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DOCUMENTATION

feedWare CX
Integration manual

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1 Camera interfaces

The communication to our vision system (smart camera) is done via Telnet over Ethernet, or alternatively via a serial interface (RS232). Your controller (robot, PLC, or similar) communicates exclusively with the camera, while the camera is connected to the feeder and controls it automatically. The image acquisition of the camera is triggered by the feeder via a dedicated output (trigger out). In addition to these communication paths, a digital output (24V PNP) from your controller to the feeder is required ('pick' signal).

The following figures show both connection options:

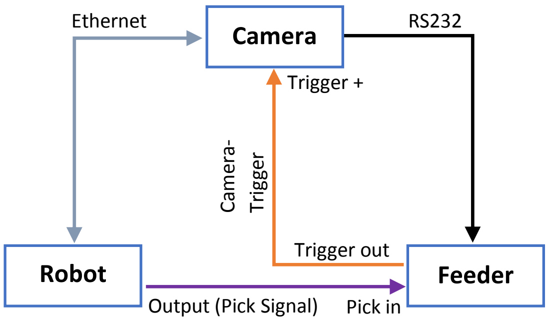


Figure 1: Standard variant:
Robot camera connection via network

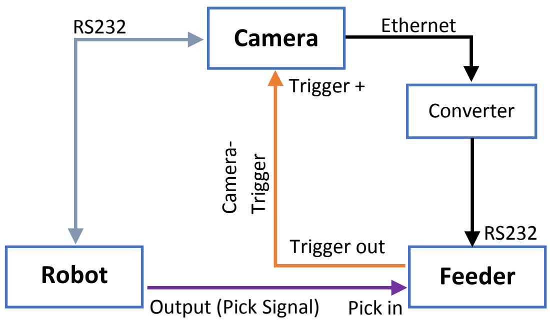


Figure 2: Robot camera connection via serial interface (incl. Ethernet-RS232 converter)

If the communication between robot and camera is to be done via RS232 (Figure 2), an Ethernet-to-RS232 converter is required for the feeder control, since the feeder has only one RS232 interface. The serial connection (Rx/Tx) of the camera is made via the Cognex breakout cable. The Ethernet connection is made via a separate network cable. Both cables are always included in the scope of delivery. A wiring diagram of the standard variant, robot via Ethernet to the camera, can be found here: LINK.

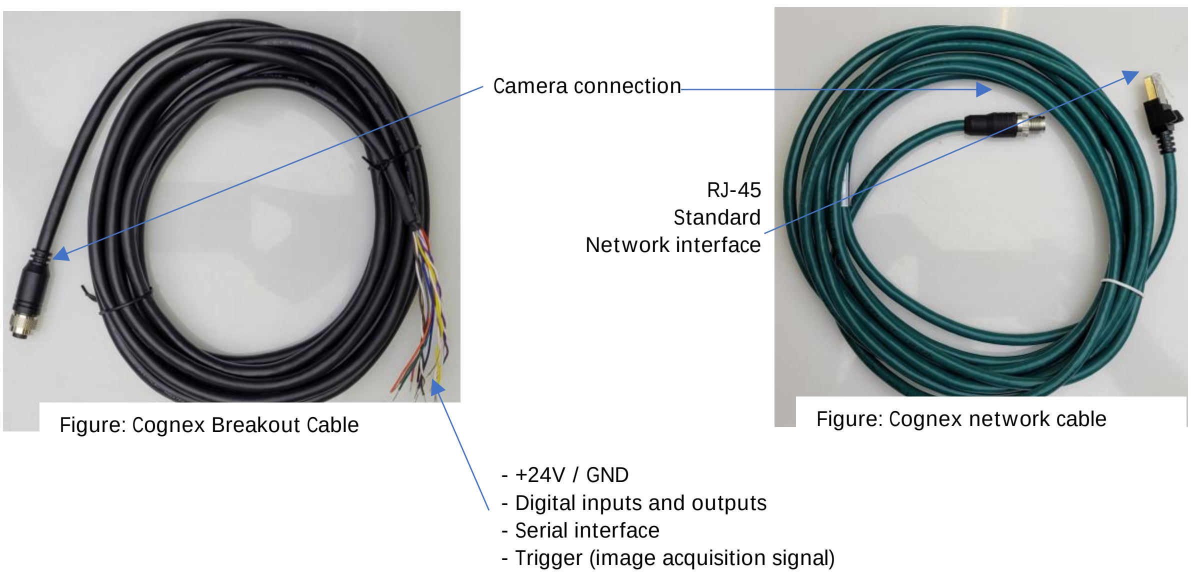


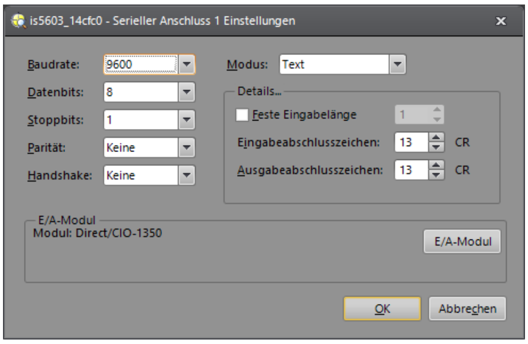
Figure: Cognex Breakout Cable

Figure: Cognex network cable

1.1 Settings: Connection via Ethernet (default)

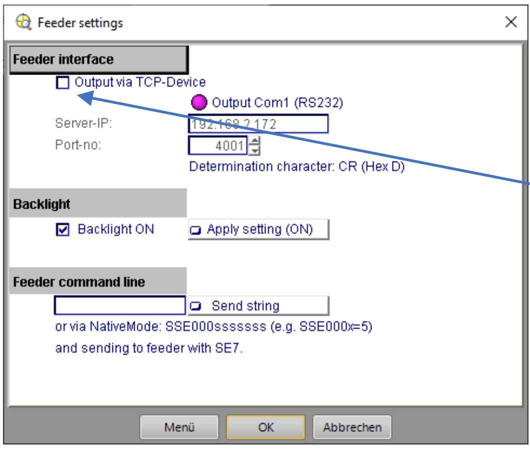
The preferred communication method is to control our system via network (Ethernet). In this configuration, the feeder is connected to the camera via RS232. For this, the following settings are necessary, which are set by default at delivery:

1.) Camera settings:



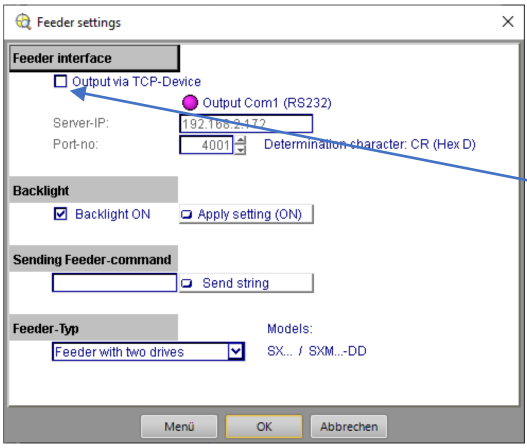
In the Cognex In-Sight Explorer under Sensor/Serial Port Settings, the settings must be set as shown in the adjacent figure (for communication with the feeder).
It is important that the mode is set to 'Text'.

2.) FeederSX job settings:



In the FeederSX job (production job) under Settings/ Feeder settings, the Output via TCP-Device checkbox must be unchecked to send the feeder commands via the RS232 interface to the feeder. See figure on the left.

3.) Calibration job settings:

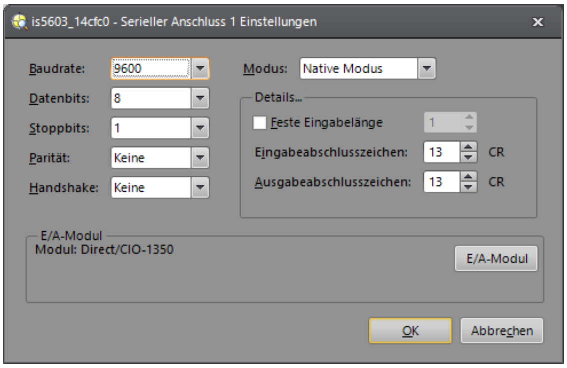


In the calibration job under Menu/Feeder settings, the Output via TCP-Device checkbox must be unchecked in the Feeder Interface area. See figure on the left.

1.2 Settings: Connection via serial interface

If you want to connect your controller to our system via the serial interface, the following three settings must be made:

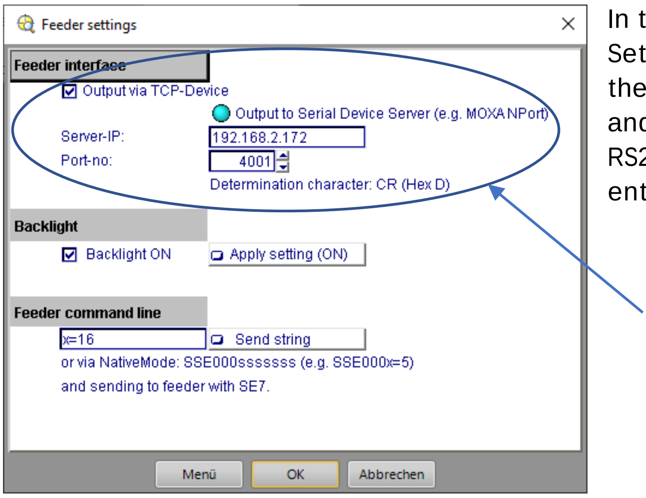
1.) Camera settings



In the Cognex In-Sight Explorer Menu under Sensor/Serial Port Settings, the setting for 'Mode' must be 'changed to 'Native Mode.

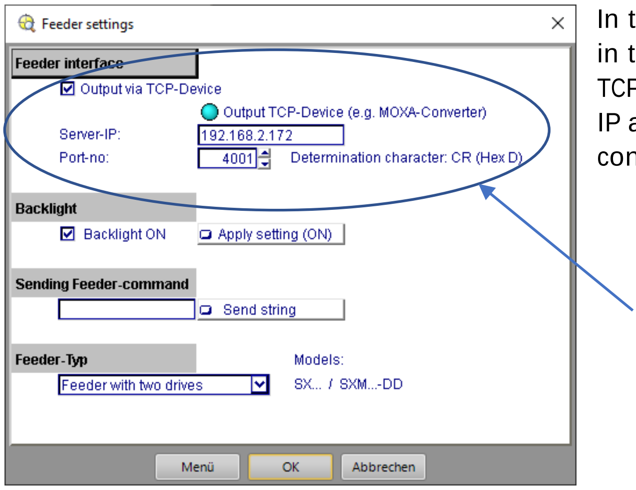
The remaining settings must match those of your controller for communication to be possible.

2.) FeederSX job settings:



In the FeederSX job (production job) under Settings/Feeder settings in the area Feeder Interface the checkbox Output via TCP-Device must be selected and the IP address & port number of the Ethernet to RS232 converter for the feeder communication must be entered.

3.) Calibration job settings:



In the calibration job under Menu/Feeder settings in the area Feeder Interface the checkbox Output via TCP-Device has to be selected and the IP address & port number of the Ethernet-to-RS232 converter for the feeder communication.

2 Initial commissioning of the camera

For initial start-up, a computer must be connected to the camera network. Install the program "Cognex In-Sight Explorer" on the PC to access the camera. The program can be downloaded free of charge from the Cognex website: LINK

In order to start up the camera, it must be correctly wired and powered. A wiring diagram can be found here: LINK

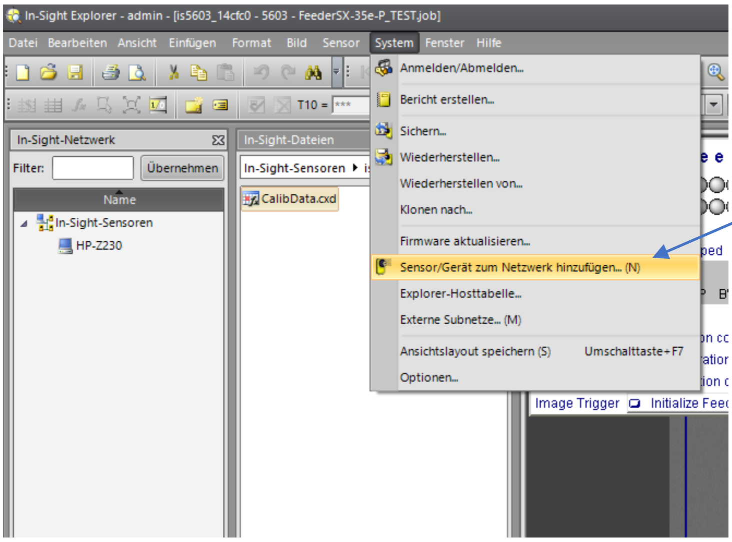
In addition, the lens (and if applicable, the IR pass filter) must be mounted on the camera. An infrared filter is optional and is only required when working with an integrated IR backlight in the feeder.

2.1 Step 1: In-Sight Explorer Configuration

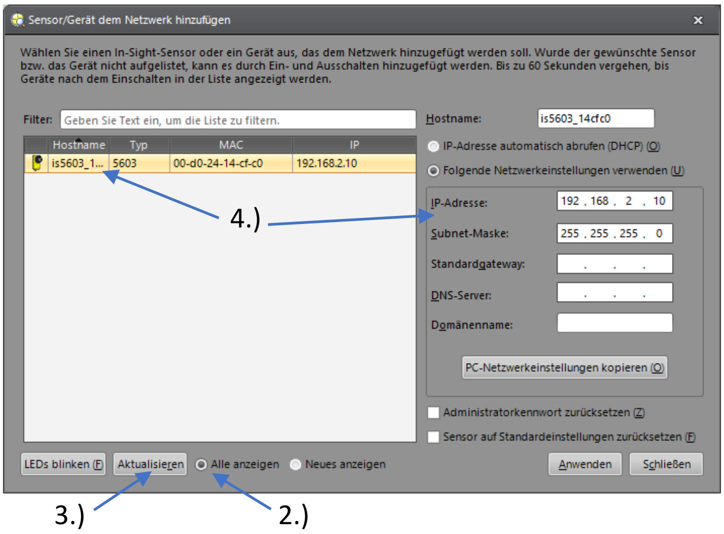
After installing the In-Sight Explorer software, it must be properly configured before you can work with our system. You can find the setup instructions here: LINK

2.2 Step 2: Find camera and change IP address

The computer and the camera must be on the same network for communication to be possible. We always ship255.255.255.0 the camera with the default IP address and192.168.2.10 subnet mask. If you are in a different address range and want to change the camera's setting, proceed as follows:



1.) In the In-Sight Explorer Menu, select System / "Add Sensor/Device to Network".

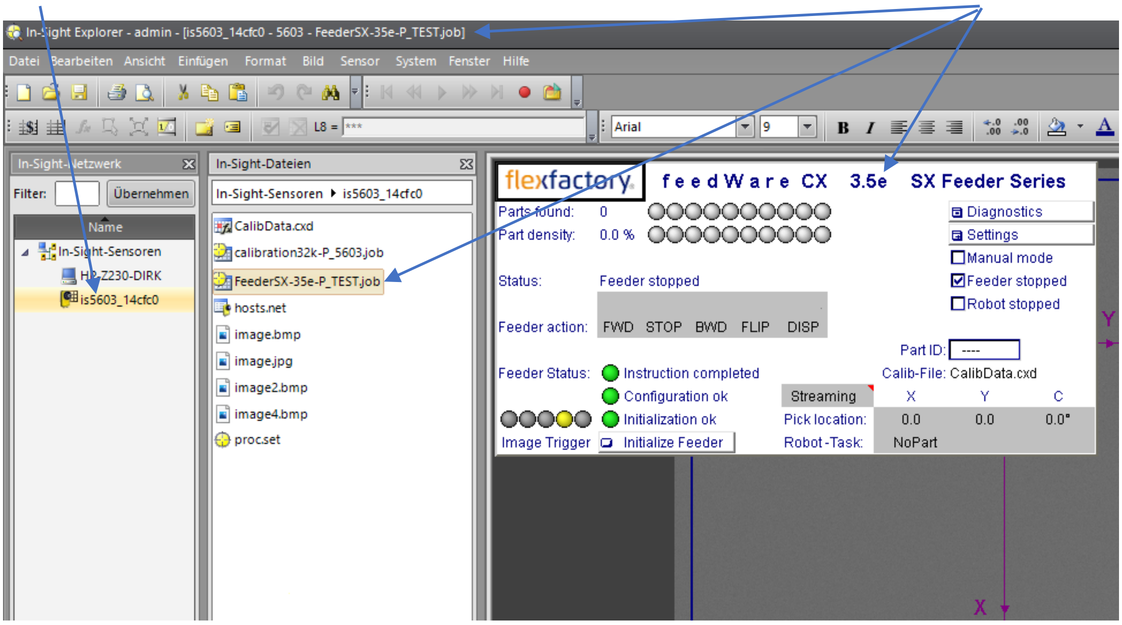


2.) Select "Show all

3) Press "Refresh" and after a few seconds all cameras found in the network will be displayed, no matter which IP address is set.

4.) Now the desired camera can be selected and the network details can be changed.

After the IP settings are ok and camera & computer are in the same network, the camera will be visible in In-Sight Explorer under "In-Sight Network/In-Sight Sensors".
Double-click to establish a connection. Now the currently loaded camera job is displayed.



2.3 Step 3: Switch on the lighting

To make the necessary image adjustments, make sure that the existing lighting is turned on.

When using Toplight:
Our toplights are always white light version. The on/off status of this lighting can therefore be easily checked by eye. We recommend to leave the toplight permanently on during production.

When using backlight:
Our backlights are integrated into the feeders and are switched on as soon as the feeder is supplied with power.

> The light from most backlights is not visible because the preferred light color for our backlights is infrared (IR). Infrared light is not visible to the human eye.

You can check the on/off status of a non-visible light using the camera image and/or the backlight indicator LED (on the side of the feeder)).

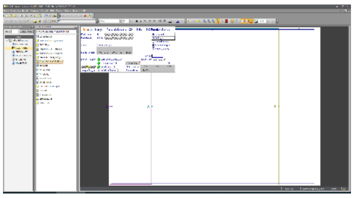
2.4 Step 4: Place part on the conveying surface

Place any part on the pickup surface of the feeder. It is important that the part has a good contrast to the feeding surface, otherwise it will hardly be visible to the camera.

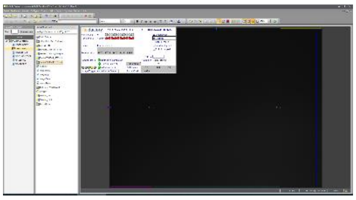
2.5 Step 5: Trigger image and set exposure time

Next, the camera should be switched offline with the "Online/Offline" button in the In-Sight Explorer Toolbar. After that, a picture can be taken manually with the "Trigger" button or the (F5) key.
If these two icons are not visible in your In-Sight Explorer Toolbar, make sure the toolbar is enabled under "View/Toolbars/Job Display".

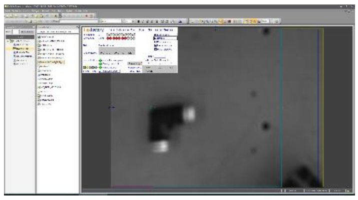
After image capture, the camera image view will be completely black, white or grayish.



A completely white image results from overexposure. In this case, the exposure time should be set smaller.



A completely black image results from underexposure. In this case, the exposure time should be set higher.



A grayish blurred image indicates that the exposure time is set approximately in the correct range.

The exposure time can be changed under "Settings/Preferences/Exposure Time" and a new image can be triggered with the "Trigger" button. The exposure time should be adjusted until a grayish image is visible.

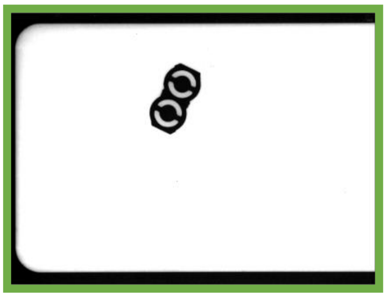
2.6 Step 6: Check aperture and adjust focus

Check that the aperture (upper ring & set screw) on the lens is set to 4 (default value). If necessary, change this setting manually and tighten the set screw again to secure the value.
After the exposure time has been set in the approximate range, a continuous image capture can be activated with the "Live Video" button. In this view, a manual change of the sharpness can be directly displayed and checked. Adjust the lens manually to the max. sharpness (lower lens ring & adjusting screw).
After changing the focus or aperture, the exposure time may need to be adjusted again.

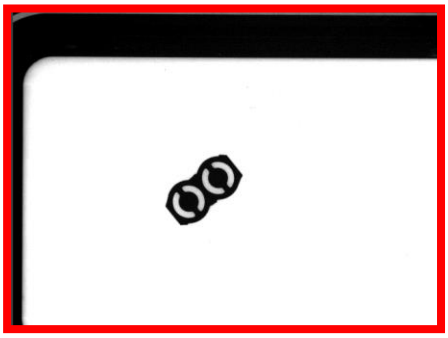
2.7 Step 7: Check camera position and height

Check the positioning of the feeder or camera above the feeder. The camera must see the complete working area and should not look much beyond the feeder edge. If the positioning is not correct, adjust the camera or feeder position accordingly.

The camera should be centered on the feeders pickup area so that only a small border is visible in front and on the sides:



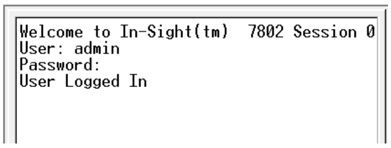
Here are examples of poor camera positioning:



3 Establishing a connection to the camera

The connection from your controller to the camera is established via Telnet over Ethernet, i.e. using the IP address (default: 192.168.2.10) and port number (default: 23). As soon as the port is opened, the camera sends the following welcome message via the interface and waits for the user name to be entered (default: admin):

Welcome to In-Sight(tm) xxxx Session 0
User:



Attention: No terminator (CR LF) is appended after the string "User:". After the input of the user name is completed with the terminator, the camera sends the string:

Password:

(again without terminator) and waits for the password to be entered (default: no password, so only the terminator). If the login was successful, the camera sends the string:

User Logged In

(this time with Terminator).

Users and passwords can be managed individually in the In-Sight Explorer under "Sensor/User Access Settings ".

4 Online/Offline state of the camera

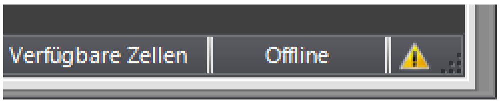
The camera can be switched on and offline.
In the online state, the camera is active, i.e. it can communicate with the feeder and images can be captured automatically.
In the offline state, the camera is in idle mode. New jobs can only be loaded and saved in this state. However, we also recommend teaching in new parts in the offline state.
The camera can be switched online or offline in two different ways: Manually via the In-Sight Explorer or automatically via the Native Mode protocol from a robot or system controller. These two ways are explained below.

4.1 Manually via In-Sight Explorer

In the In-Sight Explorer, the camera can be switched on or off manually with this button. 
(or via the Sensor/Online menu) to switch the camera manually online or offline.

The status of the current state is displayed in the In-Sight Explorer at the very bottom right:

or



Furthermore, the camera status in the In-Sight Explorer can look like this:

This status is displayed if the camera was switched offline via Native Mode interface, e.g. by a robot or PLC control.
Note: for security reasons, the camera cannot be manually set online via the In-Sight Explorer in this state, but must be switched online via the Native Mode interface.

4.2 Automatically via Native Mode protocol

From an external controller, the camera can be set to the on or offline state using the native mode command SOx (Set Online, x: 0=offline; 1=online).

Telnet 192.168.2.10

```
User Logged In
SO1
1
```

Sent: SO1 = Set camera online
Received: 1 = Ack. (Camera was set online)

Telnet 192.168.2.10

```
User Logged In
SO0
1
```

Sent: SO0 = Set camera offline
Received: 1= Ack. (Camera was set offline)

Furthermore, the robot may not be able to bring the camera online:

Telnet 192.168.2.10

```
User Logged In
SO1
-5
```

Sent: SO1 = Set camera online
Received: -5 = camera can not be set online

In this case, the camera was switched offline manually via In-Sight Explorer and therefore cannot be switched online automatically for security reasons. It must first be manually switched back online before an external controller can take control.

4.3 Status request via Native Mode Protocol

The current online/offline status can be queried via the interface with the command GO (Get Online state).

Telnet 192.168.2.10

```
User Logged In
GO
0
```

Return value =0 Camera Offline

Telnet 192.168.2.10

```
User Logged In
GO
1
```

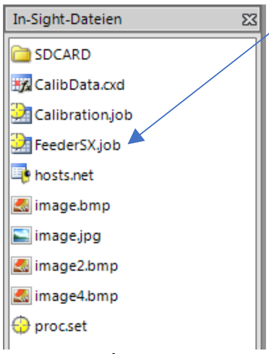
Return value =1 Camera Online

> For security reasons, the camera can only be switched online via the channel that was used to switch it offline.

5 feedWare CX Software Package

Our feedWare CX software package consists of the license key for a specific camera device and two program modules: The main job ("FeederSX"), which is responsible for part detection and preparation with the feeder, and the "Calibration" job, which in interaction with the robot program manages the coordinate matching process between camera and robot.
These jobs can be copied as desired for different components, as well as be transferred to and copied from other cameras, provided the cameras are of the same type and licensed.

5.1 FeederSX Job



The FeederSX job is used to detect the parts and control the feeder during production and is therefore the "production job". One FeederSX job is required for each part type. The job can be copied, renamed and set according to type. Each part type must be taught in once and then has its own production job.
Well over 1'0 00jobs can be stored on the camera's internal memory, and even significantly more via the SD memory card expansion.

Preparation:
In the FeederSX job, each part type is taught once. During manual teach-in, the following data is specified and saved:

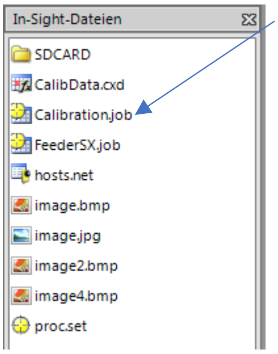
- Detection pattern and reference point / gripping point
- additional inspections, if necessary
- Gripper zones and areas to prevent overlapping
- Areas to determine the density level for the feeder control logic
- Feeder motion parameters

Details on teaching parts can be found in our FeedWareCX UserGuide: LINK

Production:
For production, the robot simply has to load the appropriate job, start automatic mode and wait for a coordinate on the camera where it can pick up a part. The feeder camera system automatically separates the parts until there is a pickable part and then transmits its position to the robot. Once the robot has received a valid coordinate, it must set the pick signal and go pick up the part. When the robot moves away, i.e. as soon as it has left the camera image, the pick signal must be reset, which automatically triggers a new image capture, followed by the next coordinate output.

The robot can also start the feeder emptying in this job (see chapter 9.4).

5.2 Calibration Job



The Calibration Job is required for the coordinate matching process with the robot ("Calibration"). Since the calibration only has to be performed with one specific calibration part and is valid for all production jobs, only one calibration job per camera is necessary.
In very rare cases, it may be necessary to perform two different calibrations (see Chapter 11: Calibration). Then this job can be copied and adapted for a second calibration part.

In this job, neither the automatic system can be started nor the feeder emptying can be performed.

6 Native Mode Protocol

The Native Mode Protocol is an ASCII protocol from Cognex to control an InSight system over Telnet via Ethernet or RS232 serial port. The feedWare CX software is based on this Native Mode interface. A command line is always terminated with 'Carriage Return 'and 'Line Feed' (CR + LF) (ASCII Characters 13 + 10).

Predefined native mode commands (events)
In the feedWare CX software there are predefined native mode commands, called events. These are described in the following table:

Command	Function	More info in chapter
SE1 <CR LF>	Starts the calibration process in the camera	Calibration sequence
SE2 <CR LF>	Saves the calculated calibration data to the defined . cxd file	Calibration sequence
SE6 <CR LF>	All motion parameters are transferred to the feeder and then the initialization (reference run) is executed.	Emergency stop
SE7 <CR LF>	The feeder command in camera cell E000 is sent to the feeder	Feeder emptying

6.1 Simple Native Mode commands

The following is an example of a Native Mode command:

SO1<CR LF>

The command consists of three segments:

1 2 3
SO 1 <CR LF>

<u>Segment 1 - Command type</u>
The first two letters of a command string always define the command type. SO Corresponds to the Native Mode command "Set Online". This command sets the camera to the desired online state.

<u>Segment 2 - Status</u>
In the SO command, the second segment indicates the desired online status. (1 = Online, 0 = Offline)

<u>Segment 3 - Terminator</u>
Each command must be terminated with CR + LF (Carriage Return + Line Feed = ASCII Characters 13 + 10).

Other examples of simple Native Mode commands:

1.) SE1 //Set Event <u>1</u> (Start calibration sequence)
2.) SO0 //Set Online <u>0</u> (Set camera offline)

6.2 More complex Native Mode commands

The following is an example of a somewhat more complex native mode command:

SSE000x=7<CR LF>

The command consists of four segments:

1 2 3 4
SS E000 x=7 <CR LF>

<u>Segment 1 - Command type</u>
Corresponds to the Native Mode command and is always 2 letters long. SS is the "Set String" command.

<u>Segment 2 - cell number</u>
If a cell is referenced in the table during a command, segment 2 defines the cell position and is always 4 characters long. This segment again consists of two parts. The first character is the column letter and the characters 2 to 4 stand for the row number.
In the example above, cell E000 is referenced:

	A	B	C	D	E	F	...
000							
001							
...							

<u>Segment 3 - Value</u>
Is the value that is sent to the camera and can have different lengths depending on the command type (here SS). In our example SS (Set String) the string "x=7" is written as a string into the cell E000:

	A	B	C	D	E	F	...
000					x=7		
001							
...							

<u>Segment 4 - Terminator</u>
Each command must be terminated with CR + LF (Carriage Return and Line Feed = ASCII Characters 13 + 10).

Other examples of more complex native mode commands:

1.) SIT0121<CR LF>

SI T012 1 //Set integer "1" into cell T012 (stop feeder automatic)

2.) SFP00089.53<CR LF>

SF P000 89.53 1 //Set float value 89.531"" into cell P000 (robot coordinates)

3.) SIH0000<CR LF>

SI H000 0 //Set integer "0" into cell H000 (Calib: image acquisition)

6.3 List of all Native Mode commands

GO = Get Online state
GV = Get Value
GF = Get File
GJ = Get Job
LF = Load File
SE = Set Event
- SE1 = Start calibration process
- SE2 = Save calibration process in calibration file
- SE6 = Send feeder parameters
- SE7 = Send single command to feeder (from cell E000)

SF = Set Float
SI = Set Integer
SJ = Set Job
SM = Send Message
SO = Set Online (0=Offline; 1=Online)
SS = Set String
TF = Save/Store File

6.4 Camera responses to Native Mode commands

The camera responds to any Native command.

> The following response(s) of the camera to a Native Mode command must always be waited for and evaluated

e.g. Command:
SIT0121<CR LF> //Feeder automatic stop

Camera response:
1<CR LF> // Command understood and executed

Standard responses of the camera are shown in the following table:

1	Command understood or successfully executed
0	Command not executable
-[number]	A negative return value signals that execution of the command is not possible (for a detailed description of the respective error code, see the Insight Explorer help under 'Communications Reference/Native Mode')

For status queries with "Get" read commands, the camera always responds with two return values.
e.g. Command:
GVM017 <CR LF> //Get Value/Read Value from Cell M017

Camera response:
1<CR LF> //1st standard response (1 = command understood/executed)
1.000<CR LF> //2. Contents of cell M017 is 1.000

1. the first answer is a standard answer, shown in the table above.
2. the second response is the actual cell content, which is requested with the "Get" command.

Read commands of the type "Get Value / GV" are required, for example, to read out the feeder status in the production and calibration job. Details on this in the "Status queries" chapter

6.5 Test Native Mode Commands Manually

To test Native Mode commands, you can connect to the camera via Telnet Client from a computer connected to the camera network and then manually send commands to the camera and receive responses. Windows 10 includes a Telnet Client by default. Under the following link you will find a short tutorial on how to activate this Telnet Client under Windows 10: LINK

7 Load and save camera jobs

Note: Camera jobs can only be loaded or saved when the camera is offline.

7.1 Manually via the In-Sight Explorer

Loading:
To load a camera job, drag and drop the desired camera job from the In-Sight Files column to the Camera Image area.

Save: 
Click the floppy disk icon in the ribbon to save the current job or select >File >'Save Job As...' to save the job under a new name.

7.2 Automatically via Native Mode

Store
There are two ways to open jobs on the camera via Native Mode:

Option 1 - Native Mode Command "LF" (Load File)
With the Native Mode command "LF + Job Name", jobs can be opened on the camera by their file name.

Example:

Job Name:	FeederSX.job
Load command:	LFFeederSX.job<CR LF>

Option 2 - Native Mode command "SJ" (Set Job)
The Native Mode command "SJ + Job Number" can be used to open jobs using a number at the beginning of the file name on the camera. This requires that each job name on the camera starts with a number from 0 to 999.

Example:

Job Name:	8FeederSX.job
Load command:	SJ8

Annotation:
Since jobs can only be loaded offline, the camera must first be switched offline before loading (command "SO0"). After loading, the camera should be put online again (command "SO 1").

Save:
It makes no sense to save the FeederSX job via Native Mode, but the Calibration Job should be automatically saved/overwritten by the robot after each run.

> Save the calibration job only after successful calibration, but never with active "Error" status, otherwise an error status will be displayed each time this job is opened.

Example:

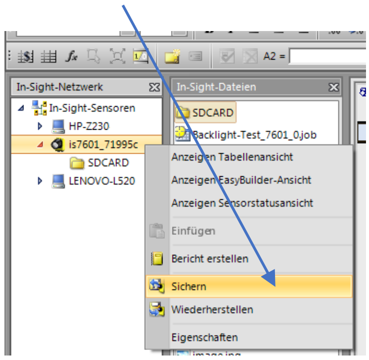
Job Name: Calibration.job

Memory command: TFCalibration.job<CR LF>

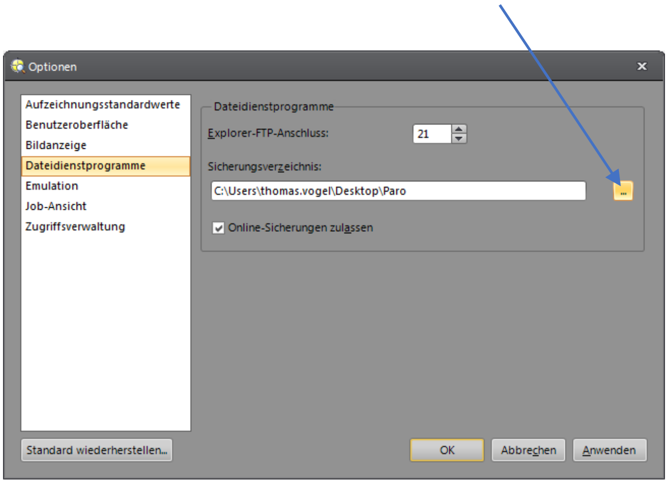
Notice:
Since jobs can only be saved offline, the camera must first be switched offline with the "SO0" command before saving. After saving, the camera should be put back online with "SO 1".

7.3 System backup

The camera data, i.e. all jobs, calib data and sensor settings, can be backed up to the computer via the Insight Explorer. To do this, right-click on the desired camera in the "In-Sight Network" area and select "Save". This saves all camera data locally on the computer.



The backup directory can be changed here:
System/Options.../File Utilities/Backup Directory



8 Data exchange during production

Data exchange during production can be performed in three different methods. Each programming prefers a different method for data exchange. Read these three methods carefully and decide which method is most suitable for your programming.

The transmitted information is identical for all three methods of data exchange. Pick status, pick coordinate and any feeder errors are sent or can be read out:

The pick status is either a coordinate string or a NoPart string:

- Pick status, with coordinate to pick a part:
  Pick;Xvxxx.xxx;Yvyyy.yyy;Cvccc.ccc; <CR LF>
  (Total always 35 characters, without <CR LF>)
  v = representative for the sign and can take the values '+' or '-'.
  x = X robot coordinate
  y = Y robot coordinate
  c = orientation of the part (in degrees, 0...360)

  We recommend that on the robot side it is checked each time whether the received tap point is within an allowed XY range of the application.

- Pick status if no tangible part was detected:
  NoPart
  This message from the camera means that an image has been captured, but no part has been detected as tangible. In this case, the feeder automatically shakes to provide a new part. This process/status is repeated until a part is detected as being grippable.

"NoPart" counter
The number of successively received "NoPart" strings from the camera should be counted or monitored in the robot. After about successively10 received "NoPart" strings, it can be assumed that no parts can be detected. This happens when there are no more parts in the feeder or the wrong detection job has been selected for the parts present. Therefore, when this counter is reached, the system should be paused and a message should be displayed informing the operator that no parts are present or none have been detected.

Feeder Error Status
In the event of a feeder malfunction, this information is transmitted to your controller with the corresponding error code instead of the pick status. The error string looks as follows:

ERROR_m1x_m2y

m1 / m2 = motor 1 / motor 2

x = Error code of motor 1 (see table)
y = Error code of motor 2 (see table)

Code	Error Message	Details / possible cause
2	Invalid command	Drive received a command which is not supported
3	Servo error on this drive	Drive is overloaded or blocked
6	Drive not initialized	Drive hasn't been initialized yet or lost its state due to power cycle
7	Error on other Drive	Servo error has occurred on other Drive and is reported to this Drive

8.1 Method 1: Streaming Mode

The "Streaming Mode" is the continuous, automatic data exchange between camera and external control/robot during production. As soon as the streaming mode is started by the robot, the camera automatically sends a string with the pick coordinate, NoPart or an error to your controller after each image acquisition. This data string must be read from the input buffer by your controller, evaluated and processed accordingly.

The advantage of this method is that the information is actively sent by the camera at the earliest possible moment without any further setup. Your controller is therefore only in 'listening mode' during operation.

The command SM "Start "0 starts the streaming mode on the camera. This command string must usually be assembled from individual parts using the ASCII description of the quotation marks (Dec 34), since these are interpreted as a limitation for a string in many programming languages:

SM+Chr(34)+Start+Chr(34)+0.

The SM "Stop "0 command can be used to stop the streaming mode again.

Pick signal in streaming mode
A digital output ("pick signal") from your plant to the feeder is required (pick in, 24V, PNP).
In the active state of this signal, the continuous image acquisition of the camera stops and locks any feeder movements so that the robot can pick up parts safely.

The pick signal should be set ON immediately after obtaining a valid coordinate on the robot to pause continuous image acquisition and any feeder movements.
If the pick signal is not set immediately after a coordinate is received, the camera will continue to take images and correctly detected parts could be lost. Furthermore, continuous image acquisition and sending of coordinates could result in buffer overflow.

When the robot arm has left the image area on the feeder after picking, the pick signal is to be set OFF again. With this negative edge, a new image acquisition is triggered immediately and a string with the current information is output afterwards.
If no part is available (NoPart), a part preparation is automatically triggered by the feeder.

Here is a short example from a streaming mode flow:

SM "Start" 0	// Plant sends Streaming Mode Start command
1	// Camera response (1=executed)
NoPart	// Output string: no part found (→ feeder action)
Pick; X+300.128;Y+184.932;C+062.415;	// Output string: part found; coordinate
NoPart	// Output string: no part found (→ feeder action)
NoPart	// Output string: no part found (→ feeder action)
Pick; X+128.123;Y+134. 917;C+128.722;	// Output string: part found; coordinate
Pick; X+281.732;Y+221.408;C+110.298;	// Output string: part found; coordinate
NoPart	// Output string: no part found (→ feeder action)
ERROR_m20_m13	// Output string: Error at feeder drive 1
SM "Stop" 0	// Plant sends streaming mode stop command
1	// Camera response (1=executed)

8.2 Method 2: Streaming mode without continuous image acquisition

Automatic image acquisition can be switched off in the detection job under *>Settings >Motion Parameter* by entering the value "0" in the *Trigger Timer* field. By switching off the continuous image acquisition, the pick signal does not have to be set directly after receiving a coordinate, so the robot can evaluate the data string at any time.
Please make sure that this setting is done in every existing job on the camera if you have chosen this method.

The disadvantage of this method is that after activating the streaming mode, the pick signal must first be set once and immediately reset in order to trigger an initial image capture and associated data output.

The command SM "Start "0 starts the streaming mode on the camera. This command string must usually be assembled from individual parts using the ASCII description of the quotation marks (Dec 34), since these are interpreted as a limitation for a string in many programming languages:

SM+Chr(34)+Start+Chr(34)+0.

To stop the streaming mode again, send the command SM "Stop "0

Pick signal in streaming mode without continuous image acquisition
The so-called "pick signal" (output of your controller to the feeder) must also be connected with this method. When this signal is active, all feeder movements are blocked so that the robot can pick up parts safely.

<u>The pick signal should be set ON when the robot moves to the feeder but is still outside the pick area.</u>

<u>When the robot arm has left the image area on the feeder after picking, the pick signal is to be set OFF again.</u> With this negative edge, a new image acquisition is triggered immediately and a string with the current information is output afterwards.
If no part is available (NoPart), a part preparation is automatically triggered by the feeder.

Here is a short example from a streaming mode flow:

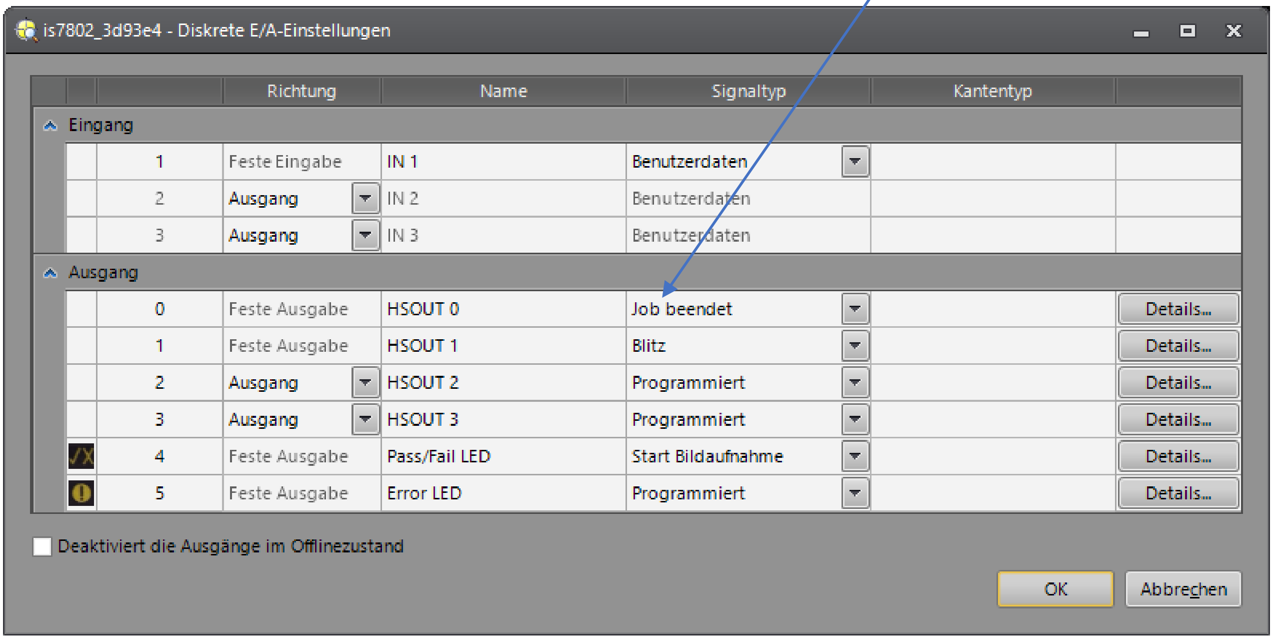
```
SM "Start" 0                          // Plant sends Streaming Mode Start command
1                                     // Camera response (1=executed)
NoPart                                // Output string: no part found (→ feeder action)
Pick;X+300.128;Y+184.932;C+062.415;   // Output string: part found; coordinate
NoPart                                // Output string: no part found (→ feeder action)
NoPart                                // Output string: no part found (→ feeder action)
Pick;X+128.123;Y+134.917;C+128.722;   // Output string: part found; coordinate
Pick;X+281.732;Y+221.408;C+110.298;   // Output string: part found; coordinate
NoPart                                // Output string: no part found (→ feeder action)
ERROR_m20_m13                         // Output string: Error at feeder drive 1
SM "Stop" 0                           // Plant sends streaming mode stop command
1                                     // Camera response (1=executed)
```

8.3 Method 3: Read out data

Instead of the coordinate string being actively sent from the camera to your controller after evaluation, the information can also be read from the camera. For this, however, an additional signal must be wired from the camera to the controller and a setting in the camera must be changed in order to transmit the correct time for reading the updated data. With this method, the streaming mode is not used or started.

Wiring signal:
The HSOUT output from0 the camera (in the Cognex Breakout Cable, cable color: blue) must be wired to an input on your controller.

Camera setting:
Under Menu > *Sensor > Discrete I/O Settings* HSOUT must be set to 0"Job Finished". Here also the pulse length of this signal can be defined.



The additionally wired signal "Job Finished" now always sends a short pulse when the image evaluation has been performed. After the robot has received this signal, it can read out the new information (data string) from cell R002 with the "GVR002" command. With value "NoPart" the feeder prepares parts, i.e. your controller must wait for the next signal impulse before the cell can be read again.

Pick signal when reading out the coordinates
This method also requires a digital output ("pick signal") from your controller to the feeder (pick in, 24V, PNP). By setting this signal, the continuous image acquisition is stopped and any feeder movements are blocked so that the robot can pick up parts safely.

<u>The pick signal should be set to ON immediately after reading out a pick coordinate in order to pause continuous image acquisition and any feeder movements</u>. If the pick signal is not set immediately after reading out a coordinate, the camera will continue to take images and correctly detected parts could be lost, which in turn could result in the feeder being triggered.

<u>When the robot arm has left the image area on the feeder after picking, the pick signal is to be set OFF again.</u> With this negative edge, a new image acquisition is triggered immediately and the signal for reading out the current information is output afterwards. If no part is available, a part preparation is automatically triggered by the feeder.

9 Control of the camera during production

9.1 Load feeder job and start feeding

1. set camera offline	Command:	SO0
Wait for response from camera		1
2. load recognition job	Command:	LF< filename>
Wait for response from camera		1
3. stop automatic feeder	Command:	SIT0121
Wait for response from camera		1
4. set pick signal to low (0V)		
5. set camera online	Command:	SO1
Wait for response from camera		1
6. Wait 2 seconds (initialization is performed).		
7. status 1 query	command:	GVM017
Wait for 1st answer from camera		1
Wait for 2nd answer from camera		1.000
8. status 2 query	command:	GVM016
Wait for 1st answer from camera		1
Wait for 2nd answer from camera		1.000
9. status 3 query	command:	GVM018
Wait for 1st answer from camera		1
Wait for 2nd answer from camera		1.000
10. start feeder automatic	Command:	SIT0120
Wait for response from camera		1
Start streaming mode	Command:	SM "Start "0
Wait for response from camera		1

9.2 Procedure at E-stop

> In an emergency stop situation, the power supply and air supply to the feeder must be switched off to allow the conveyor platform and hopper to move freely.

Before switching on the feeder again, the feeder automatic should be stopped in the camera with the command "SIT0121". After switching on the power supply, the feeder parameters must be sent again from the camera to the feeder. This is triggered with the command "SE6". After the parameter transmission, the feeder is initialized automatically.
Afterwards, briefly check the feeder status with the commands "GVM017", "GVM016" and "GVM018" and then the automatic feeder can be restarted with the command "SIT0120".

The chronological procedure for starting the feeder after an emergency stop is as follows:

1.)	Feeder automatic OFF	command: SIT0121
2.)	Voltage + Air ON	
3.)	Transfer feeder parameters (+Init)	Command: SE6
4.)	Wait 2 seconds	
5.)	Check feeder status 1	Command: GVM017
6.)	Check feeder status 2	Command: GVM016
7.)	Check feeder status 3	Command: GVM018
8.)	Feeder automatic ON	command: SIT0120
9.)	Pick signal OFF	

9.3 Stop/pause automatic operation

When stopping the complete system, streaming mode and feeder automatic must be stopped. A started feeder movement will be continued unhindered and finished normally, therefore this stop is not suitable for emergency stop situation.

The chronological sequence is as follows:

1.)	Feeder automatic stop	command: SIT0121
2.)	Stop Streaming Mode	Command: SM "Stop "0
3.)	24V Set pick signal to LOW (0V)	

9.4 Empty feeder

The feeder can be emptied via a command sequence. Please note that the feeder does not contain any additional sensors that check the remaining fill level. An emptying takes place over a predefined duration. A one-time test emptying with full hopper should be performed for each part type to determine the necessary emptying time and movement intensity. These parameters are specified in the 'Feeder motion-parameter' menu when setting up a part. The average time for emptying is about 30 seconds.

The chronological sequence is as follows:

1.)	Stop streaming mode	Command: SM "Stop "0
2.)	Stop feeder automatic	Command: SIT0121
3.)	24V Set Pick Signal Low (0V)	
4.)	Empty feeder (2 commands)	1st command: SSE000x=7 2. command: SE7

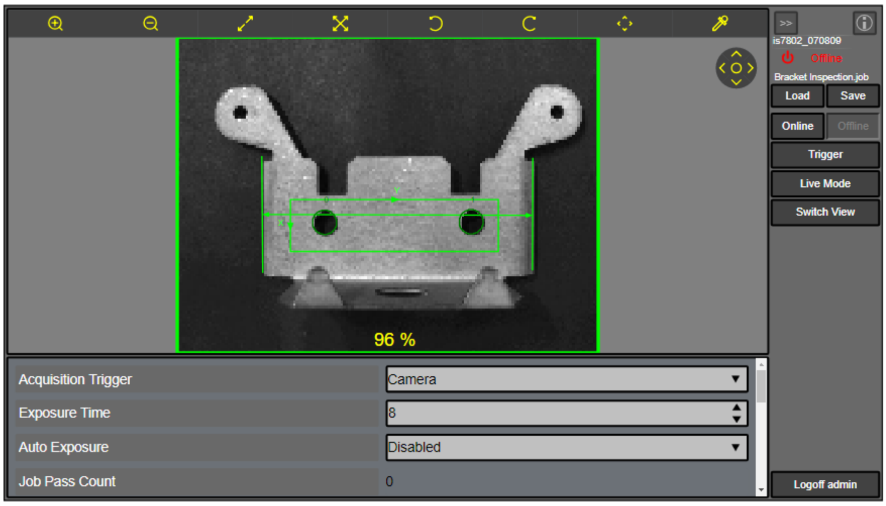
Emptying at the feeder is now performed.

5.)	Read status of emptying	Command: GVM016

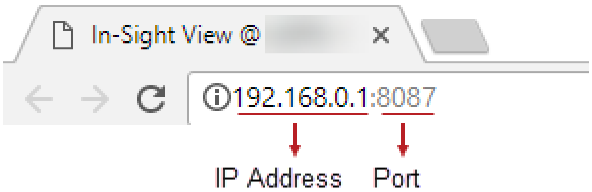
If the second return value is 0.000, the emptying process is still running. Only when receiving 1.000, the emptying of the feeder is finished.

10 Display camera image in browser (Web HMI)

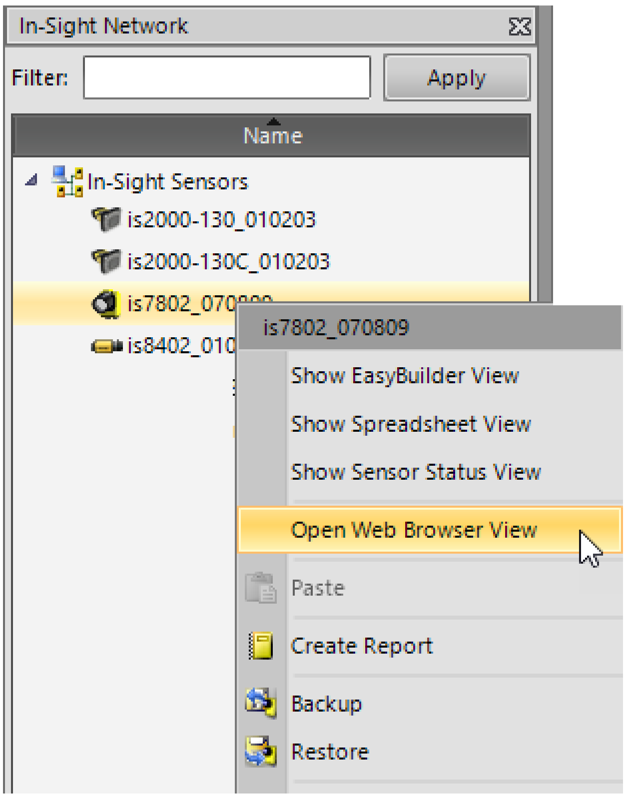
The camera image can be displayed in a browser (Chrome or Microsoft Edge) for visualization. Please note that this is only supported from camera firmware version 5.9.0. The web HMI view will then look something like this:



The Web HMI can be easily displayed by entering the camera IP address and port number in the address bar of a supported browser.



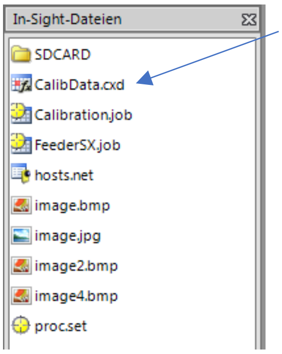
Alternatively, it can be opened by right-clicking on the camera and then selecting "Open Web Browser View".



Details on supported web browsers and camera versions can be found in the Cognex Help.

11 Calibration

Calibration is the process of matching coordinates between the vision system and the robot. To determine the required data, we use an automated 4-point method. This method offers the great advantage that the process can be carried out fully automatically, without any operator action, if required.
In order for this process to be carried out with any robot, a corresponding sequence must be programmed on the robot side, which is described in detail below.
Short version of the sequence: The robot places a calibration part at four predefined points on the feeder (in four 90° angular steps each) and informs the camera of the corresponding deposition coordinate in the robot system. Together with the pixel coordinates that the camera captures in the process, this results in four pairs of points, which are then used to convert the camera coordinates into robot coordinates. This information is stored on the camera in a . cxd file.



The CalibData.cxd file is not available when the camera is delivered and is only generated after successful calibration. Without this file, you cannot recognize any parts in the production job (FeederSX). Therefore, make sure that the calibration has been performed before working with the production job.

During production, all camera programs access the data in the . cxd file and can thus output the position of tappable parts directly in robot coordinates.

The following link shows a video of the calibration procedure: LINK

For various robot brands we provide sample programs which include this calibration procedure. These programs are available for download free of charge on our website.
Under the following link you will be directed to the sample programs on our homepage: LINK

11.1 Calibration part

Quantity:
Basically, one calibration can be used for several production parts or detection jobs, i.e. usually only one calibration part is required. An exception is if there is a large height difference between the largest and the smallest production part (more than approx. 10mm). In this case, the accuracy during tapping can be increased by creating different calibrations, with different height calibration parts.

Shape:
Height: To achieve the most accurate calibration, the calibration part should be as high as the parts to be separated. If the parts have different heights, the average value of the lowest and highest part should be used. As mentioned above, if the height difference is more than 10mm, a second calibration part is recommended for separate calibration.

Example:
Maximum height smallest part 10mm
Maximum height largest part: 14mm
Calibration part should be 12mm high.

Structure: The calibration part must be asymmetrical and have a stable rest position. Rolling parts should not be used. If a structured conveying surface is used in the feeder, the calibration part should be of such a size that it lies stably on the nubs/grooves and does not lie at an angle in the structure.

Material:
The calibration part must be made of stable material. It must not deform when gripping or over time. Metal or plastic is the recommended material.

Surface:
Ideally, the surface should not have any rough unevenness so that only the outline of the calibration part and no unnecessary interfering contours on the surface of the part are taught during teach-in. By increasing or decreasing the exposure time, smaller contours/irregularities of the surface can usually be masked out.

Furthermore:

- For backlight applications, make sure that the material of the calibration part is not translucent. The color of the part is not important here
- In Toplight applications with a white feeder plate, the part should appear as black as possible in the image. This is achieved by a dark, matte (non-reflective) surface.
- In Toplight applications with a black feeder plate, the part should appear as white as possible in the image. This is achieved by a bright (or reflective) surface.

If a production part meets these requirements, it can also be used for calibration. In this case, no specific calibration part is required.

If a created calibration part or a production part does not meet the calibration part requirements, it can usually be adapted to the requirements by making small changes.

For example:

Calibration part	Improvement measure:
is mirroring/reflecting	Roughen the surface of the part and paint it black matte. (spray or paint) *
has disturbing contours on the surface	Paint part completely matte black or white, depending on the color of the conveying surface. (spray or paint)
is transparent	Paint part completely matte black or white, depending on the color of the conveying surface. (spray or paint)
is rolling	Grind the part on one side to achieve a stable rest position. or Glue/screw a small area to the part to achieve a stable rest position.
is symmetrical	Cut or sand off one corner.

* Only necessary for Toplight applications with white conveying surface

If a calibration part is machined or manufactured, it is recommended to label it accordingly and to keep it in a place where it can be easily found.

11.2 Teach-in calibration part

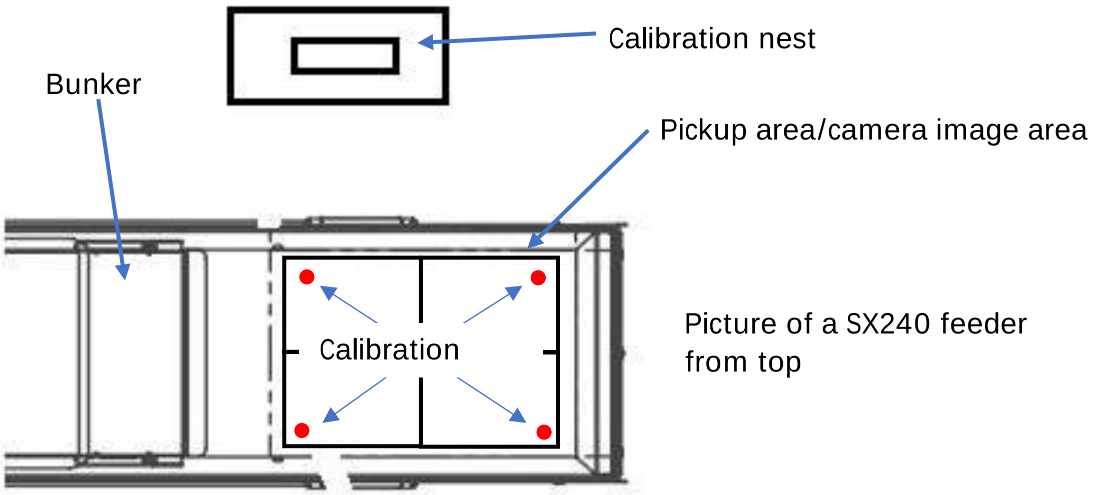
First, the calibration part is to be taught-in with the Cognex Insight Explorer software in CalibrationXX.job (XX = representative for software version).
Care should be taken to ensure that no unnecessary contours are taught in on the surface, i.e. if possible only the outline of the calibration part should be taught in as a reference.
For instructions on how to teach-in a part in the camera software, please refer to the document "FeedWare_User_Guide", which is available on our homepage: LINK

11.3 Calibration nest

A mechanically fixed deposit position (nest) is to be set up within the reach of the robot, from where the calibration part can be picked up during the automatic sequence.
Ideally, this nest is designed in such a way that the part is centered when it is placed in it, i.e. it is always in exactly the same position where it can also be repeatedly picked up exactly by the robot.

11.4 Calibration points

On the robot side, 4 points must be taught in on the feeder gripping surface. These points should be positioned towards the corners of the image area, but only to such an extent that the calibration part is still reliably detected by the camera at these positions and can be rotated 360° by the gripper.
The arrangement of points 1-4 should be clockwise or counterclockwise (not crosswise).



11.5 Calibration point angle

The calibration part is placed at each of the calibration points in four 90° steps in order to determine any errors. The robot should therefore be able to approach the 4 calibration points at angles of 0°, 90°, 180° and 270°. If one or more angles on the calibration points cannot be approached (e.g. due to collision of the gripper with adjacent equipment), other angles can also be used. However, angles used must meet the following conditions: Angles W1 and W2 can be freely selected, whereby W2 must be larger than W1 and W2 must not exceed 180°. Angle 3 is then calculated from W1 + 180° and angle 4 is calculated from W2 + 180°. The further apart the angles, the more accurate the calibration, which is why the standard angle steps for a calibration point are 90° in each case, i.e. 0°, 90°, 180°, 270°.
Angle conditions to be observed:

W1 = <W2
W2 = <180°
W3 = W1 + 180°
W4 = W2 + 180°

Other possible angles are therefore, for example: (W1, W2, W3, W4)
20°, 50°, 200°, 230°
30°, 150°, 210°, 320°
80°, 100°, 260°, 280°

12 Calibration sequence

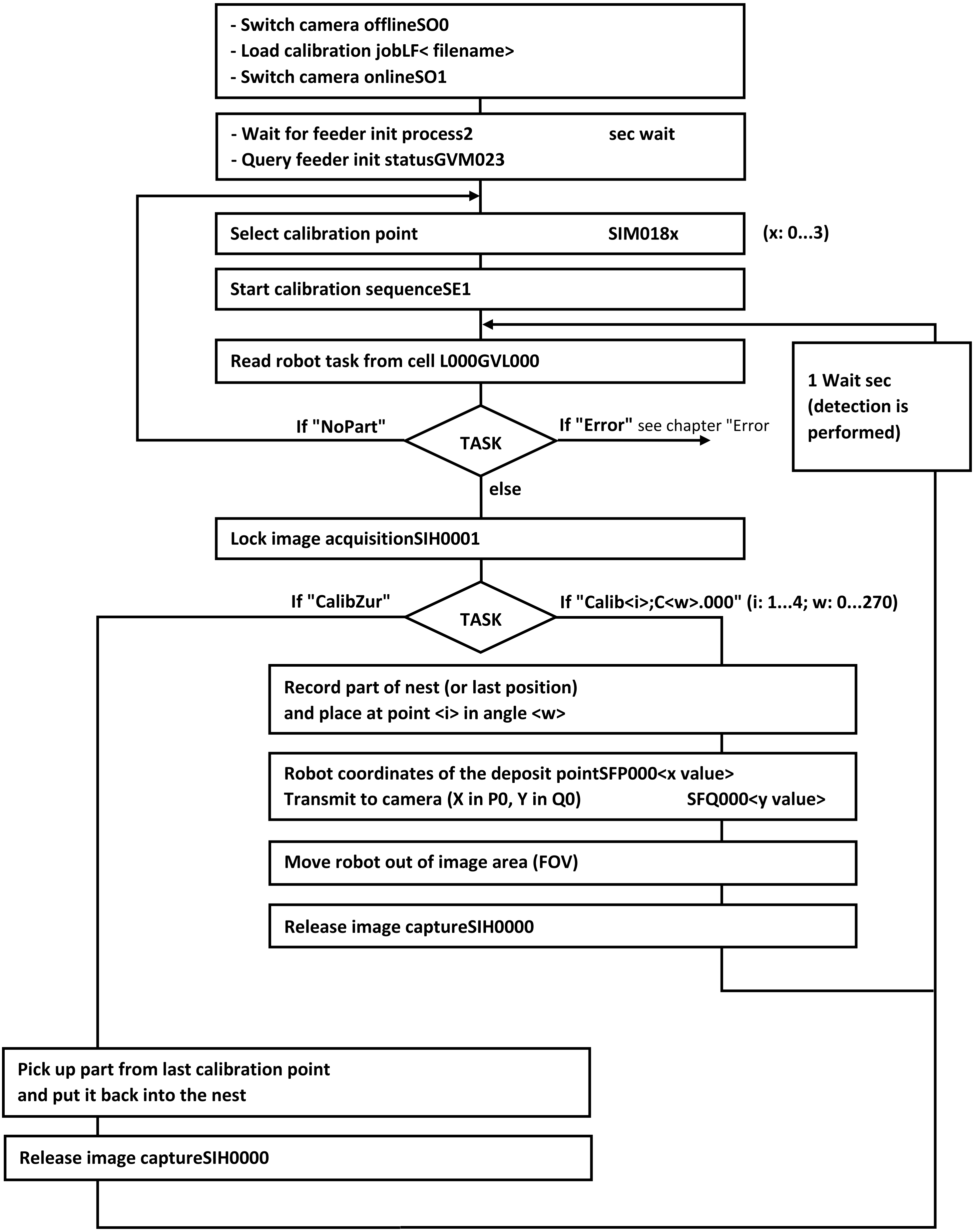
Here roughly the procedure for one calibration point (out of 4):

1.) The robot grabs the calibration part from the nest
2.) The robot starts the calibration from point 1 in the camera
3.) The robot places the calibration part at the point in the 1angle 0
4.) The robot sends its coordinates of deposit point 1 to the camera
5.) The robot moves out of the camera image, the camera detects the deposited calibration part
6.) The robot grips the part at point 1 in angle 0 and sets it back to point in 1angle 90
7.) The robot moves out of the camera image, the camera detects the deposited calibration part
8.) The robot grips the part at point 1 at angle 90 and sets it back to point at 1angle 180
9.) The robot moves out of the camera image, the camera detects the deposited calibration part
10.) The robot grips the calibration part at point 1 at angle 180 and sets it to point at 1angle 270
11.) The robot moves out of the camera image, the camera detects the deposited calibration part
12.) The robot picks up the calibration part at point 1 at angle 270 and places it back in the nest.
13.) Point 1 Done. Now the calibration procedure is repeated for the next 3 calibration points...

This is the calibration of one point. The same procedure is performed on a total of four points and usually takes only about 1 minute in total.

Important:
During the calibration procedure, make sure that the calibration part is not displaced when it is placed down and picked up.
If the part slips when placed on a calibration point, we recommend attaching another calibration part or an anti-slip surface to the calibration part.
If the part should move from a calibration point in the gripper during pickup, the part must be placed in a centering deposit (back in the nest) after each pickup from the robot and gripped there again exactly. With this method, there is therefore an intermediate step after each pickup from the feeder, for centering the part. This is the only way to ensure that the part always sits the same way in the gripper and is positioned exactly the next time it is placed down so that an exact calibration is achieved.

On the next page you will find the detailed calibration procedure, shown in a flow chart and in text form.
This sequence must be programmed into the robot or the system controller.



Important: When the procedure is finished, i.e. all points have been run through, the results must still be saved to the specified file (. cxd) with the command SE2. It is also recommended to save the calibration job: TF< filename> (in offline state). The job should never be saved in the "Error" state.

On the next page, another illustration of the calibration sequence as it is to be programmed in the robot:

1. set camera offline	SO0
Wait for response from camera	1
2. load calibration job	LF< filename>
Wait for response from camera	1
3. set camera online	SO1
Wait for response from camera	1
4. Wait 2 seconds (initialization is performed).	
5. status queries	GVM023
Wait for 1st answer from camera	1
Wait for 2nd answer from camera	1.000

---

6. select calibration point	SIM018(A)
Wait for response from camera	1
7. start calibration sequence	SE1
Wait for response from camera	1

---

8. read robot task	GVL000
Wait for 1st answer from camera:	1
Wait for 2nd answer from camera:	Calib(A);C(B).000
9. lock image acquisition	SIH0001
Wait for response from camera	1
10. pick up the calibration part and place it at point (A) in the angle (B).	
11. transfer robot coordinates	SFP000<x value>
Wait for response from camera	1
	SFQ000<y value>
Wait for response from camera	1
12. move robot out of the camera field of view	
13. unlock image capture	SIH0000
Wait for response from camera	1
14. Wait 1 second (detection is performed).	
15. continue until all 4 angles (B) are through at point (A) (repeat 3 more times)	

3x

---

16. read robot task	GVL000
Wait for 1st answer from camera	1
Wait for 2nd answer from camera	CalibTo
17. lock image acquisition	SIH0001
Wait for response from camera	1
18. remove calibration part from feeder pick-up surface	
19. unlock image capture	SIH0000
Wait for response from camera	
20. Wait 1 second (detection is performed - image blank).	
21. read robot task	GVL000
Wait for 1st answer from camera	1
Wait for 2nd answer from camera	NoPart

22.) Perform the whole procedure again with the other points (A) (repeat 3 times).

3x

A=calibration point, is value 0, 1, 2, 3; B = angle, is value: 000, 090, 180, 270).
After the calibration routine is finished, the calibration data must be saved in the . cxd file on the camera.
This is done with the following command:

Create calibration file (. cxd)	SE2
Wait for response from camera	1

In addition, the calibration job run through is to be saved with the collected data:

1. set camera offline	SO0
Wait for response from camera	1
2. save calib job	TF< filename>. job
Wait for response from camera	1
3. set camera online	SO1
Wait for response from camera	1

12.1 "Error" status in calibration job

The robot task "Error" (cell L000) in the calibration job, can be caused by a badly recognizable calibration part or a calibration part placed too far outside by the robot (so that it is no longer completely visible in the camera image). Check this and reload the job to reset the "Error". Never save the calibration job in error status, otherwise this status will be visible every time the job is opened and calibration will be prevented.
If you still saved the job in "Error" status, you can remove the task as follows:

1. set camera online	SO1
Wait for response from camera	1
2. lock image acquisition	SIH0001
Wait for response from camera	1
3. start calibration sequence	SE1
Wait for response from camera	1
4. unlock image capture	SIH0000
Wait for response from camera	1
5. Set camera offline	SO0
Wait for response from camera	1
6. Save Calib Job	TF< filename>. job
Wait for response from camera	1

This procedure can also be done manually via the In-Sight Explorer. SIH0000 or 1 corresponds to set or remove the checkbox in cell H0 (in the Custom View) and SE1 corresponds to the "Start procedure" button.

13 Calibration accuracy

The accuracy of a calibration depends on various factors:

- Recognition of the calibration part
  The exact recognition of the calibration part is decisive. See chapter "Calibration part".
- Exposure to extraneous light
  Exposure to extraneous light should be minimized and sunlight should be avoided completely.
- Camera mounting distance
  The distance between the feeder and the camera depends on the focal length of the lens.
  The lens should be selected to provide the greatest possible distance between the camera and feeder, minimizing distortion and thus improving accuracy.
  Tables of suitable camera mounting distances can be found on our homepage: LINK

14 Reaching the maximum system speed

The speed of the separation depends on various factors. The optimization of one factor usually already brings improvements. In the following, we show these factors and explain how they can be improved.

14.1 Feeding behavior

The performance depends strongly on the quality of the feeding behavior of the parts. The feeders can be equipped with different conveying surfaces to achieve optimum feeding behavior for different parts.

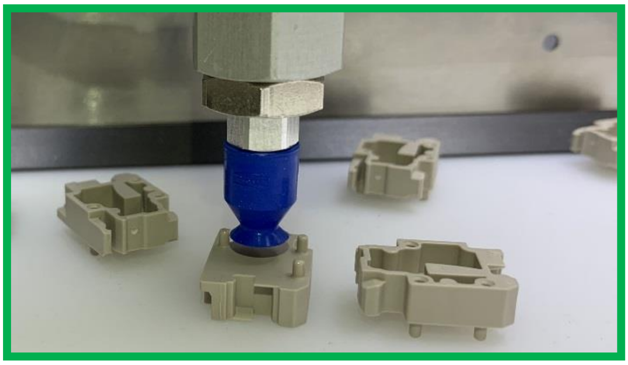
14.2 Pick up region

To achieve the best possible performance, the robot gripper must be able to reach all grippable parts in the entire working area on the feeder, at any angle of rotation.

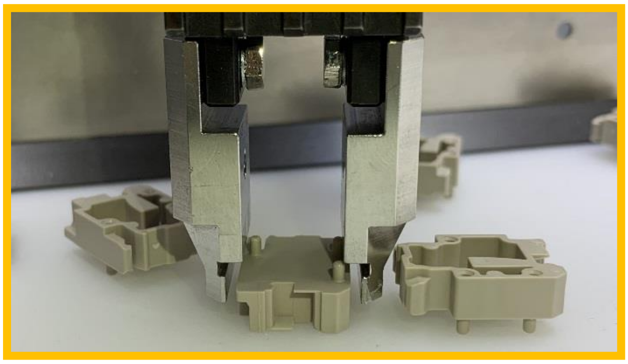
14.3 Gripper zones

If necessary, our camera software checks whether the gripper zones (= free zones for gripper fingers) are not occupied in order to prevent a collision of the gripper fingers with neighboring parts. To ensure that as many parts as possible are pickable after a feeder movement, these gripper zones should be as small as possible. This is achieved with small, narrow gripper fingers. Suction grippers are best, since they do not require any free zones for gripper fingers.

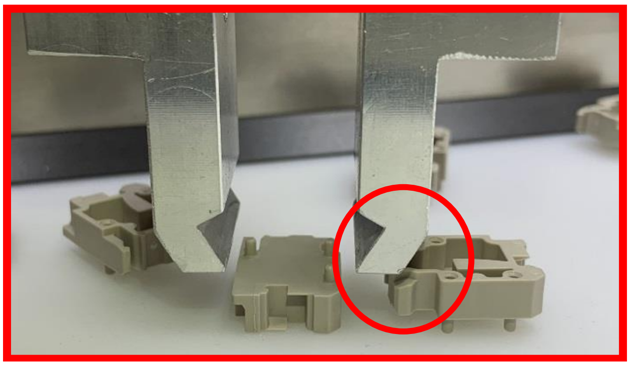
Here is an example of a pickable part surrounded by nearby upsidedown parts:



Suction grippers do not require gripper free zones around the pickable part and are therefore ideal for optimum output



Slim gripper fingers are also okay, since the required free zones can be kept small. So care should be taken to design the gripper as narrow as possible.



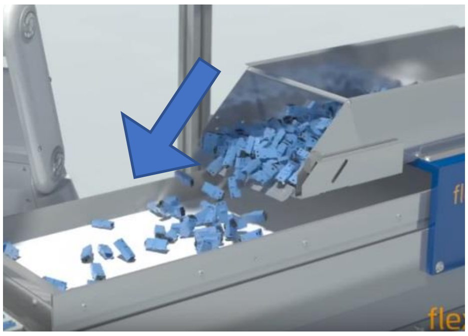
Large grippers are bad for cycle time, because the camera then often has to ignore pickable parts, because otherwise it would lead to collision due to the size of the gripper fingers.

14.4 Feeder movements

The ideal feeder movements must be determined per part. For a high conveying capacity, it is advantageous to keep the movements as short as possible, but still in such a way that the parts are sufficiently conveyed in the desired direction and well redistributed. The duration of a feeder action is defined by the number of strokes ('turns' or 'distance') of the corresponding movement.

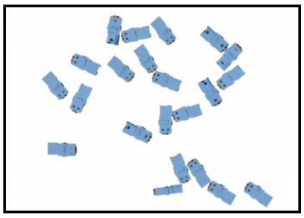
SX240 & SX340: Larger amplitude in the front area of the pick-up surface
Since the feed surface of the SX240 and SX340 does not move in parallel, there is a greater amplitude of movement towards the front. This means that with these feeders, parts at the front end of the pickup surface rotate better than those at the rear. For poorly rotating parts, this can be exploited by conveying such parts more to the front where they rotate better.

14.5 Feeding from the bunker



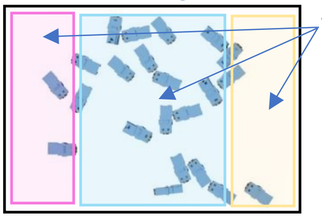
The feeding of parts from the hopper ('Dispense') is crucial for optimal conveying performance. If too many parts fall into the work area, it will take longer for parts to be released; if too little material is conveyed, the probability that parts will be correctly positioned for removal is reduced. Conveying from the hopper should therefore be set so that a reasonable quantity of parts falls into the working area.
When setting the hopper movement, please note that during operation the hopper is not only fed when the pick-up surface is completely empty. To set the ideal feed quantity, the hopper should be filled as it is during production, for example, and with some parts on the pick-off surface.

14.6 Part distribution in the work area



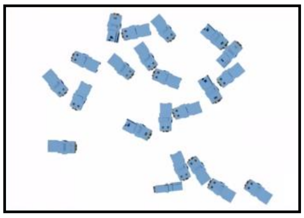
A good distribution of the parts in the working area is essential for a high output. This means that during a feeder movement, the parts should be distributed as homogeneously as possible and not move too strongly in one direction. If, for example, after a movement many parts are lying on top of each other at the front feeder edge or a large area is free of parts, this indicates a poor setting of the feeder movements and/or the feeding logic ('Feeding settings').

14.7 Setting the Feeding logic



The positioning of the Feeding Zones, which measure the degree of occupancy in the working area, as well as the settings of the %-Limits have a direct influence on the distribution and thus on the conveying performance. Details about the feeding logic can be found in the FeedWare CX user guide "FeedWare_User_Guide". [LINK]

14.8 Number of parts in the pickup area



The number of parts on the pickup surface should always be kept within an optimum range. The ideal number must be determined during a test run. With the settings from when onwards material is fed (Dispense Limit) and how much material is fed (Dispense movement: distance & speed), the quantity of parts in the working area can be kept within an ideal range.

14.9 Detection quality

The recognition should be set up in such a way that the camera recognizes every correct and exposed part. It must therefore be ensured that tangible parts are always recognized as such.

14.10 Recognition speed

The detection speed must be optimized especially if the robot has not yet received a new coordinate when it would be ready to start. The current evaluation time is displayed in the In-Sight Explorer at the bottom next to the online status. The detection time varies depending on the number of parts in the image. The detection time depends mainly on the PatMax teach-in and less on other searches/settings.

14.11 Settling time

After a feeder movement, it is always necessary to wait a certain time before taking a picture, so that the parts are at rest. This settling time should be set as high as necessary, but as short as possible. To reduce settling time we offer different structured conveying surfaces. This is especially important for rolling parts.

14.12 Free image area

While the robot does not pick up from the feeder, i.e. feeder and camera work autonomously and prepare parts, the camera image must not be disturbed by external machinery (e.g. robot arm).

14.13 Feeder attachment

The feeder must be mounted on a stable/stiff frame that stands on solid ground. If the base housing of the feeder also wobbles when the pick-up surface is shaken, the feeder is not mounted on a sufficiently stable base. In this case, the feeder movements will be damped, which may reduce the conveying capacity and thus the output will be reduced.