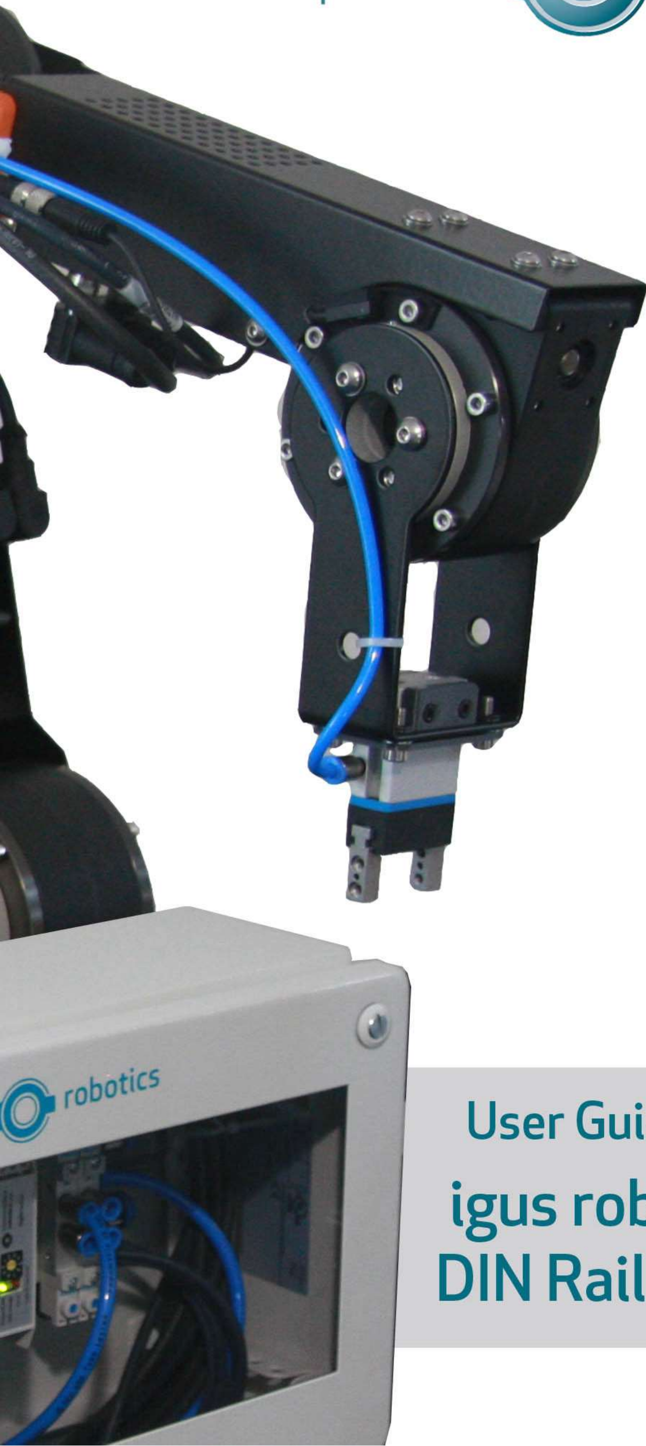
commonplace robotics GmbH



User Guide

igus robolink with DIN Rail Robot Controller

User Guide igus robolink with DIN Rail Robot Controller
Version 2018/02 V10

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

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Contents

1. Safety instructions

- When controlling a robot arm or setting up a robot work cell: Pay attention to person safety! Ensure that no person is in reach of the arm!
- Robot arm and control system are only parts of the complete application which has to be assessed and secured based on the current regulations.
- The Modular Robot Control modules do not provide any safety rated features. To provide the necessary person safety the Safety Option or other application specific components have to be included.
- Depending on the options the control includes a power supply unit that receives 110 / 230V mains voltage. These components may only be handled by qualified personnel!
- Isolate the control cabinet from the 110 / 230V mains electricity prior to opening it.
- Do not Hot-Plug any connectors or modules, always switch of the power supply!
- The robot arm has to be mounted on a solid stand.
- Use and store only in dry and clean environments
- Use only at room temperature (15° to 32°C)
- The ventilation system of the control must work without restrictions. The fan has to point upwards, or, with less efficiency, to the side. It must not point downwards.
- It is necessary to backup important data before the installation of the CPRog software.

2. Specifications

Robot Arm (if included)	
Type	igus robolink
No. of Joints	Depending on version: 4 - 5
Payload	Depending on version: 0.5 – 3 kg
Robot Control	
Power Supply	24V >=5A
Form Factor	DIN rail modules ME format with 5 pin bus connector
Communication	CAN field bus 500 kBaud USB-to-CAN adapter PCAN-USB by Peak System
Supply Module	Generation of 5 V logic supply: max 2A Slow start phase to prevent overcurrent 1 channel E-Stop functionality, no safety rating
Stepper Module	Drives bipolar stepper motor RMS current standard version: up to 1.2 A RMS current HighCurrent version: up to 2.2 A Microstepping 1/256 Trinamic stallGuard2 and coolStep technologies RS422 Quadrature encoder input a/b or single ended 24V or 5V reference switch input, rising or falling edge
Digital In/Out Module	7 digital inputs, 12 – 24 V, optocoupler based 7 digital outputs, reed relays, max 500 mA
Embedded Control (if included)	
Platform	Phytec Regor or similar, CPU e.g. Texas Instruments AM3352
Operating System	Linux
Software	TinyCtrl Robot Control Software
Connectivity	Controls the stepper and IO boards using the CAN bus Communication with CPR via Ethernet, RS232 display connection
CPRog	
Requirements	CAD enabled computer with e.g. Intel i3 processor and Windows 7 or 10, free USB port, installation via CD-ROM

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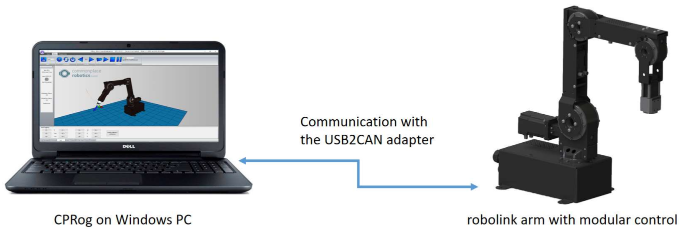
3. Introduction

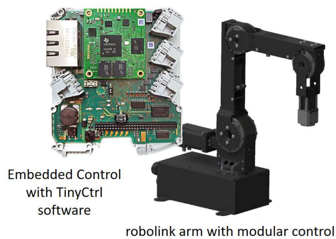
The robolink robot arm with the modular control forms a low-cost robot system usable for simple to medium industrial application, as well as for education and R&D. There are three ways to operate the robot:

Standard and described in this document: CPRog on a Windows PC
The graphical Windows software CPRog can be used to program and to run the robot. The PC must always be connected to the robot.

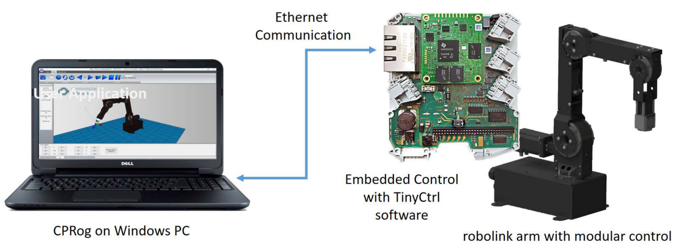


The two following ways are optional and require the embedded robot control. They are described in detail in the according user guide.

Embedded Control - Operation To replay a program, only the embedded control is necessary. The user can monitor and operate (e.g. start / stop, …) the robot using a touch display.



Embedded Control - Programming The robot is run by the embedded control. The user can monitor and program the robot with the CPRog graphical interface.



4. Wiring and installation

Depending on your order it may be necessary to combine the robolink robot arm with the modular control.

4.1 Robot arm assembly

Please refer to the igus documentation.

The robot arm must **be mounted on a stable surface** to prevent tipping. Refer to the robolink documentation for mounting hole pattern.

4.2 Connector wiring

The wire colors in this document follow the igus conventions. All connectors are indexed to prevent accidental miswiring within a module.

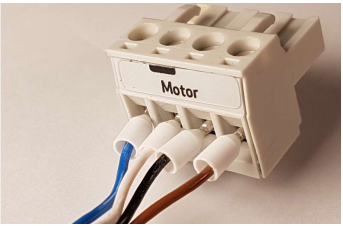
Care must be taken during wiring! **Wrong wiring** of the connectors can **destroy the electronic modules or the motor encoder!**

After wiring the cables must be fixed inside the control cabinet to provide strain relief. This can e.g. be accomplished using cable straps.

The cables should be unmantled approx. 20 cm to allow flexibility inside the control cabinet.

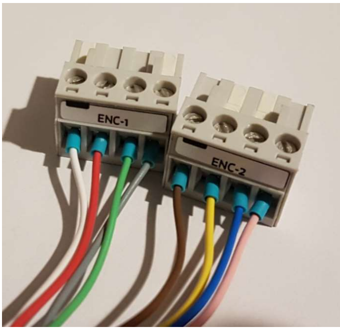
4.2.1 *Stepper motor module – motor encoder version*

The stepper motor module moves a bipolar stepper motor according to the set point positions provided by the CAN bus.
This version reads encoder signals with line driver (RS422). There are two connectors on the motors for this version. The reference switch has a separate cable, i.e. three cables per joint. Please verify the wire colors with your igus robolink documentation! The encoder for joints 1 to 4 are connected using a M12 connector. The joint 5 encoder is connected with a pin header, the cable colors differ.



Motor Connector:
Connects a bipolar stepper motor.

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



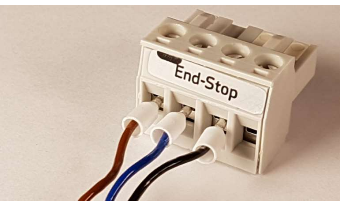
Encoder Connector 1:
Connects a quadrature encoder with line driver

Pin 1 (left):	white,	A
Pin 2:	red,	5V DC supply
Pin 3:	green,	B
Pin 4:	grey (joint5: blue),	0V

All 8 lines (Encoder Connector 1 and 2) have to be connected to get encoder readings!

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

Pin 1 (left):	brown	A-N
Pin 2:	yellow,	B-N
Pin 3:	blue (joint5: pink),	Index
Pin 4:	pink (joint5: grey),	Index-N



End Stop Connector:
Connects one or two end stops or reference switches

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

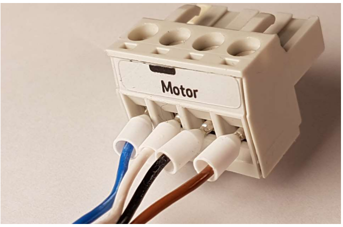
If during test the joint 5 module does not work correctly it can help to change the encoder direction, see section 7.

4.2.2 Stepper motor module – AE version (encoder on the gear output)

The stepper motor module moves a bipolar stepper motor according to the set point positions provided by the CAN bus.

This version reads single encoder signals on 5V level. In this version there is one connector on the motor, and an encoder module on the output side of the gearbox. The reference switch is combined with the encoder. There are only two cables per connector.

Please verify the wire colors with your igus robolink 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 single quadrature encoder, part 1

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

Encoder Connector 2:
Not necessary

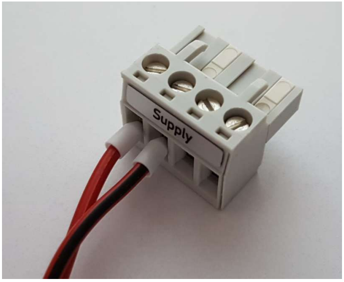
End Stop Connector:
Connects one or two end stop or reference switches

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

If during test the joint 5 module does not work correctly, it can help to change the encoder direction, see section 7.

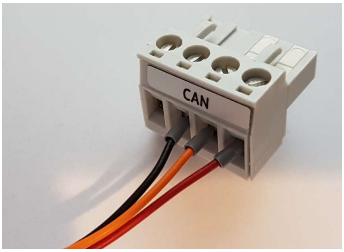
4.2.3 Supply module

The Supply Module generates 5V Logic supply, handles the emergency stop and soft-start relay, and feeds the signals into the DIN rail bus system.



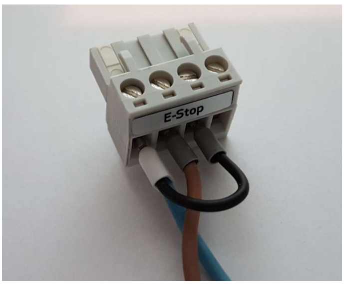
Supply Voltage Connector:

Pin 1 (left):	red,	24V supply
Pin 2:	black,	GND
Pin 3:	nc	
Pin 4:	nc	



CAN Connector:
Connects to the CAN-to-USB adapter

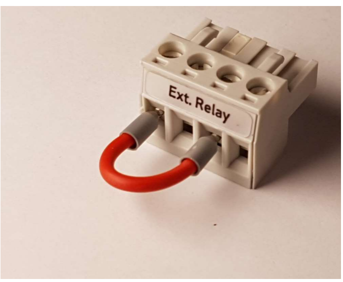
Pin 1 (left):	nc	(5V logic supply out)
Pin 2:	black,	GND
Pin 3:	orange,	CAN-L
Pin 4:	red,	CAN-H



Emergency Stop Connector:
Reads the emergency stop state

Pin 1 (left):	blue,	E-Stop Channel 1
Pin 2:	brown,	24V out signal supply
Pin 3:	black,	E-Stop Channel 2
Pin 4:	nc	

This functionality is implemented single channel. Adjust to your safety requirements with an additional safety relay!



Motor Power Routing: Allows to route the motor supply lines through external safety relays.

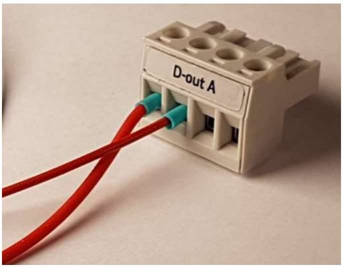
Pin 1 (left):	Motor-Out
Pin 2:	nc
Pin 3:	Motor-In
Pin 4:	nc

4.2.4 Digital in/out module

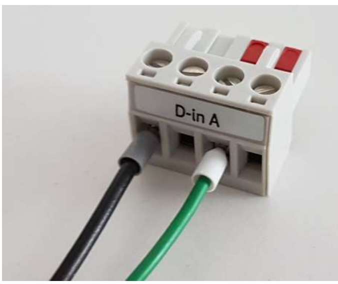
The Digital IO modules provide input and output channels, e.g. to operate the gripper valve. The output channels can switch up to 500 mA. The input channels are optocoupler driven and accept 12 to 24V.

The relays of this module must not switch large capacitive loads. If the current is above 500 mA even for a short period of time the relay might stick!

The DigitalIO module is decoupled from the internal supply, it does not provide supply voltage for the inputs or outputs.
The main supply can be used as an input for the digital outputs.



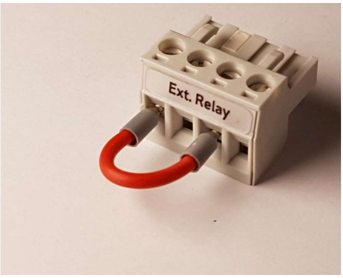
Digital Out Connector:
The output relays connect the supply pin with the according D-Out pins (left to right)
Pins D-Out A (left to right)
Pin 1: Supply for the outputs (only on D-Out A)
Pin 2: Digital Out Channel 1
Pin 3: Digital Out Channel 2
Pin 4: Digital Out Channel 3
The D-Out B pins are (from left to right) the output channels 4 to 7.



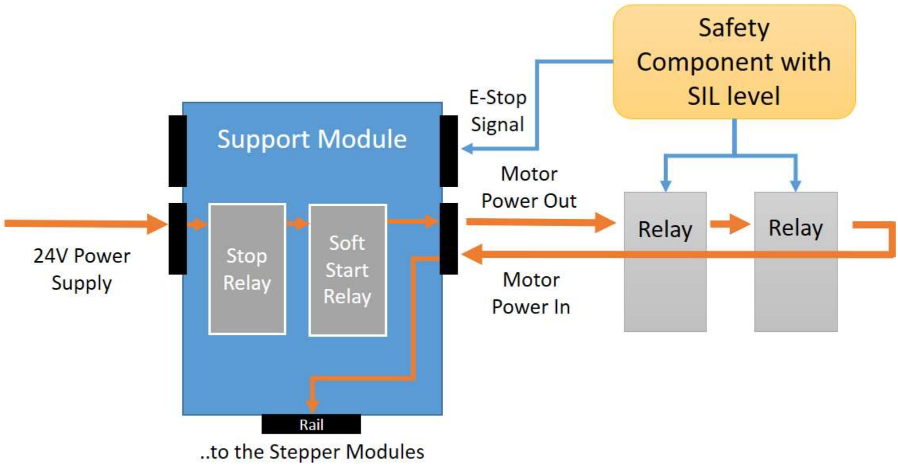
Digital In Connector:
The 24V inputs activate an optocoupler LED. Pin1 on Din-A is the according GND pin.
Pins D-In A (left to right):
Pin 1: Signal GND (for all 7 channels)
Pin 2: D-In 1
Pin 3: D-In 2 (the green wire on the picture)
Pin 4: D-In 3
The D-In B pins are (from left to right) the input channels 4 to 7.

4.3 Wiring of the safety interlock option

If a sophisticated interlock system is required for operational safety, external relays can be used to prevent or interrupt any robot motion.



One or two relays can be connected using the motor power routing connector (on the left).
This enables the user to equip the system with safety components to comply with the "safety integrated level" (SIL) required by the application.



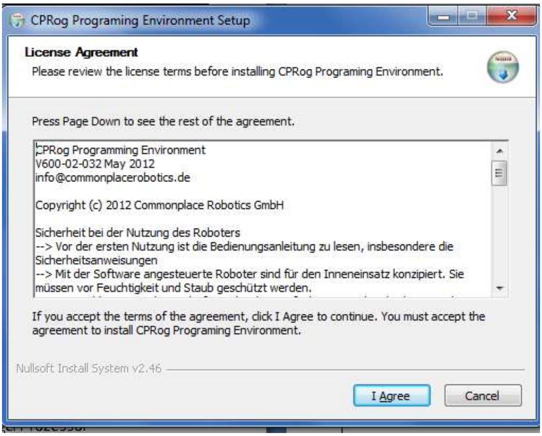
Pic. 1: Schematic wiring of the optional safety interlock with the support module.

4.4 CPRog software installation

Insert the CPRog CD into the drive.

Depending on the configuration of your operating system, the CD menu may open automatically. Otherwise you have to start it manually: D:\.autorun\autorun.exe

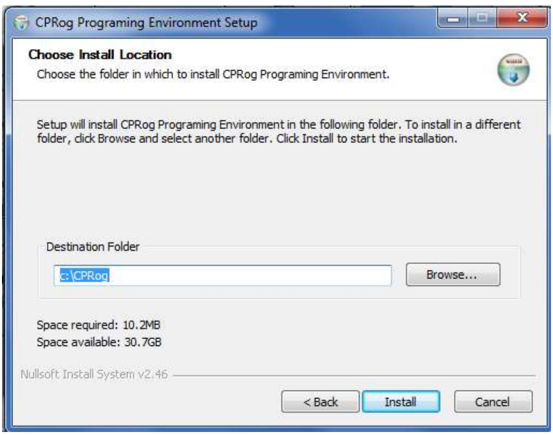
Choose the first button "CPRog Installation"



You may have to allow changes to be made on your system.

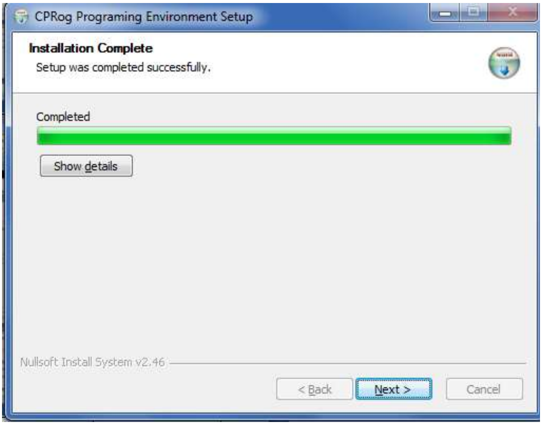
After the installer has started you need to choose between English and German as language.

Then you need to confirm the license agreement.



In the next step you can choose where to install CPRog. The recommended directory is `C:\CPRog`.

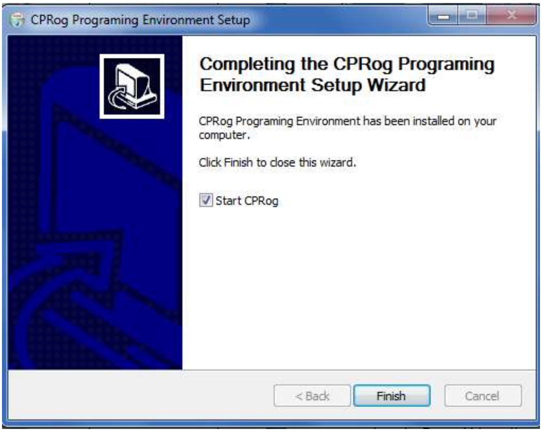
When installing in a Windows program-directory such as `C:\Program files(x86)` CPRog requires elevated rights (run as administrator).



The installation normally takes only a few seconds.

The installer checks, if DirectX 9.5 is installed. If not, it will install theses libraries from the CD or via download. This will take some minutes.

The installation of DirectX 9.5 is necessary, even if e.g. DirectX 11 is already installed.



When finishing the installation, you can choose to start CPRog directly.

Now you can start CPRog using the link on the desktop or via the start menu.

After the start you must open the appropriate project with your robot from the circle-Menu at the top left corner.

Installation Failure: The installation assistant checks, if all necessary extensions are available, especially the .NET-Framework and DirectX 9.5. If this is not the case an error message will appear. DirectX is installed automatically, but the .NET-Framework has to be installed manually:

Search the net for "Microsoft .NET download" and install

4.5 Installation of the driver for the USB adapter

The robot is delivered with the PCAN USB adapter from www.peak-system.com. To use the adapter the appropriate driver has to be installed from the CPRog installation CD (button "Install USB-CAN adapter") or the manufacturer's installation CD.

After starting the installation, you need to

- accept the license agreement and
- set the installation folder.

In the next step please check the PCAN-USB device and the PCAN-View CAN-Bus Monitor as shown on the following picture for installation.

Choose for installation:

- PCAN-USB
- PCAN-View

The PCAN-View monitor allows to check if the adapter is connected correctly.

4.6 Licensing

CPRog software requires a license key. This key normally installed automatically with the CPRog installer. Nothing has to be done.

If it is not, e.g. because you have installed a demo version, please see the following information. The key (XML file) has to be placed into directory

```
\CPRog\Data\License
```

The CPRog installer copies the key Demo.xml into the directory. With this key CPRog starts in demo mode. The runtime is limited to 10 minutes; afterwards you need to restart CPRog.

When you do need a license key, please send a short email with the following information to licensing@cpr-robots.com:

- Your Name or the name of the responsible contact person
- Your companies / organizations name

We will send you your key via email. After starting CPRog, your licensing data are shown in the main window. To display the complete licensing information, use click on the program button →License.

Please do not change the content of the license file, as this would render it invalid!

A standard license allows the installation and use of CPRog on an arbitrary number of computers in the company or organization of the license holder.

4.7 Test of the joint modules

Please follow this procedure if you combine a robot arm with the modular robot control by yourself. If arm and control unit have been delivered by Commonplace Robotics, then the arm has already been tested and this procedure can be skipped .

Do not hot-plug the control modules or any connectors! Always disconnect the controller from power before working on the connections. Especially when working within the control cabinet, the 110/220V mains connector must disconnected!

After wiring the motor cables, please proceed as follows:

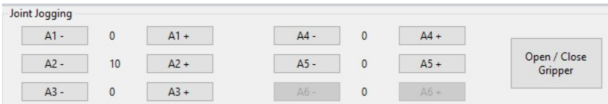
➔ At first test the robot control without connecting the arm to the modules:
  - Install and start the CPRog software and the PCAN-USB driver as shown in the section before.
  - Connect the USB adapter to PC and robot control.
  - Connect the Emergency Stop to the Support Module
  - Connect the robot control to power
  - Now the green LEDs on all control modules are on.
  - Press 'Connect' on the CPRog software.
  - Now the green LEDs on the Steppermotor and DigitalIO modules are blinking to show activity on the CAN bus.

➔ Test the single joint modules.

- Disconnect the power supply / unplug the mains connector
- Close CPRog
- Connect the plugs of a single joint (motor, 2 encoders and end-switch) to the corresponding stepper motor module.
- Connect power and start CPRog
- Press 'Connect', 'Reset' and 'Enable' to activate the motor.

  The indicator in the left panel of CPRog should be green now.
- Move the joint with the Jog buttons on the lower side of CPRog.

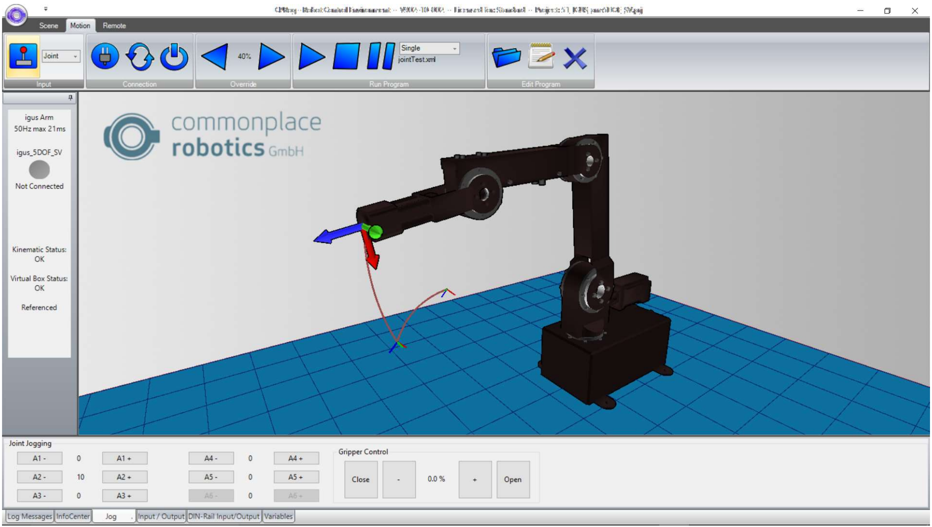
- Pay attention to only move the connected joint. When jogging a different joint the module will change into error status.
- Perform this check for all motors

➔ When successful disconnect power and connect all joint cables.

5. The CPRog programming environment

5.1 Introduction

The CPRog programming environment allows to control and program the robolink robot arm. It is possible to work online or offline, i.e. with or without a connection to the robot. CPRog is a Windows software.



Pic. 2: CPRog User Interface

At the top the three ribbons "Scene", "Motion" and "Remote" provide access to the main functionalities. On the left panel information on the current state of the robot are provided.

At the bottom of the program window there are four tabs:

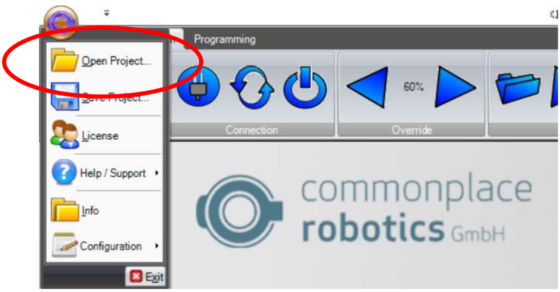
- "Log Message": Messages regarding the programs state
- "Info Center": Shows joint values, the Cartesian position and further info
- "Jog": Buttons to move the robot
- "Input / Output": View and set digital IOs (not recommended for robolink)
- "DIN Rail Input / Output": Digital IO for the modular control
- "Variables": Shows the current state of program variables

Further functionality, e.g. loading a different project or to reference the robot, is located in the menu that opens when you click on the round logo in the top left corner.

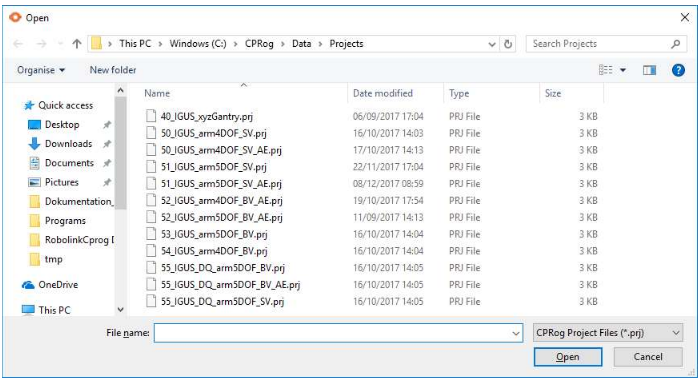
5.2 Choosing and loading the correct robot configuration

After the first start of the software, the appropriate project configuration for your robot arm needs to be loaded from the circle-menu at the top left corner of the program window.

CPRog has a project based configuration. You have to choose the project suitable for your robot ram: robolink 4 or 5 degrees of freedom (DOF), small or big version. To do that, click on the circle in the upper left corner and choose "Open Project". Now choose the file with your robot arm. CPRog remembers your choice. If you have trouble selecting the correct file, see section 5.2.1.



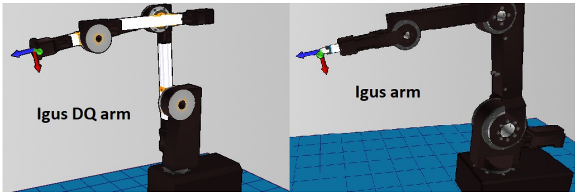
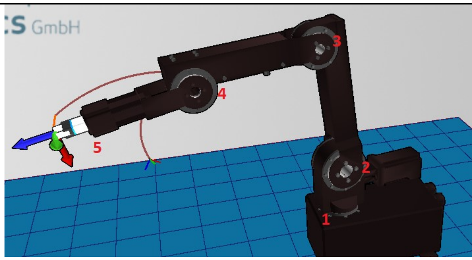
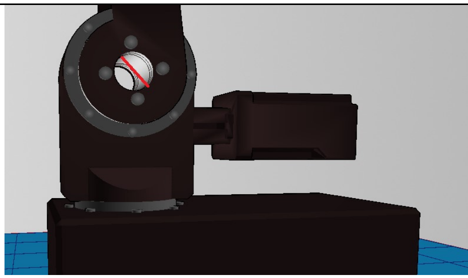
Pic. 3: "Open Project" menu entry



Pic. 4: "Open Project" dialog. Select the correct project file here.

5.2.1 *Identify your robot*

The name of the configuration file is composed as follows. Use the table below to identify the filename: <#><IGUS_DQ_arm/IGUS_arm>_<4DOF/5DOF>_<SV/BV>_<AE/ME>.prj

robolink DQ arm or robolink D arm? There are several types or robolink robot arms, the most common is the D arm, named just "IGUS arm".	
4 DOF or 5 DOF? DOF is the acronym for "degrees of freedom", meaning the robot joints . The robot on the right is 5 DOF. Note: the white gripper is not counted.	
BV or SV? meaning the big version with 2,5 kg payload, or the small version with 0,5 kg payload. Measure the diameter of joint 2. 5cm → BV 3cm → SV	
AE or ME type of encoder? ME versions use a motor encoder, AE version use a encoder on the gear output. Count the number of sockets of any of the modules labelled "Stepper Motor Driver Module" on the DIN Rail. 4 sockets → ME 3 sockets → AE	

5.3 Navigation using the mouse

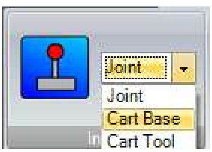
A 3 button mouse is recommended to navigate in the CPRog 3D environment:

- Left button: select robots and other objects
- Middle button: navigate in the scene
  - Rotate: drag the mouse while holding the middle button
  - Pan: drag the mouse while holding the middle button and pressing down the CTRL-key
  - Zoom: drag the mouse while holding the middle button and pressing down the SHIFT-key (zooms to the center of the scene)
- Mouse wheel: zoom to the current cursor position
- Right button: open the context menu

The function of the left mouse button can be changed in the upper menu area at Scene/Navigation. Possibilities are selection, rotation, panning or zooming.

5.4 Moving the robot with joypad or software buttons

The robot can be moved (or "jogged") manually by using a joypad or software buttons (see pic 6), as long as no program is running. The main elements are the button to connect the joypad, the combobox to choose the motion type and the override, which is used to scale the motion speed.

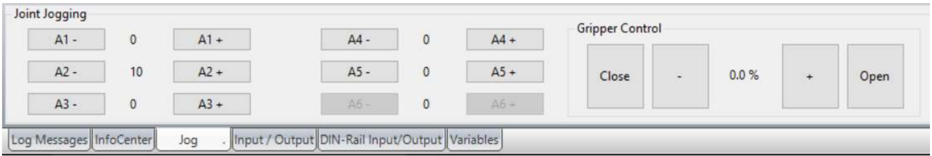


Pic. 5: Elements to jog the robot

Upon start of CPRog,it tries to connect to the joypad. A connection can be initiated manually by clicking the joystick button. When the connection succeeds, a green ok sign is shown on the joystick button.
The device must have the type "Joystick" or "Gamepad". Further information on the connection attempt is provided in the log window.

The **"Joint"** mode (Pic4) allows to turn the single robot axis from A1 to A6, if available. In "Cartesian" mode (**Cart Base**) the robot moves in straight lines following the x, y and z coordinate axis. The rotation is defined with the B commands. In "Cartesian Tool" mode (**Cart Tool**) the robot moves aligned to the current tool coordinate system.

The **override** scales the motion **speed** between 0 and 100%.

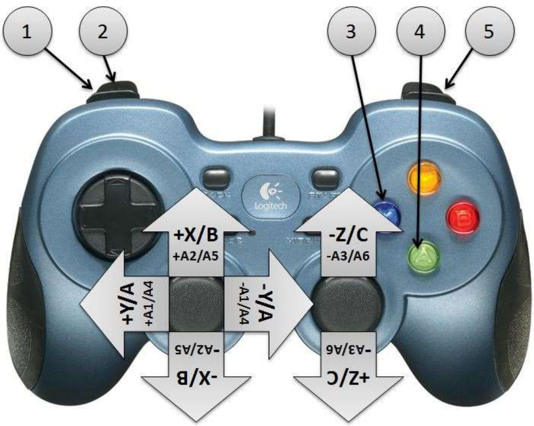


Pic. 6: Buttons to jog the robot in joint mode.

When the **virtual walls** are active the robot blocks further motions when leaving the allowed area.

When the robot is **not yet fully referenced** , the position of real robot compared to the virtual robot may differ. Only joint motion is allowed in this case. The reference status is shown on the left panel of CPRog. For referencing see section 6.3.

The most convenient way to move the robot is with a connected joypad, the picture below shows the assignment of keys.



Reference:

1. Change motion mode
2. Change active robot
3. Open / close gripper
4. Record a motion point
5. Change button assignment:
   when pressed it is not +X, but +B

Pic.7: Assignment of keys for the joypad. Upper markings for Cartesian mode, lower for joint mode.

5.5 Moving the robot using the graphics

The robot can be moved by dragging its links in the graphical 3D environment alternatively to the joypad or software button control. When selecting a joint of the robot with the left mouse button, the joint outlines blink red. When selecting the joint and moving the mouse with the left mouse button pressed, this joint will rotate forward or backward, depending on the mouse motion.

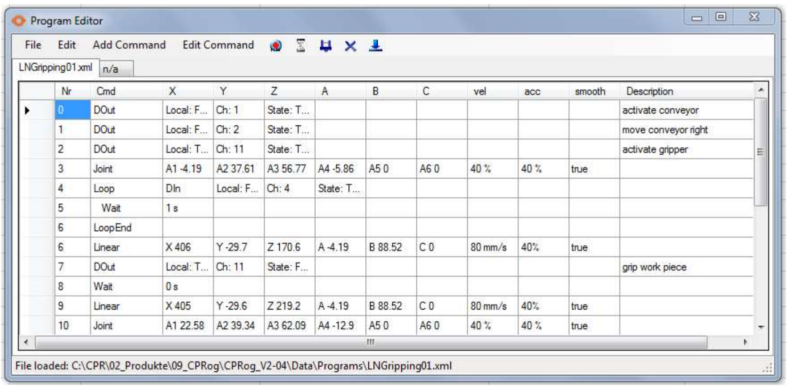
5.6 Writing robot programs

CPRog allows to set up robot programs which are stored as .xml files. To edit these files, the integrated program editor is well suited, but it is also possible to make small changes with a standard text editor.

5.6.1 Editing a program

In the "Motion" ribbon at the top of the program window, use the "TextEdit" Button in the "Edit Programs" area to opens the TextEdit Program editor. The editor contains a syntax check. Illegal cells are marked red, the syntax for the command is shown in the bottom line for assistance.

If there are errors in the program, it cannot be saved.



Pic. 8: TextEdit program editor

The five picture buttons allow direct interaction:

-  Synchronize changes
-  Record a motion command (linear or joint motion according to the robots current motion type) with the current robot position
-  Record a break
-  Record a gripper command
-  Delete the selected line
-  Set the selected line as starting point for the next program start

All fields of the commands can be edited directly to e.g. change the velocity. Changes are accepted when clicking on another line or field.
The "Delete" key removes the current line. To remove text in a cell use the "Backspace" key.
A line can be copied with Ctrl-C and pasted using Ctrl-V (or in the Edit menu).
All new commands are inserted in the line above the selected line.
When choosing "Save" from the File menu the current program is written and loaded by the robot, so that it is in sync with the text editor.
When choosing "Save As" from the File menu, the current program is saved under a different name. The new file is loaded by the robot.

5.6.2 Command specification

The following table shows the list of commands and their availability on CPRog and TinyCtrl, the embedded control software. The implementation for TinyCtrl is ongoing.

The detailed command specification is provided in a separate document. For updates check our Wiki: http://wiki.cpr-robots.com/ in the section Programming Environment CPRog.

Command	Functionality
Motion	
All: Abort Condition	Motion commands can be interrupted
All: Smoothing	Smooth transition between motions
All: Acceleration	Defined accelerations for motions
Joint	Move in joint coordinates
JointByVariable	As above, target defined by variable
Linear	Move linear in cartesian xyzabc position
LinearByVariable	As above, target defined by variable
RelativeBase	Relative motion in base coordinates
RelativeTool	Relative motion in tool coordinates
RelativeJoint	Relative motion in joint coordinates
Matrix	Approach matrix positions
Input / Output	
DigitalOut	Set a digital output to high or low
Gripper	Open or close the gripper
Structure	
LoopCounting	Repeat a defined number of iteration
LoopConditional	Repeat until a condition is true
If-Then-Else	Conditional branch
Wait	Wait a defined time span
WaitConditional	Wait until a condition is true
Sub	Call a sub program defined in another .xml file
Advanced	
DefPosVariable	Defines a position variable
DefNumberVariable	Defines a number variable
Variable Operations	Add, subtract, set values to variables and variable sections
PluginTargetPos	Get a target position from e.g. a camera

6. Jog the robot and start a program with CPRog

This procedure is valid for scenario 1 of the introduction: The robot arm is connected to a Windows PC with a USB2CAN adapter. The PC runs the CPRog software.

6.1 Connect to hardware

The real robot can be controlled in the same way as the simulated one, only the hardware has to be connected: connect, reset errors and enable motors.

Prerequisites are that the robot is connected via the USB-CAN adapter and the power supply of the robot is plugged in, switched on and emergency button released. Read section 4, if you need to wire up your robot and section 5, if you still need to install the software and drivers

Pic.9: Buttons to connect to the hardware, reset the errors and enable the motors

Step 1: Connect to hardware. This step initializes the USB-CAN interface. The "LED" indicator in the left panel of CPRog switches from grey to red.
Below the "LED" several error messages are displayed.

Step 2: Reset the errors. This button resets the error memory of the joint module controller in the robot. The joint values are copied from the real robot to the simulation environment.

The 3D visualization of the robot must match the current position of the real robot now. This must be verified every time the errors are reset! If this is not the case, continue with section 6.3.
The "LED" stays red. The error messages get cleared, only "Motors not enabled" is remaining.
If further error messages remain visible, try again and see section 9.2 for possible approaches.

Step 3: Enable the motors. The "LED" is green now.

6.2 Jogging the robot

It is now possible to jog the robot with the jog buttons, using the mouse in the graphical, or with a game pad, see section 5.4.

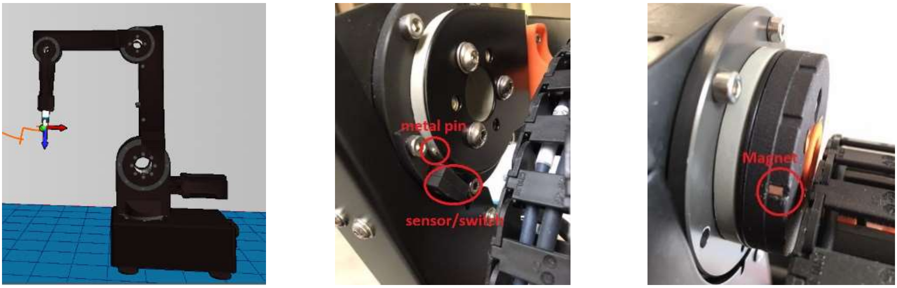
6.3 Referencing the robot

When the robot is not fully referenced, only joint motion is allowed. To avoid unintended motion, it is not possible to move the robot in Cartesian motion or to start a robot program!
The reference status is shown on the left side of CPRog.

The stepper control modules store the motor position in an EEPROM. But due to gravity or other forces the joints can move / fall down when not powered. After that, the joint modules do not have the correct joint position. Hence the robots needs to be referenced. In factory default settings of the joint modules each joint performs an oscillating motion with increasing amplitude until it hits the reference switch. Then a slower motion is performed to find the precise location of the reference switch. This position is defined as the new zero position. An offset is added, if the reference point is not in the joint zero position.

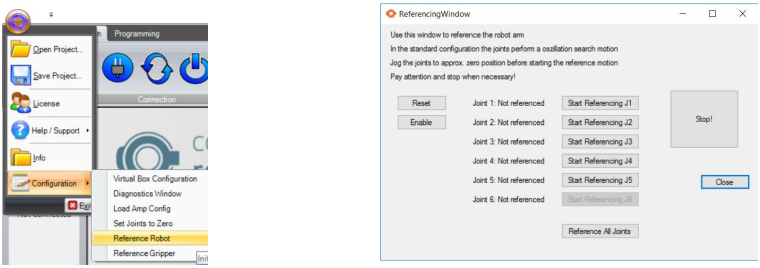
Here the step-by-step instructions to reference the robot:

- ➔ Start the robot control and CPRog
- ➔ Connect, reset and enable the motors by clkicking the corresponding software buttons.
- ➔ Move (jog) the robot roughly into the a zero position, so that the activating metal pins or magnets are close to the reference sensors. Do this for every axis. See pic. 10 for guidance.



Pic. 10: Left: zero position. Middle: metal pin and sensor. Right: magnet (sensor not shown). Overlay metal pin or magnet with sensor.

➔ In CPRog, click the program icon at the top left to go into the main menu. Then go to "Configuration" and "Reference Robot". The ReferencingWindow opens.



Pic. 11: Robot referencing menu entry (left), referencing window (right)

➔ Press on the joints to reference ("Start Referencing J<x>"). Several joints can perform the referencing motion in parallel.

➔ You can also click on "Reference All Joints", then the joints start referencing in a sequence defined in the project file.

➔ After all joints stop moving, the robot should be referenced,click "Reset" and "Enable". Close the Referencing Window.

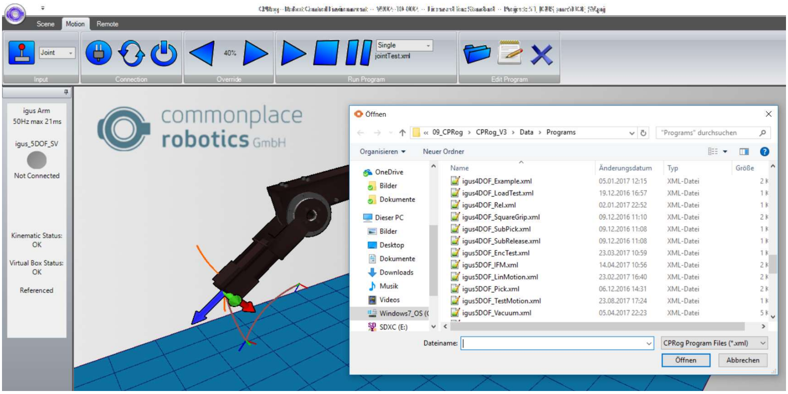
➔ Now it is possible to move in Cartesian motion.

6.4 Running a program

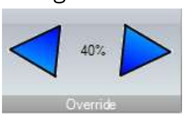
The programs needs to be loaded and started.

1. Load the program:
   Press on the folder symbol in the "Edit Program" area of the "Motion" ribbon.

2. Choose a program, e.g. igus5DOF_TestMotion.xml



3. Set the override (=percentage of maximum velocity):
   Before starting a new program set the Override to e.g. 20%. Pay special attention during the first complete run of the program.



4. Start the program:
   Press on the play symbol in the "Run Program" area of the "Motion" ribbon.

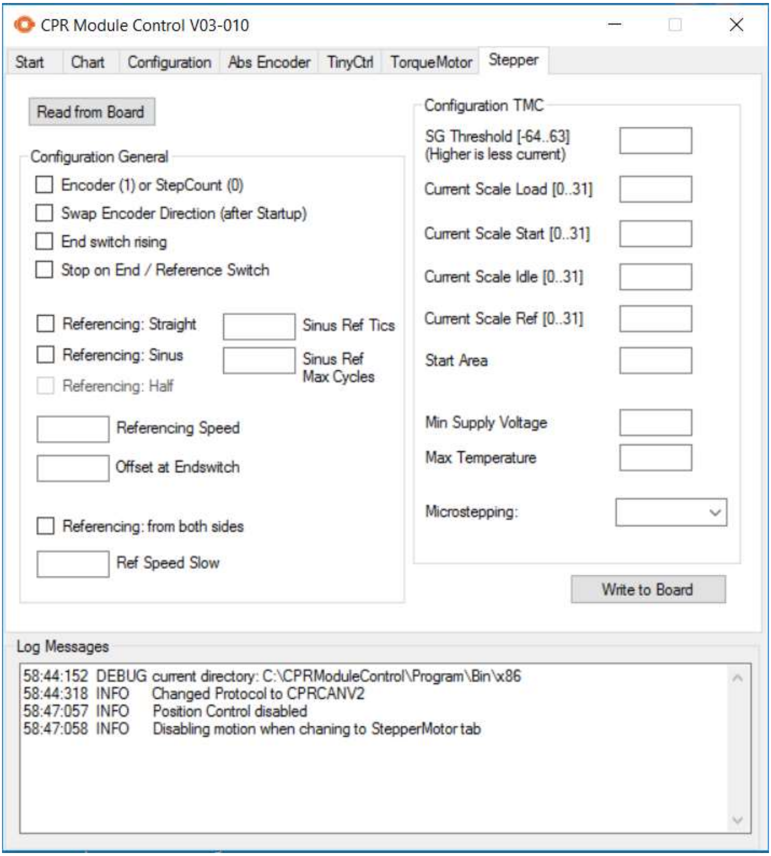
5. Stop or Pause the program:
   After a click on the "Pause" symbol, the robot pauses. It resumes operation after a click on the "Play" symbol. After pressing the "Stop" symbol, the program terminates. A subsequent press on "Play" starts the program from the beginning.

7. Configuration and maintenance

7.1 Module configuration

The parameter of the joint modules, especially the motor current, can be adjusted. When shipped, the joint modules are set to a medium power level. The power level can be adjusted: Less current (with less payload, slower speeds) to generate less heat; Higher current to get the full performance.

This configuration can be done with the software tool "CPR Module Control", it can be downloaded from the CPR Wiki: http://wiki.cpr-robots.com/



Pic. 11: CPR Module Control software, stepper page.

Please refer to the documentation provided with the software.

The parameter on the left define the behavior during referencing. The parameter on the right define the motor currents and microstepping.

- ➔ The "Current Scale" parameter defines the maximum current during operation (Load), slow motion (Start), without motion (Idle) and during referencing (Ref). The stepper driver modules use the Trinamic CoolStep technology to adapt the motor current between the values entered here and a lower limit which is a fraction of this value. This means that with lower current scale values the overall power consumption and the heat generation is lower. However, it can happen that the available torque is not sufficient, e.g. with high payloads. Then the motor stalls. To prevent stalls, use higher values. Be aware that the system will get warmer / hotter in this case.

- ➔ The "Current Scale Ref" parameter can be set separately e.g. to limit damage to collisions during reference motions.

- ➔ When using the module without encoder a microstepping of max. 1:64 should be used.

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- ➔ The direction of rotation of the encoder can be changed using the check-box "Swap Encoder Direction". The change is
- ➔ applied after the next cold start of the control.
  This is useful especially for joint 5. If the encoder direction does not match the motor direction, the joint does not move correctly, but accelerates until a position-lag error occurs. Then it is necessary to change the encoder direction and restart the system. Afterwards the joint should work fine.

7.2 Robot calibration

The zero position of the robolink arms are defined by the reference switches (see section 6.3). But also the angle between this reference position and the zero position has to be defined. When the robot has been delivered by Commonplace Robotics, this already has been done. If you need to do it yourself, please refer to the instructions on the wiki.cpr-robots.com.

7.3 Application configuration

The application configuration can be done by adapting the parameters in different XML files.

7.3.1 Project file

The project file contains the project-specific information, e.g. which robot to use, which gripper to adapt or how many digital IO boards to connect. It can be found in

C:\CPRog\Data\Projects\

Please refer to the examples to get to know different combinations. The CAD files have to be in .stl (only ASCII) or AliasWavefront .obj format, units are mm.

7.3.2 Robot configuration

For each robot in the CPRog simulation an XML config file exists, e.g.

C:\CPRog\Data\Robots\igus_5DOF_SV\igus_5DOF_SV.xml

This file contains e.g. max / min joint values, maximum joint velocities, the length of the arm elements or the CAN ids.

7.4 Updating CPRog

Updates of the CPRog programming environment can be found at wiki.cpr-robots.com in the CPRog section. Please rename your old CPRog folder to e.g. c:\CPRog_Data before starting the installer.

You might have to copy the following items from the old installation:

- Your robot programs
- Custom changes to the configuration files.

8. Interfacing

8.1 PLC interface

The Programmable Logic Controller (PLC) interface allows to integrate the robolink arm into a production system controlled by a master PLC. Digital inputs can enable the robot and start a program; digital outputs provide information on the status of the robot. This way the robot can operate without manual interaction.
The interface can be configured and switched on in the project file. Further details are found on the wiki, section PLC Interface: http://wiki.cpr-robots.com/index.php?title=PLC_Interface

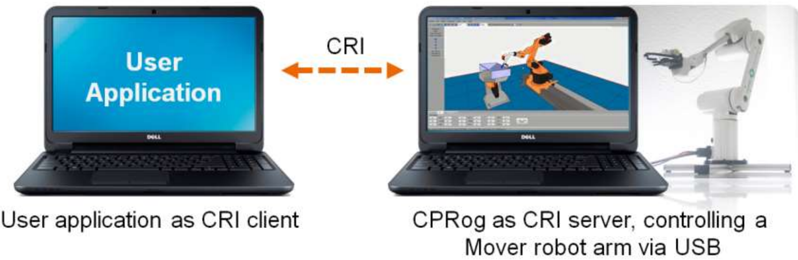
8.2 Plugin interface

CPRog provides a plugin interface to easily integrate e.g. vision systems, machines or PLCs. The plugin is a bridge between the external system and the CPRog program execution and has several defined functions.
Example: The IFM O2D smart camera can detect a learned model and provide the position via Ethernet. The corresponding plugin reads this position from the ethernet line and stores it, when requested, into a position variable. This way the robot can move to the position that is provided by the smart camera.

Further information and also C# example code for a plugin can be found here:
http://wiki.cpr-robots.com/ Section Programming Environment CPRog.

8.3 CRI interface

The Container Runtime Interface (CRI) allows to connect via Ethernet and jog the robot, send motion commands and start programs.



With this setup you can use CPRog functionality and implement custom algorithms in a CRI client, e.g. a vision system. Possibilities then are e.g.:

- Send a list of motion or digital out commands to the robot and then start the assembled program.
- Jog the robot arm by sending jog values.

Motion are possible in joint or Cartesian space. The CRI documentation and an example CRI client written in C# can be downloaded on our Wiki in the Interfacing section:
http://wiki.cpr-robots.com

8.4 ROS – Robot Operating System

The Willow Garage Robot Operating System (see www.ros.org) is wide spread in the research community, especially for dealing with service robots. Packages for the robolink arm are in preparation to connect to the hardware and to command the robot by joint and position messages. An RViz plugin and a moveIt interface are available. The packages can be downloaded at https://www.github.com/CPR-Robots

8.5 Direct access using the CAN protocol

It is also possible to access the robot controller on CAN field bus level directly, using a custom control software. The necessary protocol specifications are found in the following section. Code examples can be found on the Wiki in the Interfacing section: http://wiki.cpr-robots.com

8.6 CAN protocol specification

The robot control uses the CPR-CAN-V2 protocol, a custom CAN protocol with 32 bit position data width. The protocol description is available on our Wiki in the Interfacing section:

http://wiki.cpr-robots.com

Please also refer to the C++ implementations found on www.github.com/CPR-Robots for code examples. The robolinnk arm has the standard CAN IDs 0x10, 0x20, 0x30, 0x40, 0x50 (if available) for the joint modules.

9. Troubleshooting and support

9.1 Error codes

The robot controller provides several types of status/error indicators:

- Status LEDs on the DIN rail modules
- CPRog status, communicated with the CAN status byte

9.1.1 DIN rail module - status LEDs

Support Module:
Green LED on: Logic supply is available
Green LED blinking: CAN communication with the module
Orange LED: Error
Red LED: Emergency Stop button not released

Stepper Motor Module:
Green LED on: Logic supply is available
Green LED blinking: CAN communication with the module
Orange LED: End switch triggered
Red LED: Module not ready to run: motor not enabled or error state

Digital In/Out Module:
Green LED on: Logic supply is available
Green LED blinking: CAN communication with the module
Orange LED: Status of input or output is changing
Red LED: Error

9.1.2 CAN-bus and CPRog status bar

Error	Bit in error byte	Meaning	Possible action
Bus dead		The CAN bus is not accessable. Normaly the reason is that the robot does not have power.	Check all plugs and the emergency button. See wiki.cpr-robots.com, section 'Troubleshooting'
Temp	Bit 1	Module temperature limit exceeded	Check temperature and ventilation
E-Stop / Supply	Bit 2	Insufficient E-Stop or Motor supply voltage	Check if emergency switch is released
MNE Motor not enabled	Bit 3	Not an error. Motor needs to be enabled by explicit command	Enable motor when appropriate.
COM Comm Watch Dog	Bit 4	Interval without command was too long	Provide the position or velocity commands in a reliable and short enough time interval. Increase maxMissedCom.
LAG Position Lag	Bit 5	Position is too far away from the setpoint position	Provide setpoint positions accessible from the current motor position. Increase maxLag.
ENC Encoder Error	Bit 6	Error in motor encoder or absolute encoder	Check connection cable motor – motor controller
OC Over Current	Bit 7	Current value too high	Decrease applied load on motor. Increase maxCurrent.
DRV	Bit8	Driver or SVM error	Module specific, e.g. overload

After an error reset the normal state is 0x04 (Motor not enabled).
After enabling the motor the status is 0x00, now the motor is ready to move.

To reach this state (0x00), the communication has to provide values in a fast and reliable way and, when in position control, in the reach of the motor. These restrictions are taken to prevent unwanted motion due to e.g. a blue screen on the control PC, a broken communication, or programming bugs.

9.2 Troubleshooting

Please get in contact with us, we are happy to help:

- Mail: support@cpr-robots.com
  Please add a description of the problem, the robots serial number (found at the base) and the three files „install.log", „startUpLog.txt" and „logMessages.log". They are found in c:\CPRog\.
- Phone: ++49 5402 / 968929-0 in Germany, GMT+1

9.2.1 Hardware

- Green LEDs on the rail modules are not on?
  Check the power supply and the fuse.
- Motors do not move? Check the emergency stop state. The red LED on the support module most not be on.
- The modules do not react on the software commands. The green LEDs are not blinking.
  There must not be an empty slot between the support module and the joint modules. The CAN connection is interrupted by such an empty slot.
- The motor stalls: it does not finish a motion and makes ascending sounds.
  This happens if the load of the motor was too high:
    - Check if there was a collision
    - If this happens several times increase the motor current, see chapter 7.
- Joint 5 does not move in a controlled way, but accelerates until a pos lag error occurs: Try to change the encoder direction, see section 7.
- If CPRog cannot connect: close or reset the PCAN-View software, if it is running.

9.2.2 Software

- If there are problems with CPRog check our wiki for a new version:
  http://wiki.cpr-robots.com

9.3 CE Declaration of incorporation

In terms of the EC Machinery Directive 2006/42/EG, Annex II, Part B

Manufacturer / Distributor	Commonplace Robotics GmbH Im InnovationsForum Bissendorf. 1 49143 Bissendorf, Germany

We hereby declare that the following products

- Drive Module Stepper 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)

meet the applicable basic requirements of the EC Machinery Directive 2006/42/EG.

The incomplete machine may not be put into operation until conformity of the machine into which the incomplete machine is to be installed with the provisions of the EC Machinery Directive 2006/42/EG is confirmed.

Applied harmonized standards, especially:

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

The technical documents required in Annex VII, Part B have been created and can be forwarded to state offices.

Responsible for documentation: Dr.-Ing. Christian Meyer

Melle, December 2016 Dr.-Ing. Christian Meyer


commonplace