RGM®

User Manual

Edition: C, May 2019

Part Number: 903-800006-00

Original Documentation

For safe and proper use, follow these instructions.
Keep them for future reference.

KOLLMORGEN®

Because Motion Matters™

Record of Document Revisions

Revision	Remarks
A, 10/2017	Launch version
B, 06/2018	RGM-C
C, 05/2019	EtherCAT 5A and 10A versions

Trademarks

- EtherCAT is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH
- Windows is a registered trademark of Microsoft Corporation

Current patents

- US Patent 8,154,228 (Dynamic Braking For Electric Motors)
- US Patent 8,214,063 (Auto-tune of a Control System Based on Frequency Response)

Patents referring to fieldbus functions are listed in the matching fieldbus manual.

Technical changes which improve the performance of the device may be made without prior notice!

Printed in the United States of America

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1 Table of Contents

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2 Introduction to RGM

2.1 General

2.1.1 About this manual

This manual describes the RGM robotic joint modules. Each RGM combines a frameless torque motor, low voltage DC drive, brake, strain wave gear, dual feedback system, and a thermal sensor in a single joint assembly to be used in a robot configuration. Please review the entire manual which includes information on:

- Power
- Speed and Torque Ratings
- Duty Cycle
- Rotation Limits
- Thermal Ratings and Monitoring Thermistor
- Brake Function
- Installation and Mounting
- Rear Cover Removal and Daisy Chaining
- Wiring
- RGM EWV
- CANopen
- End Effectors

2.2 Safety

This section helps you to recognize and avoid dangers to people and objects.

2.2.1 You should pay attention to this

Specialist staff required!

Only properly qualified personnel are permitted to perform such tasks as transport, assembly, setup and maintenance. Qualified specialist staff are persons who are familiar with the transport, installation, assembly, commissioning and operation of motors and who bring their relevant minimum qualifications to bear on their duties:

- Transport: only by personnel with knowledge of handling electrostatically sensitive components.
- Mechanical Installation: only by mechanically qualified personnel.
- Electrical Installation: only by electrically qualified personnel.
- Setup: only by qualified personnel with extensive knowledge of electrical engineering and drive technology

The qualified personnel must know and observe IEC 60364 / IEC 60664 and national accident prevention regulations.

Read the documentation!

Read the available documentation before installation and commissioning. Improper handling of the motor can cause harm to people or damage to property. The operator must therefore ensure that all persons entrusted to work on the motor have read and understood the manual and that the safety notices in this manual are observed.

Pay attention to the technical data!

Adhere to the technical data and the specifications on connection conditions (rating plate and documentation). If permissible voltage values or current values are exceeded, the motors can be damaged, for example by overheating.

Perform a risk assessment!

The manufacturer of the machine must generate a risk assessment for the machine, and take appropriate measures to ensure that unforeseen movements cannot cause injury or damage to any person or property. Additional requirements on specialist staff may also result from the risk assessment.

Transport safely!

Lift and move motors with more than 20 kg weight only with lifting tools. Lifting unassisted could result in back injury.

Hot surface!

The surfaces of the motors can be very hot in operation, according to their protection category. Risk of minor burns! The surface temperature can exceed 100°C. Measure the temperature, and wait until the motor has cooled down below 40°C before touching it.

2.3 Package

2.3.1 Delivery Package

- Joint from the RGM series
- RGM Flyer

2.4 Important Brake Usage Guidelines

⚠WARNING

The RGM brake is designed for use as a static holding brake (park brake) only. It is not intended to be used as a dynamic brake or to be suddenly engaged while the RGM is moving. Permanent damage to brake assembly components may occur if brake is engaged while still in motion.

During controller and application software development, software bugs may cause trajectory errors or other types of errors. These errors may trigger unexpected events that cause the drive to fault and disable, suddenly engaging the brake while RGM is in motion. To avoid accidental damage, it is recommended during development activities that users configure the fault event actions using RGM Workbench to “NONE” or set the range where the event is triggered to a value that is well outside normal operation. Fault event actions can be reset to operational values after the development process is complete and the risk of accidental brake damage is minimized.

The user must determine whether the loss of functionality and lack of fault monitoring to protect the brake during development activities warrants the risk of increasing operational and safety concerns.

For assistance in disabling fault events, please contact Kollmorgen Applications Engineering.

3 Power Supply Voltage & Current Ratings

RGM requires 48 VDC nominal supply voltage (44 VDC minimum, 52 VDC maximum). The RGM drive will experience an Overvoltage fault at 55VDC. Kollmorgen recommends that an electrolytic capacitor with at least 15,000 microfarads capacitance be installed between the DC power supply and the first joint. It is also recommended that the power supply be capable of handling a regenerative load (i.e., a regen resistor in the power supply is turned on if the DC bus exceeds 52VDC). As a reference, for a 6 axis (6 DOF) robot, a switching DC supply with approximately 12 Amps (600W) capacity is suggested.

4 Rotation Limits

RGM joint assemblies may be rotated continuously in either direction when used as a single axis when the pass through wiring is not installed.. However, when assembled into a robot with multiple axes/degrees of freedom and the "daisy chain" wiring in the center of the output plate is used to connect joint-to-joint or joint-to-arm, the maximum rotation in either direction is +/- 360° mechanical. If this angular limit is exceeded, connecting wires may be damaged and the warranty will be voided.

5 Maximum Thermal Ratings

The gear used in RGM is the most thermally sensitive component in the assembly. **It is restricted to a maximum case temperature of 65°C.** Users are advised that when operating RGM in ambient temperatures higher than the standard rated temperature of 20°C, de-rated torque/speed performance should be expected and duty cycles should be adjusted lower than shown in Duty Cycle to prevent exceeding 65°C case temperature of the gearing. Otherwise, grease may be degraded and premature failure of the gearing may occur. If RGM is used outside the recommended thermal rating of the gearing, RGM warranty may be voided. RGM is equipped with an internal linear thermistor on the gearing case to assist customers with proper thermal and duty cycle management, so that maximum performance and longest life of RGM can be achieved.

6 Monitoring Thermistor

The thermistor in RGM is connected to the drive electronics printed circuit board inside the rear cover. When the user's computer/controller is communicating with RGM via the serial port or CANopen communication bus drive analog input 4 is the gear case (65°C max rating) thermistor. It is the user's responsibility to include provisions in the control system to monitor the thermistor at frequent intervals and take actions such as reducing speed of motion or reducing duty cycle to keep gear case temperature within rated limits.

Name	Index	Type	Access	Units	Range	Map PDO	Memory
Gear Thermistor	0x2206	INT16	RO	millivolts	-2^{15} to $+2^{15}-1$	T	R

7 Brake Function

Please be sure to review "Important Brake Usage Guidelines" (➜ p. 8)

RGM joints utilize a plunger and disc brake design. The brake disc spins with the motor. To engage the brake a plunger is moved such that it inhibits the motion of the brake disc. The brake is released by sending power to a solenoid which pushes the plunger against a spring to clear the spinning brake disc.

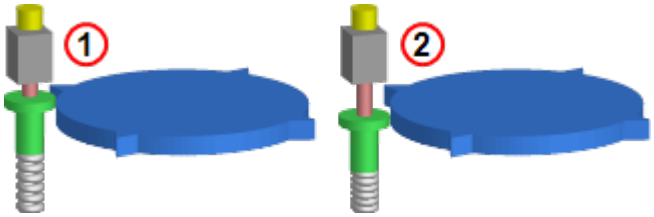


Figure 1: (1) The brake is engaged, (2) the solenoid is active, pushing the plunger clear of the brake.

The brake cannot be released when it is actively holding a load.

7.1 About the Brake Function

RGM is equipped with a power-off park brake, meaning that the brake is mechanically engaged and prevents rotation (within its inherent +/- 0.9° backlash characteristic) of the output plate when no power is applied. In normal operation, when the RGM drive is enabled by the user's controller, the energized brake coil will release, accompanied by an audible "click". Normal motion commands may be performed after the brake releases. In the same manner, when the RGM drive is disabled by the user's controller, power is removed from the coil and the brake will mechanically engage with an audible "click".

Brakes can be released in either of two ways:

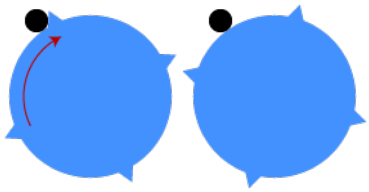
- "Manually Releasing the Brake" (➜ p. 11)
- "Servo Command to Remove Load" (➜ p. 12)

7.2 Manually Releasing the Brake

The brake may be manually released in order to rotate the output plate of the RGM unit by hand, when no power is available to electrically release the brake.

The brake cannot be released when it is actively holding a load.

The plunger (see "Brake Function" (➜ p. 10)) is under load and prevents the brake from being released. The RGM device needs to be rotated in the direction opposing gravity, ending between stops, so the plunger is no longer being engaged by the brake.



To begin you must first remove the three screws and the blue rear cover as shown.7.2 Manually Releasing the Brake

1. Lift the robot's arm a little bit and move it back and forth. Hold the arm in a neutral position.
   It will not move far due to the brake, but there is a small degree of movement available.
2. Push and hold the brake release button to engage the solenoid and compress the spring.

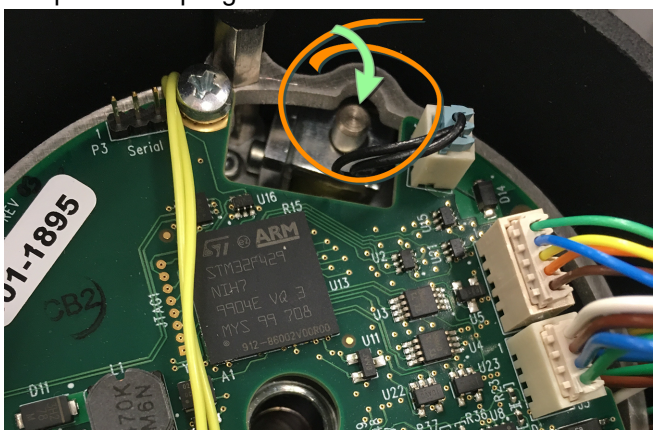
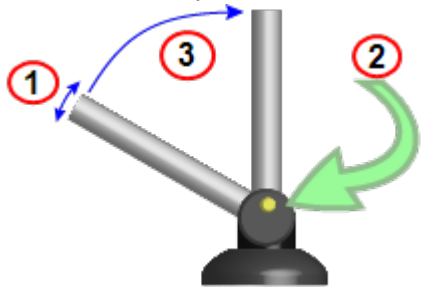


Figure 2: Push to release the RGM's brake.

3. Rotate the arm to a neutral or home position where there is no load on the device, such as straight up. As long as the button is held downward to keep the spring compressed, the user may manually rotate the unit to desired position.



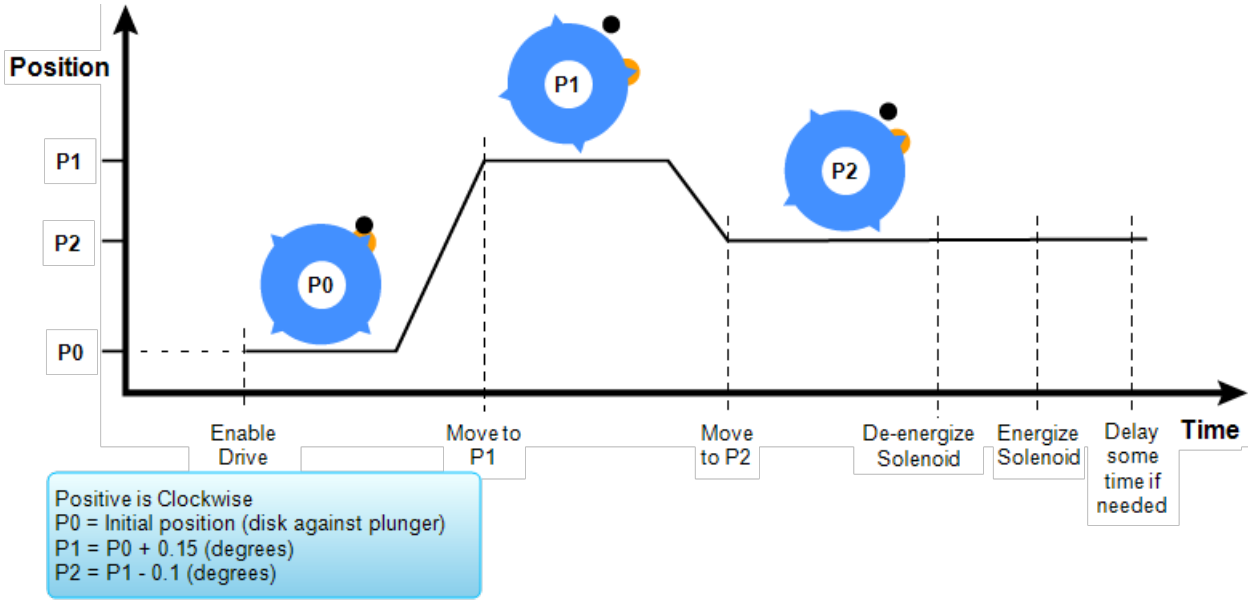
7.3 Servo Command to Remove Load

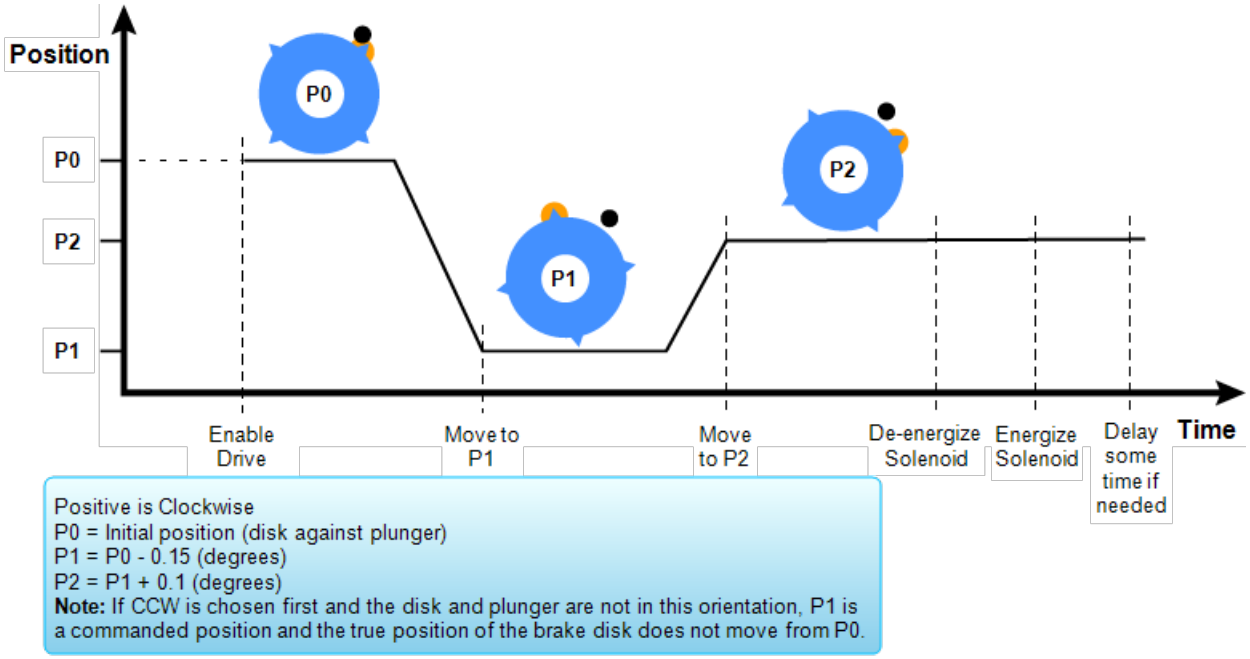
The brake cannot be released when it is actively holding a load.

A servo command may be used to move the arm off of the plunger.

- If a dynamic model is used, issue a servo command in the correct direction.
- If a dynamic model is not used, the correct direction to remove the braking force from the plunger is unknown, therefore use the method outlined below to remove the braking force from the plunger.

The plunger (see "Brake Function" (➜ p. 10)) is under load and prevents the brake from being released. A series of two moves, clockwise then counter-clockwise or vice versa, may be performed to remove the force of the brake from the plunger, ending between stops, so the plunger is no longer being engaged by the brake.





7.3.1 Brake Release Steps

1. **Enable the drive**
2. **Calculate motion 1 according to actual position**
   BrakeOffset1 := 0.15;
   GVL.RGM1_BrakeControlPosition_Fwd := LREAL_TO_REAL(Axis1.ActualPosition + BrakeOffset1);
3. **After motion 1 is finished, calculate motion 2**
   BrakeOffset2:= 0.1;
   GVL.RGM1_BrakeControlPosition_Back := LREAL_TO_REAL(axis1.ActualPosition - BrakeOffset2);
4. **After motion 2 is finished, de-energize the solenoid**
   set 0x2193.1=0, delay time 200ms
5. **Energize the solenoid**
   set 0x2193.1=0x40000100h, delay time 300ms

7.3.2 Solenoid Digital Output Commands

CANopen Object	0x2193.01h
Variable Type	LWORD
Support SDO, PDO	both supported
Default Value	0x40000100h, this means once drive is enabled, brake will power on automatically. If you are mapping it to PDO, the default variable value will be set to zero. Make sure 2193.01=0x40000100h before enabling

Once joint is enabled:

Set 0x2193.1=00 00 00 00 00 00 =0x0h, power off brake

Set 0x2193.1=00 01 00 40 00 00 = 0x40000100h, power on brake, brake is released

7.3.3 Example with Keba Teach Pendant

```
backforward
WaitTime(2000)
//DynOvr(20)
MoveRobotAxis(A1, IEC.RGM1_BrakeControlPosition_Fwd)
MoveRobotAxis(A2, IEC.RGM2_BrakeControlPosition_Fwd)
MoveRobotAxis(A3, IEC.RGM3_BrakeControlPosition_Fwd)
MoveRobotAxis(A4, IEC.RGM4_BrakeControlPosition_Fwd)
MoveRobotAxis(A5, IEC.RGM5_BrakeControlPosition_Fwd)
MoveRobotAxis(A6, IEC.RGM6_BrakeControlPosition_Fwd)
WaitIsFinished()
WaitTime(100)
IEC.BrakeMoveForwardIsDone := TRUE
WaitTime(100)
MoveRobotAxis(A1, IEC.RGM1_BrakeControlPosition_Back)
MoveRobotAxis(A2, IEC.RGM2_BrakeControlPosition_Back)
MoveRobotAxis(A3, IEC.RGM3_BrakeControlPosition_Back)
MoveRobotAxis(A4, IEC.RGM4_BrakeControlPosition_Back)
MoveRobotAxis(A5, IEC.RGM5_BrakeControlPosition_Back)
MoveRobotAxis(A6, IEC.RGM6_BrakeControlPosition_Back)
WaitTime(100)
WaitIsFinished()
IEC.BrakeMoveIsDone := TRUE
WaitTime(100)
>>>EOF<<<
```

7.3.4 Keba Brake Commands with 6 Axis

```
IF PowerIsOn AND GVL.BrakeMoveIsDone THEN
   mycount1 := mycount1 + 1;
   BrakeSignal_1 := 16#0;
   BrakeSignal_2 := 16#0;
   BrakeSignal_3 := 16#0;
   BrakeSignal_4 := 16#0;
   BrakeSignal_5 := 16#0;
   BrakeSignal_6 := 16#0;
   PowerIsOn := FALSE;
   GVL.BrakeMoveIsDone := FALSE;
   myVar1 := TRUE;
END_IF;

IF DelayTime1.Q THEN
   mycount2 := mycount2 + 1;
   myVar1 := FALSE;
   BrakeSignal_1 := 16#40000100;
   BrakeSignal_2 := 16#40000100;
   BrakeSignal_3 := 16#40000100;
   BrakeSignal_4 := 16#40000100;
   BrakeSignal_5 := 16#40000100;
   BrakeSignal_6 := 16#40000100;
   myVar2 := TRUE;
END_IF
```

After move 1 and 2 are done, cycle the brake solenoid.

BrakeSignal = 16#0 means solenoid is not energized

BrakeSignal = 16#40000100 means solenoid is energized

8 Bolting Joint-to-Joint, Mounting Screws

When assembling multiple RGM units together in a joint-to-joint configuration or adding an arm to the output plate of an RGM, the required screw sizes and tightening torque values are listed in the table below. Class 12.9 steel socket head cap screws are suggested, with a corrosion resistant coating such as Zinc. Stainless steel screws are not recommended due to their reduced strength.

RGM Mounting Screws

Model	Fastener Size	Torque (Nm)
RGM14	M3 x 8mm long SHCS	1.81
RGM17	M3 x 6mm long SHCS	1.81
RGM20	M3 x 8mm long SHCS	1.81
RGM25	M4 x 10mm long SHCS	4.29
RGM32	M5 x 14mm long SHCS	8.5

These fasteners are available as an RGM Customer Kit option.

NOTE

The application of removable thread locking adhesive to all screws is recommended.

9 Environmental Requirements

Normal performance ratings for RGM may be achieved in a room ambient temperature of 20°C. RGM may be used in ambient temperatures up to 40°C with de-rated performance and duty cycle capabilities. In such cases, it will be necessary to monitor the thermistor and adjust the motion cycle accordingly to protect the gearing. RGM is designed for stationary mounting in a general indoor industrial environment. RGM should not be used in applications where excessive dust, high shock and vibration (vehicles, etc.), corrosive substances, explosive materials or operation in a vacuum are required. See IP Rating for moisture resistance and IP rating details. Consult factory for non-standard applications.

10 IP Rating

RGM is designed to meet an IP54 rating (resistant to dust and splashing water) when properly installed using the rear cover gaskets, cover screws with o-rings, plastic joint-to-joint seal rings and joint-to-joint flexible seal bands (see Environmental Requirements), which are available for purchase from Kollmorgen as an accesory (RGMXX-CUST-KIT). The customer has responsibility for assuring proper fit of the rings and bands when assembled into the application and for properly installing and confirming a seal at the rear cover if it has been removed. The customer's hardware design must include proper sealing provisions (fit, o-ring, gasket, etc.) at the RGM mounting flange to achieve IP54 compliance.

11 Joint-to-Joint Connection of RGM Devices

Connecting RGM devices in a daisy chain is quite simple with a few basic steps.

1. Putting the plastic ring and flexible band on for IP protection.
2. Guiding the power and communication wires from one device through the second.
3. Bolting the devices together.
4. Connecting the wires.

These steps are covered in the following sections:

- "Joint-to-Joint Connection Instructions" (➜ p. 17)
- "Power and Communication Wiring Instructions" (➜ p. 21)

11.1 Joint-to-Joint Connection Instructions

This section provides instructions on connecting two RGM devices. Included in this process is the optional ring and band which provide an IP rated seal.

RGM units are provided with wires (4 for CAN, 6 for EtherCAT) that pass through the center of the gear output plate to make it easy for the user to “daisy chain” power and communication from one robot joint to the next. Red (+) and Black (-) provide 48VDC supply to the next joint. The twisted pair with White (High) and Blue (Low) provide CANopen or EtherCAT communication to the next joint. Great care must be taken to avoid damaging these wires when bolting two RGM assemblies together in a joint-to-joint configuration..

1. Remove the 3 screws and blue rear cover as shown in **Figure 3**.

Figure 3: Remove the blue cover.

2. Place the flexible band over the housing behind the output plate, as shown in **Figure 4**..

Figure 4: The flexible band is placed around the RGM device.

3. Place the plastic ring into the housing pilot at the output plate as shown in **Figure 5**. Confirm that the plastic ring is pushed inward until it is flush with the housing so it does not obstruct access to the threaded holes on the OD of the mounting plate.

Figure 5: The plastic ring is placed in the RGM device.

4. Route the incoming wires through the upper access hole in the housing as shown in **Figure 6**. Care must be taken to route them cleanly around the motor power wires that attach to the drive PCB in this same area.

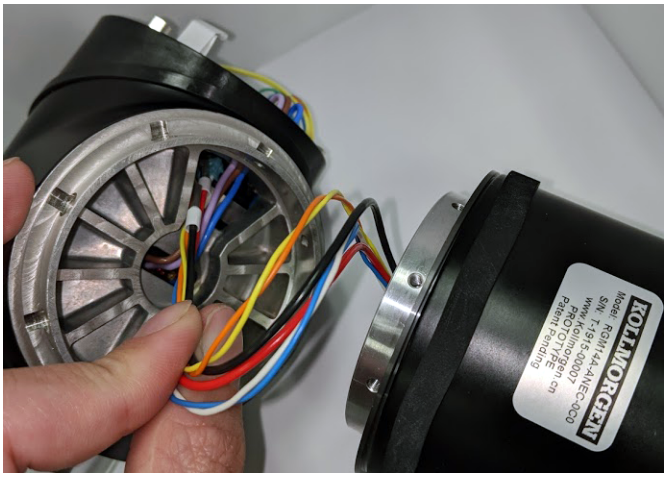


Figure 6: Routing wires between joints

5. As the two joints are gradually drawn together to reach their final bolting position, avoid slack and keep constant tension on the wires to avoid pinching or mashing them. See **Figure 7**.

Figure 7: Keep wires taut to avoid pinching

6. Align the screw holes so the devices may be joined.

Figure 8: Screw holes are aligned.

7. Apply a thread adhesive to the fasteners.
8. Bolt the two RGM devices together and torque them to the listed rating. See "Bolting Joint-to-Joint, Mounting Screws" (➜ p. 15)

Figure 9: Tighten the screws to the appropriate torque rating.

9. Slide the plastic ring over the fasteners until it touches the stationary flange of the second RGM device as seen in **Figure 10**.

Figure 10: The plastic ring is slid over the fasteners.

10. Move the flexible band over the plastic ring to hold it in place.

Figure 11: The flexible band secures the plastic ring in place.

11.2 Power and Communication Wiring Instructions

In order to complete joint-to-joint connection of RGM devices, they must be wired together.

RGM units are provided with wires (4 for CAN, 6 for EtherCAT) that pass through the center of the gear output plate to make it easy for the user to “daisy chain” power and communication from one robot joint to the next. Red (+) and Black (-) provide 48VDC supply to the next joint. The twisted pair with White (High) and Blue (Low) provide CANopen or EtherCAT communication to the next joint. Great care must be taken to avoid damaging these wires when bolting two RGM assemblies together in a joint-to-joint configuration..

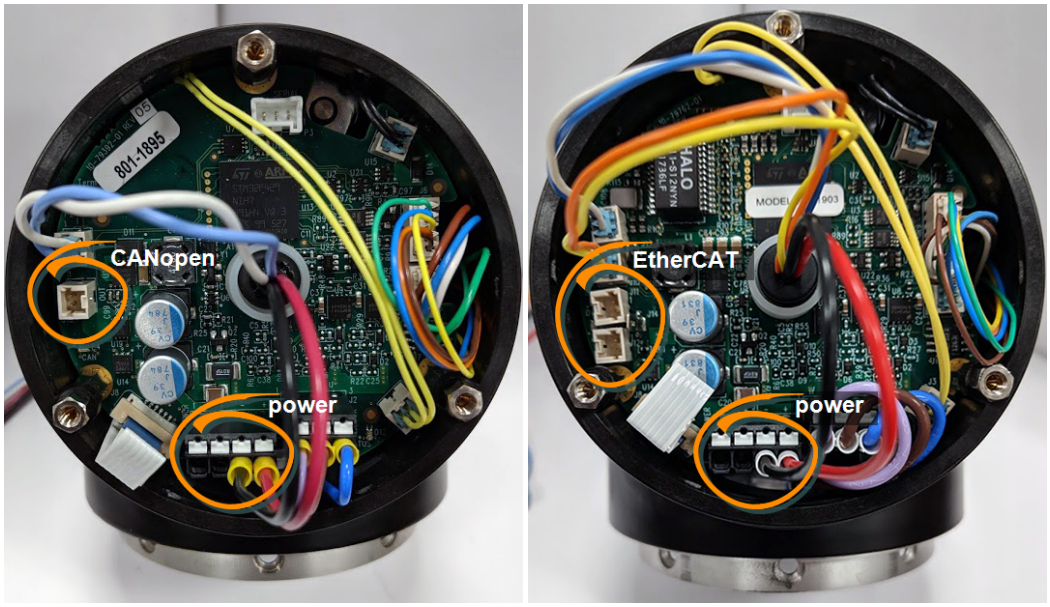


Figure 12: Examples of the CANopen and EtherCAT versions of RGM devices.

1. Insert the red and black power wires with ferrules into the vertical poke-in connector shown in **Figure 12**. Note polarity on the PCB silkscreen, insert red into the “+” position and black into the “-“ position. For easier assembly, be sure the smooth side of the crimped ferrule is facing the white spring side of the connector slot when pushing it in. See Board Layout (➜ p. 26) for a diagram of the PCB.
2. After insertion, give the wires a light tug to confirm they are properly inserted.

   TIP

   If the wire needs to be removed from the poke-in connector, push downward on the white spring portion of the connector with a small screwdriver and lightly pull upward on the wire until it releases.
3. Plug the CANopen or EtherCAT (blue and white twisted pair) into connector P1 on the drive PCB as shown in **Figure 13**. The connector is keyed and can only be inserted in one position.

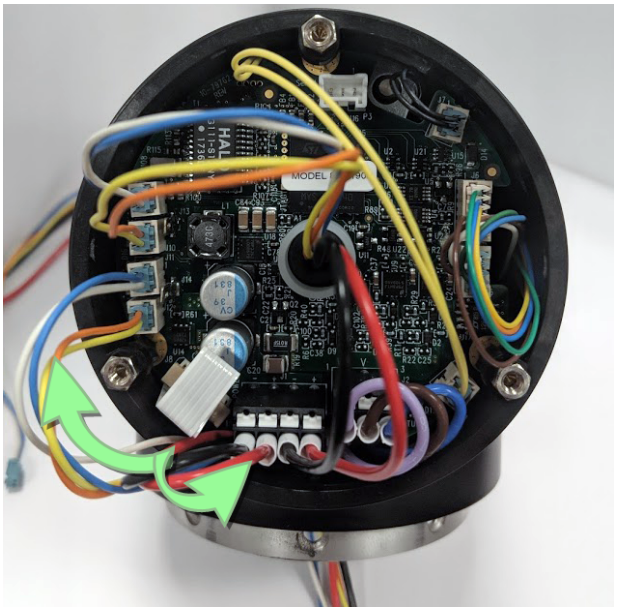


Figure 13: Example of an EtherCAT RGM showing cables coming through the housing.

12 Daisy Chain Wire Sizes, Colors, and Functions

Color	Function	Size				
		RGM14	RGM17	RGM20	RGM25	RGM32
Red	48 VDC Positive	20 AWG		18 AWG		
Black	48 VDC Negative	20 AWG		18 AWG		
White	CANopen RX+	24 AWG				
Blue	CANopen RX-	24 AWG				
Yellow	EtherCAT TX+	24 AWG				
Orange	EtherCAT TX-	24 AWG				

CANopen connector housing – TE part number 5-292271

TE crimp tool 937317-1

13 RGM Workbench Software & Drive Commissioning

Please refer to separate document "RGM Workbench User Manual" for software and interface instructions.

14 Serial Cable Part Number

A serial communication cable (part #969745) is available for purchase from Kollmorgen.

15 CANopen Termination

RGM drive CAN addresses are assigned electronically via the serial port (connector P3) during the commissioning process. See separate documents for further instructions.

- RGM Workbench User Manual
- RGM CANopen Manual

Note that the CANopen network requires 1 termination resistor at the source (master) and 1 termination resistor at the final drive at the end of the network. RGM drive PCB is equipped with a jumper resistor at connector location P2. Placing the jumper across both posts of connector P2 puts the termination resistor into the circuit. Removing the jumper or moving it to a position that only contacts one of the P2 posts will remove the termination resistor from the circuit.

16 Brake Initialization

When the RGM joint is enabled it is possible that, depending on the robot position, gravitational forces from the robot's weight can prevent the brake from disengaging. The recommended initialization sequence is to:

1. Enable the drive.
2. Then move the axis back and forth to insure the brake solenoid is fully retracted

The RGM uses a pin in spoke brake, a 4 spoke wheel is on mounted on the motor, this means there is a brake position every 90 degrees of the motor position or .89 degrees of the gear output. The pin which contacts the spokes during braking is activated with a solenoid. Power must be applied to the solenoid to release the brake. Once the solenoid is energized to release the brake, the controller needs to move (shake) the joint back and forth to ensure the brake pin is not hung on the brake wheel. The recommended move distance is +/- 0.5 degrees of gear motion.

Typical Motion Parameters

T move	Degree	Deg/sec	Deg/sec^2
0.05	1	40	1600
0.1	1	20	400
0.2	1	10	100

16.1 RGM Enable/ Brake Initialization Procedure

1. Controller Enables Drive, this turns on Power bridge and applies 48 Vdc to brake for 300 mseconds
2. Controller commands +/-.5-degree relative motions with motion time of .06 seconds
    1. +.5 degrees
    2. -.5 degrees
    3. +.5 degrees
    4. -.5 degree
3. Perform a longer move to insure brake is not stuck on the pin.

Times shown are typical

17 Regeneration Warning

A rotating motor has kinetic energy, regeneration occurs when the kinetic energy that was stored in the motor during motion is returned to the system during deceleration. This energy must be absorbed by the DC bus capacitors, which in turn raises the bus voltage or is dissipated by friction.

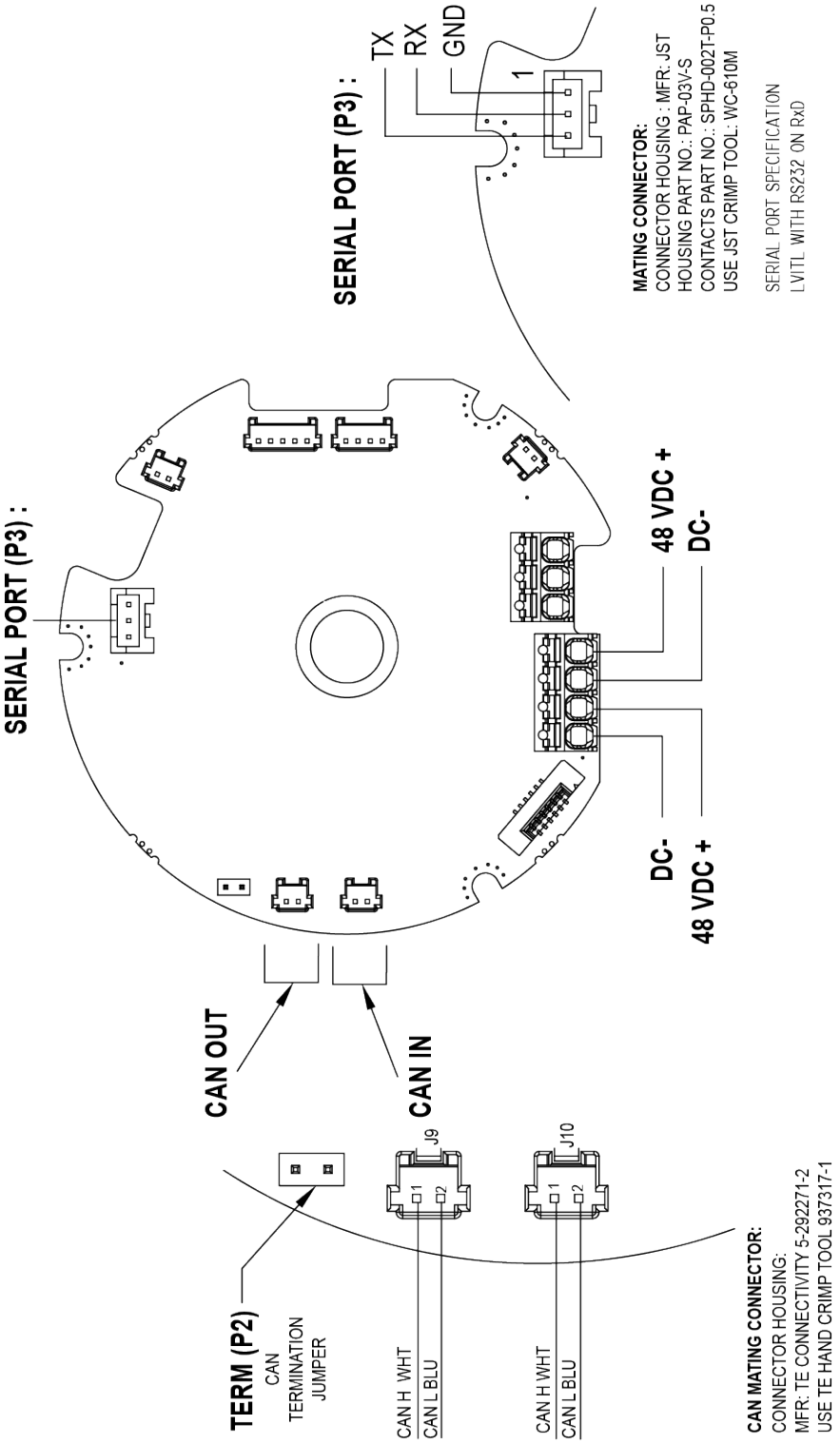
It is possible under certain conditions that regenerative action will raise the bus voltage above the RGM drives rated maximum voltage. If this occurs the drives will shut down with an over voltage fault. If regeneration does shut down the drive, the user will either need to modify the application by slowing down the process, or use a power supply with regeneration capability.

18 End Effectors

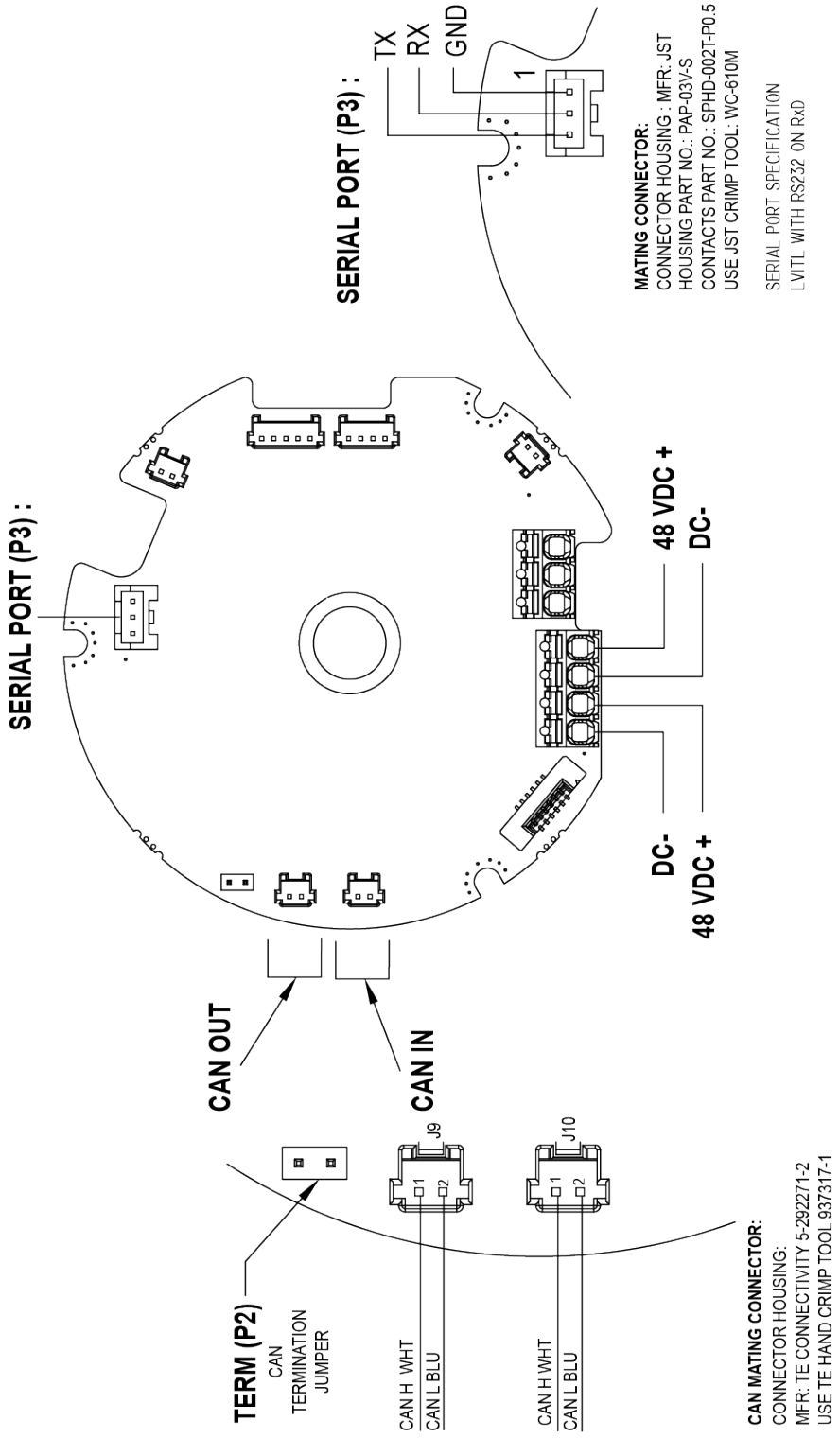
Kollmorgen does not currently offer tool mount or end effector accessories for RGM. If customers intend to design their own mechanical interface for mounting an end effector, mechanical dimensions of the RGM output plate can be found on the Kollmorgen website. If the end effector will rely upon the RGM daisy chain wiring for DC power, then motion of the output plate must be restricted to +/- 360°. If end effector power will be provided by another wiring path, and the RGM daisy chain will not be used for this purpose or connected to the end effector, then continuous rotation of the RGM output plate is possible. Customer is responsible for communication and I/O to the end effector external to the RGM wiring circuit.

19 Board Layout

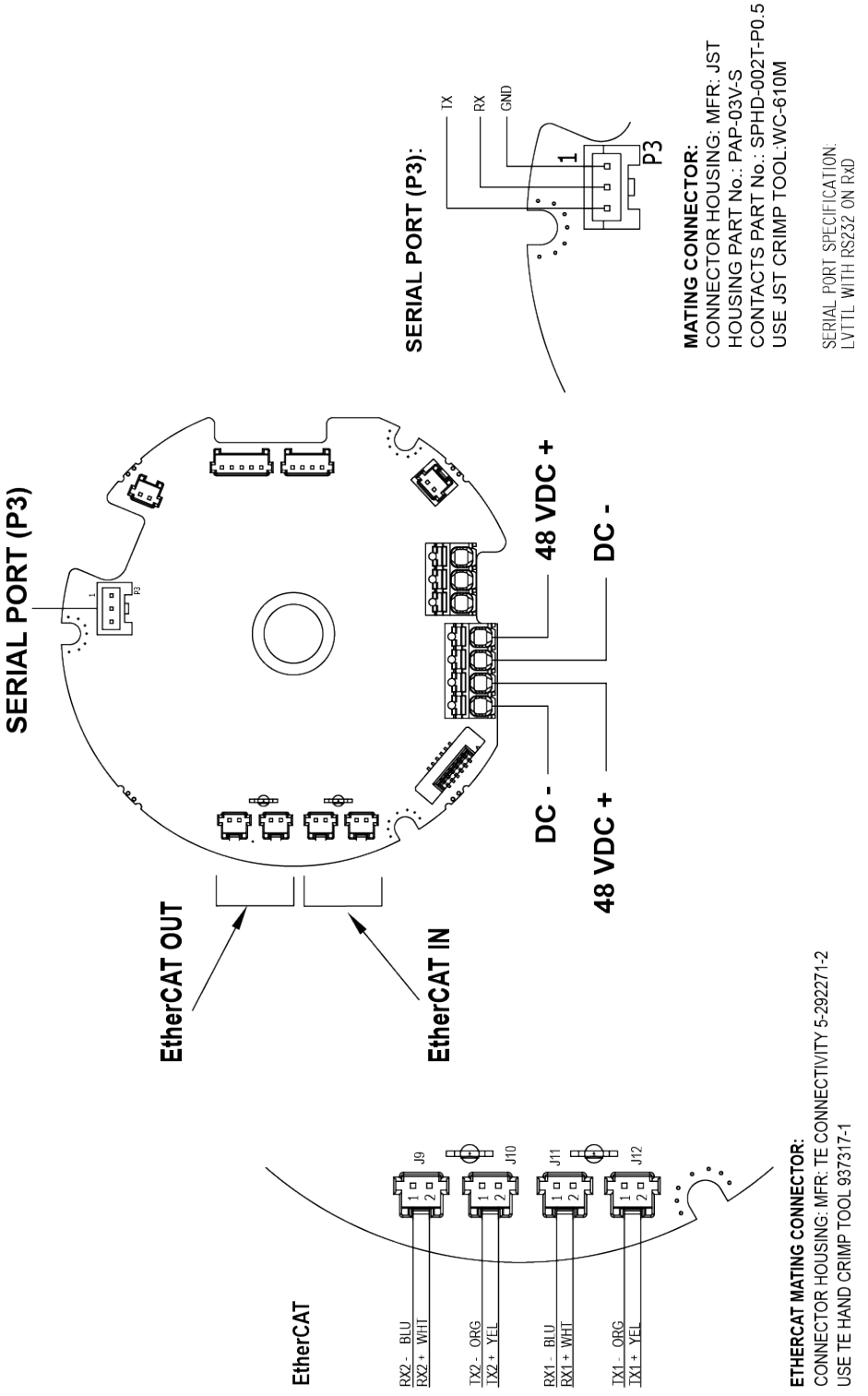
19.1 CANopen 5A



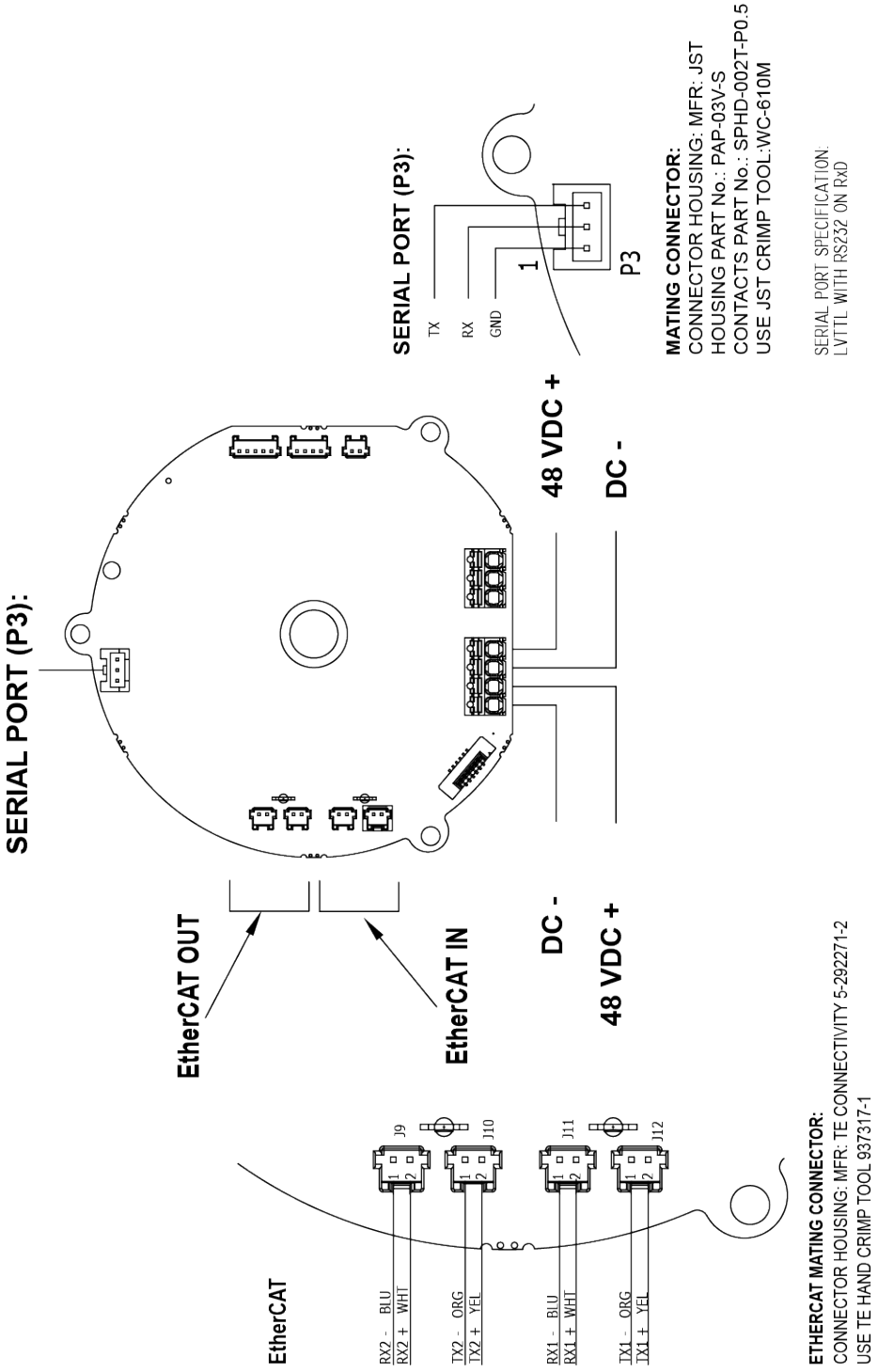
19.2 CANopen 10A



19.3 EtherCAT 5A



19.4 EtherCAT 10A



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About Kollmorgen

Kollmorgen is a leading provider of motion systems and components for machine builders. Through world-class knowledge in motion, industry-leading quality and deep expertise in linking and integrating standard and custom products, Kollmorgen delivers breakthrough solutions that are unmatched in performance, reliability and ease-of-use, giving machine builders an irrefutable marketplace advantage.

Join the Kollmorgen Developer Network for product support. Ask the community questions, search the knowledge base for answers, get downloads, and suggest improvements.

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