MANUAL
Connecting ArtiMinds RPS with KUKA Robots

Quick Start Guide

Version 2.4

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Content

Preface

Target Group and Prerequisites

This manual targets users that want to program robots of the manufacturer KUKA with the programming software ArtiMinds RPS. It provides information about peculiarities when setting up a connection between ArtiMinds RPS and the robot and tries to provide as much guidance about the robot hardware as possible.

Basic knowledge on robotics, robot operation, and network setups is expected.

Orientation in the Documentation

Apart from the "Manual – Connecting ArtiMinds RPS with KUKA Robots" that you are currently reading, the following related documentation is also available:

- ArtiMinds RPS – Training Manual
- ArtiMinds RPS – Installation and Technical Infos
- ArtiMinds LAR – Installation and Technical Infos
- ArtiMinds Manual – EtherCAT Sensors on KUKA Robots

Operating Instructions and Other Documents

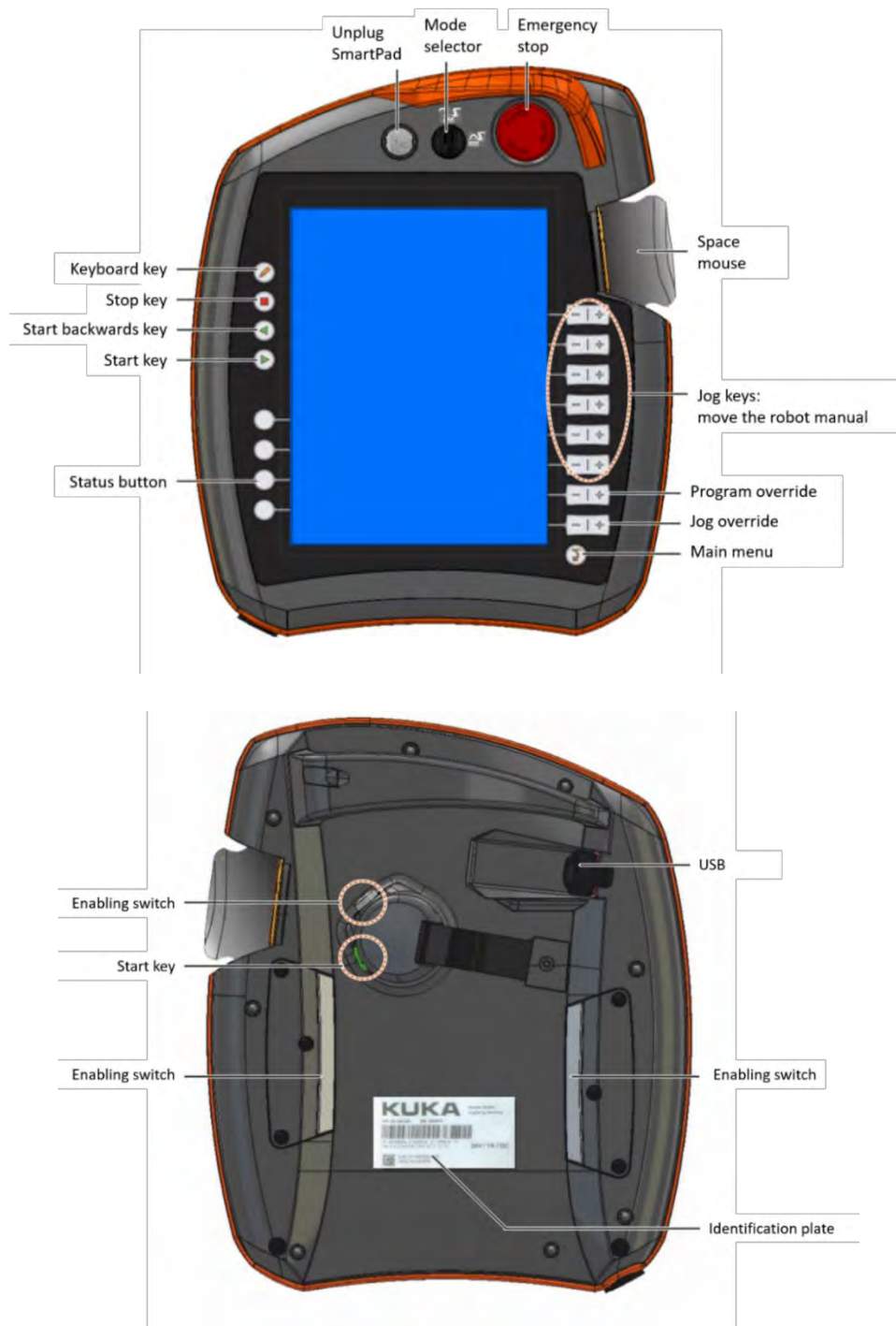Despite every effort being made to provide a complete and thorough picture, this manual cannot replace the official KUKA documentation and a basic KUKA user training. ArtiMinds has no influence about the development and releases of software and hardware provided by KUKA. Documented functionalities of the KUKA robot system might be changed at any time by KUKA.

Take appropriate precautions when operating heavy machinery.
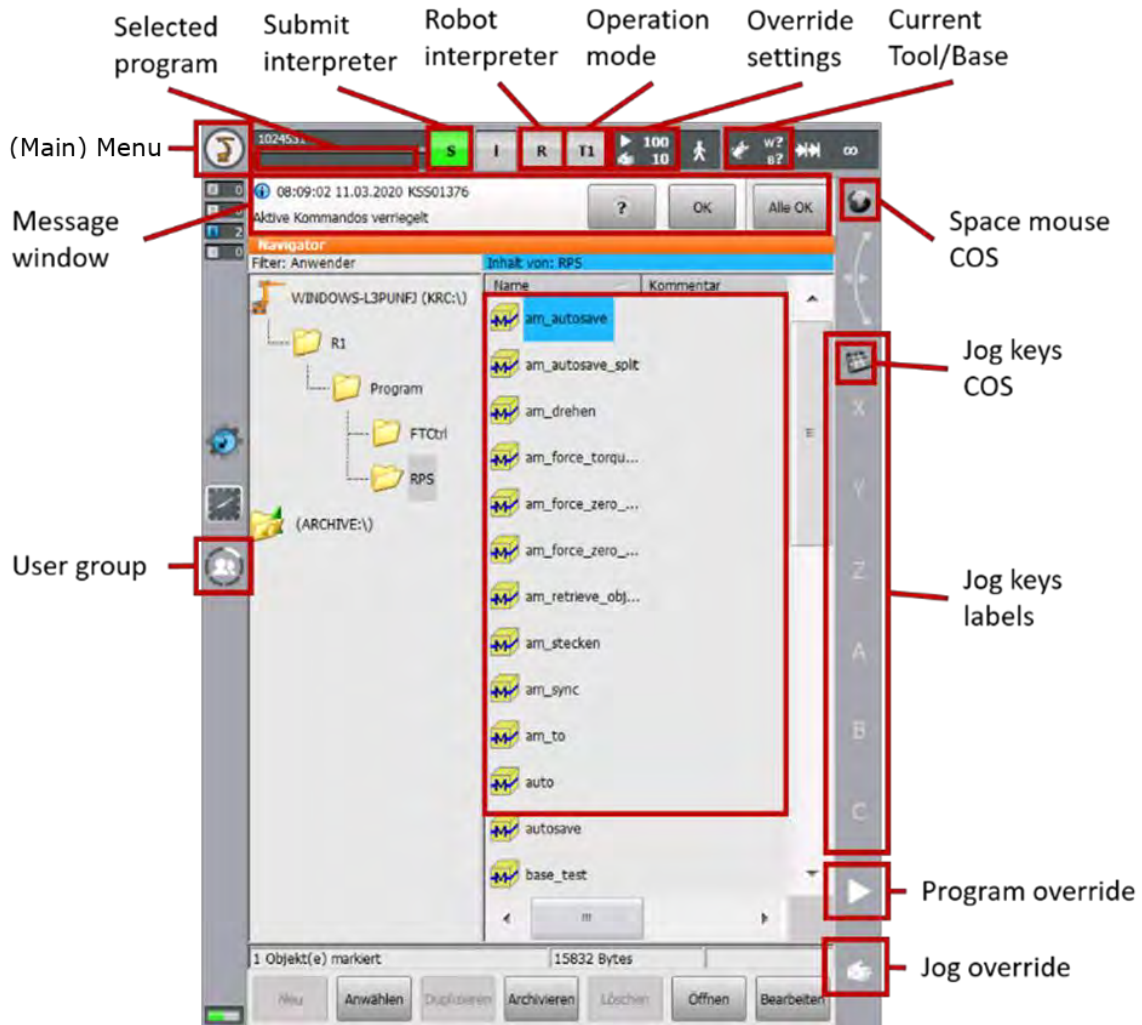
1   Overview of the KUKA Robot System

This chapter mainly explains some basic terms and provides an overview of important operating keys of a KUKA robot. Further information can be found in the KUKA manuals. Users who are already familiar with the KUKA robot system can skip this topic.

The following pictures will give you a brief overview about the KUKA controller.

Source: KUKA

Function	Location	Summary
(Main) menu	Top left corner	Setup and configuration of the robot
User group	Center left	Manage the current user goup. Some settings are only available to the Expert/Administrator user. Default password: "kuka"
Current override	Top right	*"Program" (play symbol):* Percentage value of the program-med velocity *"Jog" (play + hand symbol):* Percentage value of the velocity for manual motions
Set override	Bottom right corner	Setup the overrides
Robot interpreter	Top center	Displays the currently selected program and the program status: Gray: No program selected Yellow: Program is ready to start (first line of selected program) Green: Program is being executed Red: Selected and started program has been stopped Black: Program has finished

Function	Location	Summary
Current Tool/Base	Top right	Displays the current selected Tool/Base id. ?: No Tool/Base selected
Operation mode	Top right	Change/Select the operation mode of the robot: T1: For test operation, programming and teaching, max. velocity of 250 mm/s T2: For test operation, programmed velocity, jog mode not possible AUT: Robot without higher-level controllers, programmed velocity, jog mode not possible EXT: Robot with higher-level controllers, programmed velocity, jog mode not possible

Please notice that some functions on the KUKA teach pendant are only available if no program is selected. Also pay attention to the selected user group, some settings are only available to the Expert/Administrator user.

The KUKA controller uses a multi-file system, therefore it may happen that changes made to the file system via the mounted network share are overwritten. It helps to open the altered file on the teach pendant again, adding a space symbol and closing the file. This also triggers the parsing of all dependencies.

The KUKA controller uses an advance run system, so certain commands are executed earlier while the robot still executes a former motion command. This can lead to the premature execution of commands which can be suppressed by certain blocking commands (e.g. "WAIT for TRUE"). This is relevant when a vision system is used. The recording of the camera image should only be triggered after the robot arrived at the correct position (advance run must not trigger the camera).

KUKA provides a software called KUKA.WorkVisual to communicate with a KUKA robot from a computer and configuring it. It is recommended to use this software, although ArtiMinds RPS does not need it during execution. Many options, especially safety relevant settings and hardware extensions, can only be altered via KUKA.WorkVisual.

2 Prerequisites

2.1 Supported Platforms

Currently the controller generation KR C4 and KR C5 are supported, running KUKA.SystemSoftware (KSS) up to version 8.6.8 (KR C4) and 8.7.3 (KR C5). Newer versions will most likely work, but have not been fully verified yet.

2.2 Required Technology Packages

The following technology packages are required for basic ArtiMinds RPS usage:

- KUKA.DirectoryLoader: Required to transfer and start programs on the robot
- KUKA.EthernetKRL: Required to send and receive data over network
  Attention:
  - Some versions of EthernetKRL have a bug that causes blocking of the used communication ports, resulting in an error in *KRC\Roboter\log\EthernetKRL\EKI*.log* like:
    ```
    CTcpSock: Socket *** on port **** failed to bind with code 48
    ```
    You will need to upgrade EthernetKRL if this occurs.

The following technology packages are required for force guided motions:

- KUKA.RobotSensorInterface (RSI): Required for sensor adaptive motions.
- KUKA.ForceTorqueControl: Required to connect to a Force-Torque Sensor

ⓘ Some technology package versions are known to have bugs. You can find an up-to-date list of buggy versions in the document "ArtiMinds Required 3rd party software.pdf". Please contact support@artiminds.com if you suspect that a KUKA technology package causes errors.

Please consult your KUKA sales representative to obtain the required technology packages. KUKA.WorkVisual or "Main (Menu) → Start-up → Add-on Software" (German KUKA "Hauptmenü → Inbetriebnahme → Zusatz-software") on the robot teach pendant (KUKA SmartPad) can be used to verify the installed technology packages on the KUKA controller.[1]

Additional system requirements about ArtiMinds RPS can be obtained in the document "ArtiMinds RPS - Installation and technical information for use in corporate IT environments".

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[1] Setting is only visible if logged in as Expert/Administrator user (default password "kuka").

3   Installation

3.1   ArtiMinds Robot Programming Suite (RPS)

Additional information about ArtiMinds RPS installation and technical details can be found in "ArtiMinds RPS Installation and Technical Infos Release <Version>.pdf".

3.2   ArtiMinds Learning and Analytics for Robots (LAR)

Additional information about ArtiMinds LAR installation and technical details can be found in "LAR <Version> Setup and User Manual.pdf".

3.3   Usage of Force-Torque Sensor

There are several ways to connect the sensor to the robot, depending on the brand of sensor that you are using. In all cases the measured data is read over the RSI interface and partly processed via the ForceTorqueControl technology package.

Prerequisites:

The RSI network interface that connects to your sensor must be configured to a different subnet than the regular interface used by ArtiMinds RPS (see chapter 4.4).

Apart from that, please follow a separate manual from KUKA or the sensor manufacturer to connect your specific sensor. If you connect the sensor via EtherCAT, ArtiMinds also offers a specific manual for that (*ArtiMinds Manual – EtherCAT Sensors on KUKA Robots<VERSION>.pdf*).

4 Configuration

4.1 Network Setup

Physically connect the KUKA robot and the computer that runs ArtiMinds RPS to the same network (Ethernet recommended, no WIFI) e.g. by using a network switch.

Often computer and network switch are able to set suitable IP addresses automatically. If static IP addresses are used (recommended), please make sure that the robot and computer are in the same network.

The IP address of the KUKA robot can be configured on the KUKA teach pendant by clicking on the "(Main) Menu" button (KUKA robot icon), then "Start-up → Network Configuration" (German KUKA: "Hauptmenü →

Inbetrienahme → Netzwerk"). Setting is only visible if logged in as Expert/Administrator user (default password "kuka") and no program is selected.

On the computer the IP address is set in the "Windows Control Panel → Network and Sharing Center" (Windows 7 or newer). Here you can see an overview of all network adapters. Click on the network adapter that is connected to the KUKA robot and then on "Properties" to verify or alter the IP address of the computer.

Optionally you can use the Windows command shell (opening the Windows start menu and typing in "cmd.exe") and execute the command "ping IP_ADDRESS_OF_THE_ROBOT" to verify that the connection is working. Replace IP_ADDRESS_OF_THE_ROBOT with the IP address of your robot, for example "ping 192.168.2.10".

If the "ping" command is not working, check the Windows firewall if it blocks the connection. Also make sure that no additional anti-virus or security software is involved. Consult the manual *"ArtiMinds RPS - Installation and technical information for use in corporate IT environments.pdf"* for more details and what network ports must be open.

Note: During programming, the robot will try to establish a connection to the PC. The configuration on the robot must be adjusted if the IP address of the PC is changed after initial setup, or if another PC is connected. See chapter 5.3 for details.

4.2 Network Drive Setup

4.2.1 KUKA Robot

Configuring the basic network share is always needed when ArtiMinds RPS should be able to communicate with the robot and generate robot programs. For this, the hidden KUKA C: drive has to be shared and mounted as a network drive on the computer. All following steps are executed on the KUKA teach pendant.

1. Log in as Administrator on the robot, go into the settings, then "Start-up → Service → Minimize HMI" (German KUKA: "Inbetriebnahme → Service → HMI minimieren").
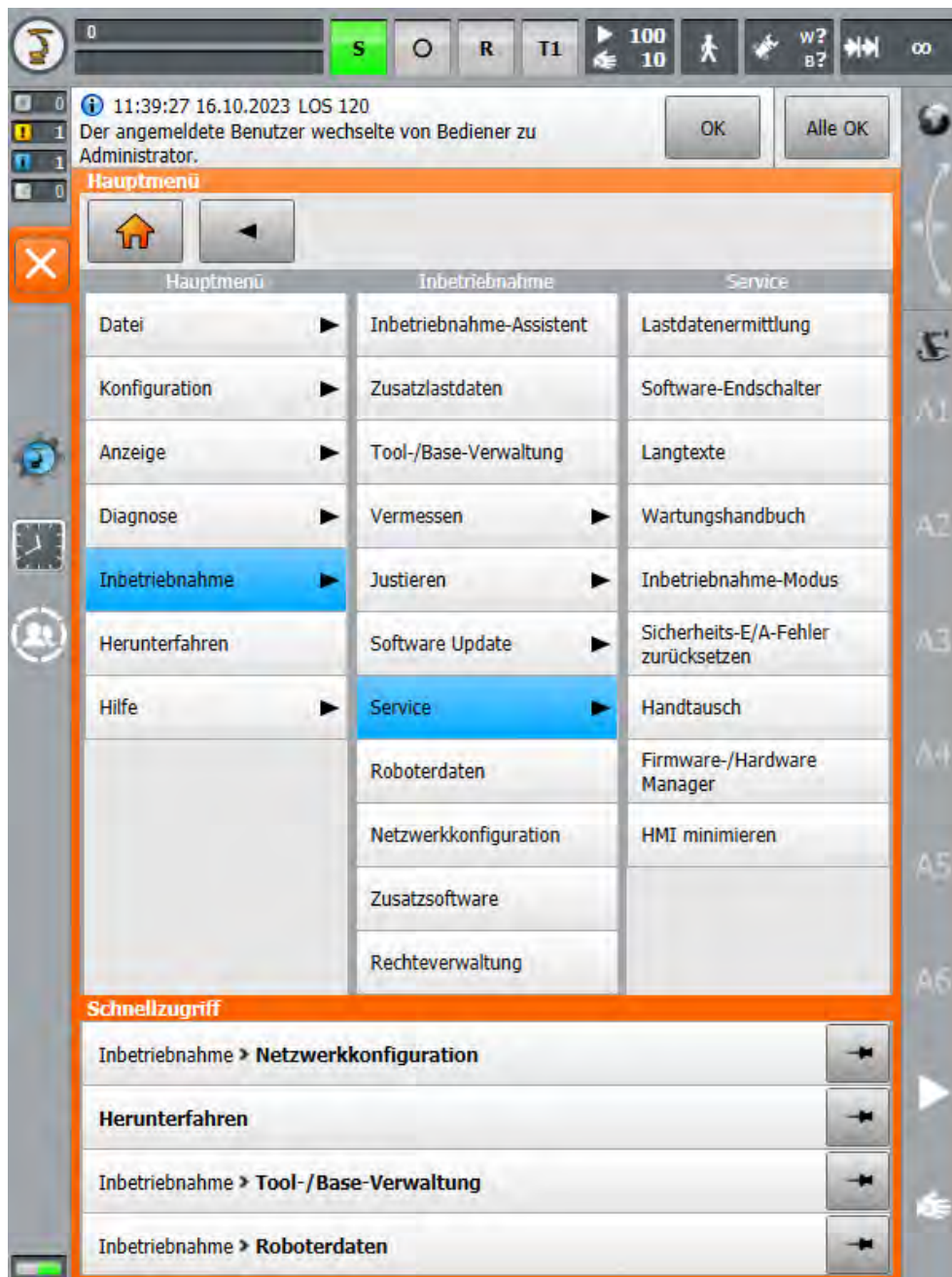
2. Now the KUKA user interface is disabled and the underlying Windows operating system that runs on the KUKA controller is visible. Select the C: drive and open its "Properties". Then go to the "Sharing" tab.
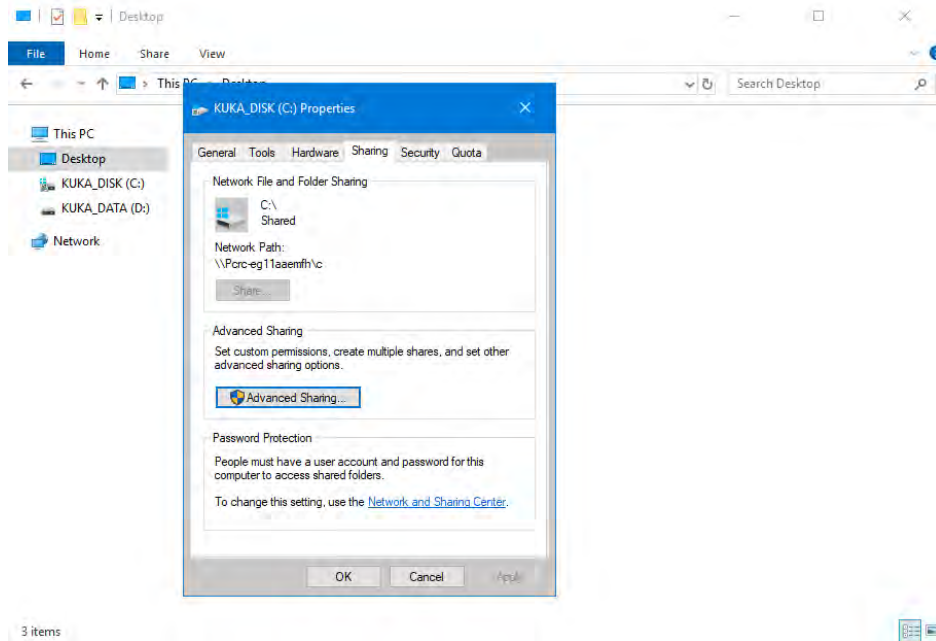

3. Click on the "Advanced Sharing → Permissions" button and enable all access rights of the "KukaUser" user. All checkboxes for "Full Control", "Change" and "Read" need to be enabled. If the "KukaUser" is not visible, create it via the "Add" button.
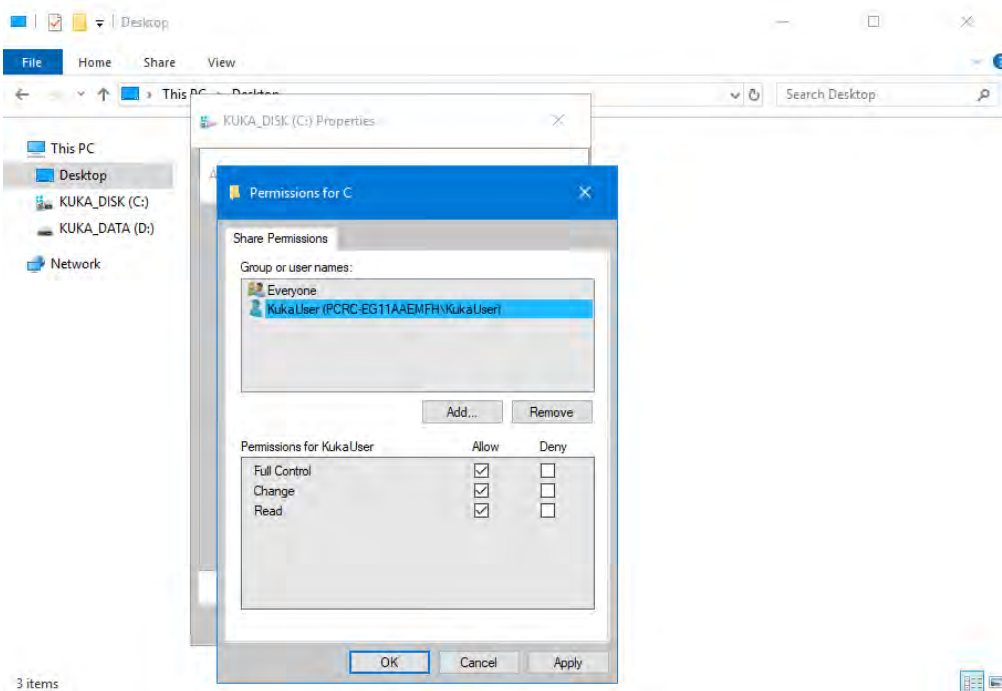
4.2.2   Computer

Now the C: drive of the KUKA is visible to the computer and can be mounted as any regular network drive in Windows. On the computer execute the following steps:

1. Open a Windows Explorer window and type in "\\IP_ADDRESS_OF_THE_ROBOT", e.g. "\\172.30.1.100".
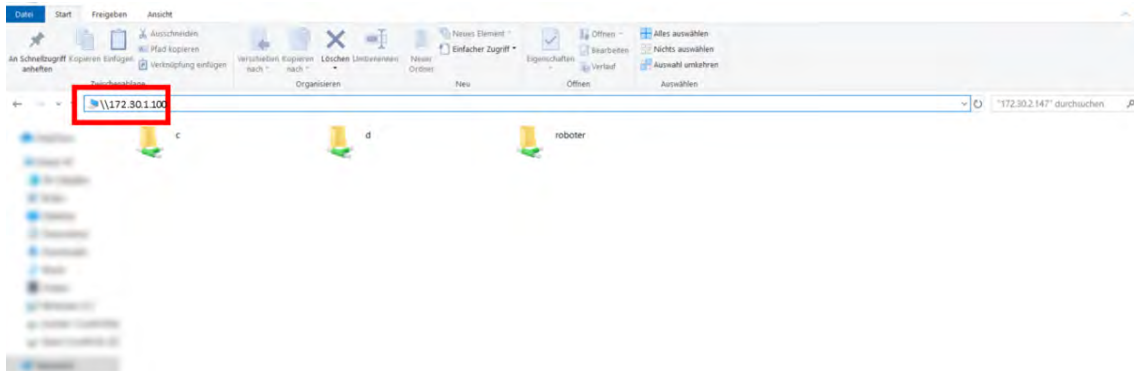
2. Click with the right mouse button on the C: drive and then on "Connect Network Drive…".
   If login credentials are required, enter the usersname and password of the KUKA.
   Default user: "kukauser" with the default password "68kuka1secpw59".
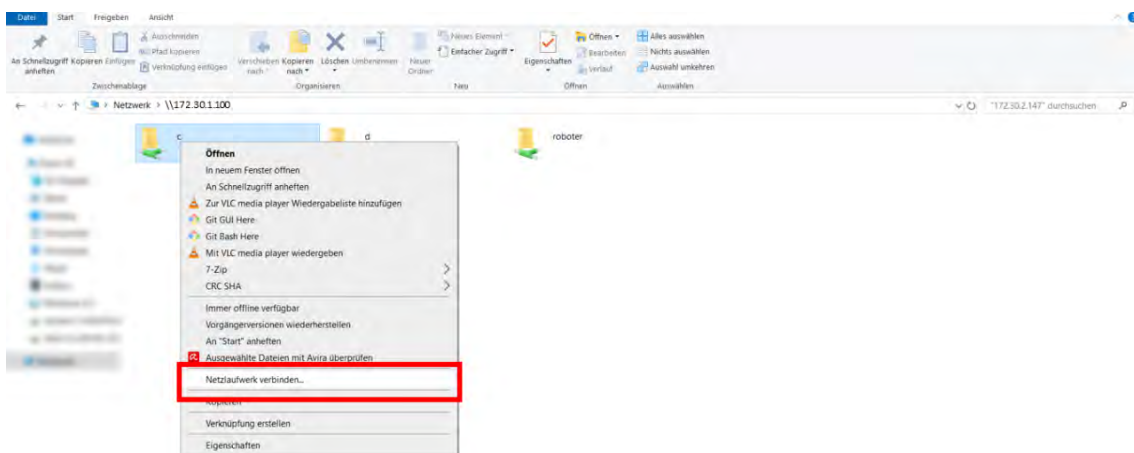
3. Select a free local drive letter and enable the "Reconnect at sign-in" checkbox. Remember the chosen drive letter (in this case W:) for later.
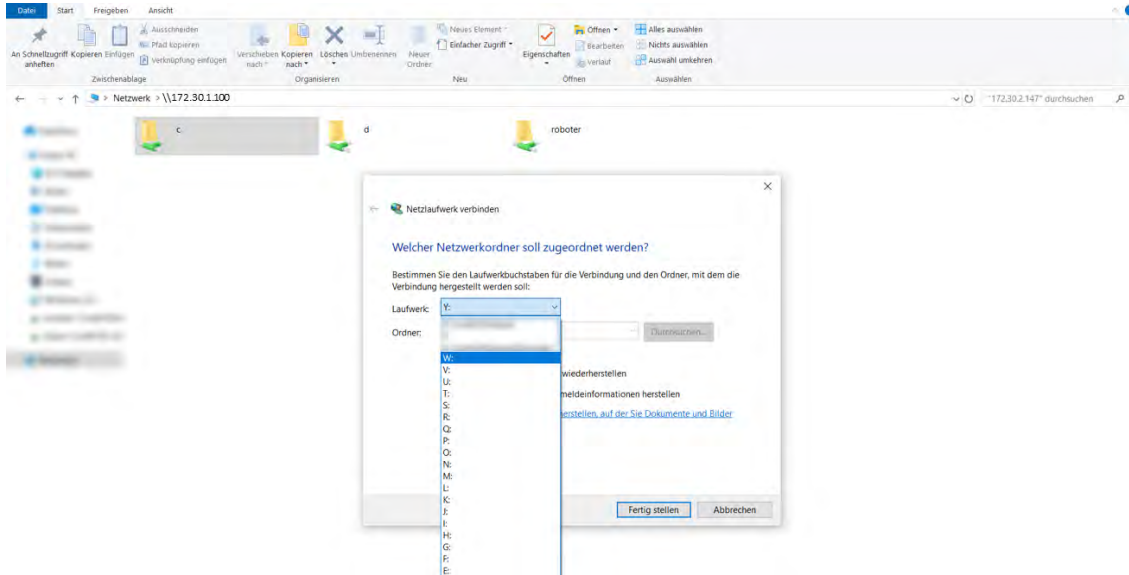
4.3 KUKA Directory Loader

Check and adapt the setup of the DirectoryLoader by defining the temporary upload directory somewhere on the C: drive. Create the folder if it does not exist already. **Attention:** The DirectoryLoader mechanisms might be configured to delete the content of the folder on a regular basis. Therefore, do not use folders which contain relevant files!

ArtiMinds RPS copies its programs temporarily into this folder. The KUKA DirectoryLoader then performs a syntax check and if no errors are found it copies the files from that folder to the KUKA programs folder. Remember the name of the (created) temporary folder as it will be needed in chapter 4.5.2 again.

The configuration is specific for the KSS Version, e.g.:

1. KSS => 8.5:
   Open the file C:\KRC\ROBOTER\KRC\R1\TP\DirectoryLoader\directoryloader.dat
   (the directory may be hidden). Create or adapt the line
   DLSourceDir[]="C:\DirLoaderInbox\"
2. KSS < 8.5:
   Open the file C:\KRC\ROBOTER\KRC\R1\System\$config.dat
   (the directory may be hidden). Create or adapt the lines
   KRDLSOURCEDIR[]="C:\DirLoaderInbox\"
   BOOL PGNOcaseKRDL=FALSE

Restart the KUKA controller. After booting up the robot, have a look at the log messages and make sure the DirectoryLoader started without errors.

4.4   KUKA Robot Sensor Interface (RSI)

This chapter is only necessary if force-torque control is to be used or if high-resolution data is to be visualized or recorded in ArtiMinds LAR. That requires fast data streaming of 4 ms via RSI. If this is not the case, skip this chapter and immediately go to chapter 4.4.1.

Please note that there are additional manuals available to configure force-torque sensors with ArtiMinds RPS. Also have a look at the official KUKA documentation on configuring force-torque sensors and RSI with KUKA.Work-Visual (e.g. "Kuka.RobotSensorInterface 4.0" manual).

The RSI technology package requires an additional subnet for data streaming. For details see the KUKA documentation below (e.g. chapter 5). **Pay close attention to the IP address setup.** KUKA recommends using similar network segments. In this manual we use 172.30.**1**.XXX for the Ethernet KLI network and 172.30.**2**.XXX for RSI. These IP addresses are only meant as an example and other addresses can also be used.

Use "Real-time/Mixed IP address" in the KUKA network configuration. Do not use the KUKA KONI network for connecting a force-torque sensor as this network is optional and not real-time capable.
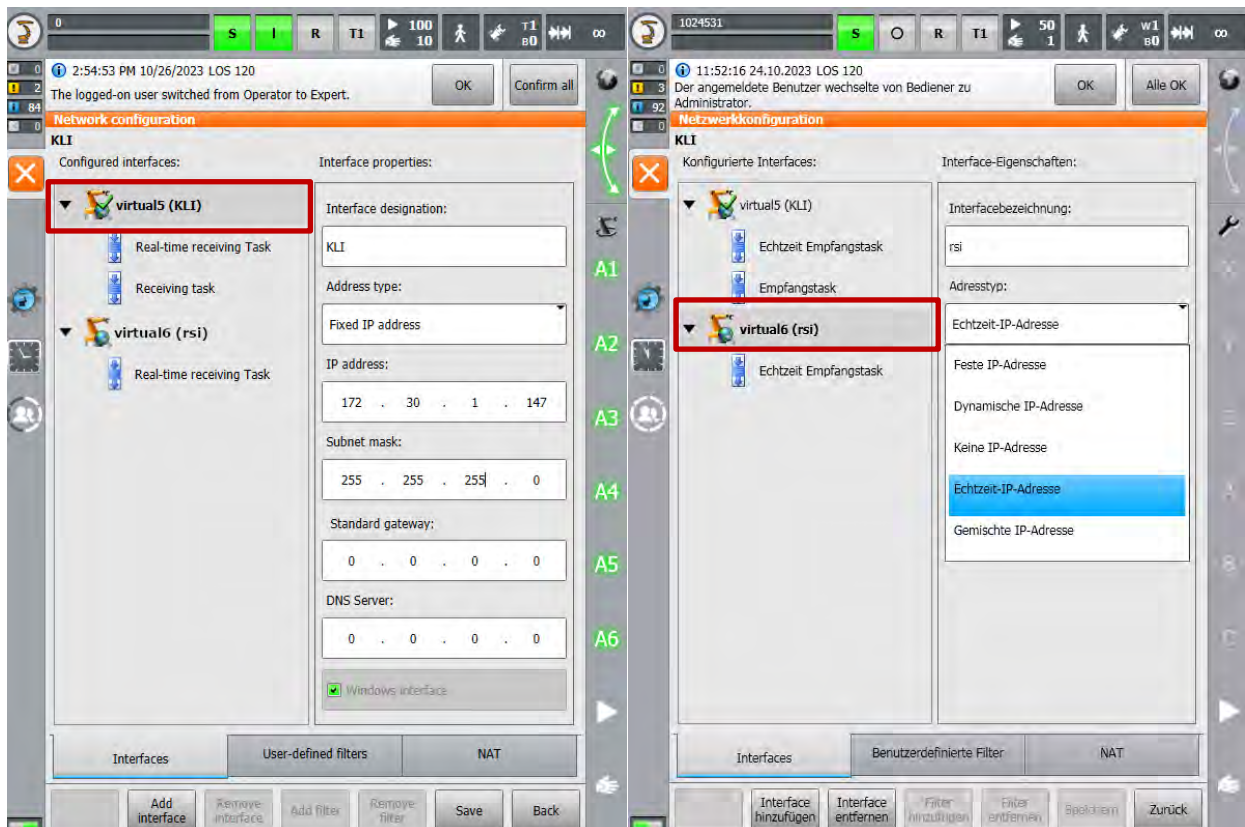
"Main Menu → Start-up → Network Configuration" (German KUKA: "Hauptmenü → Inbetrienahme → Netzwerkkonfiguration").

Manuals for KUKA can be found on the KUKA website or on the KUKA controller itself (KUKA D: drive: e.g. enter \\<*IP_ADDRESS_ROBOT*>*d**KUKA_OPT* in Windows explorer with mounted D drive).
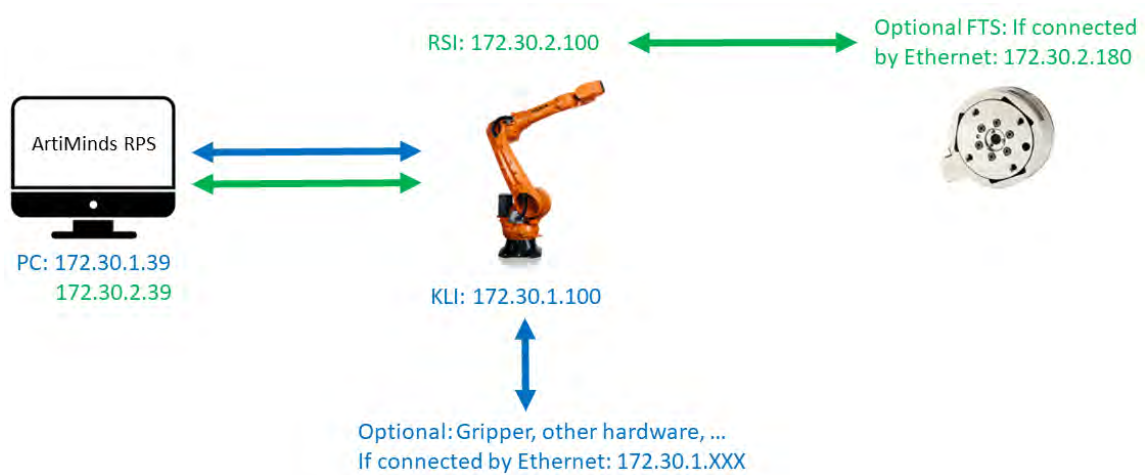
The above image shows the configuration used in this example. The KUKA robot has a KLI and RSI network. The force-torque sensor is connected via RSI and additional hardware (e.g. gripper) via KLI. Both networks are in a similar subnet as required by KUKA.

ATI Net-F/T sensors do not require a mapping of the channels in KUKA WorkVisual. For ATI ForTTran or EtherCAT based sensors, please consult our additional manual "Instructions for using Ethercat-based sensor on KUKA robots.pdf" as additional configuration is required.

The correct configuration of the force-torque sensor can be confirmed on the KUKA teach-pendant by navigating to "Configuration → FTCtrl → Sensor".

4.4.1   Computer

1. Go to Windows network settings. On the computer open the Windows Control Panel and then "Network and Sharing Center" (Windows 7 or newer). Here you can see an overview of all network adapters. Click on the network adapter that is connected to the KUKA robot and then on "Properties".
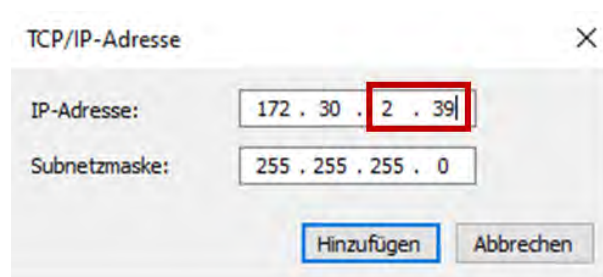2. Select TCP/IPv4 and click "Properties"
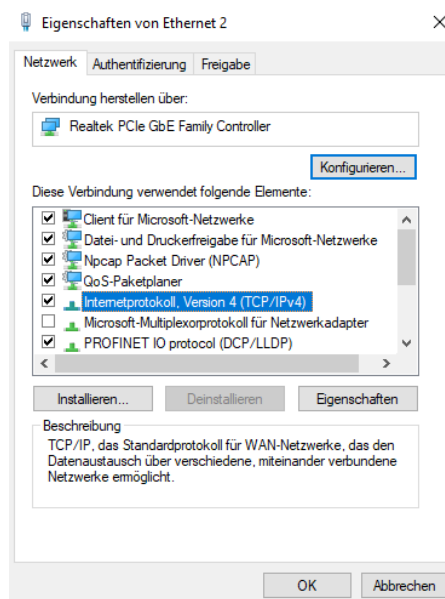
3. Click on the "Advanced…" button.
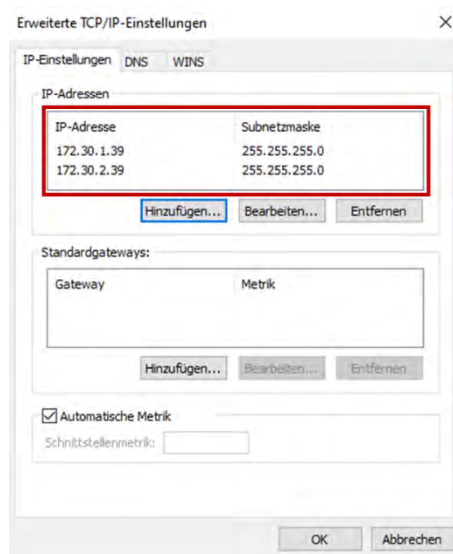

4. Click on "Add…" and add another network interface.
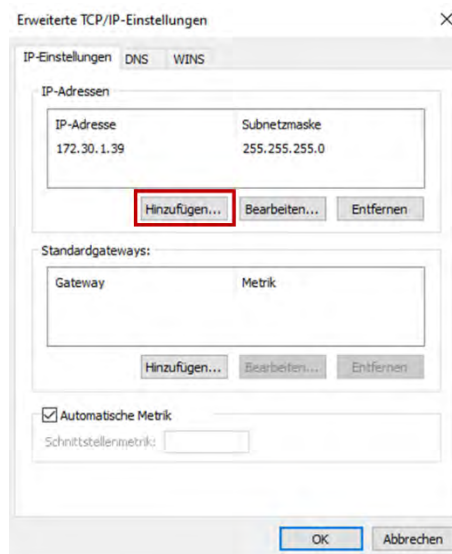
5. The additional network interface should have the same IP address, but in a different subnet (only required for RSI). Add the same subnet mask and click on "Add".

- The network should look like this (adapt the IP addresses as needed):
  172.30.1.39: Network interface to the KUKA robot
  172.30.2.39: RSI robot sensor interface

4.4.2   KUKA Robot

The IP address of the KUKA robot can be configured on the KUKA teach pendant by clicking on the "(Main) Menu" button (KUKA robot icon), then "Start-up → Network Configuration" (German KUKA: "Hauptmenü → Inbetrienahme → Netzwerk"). This setting is only visible if logged in as Expert/Administrator user (default password "kuka") and no program is selected.

Detailed information about the network setup for RSI can be found in chapter *5.1 Configuring Ethernet via KLI network configuration* of the *Kuka.RobotSensorInterface 4.0* manual.

4.5   ArtiMinds Robot Programming Suite (RPS)

Start ArtiMinds RPS on the computer which is connected to the KUKA robot.

4.5.1   Coordinate Systems Setup

The **Robot Configurator** allows you to define and setup your hardware. Launch it via "File → Robot → New Robot Setup". In the first pages, setup your components and coordinate systems as required.

Attention: If you choose to mount your robot base differing from the world origin via "Mounting: Robot Arm", you have to apply the same offsets in the machine-data configuration in KUKA.WorkVisual ("Editors → Machine Data Configuration")! Since this is a safety-critical step, ArtiMinds RPS cannot perform it automatically.
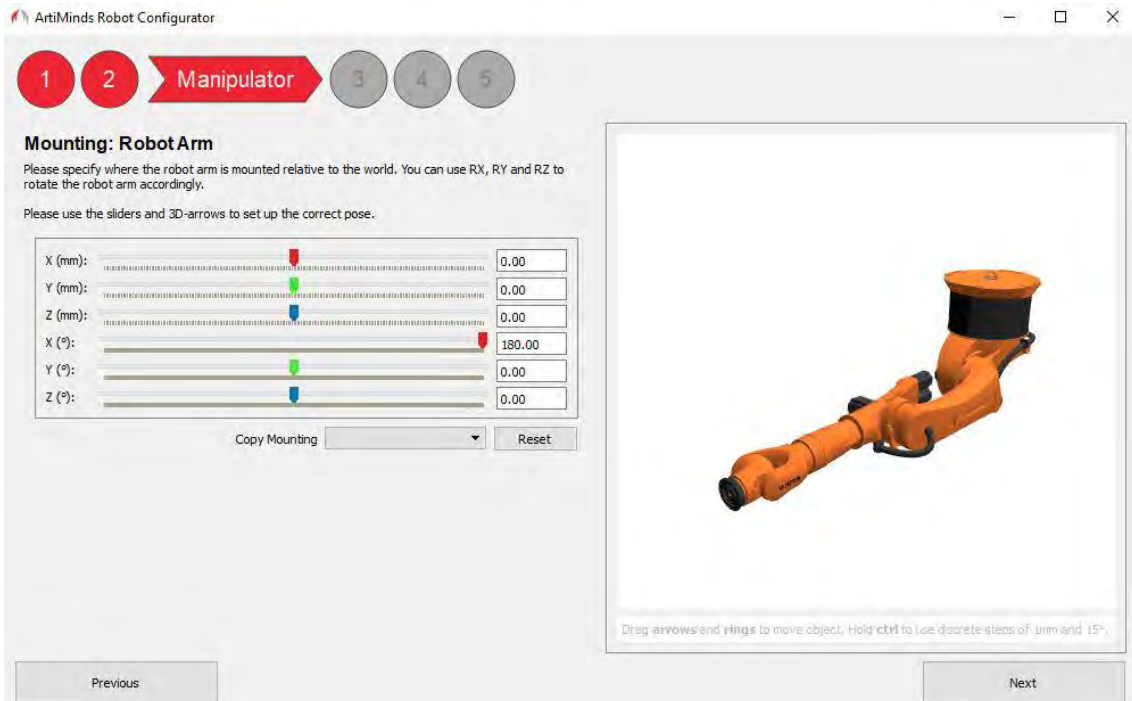
4.5.2 Network setup

On the "Setup Communication" page make sure to choose the right network device of your computer ("PC": "IP") with an IP in the same subnet as the robot's main Windows network IP. Then enter the main IP address of the robot on the "General" tab below.
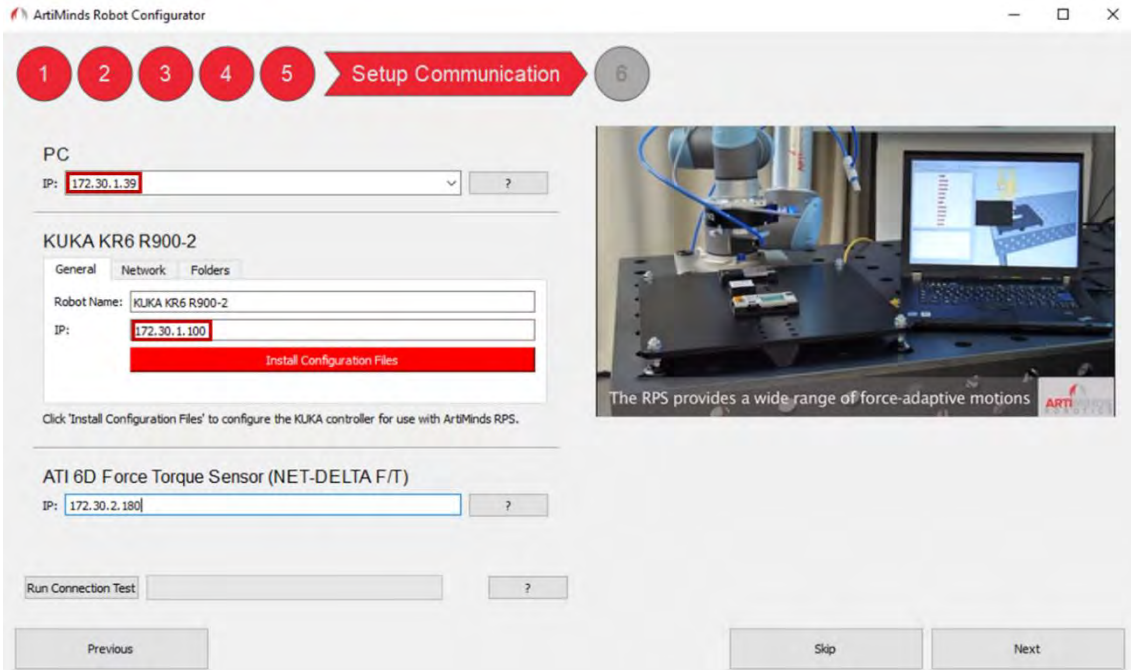
Switch to "Network" and enter the drive letter of the previously mounted network drive of the robots C: drive (W in the example above). Keep the credentials if they did not change on the robot.
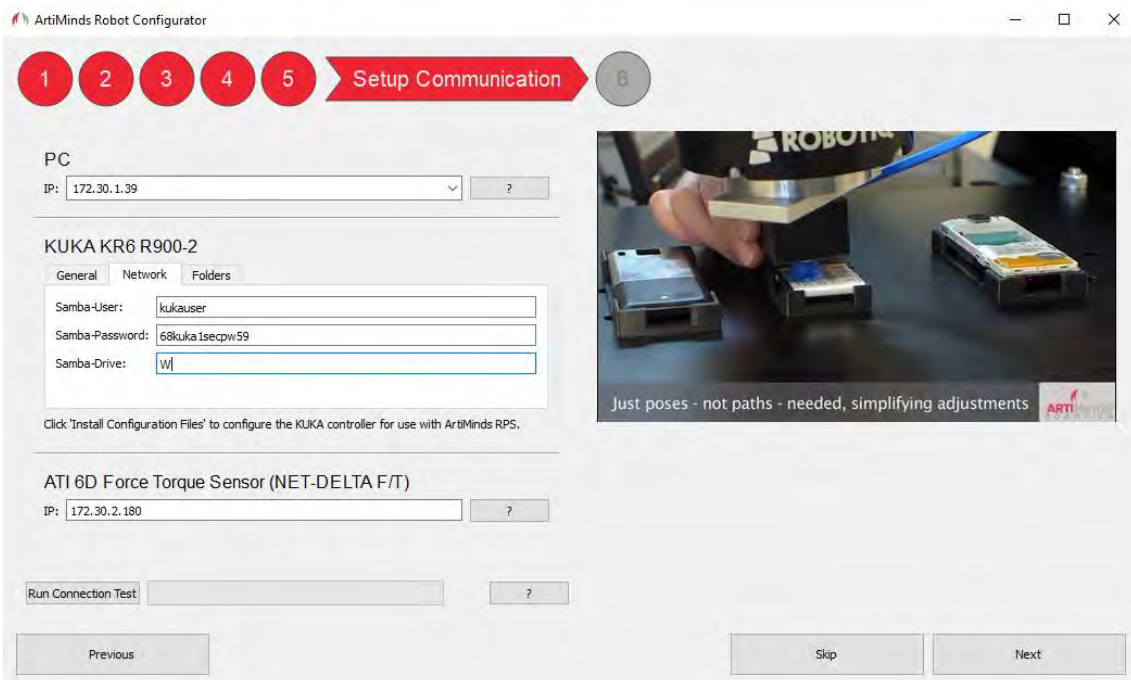
Also, keep the entries in the "Folders" tab if not changed manually on the robot. "Directory Loader Source Folder" should point to the folder that has been created on the KUKA C: drive in step 4.3.
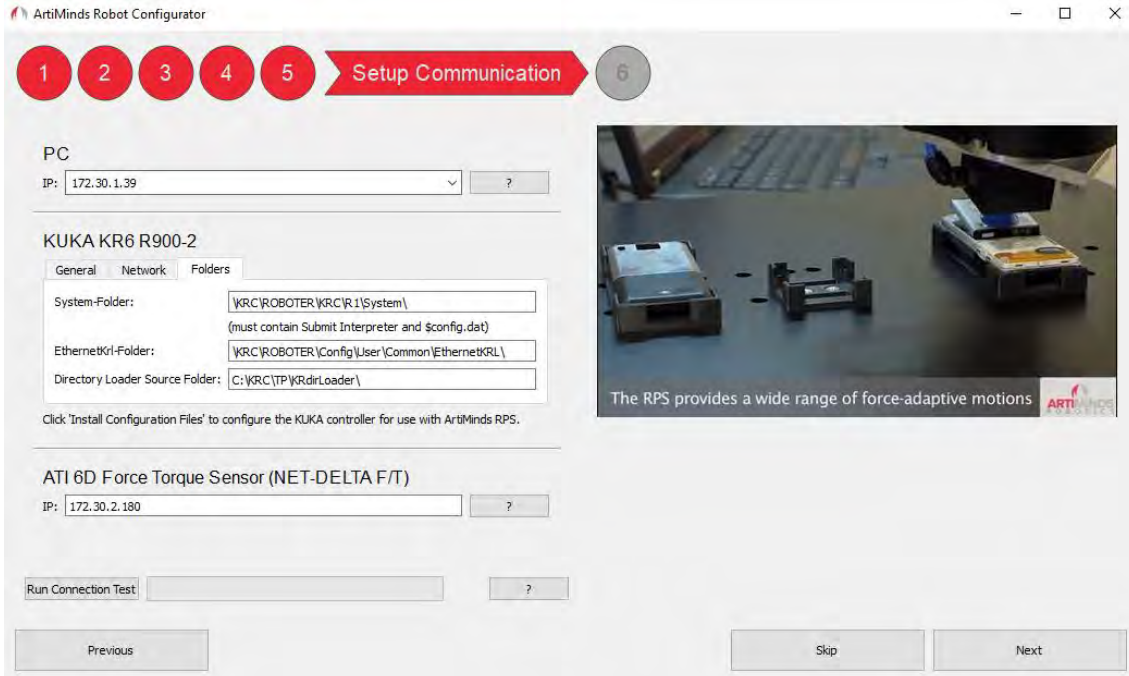
When testing the connection, ArtiMinds RPS tries to copy and modify several files on the robot. For that purpose, the Submit Interpreter has to be stopped and deselected: Click on the green "S" indicator on the KUKA teach pendant and choose "Deselect" (German KUKA "Abwählen"). Click the "Install Configuration Files" in the "General" tab so that ArtiMinds RPS can copy and modify various files on the robot controller. It's also possible to read in settings from the controller directly, so that not everything has to be configured manually. Restart the KUKA controller, so that the new files are read in. Afterwards you can test the communication in ArtiMinds RPS by clicking the "Run Connection Test" button.

> ⓘ Select a Tool and Base on the Teach Panel before running the Connection Test. Otherwise, ArtiMinds RPS will display the "No response from Robot" error message.

If the connection test is not successful, it may be easier to skip the connection test for now ("Skip" button) and complete the ArtiMinds Robot Configurator. You will be prompted to visit the settings after closing the Robot Configurator. Otherwise go to "File → Settings → Kuka" in ArtiMinds RPS and check the settings individually (see next chapter).

One simple way to test the communication with the KUKA robot in general later is by clicking on the "Offline" toggle button in the main menu bar at the top of ArtiMinds RPS. ArtiMinds RPS should switch to "Online" mode. Press the "Record" button (also in the main menu bar) to retrieve the current position of the real KUKA robot. The virtual robot in ArtiMinds RPS should show the same pose. Make sure a tool is selected on the teach pendant of the KUKA robot.

4.5.3   RPS Settings Pages

The following options are all available in the KUKA settings pages of ArtiMinds RPS ("File → Settings → Kuka").

Go to "General -> Network" and make sure the "IP" dropdown shows the IP address of the PC network adapter that is connected to the KUKA robot controller. You may have to switch from "Project Settings" to "Default Settings" at the top to alter this setting. In the above example 172.30.1.39.
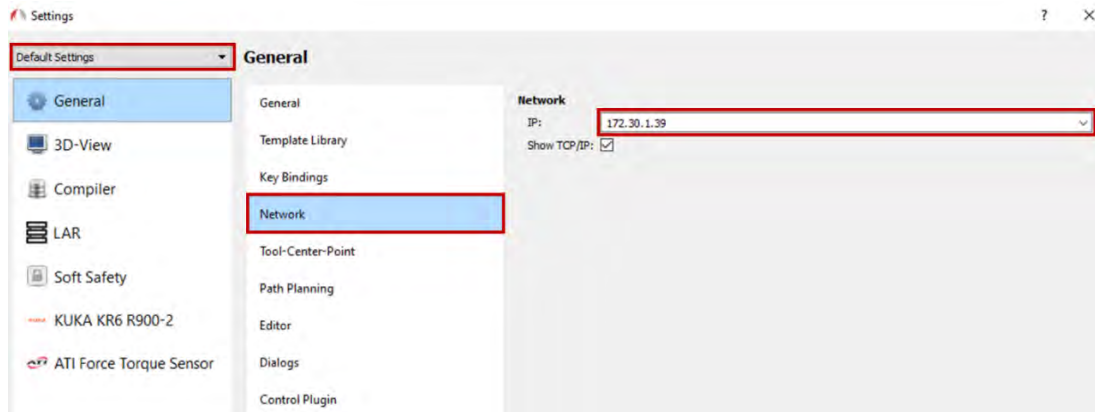
Open the Kuka settings pages in "Kuka → Network" and confirm all settings are correct.

4.5.4   Network Tab

The "Kuka Controller IP" should contain the IP address of the KUKA robot. In the above example 172.30.1.100. The Robot and ArtiMinds RPS should be in the same subnet (here first three numbers equal, e.g. 172.30.1.XXX as the subnet mask 255.255.255.0 has been used).

Note: During programming, the robot will try to establish a connection to the PC. The configuration on the robot must be adjusted if the IP address of the PC is changed after initial setup, or if another PC is connected. See chapter 5.3 for details.

"Samba-Network-Drive" should contain the drive letter of the KUKA C: drive that has been used for mounting on the computer. Here W:.

Make sure the "Samba-User" and "Samba-Password" are correct. You can keep the default values if this has not been altered on the KUKA. This is required for file transfer to the robot.
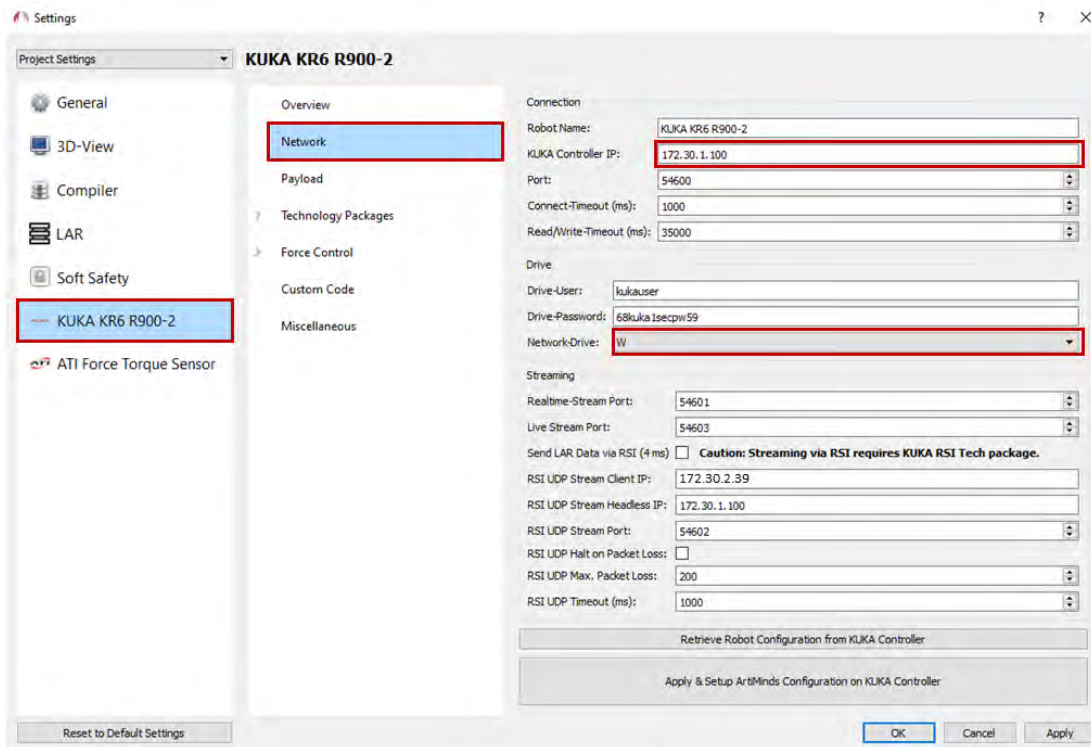
"RSI UDP Stream Client IP": These settings are only relevant if a force-torque sensor with RSI or ArtiMinds LAR is used (see chapter 4.4). This is the IP address of a network interface of your computer (172.30.2.39 in the example of chapter 4.4). This can simply be an additional address of your main network adapter and does not require additional hardware (see chapter 4.1). It will be used as target for the real-time UDP packages sent from the robot via RSI to realize 4ms data logging. The setup of RSI UDP Stream Headless IP depends on the ArtiMinds LAR setup. Chapter 4.6 contains a detailed description for LAR setup.

Enable the "Send LAR Data via RSI (4ms)" checkbox if needed. It creates an RSI container to stream high resolution real-time data in addition to the live data sent via the submit interpreter.

The other settings usually do not need to be modified. However, the ports must be open in the Windows firewall and must also not be blocked by any other security software that may be installed on the computer.

Do **NOT** add those ports to the port-forwarding rules of the KUKA HMI Network Settings.

It is recommended to press the "Retrieve I/O Settings from KUKA KRC4" in the "Network" tab and the "Retrieve Acceleration Limits from Controller" in the "Options (Expert)" tab once so that ArtiMinds RPS settings are consistent with the KUKA controller.

Whenever you make changes, make sure you deselect the Submit Interpreter on the KUKA teach pendant first (green "S" icon at the top). Then click the "Apply & Setup ArtiMinds Configuration on KUKA KRC4" button in the ArtiMinds RPS KUKA settings page. This will write all ArtiMinds settings to the KUKA controller.

Restart the KUKA controller so that the new settings are read in and confirm that the Submit Interpreter is running again. Otherwise check the error list on the KUKA.

Individual settings and configurations can be written to the KUKA controller by using the other tabs in the ArtiMinds RPS KUKA settings page ("Submit Interpreter", "KUKA.DirectoryLoader"…).

4.5.5   Payload Tab

Configures the payload mounted to the robot flange.

- "Robot Payload": Important for teaching and dynamics calculation of motions. Complete weight attached to the robot flange
- "Force Sensor Payload": Mainly important for gravity compensation and force-based applications. The weight after the buttom half of the force-torque sensor.It is recommended to execute the KUKA.LoadDataDetermination program on the KUKA teach pendant ("Start-up -> Service -> Load data determination") to determine the exact values

4.5.6   Technology Packages Tab

- **Submit Interpreter Tab:** Change the IDs of the global flags. Make sure they do not collide with your project specific programming or with flags already used on the KUKA controller.
  "Submit program folder" should contain the path to the $config.dat file on the KUKA controller.
- **DirectoryLoader Tab:** Click on "Load directory loader settings from KUKA controller". This should result in the correct settings for your robot and the settings above should reflect the settings from the previously adapted configuration files on the robot. Make sure the correct Directory Loader version is selected.
  "DLSourceDir[] = " is configured in chapter 3.2 and contains the created temporary DirectoryLoader inbox folder on the KUKA C: drive. Pressing the "Apply" button only copies the Directory Loader specific settings.
- **EthernetKRL Tab:** This defines the directory, where data-format definitions are stored. Keep at default settings.
- **ForceTorqueControl/RSI Tab:** Change these values according to your robots KSS / RSI version and according to the force-torque sensor that you are using. If you're using an ATI sensor that is connected via EtherCat, select the "EtherCat (FieldBus)" checkbox and not the "ATI" one.

4.5.7 Force Control Tab

- **Force-based Guiding:** Defines PID controller based parameters for force-based guiding. These settings affect all robot programs.
- **Force Controller:** Defines PID controller based parameters for force-based applications. These settings affect all robot programs. Presets are provided to alter the reactivity of the robot when measuring forces.

4.5.8 Custom Code

Here you can insert custom initializations, custom code and custom function definitions, which will always be compiled into the generated .src and .dat files. The entered code will not be checked, so make sure the syntax of the code is correct.

4.5.9 Miscellaneous

Change the priorities of the interrupts defined by ArtiMinds RPS if they collide with your project specific programming. ArtiMinds RPS generates tools and bases for the created robot program as needed. "Tool Indices Range" and "Base Indices Range" allow to restrict the allowed indices used for tools and bases by ArtiMinds RPS. This helps preventing overwriting already defined tools and bases on the KUKA robot controller. You must also read the acceleration limits once from the controller, to allow a correct simulation and runtime estimation within ArtiMinds RPS.
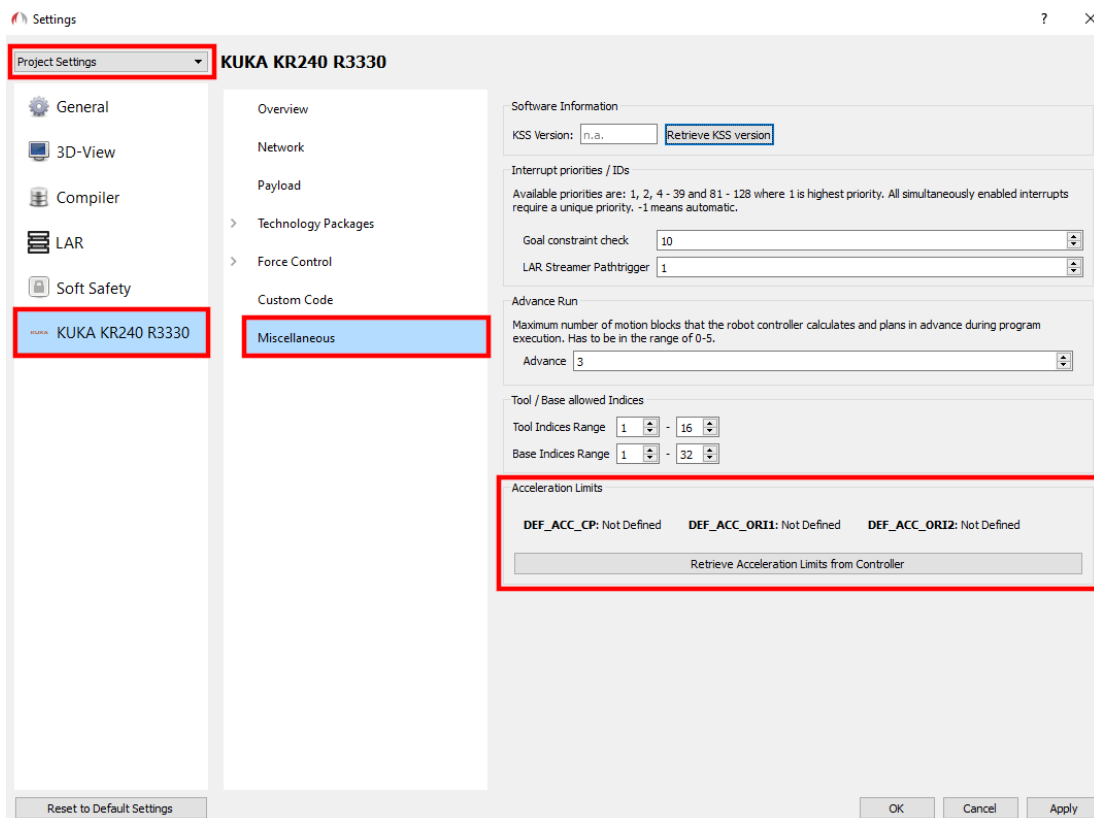
4.6 ArtiMinds Learning and Analytics for Robots (LAR)

ArtiMinds LAR captures and stores data of program executions ("Runs") in a SQL database. One ArtiMinds LAR database can store program data of multiple robots. In order to stream data from the robot into the database, a running instance of either ArtiMinds RPS or ArtiMinds hRPS is needed.

The general data flow is displayed in the image below. The data recorded by the robot during execution is streamed to ArtiMinds RPS and then transferred to ArtiMinds LAR.

If the robot is in productive operation it is not necessary to use ArtiMinds RPS with graphical user interface. Then ArtiMinds headless RPS can be used. ArtiMinds headless RPS is capable of receiving data from multiple robots at the same time (contrary to ArtiMinds RPS, which can only receive data from one Robot at a time).

Depending on the installation setup (local or distributed mode → see chapters 4.6.1, 4.6.2, 4.6.3) of ArtiMinds LAR, the current operation mode and the overall network setup, it is possible to configure the robot, RPS/hRPS and LAR server in different ways.

If RSI should be used for high performance data streaming, some network devices must have an additional IP adress in the RSI subnet (see chapter 4.4). The first network (non RSI network) is referred to as **network N1.** On the KUKA controller this network is also called **KLI** (KUKA Line Interface). The second **network N2** is the **RSI** network (Robot Sensor Interface).

First, an overview of the different modes is given. Then, in the following chapters the setup process is described in detail for each mode.

There are several ways in which you can set up the IT infrastructure for ArtiMinds LAR. Which option is the right one depends on individual requirements. The different options are described in more detail below.

Mode	RPS	hRPS	LAR	Typical usecase	Number of robots
Local	PC	✖	PC	Comissioning	1
Mixed	PC	✖	Server	Comissioning	1
Distributed 1	✖	Server	Server	Production line	Multiple
Distributed 2	✖	IPC	Server	Multiple production lines	Many

[1] in Distributed mode, ArtiMinds RPS will still be used to initially create the robot programs.

4.6.1 Local Mode

The simplest setup is **local mode**. For this mode ArtiMinds RPS and ArtiMinds LAR are installed on the same computer. The robot program is created with ArtiMinds RPS and transferred to the robot (see chapter 5.1). During execution of the program, the robot connects to the computer and streams the data to ArtiMinds RPS. Within ArtiMinds RPS the data is processed and forwarded to ArtiMinds LAR (on the same computer). ArtiMinds LAR stores the streamed data in the database (on the computer). The data can be visualized in the browser. This setup is typical during comissioning.
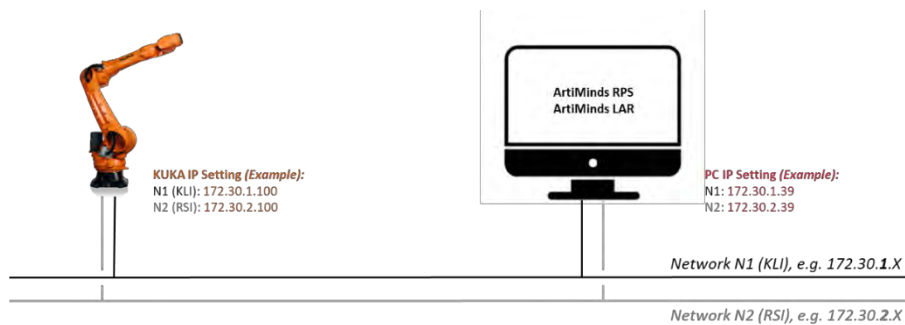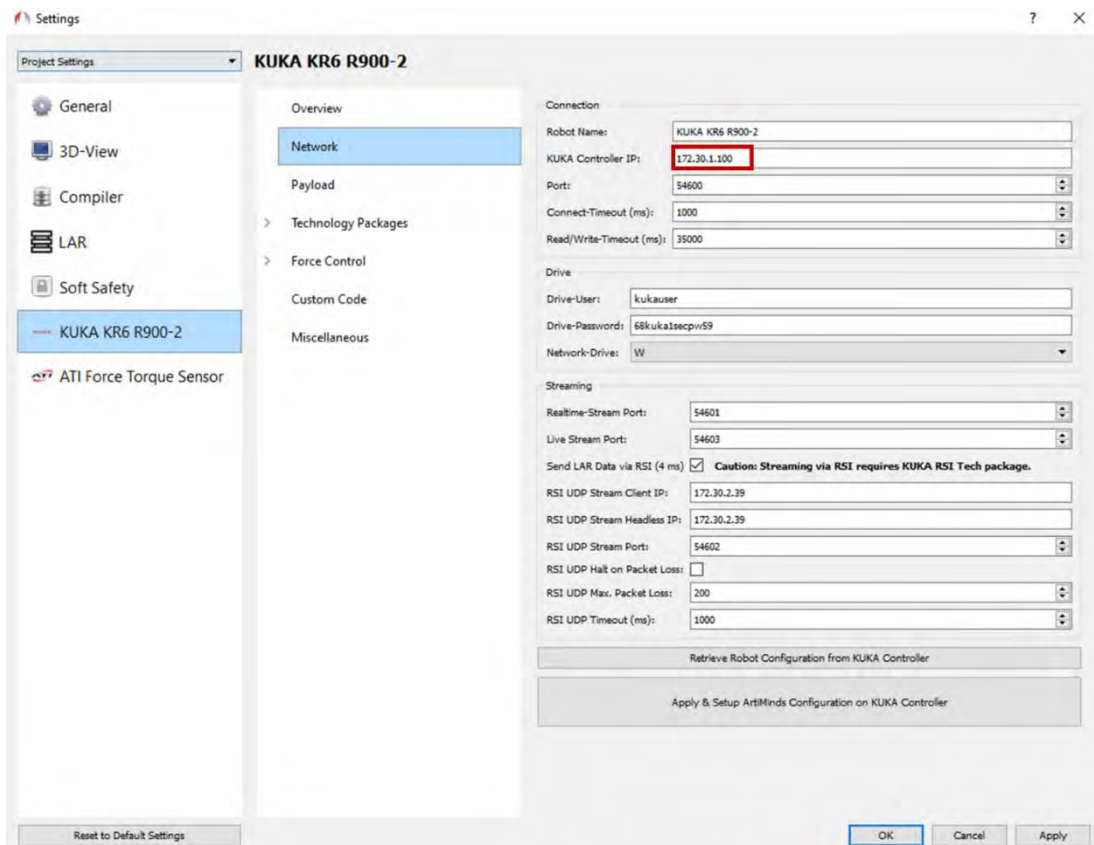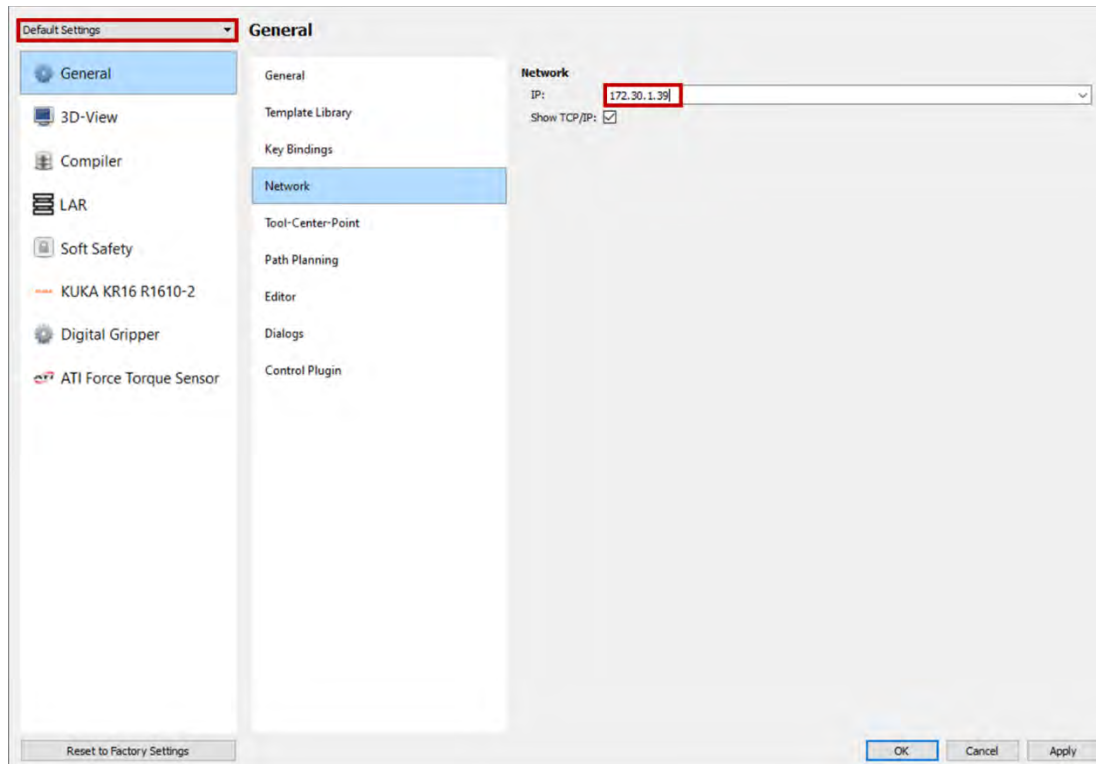

Figure 1 - Local mode

Configuration for Local Mode

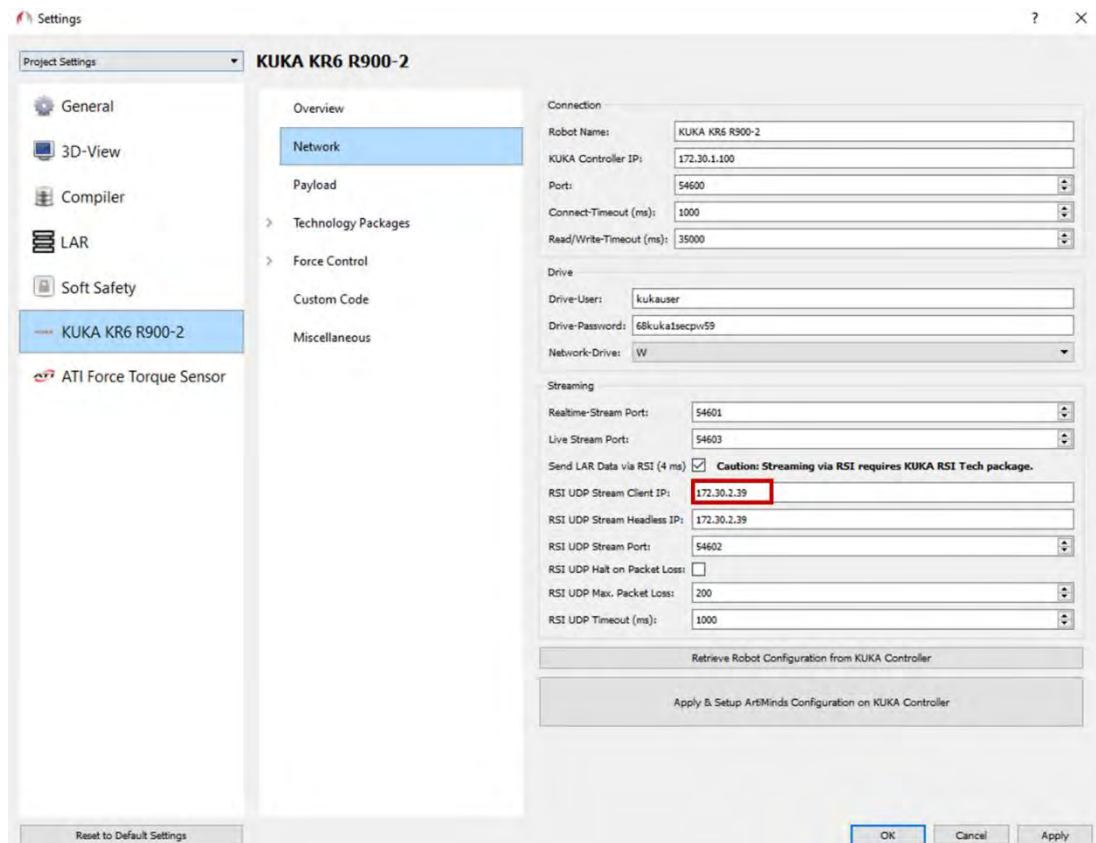The following steps are necessary to configure ArtiMinds LAR in local mode.
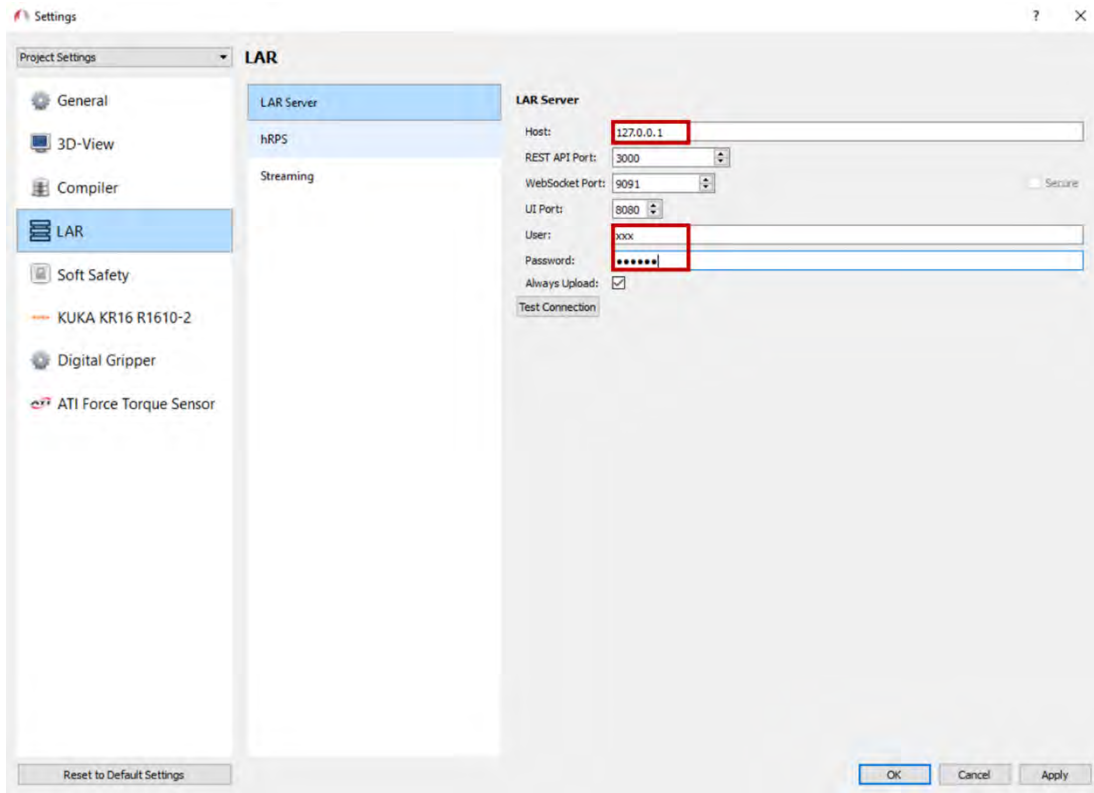
1. Robot IP address N1

2. Computer/RPS IP address N1 (important: switch to default settings)

3. Computer/RPS IP address N2

4. LAR IP address (127.0.0.1 → localhost) + credentials

4.6.2   Mixed Mode

For the **mixed mode** setup, ArtiMinds LAR is installed on an additional server. In this case, the robot data is first streamed (N1 & N2) to the computer and then after processing in ArtiMinds RPS forwarded to ArtiMinds LAR on the server. With this setup it is possible to separate the production network (robot and computer) and the network of the server (computer and server).
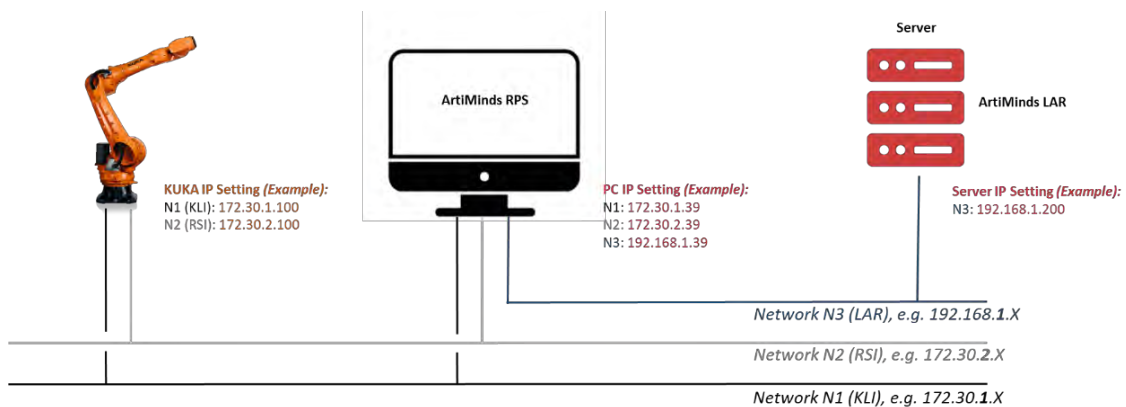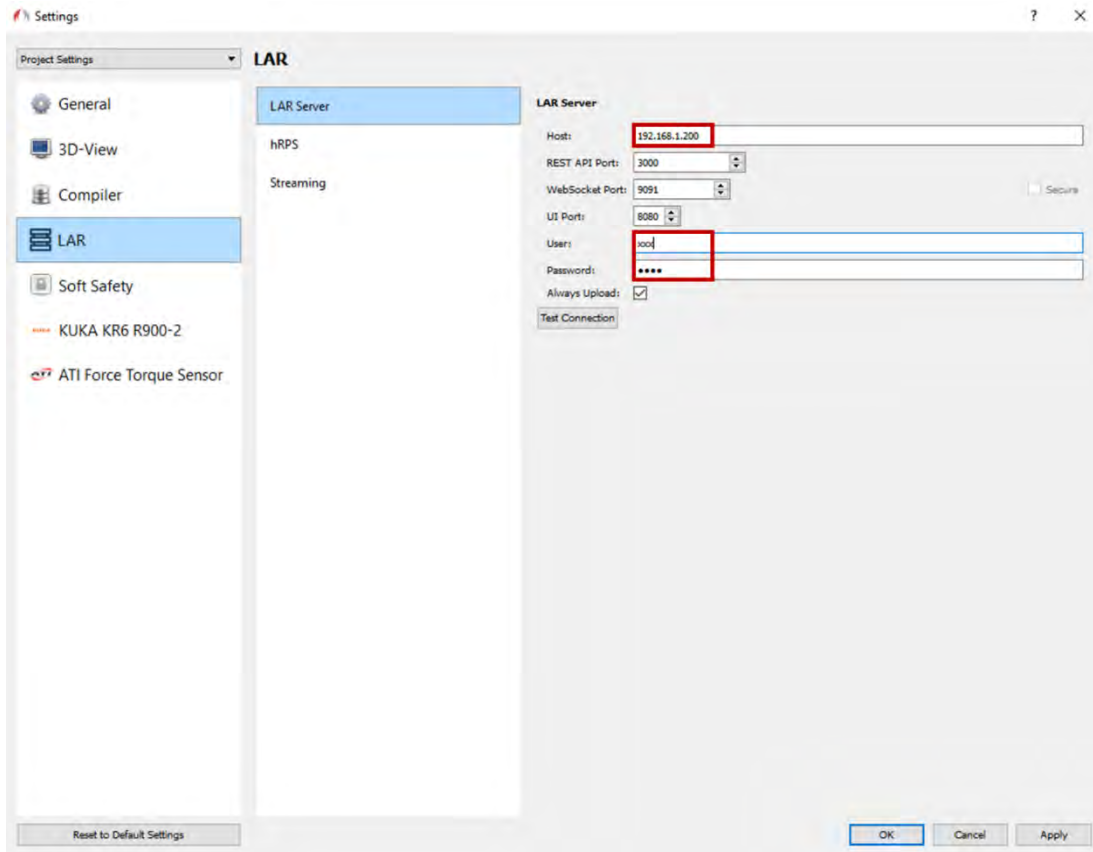

Figure 2 - Mixed mode

Configuration for Mixed Mode

The following steps are necessary:

1. Robot IP address N1 (see above)
2. Computer/RPS IP address N1 (see above)
3. Computer/RPS IP address N2 (see above)
4. LAR IP address + credentials in the new network N3

4.6.3   Distributed Mode

The main difference between the **distributed mode** and the modes above concerns the data flow. For the distributed mode the robot connects to ArtiMinds **headless RPS**. ArtiMinds headless RPS is a multi instance RPS without graphical user interface. ArtiMinds headless RPS can connect to multiple robots at the same time. For each connected robot, headless RPS will spawn one "worker" (internal mechanism). This worker collects and processes all data streamed by the robot and transfers the data to ArtiMinds LAR. ArtiMinds RPS (with GUI) installed on the computer is only used for programming. Therefore, during operation it is not necessary to connect the computer. For the distributed mode there are two different options:

Distributed Mode 1: ArtiMinds headless RPS and ArtiMinds LAR on the same device

- Recommended for automation lines with one of few robots streaming data into one ArtiMinds LAR database. The server must be connected to the production networks N1 and N2.
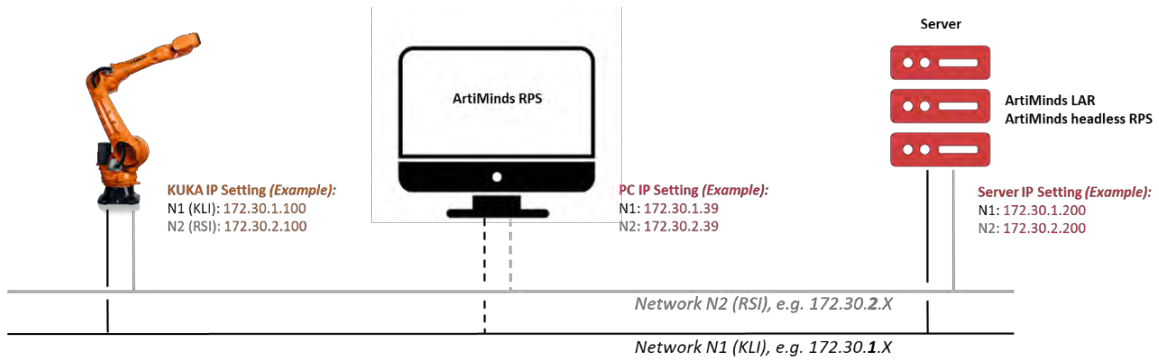

Figure 3 - Distributed mode (1)

Configuration for Distributed Mode 1

The following steps are necessary:

1. Robot IP address N1 (see above)
2. Computer/RPS IP address N1 (see above; only for programming)
3. Computer/RPS IP address N2 (see above; only for programming)
4. LAR IP address + credentials N1

5. Headless RPS IP address N1

6. Headless RPS IP address N2
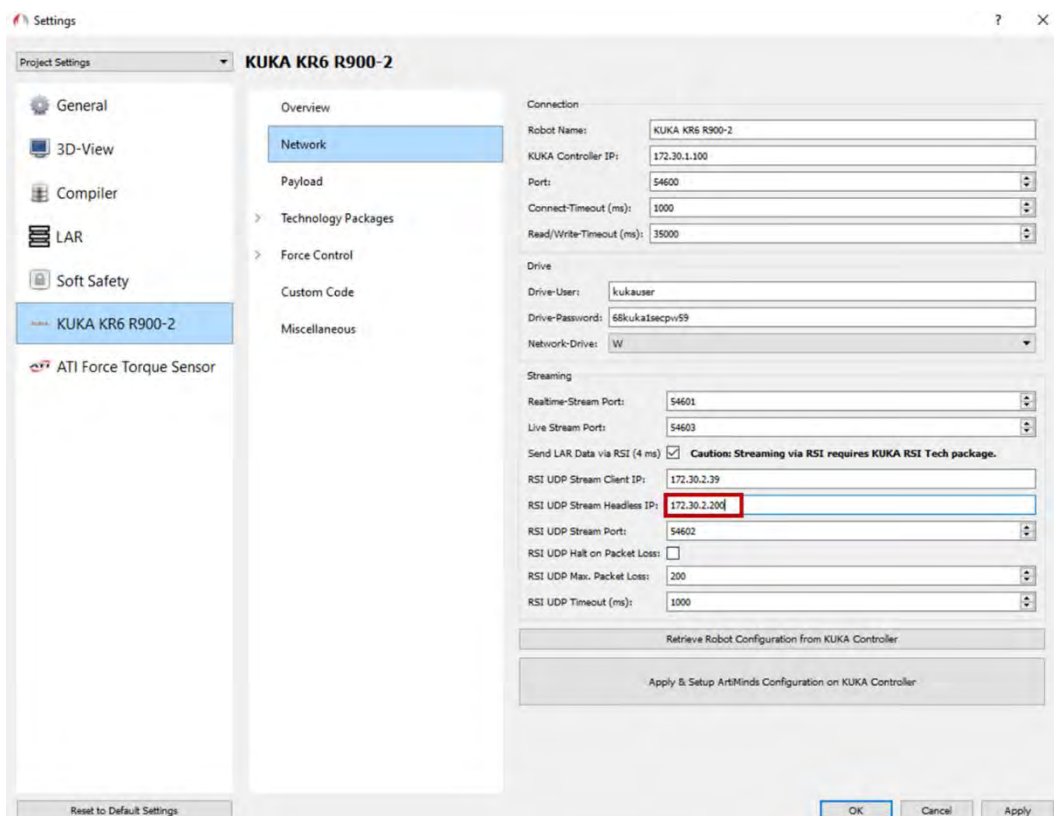
Distributed Mode 2: ArtiMinds headless RPS and ArtiMinds LAR on different devices

- Recommended if it is necessary to separate the server from the production network, i.e. if it's desired to access the ArtiMinds LAR analyses from a separated office network.
- Recommended if multiple automation lines (potentially each with an individual, separated production network) with multiple robots stream into one ArtiMinds LAR database.
- In this use-case, the IPC must be an edge device connecting both, the local production network (N1 and N2) and the data network (N3).
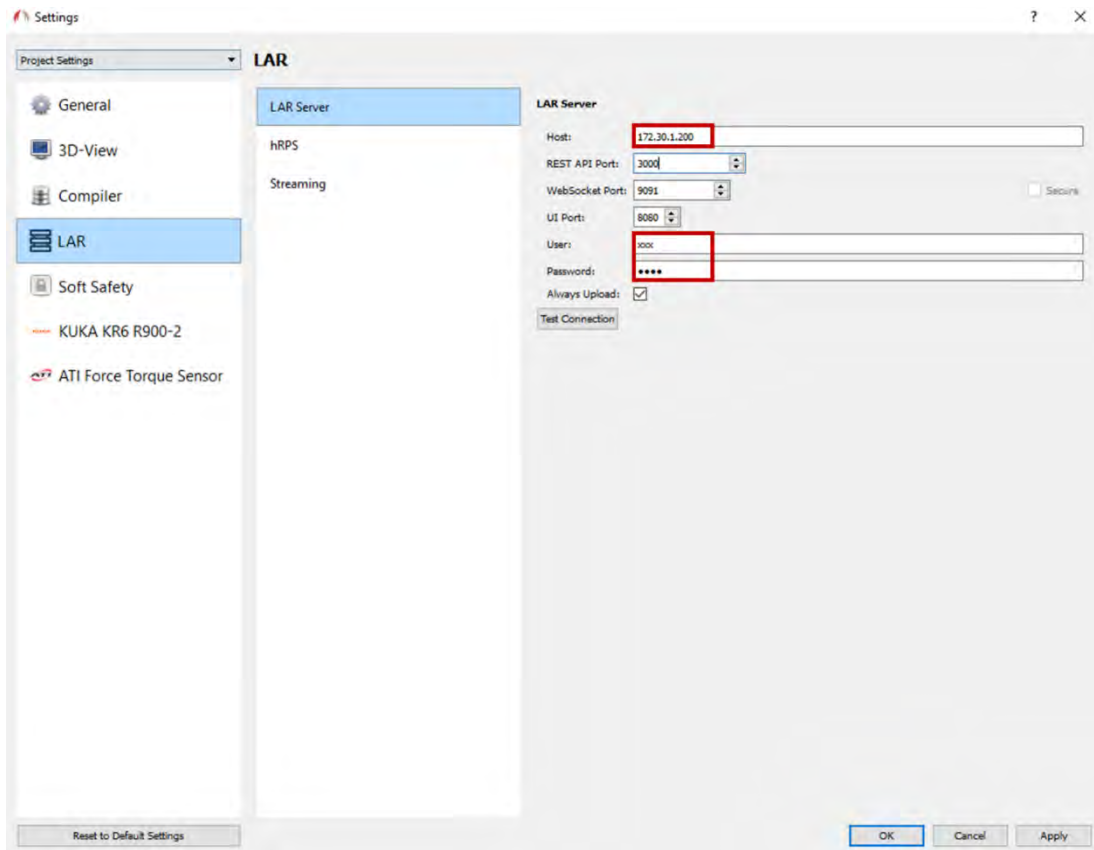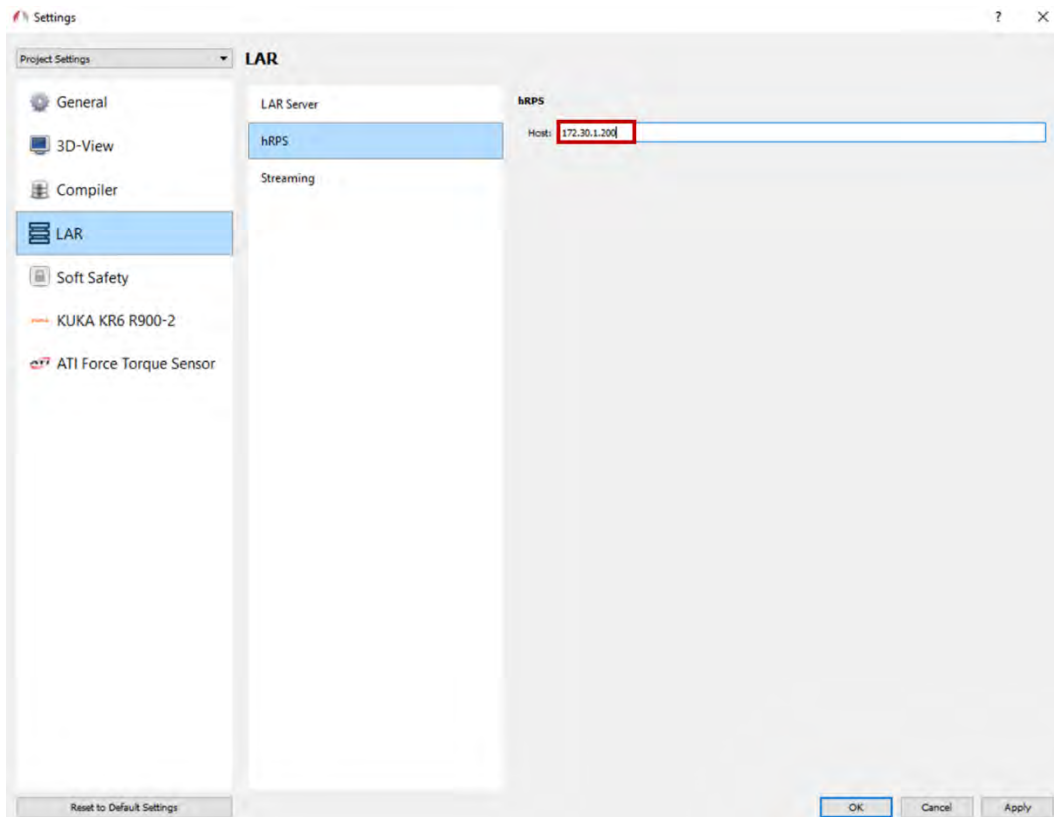

Figure 4 - Distributed mode (2)

Configuration of Distributed Mode 2

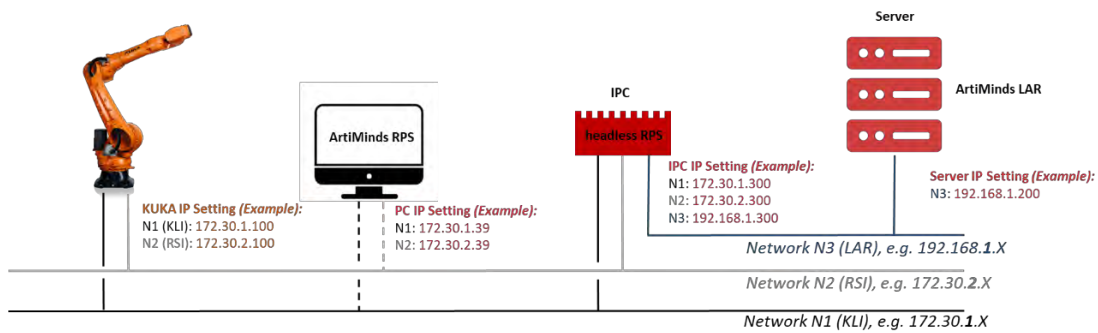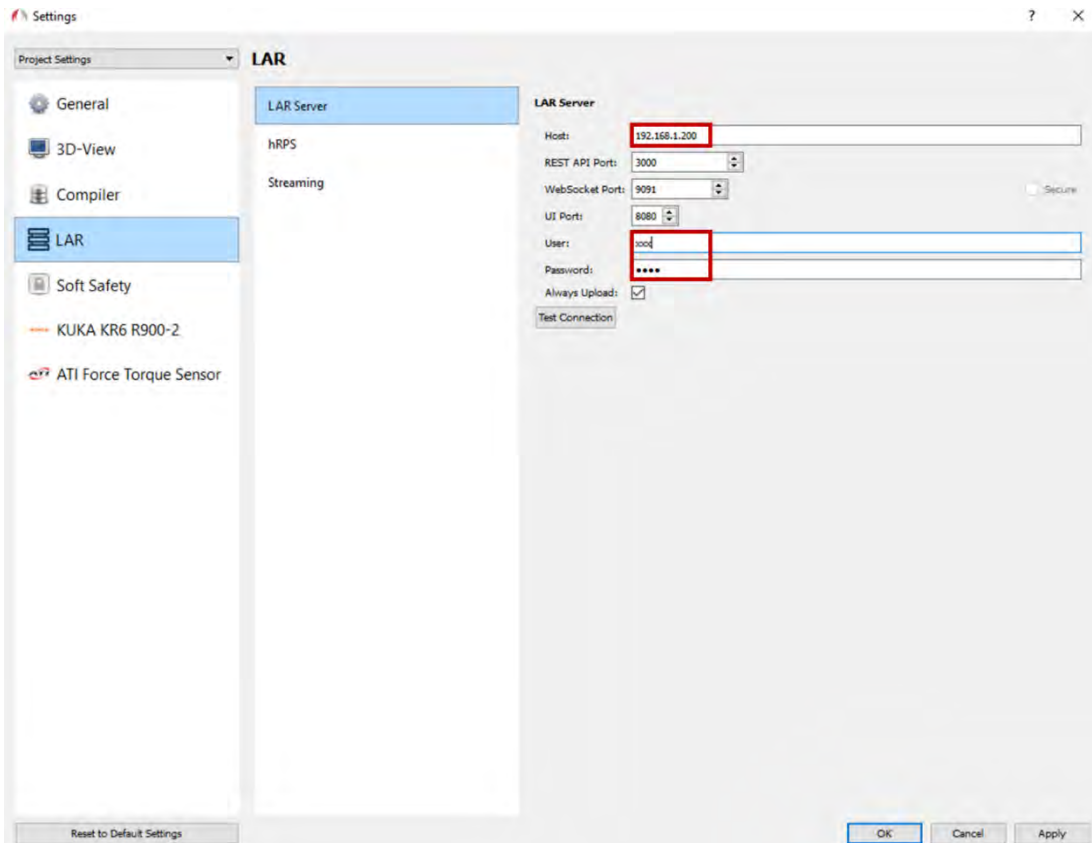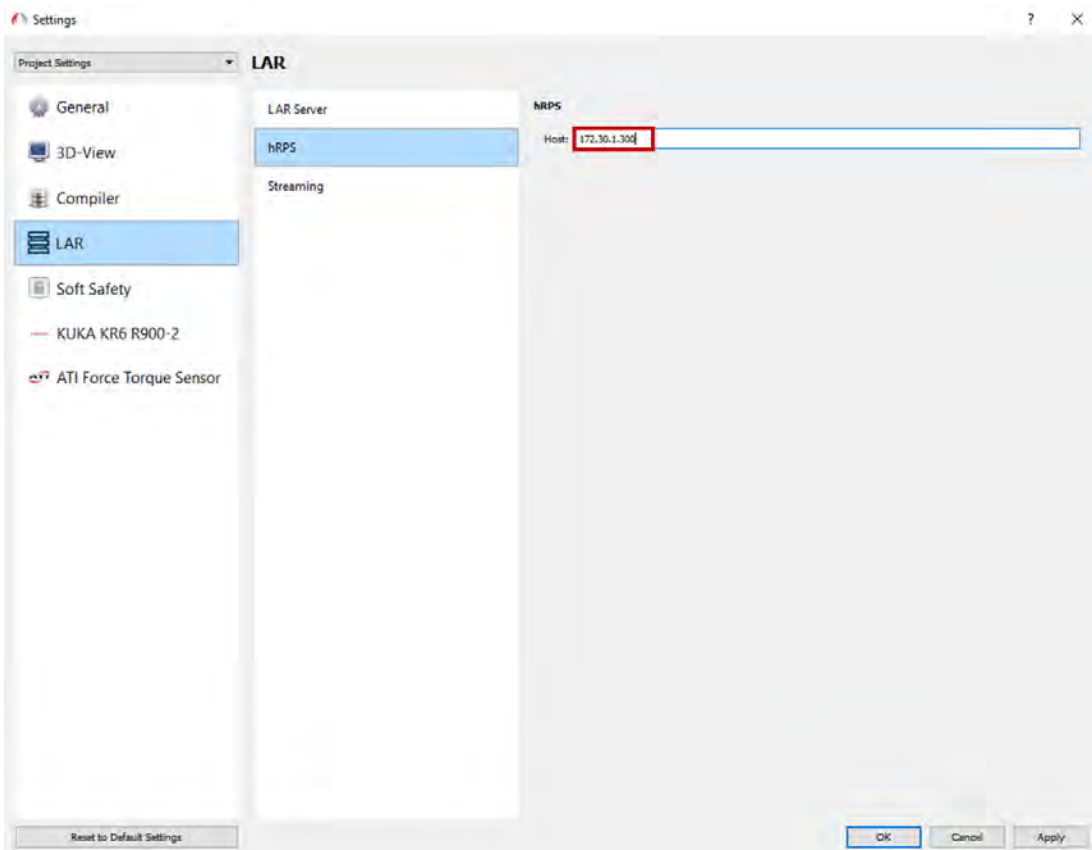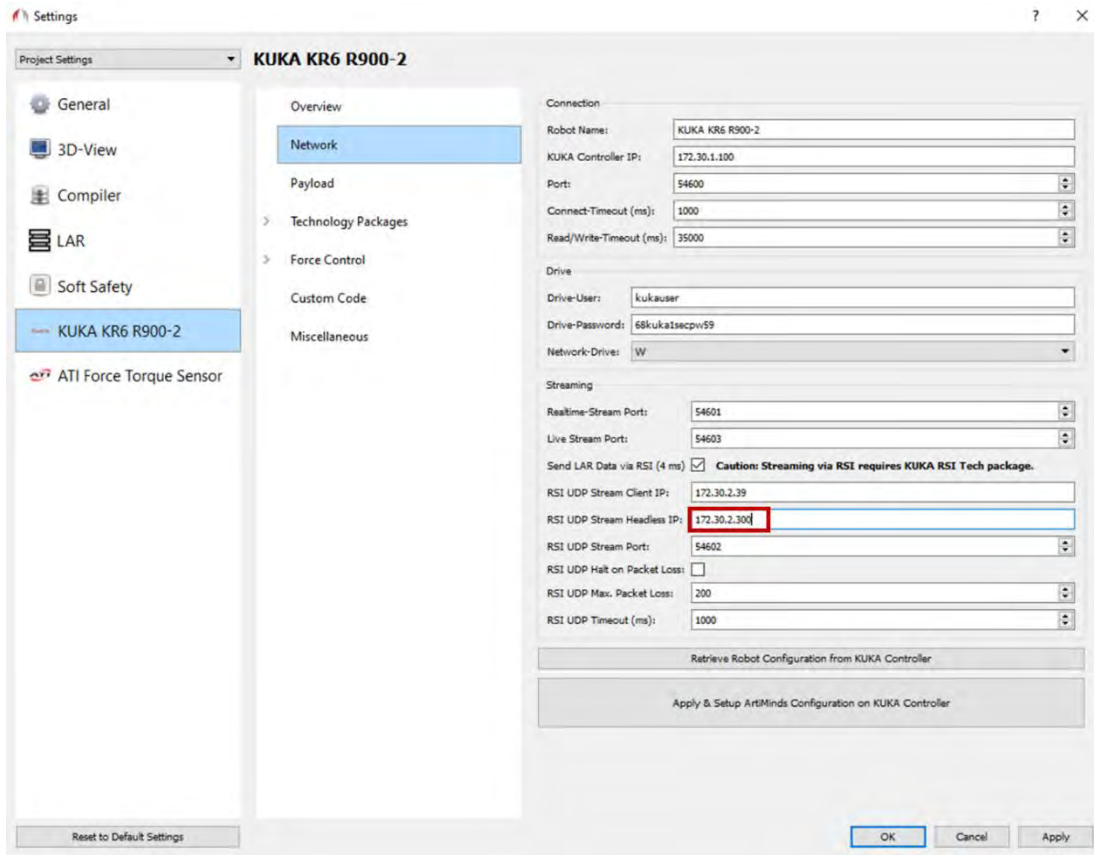The following steps are necessary:

1. Robot IP address N1 (see above)
2. Computer/RPS IP address N1 (see above; only for programming)
3. Computer/RPS IP address N2 (see above; only for programming)
4. LAR IP address + credentials N3

6. Headless RPS IP address N1

7. Headless RPS IP address N2

5 Operations

5.1 Copying programs to the robot

5.1.1 ArtiMinds RPS

After you created a program, you can use the red "Play" button to initiate a transfer of the generated source code to the robot:

1. Click the red "Play" button.
2. The current pose of the robot is queried from the robot and if it does not correspond with the set home-position of your program, a joint-based transfer motion is generated and simulated. Acknowledge it by clicking "Yes".

5.1.2 KUKA robot

DirectoryLoader Version >= 3.0:

No manual actions are required on the teach pendant. Status messages about the copy-process will be displayed on the teach pendant and the program is activated automatically after a successful transfer.

DirectoryLoader Version < 3.0:

1. On the teach pendant you will be asked to switch to external mode. Do so by turning the key, choose "Ext" and turn the key back to operational mode. You have a timeout of 30 seconds to do so.
2. The program is copied to the robot and you will be asked to switch to an execution mode. Again turn the switch and choose "T1" / "T2" or "Auto". Attention: The robot will perform with full speed in Auto mode! Turn switch back.
3. The program will be loaded for execution.
4. Depending on the chosen mode you can now start execution:
5. In T1 / T2 mode: Hold down one of the dead-man switches on the backside of the panel and press and hold the green play-button on the front. The robot will drive to its home position and stop there. Let go of the play-button. Press and hold it down again to start executing the actual program.

In Auto mode it is sufficient to press the play-button only once to start the execution of the complete program. Make sure the robot is at its home-position. Otherwise let it drive to home-position on T1 / T2 mode as described above.

5.2 Teaching/Demonstrations

"Use Demonstration" button in the wizard of an ArtiMinds RPS template: When teaching target points of templates with the robot, make sure to have the right tool selected on the teach pendant. Especially if you defined the weights of your tools, always choose the same tool for demonstration and execution. Otherwise calibration issues will occur. The same applies when using the "Record" button in the main menu bar at the top.

5.3   Change IP adress of the connected PC (with ArtiMinds RPS)

The connection between the KUKA robot and the PC which runs ArtiMinds RPS is established by the robot. Therefore, the setup of the KUKA robot must be adjusted when the IP address of the PC is changed. First check if the correct IP address for the PC is selected:
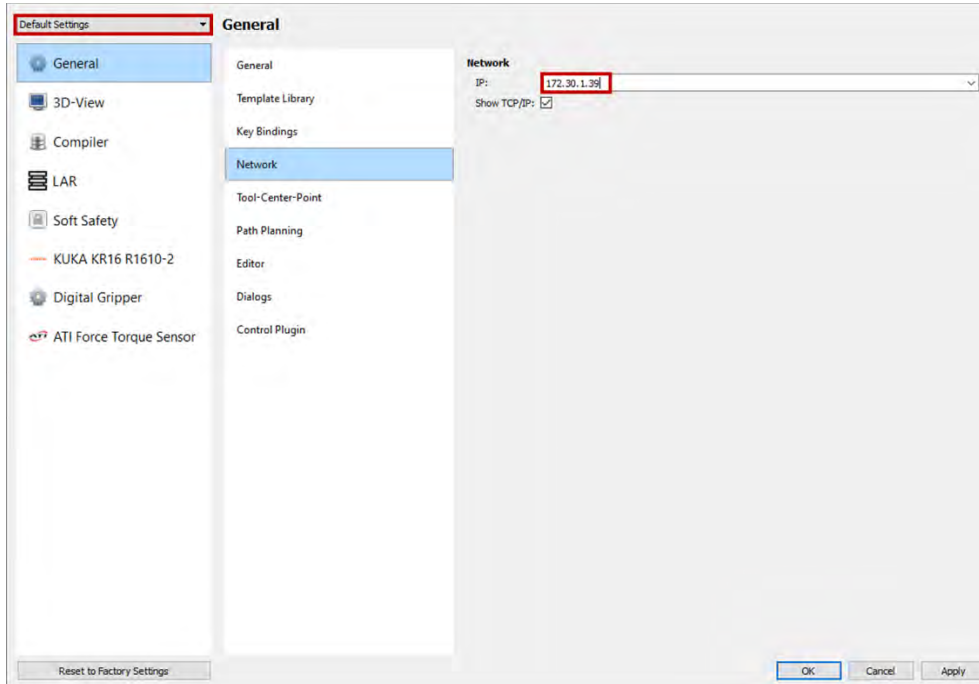
Then go to the KUKA settings page, click the "Apply & Setup" button and following the instruction of the user dialog:
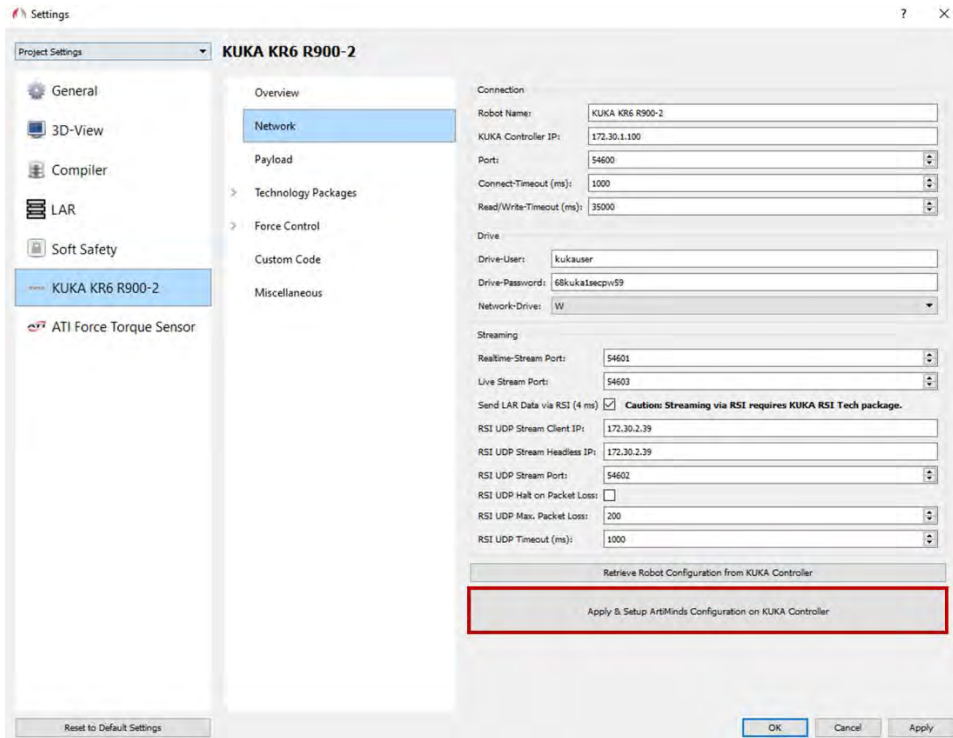
5.4 Live data streaming with the headless RPS (hRPS)

If you intend **LAR via Headless RPS**, you must use the main menu bar to copy your programs to the robot: "Run → Compile → Copy to robot". As only here you have the option to activate "Redirect live data to headless RPS".
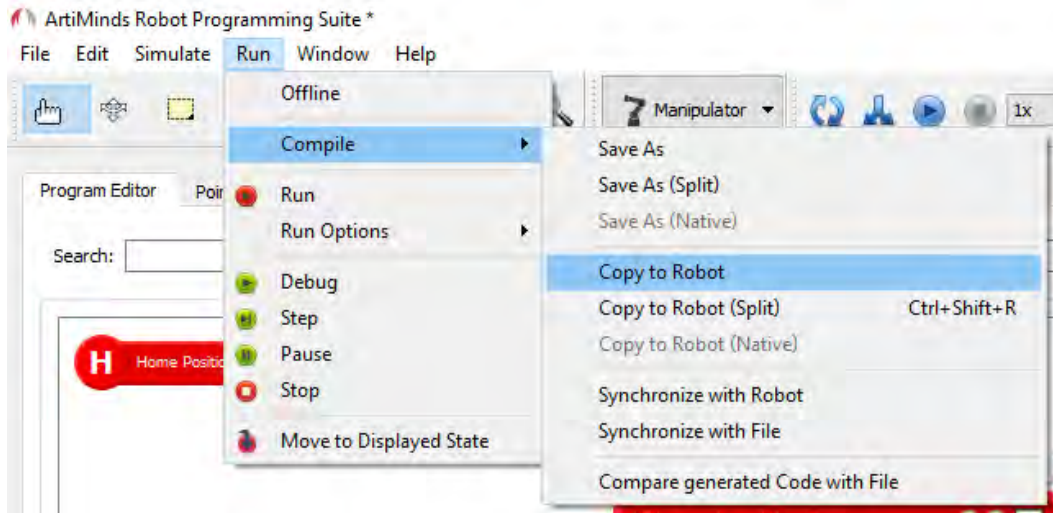
After clicking "Copy to Robot", a pop-up window will appear. Make sure that the checkbox is selected to forward the live data to the headless RPS. For better understanding, take a look at the following screenshot.
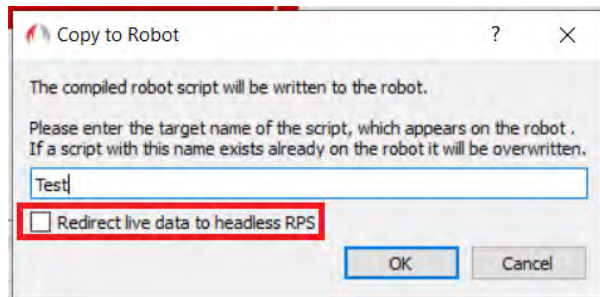
7. Troubleshooting

General Troubleshooting Advice

- Always *read* the log/error messages on the teach pendant of the KUKA robot *before* acknowledgment.
- General KUKA advice (not related to ArtiMinds RPS): In many error cases, restarting the robot controller will fix the issue.
- Additional help pages and manuals are provided, e.g. for configuring force-torque sensors or grippers.
  - Open the online help by pressing the "F1" key in ArtiMinds RPS.
  - The latest version of KUKA related help documents can be found in the downloads section of www.artiminds.com

I cannot mount the KUKA controller as Network Drive as suggested in chapter 4.2

- Make sure that Port 445 is listed in the Port-Forwarding list of the KUKA Control Panel Network Settings.
- Check that an Ethernet connection is established to the controller, and that the controller's IP address and your own PC IP address are in the same subnet.

I cannot Apply & Setup the ArtiMinds configuration on the KUKA Controller (Setup fails)

- Make sure that the submit interpreter is deselected on the KUKA Teach Panel *prior* to applying the setup.
- Check that the sps.sub and $config.dat file have write access: Access the files via Windows Explorer (mounted network drive) and check the file permissions and properties there. Default folder: *KUKA_Disc(C:)/KRC/Roboter/KRC/R1/System/*

I cannot go *Online* (Pressing the Online/Offline Button in ArtiMinds RPS fails)

- Check the IP settings:
  - *Settings → General → Network* should list the IP address of your own computer. (**Common error!**)
  - *Settings → KUKA → Network* should show the IP address of the robot under *KUKA Controller IP*.
  - Does your own computer share a network with the KUKA controller? I.e. are both IPs in the same subnet?
- If you are sure that all IP settings are correct, check if your firewall prevents a connection:
  - Acknowledge all error messages on the teach pendant.
  - Make sure that the submit interpreter is running ("S" indicator is green)
  - On KUKA: Start the "Diagnostic Monitor" (on the KUKA Teach Panel: *Diagnosis → Diagnostic Monitor → Module KRC (KRC-Interpreter)*): It should list at least three open connections for the Submit program.
    - If less than three open connections are shown: Read the EthernetKRL log for error / warning messages (C:\KRC\ROBOTER\LOG\EthernetKRL)
    - Potentially the installation of the ArtiMinds configuration failed. Try to repeat the setup from chapter 4.5.4.

o While the Submit Interpreter is running, use the following PowerShell commands on your PC (search for "PowerShell in the Windows start menu) to test if both ports can be reached over network:

```
Test-NetConnection -RemoteAddress 172.30.1.39 -Port 54600
Test-NetConnection -RemoteAddress 172.30.1.39 -Port 54601
```

➔ Replace `172.30.1.39` by the IP address of the robot! The commands test if a network device (i.e. the KUKA robot) can connect to your PC. If these tests fail, check your Windows Firewall and additional installed security software on your PC. Your PC must allow incoming connections at those ports (You can change the used ports in *ArtiMinds RPS File → Settings → KUKA → Network.* Note: You have to re-apply the setup after changing connection settings).

o If this test fails, make sure you did **not** add the ports to the NAT settings of the controller (*KUKA Teach Panel → Start-up → Network configuration → Advanced → NAT*)!

I cannot copy programs from ArtiMinds RPS to the robot (Run → Compile → Copy to Robot fails)

- When you try to overwrite a program that already exists on the robot, make sure that the program is neither selected nor opened in the Editor on the Teach Panel.
- Verify that the directory loader folder on the robot is empty, otherwise delete all existing files here.
    - On the robot, navigate to the Directory Loader source directory (default path: *\KRC\TP\KRdirLoader*) and verify that the folder is empty. Sometimes the robot fails to correctly delete old programs here, thereby breaking Directory Loader completely.
- Check the syntax of manually added code in *Code* or *MultiCode* templates and in the custom code section in the settings page: *File → Settings → Kuka → Custom Code (Expert)*.
    - You can copy/paste your code in KUKA.WorkVisual for initial syntax checking.
    - Note: Line breaks in custom code have to be the Windows *\cr\lf* linebreaks.

I can copy programs, but the controller tells me that variables are not defined

- If variables within the .src files are unknown, open up the according .dat file on the teach pendant, add a "Space" character at the end of an arbitrary line and save the .dat again. This will trigger a reparsing.
- Oftentimes it helps to simply copy the program again using *Run → Compile → Copy to Robot*. The parsing of KUKA.DirectoryLoader sometimes needs a few attempts.

Network issues: Communication to a hardware device is not possible

- Check Ethernet KRL: On the KUKA Teach Panel, go to *Diagnosis → Diagnostic Monitor → EKI: EthernetKRL*
  At least 3 "Submit program connections" should be visible without error. In case of errors, check the EthernetKRL logs for further details ("KRC\Roboter\log\EthernetKRL").
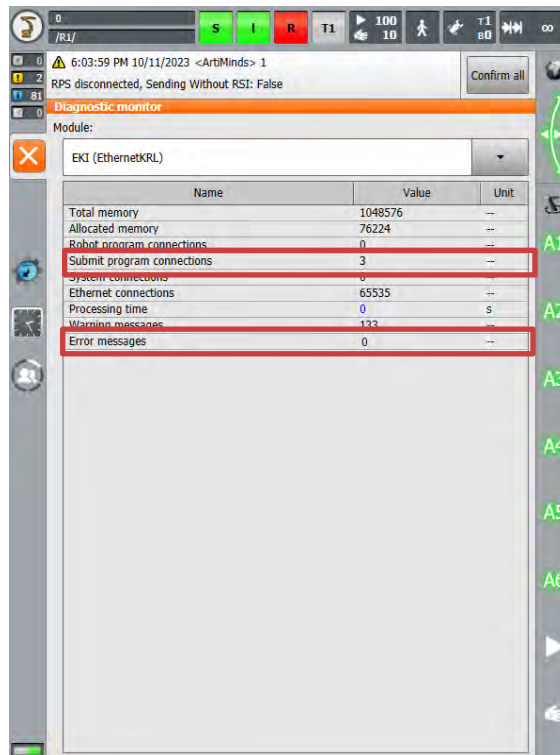
**The KUKA Teach Panel displays RSI related error messages**

- "*RSI bad*" **error**: Check if you are using a real-time capable network for RSI.
  On the KUKA teach pendant go to *Network settings → Advanced.* Choose the second virtual interface called "RSI" (or any other custom name, given by you during the setup in chapter 4.4). Here, the address-type must be *Mixed IP Address* or *Real-Time Network*.
  - It is highly recommended to use the same IP address for KLI and RSI with different subnets, e.g.
    KLI: 172.30.1.XXX   Subnet mask: 255.255.255.0
    RSI: 172.30.2.XXX   Subnet mask: 255.255.255.0
  - Note: KUKA does not allow certain IP ranges for incoming connections. Usually, the IP range 192.168.0.0 … 192.168.0.255 is blocked for internal communication. Make sure that the RSI and KLI IP address are not in this blocked IP range.
- "*RSI_Create: Allgemeiner Fehler*" **error**: or any other errors **related to the ATI force-torque-sensor**, please check the RSI log on the robot controller for the following messages:
  ```
  ERROR tFctCall 1:05:09.323 : ATINetRDTDriver: HTTP connect to 192.168.0.1 failed: -
  ERROR tFctCall 1:05:09.323 : ATINetRDTDriver: Failed to set the sensor's active
          configuration to 0 (HTTP). (Code=10)
  ERROR tFctCall 1:05:09.323 : ATINetRDTDriver: HTTP configuration failed <10>
  ERROR tFctCall 1:05:09.323 : ATINetRDTDriver creation failed
  ```

- o The Controller cannot establish a network connection to the ATI Net F/T Box at the given IP address. Check the ATI Net F/T Box IP address! If the IP address is correct, double check all cables, especially the cables between the ATI Net F/T Box to the network switch / KUKA controller.
- • "*RSI I/O Konfigurationsdatei nicht gefunden*":
    - o The file "KUKA_Disc(C:)/KRS/Roboter/Config/User/Common/RSIIO.xml" is missing, which indicates that KUKA.RealtimeSensorInterface and KUKA.ForceTorqueControl are not installed correctly. Please reinstall these technology packages and check that this file exists afterwards.

ArtiMinds RPS cannot receive live data from the robot (Streaming health icon is red)

- • Hover over the streaming health icon to see which component is affected. Make sure that all listed ports are free to use and not blocked by a firewall or other programs.
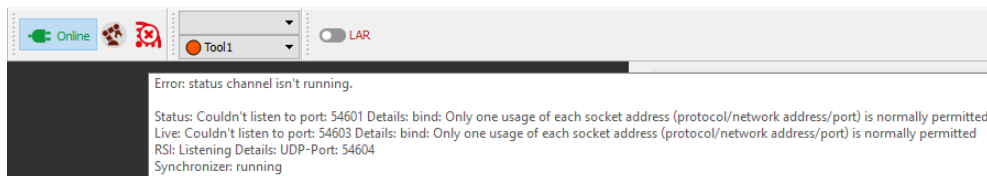
Unclear errors while any component *other* than ArtiMinds RPS uses KUKA Flags

- • *If any Submit Interpreter or other program runs on the KUKA controller that was <u>not</u> created by ArtiMinds RPS:*
    - o On the KUKA Teach Panel go to "*Main Menu → Display → Variable → Flags*" and check the used flags.
    - o If you have a list of flags used by other programs, make sure that ArtiMinds RPS uses different flags: In ArtiMinds RPS go to "*File → Settings → KUKA → Technology Package → Submit Interpreter*". Here you can specify which flags should be used by ArtiMinds RPS generated programs / Submit Interpreters.

I cannot start the Submit Interpreter, after I applied the ArtiMinds Setup configuration

- • Check that ArtiMinds RPS does not use any KUKA Flag that is also used by your own programs:
    - o In ArtiMinds RPS go to "*File → Settings → KUKA → Technology Package → Submit Interpreter*". Set the Flag ranges to any range that is not used by other programs developed by yourself or a system integrator.

KRC DIAG / further support

- • When further support is needed, please contact support@artiminds.com and provide a KRCDiag file for easier debugging if possible. A KRCDiag can be generated as follows:
    1. Connect an USB drive to the KUKA teach pendant (formatted as FAT32).
    2. On the KUKA teach pendant click on "File -> Archive -> USB (KCP) -> KRCDiag" (German KUKA "Datei -> Archivieren -> USB (KCP) -> KRCDiag").
    3. The KRCDiag file is written to the USB drive. Depending on the stored data on the robot, the file can have sizes of 30MB+.

Notes

Publication History

Date	Version	Description
June 2019	1.0	First Version
November 2019	1.1	Added section 2.1 about moving robot base via Machine-Data-Configuration in KUKA.WorkVisual. Corrected section 1.3 with KSS specific variable names
November 2019	1.2	Added hint to create DirectoryLoader target folder on robot if not present. Section 1.3
November 2019	1.3	Changed example target directories for DirectoryLoader in section 1.3
January 2020	1.4	Extended section 1.4: Copy to robot with DirectoryLoader 3.x. Clarified variable declaration in section 1.3.
March 2021	1.5	Restructured network setup. Changed capitalization of DLSourceDir. Added pages of the KUKA settings dialogs. Clarified the IP settings for RSI streaming
May 2022	1.6	Fixed some spelling errors and improving the layout
May 2022	1.7	Added images, additional explanations and reworked the structure
May 2022	1.8	Formatting
May 2022	1.9	Added additional image to explain the KUKA teach pendant user interface.
October 2022	1.10	Extended list of broken EthernetKRL versions and the resulting error messages
January 2023	1.11	Added hints to not add Ports to Port Forwarding settings on the HMI. Added troubleshooting for SMB Port. Added troubleshooting for write protected config files on the controller.
December 2023	2.0	Restructure, additional explanations (mainly LAR and RSI), retook pictures
March 2024	2.1	Added information about potential bugs in KUKA technology packages
April 2024	2.2	Improved section about network setup for the computer
May 2024	2.3	Added Troubleshooting information
September 2024	2.4	Completely revised Troubleshooting chapter. Added Preface. Minor optimizations