Engineering Note

SPE

Integration to PROFINET PLC

METTLER TOLEDO

Menu

1. Overview

This Engineering Note is based on integration of Mettler Toledo's Automated High Precision Weighing Module (APW) SPE with a PROFINET PLC. Go to www.mt.com/spe to download all the necessary files and documents.

Note: The configuration used in this sample code is based on the default settings：

- **Siemens TIA Portal:** **V14 SP1**
- **SAI data format:** **2-Block format (8-Block format is optional)**
- **Device Name:** **(empty)**
- **IP Address:** **(empty)**
- **SPE device firmware version: 4.0.1.20231123 or higher**
- **GSDML file:** **GSDML-V2.43-MT-SPE-20230713.xml**

It is recommended to integrate one SPE into the PLC PROFINET network and go through the sample code and each Function Block before adding more devices.

2. Setup of Project Development Environment

2.1. Electrical Integration

The SPE weigh module has two M12, D-coded female Ethernet ports with the same functionality, one located at the bottom and one at the rear side. One of it must be energized with Power over Ethernet POE (Mode A, Class 1 PD below 3.84 Watt).

Please refer to SPE weigh module Installation Instructions from www.mt.com/spe

2.2. SPE Industrial Ethernet Configuration

The SPE's industrial Ethernet communication can be configured using the APW-Link configuration tool. Get APW-Link from www.mt.com/apw-link.

The default IP address is "192.168.0.55" and port number is "80". Under the Industrial ethernet Configuration tab, choose SAI Block Format (2 block format or APW 8 block format) to work on. SAI block format will be explained in Chapter 3 – SAI Data Structure.

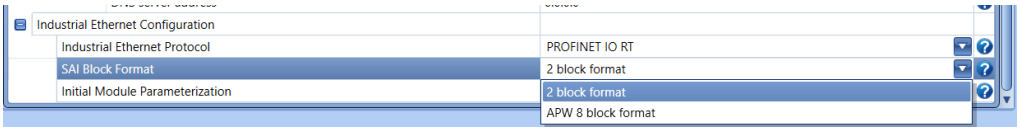


Figure 2-1: APW-Link SAI Block Format selection

Next, choose to either enable or disable the Initial Module Parameterization. Certain Industrial Ethernet systems (e.g. PROFINET) allow initial module parametrization. If supported, module parameters are sent from the PLC to the device (weigh module) during connection setup. Examples of module parameters: weighing environment, cut-off frequency, and timeout settings.
In Siemens TIA portal (PROFINET system), initial module parametrization cannot be disabled if the module device manufacturer supports this feature (defined by the device description file). With this command, the module can be configured to ignore the parameters sent by the PLC and thereby disabling this functionality.

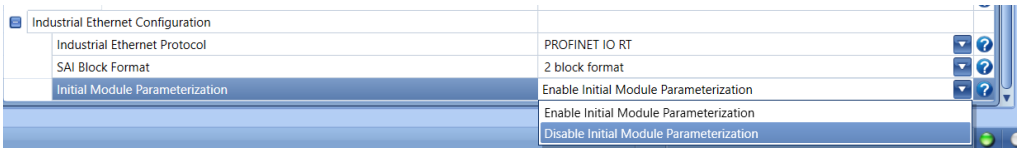


Figure 2-2: APW-Link Initial Module Parameterization selection

After finished configuring all the Industrial Ethernet settings, click the “Write Settings” button and then manually power cycle the weigh module.

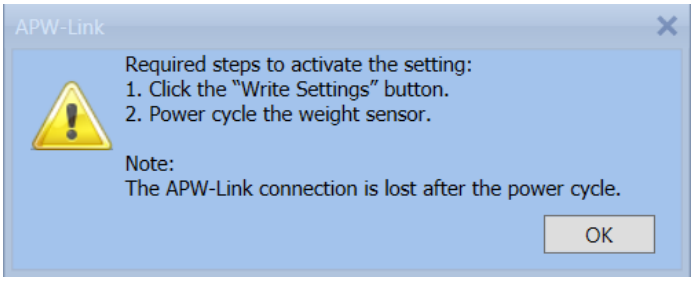


Figure 2-3: Write settings and power cycle the weigh module after settings

2.3. Open the Sample Code

To open and use this sample code "SPE_PRNT_V1_00.ap14", you need to use Siemens TIA Portal version 14 SP1 or higher. All the required GSDML files will be installed automatically when opening the sample code.

2.4. Select the Suitable PLC Project

There are two PLC projects included in one sample code. Both projects are using the Siemens S7-1200 PLC.

1. "S7-1200 SAI 2 Blocks" uses S7-1200 PLC with SPE weigh module configured to communicate in SAI 2-Block data structure.

2. "S7-1200 SAI 8 Blocks" uses S7-1200 PLC with SPE weigh module configured to communicate in SAI 8-Block data structure.

Additionally, there is a HMI project “HMI_SiemensDemo” available for reference if HMI design is required. Choose the most relevant project according to your weighing application needs.

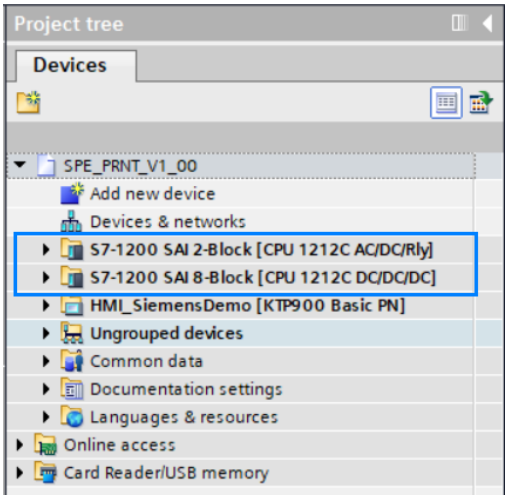


Figure 2-4: two projects in the sample code

To change the PLC model: Go to Device Configuration under the project folder, right click on the current controller, select "Change Device" and choose the new controller as well as its firmware version.

Figure 2-5: Change controller type

Compile and download the project into the controller.

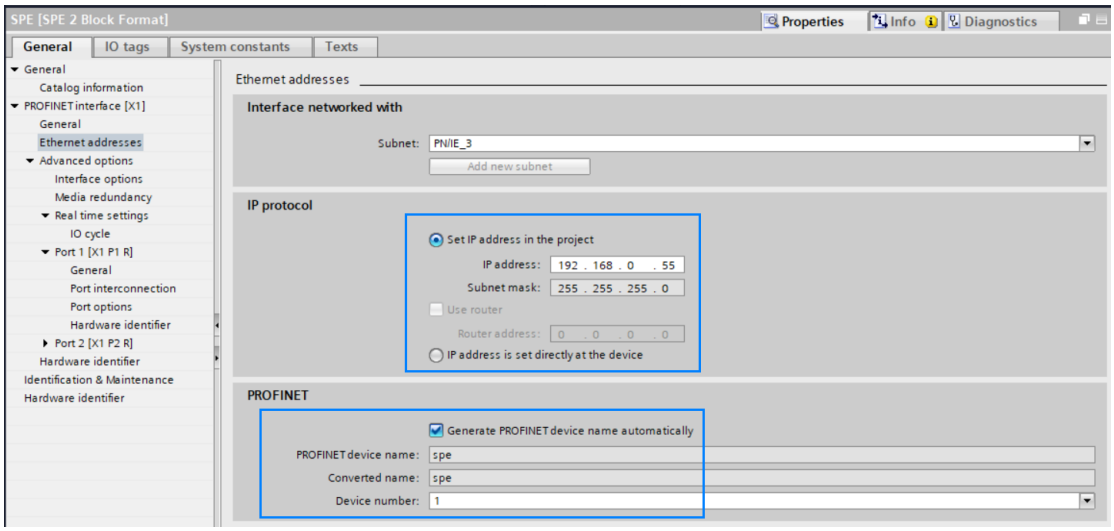


Figure 2-6: SPE Device Properties – Ethernet Addresses

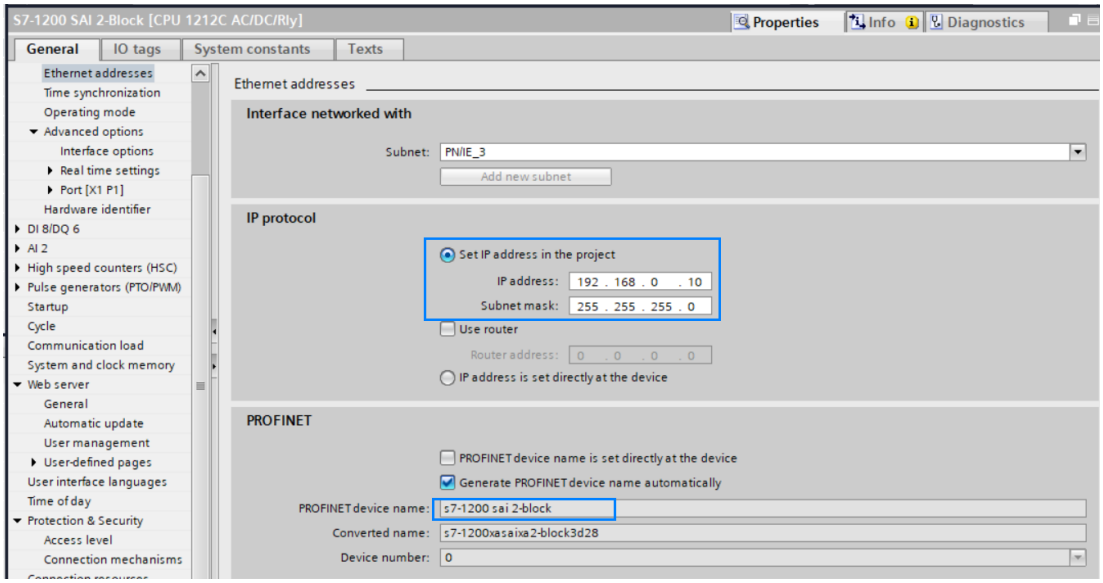


Figure 2-7: PLC Device Properties – Ethernet Addresses

Select the "MT_APW_Application" program, click on "Go Online" button to start using the sample code.

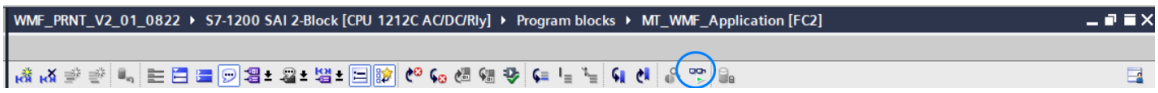


Figure 2-8: go online with MT_APW_Application

3. SAI Data Structure

In the “S7-1200 SAI 2 Blocks" sample project, the SPE's SAI data format is the default "2 block format". For more details on SAI data structure, please refer to the User’s Guide: Standard Automation Interface (SAI) and APW specific Reference Guide: Standard Automation Interface (SAI) APW Products English, which are downloadable from the SPE Download Page www.mt.com/spe.

SAI 2 Block Format consists of a single Measuring Block and a Status Block. In the figure below, the Read and Write are referring to the PLC point of view. The SAI input and output data structure has been assigned with the respective I and Q addresses in the Device Overview.

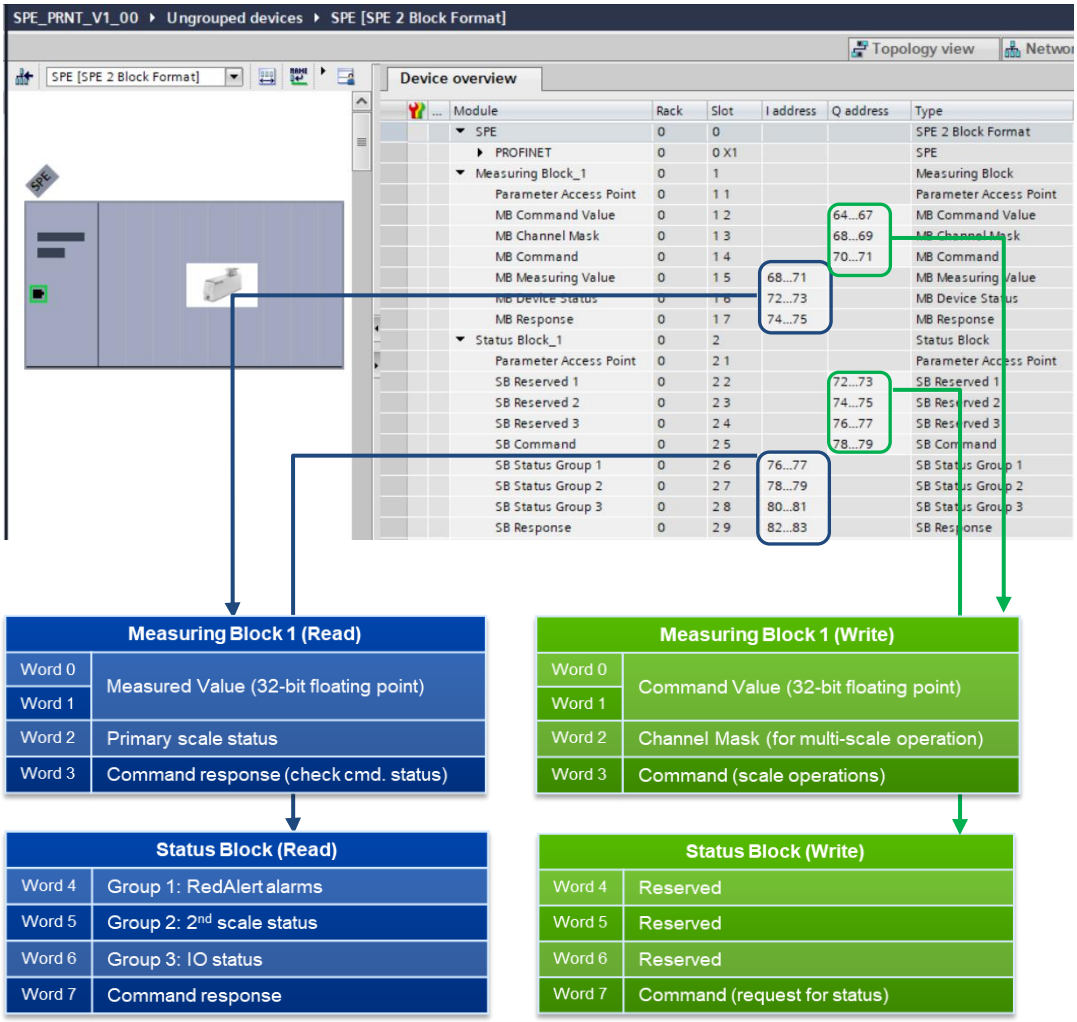
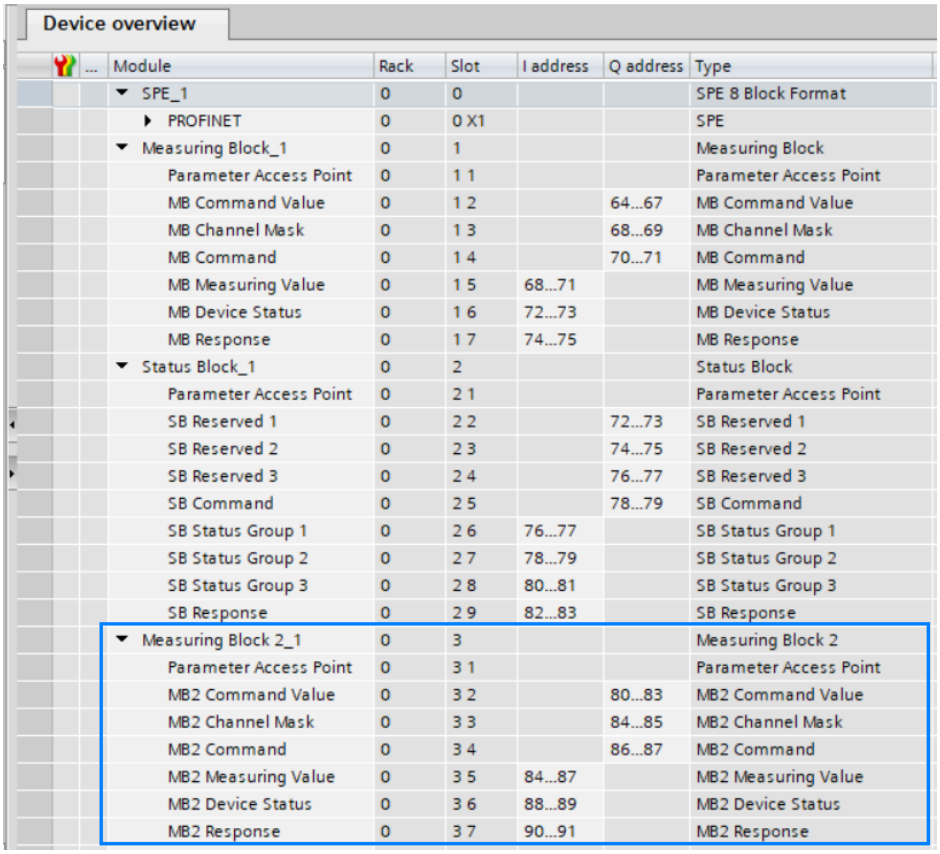


Figure 3-1: SAI Data Structure as shown in the Device Overview

The I and Q addresses above will be used as input parameters in 4. Function Blocks

The SAI 8 Block Format builds on the format structure used by the 2 Block format; providing support for higher cyclic data throughput (488 Hz update rate). This format was designed for applications where the users would need to control precise filling cut-off or other actions based on the weight data.

The measuring value of Fast Weight Update Channel is in SAI Block 3. The structure of Block 3 (as well as all subsequent function blocks) is identical to SAI Block 1, consisting of one floating point measuring value, one status word and a response integer.



Device overview

Module	Rack	Slot	I address	Q address	Type
SPE_1	0	0			SPE 8 Block Format
PROFINET	0	0 X1			SPE
Measuring Block_1	0	1			Measuring Block
Parameter Access Point	0	1 1			Parameter Access Point
MB Command Value	0	1 2		64...67	MB Command Value
MB Channel Mask	0	1 3		68...69	MB Channel Mask
MB Command	0	1 4		70...71	MB Command
MB Measuring Value	0	1 5	68...71		MB Measuring Value
MB Device Status	0	1 6	72...73		MB Device Status
MB Response	0	1 7	74...75		MB Response
Status Block_1	0	2			Status Block
Parameter Access Point	0	2 1			Parameter Access Point
SB Reserved 1	0	2 2		72...73	SB Reserved 1
SB Reserved 2	0	2 3		74...75	SB Reserved 2
SB Reserved 3	0	2 4		76...77	SB Reserved 3
SB Command	0	2 5		78...79	SB Command
SB Status Group 1	0	2 6	76...77		SB Status Group 1
SB Status Group 2	0	2 7	78...79		SB Status Group 2
SB Status Group 3	0	2 8	80...81		SB Status Group 3
SB Response	0	2 9	82...83		SB Response
Measuring Block 2_1	0	3			Measuring Block 2
Parameter Access Point	0	3 1			Parameter Access Point
MB2 Command Value	0	3 2		80...83	MB2 Command Value
MB2 Channel Mask	0	3 3		84...85	MB2 Channel Mask
MB2 Command	0	3 4		86...87	MB2 Command
MB2 Measuring Value	0	3 5	84...87		MB2 Measuring Value
MB2 Device Status	0	3 6	88...89		MB2 Device Status
MB2 Response	0	3 7	90...91		MB2 Response

Figure 3-2： SAI Block 3 is the Measuring Block 2_1 in the SPE Device Overview

By default, upon powering up the SPE weigh module, the Fast Weight Update Channel weight value (MB2 Measuring Value) reports the exact same net weight as the Main Weight Channel (MB Measuring Value).

To receive the net weight with high update rate through the Fast Weight Update Channel (Measuring Block 2), the PLC must write the decimal value "14" into the Measuring Block 2 Command word (MB2 Command). However, all these PLC commands and responses have been taken care by the “S7-1200 SAI 8 Blocks" sample project.

4. Function Blocks

About the "ID" input parameter for all the acyclic communication function blocks:

For all the function blocks which involve acyclic communication between the PLC and the SPE, the "ID" input parameter is required. Examples of function block with acyclic communication are external adjustment and APW module parameters read/ write.

For S7-1200 and S7-1500 PLCs, the ID is the Hardware Identifier which can be identified as "(Device name)~Head".

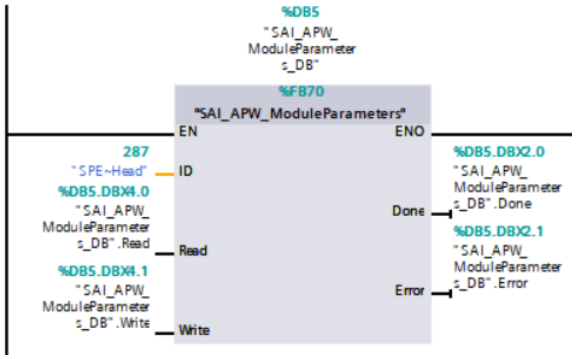


Figure 4-1: the ID parameter for Siemens S7-1200 and 1500

4.1. Main Weight Channel Control

This function block reads in all the important real-time, cyclical weighing data such as weight value, Data OK bit, Motion bit, Net mode bit and critical alarm bit.

Set the scale command bit one at a time to trigger different commands such as tare stable, zero stable, tare immediate, zero immediate, preset tare and clear tare. A successful execution of a scale command will set the Done bit on, else the Error bit will be set on instead.

The cyclic weight data can be reported automatically right after any scale command. The type of weight data (gross, net, or tare) being reported depends on the setting for WeightCmd. By default, the WeightCmd is decimal "3" and the function block will return a net weight value every time after any scale command such as tare or zero. Similarly, if the WeightCmd parameter is configured as decimal "0" or "1" the function block will then return a gross weight after any scale command.

This function block is occupying the SAI Measuring Block 1 input and output addresses.

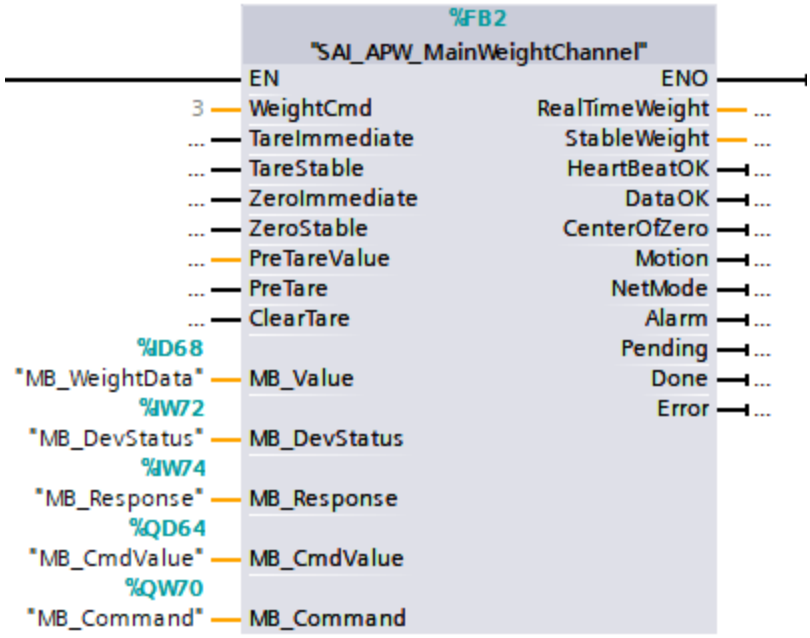


Figure 4-2: SAI_APW_MainWeightChannel Function Block

Table 4-1: SAI_APW_MainWeightChannel Function Block Parameters

Input Parameters	Data Type	Values	Description
WeightCmd	Word	0, 1	Report gross weight value
		2	Report tare weight value
		3 (default)	**Report net weight value**
		5	Report gross weight value (with internal resolution)
		6	Report tare weight value (with internal resolution)
		7	Report net weight value (with internal resolution)
TareImmediate	Bool		Trigger this bit to perform immediate tare command. This tare command doesn't check for stability criteria. Upon completion of this command, the input bit will be reset.
TareStable	Bool		Trigger this bit to perform stable tare command. This tare command requires the weight value to remain stable within the stability criteria (+-1d within 0.3 second) for a predefined timeout range (3 seconds by default), failing which, the command will return an error. Upon completion of this command, the input bit will be reset.
ZeroImmediate	Bool		Trigger this bit to perform immediate zero command. The zero command can only be executed when the weight value is within the zero range (+-2% by default). Else, the command will return an error. Upon completion of this command, the input bit will be reset.
ZeroStable	Bool		Trigger this bit to perform a stable zero command. This zero command requires the weight value to remain stable within the stability criteria (+-1d within 0.3 second) for a predefined timeout range (3 seconds by default). Furthermore the

			weight value has to be in the zero range to trigger this command, failing either condition; the command will return an error. Upon completion of this command, the input bit will be reset.
PreTareValue	Real		The preset tare value which has to be configured before issuing the PreTare command. Valid PreTare value is between scale's zero point up to maximum capacity.
PreTare	Bool		Trigger this bit to perform a preset tare command. The PreTareValue has to be configured prior to issuing this PreTare command. Upon completion of this command, the input bit will be reset.
ClearTare	Bool		Trigger this bit to perform a clear tare command. This command removes the tare and brings the scale into gross mode. Upon completion of this command, the input bit will be reset.
MB_Value	Real		Refer to Device Overview, input address of MB Measuring Value
MB_DevStatus	Word		Refer to Device Overview, input address of MB Device Status
MB_Response	Word		Refer to Device Overview, input address of MB Response
MB_CmdValue	Real		Refer to Device Overview, output address of MB Command Value
MB_Command	Word		Refer to Device Overview, output address of MB Command
Output Parameters	Data Type	Values	Description
RealTimeWeight	Real		Real-time weight value, can be gross, tare or net weight
StableWeight	Real		Stable weight value, the last real-time weight during Motion = 0
HeartBeatOK	Bool		1 - Device is communicating OK
DataOK	Bool	0	This bit gets set to 0 when the device is still operational but the value being reported cannot be guaranteed to be valid. The following conditions cause the Data Okay bit to be set to 0: • Device is powering up • Device is in setup mode • Device is in test mode • Over capacity condition occurs - When the A/D converter is at its limit - Product dependent over capacity that occurs when the device determines it cannot trust the weight • Under capacity condition occurs - When the A/D converter is at its limit - Product dependent under capacity that occurs when the device determines it cannot trust the weight
		1	Weight data is normal, valid
CenterOfZero	Bool		1 = Gross weight value is at a value of zero +/- one quarter of a weight and measures verification interval denoted as "e".
Motion	Bool	0	Weight value is stable
		1	Weight value is in motion

NetMode	Bool	0	Weighing is in gross mode
		1	Weighing is in net mode
Alarm	Bool	0	No alarm
		1	Also called the RedAlert alarm. If this bit is true it is an indication that the control device should stop until the source of the alarm is evaluated and corrected. The control system should use a Field Value command or evaluate the RedAlert status block to determine the nature of the alarm.
Pending	Bool	0	Zero, tare or clear tare command is completed, or failed
		1	Zero, tare or clear tare command is in process
Done	Bool	0	Zero, tare or clear tare command is in process, or failed
		1	Zero, tare or clear tare command is successful
Error	Bool	0	Zero, tare or clear tare command is in process, or succeeded
		1	Zero, tare or clear tare command is not completed due to error

4.2. Fast Weight Channel

SPE modules by default have a Main Weight Channel for weight values with an update rate of 122 values per second and includes filters optimized for gross-tare weighing.

The SPE firmware versions 4.0.1 and higher include an additional Fast Weight Update Channel with an increased weight update rate of 488 values per second for sending and 244 values per second for receiving data. This Fast Weight Update Channel is tailored to address the needs of filling applications where precision is required.

This increased weight update rate enables the user to make control decision much quicker than in previous versions. The dual channel concept and an 8-block Standard Automation Interface (SAI) format allows the user to simultaneously observe weight values at 122 Hz and at 488 Hz. This new firmware allows separate filter settings on the Main Weight Channel (adaptive or linear filter) and the Fast Weight Update Channel (linear filter, or FCUT2). With this functionality, the Fast Weight Update Channel is optimized on speed, and the Main Weight Channel can be tuned to achieve more stability.

The Function Block “SAI_APW_8B_FastWeightChannel” is only available in the SAI 8 Block project. This Function Block occupies the SAI Measuring Block 2 input and output addresses.

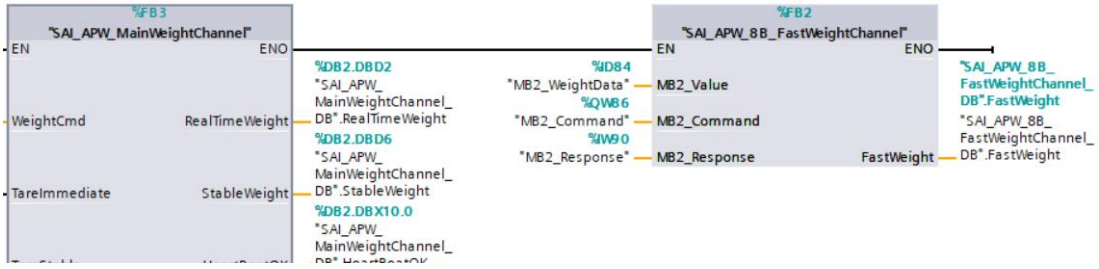


Figure 4-3: SAI_APW_8B_FastWeightChannel Function Block

Table 4-2: SAI_APW_8B_FastWeightChannel Function Block Parameters

Input Parameters	Data Type	Values	Description
MB2_Value	Real		Refer to Device Overview, input address of MB2 Measuring Value
MB2_Command	Word		Refer to Device Overview, output address of MB2 Command
MB2_Response	Word		Refer to Device Overview, input address of MB2 Response
Output Parameters	Data Type	Values	Description
FastWeight	Real		Real-time fast channel net weight value at 488 Hz. The cut-off frequency of fast weight channel is the FCUT2 setting on Function Block “SAI_APW_ModuleParameters”.

4.3. APW Diagnostic Status

Real-time diagnostic status of the APW module can be read from the SAI Status Block_1. This function block issues Status Block command “21” to receive RedAlert alarms, alarms and secondary scale status word from the connected APW.

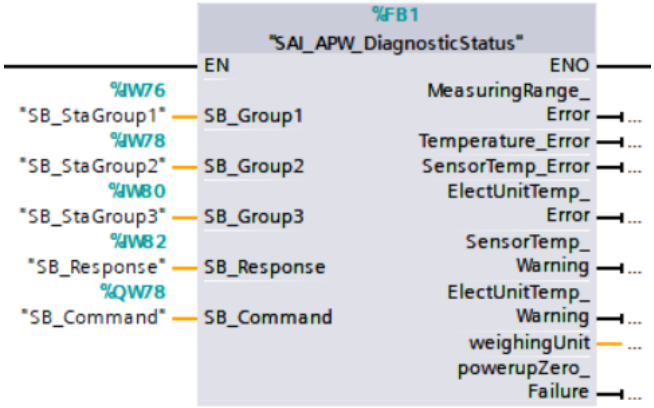


Figure 4-4: SAI_APW_DiagnosticStatus Function Block

Table 4-3: SAI_APW_DiagnosticStatus Function Block Parameters

Input Parameters	Data Type	Values	Description
SB_Group1	Word		Refer to Device Overview, input address of SB Status Group 1
SB_Group2	Word		Refer to Device Overview, input address of SB Status Group 2
SB_Group3	Word		Refer to Device Overview, input address of SB Status Group 3
SB_Response	Word		Refer to Device Overview, input address of SB Response
SB_Command	Word		Refer to Device Overview, output address of SB Command
Output Parameters	Data Type	Values	Description

MeasuringRange_Error	Bool	0, 1	1 = Weight data can no longer be trusted due to loss of data or mechanical damage of the weigh module.
Temperature_Error	Bool	0, 1	1 = Sensor is outside of the allowed operating temperature range. The weight value can be affected or the components can prematurely fail.
SensorTemp_Error	Bool	0, 1	Error – Temperature (weight sensor)
ElectUnitTemp_Error	Bool	0, 1	Error – Temperature (electronic unit)
SensorTemp_Warning	Bool	0, 1	Warning – Temperature (weight sensor)
ElectUnitTemp_Warning	Bool	0, 1	Warning – Temperature (electronic unit)
weighingUnit	Bool	0, 1	Unit bits are used to indicate the weight unit. Some common units are g – “0”, kg – “1”, lb – “2”, mg – “5”, ug – “6”.
powerupZero_Failure	Bool	0, 1	1 = Scale has not been able to complete its power-up restore / reset of zero.

4.4. APW Module Parameters

APW operating parameters such as weighing environment and filters, weighing stability criteria and general timeout can be read or write by using this function block. This function block works together with the data block “APW_ModuleParameters”. Change the settings in this data block before writing them into the connected APW.

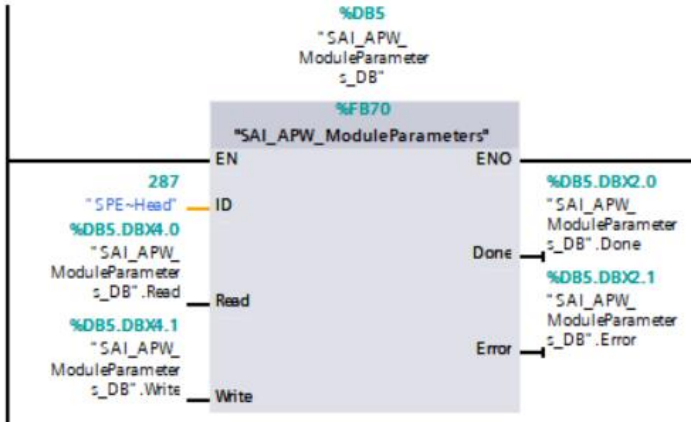


Figure 4-5: SAI_APW_ModuleParameters Function Block

Table 4-4: SAI_APW_ModuleParameters Function Block Parameters

Input Parameters	Data Type	Values	Description
HW_ID	HW_IO	Example: "SPE~Head"	ID parameter to select the module for which a data record is to be written. Use only the hardware identifier (HW ID) of the module for the ID parameter.

			In this sample program, the ID parameter of the device can be found under Device Properties > Slot 0 Hardware Identifier.
Read	Bool		Set this bit to “1” in order to read all the APW module parameters into the data block “APW_ModuleParameters”.
Write	Bool		Set this bit to “1” in order to write all the APW module parameters from the data block “APW_ModuleParameters”.
Output Parameters	Data Type	Values	Description
Done	Bool	0, 1	Module parameter read/ write is completed
Error	Bool	0,1	Module parameter read/ write failed

All the read/ write module parameters are stored in the data block “APW_Module Parameters”.

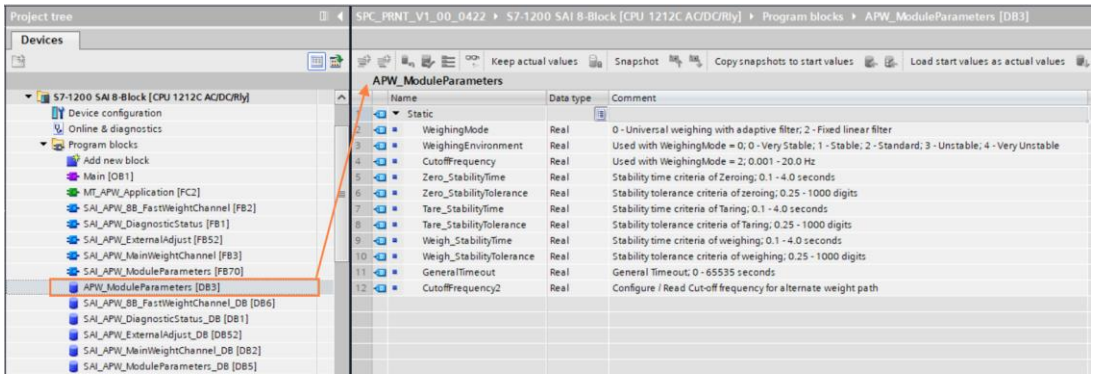


Figure 4-6: APW_ModuleParameters Data Block

4.5. APW Internal Adjustment

Use this Function Block to perform scale adjustment with built-in internal weight.

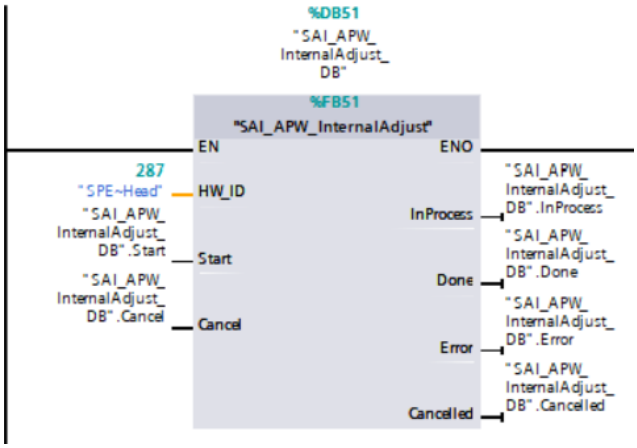


Figure 4-7: SAI_APW_InternalAdjust Function Block

When the operating environment is in stable condition, trigger the Start input bit to run the adjustment procedure.

Table 4-5: SAI_APW_InternalAdjust Function Block Parameters

Input Parameters	Data Type	Values	Description
HW_ID	HW_IO	Example: "SPE~Head"	ID parameter to select the module for which a data record is to be written. Use only the hardware identifier (HW ID) of the module for the ID parameter. In this sample program, the ID parameter of the device can be found under Device Properties > Slot 0 Hardware Identifier.
Start	Bool	1, 0	Trigger this input bit to start the adjustment process.
Cancel	Bool	1, 0	Trigger this input bit to cancel/ abort the adjustment process after being started.
Output Parameters	Data Type	Values	Description
InProcess	Bool	1	Adjustment is started and in process
		0	Adjustment is not started
Done	Bool	1	Adjustment is completed successfully
		0	Adjustment is in process or in error state
Error	Bool	1	Adjustment failed due to error
		0	No error
Cancelled	Bool	1	Adjustment is cancelled successfully
		0	No cancellation

4.6. APW External Adjustment

Use this Function Block to perform scale adjustment with external weight.

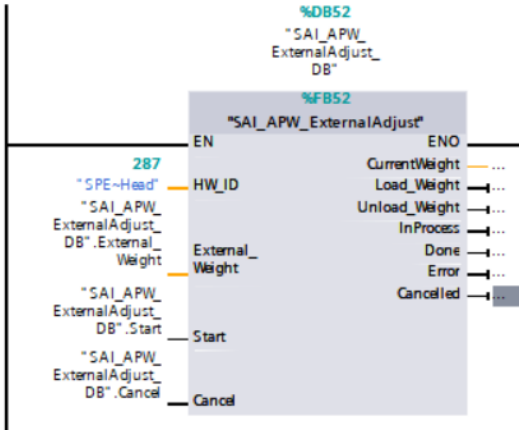


Figure 4-8: SAI_APW_ExternalAdjust Function Block

Configure the "External_Weight" according to the adjustment weight to be used. The weight unit is gram by default. Trigger the Start input bit to run the adjustment procedure.

Table 4-6: SAI_APW_ExternalAdjust Function Block Parameters

Input Parameters	Data Type	Values	Description
HW_ID	HW_IO	Example: "SPE~Head"	ID parameter to select the module for which a data record is to be written. Use only the hardware identifier (HW ID) of the module for the ID parameter. In this sample program, the ID parameter of the device can be found under Device Properties > Slot 0 Hardware Identifier.
External_Weight	REAL (32 bits)	Example: "200.00"	This is the span weight value for the sensitivity adjustment.
Start	Bool	1, 0	Trigger this input bit to start the adjustment process.
Cancel	Bool	1, 0	Trigger this input bit to cancel/ abort the adjustment process after being started.
Output Parameters	Data Type	Values	Description
CurrentWeight	REAL (32 bits)	Example: "200.00"	The required reference weight here is shown here.
Load_Weight	Bool	1	User has to load the external weight according to the value displayed in CurrentWeight.
		0	No action required from the user
Unload_Weight	Bool	1	User has to unload the external weight
		0	No action required from the user
InProcess	Bool	1	Adjustment is started and in process
		0	Adjustment is not started
Done	Bool	1	Adjustment is completed successfully
		0	Adjustment is in process or in error state
Error	Bool	1	Adjustment failed due to error
		0	No error
Cancelled	Bool	1	Adjustment is cancelled successfully
		0	No cancellation

5. Sample Code Migration

5.1. Hardware Configurations

1) Under Devices & networks -> Network view, add (or drag over) a SPE 2 Block Format or 8 Block Format from the Hardware Configuration.

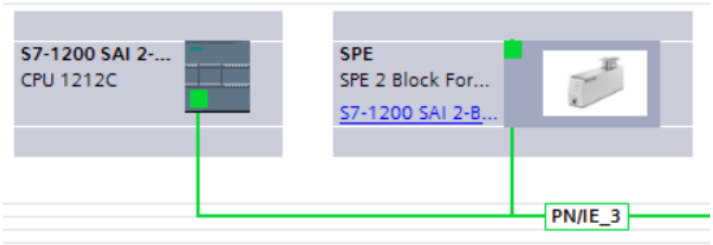


Figure 5-1: Add a PROFINET device in the Network view

2) Assign the independent PROFINET device name and IP address for the added device.

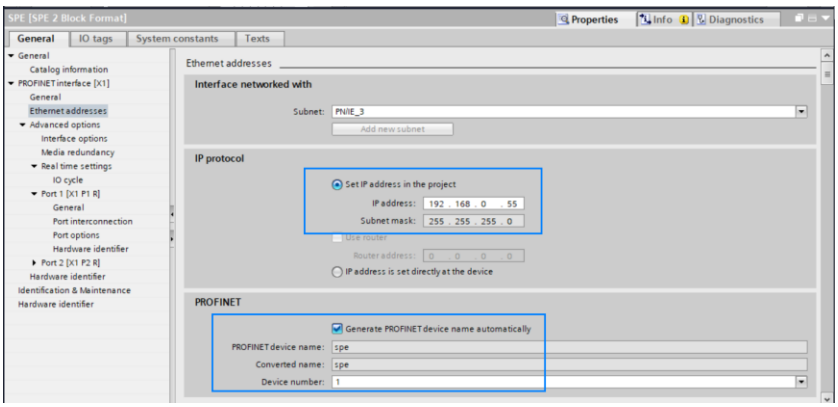


Figure 5-2: PROFINET device name and IP address

3) The sample code is following the default I and Q addresses assignment as shown below. To minimize the modification to the code, consider sticking to the same I and Q address assignment.

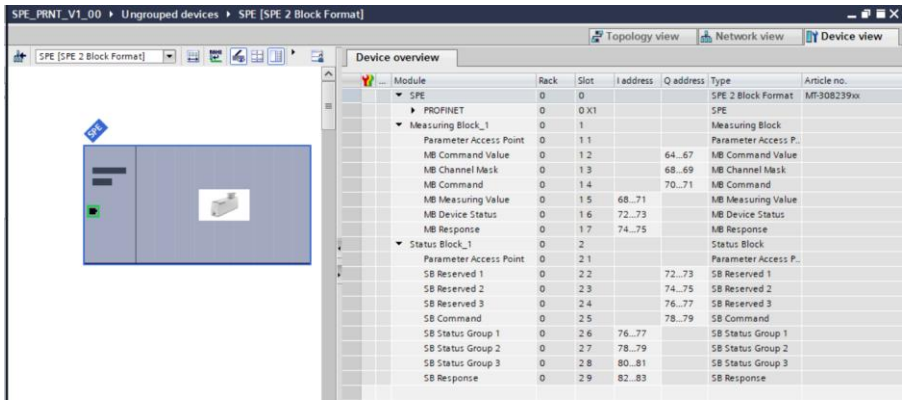


Figure 5-3: Device I and Q addresses

5.2. Duplicate Programming Files

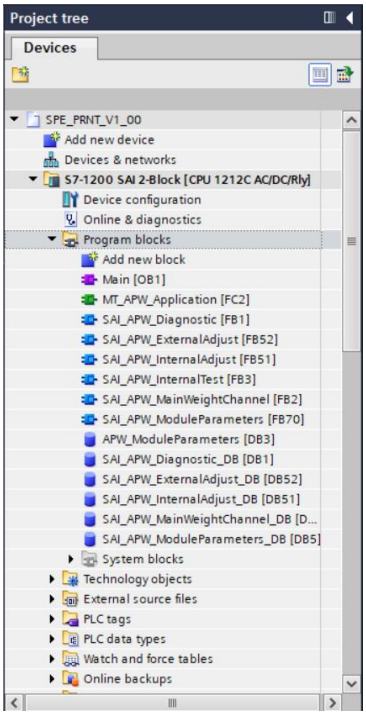


Figure 5-4: Program Blocks View in the PLC Sample Code

1) The required program blocks:

   a) MT_APW_Application (FC)

   b) SAI_APW_MainWeightChannel (FB), SAI_APW_MainWeightChannel_DB (DB)

   The function blocks below are used to perform scale adjustment from the PLC. APW-Link software can be used for all the scale adjustment or test commands.

   c) SAI_APW_InternalAdjust (FB), SAI_APW_InternalAdjust_DB (DB)

d) SAI_APW_ExternalAdjust (FB), SAI_APW_ExternalAdjust_DB (DB)

The other function blocks can be added into the programming if required.

2) Duplicate the "SPE" under the PLC tags.

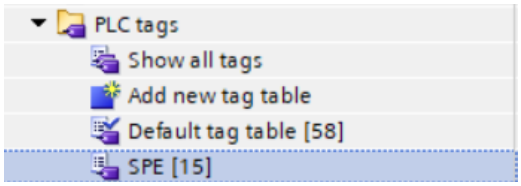


Figure 5-5: Duplicate the PLC tags

3) Duplicate all the PLC data types.

4) Lastly, in the Main (OB1) call up the function "MT_APW_Application".

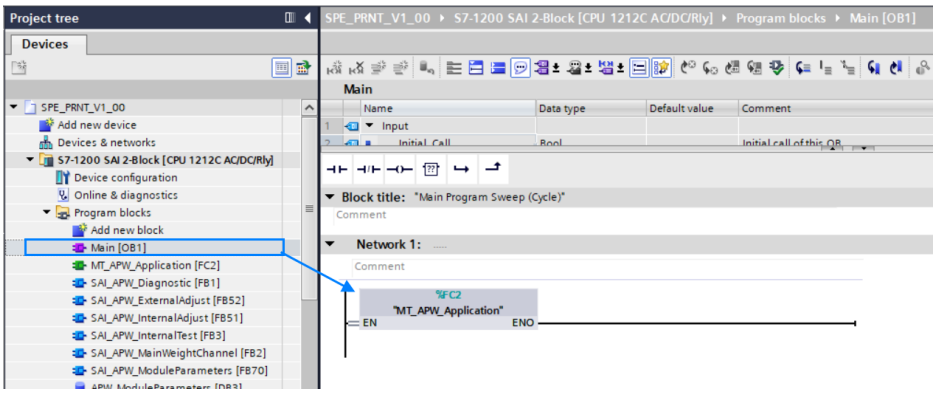


Figure 5-6: Call up "MT_APW_Application" in the Main OB