Cognex In-Sight & SIMATIC S7 300 PLC

ProfiNET Communication Manual

V1.3

The information contained in this document has been developed solely for the purpose of providing general guidance to Cognex customers who need to configure communications between an In-Sight® sensor and a SIMATIC S7-300 PLC via ProfiNET protocol and data contained in this document serves informational purposes only.

The information in this document is proprietary to Cognex. No part of this document may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, without the written permission of Cognex.

Information in this document does not represent a commitment on the part of Cognex and in especially is not intending to be binding upon Cognex to any particular course of business. Cognex assumes no responsibility for errors or omissions in this document. Cognex does not make any express or implied representation or warranty as to the accuracy or completeness of the information for a particular purpose. Cognex shall have no liability for damages of any kind including without limitation direct, special, indirect, or consequential damages that may result from the use of this document.

I. System properties

This section shows the software, firmware versions of the equipments and the hardware elements that were used for creating this document.

- Operating Systems
  - Windows XP Service Pack 3

- In-Sight Environment
  - In-Sight Explorer version 4.5.0 (build 474)
  - Camera type: In-Sight Micro 1400-10
  - Camera Firmware version: 4.5.0 (build 233

- Siemens S7 Environment
  - STEP 7 version 5.4 + Service Pack 5
  - CPU type: 315-2 PN/DP

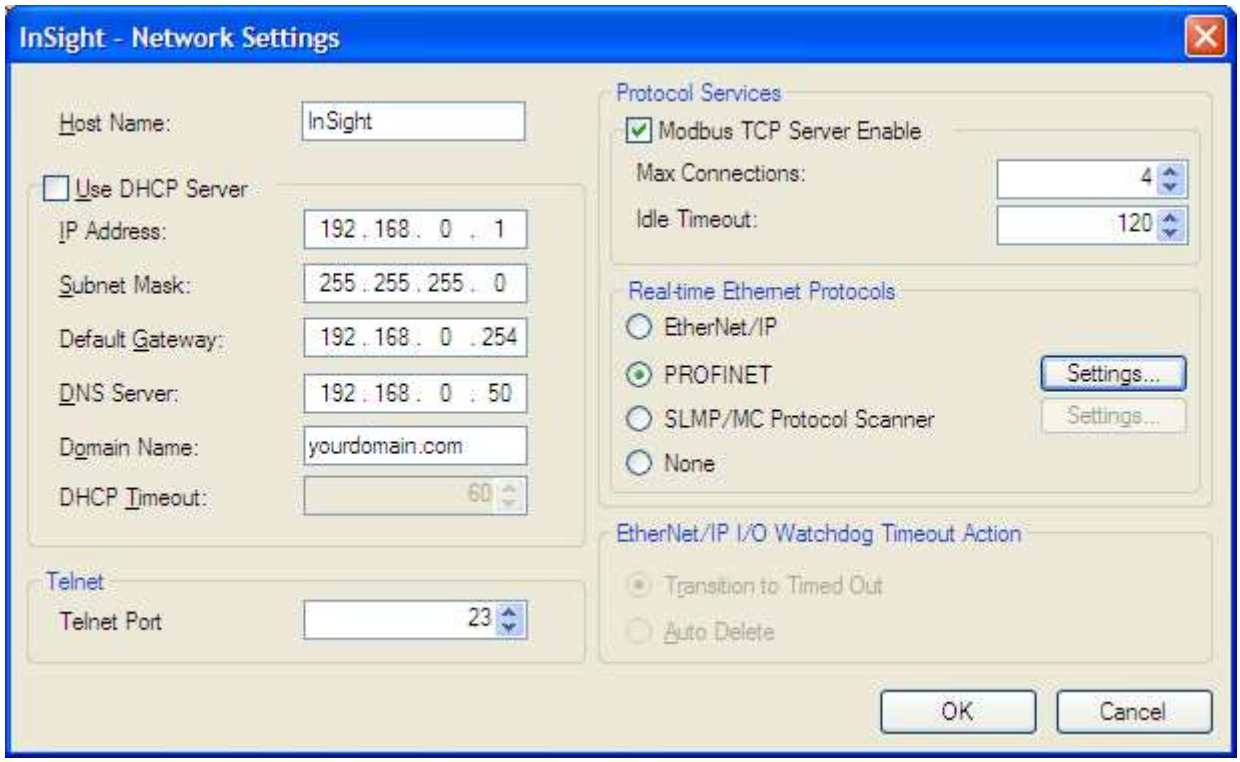
II. Enabling PROFINET Communications on an In-Sight Vision System

Before PROFINET communications can be established with an In-Sight vision system, the vision system must be configured to enable PROFINET, using the Network Settings of the In-Sight vision system.

1. Open In-Sight Explorer and connect to an In-Sight vision system.

2. From the Sensor menu, open the Network Settings dialog.

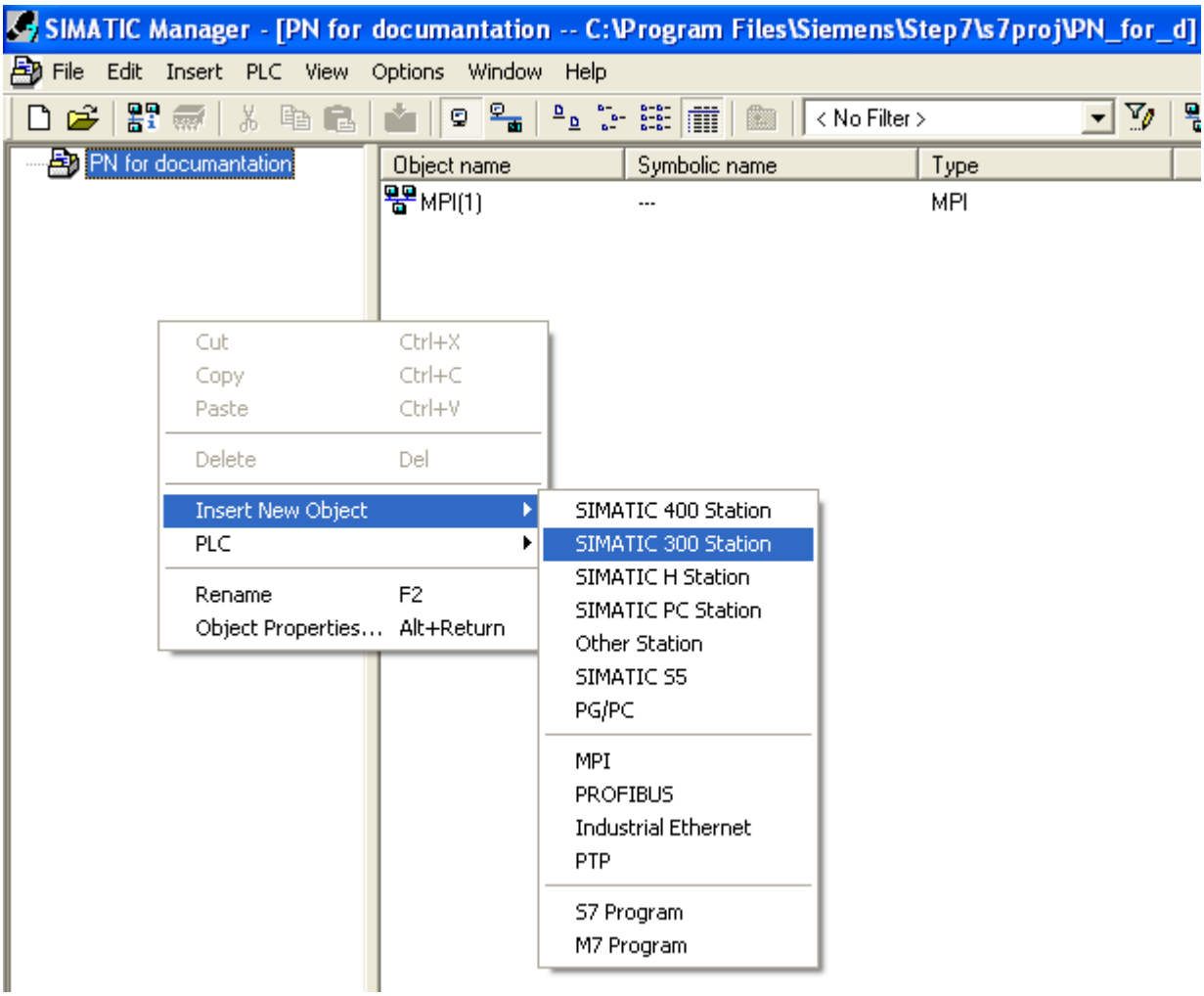
3. In the Protocol Services section of the dialog, select PROFINET protocol and press OK.



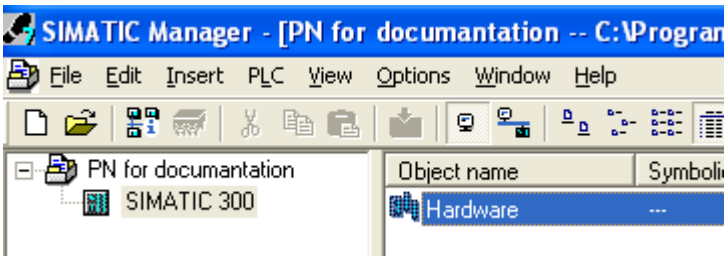
4. Restart the In-Sight vision system, and the PROFINET service will be enabled upon completion of the power cycle.

III. Creating the HW configuration and setting up the connection

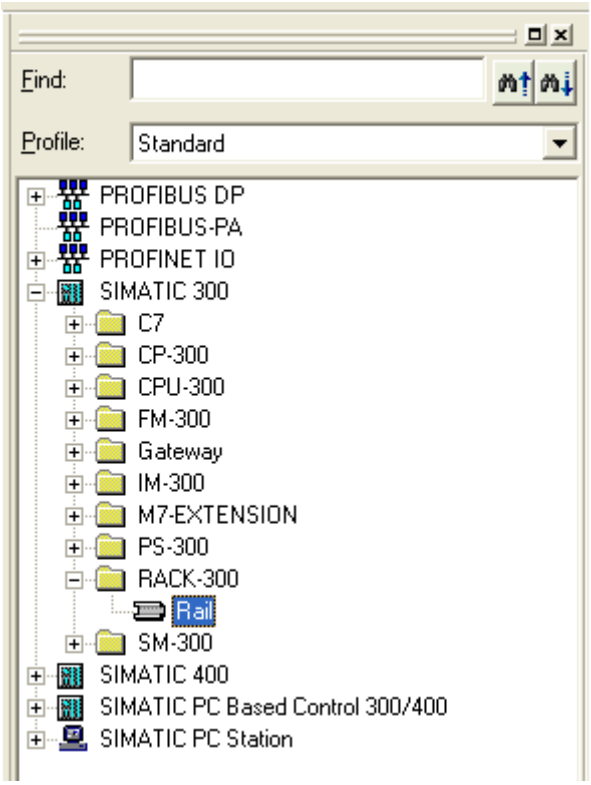
1. Open a new project in the SIMATIC Manager and insert a new station for your CPU.



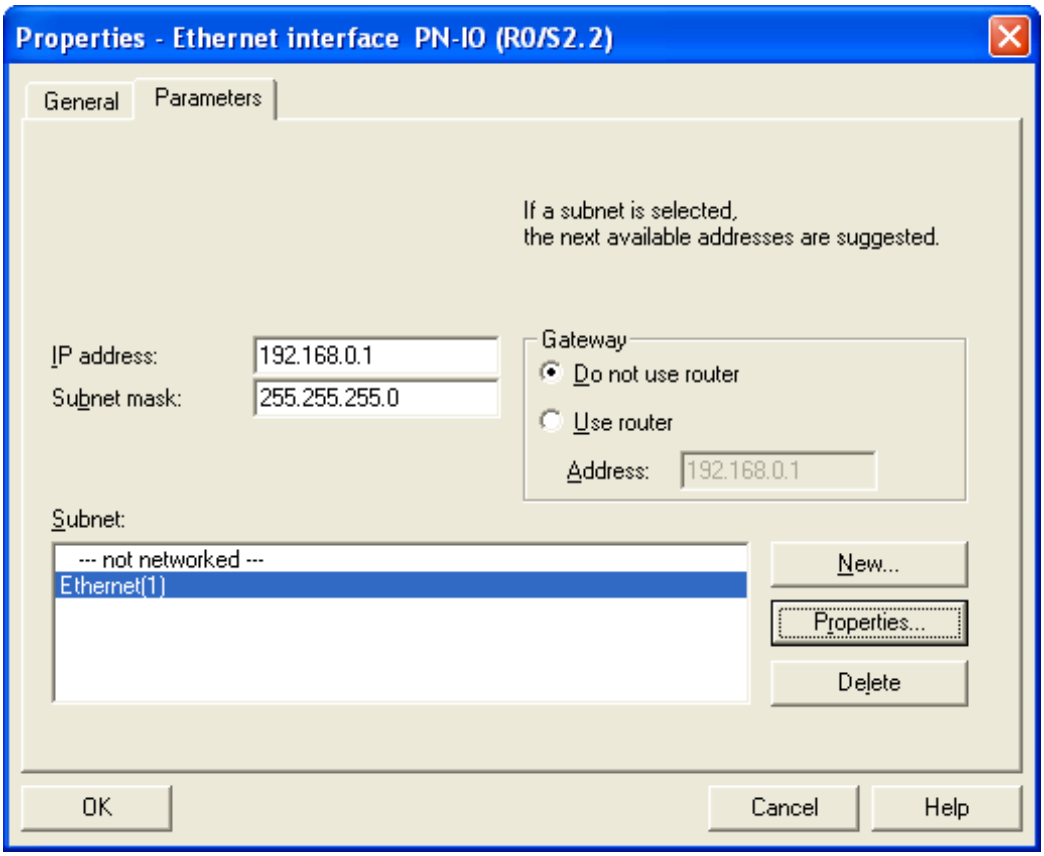
2. Select the inserted SIMATIC station and double click to the Hardware object on the right side to configure the hardware settings.



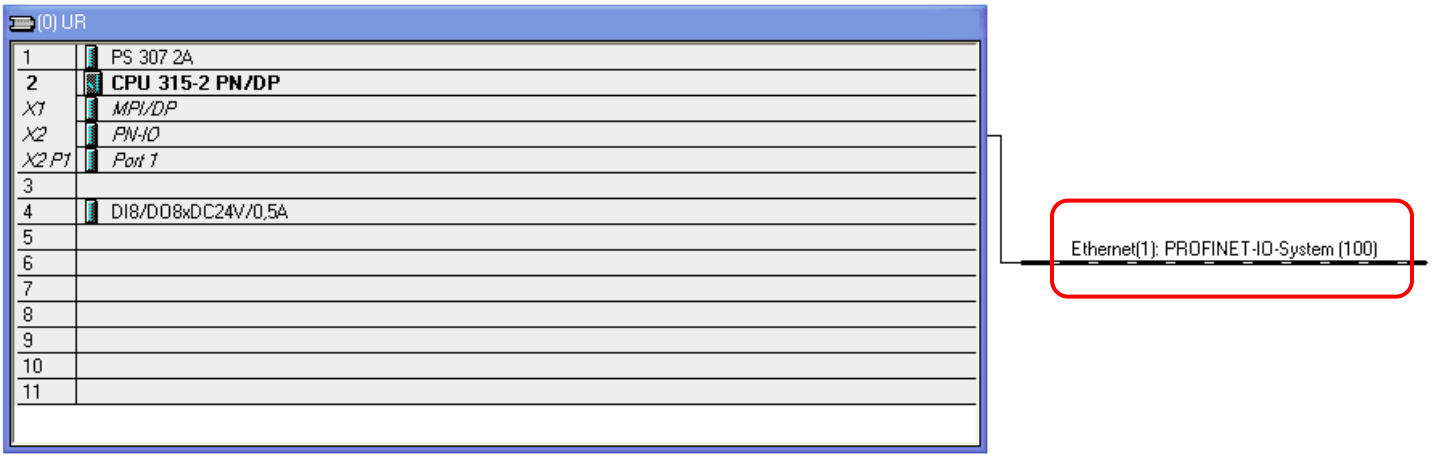
3. Add a new rail to your hardware configuration as shown on the image below.



4. Drag and drop the correct CPU type to the rail and on the Parameters tab configure the IP settings then click to the New button.



5. Configure your complete hardware environment according to your PLC setup.



Save and Compile your project, download the configuration to the PLC.

6. If this is the first In-Sight sensor to be added to the PROFINET network, the In-Sight GSD file (provided by Cognex) will need to be installed. To install the In-Sight GSD file, follow these steps:
   - From the HW Config tool, select Options > Install GSD Files from the menu.
   - Press the Browse button and select the GSD folder from the In-Sight Explorer installation CD-ROM.
   - Press the Select All button, then click the Install button to install the hardware description for the In-Sight vision sensors.

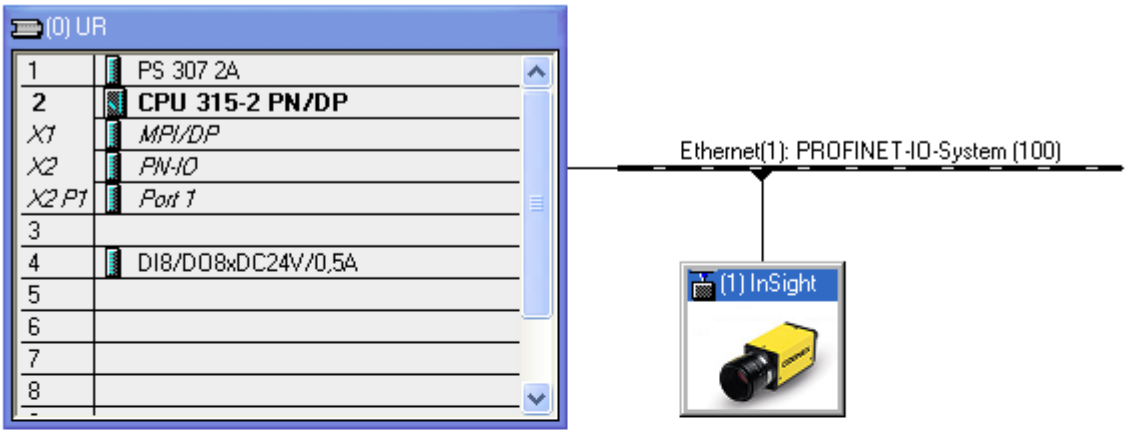
   To add an In-Sight sensor to a PROFINET network, browse to the In-Sight node of the Hardware Catalog (PROFINET IO > Additional Field Devices > Sensors > Cognex Vision Sensors), and then drag an instance of the In-Sight sensor into the PROFINET-IO-System in the hardware configuration. (The PROFINET-IO-System is marked with red on the above image.)

7. Right click on the IS camera > Select object properties. On the General tab you can set the device name then click to the Ethernet button and set the IP address finally click to the OK button.

   Note: If an underscore was used in the In-Sight camera's name in In-Sight Explorer then the underscore will be displayed as a hyphen in the sensor's name on the PROFINET network in the STEP7 software. For instance, if the camera name is InSight_1 then it will be shown as InSight-1 on the PROFINET network in STEP7.

   Note: Do not use '.' in the name of the device. It might happen that the device name is displayed like InSight.PROFINET-IO-System. In this case right click on the PROFINET-IO-System symbol (the PROFINET-IO-System is marked with red on the above image) and select Object Properties, disable the option Use name in IO device/controller.

8. The In-Sight sensor should now be displayed as a device on the PROFINET IO system, along with the In-Sight sensor's various modules supported by the particular PROFINET IO implementation.



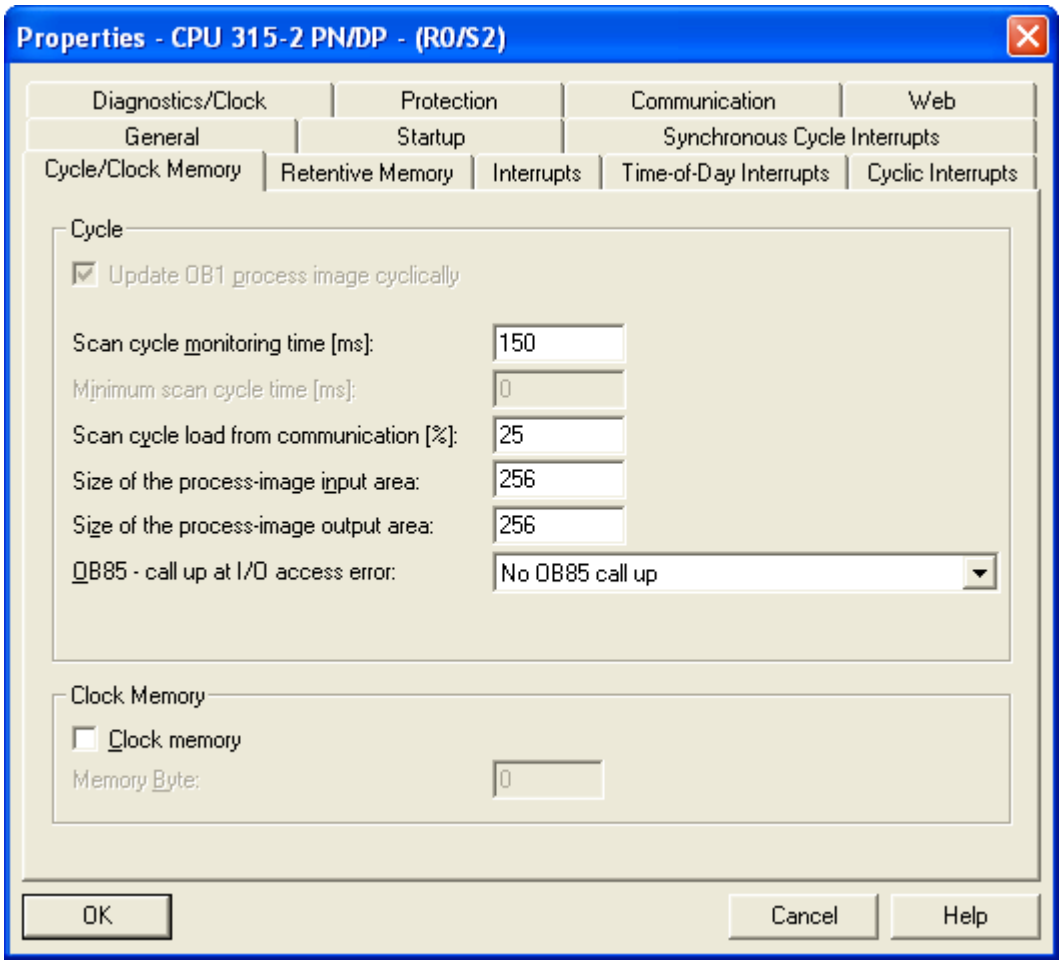
(1) InSight

Slot	Module	Order number	I Address	Q address	Diagnostic address	Comment
0	InSight	ISM1XXXXXX			2043*	
1	Acquisition Control			1		
2	Acquisition Status		1...3			
3	Inspection Control			2		
4	Inspection Status		4			
5	Job Control		256	256		
6	SoftEvent Control			3		
7	User Data - 64 bytes			257...320		
8	Results - 64 bytes		257...324			

The Siemens STEP7 software will assign default I/O addresses to each of the modules added for the In-Sight vision system based on the definitions of each module in the In-Sight GSD file (see the above figure). It is allowed to change any or all of these I/O addresses. All of the modules that map out discrete bit data (acquisition control and status, inspection control and status, and soft event control) must be assigned to addresses that are within the process-image input and output memory areas of the PLC. The newest firmware on Siemens S7 series PLCs allow the sizes of this memory area to be changed (default size is 256 bytes, I0.0 - I255.7, Q0.0 - Q255.7). Other older firmware or models that are not configurable (consult Siemens PLC documentation) have a fixed size, usually 256 bytes. This can be seen in the picture above where each of the discrete bit data modules are mapped into I/O addresses starting at 0 and the byte/word modules are assigned to addresses starting just above the process-image input and output memory areas of the PLC (256 and higher).

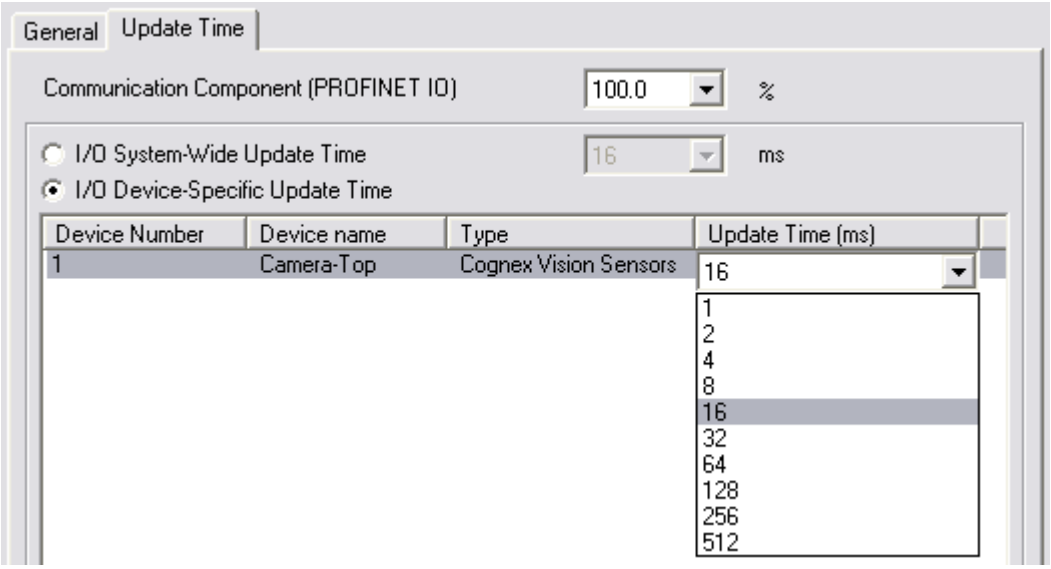
A typical use case would be a configuration as shown in the figures below, which keeps each In-Sight vision systems' I/O addresses in a more contiguous block than what the STEP7 software assigns. In order for the PLC logic to access the new I/O bit addresses, open the HW configurator in STEP7 software, open the properties of the PLC (CPU), go to the Cycle/Clock Memory tab of the dialog and the Size of the process-image input area and Size of the process-image output area. In the example the sizes of the input and output areas should be changed to 912 to so that the discrete bit data for the In-Sight vision system is accessible using the PLC's I and Q addresses for the vision system. If these process-image sizes are not changed, the bit values will not be read or written to correctly, although byte/word values will update correctly. Refer to the Siemens PLC documentation for the additional memory overhead required when these process image sizes are changed.

Slot	Module	Order Number ...	I Address	Q address	Diagnostic address
0	[illegible]	[illegible]			2043*
1	Acquisition Control			900	
2	Acquisition Status		900...902		
3	Inspection Control			901	
4	Inspection Status		903		
5	Job Control		910	910	
6	SoftEvent Control			911	
7	User Data - 64 bytes			920...983	
8	Results - 64 bytes		920...987		



All of the available modules for the In-Sight sensor are automatically added to the hardware configuration. These modules allow access to the various subsystems in the In-Sight sensor. The default UserData and InspectionResults modules are 64 bytes in size. In order to change the sizes of the modules, delete them from the list and drag the appropriately sized module from under the In-Sight Data Modules folder in the Catalog tree to the Slot in the list. The description of the modules can be found in chapter III.

Once the In-Sight vision system has been added to the PROFINET system in the HW Config utility, the cyclic transfer rate can be adjusted by opening the properties window of the PROFINET IO System. This can be done by double-clicking on the PROFINET IO System in the hardware configuration diagram. The cyclic update time can be set for the entire PROFINET IO System, or for each device, separately.



Note: If the update time is left at the default value of 1 ms, a significant reduction in vision tool performance may be observed when the PLC is connected to an In-Sight vision system. This reduction can be alleviated by increasing the cyclic update time to either 8 ms or 16 ms.

9. Save and compile then download.

10. Go to the SIMATIC Manager and select Options\Set PG/PC interface and select the TCP/IP based communication interface. Please note that your PC has to be in the same network range and must be able to communicate with the PLC.

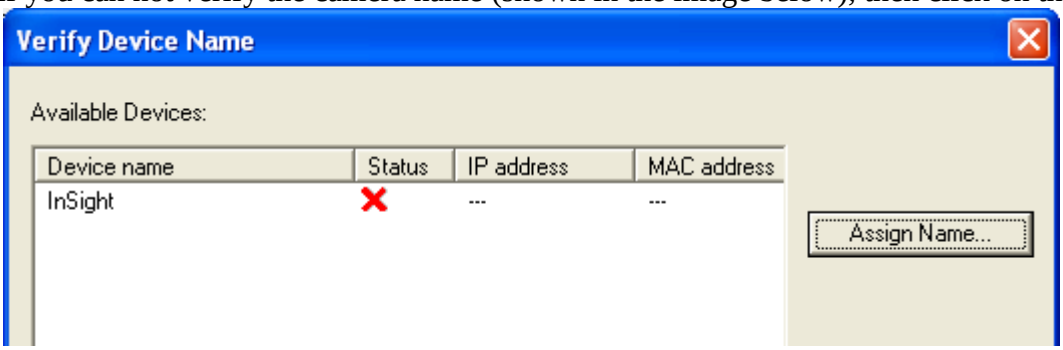
Open the Hardware Configuration window and select the Station/Open ONLINE point. If the camera is displayed with a red cross on the top left corner, than there is a communication issue. Please make sure that the camera is accessible for the PLC and the ProfiNET communication is enabled in the camera as described in chapter I.

Camera icon shown with a red cross, indicating that there is a communication issue in the network.

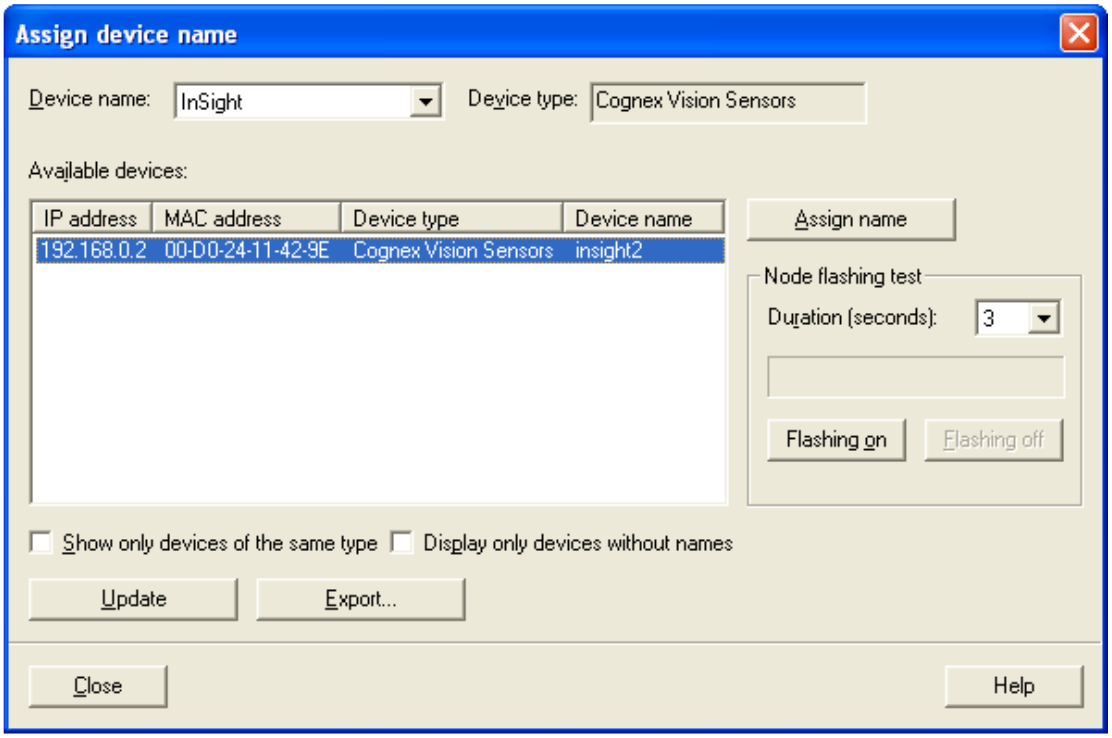
Camera icon showed without the red cross, indicating that the communication is ok.

11. In the hardware config select the PLC menu > Ethernet > Verify Device name.

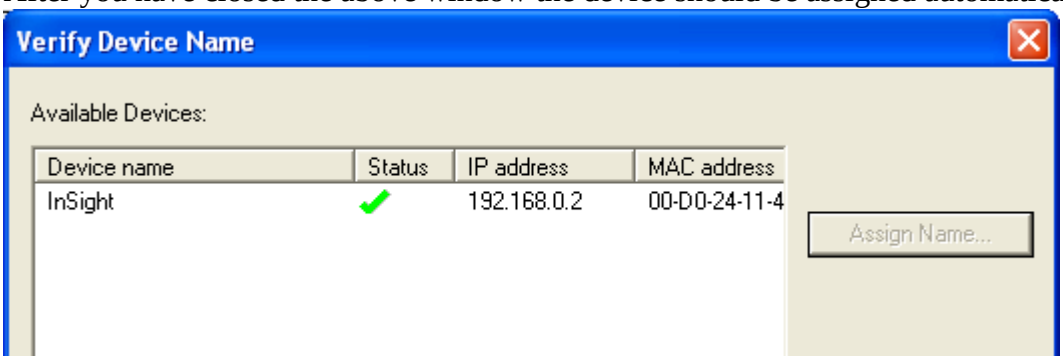
If you can not verify the camera name (shown in the image below), then click on the Assign Name button.



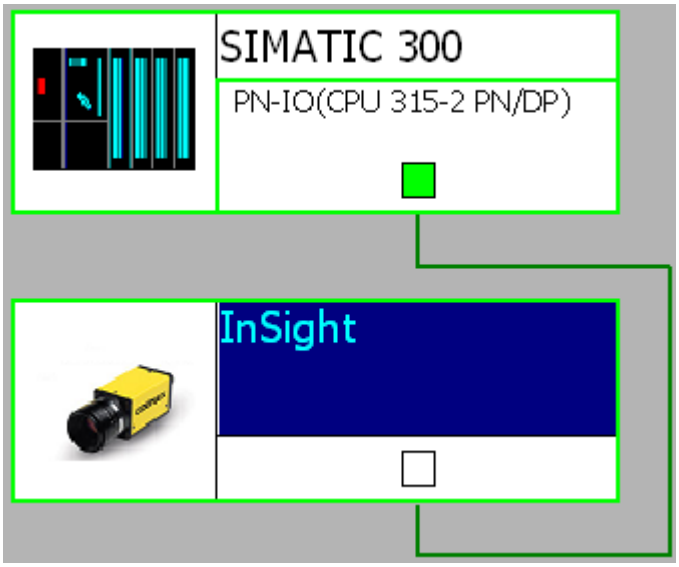
Select the camera in the available devices list and the Device name from the drop down list box in the Assign device name window and click on the Assign name button.



After you have closed the above window the device should be assigned automatically.



12. Right click on the PROFINET-IO-System symbol (black and white line in the Hardware Config window) and select PROFINET IO Topology. Select the Graphic view and on the graphical topology editor drag the green square of the InSight system onto the green square of the CPU. Than click the Online button and you should see something similar like below.



Note: If the SIMATIC system is shown with a red square this means that the CPU has a System Fail Error. This usually happens if the flash card of the CPU was not cleared before building your project and contains some parts of a previous project.

Note: If the In-Sight system is shown with a red square instead of green it means that the camera is not accessible. Please double check the IP settings of the camera and if the ProfiNET communication is enabled for the camera. Please make sure that you have done correctly the settings detailed in chapter I.

Save and compile than download the project. Now you can close the hardware configuration window.

13. In the SIMATIC Manager window save and download your project to the PLC once again.

IV. Control elements of the camera

- **Acquisition Control**: Controls image acquisition and Online/Offline status for In-Sight sensors.

Bit	Name	Description
0	Trigger Enable	This field is set to enable triggering via the *Trigger* bit. Clear this bit to reset the triggering mechanism.
1	Trigger	Setting this bit triggers an acquisition when the following conditions are met: • The In-Sight sensor is Online. • The Trigger Enable bit is set. • The AcquireImage function's Trigger parameter is set to Network or External.
2 - 6	Reserved	Unused.
7	Set Offline	When this bit is set, the In-Sight sensor is taken Offline until the bit is cleared again.

- **Acquisition Status**: Indicates the image acquisition and Online/Offline status for In-Sight sensors.

Bit	Name	Description
0	Trigger Ready	Indicates when an In-Sight sensor can accept a new trigger. This field is true when the sensor is Online, the *Trigger Enable* bit is set and the sensor is not currently acquiring an image.
1	Trigger Ack	Indicates when an In-Sight sensor has been triggered by the *Trigger* bit being set; this bit will stay set until the *Trigger* bit is cleared.
2	Acquiring	Set when an In-Sight sensor is currently acquiring an image; set by either the *Trigger* bit being set or by an external trigger.
3	Missed Ack	Set when an In-Sight sensor misses an acquisition trigger; cleared when an acquisition is successfully triggered.
4 - 6	Offline Reason	This field is a 3-bit field used to identify the cause of why an In-Sight sensor is Offline: Offline Reason / Name / Description 0 / Online / The sensor is Online. 1 / Programming / The sensor's job is being modified. 2 / Discrete Offline / A discrete signal is holding the sensor Offline. 3 / Comm. Offline / A communications protocol is holding the sensor Offline.
7	Online	This bit is set when the In-Sight sensor is Online, and cleared when the sensor is Offline. When the sensor is Offline, examine the *Offline Reason* field to determine the reason.
8 - 23	Acquisition ID	This ID increments on the completion of every acquisition regardless of the trigger source, and can be used to synchronize an Acquisition with its Inspection Results.

- **Inspection Control**: Controls the handling of job execution and inspection results.

Bit	Name	Description
0	Buffer Results Enable	When this bit is set, the *Inspection ID*, *Inspection Result* and *Inspection Results* fields are held constant until the *Inspection Results Ack* field has acknowledged them and been set. Up to eight inspections are held in the sensor's buffer. The In-Sight sensor will respond to the acknowledgment by clearing the *Results Valid* bit. Once the *Inspection Results Ack* field is cleared and there is a new set of rules sent to the PLC, the *Results Valid* bit will no longer be cleared. If the *Inspection Results Ack* bit is cleared and there are no more results in the sensor's buffer that are to be sent to the PLC, the *Results Valid* bit remains cleared.
1	Inspection Results Ack	When the *Buffer Results Enable* bit is set, the *Inspection Results Ack* bit acknowledges that the PLC has received the *Inspection ID*, *Inspection Result* and *Inspection Results* data. The next set of inspection results is then sent to the PLC. Clearing the *Inspection Results Ack* bit causes the sensor to set the *Results Valid* bit if the buffer is not empty.
2 - 7	Reserved	Unused.

- **Inspection Status**: Indicates the status of job execution and inspection results.

Bit	Name	Description
0	Inspecting	This bit is set when an In-Sight sensor is running a job.
1	Inspection Completed	This bit is toggled upon the completion of an inspection.
2	Results Buffer Overrun	This field is set when the *Buffer Results Enable* bit is set and the In-Sight sensor has discarded a set of inspection results because the PLC has not acknowledged the results, and in turn set the *Inspection Results Ack* bit. Up to eight inspections are held in the sensor's buffer; therefore, this bit is set when the ninth inspection is added to the buffer, and will overwrite the eighth inspection in the buffer. The bit is not cleared until a valid inspection occurs and a previous inspection is not overwritten.
3	Results Valid	Set when the *Inspection ID*, *Inspection Result* and *Inspection Results* fields are valid.
4	Job Loading	This bit is set when loading a new job. **Note:** This bit only functions when the job load was initiated by the PLC using PROFINET.
5	Job Load Complete	This bit is toggled upon the completion of a job load operation. **Note:** This bit only functions when the job load was initiated by the PLC using PROFINET.
6	Job Load Failed	This bit is set when the last job load attempt failed. It is cleared the next time a job is successfully loaded. **Note:** This bit only functions when the job load was initiated by the PLC using PROFINET.
7	Reserved	Unused.

- **Job Control**: The input byte of this module indicates the current job ID of the In-Sight sensor, or 255 if the current job has no ID. Setting the output byte while the In-Sight sensor is Offline will cause the job with the same ID to be loaded. Valid job ID numbers are 1 through 254.

Note: The default Job ID prefix is 0, indicating that the job will not be changed.

Note: Do not use a Job ID prefix of 255. When a job without a Job ID prefix is loaded via In-Sight Explorer, an input byte of 255 will be returned to the PLC. Therefore, it would be unclear if a job with a Job ID prefix of 255 is loaded, or a job without a Job ID prefix is loaded.

- **Soft Event Control**: Allows spreadsheet soft events to be triggered. Setting any of these bits causes the associated soft event in the In-Sight Explorer spreadsheet to be triggered.

- **User Data**: This data can be read from the In-Sight spreadsheet, using the ReadProfinetBuffer function.

- **Inspection Results**: This is the data that is written from the In-Sight spreadsheet, using the WriteProfinetBuffer function. If the *Buffer Results Enable* bit of the Inspection Control Module is set, then the inspection results will remain unchanged until the acknowledged by pulsing the *Inspection Results Ack* bit.

Byte	Name	Description
0 - 1	Inspection ID	The acquisition ID associated with this set of results.
2 - 3	Inspection Result Code	Currently unused; always 0.
4 - 259	Inspection Results	Inspection result data written from the spreadsheet, using the WriteProfinetBuffer function.

V. Example how to test the connection

(This example assumes that an In-Sight vision system has been added as an input/output device in a Siemens project shown in chapter II.) After the project has been downloaded to the controller, cyclic data transfers will be initiated, at the requested update time. To verify a proper I/O connection, follow these steps:

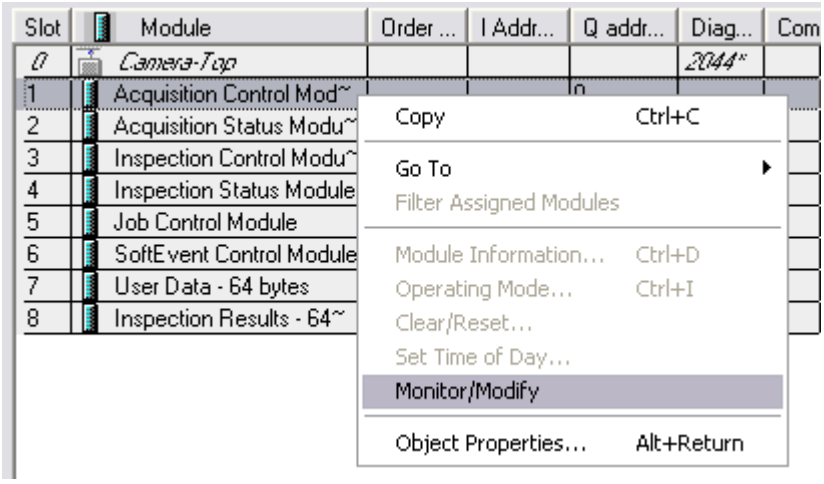
1. While working Offline, perform the Siemens configuration steps, which were outlined in the Creating the HW configuration and setting up the connection section.

2. Download the completed project to the Siemens controller and set the *Operating Mode* to *Run*.

3. Open the HW Config tool online. The In-Sight vision system should show no errors, which indicates that the I/O connection was completed successfully.

4. To verify the correct, 2-way transfer of I/O data between an In-Sight vision system and a Siemens controller, connect to the In-Sight vision system using In-Sight Explorer. From the In-Sight vision system's Spreadsheet View, open the AcquireImage property sheet (cell A0) and set the Trigger parameter to *External*. Next, place the vision system Online.

5. From the HW Config tool, with the In-Sight vision system selected, right-click on the Acquisition Control Module and select *Monitor/Modify*.



6. Next, change Input bit 0 from *false* to *true*; this enables the *Acquisition Trigger* bit.

	Address	Symbol	Displa	Status value	Modify value
1	Q 0.0		BOOL		true
2	Q 0.1		BOOL		false
3	Q 0.2		BOOL		
4	Q 0.3		BOOL		
5	Q 0.4		BOOL		
6	Q 0.5		BOOL		
7	Q 0.6		BOOL		
8	Q 0.7		BOOL		

7. After this bit has been set, whenever Input bit 1 is changed from false to true, the In-Sight vision system will acquire an image.

8. From the *Monitor/Modify* window of the *Inspection Status* module, if the Run conditionally checkbox is checked for Monitor, the Inspection Completed bit (Bit 1) can be observed changing state when the inspection completes by repeating step 6.

VI. Getting Data from an In-Sight Vision System

In order to get data from the In-Sight Explorer spreadsheet to a Siemens PLC, the data must be pushed into the PROFINET stack by using the WriteProfinetBuffer function. This function takes a buffer of data created by the FormatOutputBuffer function and writes the data to the inspection results area in the PROFINET Inspection Results module. This data is then transferred during the next update cycle.

The following steps explain how to format the data that will be sent from an In-Sight vision system to a Siemens PLC.

1. To begin, using In-Sight Explorer, create a new job.

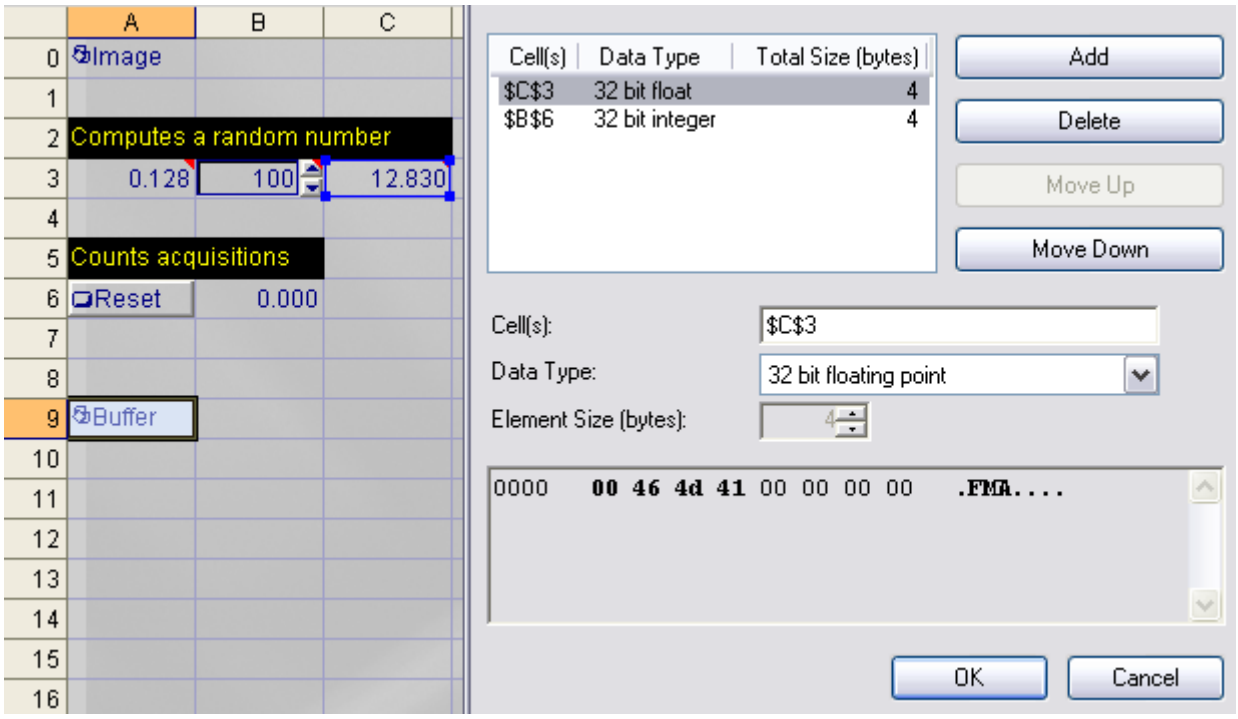
2. From the Palette's Snippets tab, add these two Snippets to the spreadsheet: *Acquisition* > *AcqCounter* and *Math & Logic* > *Random*.

3. Open the AcquireImage cell and set the Trigger parameter to *Continuous*.

4. Right-click an empty cell and select Insert Function to open the Insert Function dialog. From the left pane, click on the *Input/Output* category, then double-click the FormatOutputBuffer function, from the right pane, to insert it into the spreadsheet.

5. From the FormatOutputBuffer dialog, click on the *Add* button. This will initiate the cell selection mode; select the "Scaled random number" cell of the *Random* snippet.

6. From the FormatOutputBuffer dialog, click on the *Add* button again. This will initiate the cell selection mode; select the count cell of the *AcqCounter* snippet.



7. Close the FormatOutputBuffer dialog by clicking the *OK* button.

8. Right-click an empty cell and select Insert Function to open the Insert Function dialog. From the left pane, click on the *Input/Output* category, then double-click the WriteProfinetBuffer function, from the right pane, to insert it into the spreadsheet.

9. Set the WriteProfinetBuffer function's *Buffer* parameter as a cell reference to the recently created FormatOutputBuffer function's Buffer data structure.

10. Place the In-Sight vision system Online.

11. In the SIMATIC Manager, create a new Variable Table by right-clicking on your PLC and selecting *Variable Table* from the *Insert New Object* menu. Open the new Variable Table.

12. Add two items to the table.

Offset	Address	Display Format	Description
+4	PID 261	FLOATING_POINT	Random Number
+8	PID 265	DEC	Acquisition ID

Note: The addresses assume that the Inspection Results module is at input address 257. If the Inspection Results module is at a different address, apply the specified offset to the input address to set the correct address.

13. In the SIMATIC Manager, open *Configured PLC* from the *PLC > Connect To* menu, and then select *Monitor* from the *Variable* menu; the values displayed should be identical to those displayed in the In-Sight Explorer spreadsheet.

Note: If you are using the CP-343 communication module, then you need to use the FC11 "PNIO_SEND" FC12 "PNIO_RECV functions for sending and receiving data.

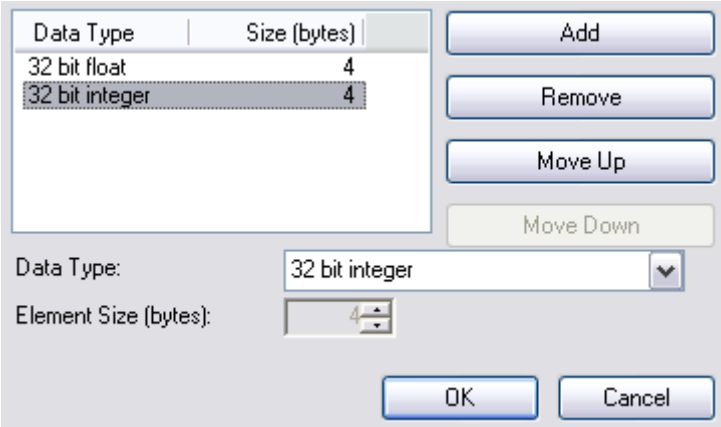
VII. Sending Data to an In-Sight Vision System

In order to send data from the Siemens PLC to the In-Sight Explorer spreadsheet, the data must be pulled from the PROFINET stack by using the ReadProfinetBuffer function. This function takes the data format created within the FormatInputBuffer function, reads the data from the data area of the PROFINET User Data module, and formats this data into the In-Sight Explorer spreadsheet. This data will be received from the PLC every update cycle.

For this example, create a new job within In-Sight Explorer and then perform the following steps to configure the data that will be received by the Siemens PLC.

1. Open the AcquireImage cell and set the Trigger parameter to *Continuous*.

2. Right-click an empty cell and select Insert Function to open the Insert Function dialog. From the left pane, click on the *Input/Output* category, then double-click the FormatInputBuffer function, from the right pane, to insert it into the spreadsheet.



3. From the FormatInputBuffer dialog, click on the *Add* button and add a 32-bit float and a 32-bit integer to the list.

4. Close the FormatInputBuffer dialog by clicking the *OK* button.

5. Right-click an empty cell and select Insert Function to open the Insert Function dialog. From the left pane, click on the *Input/Output* category, then double-click the ReadProfinetBuffer function, from the right pane, to insert it into the spreadsheet.

6. Set the ReadProfinetBuffer function's *Buffer* parameter as a cell reference to the recently created FormatInputBuffer function's Buffer data structure.

7. The Vision Data Access functions will automatically be added to the spreadsheet based on the fields added to the FormatInputBuffer function.

8. Place the In-Sight vision system Online.

9. In the SIMATIC Manager, create a new Variable Table by right-clicking on your PLC and selecting *Variable Table* from the *Insert New Object* menu. Open the new Variable Table.

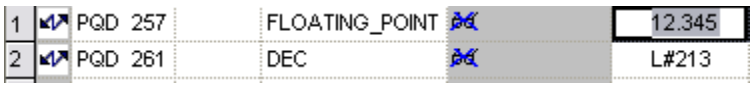
10. Add two items to the table.

Offset	Address	Display Format
0	PQD 257	FLOATING_POINT
+4	PQD 261	DEC

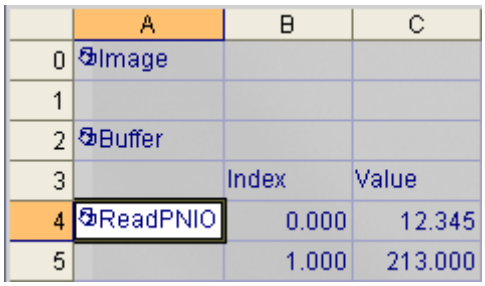
Note: The addresses assume that the Inspection Results module is at input address 257. If the Inspection Results module is at a different address, apply the specified offset to the input address to set the correct address.

11. In the SIMATIC Manager, click on the *PLC* > *Connect To* > *Configured PLC* menu.

12. Enter values for the two items added to the Variable Table and then select the *Activate Modify Values* from the *Variable* menu.



13. The values in the In-Sight Explorer spreadsheet should change to the entered values.



Note: The In-Sight system uses single precision floating precision values in the background. The specification for single precision floating point values, that allows 24 bits of precision, reserving 1 bit for a sign, and the remaining 7 bits for the exponent. This means the current implementation of the 32-bit integer is not useful for any type of ID that is more than 24 bits in length. However the rounding errors can usually be tolerated for any type of vision parameter or non-id based vision result.

VIII. Consistent data access with the S7 CPU

Although it is possible to access the In-Sight camera through the process-image input and output area (described on page 7-9), you might need consistent data from the camera. Below is a short description how to create the consistent data access. For this you will need the following system functions:

- SFC14 (DPRD_DAT) for reading the data
- SFC15 (DPWR_DAT) for writing the data

The following example will show how to access the User Data and Result in the camera. The image below shows the IO addresses. The example will use these addresses. In your project these addresses can be different so please modify the sample code accordingly.

Slot	Module	Order number ...	I Address	Q address	Diagnostic address	Comment
0	InSight	ISM1XXXXXX			2043*	
1	Acquisition Control			1		
2	Acquisition Status		1...3			
3	Inspection Control			2		
4	Inspection Status		4			
5	Job Control		256	256		
6	SoftEvent Control			3		
7	User Data - 64 bytes			257...320		
8	Results - 64 bytes		257...324			

Open an Organization Block that suits your application best. In our environment we used OB1 to get the data in all cycles. In our example we used STL language.

To read data from the In-Sight camera call the SFC14 system function:

```
CALL  "DPRD_DAT"
 LADDR  :=W#16#101
 RET_VAL:=MW100
 RECORD :=P#M 120.0 BYTE 68
```

LADDR – The IO address represented in hexadecimal number. In our case the User Data start address is 257 (decimal) which is 101 (hexadecimal). The address expects the data in WORD data type.

RET_VAL – If there is an error, the error identification number will be stored here. We used a merker address to store this information. For more details regarding the error ID numbers please refer to the help in STEP7.

RECORD – Points to the merker address where the data should be stored. We used merker block starting at address 120 to store the user data. “M 120.0” is the start address and “byte 68” shows the ordering of the data block where 68 is the data block size in bytes. In the above image the result data is from the address 257 till 324, which is a 68 byte block. You should copy the complete block. You can use smaller or larger blocks, please find details in chapter III point 8.

To write data to the In-Sight camera call the SFC15 system function:

```
CALL  "DPWR_DAT"
 LADDR  :=W#16#101
 RECORD :=P#M 220.0 BYTE 64
 RET_VAL:=MW200
```

LADDR – The IO address represented in hexadecimal number. In our case the Result start address is 257 (decimal) which is 101 (hexadecimal). The address expects the data in WORD data type.

RECORD – Points to the merker address from where the data should be copied to the camera. We used merker block starting at address 220. “M 220.0” is the start address and “byte 64” shows the ordering of the data block where 64 is the data block size in bytes. In the above image the result data is from the address 257 till 320, which is a 64 byte block. You should copy the complete block. You can use smaller or larger blocks, please find details in chapter III point 8.

RET_VAL – If there is an error, the error identification number will be stored here. We used a merker address to store this information. For more details regarding the error ID numbers please refer to the help in STEP7.