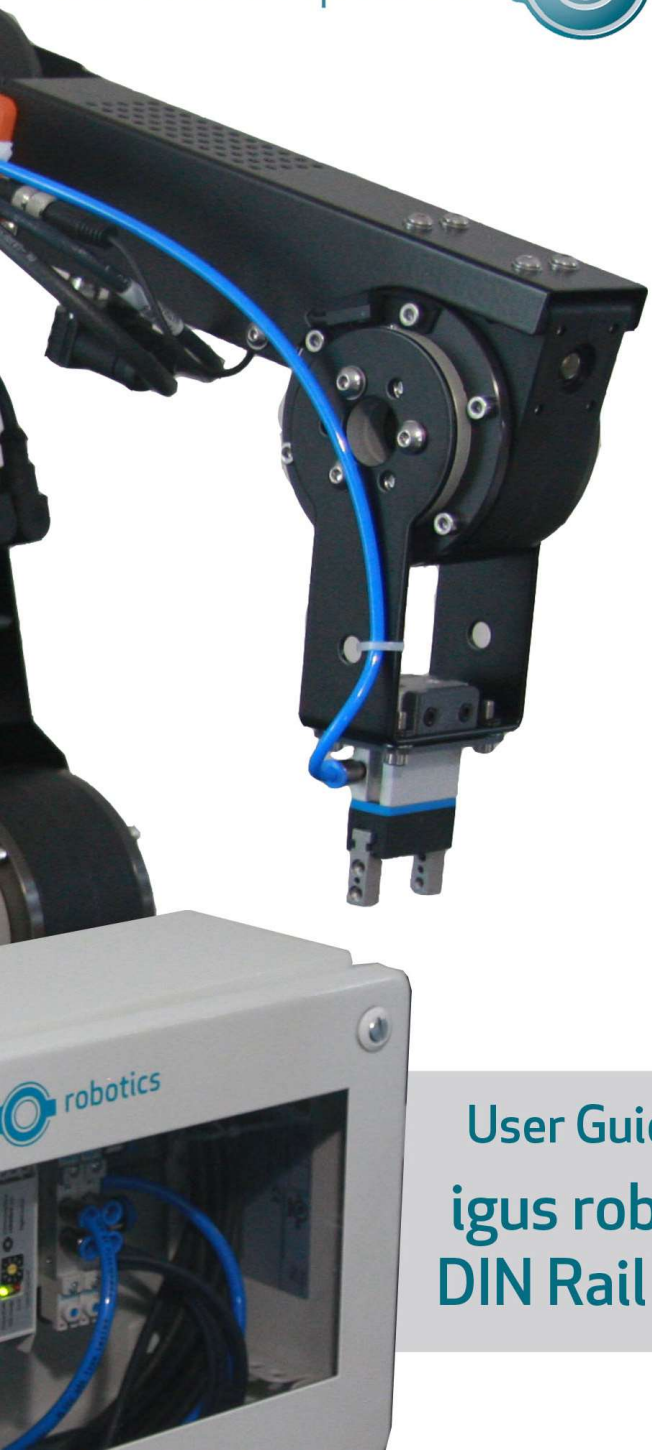
commonplace robotics GmbH



User Guide

igus robolink with DIN Rail Robot Controller

User Guide igus robolink with DIN Rail Robot Controller
Version 2019/10 V10.0-EN

Software Version CPRog	V902-10
Firmware Supply Version	0x37 - 0x0302
Firmware Version Stepper	0x42 - 0x0210
Firmware Version DigitalIO	0x39 - 0x0309

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Content

1. Safety Instructions

- Always ensure personal safety when operating a robot arm or a robot cell! Ensure that there are no persons within reach of the arm or other dangerous places!
- CE marking: Robot arm and control unit are only a part of a system which must be assessed for risks in its entirety and comply with the current safety regulations. The commissioning engineer of the system is responsible for this.
- The modular robot controller does not have any safety components. To ensure the necessary personal safety, suitable components, e.g. safety relays and door switches, must be connected.
- Depending on the configuration, the controller contains a 110 / 230 V power supply unit. This may only be connected and put into operation by qualified personnel!
- Always disconnect the 110 / 230 V line when working in the control cabinet.
- Do not install or remove any modules during operation, nor plug or unplug any connections during operation. Always switch off the system and disconnect it from the power outlet.
- The robot arm must be set up on a stable surface and screwed or otherwise secured.
- Use and store the system only in a dry, clean environment.
- Only use the system at room temperature (15° to 32°C).
- The ventilation of the system must be able to operate without hindrance. The fan must point upwards or, with reduced efficiency, to the side. He must not point down.
- Backup important data before installing the CPRog software.

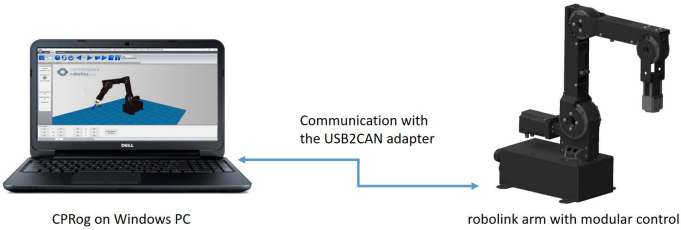
2. Features

Robot arm (if included)	
Type	igus robolink
Number of axes	Depending on version: 4 - 5
Payload	Depending on version: 0.5 - 3 kg
Robot control	
Power supply	24V >= 5A
Type	DIN rail modules ME format with 5-pin bus connector
Communication	CAN Fieldbus 500 kBaud USB-to-CAN Adapter PCAN-USB from Peak Systems
Supply modules	Provision of 5 V logic voltage: max. 2 A SlowStart function to prevent overloading of the power supply. 1-channel emergency stop function without safety classification
Stepper Modules	For operating a bipolar stepper motor RMS current, standard version: up to 1.2 A RMS current, HighCurrent version: up to 2.2 A Microstepping up to 1/256 Trinamic stallGuard2 and coolStep technologies Quadrature encoder RS422 or single ended 24 V or 5 V reference switch input, rising or falling edge
Digital In/Out Modules	7 digital inputs, 12 - 24 V, based on optocouplers 7 digital outputs, reed relay, max. 500 mA
Integrated control (if included)	
Platform	Phytec Regor or comparable, CPU e.g. Texas Instruments AM3352
Operating system	Linux
Software	TinyCtrl Robot Control Software
Interfaces	Control of the drives and I/O modules via the CAN bus, connection to CPRog via Ethernet, RS232 display connection
CPRog	
Recommended System requirements	CAD-capable PC with e.g. Intel i5 CPU and Windows 10, free USB port

3. Introduction

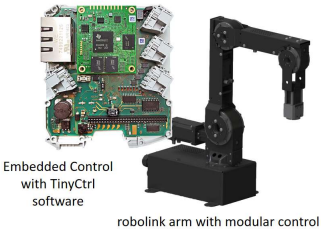
The robolink robot arm in combination with the modular controller forms a low-cost robot system, suitable for simple to medium industrial applications, as well as for training and R & D. There are three ways to work with the robot:

Standard and described here : CPRog on Windows PC The graphical Windows software CPRog is used to control and program the robot. The PC must be connected to the robot during use.

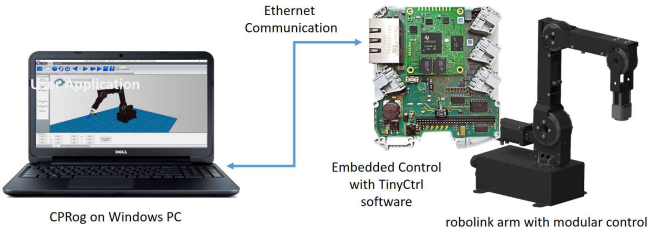


The following two options are optional and require the integrated robot control. They are described in detail in a separate manual.

Integrated control - operation: To run a program in production only the integrated control is required. The user can monitor and control the robot by a touch display (e.g. start/stop, ...).



Integrated controller - programming: The robot is operated by the integrated controller. The user can monitor, move and program the robot via CPRog's graphical user interface.



4. Wiring and Commissioning

If the robot is not combined with the controller by CPR yet, you will find information on cabling and configuration in this section.

4.1 Robot Arm Assembly

Please follow the igus documentation.

The robot must be mounted on a stable surface to prevent tipping or falling. Please refer to the igus documentation for the dimensions and distances of the mounting holes.

4.2 Cable Assembly

The wire colours in this manual correspond to the igus specifications. All connectors are equipped with guards to prevent incorrect connection within a module.

Extreme care must be taken when wiring the robot! Incorrectly wired plugs can destroy the electronics or the motor encoder!

After wiring, the cables must be fixed in the switch cabinet to prevent damage from pulling. Use cable ties, for example, for this purpose.

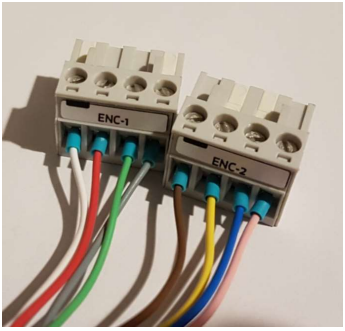
The cables should be stripped approx. 20 cm to be able to lay them better in the switch cabinet.

4.2.1 Joint Module - Motor Encoder Version

The joint module drives a bipolar stepper motor and moves it to the position specified by the controller.
In the version with motor encoders, the encoder signals are evaluated by a line driver (RS422).
The stepper motors of axis 1 to 4 have two M12 sockets for motor and encoder in this design.
The motor of axis 5 has a stranded cable and an encoder stranded socket, the cable colours of the encoder differ from A1 to A4.
The reference switch has its own cable. So there are three cables per axis.
Please match the wire colours with your igus documentation!

Motor connector :
Connects a bipolar stepper motor.

Pin 1 (left):	blue,	B
Pin 2:	white,	A
Pin 3:	black,	B/
Pin 4:	brown,	A/



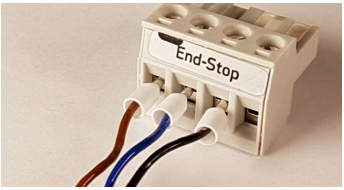
Encoder connector 1:
Connects a quadrature encoder to line driver

Pin 1 (left):	white,	A
Pin 2:	red,	5V DC voltage
Pin 3:	green,	B
Pin 4:	grey (axis 5: blue),	0V

All eight wires (encoder connectors 1 and 2) must be connected to read the encoder!

Encoder connector 2:
Connects a RS422 quadrature encoder, part 2

Pin 1 (left):	brown	A-N
Pin 2:	yellow,	B-N
Pin 3:	blue (axis 5: pink),	index
Pin 4:	pink (axis 5: grey),	index-N



End stop connector :
Connects end stop or reference switch

Pin 1 (left):	brown,	24 V
Pin 2:	blue,	GND
Pin 3:	black,	signal
Pin 4	empty	

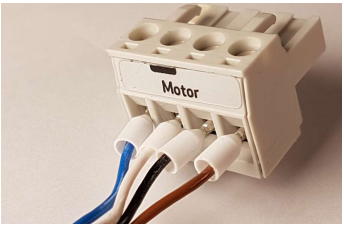
If the module for axis 5 does not function correctly during an initial test, it may be necessary to reverse the encoder direction. Please read chapter 6.1.

4.2.2 Joint Module - AE Version (Output Encoder)

The joint module drives a bipolar stepper motor and moves it to the position specified by the controller.

The output encoder version reads single-ended 5 V encoder signals. The stepper motors in this design have a single M12 socket for the motor. The reference switch is mounted with the encoder in a housing on the gearbox output side. Two cables are laid per axis.

Please match the wire colours with your igus documentation!



Motor connector :
Connects a bipolar stepper motor

Pin 1 (left):	blue,	B
Pin 2:	white,	A
Pin 3:	black,	B/
Pin 4:	brown,	A/

Encoder connector 1:
Connects a quadrature encoder single-ended

Pin 1 (left):	blue,	A
Pin 2:	red,	5 V DC voltage
Pin 3:	yellow,	B
Pin 4:	black,	0 V

Encoder connector 2:
Not required

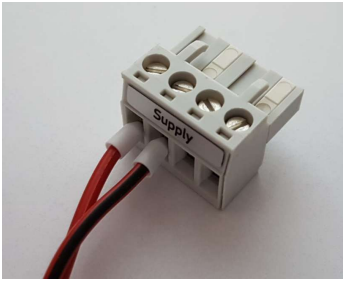
End stop connector :
Connects end stop or reference switch

Pin 1 (left):	do not connect!	24V
Pin 2:	do not connect!	GND
Pin 3:	white	Signal
Pin 4:	do not connect!	

If the module for axis 5 does not function correctly during an initial test, it may be necessary to reverse the encoder direction. Please read chapter 66.1.

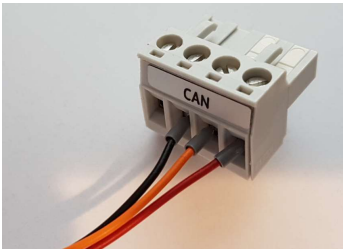
4.2.3 Supply Module

The supply module provides 5 V logic voltage, a single-channel emergency stop relay, a SoftStart relay and feeds the signals into the DIN rail bus system.



Supply voltage connector:

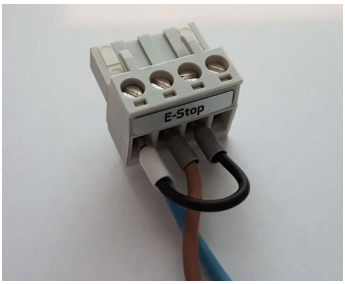
Pin 1 (left):	red,	24 V voltage
Pin 2:	black,	GND
Pin 3:	empty	
Pin 4:	empty	



CAN connector:

Connects controller and CAN-to-USB adapter

Pin 1 (left):	empty	(5 V logic voltage out)
Pin 2:	black,	GND
Pin 3:	orange,	CAN-L
Pin 4:	red,	CAN-H

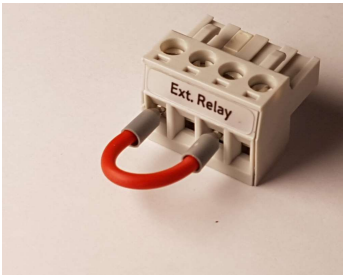


Emergency stop connector:

Connects the emergency stop switch

Pin 1 (left):	blue,	E-Stop channel 1
Pin 2:	brown,	24 V output signal
Pin 3:	black,	E-Stop channel 2
Pin 4:	empty	

Only channel 1 is wired for this wiring. Adapt this to your safety requirements! The options for connecting a safety relay are described in section 4.3



Motor power bridge:

Allows the motor current to be interrupted by external safety switches, see section 4.3.

Pin 1 (left):	Motor-out
Pin 2:	nc
Pin 3:	Motor-in
Pin 4:	nc

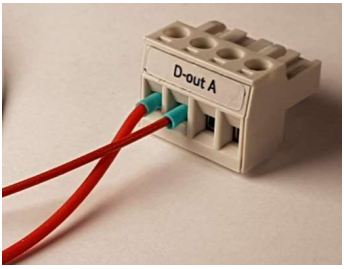
4.2.4 Digital In/Out Module

The digital IO module provides input and output channels, e.g. to operate a gripper valve. The outputs can switch up to 500 mA. The inputs use optocouplers and are compatible to 12 - 24V.

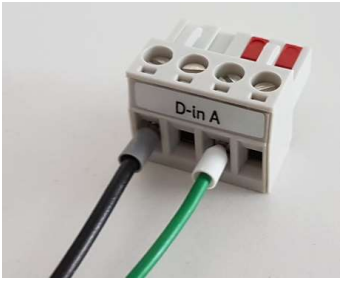
A circuit switched by the relay must not contain any larger capacitors. If the current only briefly exceeds 500 mA, the relay could stick!

For safety reasons, the Digital IO module is electrically isolated. This means that the circuits of the inputs and outputs are not connected to the internal circuits of the controller.

It is therefore necessary to connect a supply voltage for the outputs and a ground line for the inputs. For this purpose the 24V main voltage can be used, but also an independent voltage source.



Digital Out connector:
The output relays connect the pin of the power supply with the corresponding output pins.
Pins D-out A (from left to right)
Pin 1: Input voltage for all outputs
Pin 2: Digital Out channel 1
Pin 3: Digital Out channel 2
Pin 4: Digital Out channel 3
The D-out B pins are (from left to right) the outputs 4-7.



Digital In connector:
Pin 1 of D-in A is the corresponding GND pin for all input pins.
Pins D-in A (from left to right):
Pin 1: Signal GND (for all seven channels)
Pin 2: D-in 1
Pin 3: D-in 2 (the green wire on the picture)
Pin 4: D-in 3
The D-in B pins are (from left to right) the inputs 4-7.

4.3 Connection of Security Components

The robot controller does not provide any safety-relevant functions. The integrated emergency stop functionalities are single-channel. In order to operate the complete, customer-specific robot system, the commissioning engineer must carry out a risk assessment as part of the CE certification and, depending on the result, integrate additional safety components. These are usually safety relays and door switches.

The integration of safety relays is made possible by the motor power bridge connector of the support module. The motor currents are led out and in again through this plug. If this connection is interrupted, no active movement of the motors is possible.

This makes it possible to implement the safety functionality with the SIL level required by the application.

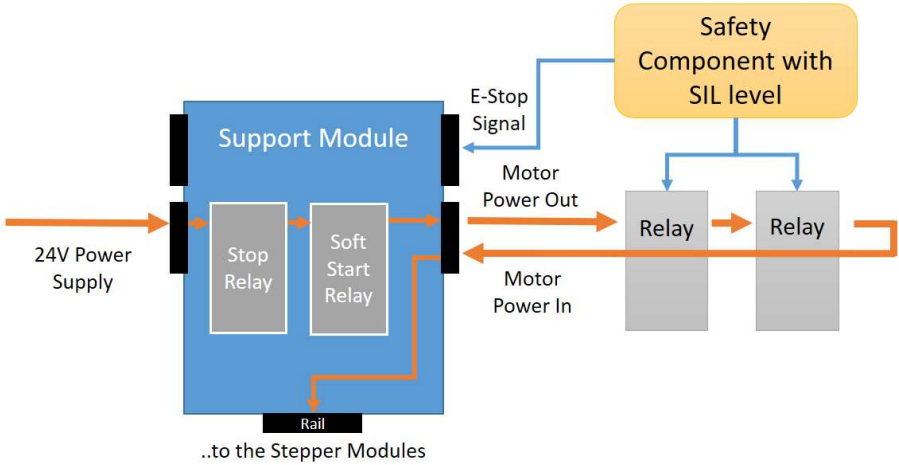


Figure 1: Schematic wiring of the safety components with the Support Module.

4.4 Test of the Joint Modules

Please follow these instructions if you connect a robot arm to the modular robot controller yourself, i.e. also carry out the cable assembly described in section 4. If the arm and controller were supplied by Commonplace Robotics, the arm has already been tested and this step is not necessary.

The control modules and any connections must not be connected or disconnected during operation! Always disconnect the controller from the mains before working on the connections. Particularly when working with the switch cabinet with 220V power supply, the mains plug must always be disconnected when working inside!

After wiring the motor cables, proceed as follows:

➔ First test the robot controller without connecting the arm:
- Install and start the CPRog software and the PCAN-USB driver as described in the previous sections.
- Connect the USB adapter to the PC and the robot controller.
- Connect the emergency stop switch to the support module.
- Connect the robot controller to the power supply.
- Now the green LEDs on all control modules light up.
- Press 'Connect' in the CPRog software.
- Now the green LEDs of the stepper motor and Digital IO modules flash to indicate activity on the CAN bus.

➔ Test the individual Joint Modules:
- Disconnect the power supply, close CPRog.
- Connect the connectors of a single axis (motor, 2 encoders and limit switches) to the corresponding stepper motor module.
- Connect the power supply and start CPRog.
- Press 'Connect', 'Reset' and 'Enable' to start the motor. The status light on the left side of the CPRog should now be green.
- Use the jog buttons to move the corresponding joint. Check that the connected axis moves correctly.
- Perform this test for all motors.

➔ After successful completion, disconnect the power supply and connect all connecting cables.

5. The CPRog Programming Environment

The robot arm is moved and programmed using the CPRog robot programming environment. Details on installation and use can be found in the corresponding documentation "User Guide Robot Control and Programming Environment CPRog ". This is included in your delivery in printed form but can also be downloaded from our Wiki: wiki.cpr-robots.com

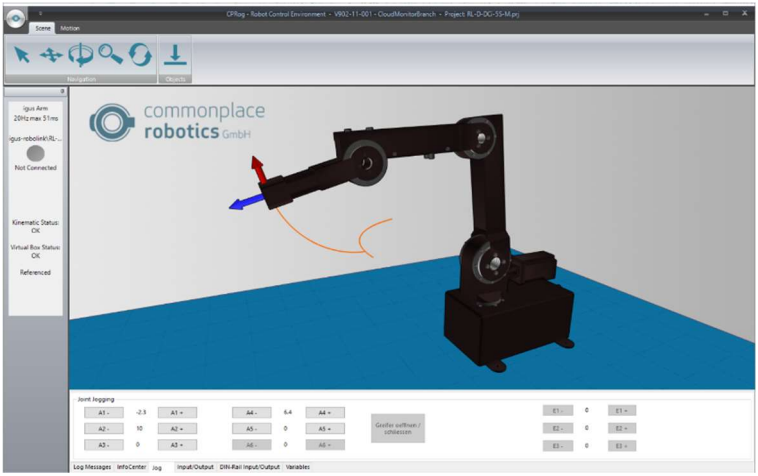


Figure 2: CPRog user interface

The documentation describes the steps for connecting, moving and programming the robot.

Further robot-specific functions are described here.

5.1 Referencing the Robot

If the robot is not completely referenced, only joint movements are allowed. To avoid collisions, cartesian movements or the start of a robot program are deactivated. The reference status is displayed on the left side of CPRog.

The stepper motor control modules store the motor position in an EEPROM. However, due to gravity or other forces, the joints can move and fall in an unpowered state. In this case, the axis modules do not have the correct position. In order to assign the correct and repeatable position to the robot, referencing must be carried out.

There are two variants of the hardware:

5.1.1 Referencing via Half Disks

The axes of the robot are equipped with inductive sensors. These are triggered by a metal disc on one half of the axle and free on the other half. During referencing, the robot moves in the direction of the transition and makes a movement there to slowly move over the flank again.

The position of the axis is set to a preset value at the position of the edge. This can be changed, see section 6.2.

5.1.2 Referencing via Pins

The axes are equipped with inductive sensors. These are triggered when they are positioned above a steel pin mounted in the output drive.

In this hardware version the axis does not know in which direction it has to turn to find the pin. Before referencing, the robot must therefore be moved manually to the rough reference position, see the following figure. This is possible in joint mode.

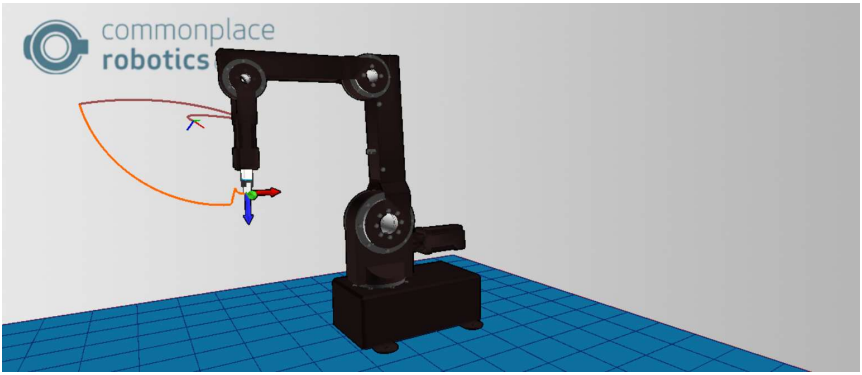


Figure 3: Reference position of the robolink robot arms

The actual referencing then performs an oscillating movement with increasing amplitude for each joint until it hits the reference switch. A slow movement is then performed to determine the exact edges of the reference switch.

The position of the axis is set to a preset value at the position of the edge. This can be changed, see section 6.2.

5.1.3 *Steps to Referencing:*

- ➔ Start the robot controller and CPRog
- ➔ Press the connect, reset and enable buttons.
- ➔ If referencing via pins: Move the robot approximately to the reference position so that the reference switches are near the activating metal pins.
- ➔ Click on the logo at the top left and go to "Configuration" and "Reference Robot" to open the referencing window, see below.
- ➔ Click the buttons to start referencing the axes. Several joints can perform the referencing in parallel.
- ➔ You can also click on "Reference All Joints", then the axes start referencing in a sequence defined in the project file.
- ➔ As soon as all joints have stopped, press "Reset" and "Enable". Now the robot is fully operational.

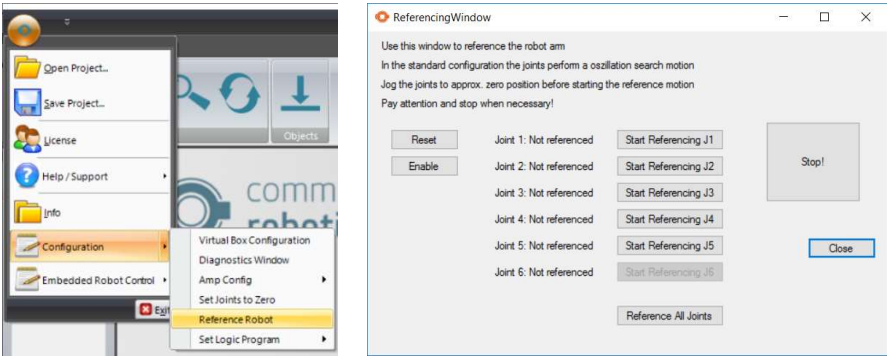


Figure 4: Menu item and referencing window

6. Configuration and Maintenance

6.1 Configuration of the Joint Modules

The operating parameters of the joint modules, particularly the motor currents, can be adapted to the application. The modules are delivered with a standard parameterization for the specific robot. Normally no change of the parameters is necessary. If the robot is to be operated at high loads or speeds, the motor currents can be increased.

This configuration can be done via the software tool "CPR ModuleCtrl". This can be downloaded from the CPR Wiki: http://wiki.cpr-robots.com/

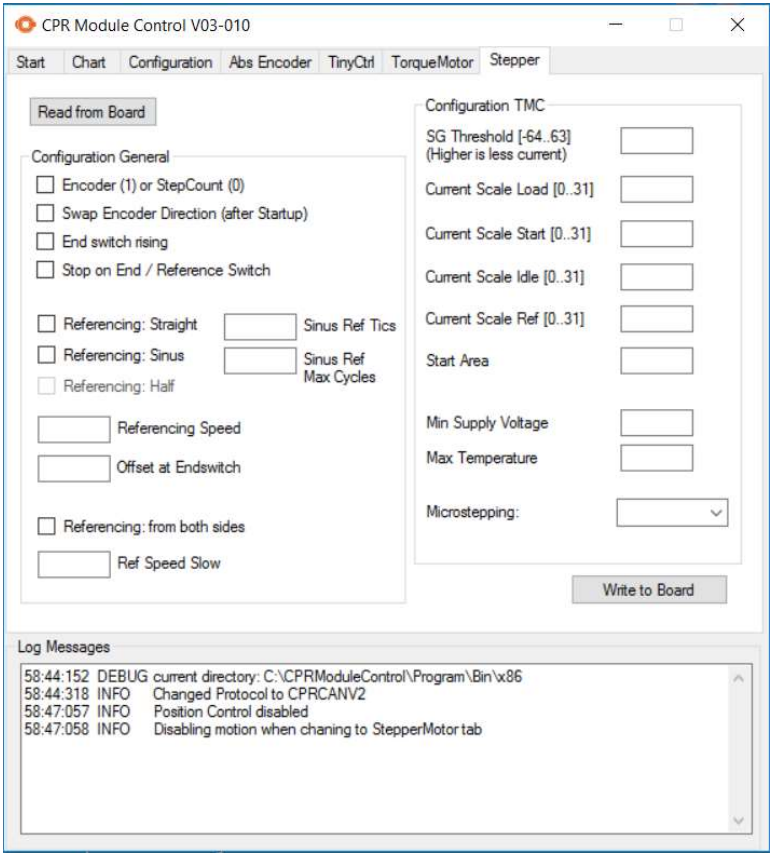


Figure 11: CPR ModuleCtrl Software, Stepper Motor Configuration Tab

The Software User Guide is also available for download on the Wiki.

Figure 11 shows the configuration of the stepper motors. The behavior during referencing is defined on the left side. Motor currents and microstepping are defined on the right side.

- ➔ The Current Scale parameters define the maximum current during normal operation (Load), during the start-up phase (Start), at standstill (Idle) and during referencing (Ref).
    - The module uses Trinamic CoolStep technology to adjust the motor current between these values and a lower limit value, which is a fraction of the current scale value.
    - At lower Current Scale values, total power consumption and heat generation are lower. However, a so-called "motor stall" can occur. In this case the current scale values must be increased.
    - At higher values, there is no motor stall, but the system becomes hotter.
- ➔ The current scale during the reference movement can be set separately to avoid damage, e.g. by collission.
- ➔ The higher the microstepping, the smoother the movement. In operation without encoder a microstepping of max. 1:64 should be used.
- ➔ It is possible to reverse the direction of rotation of the encoder. This change is valid after the next cold start of the controller. If the encoder direction does not correspond to the motor direction, the axis does not move correctly but accelerates until a position lag error occurs. In this case, the encoder direction must be changed and the system restarted. The axis should then function properly.

6.2 Calibration of the Robot

The robolink arms are referenced using reference switches. For design reasons, however, these are not exactly on the zero positions of the axes. The offset between reference switch and zero position is stored in the EEPROM of the axis modules.

If the robot was supplied by Commonplace Robotics, this offset is already set.

To perform the calibration yourself, you will find the necessary steps on the Wiki, section "Define the Zero Position Offsets": wiki.cpr-robots.com.

7. Interfaces

7.1 Hardware Interfaces: Digital Inputs and Outputs

The simplest connection, e.g. to a PLC, is possible via digital inputs and outputs. Each robolink controller is supplied with a DIO module. This provides 7 inputs and 7 outputs. A total of 3 modules can be controlled.

The outputs are controlled via reed relays and can switch up to 500 mA. This value must not be exceeded during the switching process (e.g. by charging currents of capacitors) as otherwise the relays may stick together.

7.2 Software Interfaces

Various interfaces are available from the robot controller:

- PLC interface for controlling the robot via a PLC, in particular for starting and stopping programs
- Plugin interface to integrate e.g. cameras. The plugin then transmits target positions to the robot controller.
- CRI interface to enable further interaction. This interface can be used, for example, to generate workpiece-specific programs from a database.
- ROS interface to integrate the robot into the Robot Operating System www.ros.org

Further information on the interfaces can be found in the CPRog documentation and in our wiki at wiki.cpr-robots.com.

8. Error Handling and Support

8.1 Error Codes

The robot controller provides several status information:

- Status LEDs on the electronic modules
- CPRog status information, received via CAN status bytes

8.1.1 Status LED of the Electronic Modules

Support module:
Green LED on: Logic power supply on
Green LED flashing: CAN communication with the Module
Orange LED on: Error
Red LED: Emergency stop button pressed

Stepper motor module:
Green LED on: logic power supply on
Green LED on: flashing: CAN communication with the module
Orange LED: Reference switch is active
Red LED: Module is in error state or motor is not enabled

Digital In/Out Module:
Green LED on: logic power supply on
Green LED on: flashing: CAN communication with the module
Orange LED: The state of an input or output changes.
Red LED: Error

8.1.2 CAN-Bus and CPRog Status Information

Error	Bit in error byte	Meaning	Measures
Bus dead		The CAN bus is not available. Reasons are missing power supply or missing plug connections.	Check the plug connections of the power supply and the CAN line. Restart the controlling computer.
Temp	Bit 1	The temperature of the motor modules is too high.	Check that the ventilation is installed and working. The motor current may have to be reduced.
E-Stop / Supply	Bit 2	Emergency stop or voltage too low	Check that the emergency stop switch is released.
MNE Motor not enabled	Bit 3	No fault. The motors are not released yet.	Press the "Enable motors" button.
COM Comm Watch Dog	Bit 4	The period without CAN command from the controller was too long.	The position commands via the CAN bus must be sent at short intervals. Turn off other programs or update / virus scan functions.
LAG Position Lag	Bit 5	Position lag error. The robot cannot maintain the target position.	Decrease the speed of movement.
ENC Encoder Error	Bit 6	Error in motor encoder or absolute encoder	Check the encoder cables
OC Over Current	Bit 7	Overcurrent in the motors	Reduce the motor current
DRV	Bit8	Error in motor driver or motor algorithm	Drive specific

After an "Error Reset" the normal status of the axes is 0x04 (motor not enabled).
After releasing the motors the status is 0x00, now the axes are ready for operation.

8.2 Troubleshooting

If you have any problems, please contact us:

- Mail: support@cpr-robots.com Please briefly describe the problem and send the file "logMessages.log" from the folder c:\CPRog\.

8.2.1 Hardware

- The green LED on the modules is not on?
  Check the power supply and the fuse.
- The motors are not moving?
  Make sure the emergency stop button is pulled out. The red LED on the support module must not be on.
- The modules do not react to software commands. The green LED does not flash.
  There must be no free space between the individual modules, each slot must be occupied. A free slot interrupts the CAN communication.
- The motor blocks ("motor stall"): It does not stop the movement and makes increasing loud humming noises.
  This happens when the load on the motor is too high:
  - Check whether there is a collision.
  - If the problem occurs repeatedly, the motor current must be increased (see chapter 6), or the load reduced (speed or acceleration reduced).
- Axis 5 does not move in a controlled manner, but accelerates until a position lag error occurs.
  Change the direction of rotation of the encoder, see section 6.1.
- If CPRog cannot connect:
  Close the PCAN-View software if it is open.

8.2.2 Software

- In case of problems with CPRog upgrade the software to the current version:
  Wiki, section CPRog: http://wiki.cpr-robots.com

8.3 EC Declaration of Conformity

Commonplace Robotics GmbH
Im Innovationsforum Bissendorf
Gewerbepark 9-11
49143 Bissendorf, Germany

We, the Commonplace Robotics GmbH, declare that the machine parts / components described in the following

- Stepper motor modules 2 210 022, 2 210 023
- Support Module 2 210 011
- Digital In/Out Module 2 210 033
- Modular robot controller 2 220 xxx (x: serial number)

complies with all relevant requirements of the EC Machinery Directive 2006/42/EG.

The incomplete machine must not be put into operation until conformity of the complete machine with the EC Machinery Directive 2006/42/EG has been ensured. The commissioning engineer is responsible for this.

Applied harmonized standards:

- Safety of machinery: EN ISO 12100:2010
- EMC: Directive 2004/108/EC, EN61000, EN55022, EN55011
- RoHS: Directive 2002/95/EC

The technical documentation defined in Annex VII, Part B of the Machinery Directive has been created and can be consulted by public authorities.

Responsible for the documentation: Dr.-Ing. Christian Meyer

Bissendorf, January 2018 Dr.-Ing. Christian Meyer