN torque motor



(B) Incorrect inlet/outlet

Figure 5.1.2 Installation location influence of coolant inlet/outlet

5.1.1.1 Cooling channel position

Refer to Table 5.1.1 and Table 5.1.2, that is recommended coolant inlet/outlet position for each series. (L and ΔS refer to Figure 5.1.1).【Torque motor with cooling jacket are not included(Reserved code: J□)】

Table 5.1.1 TMRW Series coolant inlet/outlet position

L (mm)	ΔS (mm)				
	20	40	60	90	140
25	TMRW13(L) TMRW43(L)	TMRW15(L) TMRW45(L)	TMRW17(L) TMRW47(L)	TMRW1A(L) TMRW4A(L)	TMRW1F(L) TMRW4F(L)
30	TMRW23(L)	TMRW25(L)	TMRW27(L)	TMRW2A(L)	TMRW2F(L)
35	TMRW73(L) TMRWA3(L)	TMRW75(L) TMRWA5(L)	TMRW77(L) TMRWA7(L)	TMRW7A(L) TMRWAA(L)	TMRW7F(L) TMRWAF(L)
43	TMRWD3(L)	TMRWD5(L)	TMRWD7(L)	TMRWDA(L)	TMRWDF(L)
35	TMRWG3(L)	TMRWG5(L)	TMRWG7(L)	TMRWGA(L)	TMRWGF(L)

Table 5.1.2 TM-2/IM-2 series coolant inlet/outlet position

L (mm)	ΔS (mm)				
	20	40	60	90	140
25	□M-2-13 □M-2-43	□M-2-15 □M-2-45	□M-2-17 □M-2-47	□M-2-1A □M-2-4A	□M-2-1F □M-2-4F
30	□M-2-23	□M-2-25	□M-2-27	□M-2-2A	□M-2-2F
35	□M-2-73 □M-2-A3	□M-2-75 □M-2-A5	□M-2-77 □M-2-A7	□M-2-7A □M-2-AA	□M-2-7F □M-2-AF
43	□M-2-D3	□M-2-D5	□M-2-D7	□M-2-DA	□M-2-DF
35	□M-2-G3	□M-2-G5	□M-2-G7	□M-2-GA	□M-2-GF

5.1.1.2 Cooling channel dimension

Cooling channel dimension for each series is given in the following Table 5.1.3 and Table 5.1.4.【Torque motor with cooling jacket are not included(Reserved code: J□)】

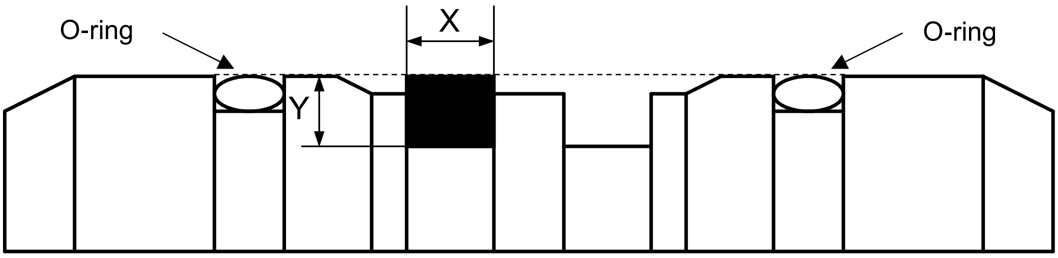


Figure 5.1.3 Cooling channel dimension diagram

Table 5.1.3 TMRW series cooling channel dimension

Type	X (mm)	Y (mm)	Inlet / Outlet internal diameter (mm)	Type	X (mm)	Y (mm)	Inlet / Outlet internal diameter (mm)
TMRW13(L)	8	5	8	TMRWA3(L)	8	5	8
TMRW15(L)	8	5	8	TMRWA5(L)	8	5	8
TMRW17(L)	9	5	8	TMRWA7(L)	9	5	8
TMRW1A(L)	8	5	8	TMRWAA(L)	8	5	8
TMRW1F(L)	9	5	8	TMRWAF(L)	9	5	8
TMRW23(L)	8	5	8	TMRWD3(L)	8	5	8
TMRW25(L)	8	5	8	TMRWD5(L)	8	5	8
TMRW27(L)	9	5	8	TMRWD7(L)	9	5	8
TMRW2A(L)	8	5	8	TMRWDA(L)	8	5	8
TMRW2F(L)	9	5	8	TMRWDF(L)	9	5	8
TMRW43(L)	8	5	8	TMRWG3(L)	8	5	10
TMRW45(L)	8	5	8	TMRWG5(L)	8	5	10
TMRW47(L)	9	5	8	TMRWG7(L)	9	5	10
TMRW4A(L)	8	5	8	TMRWGA(L)	8	5	10
TMRW4F(L)	9	5	8	TMRWGF(L)	9	5	10
TMRW73(L)	8	4	8				
TMRW75(L)	8	4	8				
TMRW77(L)	9	4	8				
TMRW7A(L)	8	4	8				
TMRW7F(L)	9	4	8				

Table 5.1.4 TM-2/IM-2 series cooling channel dimension

Type	X (mm)	Y (mm)	Inlet / Outlet internal diameter (mm)	Type	X (mm)	Y (mm)	Inlet / Outlet internal diameter (mm)
□M-2-13	8	5	8	□M-2-A3	8	6	8
□M-2-15	8	5	8	□M-2-A5	8	6	8
□M-2-17	9	5	8	□M-2-A7	9	6	8
□M-2-1A	8	5	8	□M-2-AA	8	6	8
□M-2-1F	9	5	8	□M-2-AF	9	6	8
□M-2-23	8	5	8	□M-2-D3	8	5	8
□M-2-25	8	5	8	□M-2-D5	8	5	8
□M-2-27	9	5	8	□M-2-D7	9	5	8
□M-2-2A	8	5	8	□M-2-DA	8	5	8
□M-2-2F	9	5	8	□M-2-DF	9	5	8
□M-2-43	8	5	8	□M-2-G3	8	5	10
□M-2-45	8	5	8	□M-2-G5	8	5	10
□M-2-47	9	5	8	□M-2-G7	9	5	10
□M-2-4A	8	5	8	□M-2-GA	8	5	10
□M-2-4F	9	5	8	□M-2-GF	9	5	10
□M-2-73	8	4	8				
□M-2-75	8	4	8				
□M-2-77	9	4	8				
□M-2-7A	8	4	8				
□M-2-7F	9	4	8				

Note: The water coolant inlet/outlet mentioned above must have the smallest internal diameter to ensure the minimum water flow given in the datasheet.

The maximum pressure that HIWIN torque motors can withstand is 10 bar.

Torque motor with cooling jacket（Reserved code: J□）can withstand is 5 bar.

5.1.1.3 Cooling channel configuration

The following describes two common configurations for cooling channel. Regardless of which configuration is used, it is essential to ensure that the inlet/outlet match the approved diagram position and to remove any air from the cooling loop after installation.

- **Motor shaft is mounted vertically**

  No matter motor cable outlet is facing upward or downward, coolant outlet should be above and coolant inlet should be below. (Defined by the direction of gravity.) Besides, coolant inlet and outlet must be aligned with motor cable outlet (refer to HIWIN approved drawing for motor cable outlet position). The coolant inlet and outlet of the torque motor with cooling jacket (Reserved code J□) are located on the end surface of the motor outlet side. Please refer to section 5.1.1.6 for the connection relationship between the coolant inlet and outlet and the cooling channel. The lower cooling channel (Defined by the direction of gravity) should be selected as the coolant inlet, and the upper cooling channel should be selected as the coolant outlet.

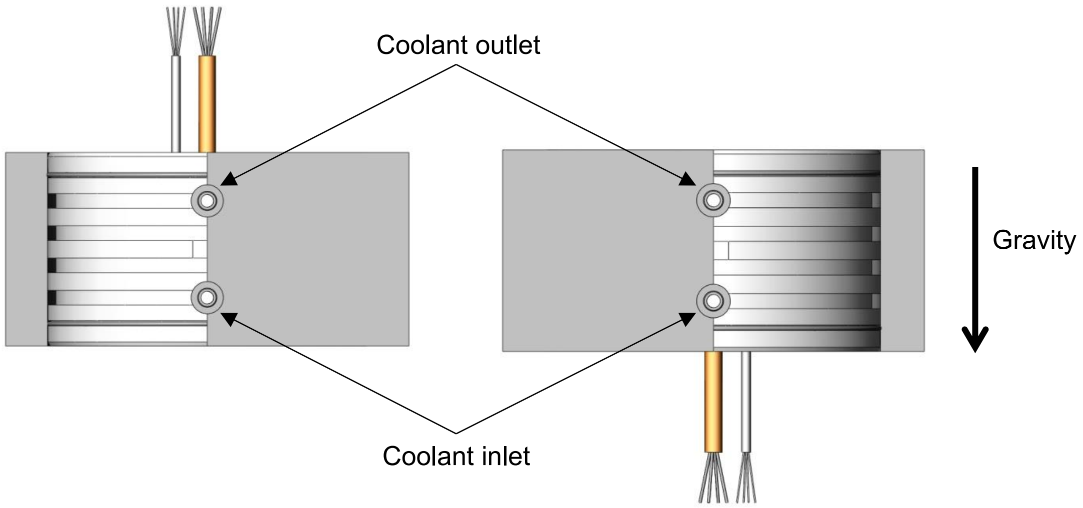


Figure 5.1.4 Coolant inlet/outlet position when motor shaft is mounted vertically

- **Motor shaft is mounted horizontally**

  Customers can decide coolant inlet/outlet direction. Coolant inlet/outlet must be aligned with motor cable outlet (refer to HIWIN approved drawing for motor cable outlet position). Note that if the coolant inlet/outlet are not located at the highest point (Defined by the direction of gravity), the air bubbles in the cooling channel may not be discharged. It is recommended to design the exhaust hole and the exhaust screw at the highest point. For the torque motor with cooling jacket (reserved code J□), it is recommended to install the coolant inlet/outlet at the highest point.

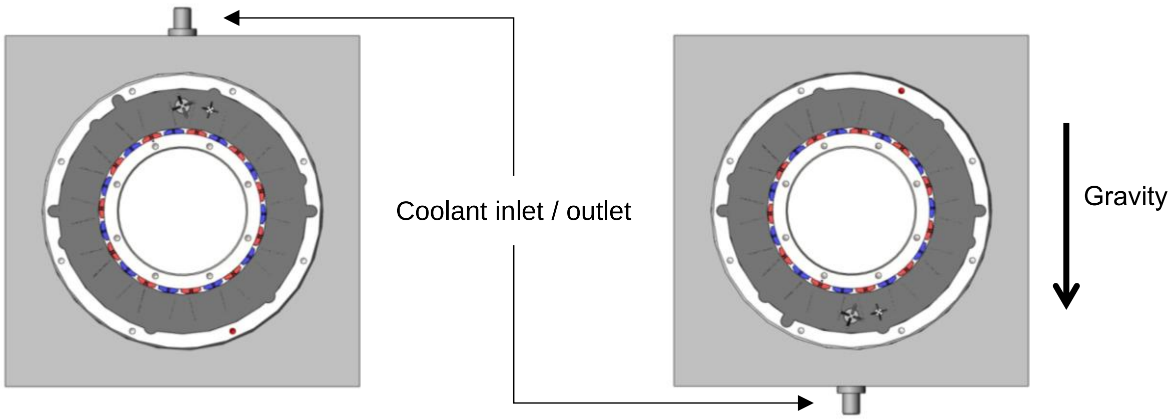


Figure 5.1.5 Coolant inlet/outlet position when mounted vertically

- **After installation, remove air bubbles from the cooling channel**

  Bubbles or cavities in the cooling channel will reduce the cooling capacity and cause local heating or even overheating. The cooling channel must be vented after installation and connection of the cooling system. The cooling channel must be designed the exhaust screw to remove air pockets.

  1. Adjust the position of the device so that the exhaust screw is at the highest point possible (Defined by the direction of gravity).
  2. Loosen the exhaust screw and turn on the cooling system.
  3. When the liquid leaks, tighten the exhaust screw as soon as possible.
  4. After wiping, check visually for leaks and no coolant dripping or flowing out.

- **Bleed out air bubble in cooling circuit after complete installation**

Air bubbles and pockets in the cooling circuit will reduce cooling capacity. It will cause the unit to be locally hot or even overheated. So after fitting and connecting the cooling system, it is necessary to bleed the cooling circuit.

The cooling circuit must be designed with vent screw to bleed out the bubbles.

1. Position the unit so that the vent screw is at the highest point as possible (relative to gravity).
2. Loosen the vent screw and operating the cooling system.
3. When liquid leaks out then tighten the vent screw as soon as possible.
4. Visually inspect for leaks after wiping. No cooling agent drips or run out.

5.1.1.4 O-ring features

O-ring features for each series are given in the following Table 5.1.5.【Torque motor with cooling jacket are not included(Reserved code: J□)】

Table 5.1.5 O-ring features

Type	Material	Shore A	O-ring thickness (mm)	O-ring internal diameter (mm)
TMRW1□/□M-2-1□	VITON	70°	2.62	152.07
TMRW2□/□M-2-2□	VITON	70°	2.62	190.17
TMRW4□/□M-2-4□	VITON	70°	2.62	221.92
TMRW7□/□M-2-7□	VITON	70°	2.5	296
TMRWA□/□M-2-A□	VITON	70°	4	370
TMRWD□/□M-2-D□	VITON	70°	4	465
TMRWG□/□M-2-G□	VITON	70°	4	550

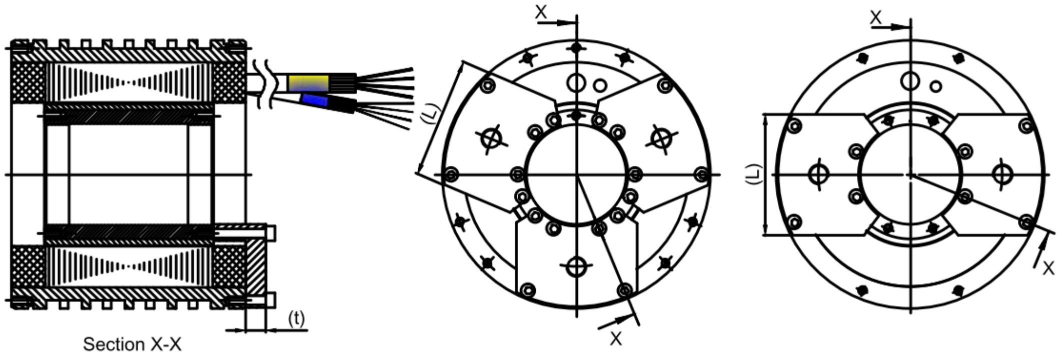
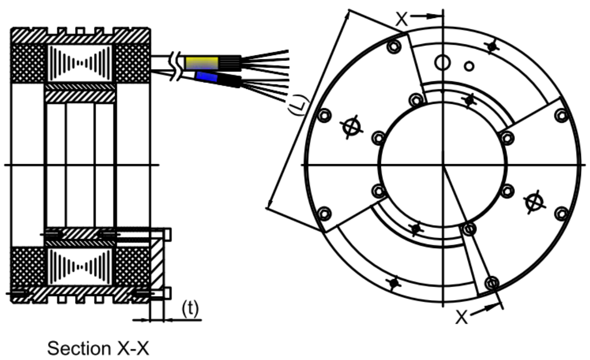
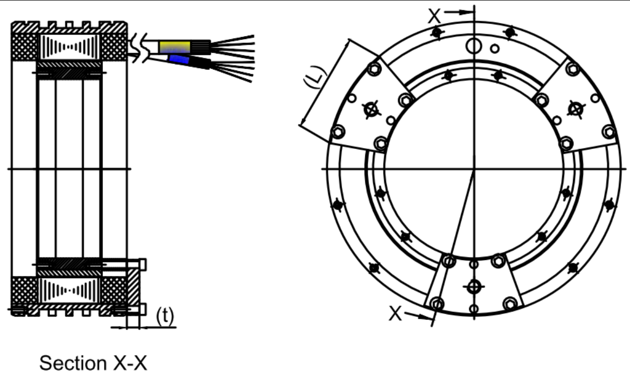
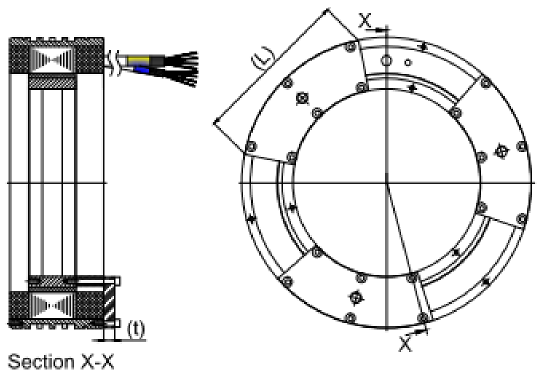
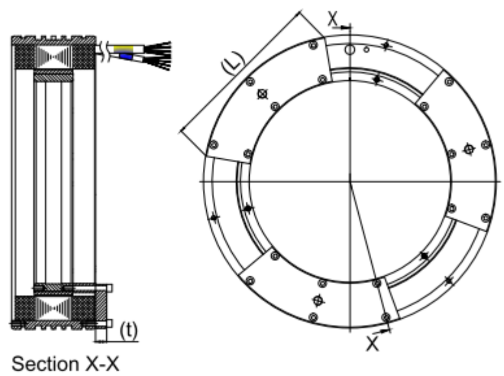
Note: Greasing the O-ring with an ordinary lubricant will help to improve the tightness.

The quality of O-ring shipped by HIWIN is defined in accordance with ISO3601 standards (Series G & Grade N); different brands of Fluor elastomers have different product names, also known as FKM and FPM. It is Viton® with DuPont™ from the United States, Dyneon™ with 3M from the United States, and DAI-EL with Daikin® from Japan. If customers need to replace O-ring by themselves, apart from purchasing directly from HIWIN, they can also contact local suppliers to obtain materials equivalent to Viton. Note that the hardness must be above 70° of Shore A. The O-ring of the torque motor with cooling jacket has been installed inside. Customers are not allowed to dismantle cooling jacket to replace the O-ring.

5.1.1.5 Fixture dimension

Fixture dimension for each series is given as below Table 5.1.6 and Figure 5.1.6.

(The default setting for the shipment of TM-2/IM-2 is to ship the stator and rotor separately. Please contact HIWIN, if shipment with complete assembled motor is required.)

<table>
<tr><th colspan="2">TMRW1 Series</th></tr>
<tr><td colspan="2">
</td></tr>
<tr><th>TMRW2 Series</th><th>TMRW4 Series</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><th>TMRW7 Series</th><th>TMRWA Series</th></tr>
<tr><td>
</td><td>
</td></tr>
</table>

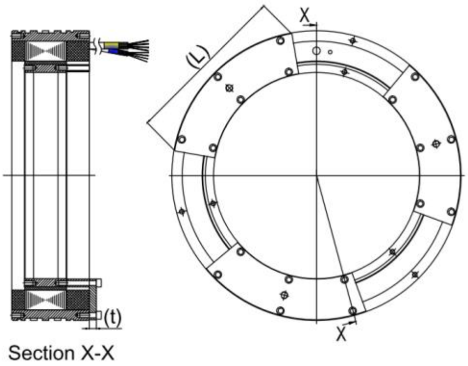
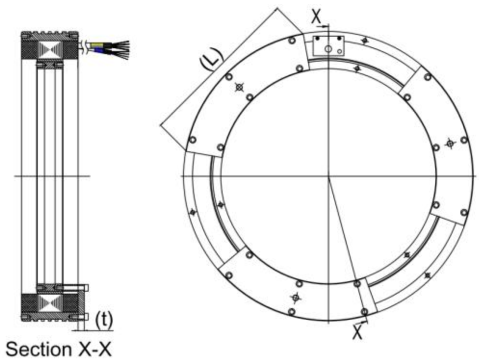
TMRWD Series	TMRWG Series
	

Figure 5.1.6 Fixture diagram

Table 5.1.6 Fixture dimension

Motor type	Fixture maximum length: L (mm)	Fixture thickness: t (mm)
TMRW1□	72	12
TMRW2□	151	10
TMRW4□	76	10
TMRW7□	166	12
TMRWA□	205	15
TMRWD□	274	12
TMRWG□	312	12

Remark: The dimension shown above may be modified in case of design purpose. Correct information is still based on the approval drawing

5.1.1.6 Cooling interface adapter for torque motor with cooling jacket(Reserved code:J□)

There is a cooling interface adapter on the end face of the stator, as shown in Figure 5.1.7. When shipped, the coolant inlet/outlet on this adapter are covered or plugged. Before connecting the cooling pipeline to the motor, do not remove the covers or plugs on the cooling interface adapter to prevent foreign objects from entering and blocking the cooling channel. The adapter has been installed on the motor before delivery. If the customers need to remove it, please follow the instructions below. The sealing performance, including the cooling interface adapter, has been tested before delivery to ensure its quality. If customers disassemble the cooling interface adapter, HIWIN will not be responsible for any leakage issues

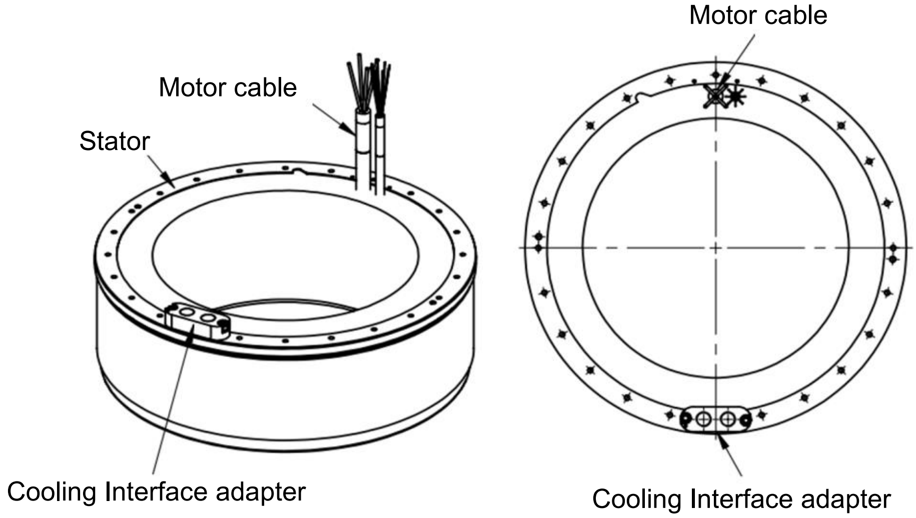


Figure 5.1.7 Cooling Interface adapter

There is a marked hole on the end face of the cooling Interface adapter. The coolant inlet/outlet closer to this marked hole is connected to the cooling channel that keep away from the motor cable. The other one is connected to the cooling channel that close to the motor cable. The direction of coolant inlet/outlet can be determined by this marked hole. (Refer to Section 5.1.1.3).

The size of the cooling Interface adapter and the specifications of the coolant inlet/outlet are shown in Figure 5.1.8, Figure 5.1.9 , and Table 5.1.7.

The O-ring is used to seal between the cooling Interface adapter and the end face of the stator. The characteristics of the O-ring for each series are shown in Table 5.1.8.

Table 5.1.7 The size of the cooling Interface adapter

Type	A	B	C	E	Coolant inlet/Outlet specifications
	Unit：mm				
TM-2-7□-....-J□	26	---	10.5	140.5	G1/4 x 9DP
TM-2-A□-....-J□	31.5	15	16	173.5	G3/8 x 9DP
TM-2-D□-....-J□	31.5	14	16	219	G3/8 x 9DP
TM-2-G□-....-J□	31.5	10	16	260	G3/8 x 9DP

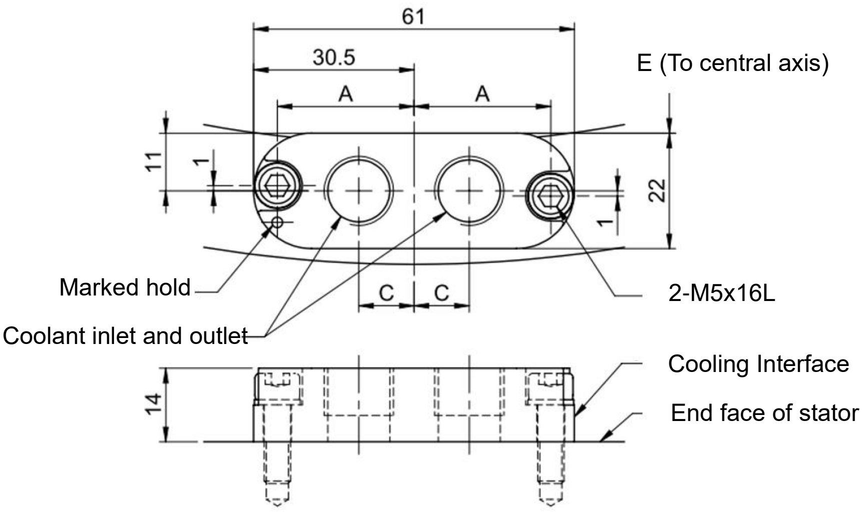


Figure 5.1.8 TM-2-7□-....-J□ cooling interface adapter

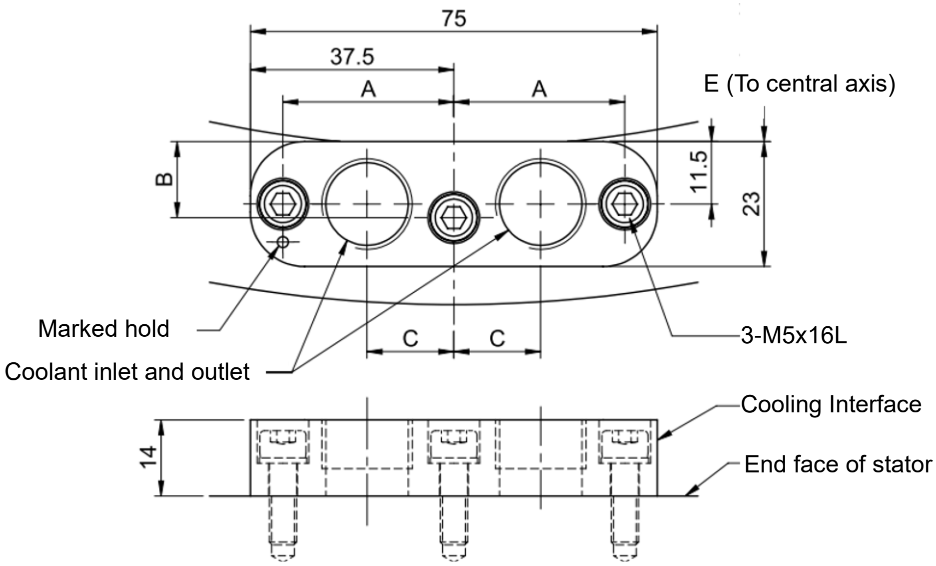


Figure 5.1.9 TM-2-A□/D□/G□-....-J□ cooling interface adapter

Table 5.1.8 O-ring features

Type	Material	Shore A	O-ring thickness (mm)	O-ring internal diameter (mm)
TM-2-7□-....-J□	VITON	70°	1.78	12.42
TM-2-A□-....-J□	VITON	70°	1.78	15.6
TM-2-D□-....-J□	VITON	70°	1.78	15.6
TM-2-G□-....-J□	VITON	70°	1.78	15.6

Note: Lubricating the O-ring with ordinary lubricants can help improve its sealing performance.

When installing the cooling interface adapter, please refer to Figure 5.1.10 for the parts configuration. The O-ring grooves on each installation surface and on the end face of the stator should be cleaned and dried. Use SEMS screws with a strength grade of 12.9 or M5x16L Nylok Blue Patch screws to secure the cooling interface adapter. Tighten the screws gradually and evenly in sections, and the tightening torque is 65-80 kgf-cm (All screws should be tightened to the same torque). Do not use liquid screw mixed meter to avoid the overflow of the screw locking agent to the O-ring, which may affect the sealing performance of the O-ring.

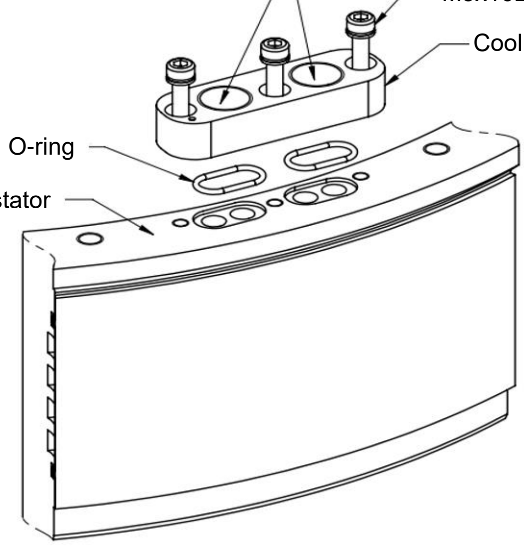


Figure 5.1.10 Parts Configuration of Cooling interface adapter

5.1.1.7 Installation of cooling connector for torque motor with cooling jacket(Reserved code :J□)

The motor is shipped with a cooling interface adapter but without a cooling connector. The specifications for the coolant inlet/outlet on the cooling interface adapter are shown in Table 5.1.7 and section5.1.1.6. Customers need to prepare a specialized straight-threaded joint with sealing material at the contact position with the adapter face. The usage and tightening torque should follow the requirements of the manufacturer. Do not use sealant to prevent it from overflowing onto the O-ring below the cooling interface adapter and affecting its sealing performance. It is also recommended not to use type seal to prevent the tape seal from getting caught between the sealing material and the adapter face and causing seal failure

5.1.2 Rotor interface design

To prevent magnet interference from affecting motor performance, there should be some space between customer's shaft and rotor magnet. The recommended dimension of external diameter(⌀D), internal diameter(⌀d) and flatness specification of rotor mounting surface (Flatness A) is given in Table 5.1.9, Table 5.1.10.

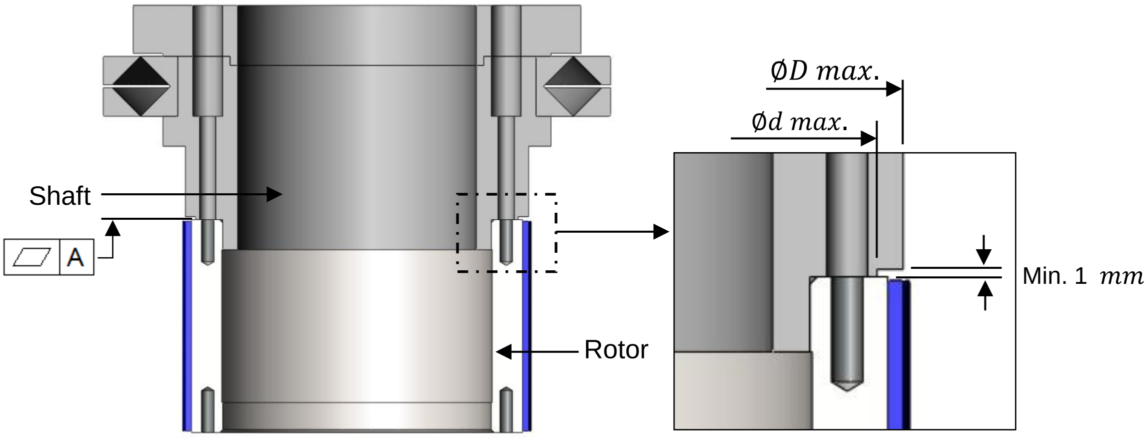
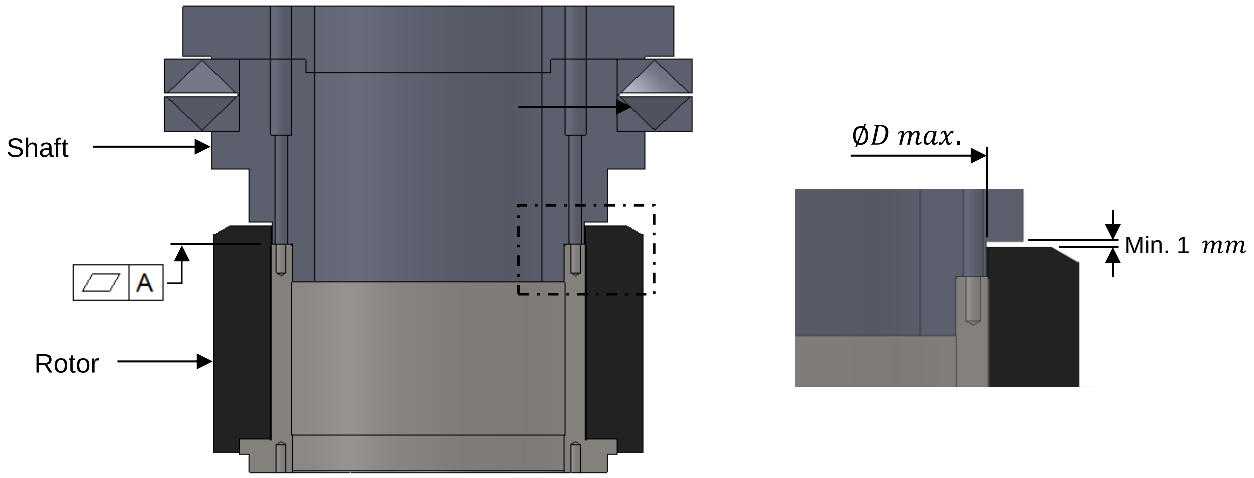


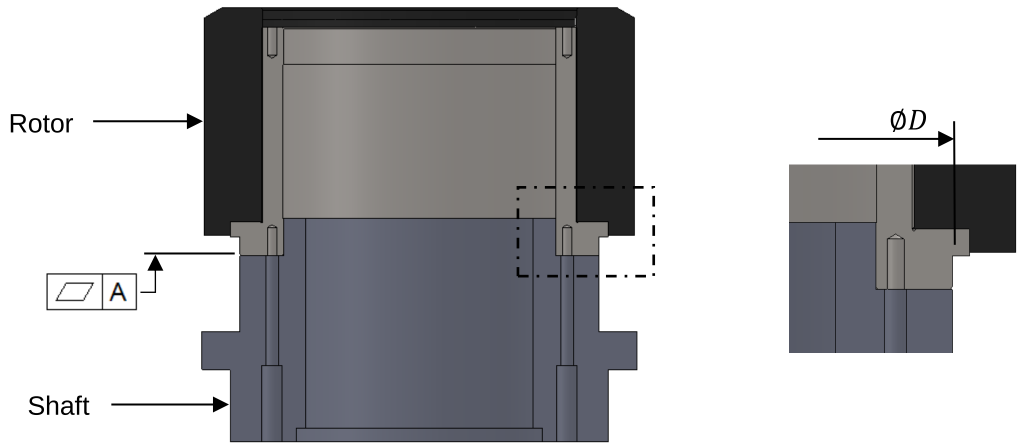
Figure 5.1.11 Rotor mounting interface (TMRW/TM-2)

Table 5.1.9 Mounting interface suggestion (TMRW/TM-2)

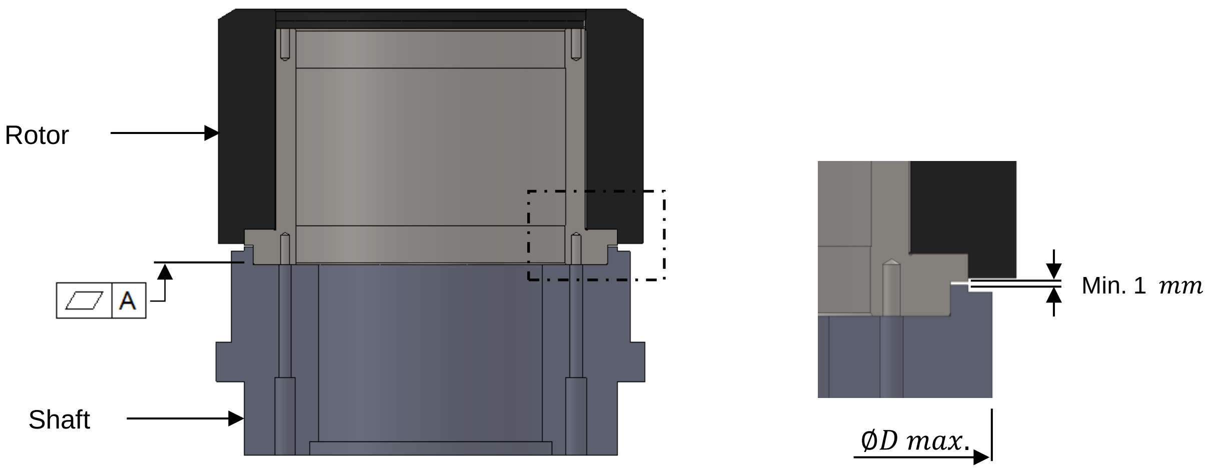
Type	$\emptyset D\ (mm)$	$\emptyset d\ (mm)$	Flatness A (mm)	Flatness B (mm)
TMRW1□/TM-2-1□	84.5	76.5	0.05	0.05
TMRW2□/TM-2-2□	118	110/108.4	0.05	0.05
TMRW4□/TM-2-4□	168	158.5	0.1	0.1
TMRW7□/TM-2-7□	233/228	222.5/218.8	0.1	0.1
TMRWA□/TM-2-A□	298	284.5	0.1	0.1
TMRWD□/TM-2-D□	383	370	0.15	0.15
TMRWG□/TM-2-G□	458	447	0.15	0.15



Type A



Type B



Type C

Figure 5.1.12 Rotor mounting interface (IM-2)

Table 5.1.10 Mounting interface suggestion (IM-2)

Type	$\emptyset D$ (mm)			Flatness A (mm)	Flatness B (mm)
	Type A	Type B	Type C		
IM-2-2□	61.5	86	118	0.05	0.05
IM-2-4□	140	N/A	168	0.1	0.1
IM-2-7□	164.5	190	228	0.1	0.1
IM-2-A□	236.5	264	298	0.1	0.1
IM-2-G□	N/A	420	458	0.15	0.15

5.1.3 Stator interface design (Without cooling jacket)

The recommended tolerance of housing's internal diameter and stator's mounting holes is **H7** or **H8**, and the recommended flatness specification of stator mounting level (Flatness B) is given in **Table 5.1.9**. Housing is suggested to be chamfered, deburred and rounded (the recommended dimension is shown in **Figure 5.1.13**) to avoid scratching O-ring and causing liquid leaking.

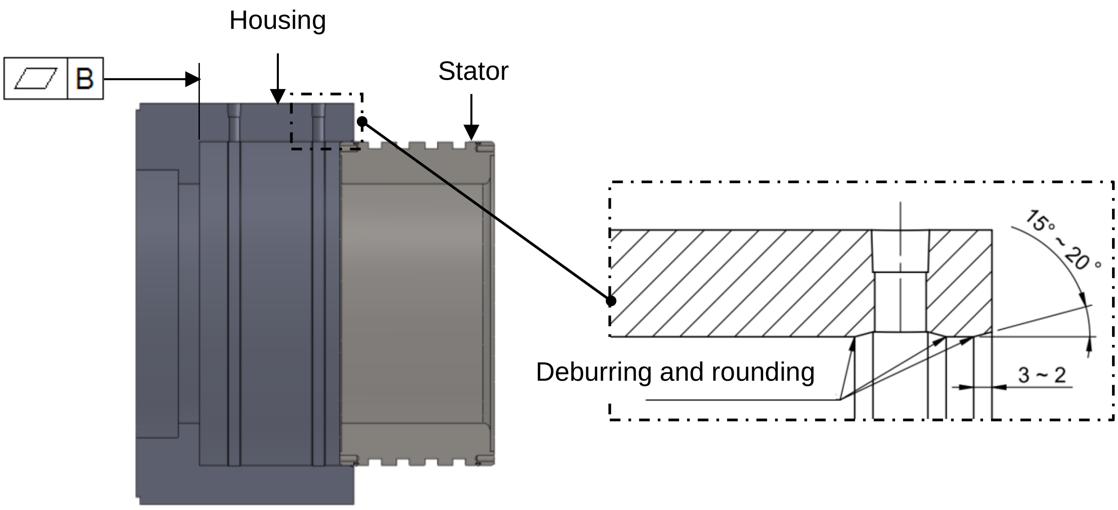


Figure 5.1.13 Stator mounting interface

5.1.4 Air gap and assembly concentricity

Air gap, existing between stator and rotor, prevents the motor from any damage during rotation. As long as you follow the standard value of air gap and the requirement of assembly concentricity established in **Figure 5.1.14** and the **Table 5.1.11** to **Table 5.1.13**, the motor will not be interfered during rotation.

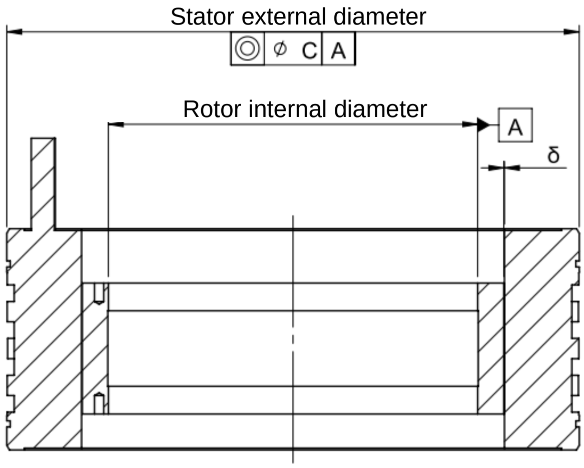


Figure 5.1.14 Air gap and assembly concentricity diagram

Table 5.1.11 TMRW series air gap and assembly concentricity dimension

Motor type	Air gap: δ (mm)	Assembly concentricity: C (mm)
TMRW1□	0.4	0.2
TMRW2□	0.4	0.2
TMRW4□	0.4	0.2
TMRW7□	0.4	0.2
TMRWA□	0.5	0.3
TMRWD□	0.5	0.3
TMRWG□	0.5	0.5

Table 5.1.12 TM-2 series air gap and assembly concentricity dimension

Type	Air gap: δ (mm)	Assembly concentricity: C (mm)
TM-2-1□	0.25	0.1
TM-2-2□	0.25	0.1
TM-2-4□	0.35	0.1
TM-2-7□	0.45	0.1
TM-2-A□	0.60	0.2
TM-2-D□	0.75	0.3
TM-2-G□	0.75	0.3

Table 5.1.13 IM-2 series air gap and assembly concentricity dimension

Type	Air gap: δ (mm)	Assembly concentricity: C (mm)
IM-2-2□	0.55	0.1
IM-2-4□	0.45	0.1
IM-2-7□	0.70	0.1
IM-2-A□	0.65	0.2
IM-2-G□	0.75	0.3

5.1.5 Force between stator and rotor

5.1.5.1 Radial force

When the concentricity of stator and rotor is offset, a radial force is generated between stator and rotor. (As Figure 5.1.15) Value of radial force for each series is given in Table 5.1.14.

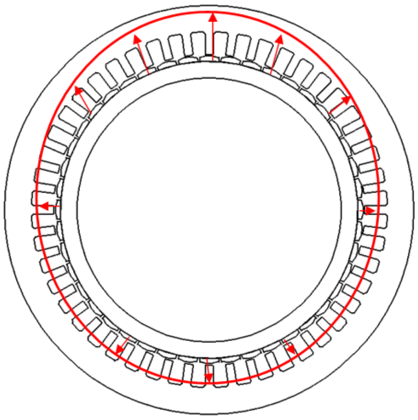


Figure 5.1.15 Concentricity of stator and rotor is offset

Table 5.1.14 Value of radial force

Type	Radial force: F (N/mm)	Type	Radial force: F (N/mm)	Type	Radial force: F (N/mm)
TMRW1A	2184	TM-2-1A	2639	IM-2-2A	6684
TMRW2A	2590	TM-2-2A	2924	IM-2-4A	3783
TMRW4A	2946	TM-2-4A	4285	IM-2-7A	9700
TMRW7A	2899	TM-2-7A	4256	IM-2-AA	16390
TMRWAA	3574	TM-2-AA	5809	IM-2-GA	20648
TMRWDA	4350	TM-2-DA	7259	-	-
TMRWGA	5158	TM-2-GA	7582	-	-

Radial force varies by length of iron core.

$$Force = \text{Radial force } F \times \frac{L}{100}$$

L stands for length of iron core. Length of iron core for each series is given as below **Table 5.1.15.**

Table 5.1.15 Length of iron core

Type	$L\ (mm)$
TMRW□**3/**□M-2-□3	30
TMRW□**5/**□M-2-□5	50
TMRW□**7/**□M-2-□7	70
TMRW□**A/**□M-2-□A	100
TMRW□**F/**□M-2-□F	150
TMRW□**J/**□M-2-□J	190
TMRW□**K/**□M-2-□K	200
TMRW□**L/**□M-2-□L	210

■ Example

Radial force of TMRW7F:

$$Force = TMRW7F's\ f \times \frac{150}{100} = 2899 \times \frac{150}{100} = 4348.5\ N/mm$$

5.1.5.2 Axial force

When rotor moves toward stator, an axial force is generated between stator and rotor. (As Figure 5.1.16) Max. value of axial force for each series is given in Table 5.1.16. “X” in Figure 5.1.16 stands for moving direction.

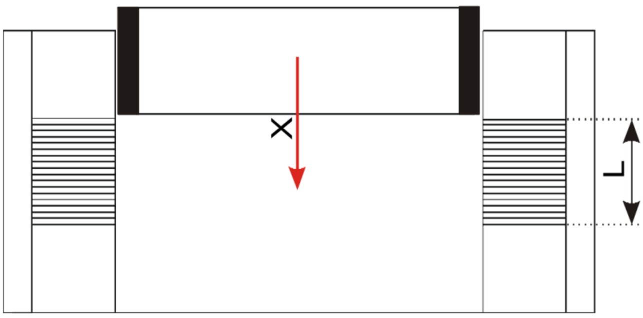


Figure 5.1.16 Axial offset of the stator and rotor

Table 5.1.16 Maximum value of axial force

Type	Axial force: $F(N)$	Type	Axial force: $F(N)$	Type	Axial force: $F(N)$
TMRW1□	118	TM-2-1□	131	IM-2-2□	185
TMRW2□	176	TM-2-2□	212	IM-2-4□	216
TMRW4□	300	TM-2-4□	232	IM-2-7□	268
TMRW7□	375	TM-2-7□	364	IM-2-A□	384
TMRWA□	528	TM-2-A□	382	IM-2-G□	480
TMRWD□	944	TM-2-D□	657	-	-
TMRWG□	1335	TM-2-G□	701	-	-

5.1.6 Screw tightening torque

Screws with a strength class of 12.9 are required for fixed screws of stator and rotor. Specification of threaded holes, quantity of threaded holes and screw tightening torque for each series are given in Table 5.1.17 and Table 5.1.18.

Table 5.1.17 TMRW/TM-2 Screw tightening torque

TMRW Series	TM-2 Series	Specification of threaded holes	Screw tightening torque $(kgf-cm)$	Screw tightening torque (Nm)
TMRW1 Series TMRW2 Series TMRW4 Series TMRW7 Series	TM-2-1 Series TM-2-2 Series TM-2-4 Series TM-2-7 Series	M5 x 0.8P x 10DP	80	7.85
TMRWA Series	TM-2-A Series	M6 x 1P x 12DP	120	11.77
TMRWD Series TMRWG Series	TM-2-D Series TM-2-G Series	M8 x 1.25P x 12DP	250	24.52

Table 5.1.18 IM-2 Screw tightening torque

IM-2 Series	Part	Specification of threaded holes	Screw tightening torque $(kgf-cm)$	Screw tightening torque (Nm)
IM-2-2 Series IM-2-4 Series IM-2-7 Series	Stator	M5 x 0.8P x 10DP	80	7.85
	Rotor	M6 x 1.0P x 12DP	120	11.77
	Rotor	M6 x 1.0P x 12DP	120	11.77
IM-2-A Series	Stator/Rotor	M6 x 1P x 12DP	120	11.77
IM-2-G Series	Stator/Rotor	M8 x 1.25P x 12DP	250	24.52

5.1.7 Direction of rotation

If the motor cable is connected according to Table 5.2.2. The rotor will rotate in clockwise direction (view towards the rotor side without cable outlet, Figure 5.1.17).

Figure 5.1.17 Illustration of rotational direction of the rotor

5.1.8 Mechanical installation

There are two ways to install the motor.

- **Install stator and rotor together**

  They are installed with the fixture provided by torque motor, and the fixture position can be either the outlet side or the other side. Before placing an order, customers can consult with HIWIN sales or engineers about the definition of the fixture position. HIWIN will offer drawing for customers to confirm.

- **Install stator and rotor separately**

  Based on the basis of customer's mechanism, a guide tool is designed for installing stator and rotor.

The recommended steps for installation are described as below.

5.1.8.1 Install stator and rotor together

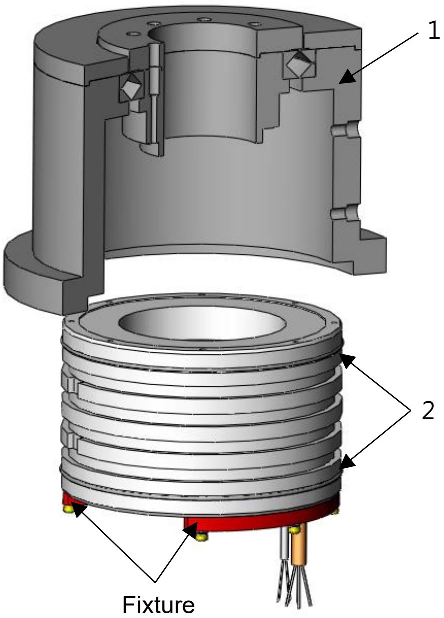
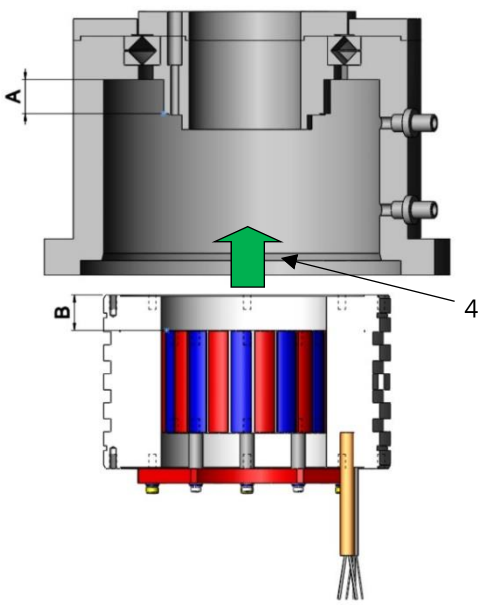
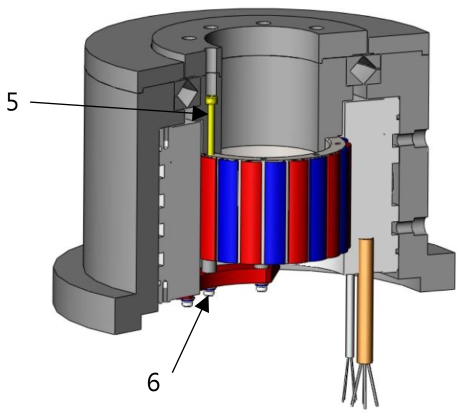
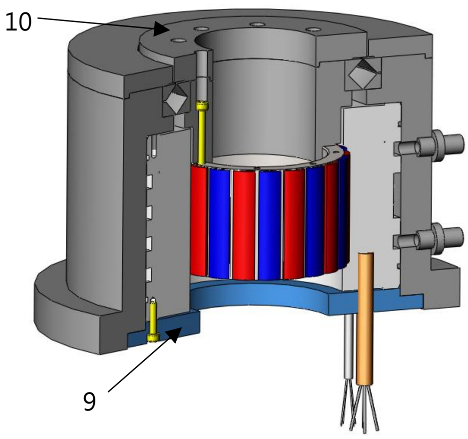
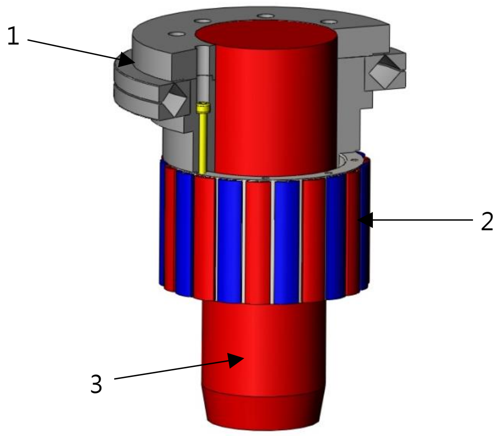
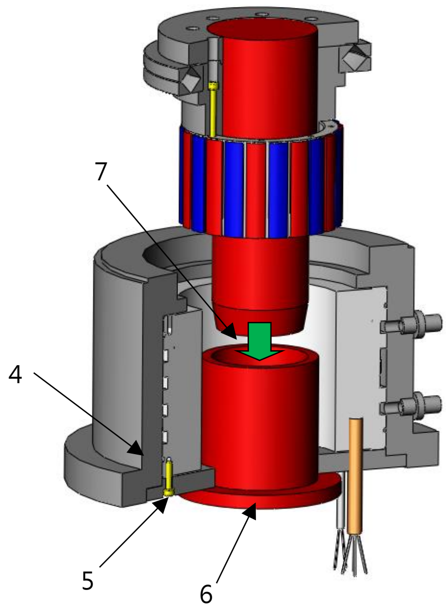
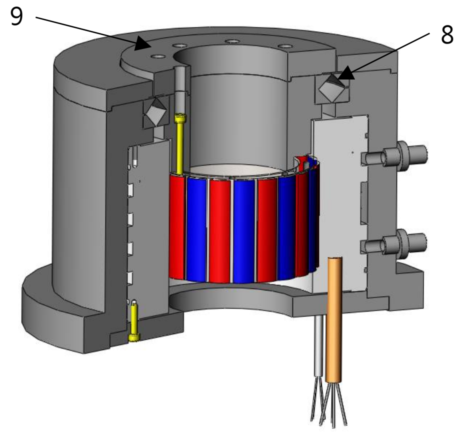
Diagram	Step
	1. Install housing, shaft, and bearing. 2. Install O-ring on stator. **Note: O-ring cannot be twisted.**

Diagram	Step
	3. To ensure that the motor is not influenced by the pull generated by the fixture and the mating parts during the assembly process, measure the space of the shaft (as A shows) and the height of stator and rotor (as B shows). 4. Place the set of stator and rotor (with the fixture) into the housing. Motor cable outlet must be aligned with coolant inlet/outlet. To avoid water leaking, O-ring cannot be damaged (refer to Section 5.1.3 for the design of housing). Pay attention to rotor's strong magnetic suction. To avoid danger, keep it away from magnetic conductors (e.g. iron objects). **Note: Refer to HIWIN approved drawing for the position of motor cable outlet.**
	5. Fix rotor on shaft. At this time, screw tightening torque is 80 percent of the specification (refer to Section 5.1.6 For screw tightening torque). 6. Loosen all the screws on the fixture about 1/8 turn. If the space A>B, loosen fixed screws of rotor first. If the space A<B, loosen fixed screws of stator first. 7. Fasten fixed screws of rotor to the specification, totally loosen the screws of fixture, and dismantle the fixture. 8. Ensure the screws are fastened to the specification.
	9. Install bottom plate and fasten fixed screws of stator (refer to Section 5.1.6 for screw tightening torque)。 10. Rotate rotating part. Ensure that it rotates smoothly and that no interference occurs. 11. Install the remaining parts, such as connector of coolant inlet/outlet, lower supporting bearing and encoder.

5.1.8.2 Install stator and rotor separately

Diagram	Step
	1. Install shaft and bearing. 2. Install rotor on shaft (refer to Section 5.1.6 for screw tightening torque). 3. Install guide tool on shaft.
	4. Install O-ring on stator. **Note: O-ring cannot be twisted.** 5. Place the set of stator into the housing, and fasten fixed screws of stator (refer to Section 5.1.6 for screw tightening torque). Motor cable outlet must be aligned with coolant inlet/outlet. To avoid water leaking, O-ring cannot be damaged (refer to Section 5.1.3 for the design of housing). **Note: Refer to HIWIN approved drawing for the position of motor cable outlet.** 6. Install lower guide tool on shaft if it is necessary. 7. Install rotating module on fixed part. To avoid the danger caused by strong magnetic suction between stator and rotor, which may even make the assembly fail, the guide tool must be contacted and combined before the installation.



8. Fix the bearing and dismantle the guide tool.
9. Check the air gap and assembly concentricity refer to Section 5.1.4.
10. Rotate rotating part. Ensure that it rotates smoothly and that no interference occurs.
11. Install the remaining parts, such as connector of coolant inlet/outlet, lower supporting bearing and encoder.

5.2 Electrical connection

5.2.1 Wiring precautions

1. Before using the product, carefully read through the specification noted on product label, and ensure the product is used with power supply specified in product requirement.
2. Check if the wiring is correct. Incorrect wiring may make the motor operate abnormally, or even cause permanent damage to the motor.
3. Select extension cord with shield. The shield must be grounded.
4. Do not connect power cable and temperature sensor cable to the same extension cord.
5. Power cable and temperature sensor cable contain shield. The shield must be grounded.

5.2.2 Cable

The standard length of the power cable and temperature sensor cable is 2000 $mm \pm 50mm$ (as shown in **Figure 5.2.1**), and the metal connector is not included. Customers can choose cables with other lengths, with an increment unit of 500 mm, up to 10000 mm (for the case of total length including extension cable longer than 10 meters, please refer to section 0).

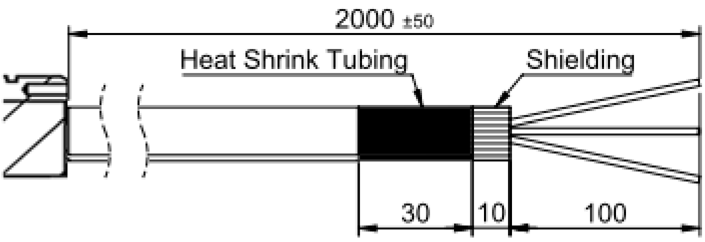


Figure 5.2.1 Cable specification

5.2.2.1 Power cable specification

IGUS's Chainflex®(CF27), Chainflex®(CF270), Chainflex®(CF310) and LAPP®'s Olflex® Servo FD 796CP, with UL and CE certificates, are used for power cable. The cross-section of wire is determined by the value of continuous current under water cooling condition. The relationship between cross-section of wire and motor type is given in Table 5.2.1.

Note: Power cable contains shield. The shield must be grounded (See 錯誤! 找不到參照來源。).

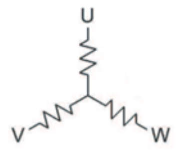
Table 5.2.1 Relationship between cross-section of wire and motor type

Cross-sectional area (mm^2)	Type				
1.5	TMRW13(L)	TMRW15(L)	TMRW17(L)	TMRW1A(L)	TMRW1F
	TMRW23(L)	TMRW25(L)	TMRW27(L)	TMRW2A(L)	TMRW2F
	TMRW43	TMRW45	TMRW47	TM-2-13-LA	TM-2-15-LA
	TM-2-17-LA	TM-2-1A-LA	TM-2-1F-LA	TM-2-23-PA	TM-2-25-PA
	TM-2-27-PA	TM-2-2A-PA	TM-2-2F-PA	TM-2-43-LA	TM-2-45-LA
	TM-2-47-LA	TM-2-73-LB	IM-2-23-PA	IM-2-25-PA	IM-2-27-PA
	IM-2-43-LA	IM-2-45-LA			
2.5	TMRW43L	TMRW45L	TMRW47L	TMRW4A	TMRW4F
	TMRW73	TMRW75	TMRW77	TMRW7A	TMRW7F
	TMRWA3	TMRWA5	TM-2-13-SA	TM-2-15-SA	TM-2-17-SA
	TM-2-1A-SA	TM-2-1F-SA	TM-2-23-PB	TM-2-25-PB	TM-2-27-PB
	TM-2-2A-PB	TM-2-2F-PB	TM-2-4F-PA	TM-2-73-PB	TM-2-75-PB
	TM-2-77-PB	TM-2-7A-PB	TM-2-7F-PB	TM-2-A3-PB	TM-2-A5-PB
	IM-2-23-PB	IM-2-25-PB	IM-2-27-PB	IM-2-2A-PB	IM-2-2F-PB
	IM-2-73-SA	IM-2-A3-PB			
4.0	TMRW1FL	TMRW2FL	TMRW4AL	TMRW4FL	TMRW73L
	TMRW75L	TMRW77L	TMRW7AL	TMRW7FL	TMRWA3L
	TMRWA5L	TMRWA7	TMRWAA	TMRWD3	TMRWD5
	TMRWD7	TMRWDA	TMRWG3	TMRWG5	TMRWG7
	TM-2-43-SA	TM-2-45-SA	TM-2-47-SA	TM-2-4A-SA	TM-2-75-SB
	TM-2-77-SB	TM-2-7A-SB	TM-2-7F-SB	TM-2-A3-PC	TM-2-A5-PC
	TM-2-A7-PC	TM-2-AA-PC	TM-2-AF-PC	TM-2-G5-SB	TM-2-G7-SB
	TM-2-GA-SB	IM-2-43-SA	IM-2-45-SA	IM-2-47-SA	IM-2-4A-SA
	IM-2-4F-SA	IM-2-73-SB	IM-2-75-SB	IM-2-77-SB	IM-2-7A-SB
	IM-2-A3-PC	IM-2-A5-PC	IM-2-A7-PC	IM-2-AA-PC	IM-2-G5-SB
	IM-2-G7-SB	IM-2-GA-SB			
6.0	TMRWA7L	TMRWAAL	TMRWAF	TM-2-4A-PB	TM-2-4F-PB
	TM-2-D3-SB	TM-2-D5-SB	TM-2-D7-SB	TM-2-DA-SB	TM-2-DF-SB
	IM-2-2A-PD	IM-2-2F-PD	IM-2-47-SB	IM-2-4A-SB	IM-2-4F-SB
10.0	TMRWAFL	TMRWD3L	TMRWD5L	TMRWD7L	TMRWDAL
	TMRWDF	TMRWG3L	TMRWG5L	TMRWG7L	TMRWGA
	TMRWGF	TM-2-A7-PF	TM-2-AA-PF	TM-2-AF-PF	TM-2-G5-SD
	TM-2-G7-SD	TM-2-GA-SD	TM-2-GF-SD	IM-2-75-SD	IM-2-77-SD
	IM-2-7A-SD	IM-2-7F-SD	IM-2-A5-PF	IM-2-A7-PF	IM-2-AA-PF

	IM-2-AF-PF	IM-2-G5-SD	IM-2-G7-SD	IM-2-GA-SD	IM-2-GF-SD
16.0	TM-2-D3-SD	TM-2-D5-SD	TM-2-D7-SD	TM-2-DA-SD	TM-2-DF-SD
25.0	TMRWDFL	TMRWGAL	TMRWGFL	TM-2-GF-SH	IM-2-AF-SF
	IM-2-GF-SH	IM-2-7F-WD			

The relationship between power cable color and signal is given in Table 5.2.2

Table 5.2.2 Relationship between power cable color and signal

Color & Number	Signal	Diagram
Black, No. L1/U	U	
Black, No. L2/V	V	
Black, No. L3/W	W	
Yellow with green	grounding	

5.2.2.2 Temperature sensor cable specification

IGUS®'s Chainflex® (CF240) is used for temperature sensor cable. There are three temperature sensors in standard specification (Type B), a set of PTC100, a set of PTC120(130) is installed on every phase winding, and a Pt1000 is installed on phase U in standard. Temperature sensors used in each Type are given in Table 5.2.3. The cross-sectional area of temperature sensor cable is 0.25 mm^2, and the pin assignment of temperature sensor cable for each type is given from Figure 5.2.2 to Figure 5.2.5.

Note : Temperature sensor cable contains shield. The shield must be grounded (See 錯誤! 找不到參照來源。).

Table 5.2.3 Temperature sensors used in each type

Type	Temperature sensor	Remarks
Type A	PTC120(130) + Pt1000	-
Type B	PTC100 + PTC120(130) + Pt1000	Standard
Type C	PTC120(130) + 3x Pt1000	-
Type D	PTC100 + PTC120(130) + 3x Pt1000	

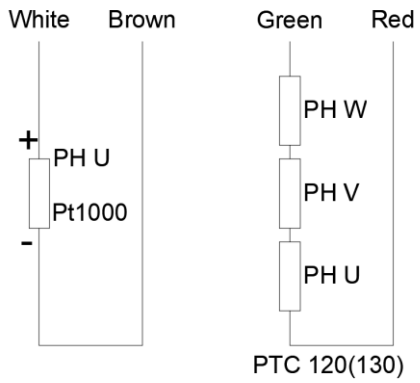


Figure 5.2.2 Type A

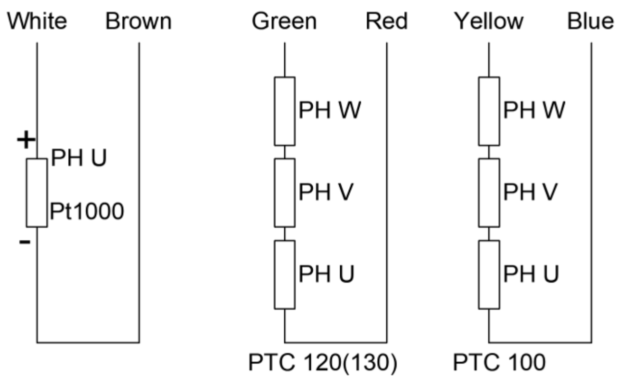


Figure 5.2.3 Type B

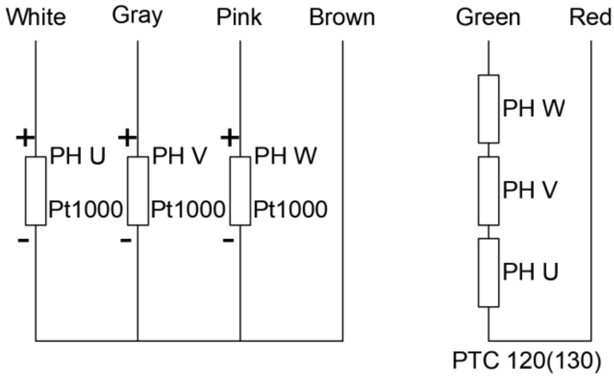


Figure 5.2.4 Type C

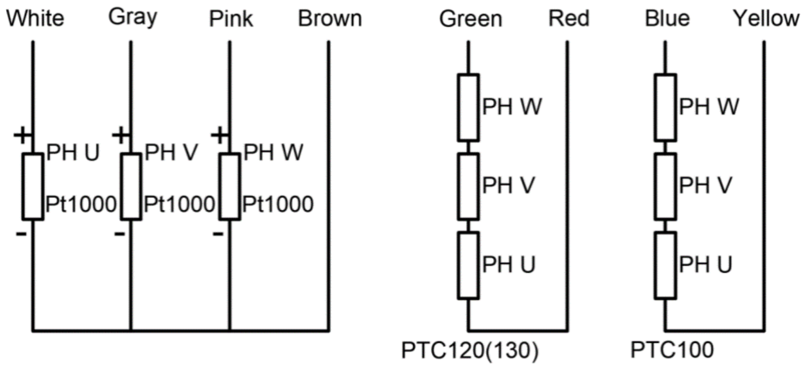


Figure 5.2.5 Type D

5.2.2.3 Electromagnetic Compatibility (EMC)

It is necessary to install and connect the cable shields properly to protect conductors. Correct installation not only protects personal safety, but also reduces noise. The power modules of the motor controller all use PWM voltage switching to control the motor. PWM switching will cause EMI radiation, which has negative effect on the sensor signal. Therefore, to make an EMC environment, shields must be used on following cables:

(1) All cables on the power module (including the adapter wires connected to modules such as filters and reactors).

(2) All motor cables (including motor power cable, temperature sensor cable and encoder cable)

(3) Sensor cables.

(4) Feedback signal cables.

To reduce interference, the following methods and tests are recommended:

(1) Independent shields must be used on motor power cables and temperature sensor cables. If the cable is longer than 1 meter, the shields at both ends of the cable must be grounded.

(2) The long cables and the motor power cables close to the sensor cables must be grounded with a shield.

(3) The grounding resistance of all grounding positions to the system should be less than 1Ω (according to standard IEEE 80).

(4) When the groundings of different machines are connected to each other, it is recommended to use ground straps or surface contact. Please try to avoid using a ground wire with a small cross-section.

(5) When the equipment is grounded, it is recommended to use a ground wire with an equivalent copper wire with cross-section area of at least 10 mm^2.

(6) Do not open or disconnect the circular connector or cable glands on the stator because the shield inside may be damaged or out of function.

(7) When a self-made cable extension cable is used, please make sure that the design and installation comply with EMC standards.

There are two types of grounding for shields. One is to use circular connector with an IP66 or above. As to the connecting method, please refer to the circular connector's installation manual. The shields must have a conductive connection to the circular connector, as shown in Figure 5.2.6. The other is single shield installation.The motor cable shield can be connected to a metal structure (such as a frame, control box or machine) by a cable clamp. During installation, the grounding position must be close to the controller and motor, as shown in Figure 5.2.7 and Figure 5.2.8. ◦

Each grounding method has the pros and cons. The most important thing is that the grounding resistance of every equipment must be as low as possible to provide a balanced electric potential for the equipment.

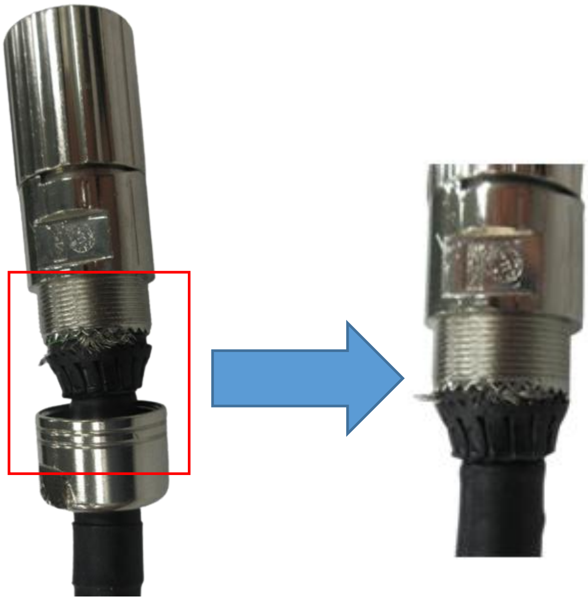


Figure 5.2.6 The shields must have a conductive connection to the circular connector

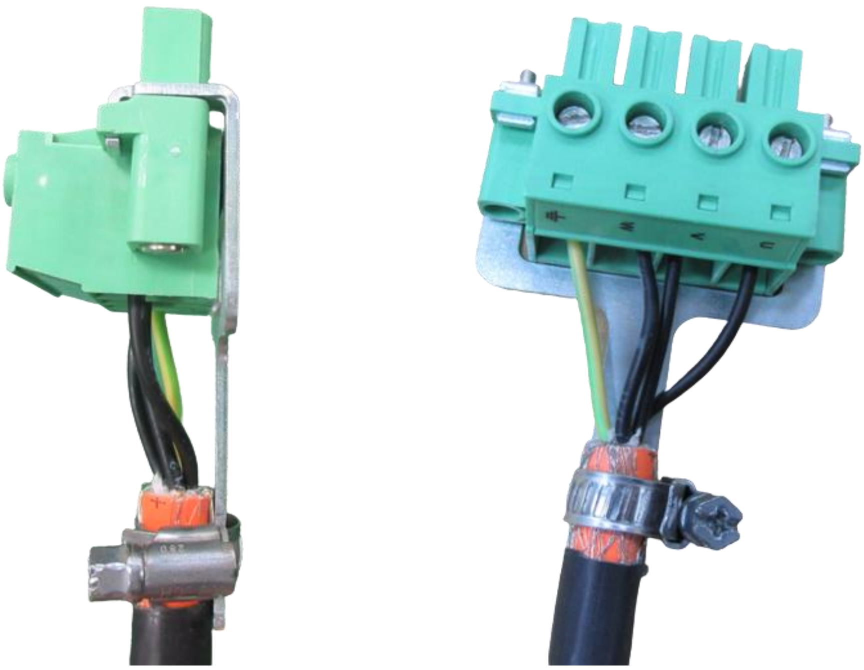


Figure 5.2.7 Use a tube ring to fix the shield on shield connecting plate

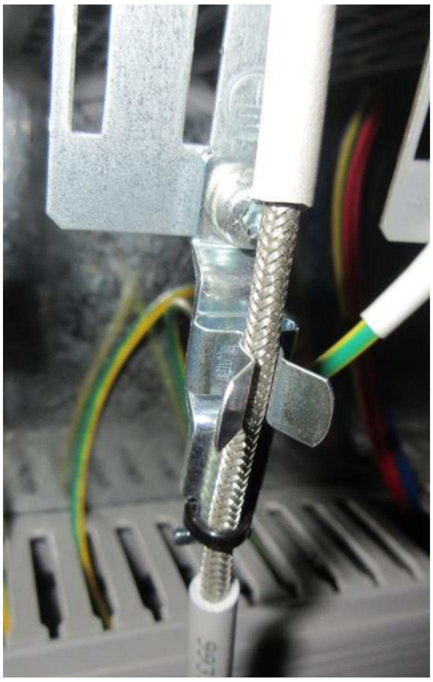
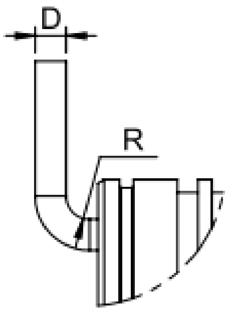



Figure 5.2.8 Use a fixed ground clamp to ground the shield

5.2.2.4 Bending radius of cable

The minimum bending radius of power cable and temperature sensor cable for torque motor is given in the following Table 5.2.4.

Table 5.2.4 Bending radius of cable

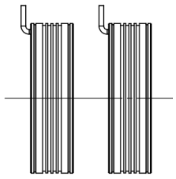
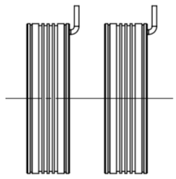
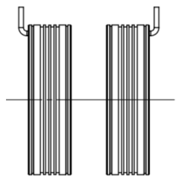
<table>
<tr><th rowspan="3">Feature</th><th rowspan="3">Diagram</th><th colspan="2">Power cable</th><th>Temperature sensor cable</th></tr>
<tr><th rowspan="2">Olflex® servo FD</th><th>Chainflex® CF27</th><th rowspan="2">Chainflex®</th></tr>
<tr><th>Chainflex® CF270</th></tr>
<tr><td rowspan="2">Min. bending radius of fixed installation</td><td rowspan="4"></td><td rowspan="2">R= 4 x D</td><td>R= 4 x D</td><td rowspan="2">R= 5 x D</td></tr>
<tr><td>R= 5 x D</td></tr>
<tr><td rowspan="2">Min. bending radius of moving installation</td><td rowspan="2">R= 7.5 x D</td><td>R= 7.5 x D</td><td rowspan="2">R= 10 x D</td></tr>
<tr><td>R= 10 x D</td></tr>
</table>

The bending radius may be different from the information provided in above table because of the modification of cable suppliers. In this case, please refer to the specification from the cable supplier.

5.2.3 Setting of parallel operation

Torque motor can perform parallel operation on the same axis. Follow Table 5.2.5 to correctly connect the power cables. The details of wiring for design 1 and design 2 are shown in Figure 5.2.11 to Figure 5.2.26.

Table 5.2.5 Connection of power cables for parallel operation

			Design 1				Design 2	
								
Series		Drive	Master	Slave	Master	Slave	Master	Slave
1	1 A	U	U	U	U	U	U	V
	TMRW 2 D Series	W	W	W	W	W	W	W
	7 G	V	V	V	V	V	V	U
2	TMRW4 Series	U	U	U	U	U	U	W
		W	W	W	W	W	W	U
		V	V	V	V	V	V	V
3	□M-2 Series	U	U	U	U	U	U	U
		W	W	W	W	W	W	V
		V	V	V	V	V	V	W

Pay attention to the following points when driving multiple motors in parallel.

1. To drive the motors in parallel, contact HIWIN Engineering Department.
2. The motors performing parallel operation should be the same type.
3. The phase sequence of back EMF for motors performing parallel operation should be the same.
4. When doing a parallel connection, please pay attention that the relative position of the stator and rotor must be set in accordance with Table 3.3.6 and Table 3.3.7. The stator reference point in TMRW is the position opposite to the outlet and □M-2 is the pin hole. The rotor reference point in TMRW is the mark point and □M-2 is the pin hole. If the motors are operated at rated load but home position mark is not aligned with outlet position, one of the motors in parallel operation may overload and overheat.
5. Power cable and temperature sensor cable contain shield. The shield must be grounded.
6. After assembly, please do not connect the motor power cable to the drive immediately. First, the user must push the motor manual. Capture the master and slave peak values which are close to each other (constant speed motion) with the scope. Confirm whether the waveforms overlap (the phase angle error between master and slave is less than ± 5°, and the same for other phases). The user can connect the motor power cable to the drive and send power only after confirmation. (refer to Figure 5.2.9, Figure 5.2.10)

Please contact HIWIN Engineering Department for parameters for parallel design.

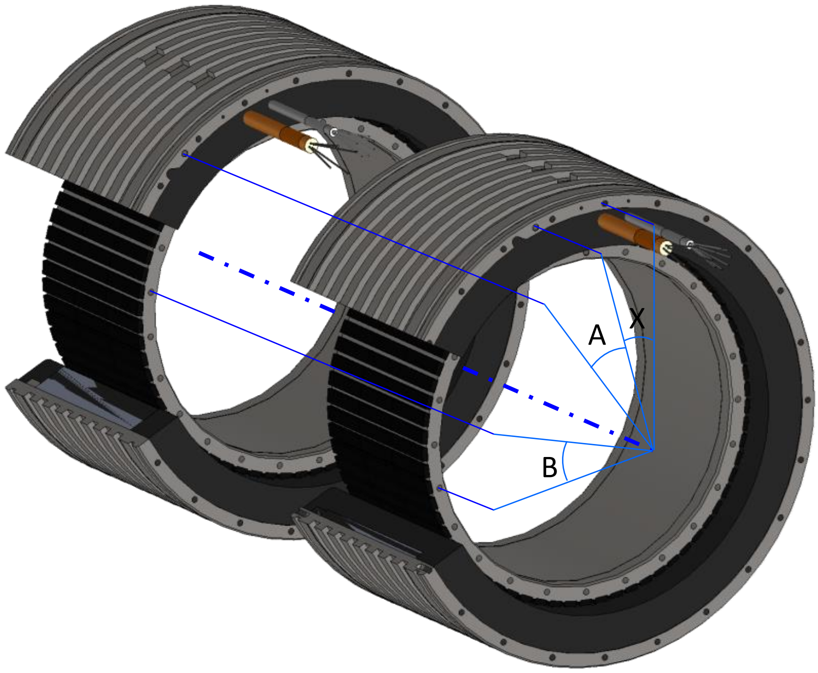
X is the angle between the stator with positioning pin and the outgoing cable.

A is the relative angle position of the pin holes of the master and slave motor stators. If it is a motor without pin holes, it is the relative angle position of the outgoing cable.

B is the relative angle position of the pin holes of the master and slave motor rotors. If it is a motor without pin holes, it is the relative angle position of the mark point.

Table 5.2.6 Design 1 position

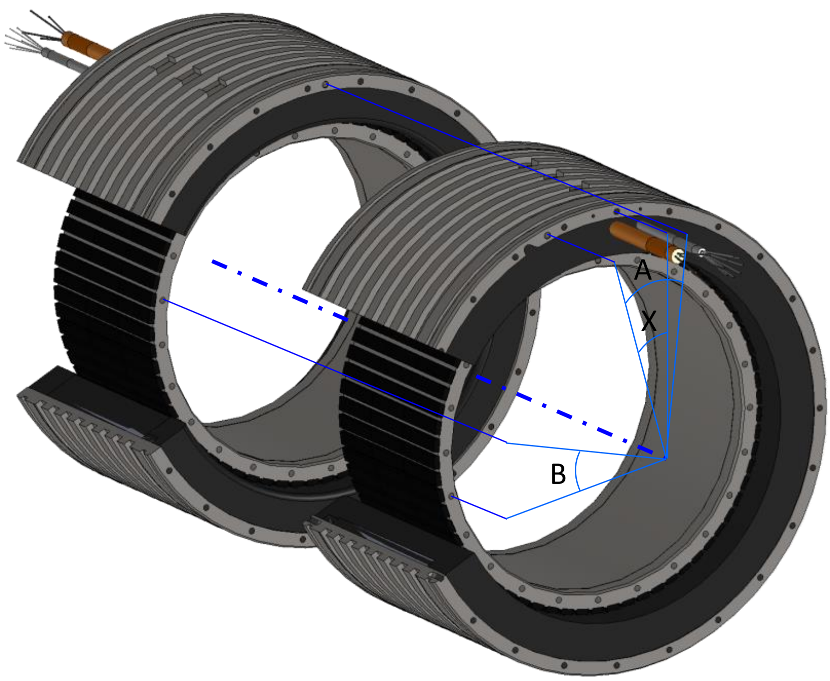
Design 1



Series	p (Pole pairs)	X [deg] (Pin)	A [deg]	B [deg]	Position error Tolerance [deg]
TMRW1	11	0	$Z \times \frac{360}{p}$		± 0.49
TMRW2	11	0			± 0.49
TMRW4	11	0			± 0.49
TMRW7	22	0			± 0.245
TMRWA	33	0			± 0.163
TMRWD	44	0			± 0.122
TMRWG	44	0			± 0.122
□M-2-1	11	30			± 0.49
□M-2-2	11	30			± 0.49
□M-2-4	22	22.5			± 0.245
□M-2-7	22	22.5			± 0.245
□M-2-A	33	20			± 0.163
□M-2-D	44	18.75			± 0.122
□M-2-G	44	18.75			± 0.122

where $Z \in$ integer, $(0, \pm 1, \pm 2)$

Table 5.2.7 Design 2 position

<table>
<tr><th colspan="6">Design 2</th></tr>
<tr><td colspan="6">
</td></tr>
<tr><th>Series</th><th>p
(Pole pairs)</th><th>X [deg]
(Pin)</th><th>A [deg]</th><th>B [deg]</th><th>Position error Tolerance [deg]</th></tr>
<tr><td>TMRW1</td><td>11</td><td>0</td><td rowspan="14">$Z \times \frac{360}{p} + 2X$</td><td rowspan="14">$Z \times \frac{360}{p}$</td><td>$\pm 0.49$</td></tr>
<tr><td>TMRW2</td><td>11</td><td>0</td><td>± 0.49</td></tr>
<tr><td>TMRW4</td><td>11</td><td>0</td><td>± 0.49</td></tr>
<tr><td>TMRW7</td><td>22</td><td>0</td><td>± 0.245</td></tr>
<tr><td>TMRWA</td><td>33</td><td>0</td><td>± 0.163</td></tr>
<tr><td>TMRWD</td><td>44</td><td>0</td><td>± 0.122</td></tr>
<tr><td>TMRWG</td><td>44</td><td>0</td><td>± 0.122</td></tr>
<tr><td>□M-2-1</td><td>11</td><td>30</td><td>± 0.49</td></tr>
<tr><td>□M-2-2</td><td>11</td><td>30</td><td>± 0.49</td></tr>
<tr><td>□M-2-4</td><td>22</td><td>22.5</td><td>± 0.245</td></tr>
<tr><td>□M-2-7</td><td>22</td><td>22.5</td><td>± 0.245</td></tr>
<tr><td>□M-2-A</td><td>33</td><td>20</td><td>± 0.163</td></tr>
<tr><td>□M-2-D</td><td>44</td><td>18.75</td><td>± 0.122</td></tr>
<tr><td>□M-2-G</td><td>44</td><td>18.75</td><td>± 0.122</td></tr>
</table>

where $Z \in \text{integer}, (0, \pm 1, \pm 2)$

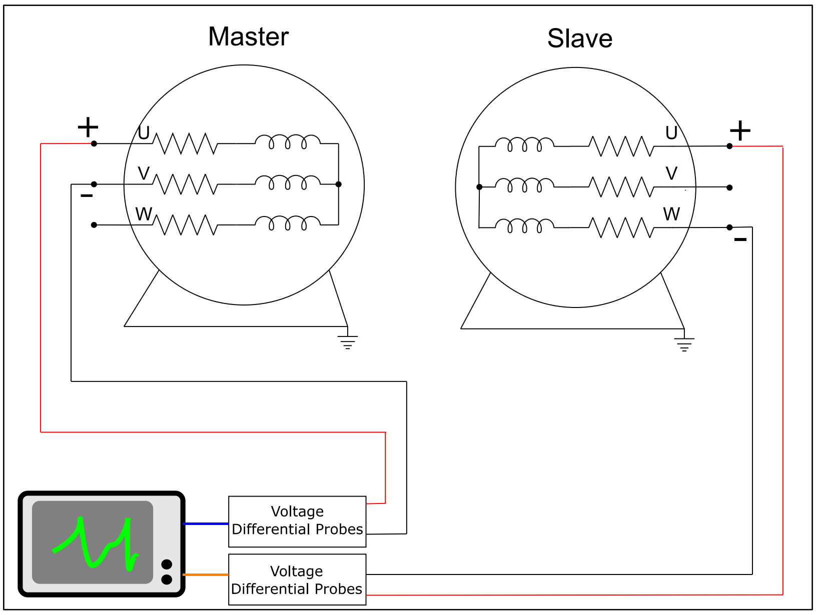


Figure 5.2.9 parallel operation test connection diagram (Ex: Design 2, Series 3, and Measuring @ Drive U-V)

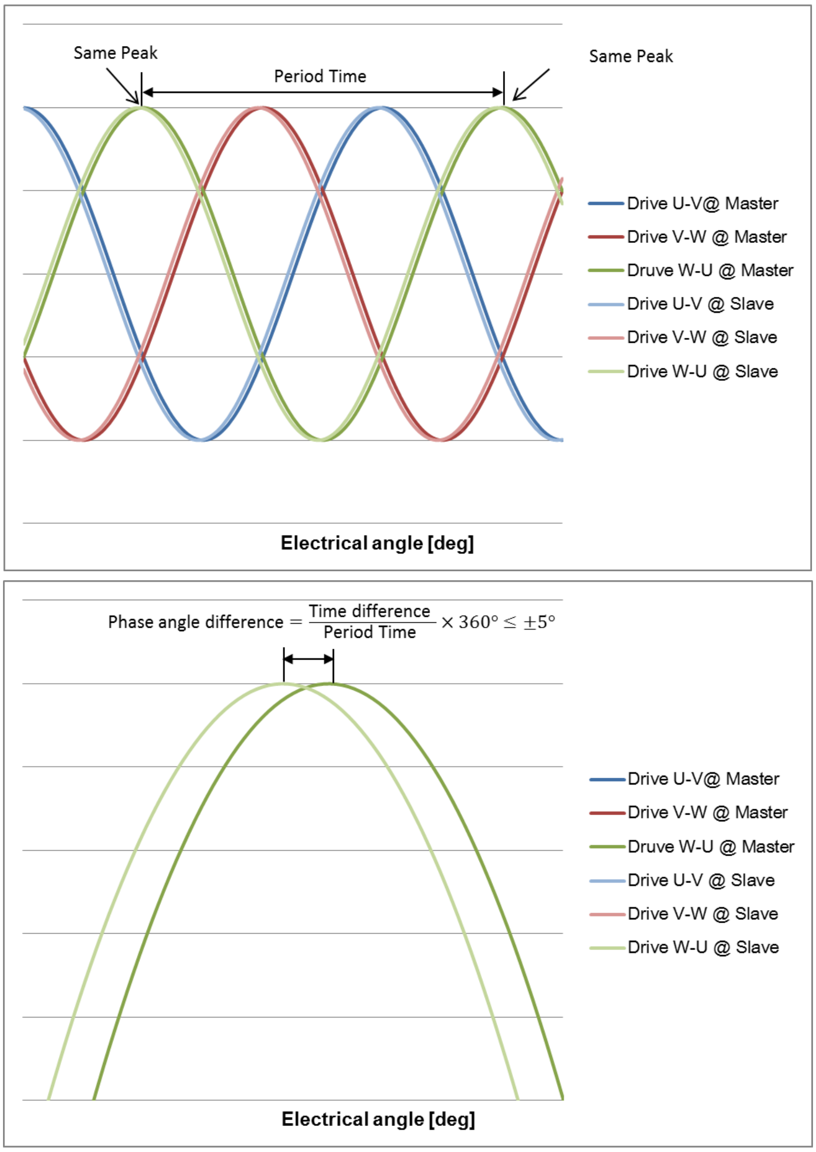


Figure 5.2.10 allowed electrical angle difference between master and slave motor.

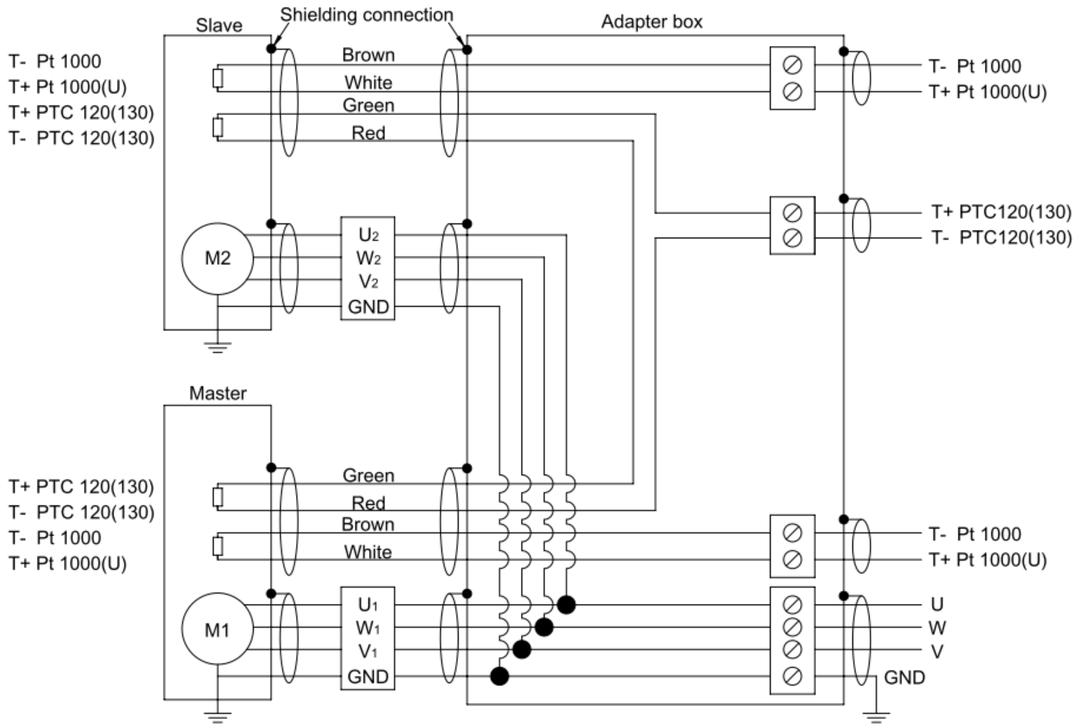


Figure 5.2.11 Type A, Design 1, Series 1~3

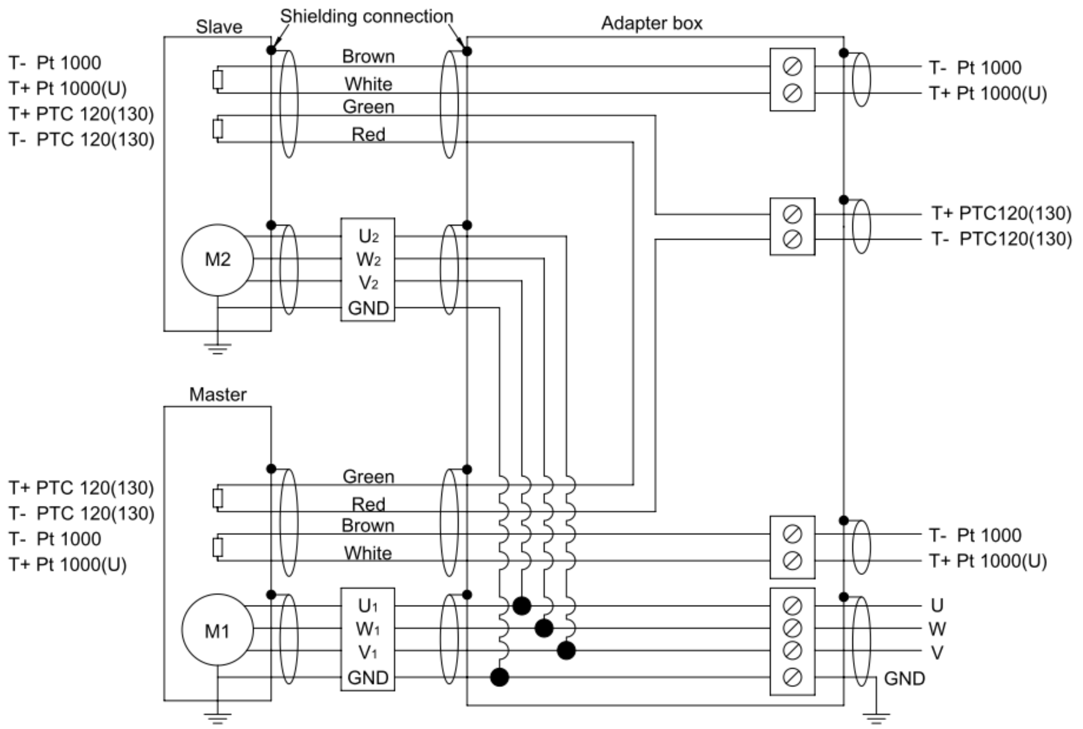


Figure 5.2.12 Type A, Design 2, Series 1

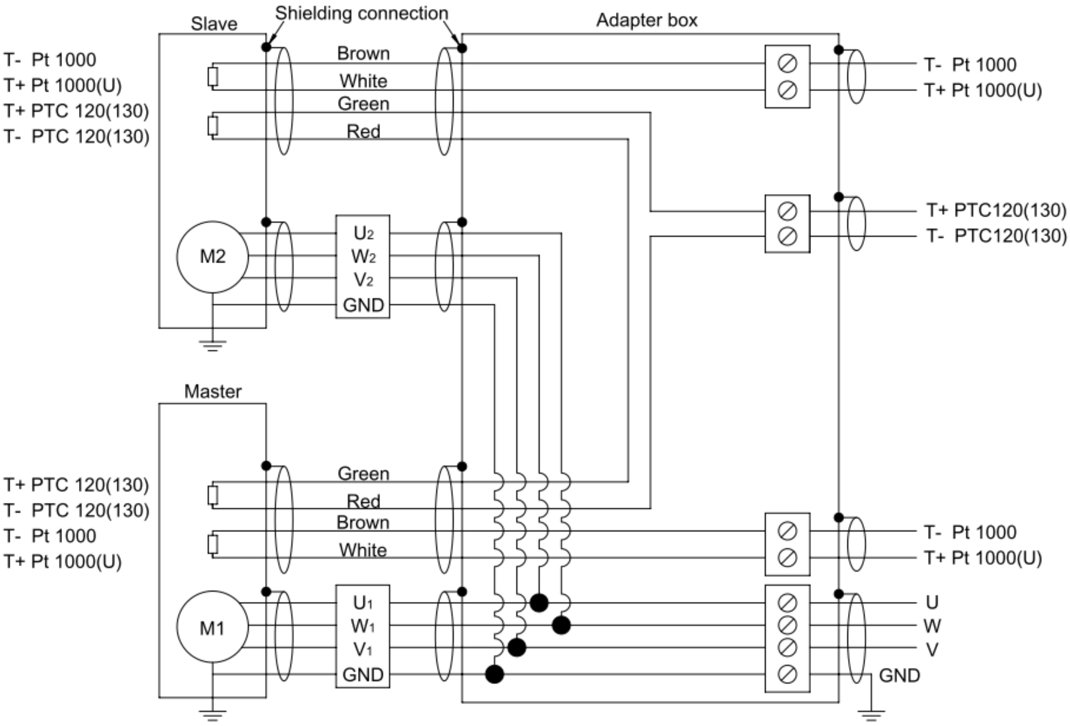


Figure 5.2.13 Type A, Design 2, Series 2

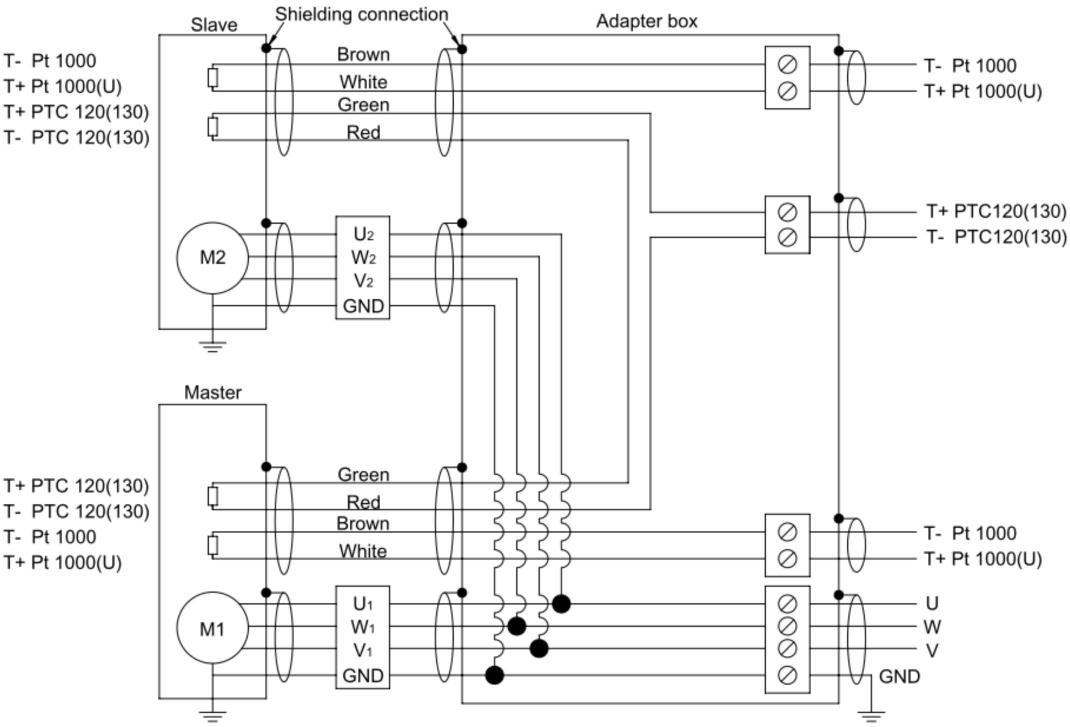


Figure 5.2.14 Type A, Design 2, Series 3

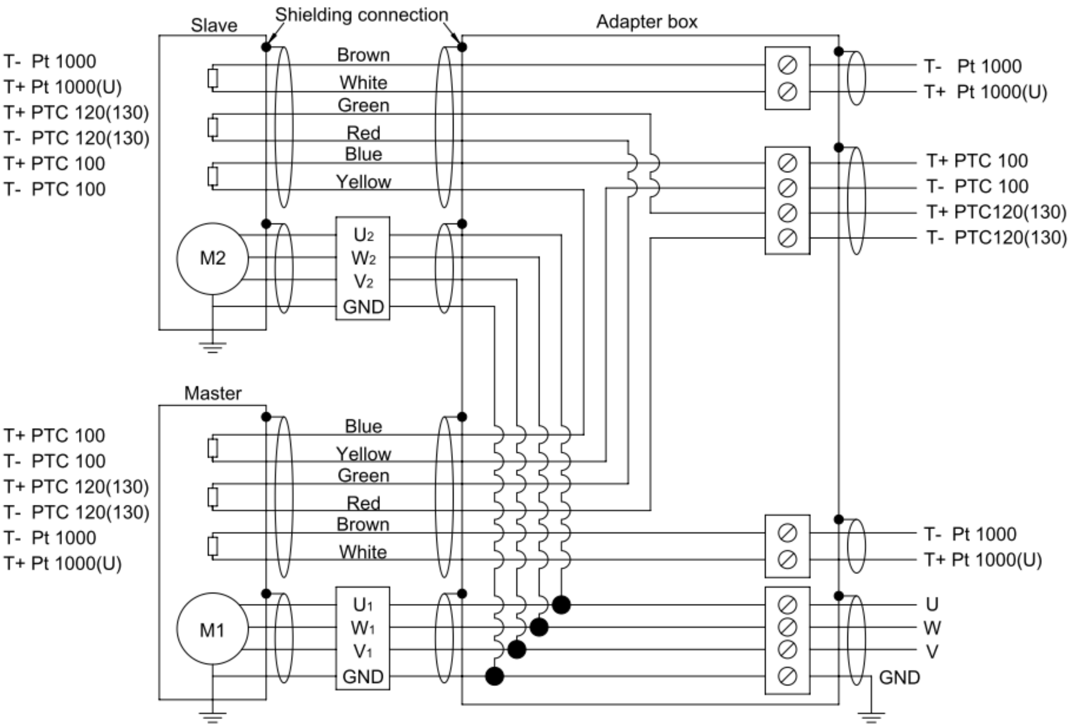


Figure 5.2.15 Type B, Design1, Series 1~3

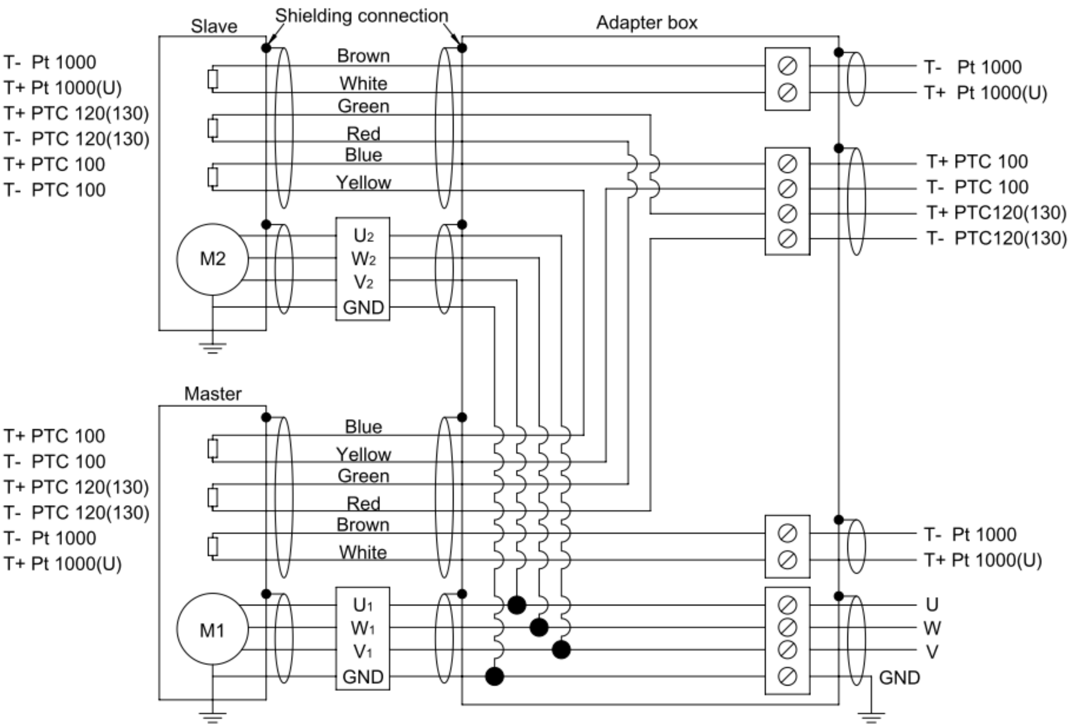


Figure 5.2.16 Type B, Design 2, Series 1

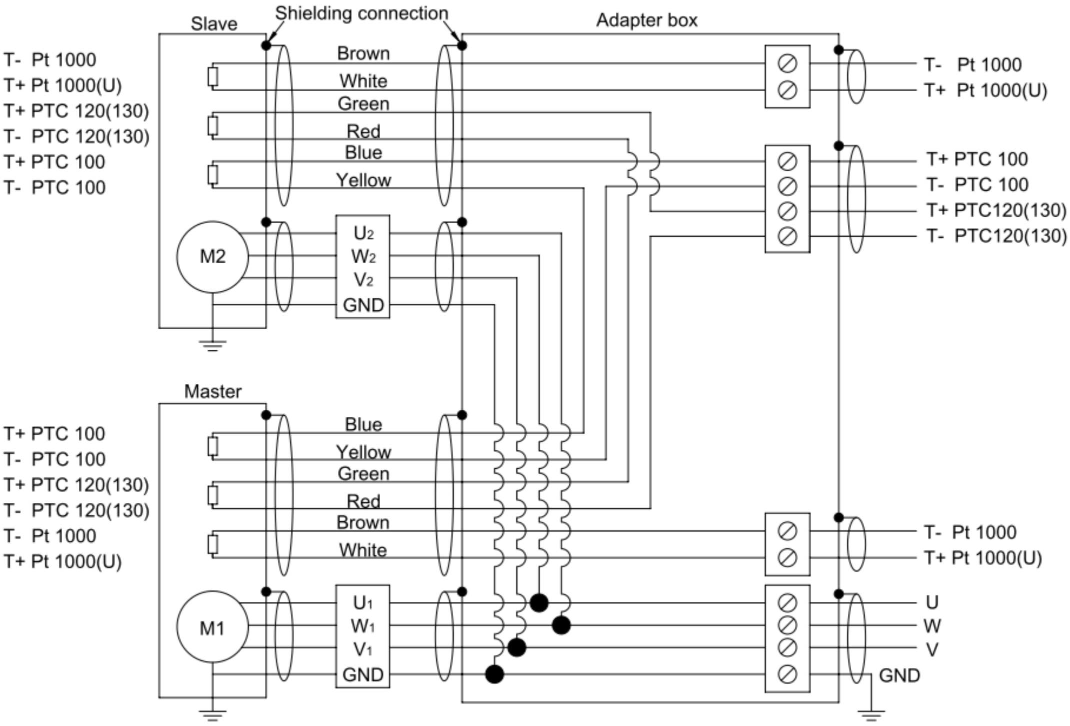


Figure 5.2.17 Type B, Design 2, Series 2

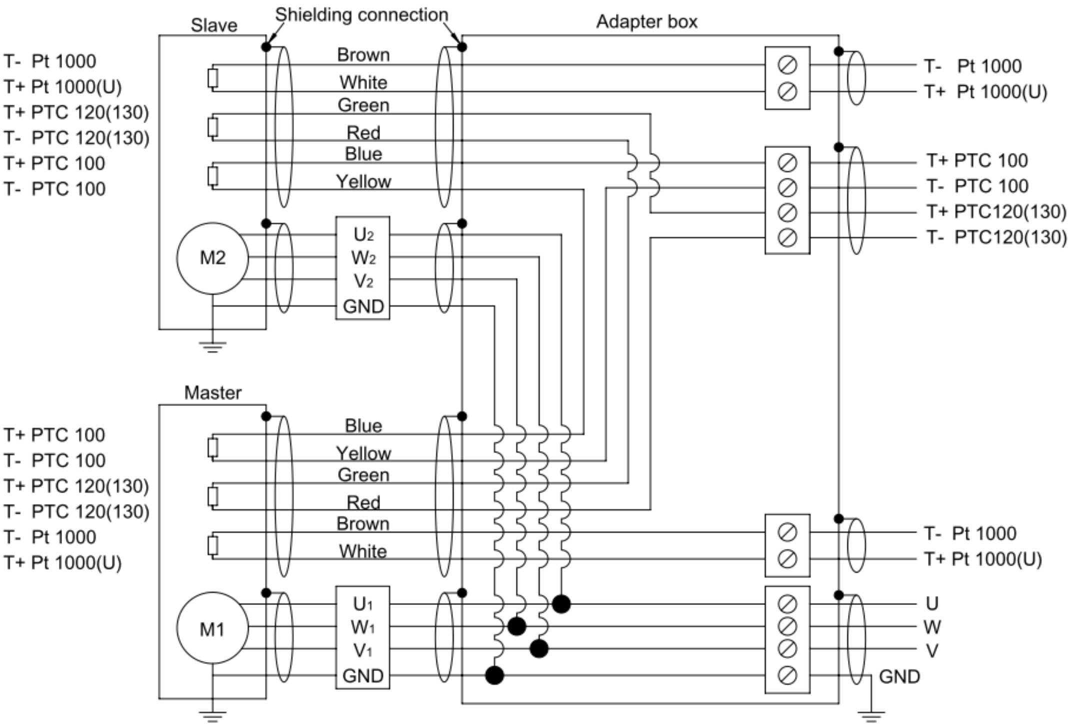


Figure 5.2.18 Type B, Design 2, Series 3

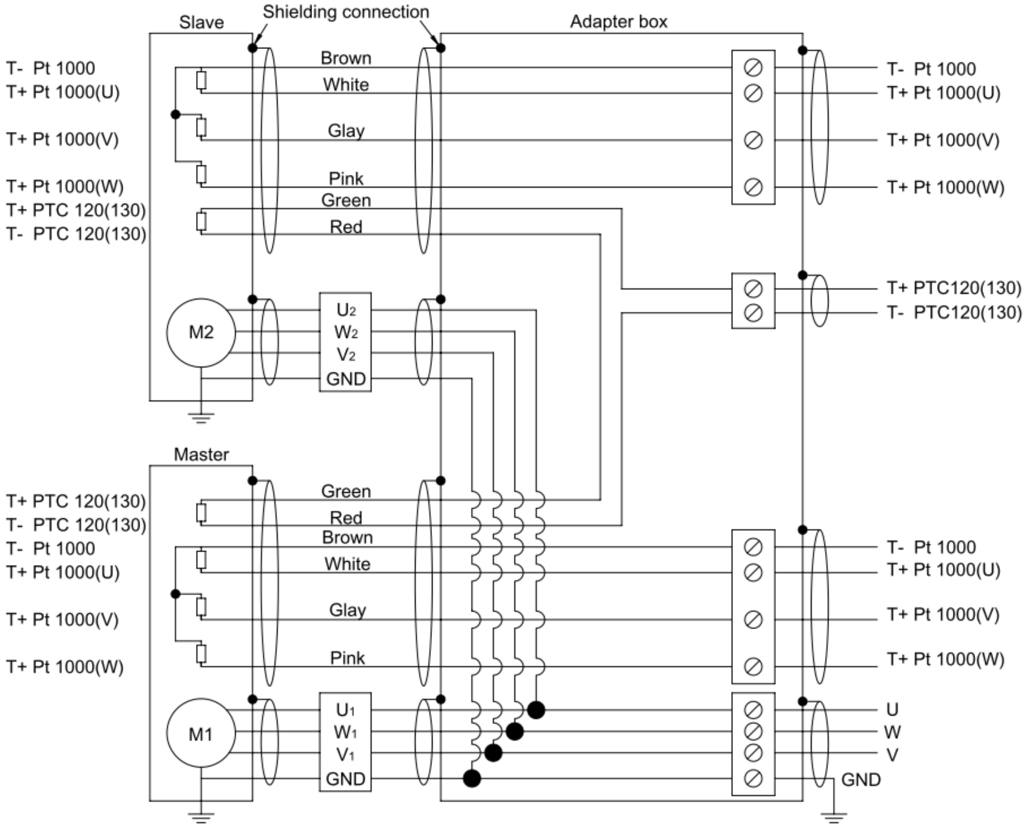


Figure 5.2.19 Type C, Design 1, Series 1~3

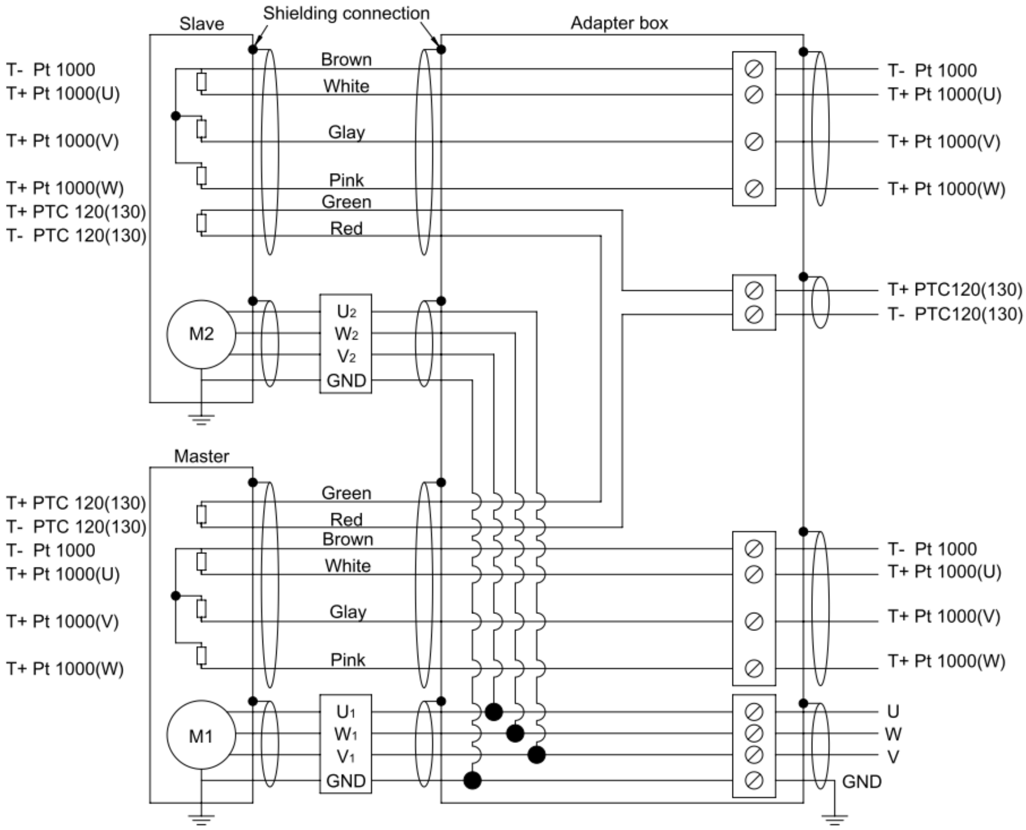


Figure 5.2.20 Type C, Design 2, Series 1

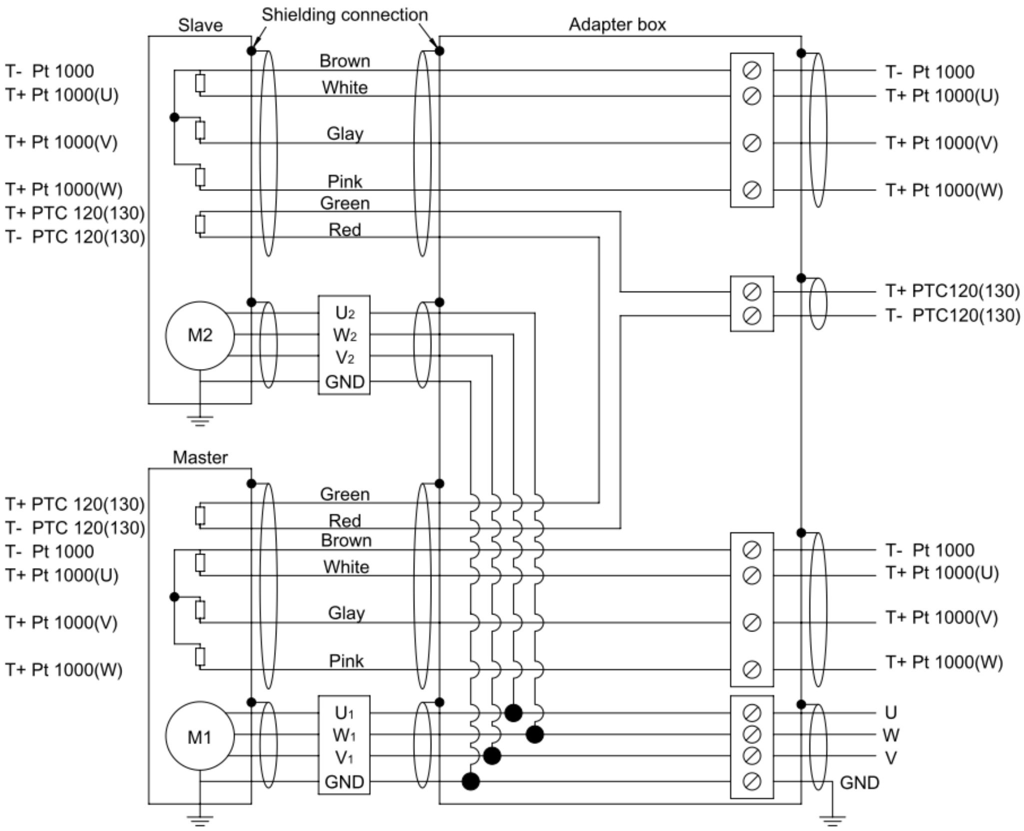


Figure 5.2.21 Type C, Design 2, Series 2

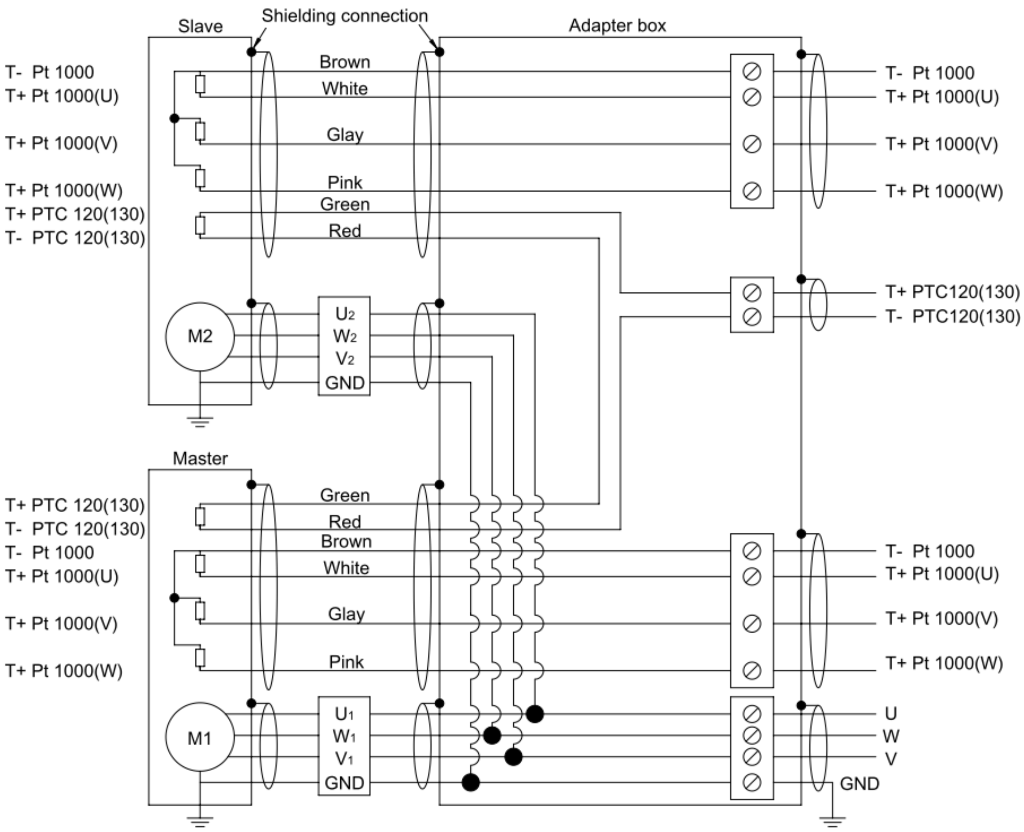


Figure 5.2.22 Type C, Design 2, Series 3

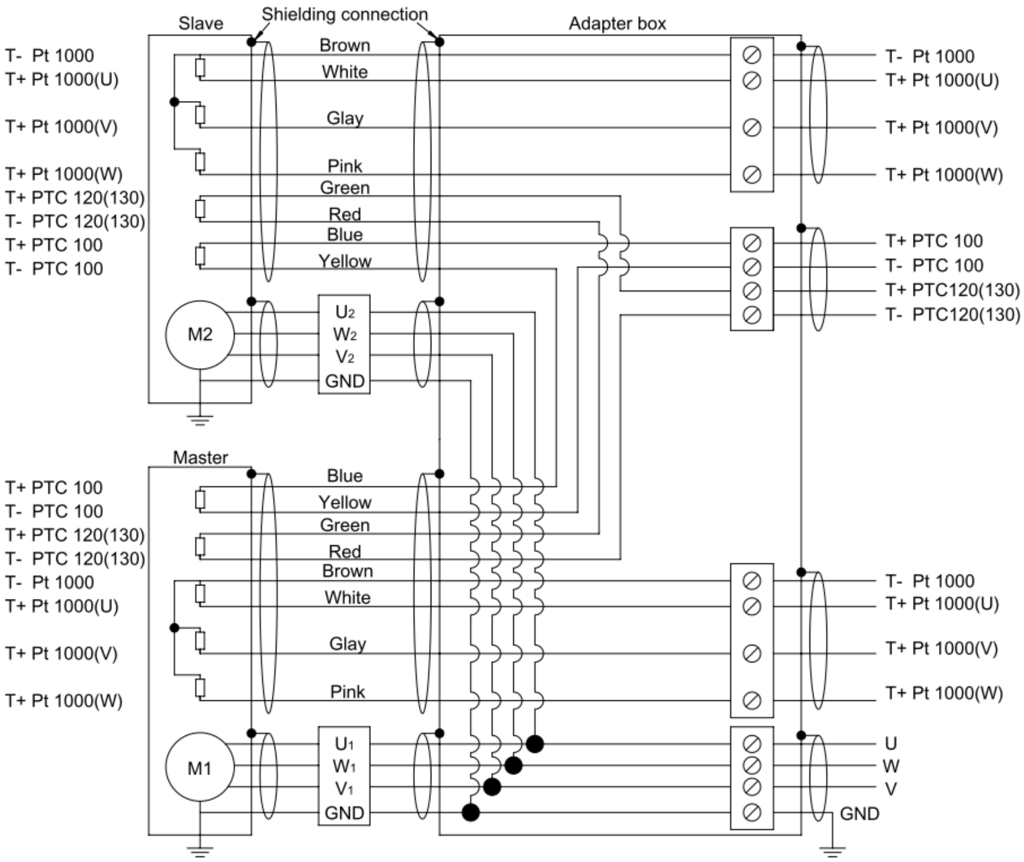


Figure 5.2.23 Type D, Design 1, Series 1~3

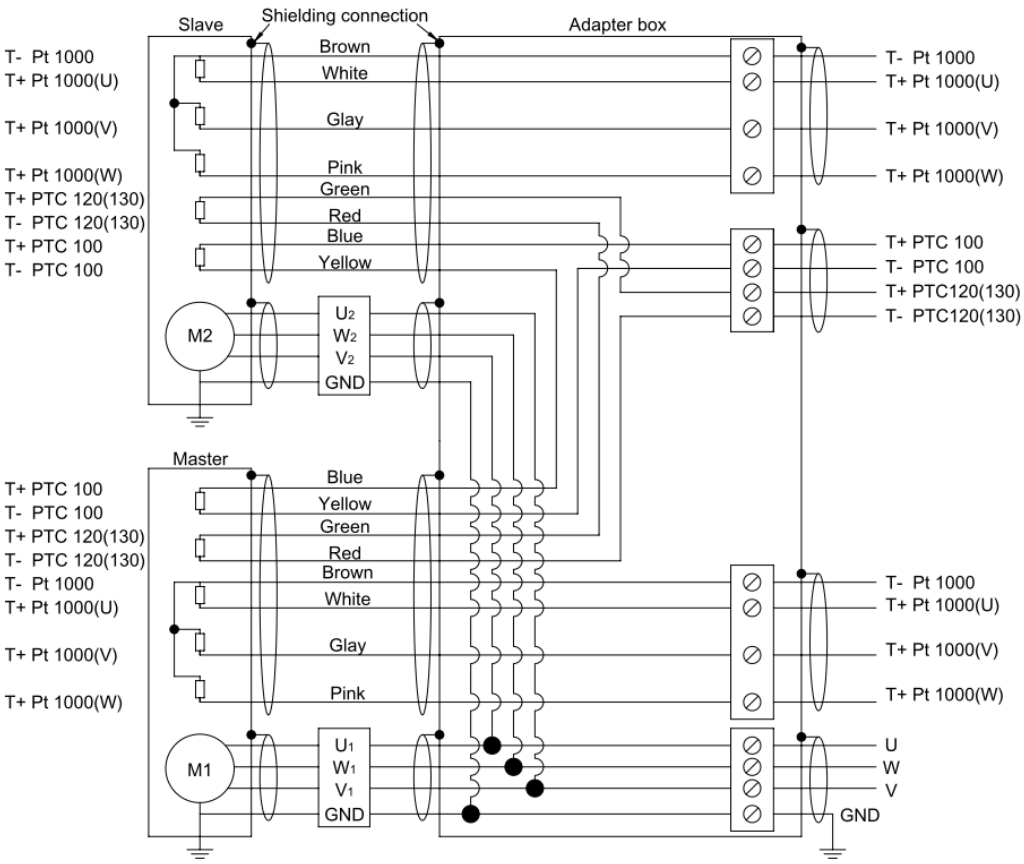


Figure 5.2.24 Type D, Design 2, Series 1

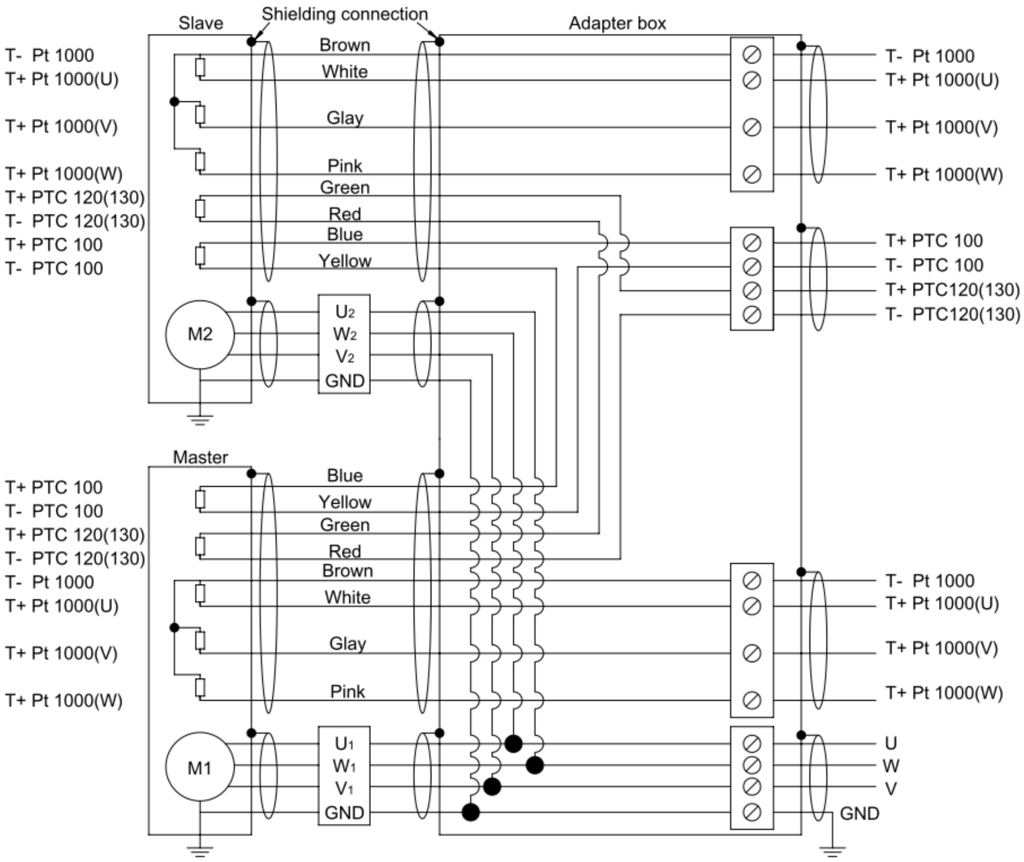


Figure 5.2.25 Type D, Design 2, Series 2

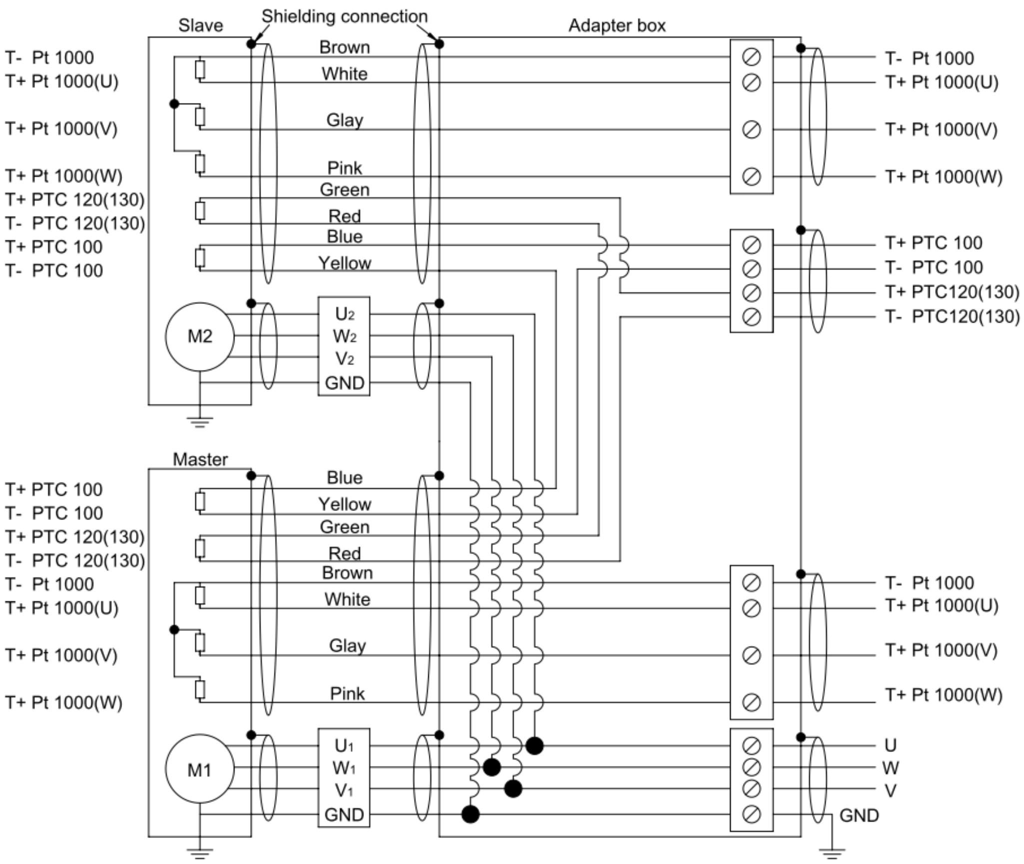


Figure 5.2.26 Type D, Design 2, Series 3

5.2.4 Temperature sensor

Pt1000 is a platinum resistance temperature sensor (RTD), which is characterized by a resistance value of 1000Ω at 0℃ and the tolerance is class B. The corresponding temperature can be converted by measuring the output resistance value. The relationship between resistance and temperature is shown in Figure 5.2.27. Operating temperature range is -55℃ ~ 190℃.

The standard relationship between resistance and temperature is as follows:

Temperature range: -55℃ ~ 0℃

$R_\theta = R_0[1 + A\theta + B\theta^2 + C(\theta - 100)\theta^3]$

In temperature range: 0℃ ~ 190℃

$R_\theta = R_0(1 + A\theta + B\theta^2)$

R_0 = 1000 [Ω] C = -4.1830 x 10^{-12} [$℃^{-4}$]

A = 3.9083 x 10^{-3} [$℃^{-1}$] θ = temperature [℃]

B = -5.7750 x 10^{-7} [$℃^{-2}$]

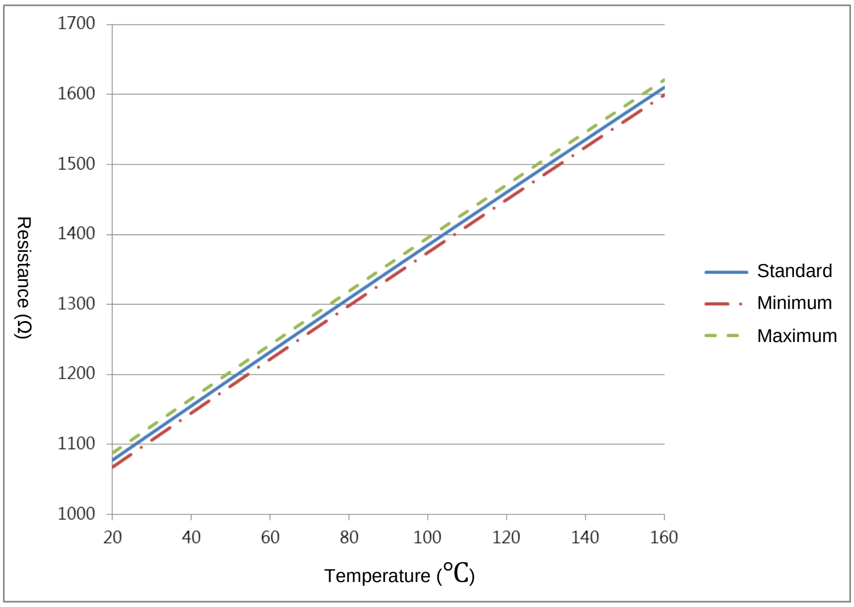


Figure 5.2.27 Relationship between resistance and temperature (Pt1000)

PTC100 and PTC120(130) are thermistors. Their output resistance changes according to coil temperature. Resistance of PTC100 rises drastically when T_{REF}=100℃, while resistance of PTC120(130) rises drastically when T_{REF}=120(130) ℃. Their features are given in Table 5.2.8 and Figure 5.2.28.

※There are 3 PTC in series, the controller must NOT trigger at a value lower than the resistance value given at ambient temperature.(refer to Table 5.2.8)

Table 5.2.8 Features of PTC

Features of	Resistance	3 PTC in series resistance
20℃<T<T_{REF} - 20K	20Ω~250Ω	60Ω~750Ω
T=T_{REF} - 5K	≦ 550Ω	≦ 1,650Ω
T=T_{REF} + 5K	≧ 1,330Ω	≧ 3,990Ω
T=T_{REF} + 15K	≧ 4,000Ω	≧ 12,000Ω

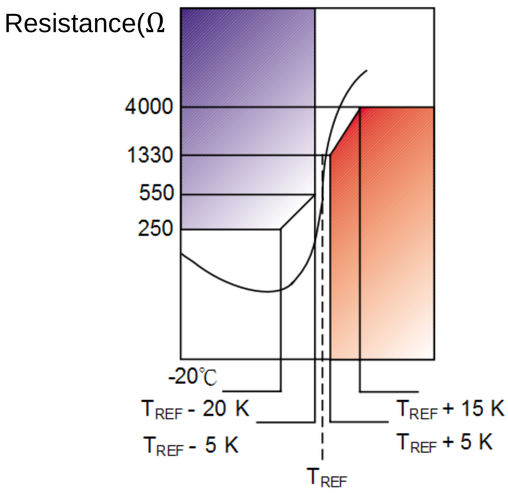


Figure 5.2.28 Relationship between PTC temperature and resistance

5.2.4.1 Temperature monitoring and motor protection

To protect the motor windings against thermal damage, every motor is equipped with a triple positive temperature coefficient (PTC) sensor, type SNM120/130 (in accordance with DIN 44082-M180). Since the degree of heating of the individual motor phases can be very different, a PTC sensor is fitted in each phase winding (U, V and W). Each PTC element has a “Quasi-switching” characteristic, i.e. the resistance suddenly increases close to the rated temperature (switching threshold, Figure 5.2.28). Due to its low heat capacity and good thermal contact with the motor winding, the PTC reacts very quickly to a rise in temperature and, in conjunction with additional protective mechanisms on the control side, ensures reliable motor protection against overload. The PTC elements located in every phase winding in HIWIN motors are wired in series; they connect via two wires.

With TMRW/TM-2/IM-2 there is an additional temperature circuit with positive temperature coefficient (PTC), type PTC 100, for redundant use or to distinguish between warning and danger temperatures.

Note:

Motor protection by temperature monitoring alone using PTC elements can be insufficient. This is the case, for example, if the motor is operated with currents above continuous current.

HIWIN advises the use of additional protective algorithm on the control side. Also, the calculation of max. operating time with currents above continuous current can be found in Section 3.3.5.3.

5.2.4.2 Connection to the drive amplifier

The temperature monitoring circuits can normally be connected directly to the drive control. If the protective separation requirements in accordance with EN61800-5-1 are to be fulfilled, the sensors must be connected to the decoupling modules provided by the drive manufacturers.

6. Commissioning

6.1 Commissioning

For parameters, please contact our engineering department. Input the corresponding data according to the requirements of the controller and driver, and adjust it according to the controller and driver manual.

- **Operation precautions**

5. Avoid excessive friction when the motor is running.
6. Ensure there is no object in the motion range of the system.
7. Before starting the motor, ensure the cooling system works properly.
8. Before starting the motor, ensure the main switch is on.
9. Before transmitting electricity, ensure at least one ground wire is connected to all electrical products.
10. Do not directly touch motor parts after motor is assembled.
11. If the current exceeds the maximum specified current, magnetic components in the motor may be demagnetized. When it happens, please contact HIWIN or local distributors.
12. Do not operate the product in an environment that exceeds its rated load.
13. When the motor is running, its temperature must be within the specification.
14. If any abnormal odor, noise, smoke, temperature rise or vibration is detected, stop the motor and turn off the power immediately.
15. Don’t cool the motor or its parts below room temperature to prevent condensation on the motor, which rapidly degenerate the windings.
16. Torque motor with cooling jacket (Reserved code: J□), During the installation and use of the stator, impacts or compression on the casing may cause leakage of the cooling fluid. Therefore, it is recommended to leave a gap between the stator installation space and the cooling casing to prevent this.
17. Torque motor with cooling jacket (Reserved code: J□), Under any circumstances, it is necessary to ensure that the cooling system is operating normally before supplying power to the stator. Even a brief temperature rise in an uncooled state can cause irreversible damage to the stator.
18. Torque motor with cooling jacket (Reserved code: J□), The hardware used to secure the cooling casing (spring pins) must not be removed, whether they are located on the upper edge, lower edge, or inserted into the fixed hole of the cooling casing. If any of the fixed hardware (spring pins) are removed and result in patent infringement, motor damage, or cooling fluid leakage, HIWIN will not be held responsible.

11. Fixed operation environment conditions must comply with EN 60721-3-3:2019 (refer to Table 6.1.1)

Table 6.1.1 Operation environment conditions.

Environmental parameter	Unit	Value
Air temperature	(℃)	+5~+40
Relative humidity	(%)	5~85
Absolute humidity	(g/m^3)	1~25
Rate of change of temperature [1)]	$(℃/min)$	0.5
Air pressure [2)]	(kPa)	78.4~106
Solar radiation	(w/m^2)	700
Movement of surrounding air [3)]	(m/s)	1
Condensation	-	Not allowed
Formation of ice	-	Not allowed

[1)] Averaged over a period of time of 5 min.

[2)] Conditions in mines are not considered. Severity value is different from Class 3K22. (up to 78.4 kPa) (altitudes up to 2000 m).

[3)] Uncontrollable air flow may affect cooling systems based on natural convection.

Mechanically active substances	Class 3S5
Mechanical conditions	Class 3M11

7. Maintenance and cleaning

7.1 Maintenance

Please read all safety instructions before performing motor maintenance

Safety Instruction
1. Obstacle removal and maintenance can only be performed by HIWIN technicians or authorized dealers, and with appropriate protective equipment. 2. Do not perform any maintenance actions while the motor is running. The controller must stop the motor first. 3. Please turn off the power and the main switch of the machine (Please refer to the machine manufacturer's instructions for operation). 4. After the power is turned off, there will be residual voltage in the system.

HIWIN torque motor is a direct drive system, there will be no wear during operation, but even so, improper operation or incorrect use environment will still shorten the life of the motor or even damage it. It is recommended to conduct measurement and maintenance every quarter:

1. Confirm the flow rate of the cooling system and remove impurities and particles.
2. Measure and eliminate partial blockage of the cooling system.
3. The detection mechanism or electrical connection must not be loosened.
4. Detect possible wear or aging of the cable.
5. Check the air gap between the stator and rotor to confirm that there is no leakage that may cause foreign matter, dust or particles to invade.
6. To test the insulation resistance of the three phases of the motor. It must meet the requirements of $1000V_{DC}$ 60 sec>100 MΩ@25℃. If the insulation resistance decreases gradually at the same temperature compared to the previous several measurements, the motor may have begun to age, so special attention should be paid.

7.2 Cleaning

Please read all safety instructions before performing motor cleaning

⚠ Safety Instruction	
⚠	1. Obstacle removal and maintenance can only be performed by HIWIN technicians or authorized dealers, and with appropriate protective equipment. 2. Do not perform any maintenance actions while the motor is running. The controller must stop the motor first. 3. Please turn off the power and the main switch of the machine (Please refer to the machine manufacturer's instructions for operation). 4. After the power is turned off, there will be residual voltage in the system. Please wait for sufficient discharge time before disconnecting all power connections. 5. Turn off the cooling system, release the pressure to discharge the cooling liquid and remove the cooling connection (Please refer the instructions of the cooling machine). 6. Disassemble the motors in order.

It is recommended to conduct measurement and maintenance every quarter:

1. Clean the metal particles on the motor regularly.
2. Regularly check the air gap between the stator and rotor of the motor to keep it clean and undamaged.

7.3 Test run

After confirming that the brake, cooling system, and power system are installed, perform a trial run and adjust it according to the controller and driver manual.

8. Disposal

8.1 Waste disposal

8.1.1 Decommissioning

When disassembling or deactivating the motor, please follow the orders instructed below:

> ⚠ **WARNING!**
>
> **Risk of injury and material damage!**
>
> If you do not follow the orders to disassemble or deactivate the motor, it may cause personal injury, death or property damage.
>
> ◆ Please disassemble or deactivate the motor according to the order below:

1. Disconnect the motor power supply and wait for the DC power supply to discharge completely.
2. Wait for the motor to cool down (at least 30 minutes), then turn off all cooling systems and vent the pressure to 0 bar.
3. Remove all power cables, signal cables and cooling tubes.
4. If necessary, isolate all power connections to avoid the risk of electric shock due to voltage generated by the rotating motor during disassembly, or braking torque due to short circuits.
5. Drain all internal coolant and dispose of it properly
6. Clean the foreign matter, debris and dust on the motor.
7. Insert the spacer between the gaps of stator and rotor.
8. When there are fixation plates of stator and rotor or self-designed stator and rotor fixing jigs, use these plates/jigs to fix the stator and rotor.
   8-1 If the guiding fixture method is used, it is necessary to confirm that the related fixture and configuration are installed.
9. Remove all the fixings at the machine end. If the stator and rotor are fixed, they can be separated from the machine at the same time; if the guiding method is used, please remove the stator and rotor in the reverse order during assembly. When removing, be careful that the o-ring may be damaged.
10. When removing the o-ring, be careful not to stretch it excessively. Stretching more than 10% may cause permanent damage; it is also not allowed to twist or use sharp tools.
11. Use the original packaging or a safe way to pack and store it correctly.

Note: If replace a new torque motor, it is recommended to use a new o-ring; when the o-ring needs to be replaced, please refer to Section 5.1.1.4. to purchase an appropriate o-ring or purchase it from HIWIN.

8.1.2 Disposal

Products need to be disposed according to the normal recycling process in accordance with laws and regulations.

⚠ WARNING!
Injury and material damage if not correctly disposed of If the torque motor or related components (especially the rotor with strong magnets) are not handled correctly, it may cause personal injury, death or property damage. ◆ Please ensure that the torque motor and related components are disposed of correctly.

Appropriate disposal process:

- The permanent magnets in the rotor assembly must be completely demagnetized.
- The components to be recycled need to be disassembled:
  - Electronic waste (e.g. encoder components, temperature control modules, etc.)
  - Electrical waste (e.g. stator, cables, etc.)
  - Scrap metal alloys (classified by metal)
  - Insulation material
- No mixing with solvents, cold cleaning agents, or residue of paint

8.1.2.1 Disposal of rotors

Rotors with permanent magnets must be disposed after a specific demagnetization treatment to avoid the danger of subsequent disposal. It is recommended to be disposed of by a professional recycling company.
After disassembling the motor, the rotor must be separately placed in a safe package.
Rotor demagnetization steps:
It needs to be placed in a dedicated non-magnetic oven for baking, and the rotor is placed on a strong and heat-resistant load. During the entire demagnetization process, the temperature in the oven must be at least 310°C (Curie point) for baking for 1 hour, and the exhaust gas generated during the baking should be treated to avoid environmental pollution.
Note: After degaussing and returning to normal temperature, the remaining gauge should be close to 10 Gauss, otherwise it is recommended to continue the above process.

8.1.2.2 Disposal of packaging

The packaging materials and packaging auxiliary materials used by HIWIN are no problematic materials. Except for wood materials, they can be recycled and reused. Wood materials should be burned.

9. Troubleshooting

9.1 Troubleshooting

Table 9.1.1 Troubleshooting

Symptom	Cause	Action
Motor cannot be rotated manually without connecting the controller	Mechanical interference	Remove interference
	Motor three-phase short circuit	Fix three-phase short circuit
Motor can't rotate at all.	Wrong cable wiring	Check the cable connected to the controller.
	Current overload	Check whether there are interfering objects and remove them. Fix the brake clamping failure.
	Over temperature protection	Check the over temperature setting of controller
	Abnormal insulation resistance	Measure insulation resistance after cooling Measurement of stator three-phase to ground (U/V/W to PE): 1000V_{DC} 60 sec>100 MΩ@25℃ If it does not reach 100 MΩ, please contact HIWIN
Wrong rotating direction	Wrong encoder setting	Check encoder setting.
	Wrong motor power cable wiring	Interchange the two-phase power cable connected to the controller.
Smell of burning	Abnormal operation of cooling system	Check cooling system.
	Wrong controller setting	Check controller setting.
	Wrong motor parameters setting	Check motor parameters setting.
Abnormal temperature of motor outer casing	Speed is too slow	Use the stall condition when electrical frequency <1 Hz
	Abnormal operation of cooling system	Check cooling system.
	Wrong controller setting	Check controller setting.
	Wrong motor parameters setting	Check motor parameters setting.
	Abnormal operation of bearing	Check installation.
Unstable rotation (vibration)	Insulation failure	Check the resistance value of phase/earth is

Symptom	Cause	Action
		larger than 50 MΩ.
	Wrong encoder installation	Check installation stiffness of encoder.
	Wrong encoder signal	Check encoder grounding and connection.
	Wrong controller setting	Check controller setting.
	Wrong motor parameters setting	Check motor parameters setting.
Hard to rotate or abnormal friction noise	Abnormal installation of rotor	Check installation.
	Unbalanced system	Check the dynamic balance
	Loose system	Fix it tight again
	Foreign object exists in air gap.	Remove foreign object.
Motor generate local high heat (uneven)	Air bubbles blocked in the cooling circuit	Remove air bubbles or increase flow rate to remove air bubbles. (see Section 3.3.7)
	Incorrect position of inlet and outlet of cooling circuit	Check the inlet/outlet of cooling circuit to fit according to approved drawing.
Use for a while, the noise come out when enable motor without rotary, frequency of noise as same as n×PWM modulation frequency. (n=1, 2, 3 ….)	Insulation failure	Check the resistance value of phase/earth is larger than 50 MΩ.

9.1.1 Troubleshooting form

In the event a breakdown or error occurs with the torque motor, this form has been designed to help the user to provide HIWIN with the most essential details so that the unit can be troubleshooted and repaired efficiently and effectively. Avoiding any possible and unnecessary downtime. Please ensure the form is filled out in full.

Caution!: Don't dismount the motor before the all possible required measurements be performed with the motor mounted in machine.

9.1.1.1 Identification of Motor and machine

Codification: TMRW{ | | }-{ | } /
{ }M-2-{ | }-{ | | }-{ }-{ | | }-{ | }

Serial number of stator (see label):____

Serial number of rotor (see label):____

Machine designation: ____

Number of axis: ____

Motor in service since (yyyy-mm-dd): ____________________________________

Factory location (Country, City):____

9.1.1.2 Conditions

Motor liquid cooling: □ No / □ Yes,

Coolant Type: □ Water +___% additive _________, □ Oil / □ Other ___ J/(kg·K) ___kg/m³

Flow rate at the motor input: _____ (l/min)

Fluid used in machine operation: □ No / □ Yes, Type:

Bearing type:

Clamp system inside: □ No / □ Yes, Type: □ Magetic, □ Hydraulic, □ Other ____

9.1.1.3 Failure situation

Failure description:

What was the status when the motor failed?

☐ during commissioning stage, comments:

____

☐ during Normal operation stage (e.q. turning, milling, stalled), please specify:

____

☐ other operation:

____

Failed axis (swivel, rotary table, brush, …):________________________________

Failure message form the Controller: □ No / □ Yes, message: ________________________

____

☐ Sudden stop, comments:____
☐ Performance degradation (vibration, ripple, noise), comments:________________________

____

☐ Other, comments:____

____

Did the same failure occur before?

□ No / □ Yes, when exactly (yyyy-mm-dd):___________, failure motor type:_____________

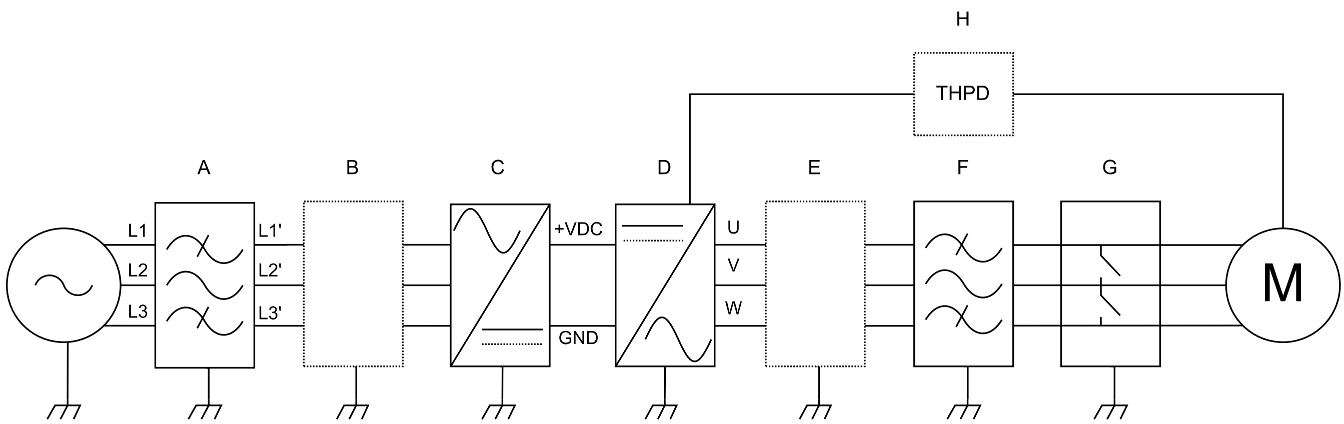
9.1.1.4 NC parameters

☐ NC(Numerical Control) type: ____
☐ Other comments:____

List all parameters regarding to the motor, or send the corresponding file to HIWIN (in case HIWIN supplied the parameter data sheet for the motor, please send HIWIN this parameter file)

____

____



A. Filter type: □ Harmonic filter □ Regen filter □ EMC filter □ Other type _______ □ No

B. Chokes & Reactors: □ Line reactor □ Commutation choke □ Other type _______ □ No

C. Power supply types: _______

D. Amplifier types: _______

E. Chokes & Reactors: □ dv/dt reactor □ motor choke □ other type _______ □ No

F. Filter type: □ dv/dt filter □ sinusoidal filter □ other type _______ □ No

G. Short circuit relay type: _______, □ No

H. THPD used? □ No / □ Yes

9.1.1.5 Electrical troubleshooting

Before starting the measurements below, switch off the power, disconnect the phases and wait until motor is cooled down to ambient temperature (25±5℃): (Precaution refer to Section 9.1)

Check the entire wiring. Any observed interruptions or loose connection?

□ No / □ Yes, where exactly:____

Measure the resistances between phases: R_{U-V}:________, R_{V-W}: ________, R_{U-W}: ________

Measure the resistance to Ground: R_{U-G}:________, R_{V-G}: ________, R_{W-G}: ________

Measure the resistance of the temperatures sensors:

R_{Pt1000}:1) _____ 2) _____ 3) _____, $R_{PTC100/120/130}$: 1) _____ 2) _____ 3) _____

9.1.1.6 Visual inspection

In visual inspection below concerns a dismounted motor. (Be sure all measurement on machine have done before dismounted motor, or may disturb the failure scene) (Precaution refer to Section 9.1)

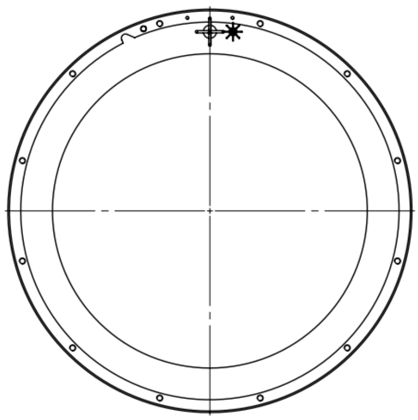
- **Stator inspection:**

Any abnormal marks on the stator (inside): □ No / □ Yes

Any abnormal smell on the stator: □ No / □ Yes

Remark the visual marks on the following figures:

- Blisters (draw ○)
- Burn point (draw △)
- Scratch (draw ☰)
- Flange wrinkle (draw ~)



Cables and connections inspection:

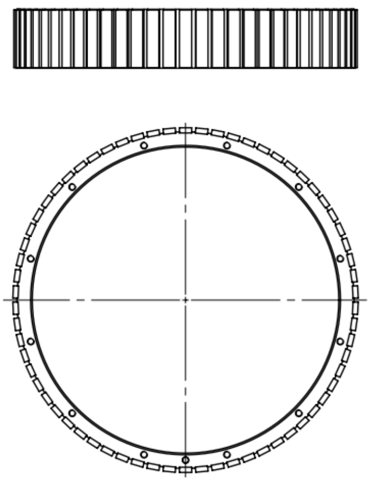
Any damage on cables/cable glands/cable connectors: □ No / □ Yes

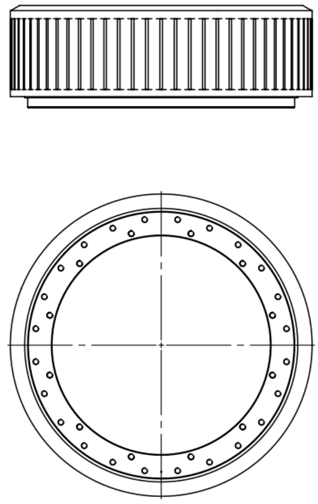
- **Rotor inspection:**

Any abnormal marks on the rotor (outside): □ No / □ Yes

Remark the visual marks on the following figures:

TM-2 IM-2





- Flying magnet (draw ○)
- Burn point (draw △)
- Metal shavings (draw ╳)
- Scratch (draw ☰)
- Flange wrinkle (draw ~)

Is the motor oily or greasy? □ No / □ Yes, comments:______________________________

Is there any metal particle on the magnets: □ No / □ Yes, something like _______________

9.1.1.7 Appendix

Please share all information with HIWIN to get a better understanding of the problem (photos, NC records, damaged parts). List all the file and parts sent to HIWIN:

____

____

____

____

____

9.1.1.8 Contact information

Company/Institute/Department: ____

Contact person: ____

Email: ____

Phone: ____

Address: ____

10. Declaration of incorporation

10.1 Declaration of incorporation

Declaration of Conformity

according to Low Voltage EC directive 2014/35/EU

Name and address of the manufacturer:
HIWIN MIKROSYSTEM CORP., No.6, Jingke Central Rd., Taichung Precision Machinery Park, Taichung 408226, Taiwan

Description and identification of the product:

Product	Torque Motor
Identification	Series: TMRW, TMRI, TM-2, IM-2, DMR

The object of the declaration described above is in conformity with the relevant Union harmonization legislation Directives.

2014/30/EU	EMC directive
2011/65/EU	RoHS directive

References to the relevant harmonized standards used or references to the other technical specifications in relation to which conformity is declared

EN 60034-1:2010 EN 60034-1:2010/AC:2010	Rotating electrical machines - Part 1: Rating and performance
EN 60034-5:2001/A1:2007	Rotating electrical machines - Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) - Classification
EN 60204-1:2018	Safety of machinery - Electrical equipment of machines - Part 1: General requirements

This declaration of conformity is issued under the sole responsibility of the manufacturer.

Taichung 408226, Taiwan 09.08.2022	**YU, KAI-SHENG, Executive Vice President**	
(Place, Date)	(Surname, first name, and function of signatory)	(Signature)

11. Appendix

11.1 Glossary

- **Back EMF constant (line-to-line):** K_v $\left(\frac{V_{rms}}{rad/s}\right)$

  The back EMF constant, K_v, is the ratio of the back EMF voltage (V_{rms}) to the motor rotational speed (rad/s) when the magnet is at 25℃. It is created at the movement of the coil in the magnetic field of permanent magnets.

- **Continuous current:** I_c/I_{cw} (A_{rms})

  The continuous current, I_c, is the current that can be continuously supplied to the motor coils at the ambient temperature 25℃, and the final temperature of coil can't exceed 120℃
  (130℃ for □M-2 series). Under this condition, the motor reaches the rating continuous torque T_c; in relation with the continuous current and coil temperature, torque motor will respond to I_c for air cooling and I_{cw} for water cooling

- **Continuous torque:** T_c/T_{cw} (Nm)

  The continuous torque, T_c, is the maximum torque the motor is able to generate continuously at the ambient temperature 25℃ and the final temperature of coil can't exceed 120℃ (130℃ for □M-2 series). This continuous torque correspond to I_c/I_{cw} supplied to the motor; in relation with continuous current and coil temperature, torque motor will respond to T_c for air cooling and T_{cw} for water cooling.

- **Inductance (line-to-line):** L (mH)

  Inductance is defined as inductance measured between lines when the motor operates at the coil temperature 25℃.

- **Resistance at 25℃ (line-to-line):** R_{25} **(Ω)**

  Resistance is defined as resistance measured between lines when the motor operates at the coil temperature 25℃.

- **Motor constant:**K_m $\left(\frac{Nm}{\sqrt{W}}\right)$

  The motor constant, K_m, is defined as the ratio of square root of motor output torque to consumption power when the coils and magnets are at 25℃. The larger motor constant represents the lower power loss when the motor outputs at the specific torque.

- **Number of poles: 2p**

  2p represents the number of poles of the rotor, where p is the number of pole pairs.

- **Peak current: I_p (A_{rms})**

  The peak current, I_p, is the current corresponding to torque output of the motor, and the motor temperature reached by current can't demagnetize magnet. Generally speaking, peak current can be granted to supply 1 second when the motor is operating in the normal condition and the input current phase is balanced. And then the motor needs to rest for at least 6 seconds after it reaches the normal temperature to supply peak current. (For more accurate time, please contact HIWIN)

- **Peak torque: T_p (Nm)**

  The peak torque, $\boldsymbol{T_p}$, is the maximum torque that the motor outputs less than 1 second. Peak current corresponding to the torque cannot demagnetize magnet.

- **Rotor inertia:J (kgm^2)**

  The rotor inertia, $\boldsymbol{J}$, is the rotary component resists any changes in its state of motion, including changes to its speed and direction. It is related to the shape and mass.

- **Stall current:I_s/I_{sw} (A_{rms})**

  The stall current, $\boldsymbol{I_s}$, is the upper limit of current when the motor is at 25℃ and in the stall condition. Depending on the heat dissipation, torque motor will correspond to $\boldsymbol{I_s}$ for air cooling and $\boldsymbol{I_{sw}}$ for water cooling.

- **Stall torque: T_s/T_{sw} (Nm)**

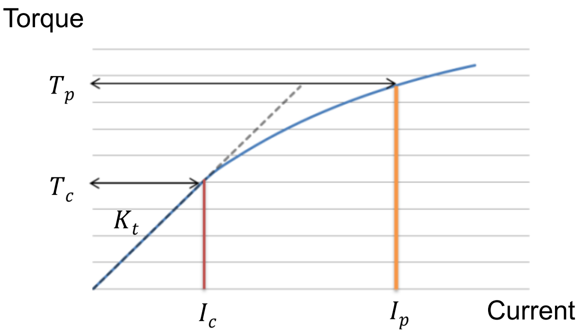
  The stall torque, $\boldsymbol{T_s}$, is the upper limit of torque when the motor is at 25℃ and in the stall condition. Depending on the heat dissipation, torque motor will correspond to $\boldsymbol{T_s}$ for air cooling and $\boldsymbol{T_{sw}}$ for water cooling.

- **Thermal resistance: R_{th} (K/W)**

  The thermal resistance, $\boldsymbol{R_{th}}$, is defined as the resistance suffered heat from motor coil to dissipate the environment (consider the natural convection and radiation for air cooling when ambient temperature is at 25℃, and the force water cooling for water cooling when the water is at 25℃). Higher thermal resistance represents the larger temperature difference between the coil and environment under the same heat source.

- **Torque constant:K_t (Nm/A_{rms}) at magnet temperature of 25℃**

  The torque constant, $\boldsymbol{K_t}$, is ratio between as the motor's output torque per RMS current. Output torque and input current shows a linear relationship at low current. The non-linear relationship is due to saturation in the iron core.



- **Maximum speed**

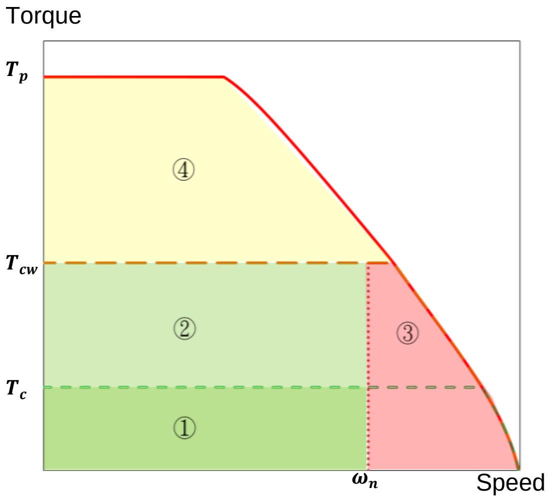
  Maximum speed is defined as maximum speed provided under specific torque (usually continuous torque). There are three conditions to define the maximum speed of torque motor: maximum speed under air-cooling continuous torque, maximum speed under water-cooling continuous torque and maximum speed under peak torque.

- **Rated speed:** $\boldsymbol{\omega_n}$ $(\boldsymbol{rpm})$

  Rated speed, ω_n, is defined as the speed at which the rotor will not be damaged due to the high temperature of the rotor (>80℃) caused by iron loss when the motor is running continuously without rest; if the speed exceeds this speed, the working cycle must be reduced or additional heat dissipation design must be conducted for rotor. Please refer to the T-N Curve for the explanation of the motor working range.

- **T-N Curve (TM-2)**

  The T-N curve is defined as the comparison chart of the torque and the speed that can be output under a certain input voltage of the motor. Considering the temperature rise of the motor, the figure can be divided into four operating ranges as shown below:



①：When the motor is air-cooled and the torque is less than $\boldsymbol{T_c}$, it can run continuously below $\boldsymbol{\omega_n}$ without break.

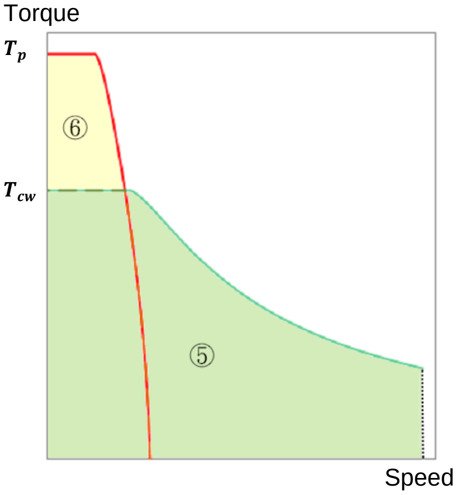
①+②： When the motor is water-cooled and the torque is less than $\boldsymbol{T_{cw}}$, it can run continuously below $\boldsymbol{\omega_n}$ without break.

③： When the motor is air-cooled and the torque is less than $\boldsymbol{T_c}$ or when it is water−cooled and the torque is less than $\boldsymbol{T_{cw}}$, the speed is greater than $\boldsymbol{\omega_n}$, the duty cycle must be reduced or additional design on rotor heat dissipation must be provided to avoid overheating of the rotor.

④： When the motor is air-cooled and the torque is greater than $\boldsymbol{T_c}$ or when it is water-cooled and the torque is greater than $\boldsymbol{T_{cw}}$, the duty cycle must be reduced. When $\boldsymbol{T_p}$ is reached, only 1 second output is allowed to avoid overheating of the stator.

- **T-N Curve (IM-2)**

  The T-N curve is defined as the comparison chart of the torque and the speed that can be output under a certain input voltage of the motor. Considering the temperature rise of the motor, the figure can be divided into two operating ranges as shown on next page:



⑤：When the motor is water-cooled and the torque is less than T_{cw}, it can run continuously below maximum speed in field weakening without break.

⑥：When it is water-cooled and the torque is greater than T_{cw}, the duty cycle must be reduced. When T_p is reached, only 1 second output is allowed to avoid overheating of the stator.

- **Maximum input voltage (V_{DC})**

  Maximum input voltage is the maximum voltage for the motor operating in the normal environment.

- **Maximum continuous power loss: P_c (W)**

  Maximum continuous power loss is the energy lost when the motor runs continuously under continuous current and the coil temperature is 120℃ (130℃ for □M-2). It mainly converts into heat. In water cooling system, the loss is mostly eliminated by coolant.

- **Maximum pressure difference: Δp (bar)**

  Maximum pressure difference is the maximum value tolerated by the pressure difference between inlet and outlet under water cooling system with pure water. It corresponds to minimum water flow q. If the operating environment is different, pressure difference must be modified by calculation (refer to Section 3.3.7).

- **Minimum water flow: q (l/min)**

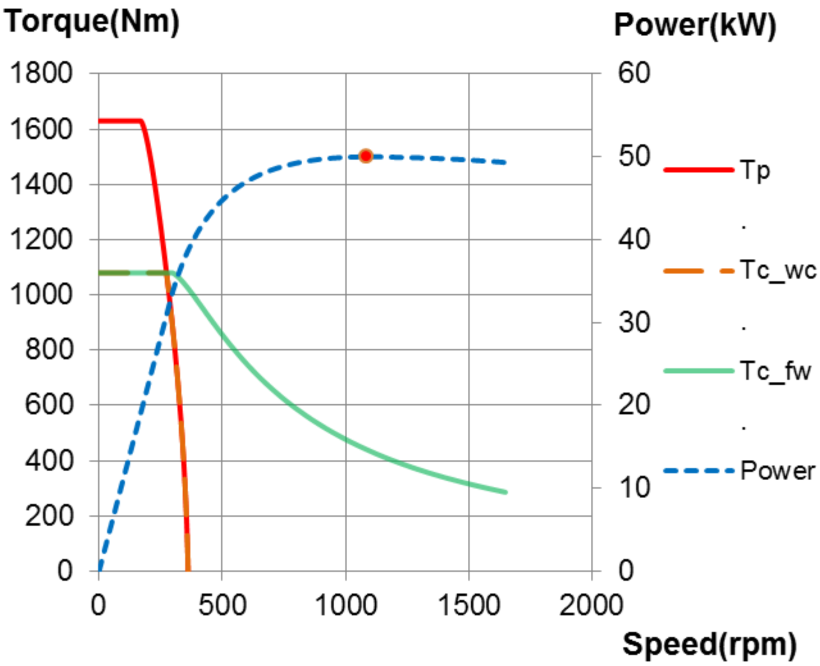
  Minimum water flow is the minimum flow required for normal cooling under water cooling system with pure water. If the operating environment is different, water flow must be modified by calculation (refer to Section 3.3.7).

- **Temperature difference under maximum power loss: $\Delta\theta$ (℃)**

  Temperature difference under maximum power loss is the temperature difference between inlet and outlet under water cooling system with pure water. Generally, it is defined as 5℃. If the operating environment is different, temperature difference under maximum power loss must be modified by calculation (refer to Section 3.3.7).

- **Rated power (kW)**

Rated power is the maximum continuous rated power as specified on the nameplate of the motor.
In IM-2 Series, the rated power in the field-weakening operation will be higher than normal operation, so the definition of rated power in IM-2 series will be the maximum continuous rated power in the field-weakening operation.
The schematic as shown as below, the red dot is the maximum continuous rated power in the field-weakening operation



11.2 Unit conversion

To convert the unit in column B to the unit in column A, multiply by the corresponding figure in the table.

■ Mass

		B			
		g	kg	lb	oz
A	g	1	0.001	0.0022	0.03527
	kg	1000	1	2.205	35.273
	lb	453.59	0.45359	1	16
	oz	28.35	0.02835	0.0625	1

■ Linear speed

		B				
		m/s	cm/s	mm/s	ft/s	in/s
A	m/s	1	100	1000	3.281	39.37
	cm/s	0.01	1	10	3.281×10^{-2}	0.3937
	mm/s	0.001	0.1	1	3.281×10^{-3}	3.937×10^{-2}
	ft/s	0.3048	30.48	304.8	1	12
	in/s	0.0254	2.54	25.4	8.333×10^{-2}	1

■ Angular velocity

		B			
		deg/s	rad/s	rpm	rps
A	deg/s	1	1.745×10^{-2}	0.167	2.777×10^{-3}
	rad/s	57.29	1	9.549	0.159
	rpm	6	0.105	1	1.667×10^{-2}
	rps	360	6.283	60	1

Force

		B		
		N	lb	oz
A	N	1	0.2248	3.5969
	lb	4.4482	1	16
	oz	0.2780	0.0625	1

Rotary inertia

		B			
		kg-m^2	lb-in^2	lb-ft^2	oz-in^2
A	kg-m^2	1	3417.63	23.73	54644.81
	lb-in^2	2.926 x 10^{-4}	1	6.943 x 10^{-3}	15.99
	lb-ft^2	4.214 x 10^{-2}	144.02	1	2302.73
	oz-in^2	1.83 x 10^{-5}	6.254 x 10^{-2}	4.34 x 10^{-4}	1

Length

		B				
		m	cm	mm	ft	in
A	m	1	100	1000	3.281	39.37
	cm	0.01	1	10	3.281 x 10^{-2}	0.3937
	mm	0.001	0.1	1	3.281 x 10^{-3}	3.937 x 10^{-2}
	ft	0.3048	30.48	304.8	1	12
	in	0.0254	2.54	25.4	8.333 x 10^{-2}	1

Torque

		B			
		N-m	lb-in	lb-ft	oz-in
A	N-m	1	8.851	0.7375	140.84
	lb-in	0.113	1	8.333 x 10^{-2}	16
	lb-ft	1.355	11.99	1	191.94
	oz-in	7.1 x 10^{-3}	6.25 x 10^{-2}	5.21 x 10^{-3}	1

■ Temperature

		B	
		°C	°F
A	°C	1	(°F - 32) x 5 / 9
	°F	(°C x 9 / 5) + 32	1

11.3 Tolerances and hypotheses

11.3.1 Tolerances

Except for the size specifications, there is tolerance of ±10% for all specification value mentioned in the motor specifications. The dimensions without marked tolerance are with general tolerances, except the effective depth of the thread and the positioning pin hole. The tolerance table is shown in the approved drawing.

11.3.2 Hypothesis of heat transfer

The assumptions of all specifications are based on water cooling and natural air cooling. For other heat dissipation conditions, individual test needs to be conducted for confirmation.
Hypothesis of air cooling condition: ambient temperature around stator/rotor: 20℃;
Hypothesis of water cooling conditions:

- Ambient temperature around the rotor: 20℃
- Inlet water temperature: 20℃
- Temperature difference between inlet and outlet water: 5℃
- External temperature of stator: 22.5℃ on average

The stator heat exchange characteristics are defined in accordance of the number of water cooling system and the interface design from Table 5.1.1 to Table 5.1.4.

11.3.3 Ambient assumptions

The continuous current is tested to comply with norms IEC60204-1 for the selected power cable at an ambient temperature of 30℃ max. for motors. Higher ambient temperature may have to be derated in order to preserve compliance with aforementioned norms.

11.4 Optional accessories

11.4.1 Thermal Protection Device

Refer to operation manual MT99UE01 for specification, wiring and related description of THPD (thermal protection device).

Figure 11.4.1 Thermal protection device

11.4.2 Features

- THPD must be used with HIWIN torque motor.
- It converts three temperature sensor inputs of motor into one analog output and two digital outputs and sends them to controller.
- Real-time temperature monitoring is realized by the delay of software compensation. Even under severe operating conditions, the motor can be prevented from overheating.
- Controller can get the complete information of motor temperature via the following methods.
  Analog temperature output: Pt1000
  Digital warning output: Alarm
  Digital error output: Error

11.4.3 Wiring of temperature module

If the temperature sensor of the motor is Pt1000, it must be used with THPD-1000-□□□. The wiring structure diagram is shown below.

□□□：120 for TMRW, 130 for □M-2.

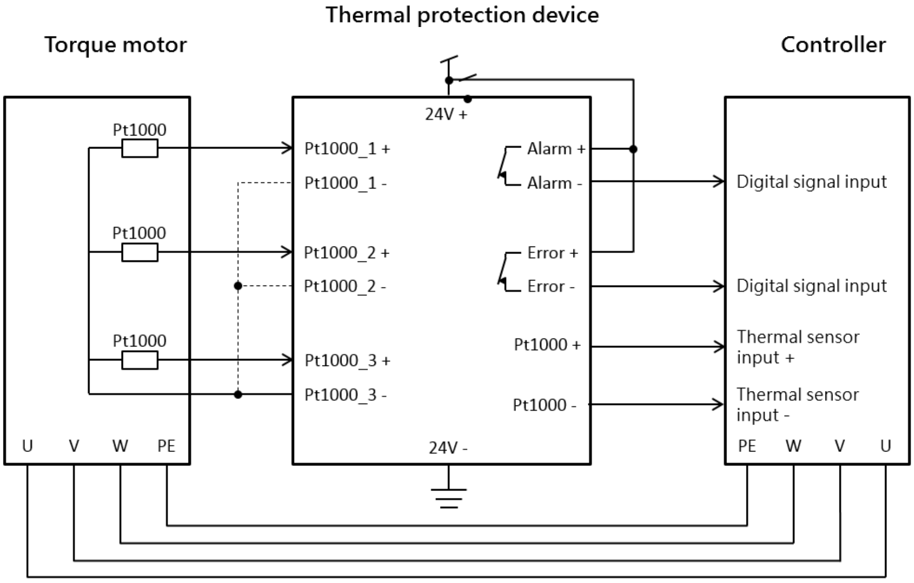


Figure 11.4.2 Pt1000 wiring diagram

11.5 Customer request form

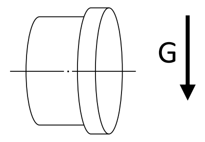
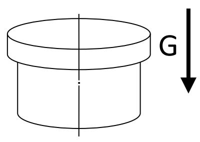
Company Name: Date

Email： Tel.： Fax.：	Contact Person： Title：

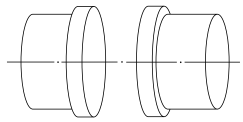
Industrial	
1.Environment	☐Normal environment (25℃) ☐Other：__________________
2.Load Type	☐Water Cooling：___ %(glycol) ☐Oil Cooling：Oil Type______ Specific：____ g/cm³ Specific heat capacity：____ cal/g℃ ☐Free-air convection： Ambient temp. ___ ℃
3.Load Conditions	☐Total moment of inertia： ____________________Kgm² ☐Load 1, qty_____ Mass：_____Kg or Material：_____ Size：_____________mm Offset of C.G：__________mm ☐ Load 2, qty_____ Mass：_____Kg or Material：_____ Size：_____________mm Offset of C.G：__________mm ☐ Load 3, qty_____ Mass：_____Kg or Material：_____ Size：_____________mm Offset of C.G：__________mm
4.Friction Torque	☐None ☐Yes:___ Nm
5.Cutting Torque (External Torque)	☐None ☑Yes:___ Nm
6.Controller	☐Siemens ☐Heidenhain ☐Fanuc ☐Mitsubishi ☐Other___
7.Drive Voltage	☐200V ☐380V ☐400V ☐565V ☐Other___ V
8.Drive Current	Rated___ Arms Max.___ Arms
9.Cable Length	☐Standard 2 m ☐Other:___ m (Max. Length≦10m)
Special Requirement:	

11.Installation

☐ Single

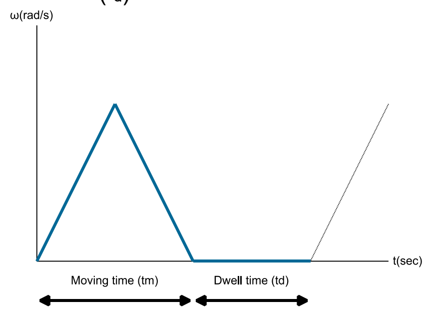
☐Laterally	☐Horizontal
	

☐Parallel operation (with one controller only)

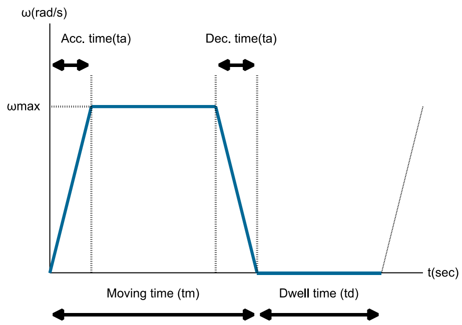


12.Motion profile

a. ☐Triangle profile (Usually in P2P application)
Moving angle(Φ):
Moving time(t_m):
Dwell time(t_d):



b. ☐Trapezoid profile (Usually in "Scanning" or "Machining" application)
Max. Speed(ω_{max}):
(Dec)Acceleration time(t_a):
Total moving time(t_m) or moving angle(Φ):
Dwell time(t_d):



1.The motors are all water-cooled design and verification. If it is oil-cooled or natural air-cooled, the actual condition of the machine needs to be monitored during operation.
2.Choose one of the exercise condition to fill in. If there are multiple application motion profiles, please fill in the most harsh conditions or contact HIWIN for assistance in evaluation.