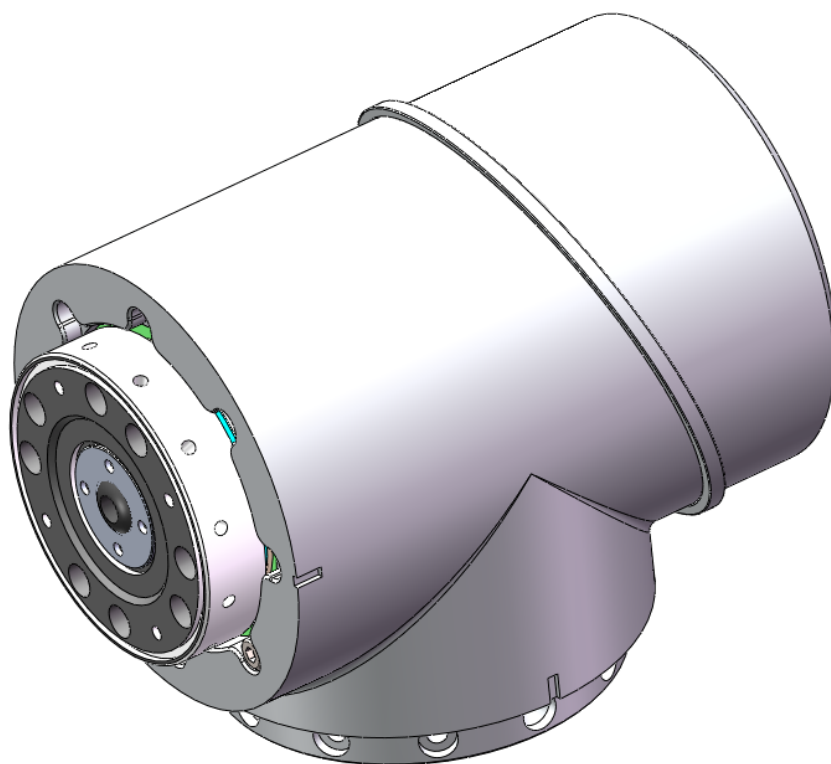


# Elephant Robotics User Manual

## Elephant Robotics® Module MS Series



Version 1.0  
Language: English

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In addition, the product information and related resources mentioned in this manual are for reference only and the contents are subject to change without notice.

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## About the manual

Welcome to use Elephant Robotics® Module MS Series and thanks for your purchase.

This manual describes how to properly install and use Elephant Robotics® Module MS Series, as well as matters needing attention.

Please read this manual and other related manuals carefully before installing Elephant Robotics® Module MS Series. After reading, please keep it in a safe place so that you can access it at any time.

## Reading objects of the manual

This manual is targeted to:

- Installer.
- Debugger.
- Maintenance staff.



Those who perform installation/debug/repair work on Elephant Robotics® Module MS Series must have knowledge of the definition of electrical wiring, mechanical characteristics and debugging methods .

## How to use

This manual should be used when doing the followings:

- Installation work: Connect the module in accordance with the wiring requirements, and power it up to 48V.
- Debugging work: Use the cable to debug the module to work.
- Maintenance work: Regularly maintain the module system to ensure that it functions as usual. Please contact technicians for maintenance when the module malfunctions due to environmental influences or improper operation of the user, or a certain component of the module system exceeds the normal service life, etc..

## Main contents of the manual

- Precautions for safe use of the module.
- Mechanical, electrical installation and commissioning of the module.
- Maintenance and repair of the module.

## Before the official reading of the manual

Before you officially read the manual, you need to know:

### 1. About Elephant Robotics® Module MS Series

Elephant Robotics® Module MS Series do apply to collaborative robots. It can be assembled into a multi-axis manipulator with multiple joints and work safely with workers to complete the processes of loading and unloading, testing and packaging in industrial manufacturing.

### 2. About help

For any questions or suggestions on the contents of the user manual, you can query on the official website of the Elephant Robotics to submit the relevant information:

[www.elephantrobotics.com](http://www.elephantrobotics.com).

### 3. Contact Information

1) Full name of company: Shenzhen Elephant Robotics Technology Co., Ltd.

2) Address: R208, B7, Yungu Innovative Industrial Park 2, Nanshan, Shenzhen, China 518057

3) Mail:

Business Cooperation : sales@elephantrobotics.com

Promotional Cooperation : marketing@elephantrobotics.com

Customer Service : service@elephantrobotics.com

Technical Support : @elephantrobotics.com

4) Tel: +86 755 8696 8565

# 1. Safety

## 1.1 Introduction

This chapter details general safety information for those who perform installation, maintenance, and repair work on Elephant Robotics®Module MS Series. Please read and understand the contents and precautions of this chapter before handling, installation and use.



According to GB 11291.1-2011, both robot manufacturers, system integrators, and individual users must perform hazard identification and risk assessment before using the robot. Conducting a hazard analysis can predict any hazards that may arise; and for hazards predicted in hazard identification, a risk assessment should be conducted to maximize personal safety and property safety.




This chapter provides a basic guide to safe use by introducing different safety alert symbols and precautions.

## 1.2 Safety Alert Symbol Description

As shown in Table 1-1, this section describes the safety alert symbols used in this manual. You can find the corresponding symbols described in this chapter in other chapters. Please note these symbols and their meanings.

Table1- 1 Safety Warning Symbol Table

 <b>Danger</b>	<p>Danger: Refers to a situation that is about to cause danger. Failure to avoid this can result in death or serious injury.</p>
 <b>Warning</b>	<p>Warning: Refers to situations that may cause danger. Failure to do so can result in personal injury or serious damage to the equipment.</p>

 <b>Caution Electricity</b>	Caution Electricity: Refers to the use of electricity that may cause danger. If this situation is not avoided, it may result in personal injury or serious damage to the equipment.
 <b>Prohibited</b>	Prohibited: Refers to things that are not allowed to do.
 <b>Attention</b>	Attention: Refers to important matters that need attention.



## 2. Product Warranty

### 2.1 Warranty

12-month limited warranty on Elephant Robotics® Module MS Series.

If the module is defective in manufacturing or material during the warranty period of the delivered product, Elephant Robotics provide necessary spare parts to replace or repair the relevant parts. But if the defects is caused by improper handling or failure to follow instructions of the user manual, the product warranty shall be invalid.

Under the principle of not violating the product warranty, if the product has exceeded the warranty period, Elephant Robotics reserves the right to charge the customer for replacement or maintenance.

Ownership of the equipment or components to be replaced or returned is vested in Elephant Robotics.

Elephant Robotics shall not be liable for any damage or loss caused by defective equipment beyond the warranty period, including but not limited to production loss or damage to other production equipment.

### 2.2 Disclaimer

Elephant Robotics shall reserve the right to upgrade the product without prior notice to continuously improve its reliability and performance. We strive to ensure the accuracy and reliability of the contents of this manual, but not responsible for any errors or omissions.

Faults caused by the following are not covered by this warranty :

1. Installation, wiring and connection of other control equipment failure to follow instructions of the user manual ;
2. Exceed the specifications or standards shown in the user manual when using ;
3. Damage caused by improper transportation ;
4. Damage caused by accident or collision ;
5. Damage caused by natural disasters such as earthquakes, floods, fire .
6. Faults other than those mentioned above which are not caused by Elephant Robotics ;

## 3. Inspection of Package

### 3.1 List of Items in the Box

No.	Shipping List	Quantity
1	Elephant Robotics®Module MS Series (Packed with cardboard box and sponge)	1
2	Instruction	1
3	Testing Report	1
4	Certification	1
5	Warranty	1

### 3.2 Product Photo Show

## 4. Description

Elephant Robotics® Module MS Series integrates harmonic reducer, frameless torque motor, electromagnetic friction disc brake, incremental encoder, absolute encoder, servo driver together. Its structure is compact and easy to install.

Its accuracy of the absolute encoder on output is  $0.1^\circ$  (mechanical) and the repetitive positioning accuracy is  $0.001^\circ$  (mechanical).

### 4.1 Harmonic Reducer

Parameter Type	Name	Unit	MS14	MS17	MS20	MS25	MS32
Reducer Parameter	Reduction Ratio	---	101	101	101	101	161
	Reducer Back Lash	arcsec	10	10	10	10	10
	Rotation Accuracy	arcmin	1	1	1	1	1

PS: Reduction Ratio is optional, this is the default configuration.

### 4.2 Frameless Torque Motor

Parameter Type	Name	Unit	MS14	MS17	MS20	MS25	MS32
Electrical Parameters of Motor	Motor pole logarithm	---	8	8	8	14	14
	Motor Rated Power	W	32	73	160	323	589
	Motor Rated Voltage	V	48	48	48	48	48
	Motor Rated Current	A	1.15	2.6	5.7	12	21
	Motor Rated Rotating Speed	rpm	2800	2800	2800	2500	3200
	Motor Rated Torque	Nm	0.197	0.4	0.83	1.86	2.7
	Motor Torque Constant	Nm/A	0.176	0.153	0.144	0.16	0.13
	Back-Emf Coefficient	V/krpm	0.0198	0.0173	0.0158	0.02	0.01

### 4.3 Servo Driver

1). As shown in the following picture, the driver of Robotic Module is a low voltage dc all-digital servo driver with high performance, high precision and multi-function developed by the advanced FPGA technology.

2). Integrated into Robotic Module, has 48V dc power supply and CAN/EtherCAT bus control.

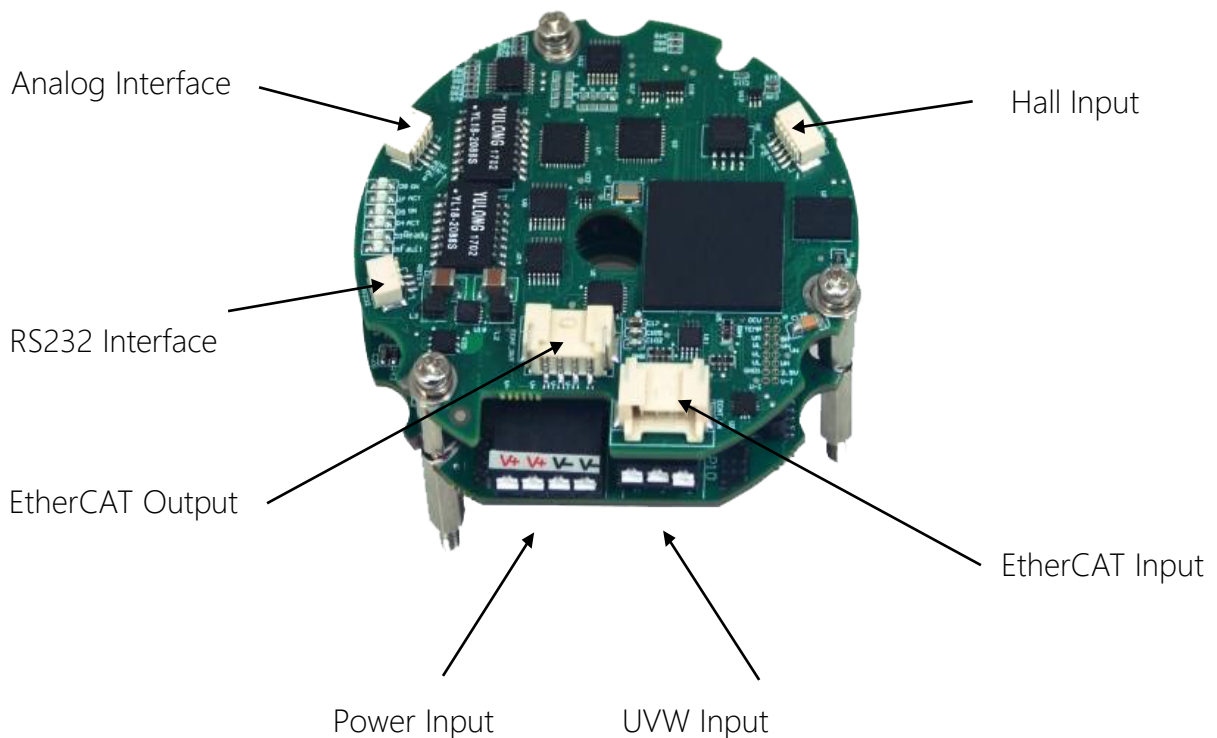
3). Equipped with comprehensive safety protection design of overcurrent, overtemperature, overvoltage and undervoltage, overspeed, blocking, position out of tolerance, short circuit, I2t, control error, etc..

4). Use feedback input of double encoder to realize full closed-loop control, including the position, velocity and current of Robotic Module.

5). Stable operation and good compatibility, has high dynamic speed response.

6). Through the driver debugging software, customers can easily set the driver and motor parameters, adjust the position, speed and current loop parameters of the PID to play out the good performance of Robotic Module.

### 4.4 Interface Description of Drives



### 1. Power Interface

PIN	Name	Description
V+	Power Supply 48V+	Positive Power Input
V-	Power Supply 48V-	Negative Power Input

### 2. Motor Interface

PIN	Name	Description
U	Motor U Phase	Motor U Phase
V	Motor V Phase	Motor V Phase
W	Motor W Phase	Motor W Phase

### 4. Brake Interface

PS: There is a Brake mark in the interface, don't connect the resistance to avoid the drive burning.

PIN	Name	Description
1	+	Connect Electromagnetic Friction Disc Brake+
2	-	Connect Electromagnetic Friction Disc Brake-

### 4. Incremental Encoder Interface

PIN	Name	Description
1	GND	Ground
2	5V	Internal Supply of Logic Power 5V
3	Z-	Differential Encoder Z-
4	Z+	Single-ended Encoder Z, Differential Encoder Z+
5	B-	Differential Encoder B-
6	B+	Single-ended Encoder B, Differential Encoder B+
7	A-	Differential Encoder A-
8	A+	Single-ended Encoder A, Differential Encoder A+

### 5. Absolute Value Encoder Interface

PIN	Name	Description
1	5V	Internal Supply of Logic Power 5V
2	GND	Ground
3	SL+	Absolute Value Encoder Data Signal
4	SL-	Absolute Value Encoder Data Signal
5	MA+	Absolute Value Encoder Clock Signal
6	MA-	Absolute Value Encoder Clock Signal

### 6. Hall Signal Interface

PIN	Name	Description
1	GND	Ground
2	5V	Internal Supply of Logic Power 5V
3	HW	Digital Hall Signal - Hall 3
4	HV	Digital Hall Signal - Hall 2
5	HU	Digital Hall Signal - Hall 1

### 7. EtherCAT Communication Interface

PIN	Name	Description
1	RX+	EtherCAT Data Receive +
2	RX-	EtherCAT Data Receive -
3	TX+	EtherCAT Data Transmit +
4	TX-	EtherCAT Data Transmit -

### 8. RS232 Communication Interface

PIN	Name	Description
1	GND	Ground
2	RX	RS232 Data Receive
3	TX	RS232 Data Transmit

### 9. Analog Input Interface

PIN	Name	Description
1	GND	Ground
2	5V	Internal Supply of Logic Power 5V
3	ANI-	+/-10V Analog-
4	ANI+	+/-10V Analog+

### 10. Digital Input Interface

PIN	Name	Description
1	IN 2	Input 2
2	OUT 6	Output 6
3	GND	Ground

### 11. Regenerative Resistor Interface (Resistor mark in the interface)

PIN	Name	Description
1	R+	Regenerative Resistor+
2	R-	Regenerative Resistor-

## 4.5 Encoder

1). Elephant Robotics® Module MS Series adopts 19-bit Biss feedback, which can achieve the repeated positioning accuracy of 0.001° .

2). Elephant Robotics® Module MS Series has an encoder at the input and output ends of reducer. The magnitude of external forces on the joint where the module is located can be determined , based on the comparison of the position and speed feedback of the two encoders. Then feeding external forces value to the controller, safety control of robots can be easily realized without additional auxiliary sensors.

Parameter Type	Name	Unit	MS14	MS17	MS20	MS25	MS32
Encoder	Incremental Encoder	P/R	20000	20000	20000	20000	20000
	Absolute Value Encoder	Bit	16/19	16/19	16/19	16/19	16/19

## 4.6 Brake

1). Elephant Robotics® Module MS Series is equipped with spring-actuated brake; which means that when not energized, the brake can prevent the rotation of reducer input shaft.

2). Under the normal operating conditions, when the drive is used by the user controller, the brake coil will pull-in the brake pad with a "click" sound. After the brake is released, the movement of motor is available. Similarly, when the drive is disabled by the user controller, the coil will be powered off, then the brake pad will push away by springs with a "click" sound.

PS: the user controller only needs to send IO signal to release and close brake.

3). MS module cannot rotate without power, but when the users fails to power the module drive or the drive fails to release the brake through IO control, and users need to manually rotate the MS module. Users should remove the brake connector from driver and connect it to adjustable power, then turn the power up from 0V with a maximum of 48V, after a "click" sound release turn the adjustable power down to 10V, then users can rotate the module to target position.



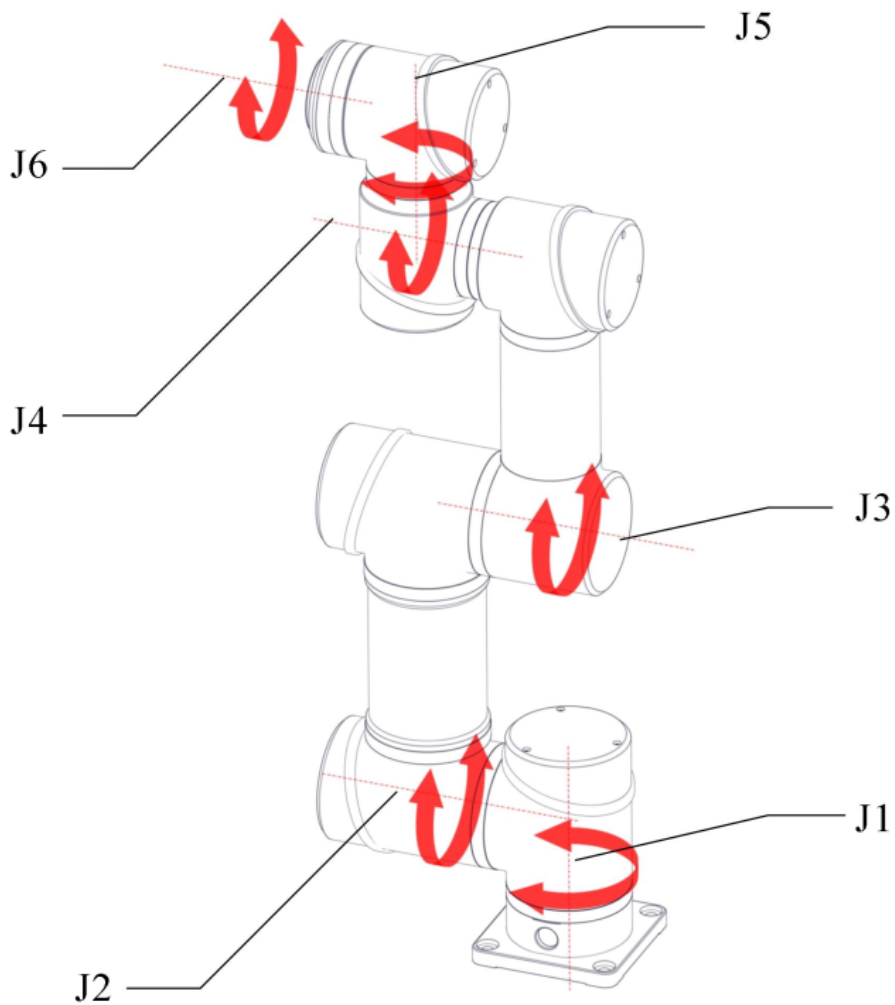
## 5. Specification & Operation Requirements

### 5.1 Module Parameter

Parameter Type	Name	Unit	MS14	MS17	MS20	MS25	MS32
Module Size	Diameter	mm	80	86	100	125	158
	Height	mm	96	98.5	114.5	144.5	176
	length	mm	116.74	137.57	148.05	157.97	188.47
Module Output	Allowable Load Torque	nm	28	54	82	157	333
	Average Load Torque	nm	13.5	39	49	108	216
	Maximum Instantaneous Torque	nm	54	86	147	284	647
	Rated Speed	rpm	25	25	25	22	18
	Maximum Speed	rpm	28	28	28	25	20
	Load cycle (as shown in appendix table 1) : continuous torque capability at rotation speed based on joint size and load cycle percentage (%)						
Module Weight		kg					
Module Precision							

## 5.2 Module Configuration Recommendation

Robot Rated Load	Base	Shoulder	Elbow	Wrist 1	Wrist 2	Wrist 3
3KG	MS20	MS20	MS20	MS14	MS14	MS14
5KG	MS25	MS25	MS25	MS14	MS14	MS14
10KG	MS32	MS32	MS25	MS17	MS17	MS17



### 5.3 Module Power and Current

The rated operational voltage of Elephant Robotics®Module MS Series is 48VDC (the minimum is 40VDC and the maximum is 56VDC). Voltage failure may occurs when bus voltage exceeds 56VDC. It is recommended that a discharge circuit be added to the power supply (For example, add regenerative resistors and capacitors to the power supply, you can refer to the 5.5 regenerative warning).

According to 6 degree of freedom(dof) manipulator with standard payload test, the following table lists the current of each type of Elephant Robotics®Module MS Series:

Type	Supply voltage (VDC)	Average Current (A)	Peak Current (A)
MS14	48(±10%)	0.5-0.8	1.1
MS17	48(±10%)	1-1.5	2.6
MS20	48(±10%)	1.5-3.2	5.8
MS25	48(±10%)	5-6	12.5
MS32	48(±10%)	7-9	15.2

PS: The above table is the limit current value of a single joint under the condition of maximum load and maximum speed. But during normal robot motion, not all joints consume these currents at the same time. As a reference, the power supply specifications for the 6-axis robot under standard load are listed below:

Recommended power specifications for classical configurations of robots.

DOF	Payload (KG)	Voltage (VDC)	Power (W)
6	3	48	500
6	5	48	1000
6	10	48	1600

## 5.4 Module Power and Communication Line

Elephant Robotics® Module MS Series comes with six or four cables (four in CAN and six in EtherCAT) through the hole of reducer output shaft, making users easily connect and communicate between robot modules in a "Daisy Chain" form.

12AWG /18AWG /20AWG Red(+) and 12AWG /18AWG /20AWG Black(-) supply 48VDC power to the next joint. The twisted pair wire with 28AWG white (high) and 28AWG green (low) enables communication to the next joint through CAN (28AWG red, black, green, and white 4 lines enable communication to the next joint through EtherCAT).

PS: In module installation operation, like bolt two MS joint modules together, extreme care must be taken to avoid damaging these cables.

Size/Color/Function List of "Daisy Chain" Cable:

Name		Color	Specification				
			MS14	MS17	MS20	MS25	MS32
Power Cable	48VDC+	Red	(20AWG)0.5 mm <sup>2</sup>		(18AWG)0.8 mm <sup>2</sup>	(16AWG)1.3 mm <sup>2</sup>	
	48VDC-	Black	silicone wire		silicone wire	silicone wire	
EtherCAT	RX+	Red	(26AWG)0.12 mm <sup>2</sup> Teflon silver plated wire				
	RX-	White					
	TX+	Yellow					
	TX-	Black					
CANopen	CAN_H	White					
	CAN_L	Yellow					

## 5.5 Environment Requirement

The normal performance level of Elephant Robotics®Module MS Series can be achieved at room temperature of 25° C. Elephant Robotics®Module MS Series can be used not exceeding 50° C , but the performance and load cycle capacity will be reduced. In these cases, you need to monitor the joint and adjust the motion period to protect the gear of reducer.

Elephant Robotics®Module MS Series is suitable for fixed installation in general indoor industrial environment, not be used in applications with excessive dust, high impact and vibration (vehicles, etc.) or the presence of corrosive substances, explosive materials, or where vacuum operation is required. Please consult our technical staff for information on non-standard applications.

IP Level: Elephant Robotics®Module MS Series is suitable to achieve Protection Grade IP54 (Dust-Proof and Water-Proof). If you need to meet this requirement, please contact our technical staff.

## 5.6 Regeneration Warning

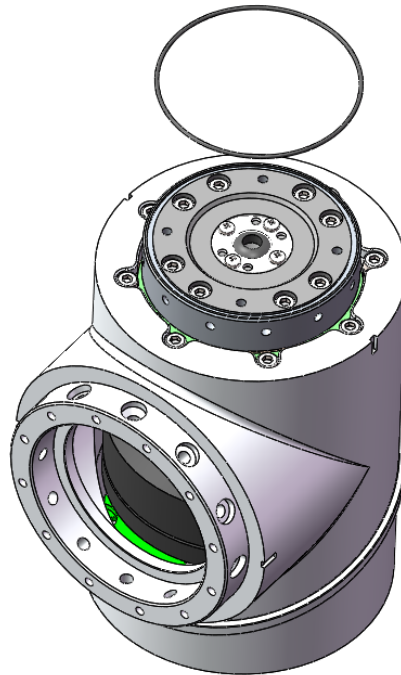
No.	Warning	Meaning	Solution
1	Short Circuit	Short circuit Protection for Drive	A discharge circuit shall be installed between the output end of 48V power supply and the main power input end to discharge the reverse electromotive force generated when the motor slows down.
2	Voltage Limited	Over voltage Protection for Drive	

## 5.7 Installation Requirement

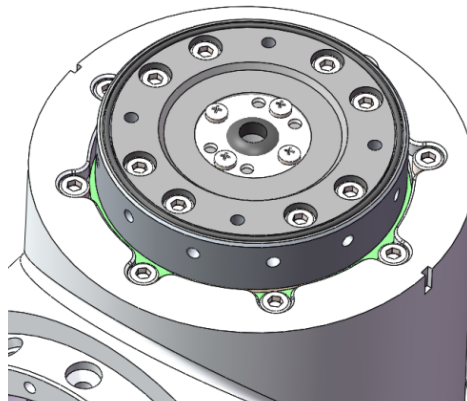
The required screw specifications and tightening torque when assembling multiple MS joint modules together or adding an arm to the output shaft of the MS joint module are listed in the following table. Hexagon screws with corrosion resistant coatings are recommended.

Installation Diagram:

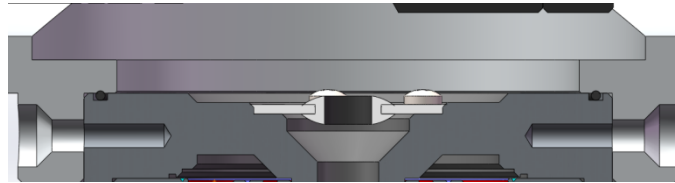
1. Apply a small amount of grease to the seal ring and place it in the seal groove corresponding to the end face.



2. Assemble the module output flange face of the installed sealing ring with the corresponding mating surface, and apply 100N pressure to flatten the sealing ring.



3. Place the corresponding countersunk head screws at the corresponding countersunk head hole, and initially lock the screws in the order of 1,2,3,4 (in the PICTURE 1), then place the cup head screws and lock the screws in the way of cross crossing as shown (in the PICTURE 2-6), and increase to the value of tightening torque corresponding to the screw equally four times.



Parameters of screws for Elephant Robotics®Module MS Series :

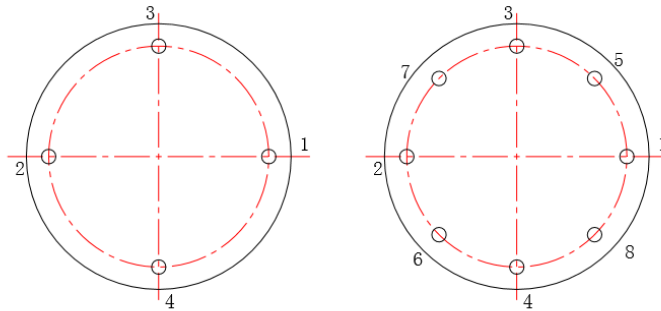
Type	Specification	Level	Tightening Torque	Quantity
MS14	Cup head hexagon socket screw M3X10	12.9	2N.m	8
	Flat head hexagon socket screw M3X10		2N.m	4
MS17	Cup head hexagon socket screw M3X10		2N.m	16
	Flat head hexagon socket screw M3X10		2N.m	4
MS20	Cup head hexagon socket screw M3X10		2N.m	8
	Flat head hexagon socket screw M3X10		2N.m	4
MS25	Cup head hexagon socket screw M4X12		4N.m	12
	Flat head hexagon socket screw M4X12		4N.m	4
MS32	Cup head hexagon socket screw M5X15		9N.m	12
	Flat head hexagon socket screw M5X15		9N.m	4

**ATTENTION:**

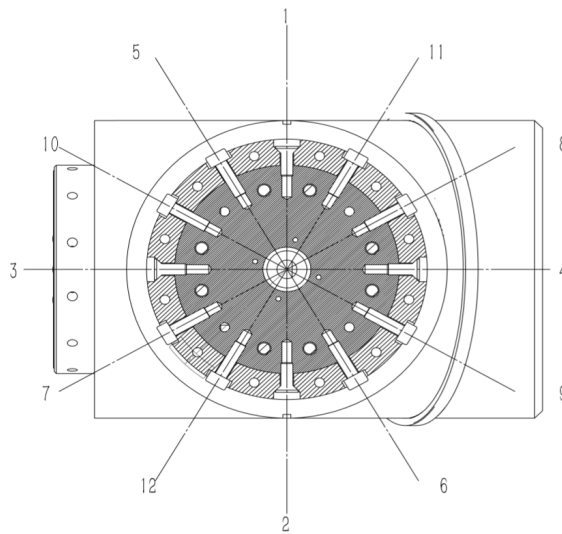
1. It is recommended to apply LOCTITE 243 thread adhesive to all screws to prevent them from loosening due to vibration.

2. The screws are locked in the form of a cross method, and the tightening torque of the screws is increased equally to four or five times.

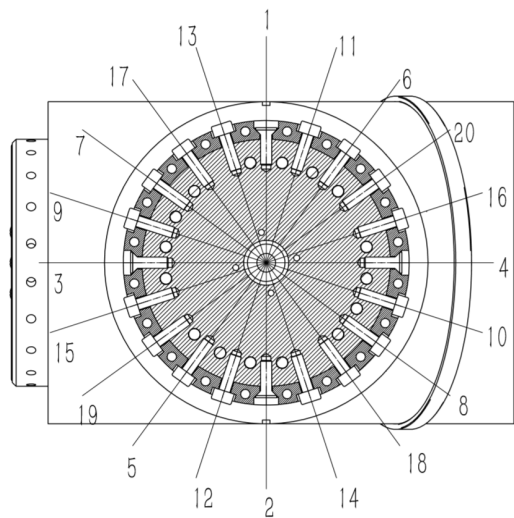
PICTURE 1: Way of Screw locking



PICTURE 2: MS14 --- Screw locking sequence diagram

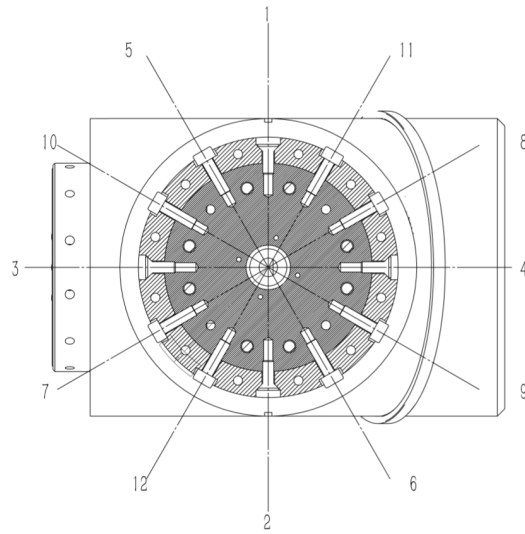


PICTURE 3: MS17 --- Screw locking sequence diagram

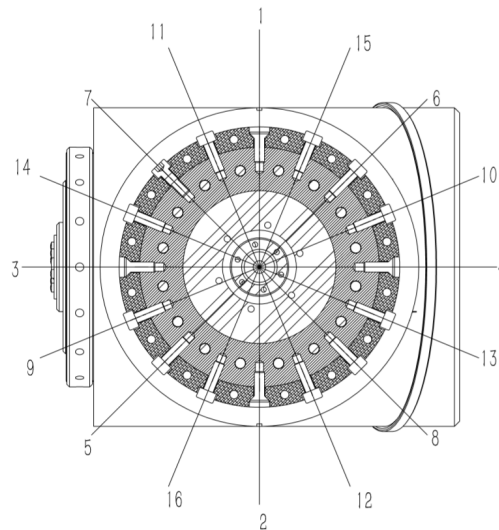




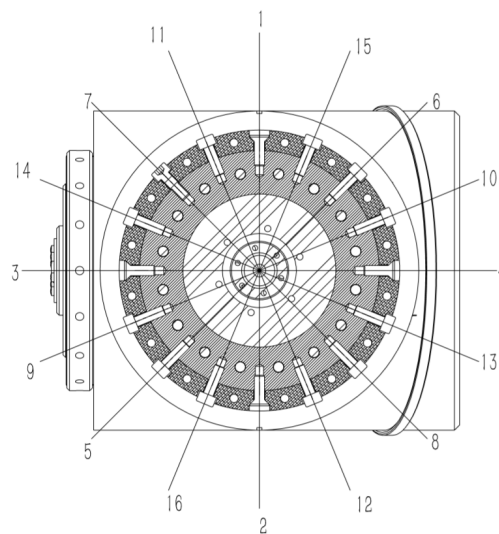
PICTURE 4: MS20 --- Screw locking sequence diagram



PICTURE 5: MS25 --- Screw locking sequence diagram



PICTURE 6: MS32 --- Screw locking sequence diagram



## 5.8 Installation Procedure

1). Remove 3 screws from the back cover of the joint.

2). Pass the joint power cord and communication wire through the next joint to be connected.

Arrange the wires so that the two joints do not press.

3). Place the two joints close together without squeezing them into the cable, install the joints together with equal force, then secure the screws listed in the table above.

4). Insert the red and black power cables into V+ (48V+) and V- (48V-), pull the cables to make sure they are tightly inserted. Then Insert the communication wire into the communication in port.

5). Remove the power cord and communication wire before removing the joint. When removing the power cord, use a small screwdriver to press the white spring of the connector and gently pull out the cable. Then remove the joint fixing screw, finally remove the joint with even force.

## 5.9 Rotation Limitation

Elephant Robotics® Module MS Series can be continuously rotated in either direction when used as a single axis. But when the device is assembled into a robot with multiple axes/degrees of freedom and a "Daisy chain" wire in the center of the output shaft is used to connect joints to joints or joints to arms, the maximum rotation Angle in either direction is +/- 360° (mechanical). If exceeded the angle limit, the wiring may be damaged and the warranty may be invalidated.

## 5.10 CAN Terminal

The CAN address and baud rate of Elephant Robotics® Module MS Series drive are assigned during debugging via the serial port (RS232 connector).

Note that the CANopen network requires a terminal resistor at the source device (the main station) and also at the last drive at the end of the network. When JP1 is short connected on PCB of MS driver, the 120 terminal resistor on the driver is connected and used. When JP1 is disconnected, the 120 terminal resistor on the driver is removed.

## 6. Software Debug

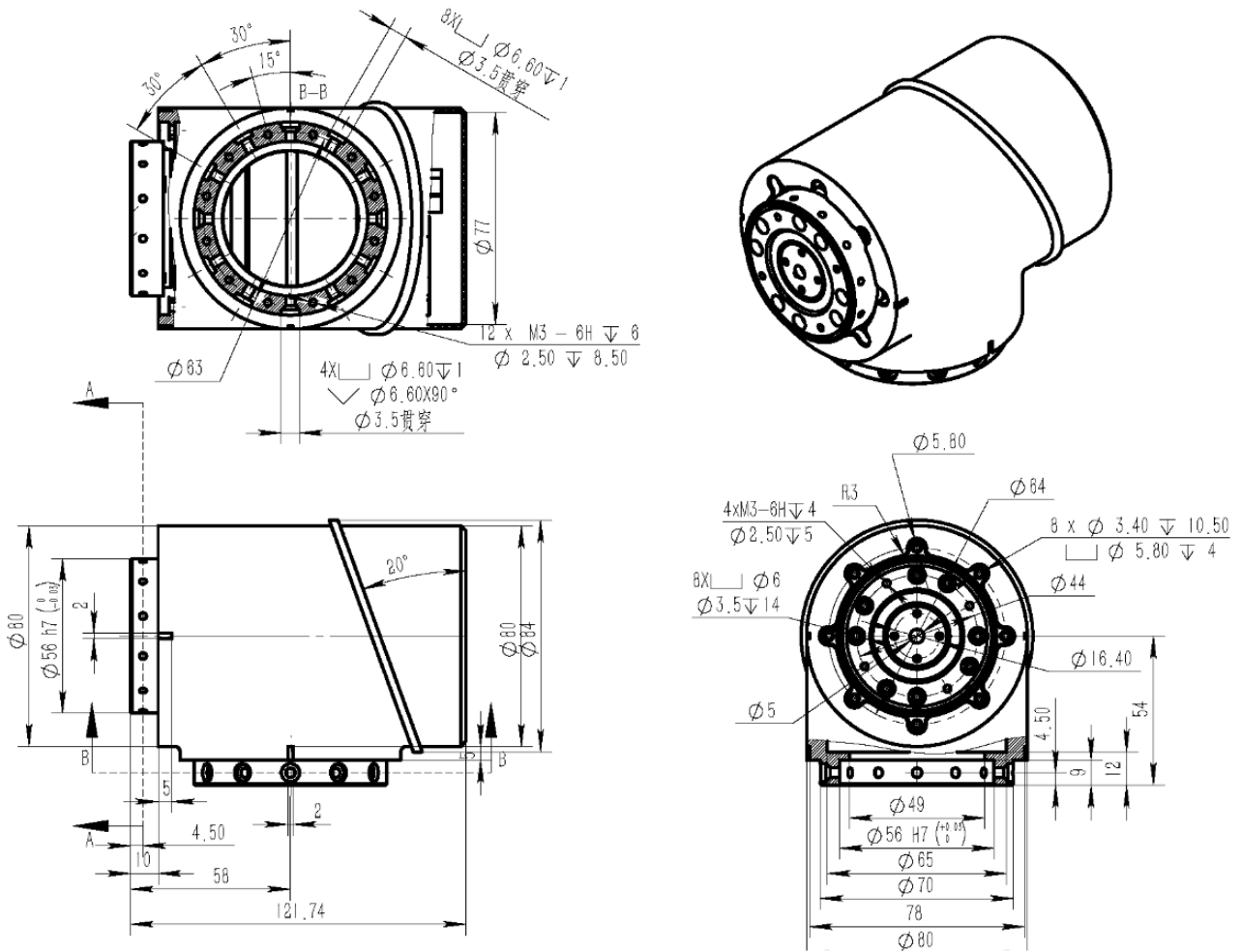
We will provide the EDS file of CANopen slave station for the user master station configuration for the CANopen joint module, and a slave station file in XML format for the user master station configuration for EtherCAT joint module. We also provide debugging upper software for users to read and set the basic parameters in the joint driver through the serial port, and the oscilloscope can monitor the operation data of the joint in real time. Please refer to the relevant module upper computer debugging instruction manual provided by our company. If there is any problem, please contact our technical department.

## 7. FAQ

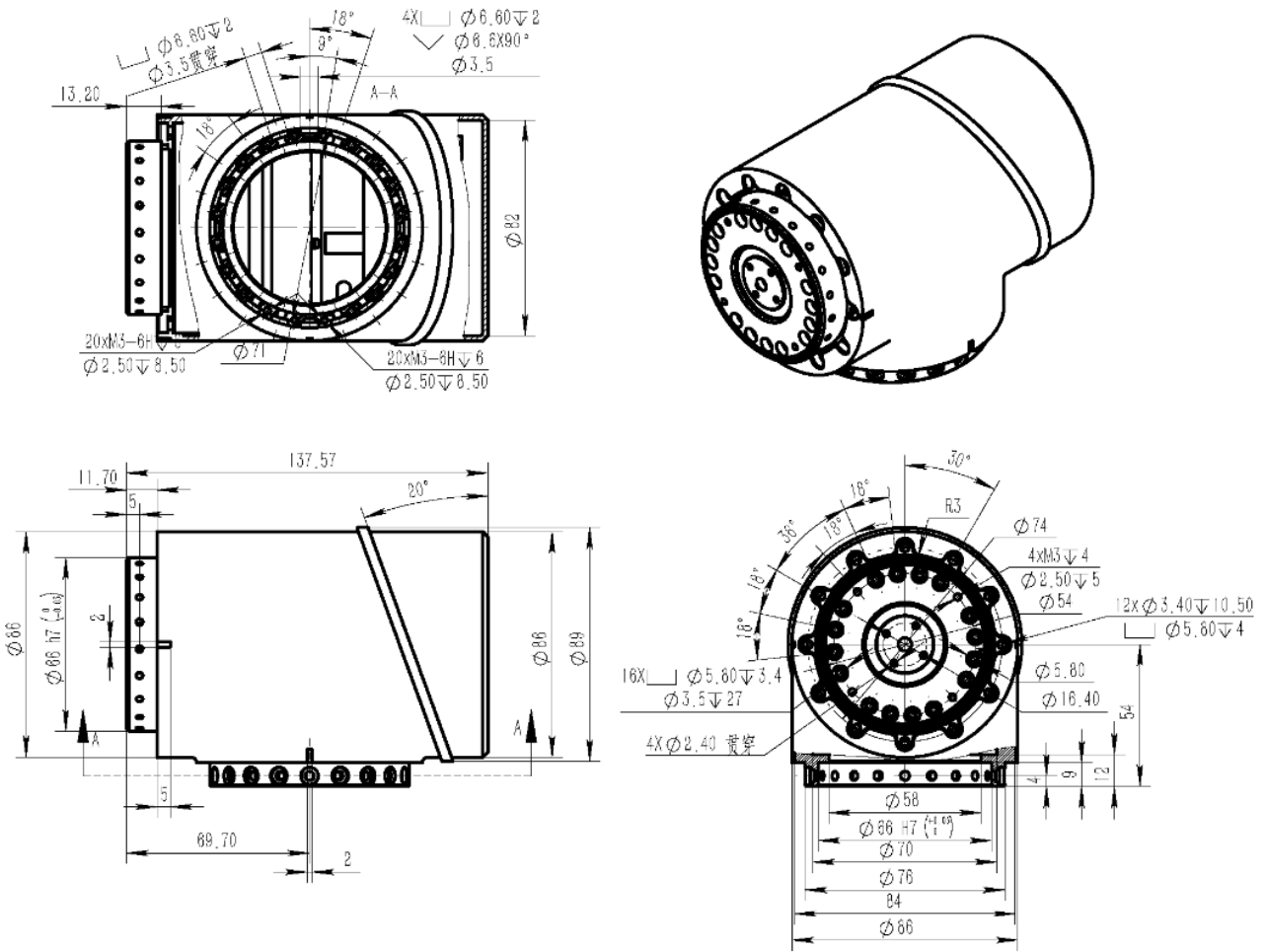
NO.	Question	Reason	Solution
1	The robot joints can be rotated by hand before being powered	Brake failure for joint module	Replace brake
2	Module is not normally energized when the power is switched on	Short circuit or connected V+/V- inversely	Check for short circuit, check for power supply
3	Abnormal communication	Poor communication line or terminal contact	Check the communication terminal for virtual welding or replugging
4	Following error	Exceed the following error set by the user	Reset the following error
		Speed and acceleration of some limiting poses are set too high	Reduces its use speed and acceleration
5	Abnormal encoder readings	The encoder wiring is loose or the encoder is damaged	Rewire the encoder or replace the encoder

## 8. Dimension

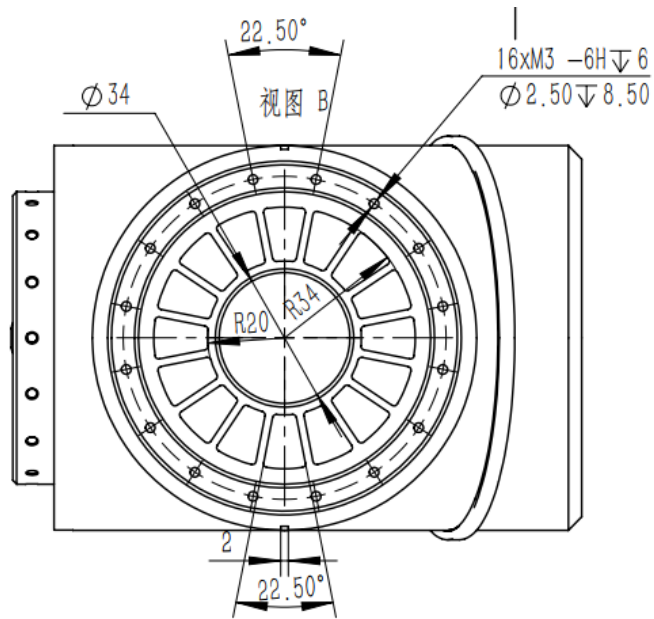
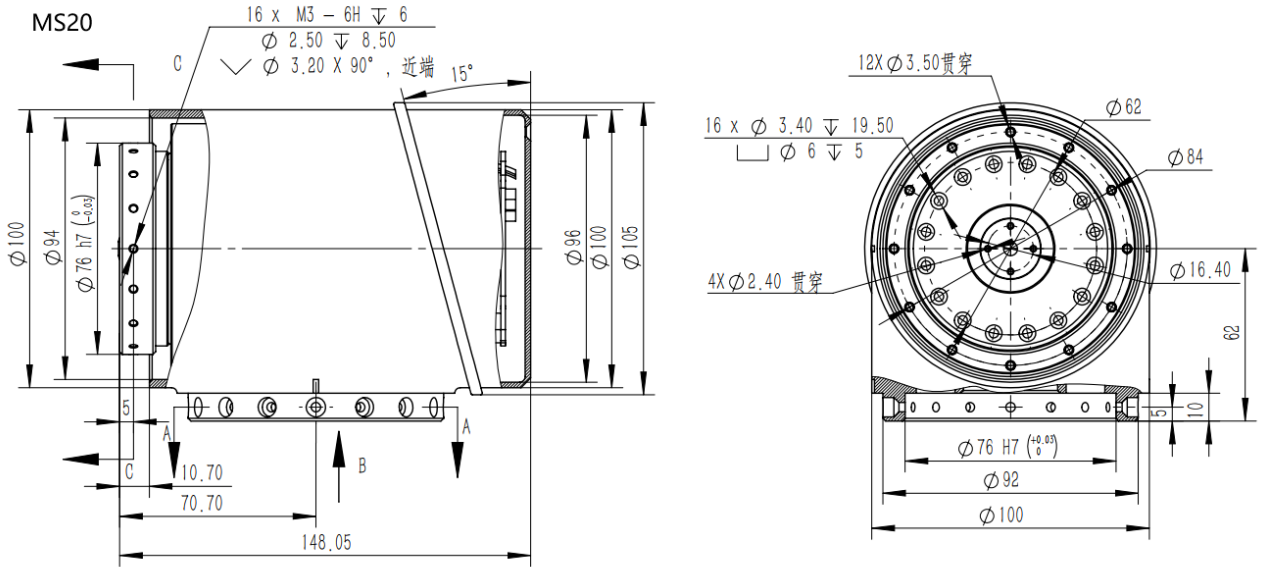
### 1). Dimension for Elephant Robotics® Module MS14



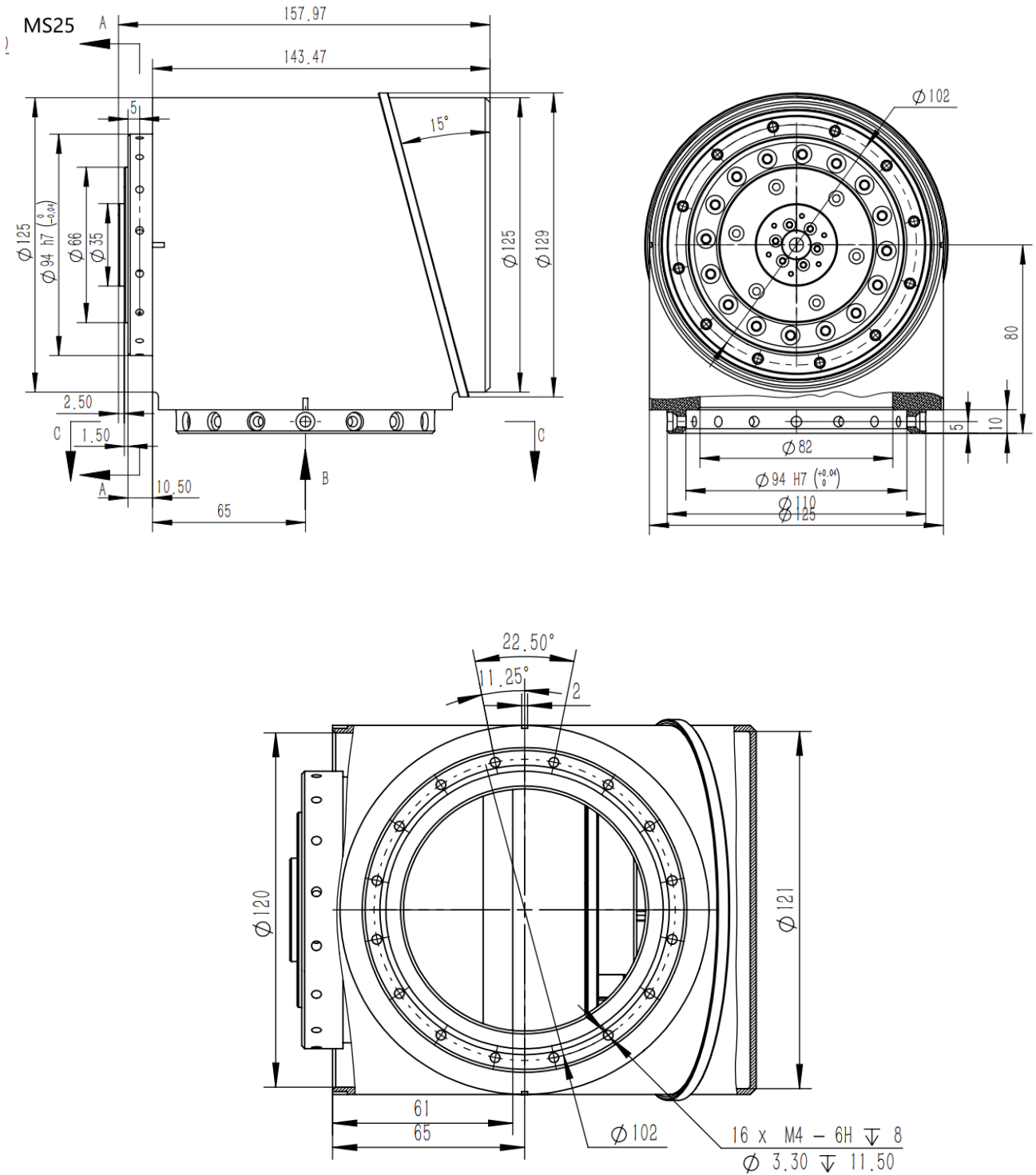
2). Dimension for Elephant Robotics® Module MS17



### 3). Dimension for Elephant Robotics® Module MS20



4). Dimension for Elephant Robotics® Module MS25



5). Dimension for Elephant Robotics® Module MS32

