

VACON[®] NXP
AC DRIVES

OPTEA, OPTE3/5
PROFISAFE FUNCTION BLOCKS FOR TIA PORTAL V13
USER MANUAL

VACON[®]

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1 INTRODUCTION

PROFIsafe safety fieldbus is supported by OPTEA and OPTE3/5 option boards in VACON® NXP drives together with advanced safety options OPTBL, OPTBM and OPTBN. Three telegram types (ST30, ST31, ST58000) are supported and their bit mapping is described in VACON® Advanced Safety Options Operating Guide found in the Danfoss Drives website.

The PROFIsafe function blocks are provided with direct mapping of safety functions to the corrects bits in these telegrams. The aim is to help the user in evaluating and testing the PROFIsafe functionality and different safety functions.

To learn more about the functionality of different safety functions, please refer to the VACON® Advanced Safety Options Operating Guide.

NOTE!

The VACON® advanced safety option (OPTBL, OPTBM, OPTBN) must be parameterized with the VACON® Safe tool before the system is ready to be used. The tool is used to configure all the safety functions that are required, the PROFIsafe safety fieldbus, and possible speed sensors for monitoring the motor speed. VACON® Advanced Safety Options Operating Guide gives more information on using the VACON® Safe tool.

2 LIBRARY COMPATIBILITY

The library has been created with TIA PORTAL V13 SP1 and STEP7 Safety SP1. Older versions of TIA Portal are not supported. If the library is used in a newer version of TIA Portal, check if the library is compatible with it. If it is not compatible, load the library in compatibility mode, or, if possible, convert it to a newer version.

NOTE!

Not all PLCs support PROFIsafe. If PROFIsafe is supported, it is usually marked with a letter 'F' in the PLC type designation. Also, TIA Portal requires STEP7 Safety software to be installed to program safety applications.

2.1 TIA PORTAL LIBRARY FOR S7-1500 PLCs

If you use an S7-1500 PLC, use the library *VACON_PROFISAFE_LIB_S1500.zal13*. The table below lists the PLCs and TIA Portal versions that the library has been tested with. If you use a PLC and/or TIA Portal version that is not in the table below, be aware that getting customer support for that combination might be limited.

Table 1.

PLC type	TIA Portal version
S7-1500 CPU 1516-F3 PN/DP	TIA Portal V13 SP1 update 4, STEP7 Safety SP1 update 4

3 HOW TO TAKE THE LIBRARY IN USE

The library is supplied as a TIA PORTAL library archive file named *VACON_PROFISAFE_LIB_S1500.zal13*.

1. Retrieve it by clicking *Options -> Global libraries -> Retrieve library*. This will extract the archive file.
2. Go to the *Libraries* tab on the right.
3. Expand *Global libraries*.
4. Click on the *Open global library* icon.
5. Drag and drop the PLC data types under the *PLC Data Types* folder of your project.

NOTE!

Add the library blocks to the program blocks of your projects first. After that, create instances of the library blocks by dragging and dropping them to your work area. Do not drag and drop them directly from the library to your work area, as this will always create a new function block and not a new instance.

4 LIBRARY CONTENTS

The library contains input and output function blocks for all the supported telegram types. The usage of these function blocks also requires PLC data types and they are included in the library.

4.1 SAFETYCONTROLST30

This function block provides an interface to activate different safety functions that are supported by PROFIsafe telegram ST30.

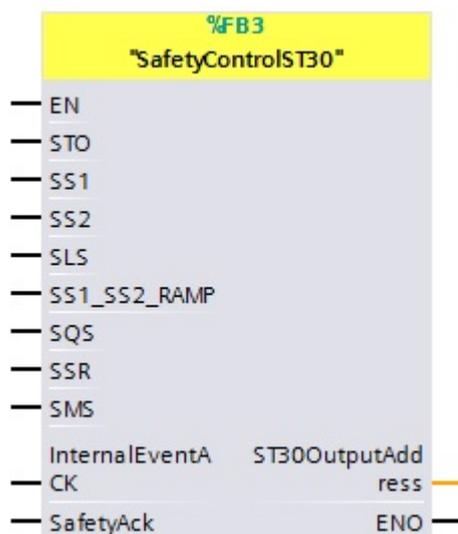


Figure 1. Function block interface

Table 2. Description of the inputs and outputs

INPUT/OUTPUT	Description
EN	Unused in safety FBs, block is always executed
STO	Activate STO (active low)
SS1	Activate SS1 (active low)
SS2	Activate SS2 (active low)
SLS	Activate SLS (active low)
SS1_SS2_RAMP	Select the monitored ramp profile for SS1 and SS2 functions
SQS	Activate SQS (active low)
SSR	Activate SSR (active low)
SMS	Activate SMS (active low)
InternalEventAck	Acknowledge safety function violation with lowering edge
SafetyAck	Acknowledge safety function with rising edge
ST30OutputAddress	Assign a PLC tag of type <i>DriveSafetyControlST30</i> to this output
ENO	Unused in safety FBs

4.2 SAFETYSTATUSST30

This function block provides an interface to different safety function statuses that are supported by PROFIsafe telegram ST30.

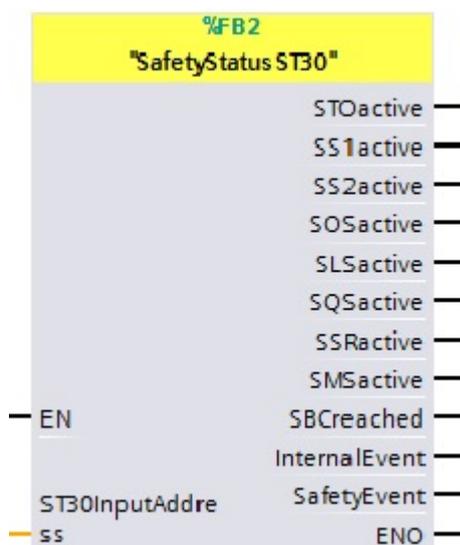


Figure 2. Function block interface

Table 3. Description of the inputs and outputs

INPUT/OUTPUT	Description
EN	Unused in safety FBs, block is always executed
STOactive	STO is active (active high)
SS1active	SS1 is active (active high)
SS2active	SS2 is active (active high)
SOSactive	SOS is active (active high)
SLSactive	SLS is active (active high)
SQSactive	SQS is active (active high)
SSRactive	SSR is active (active high)
SMSactive	SMS is active (active high)
SBCreached	Safe Brake Control signal activated (active high)
InternalEventACK	Safety function violation detected (active high)
SafetyAck	Deactivation of safety function requires acknowledgement
ST30InputAddress	Assign a PLC tag of type <i>DriveSafetyStatusST30</i> to this input
ENO	Unused in safety FBs

4.3 SAFETYCONTROLST31

This function block provides an interface to activate different safety functions that are supported by PROFIsafe telegram ST31.

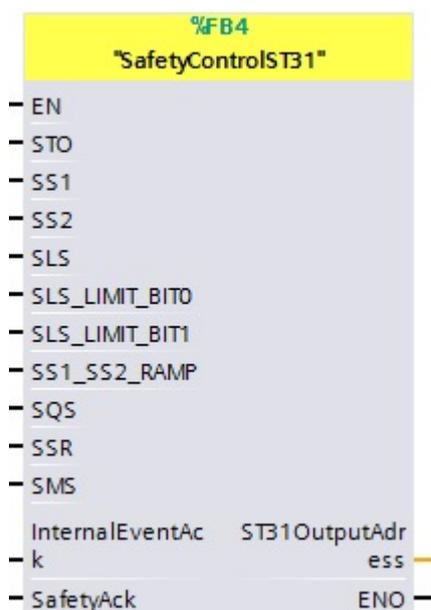


Figure 3. Function block interface

Table 4. Description of the inputs and outputs

INPUT/OUTPUT	Description
EN	Unused in safety FBs, block is always executed
STO	Activate STO (active low)
SS1	Activate SS1 (active low)
SS2	Activate SS2 (active low)
SLS	Activate SLS (active low)
SLS_LIMIT_BIT0	These bits are used to select speed limit when SLS is activated. See VACON® Advanced Safety Options Operating Guide for more details.
SLS_LIMIT_BIT1	
SS1_SS2_RAMP	Select the monitored ramp profile for SS1 and SS2 functions
SQS	Activate SQS (active low)
SSR	Activate SSR (active low)
SMS	Activate SMS (active low)
InternalEventACK	Acknowledge safety function violation with lowering edge
SafetyAck	Acknowledge safety function with rising edge
ST31OutputAddress	Assign a PLC tag of type <i>DriveSafetyControlST31</i> to this output
ENO	Unused in safety FBs

4.4 SAFETYSTATUSST31

This function block provides an interface to different safety function statuses that are supported by PROFIsafe telegram ST31.

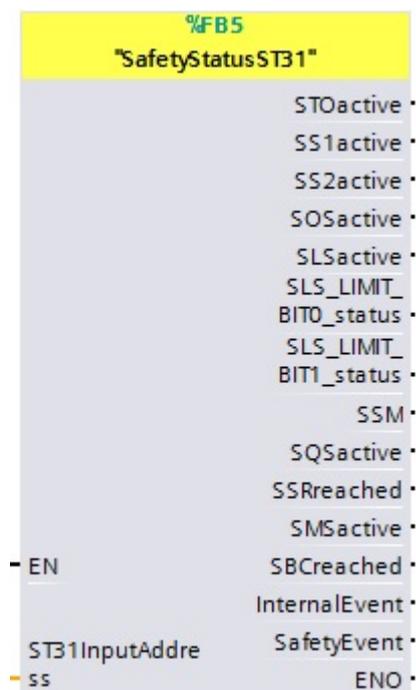


Figure 4. Function block interface

Table 5. Description of the inputs and outputs

INPUT/OUTPUT	Description
EN	Unused in safety FBs, block is always executed
STOactive	STO is active (active high)
SS1active	SS1 is active (active high)
SS2active	SS2 is active (active high)
SOSactive	SOS is active (active high)
SLSactive	SLS is active (active high)
SLS_LIMIT_BIT0_status	State of SLS_LIMIT_BIT0
SLS_LIMIT_BIT1_status	State of SLS_LIMIT_BIT1
SQSactive	SQS is active (active high)
SSRactive	SSR is active (active high)
SMSactive	SMS is active (active high)
SSM	Drive speed is between min and max limits set in SSM function (active high)

SBCreached	Safe Brake Control signal active (active high)
InternalEventACK	Safety function violation detected (active high)
SafetyAck	Deactivation of safety function requires acknowledgement
ST31InputAddress	Assign a PLC tag of type <i>DriveSafetyStatusST31</i> to this input
ENO	Unused in safety FBs

4.5 SAFETYCONTROLST58000

This function block provides an interface to activate different safety functions that are supported by PROFIsafe telegram ST58000.

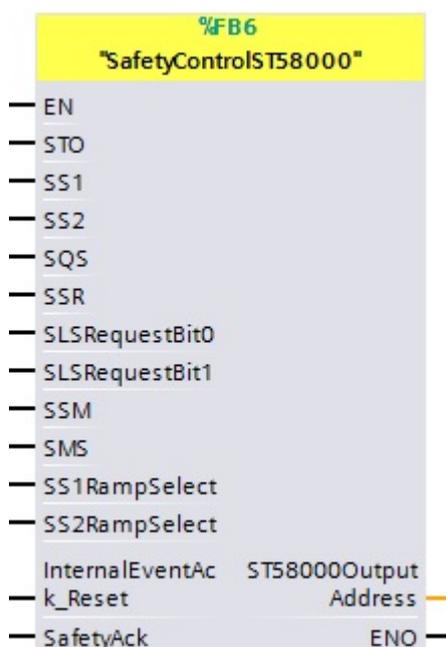


Figure 5. Function block interface

Table 6. Description of the inputs and outputs

INPUT/OUTPUT	Description
EN	Unused in safety FBs, block is always executed
STO	Activate STO (active low)
SS1	Activate SS1 (active low)
SS2	Activate SS2 (active low)
SQS	Activate SQS (active low)
SSR	Activate SRS (active low)

SLSRequestBit0	These bits are used to activate SLS and the speed limit. See VACON® Advanced Safety Options Operating Guide for more details.
SLSRequestBit1	
SSM	Activate SSM (active low)
SMS	Activate SMS (active low)
SS1RampSelect	Selection of monitored ramp for SS1
SS2RampSelect	Selection of monitored ramp for SS2
InternalEventACK_Reset	Acknowledge safety function violation with lowering edge
SafetyAck	Acknowledge safety function with rising edge
ST58000OutputAddress	Assign a PLC tag of type <i>DriveSafetyControlST58000</i> to this output
ENO	Unused in safety FBs

4.6 SAFETYSTATUSST58000

This function block provides an interface to different safety function statuses that are supported by PROFIsafe telegram ST58000.



Figure 6. Function block interface

Table 7. Description of the inputs and outputs

INPUT/OUTPUT	Description
EN	Unused in safety FBs, block is always executed
STOreached	State of STO output of advanced safety option
SS1reached	SS1 is successfully reached (no violations)
SS2reached	SS2 is successfully reached (no violations)
SQSreached	SQS is successfully reached (no violations)
SLS1reached	Speed is below SLS1 limit
SLS2reached	Speed is below SLS2 limit
SLS3reached	Speed is below SLS3 limit
SSMreached	Speed is below SSM max limit and above min limit
SMSreached	Speed is below SMS limit
SOSreached	SOS is successfully reached (no violations)
SBCreached	Safe Brake Control signal activated (active high)
STOactive	STO is active (active high)
SS1active	SS1 is active (active high)
SS2active	SS2 is active (active high)
SQSactive	SQS is active (active high)
SSRactive	SSR is active (active high)
SLS1active	SLS1 is active (active high)
SLS2active	SLS2 is active (active high)
SLS3active	SLS3 is active (active high)
SSMactive	SSM is active (active high)
SMSactive	SMS is active (active high)
SSMAboveMaxLimit	Speed is above SSM max limit
SSMBelowMinLimit	Speed is below SSM min limit
SFactivity	A safety function is currently active
ASOErrorState	Advanced Safety Option board is in error state
DIN1	State of digital input 1 of ASO
DIN2	State of digital input 2 of ASO
DIN3	State of digital input 3 of ASO
DIN4	State of digital input 4 of ASO
DOUT1	State of digital output 1 of ASO
DOUT2	State of digital output 2 of ASO

ST58000InputAddress	Assign a PLC tag of type <i>DriveSafetyStatusST58000</i> to this input
ENO	Unused in safety FBs

4.7 PLC DATA TYPES

The following PLC data types are provided:

- *DriveSafetyControlST30*
- *DriveSafetyStatusST30*
- *DriveSafetyControlST31*
- *DriveSafetyStatusST31*
- *DriveSafetyControlST58000*
- *DriveSafetyStatusST58000*

The data types must be used together with the associated function block, for example, when you use the function block *SafetyControlST30*, use a PLC data type of *DriveSafetyControlST30*.

To use a data type, create a tag in the PLC tags and set the data type to, for example, *DriveSafetyControlST30*. This tag is then assigned an address that corresponds to the first output address of the PROFIsafe telegram of the controlled drive, and to the first bit of the first output address. Then assign the output (or input) of the *ST30OutputAddress* of the corresponding function block to the created tag.



CAUTION!

An incorrect assignment of the input/output address of the PLC tag of data types *DriveSafetyControlST30*, *DriveSafetyStatusST30*, *DriveSafetyControlST31*, *DriveSafetyStatusST31*, *DriveSafetyControlST58000*, *DriveSafetyStatusST58000* will cause incorrect behavior or faults in the system.

5 USING THE LIBRARY AND PROFISAFE

This chapter will show you how to configure one VACON® NXP drive with the OPTEA PROFINET/PROFIsafe option to use PROFIsafe in TIA Portal by using this library. It will also show the basics of using VACON® Safe to configure OPTBL advanced safety option to use PROFIsafe and the safety functions STO, SQS, SMS.

5.1 PREREQUISITES

- The VACON® NXP drive with OPTEA, OPTBL, and OPTAF options
- TIA Portal V13 SP1 with Safety Advanced SP1
- GSDML file for OPTEA installed

- A proximity sensor connected to the motor and to the OPTBL option board. If no proximity sensor is available, then skip steps related to safety function *SMS* and *Speed measurement configuration* in the VACON® Safe tool.
- Experience in configuring PROFINET IO devices & networks

5.2 CONFIGURING THE OPTBL OPTION WITH VACON® SAFE

The VACON® Safe tool is used to parameterize VACON® advanced safety options (OPTBL, OPTBM, OPTBN). The tool can be downloaded from the Danfoss website <http://drives.danfoss.com/downloads/#/>.

Start the VACON® Safe tool. From the main menu, click *New file*. This will start the configuration process of the OPTBL option board. The following screen appears.

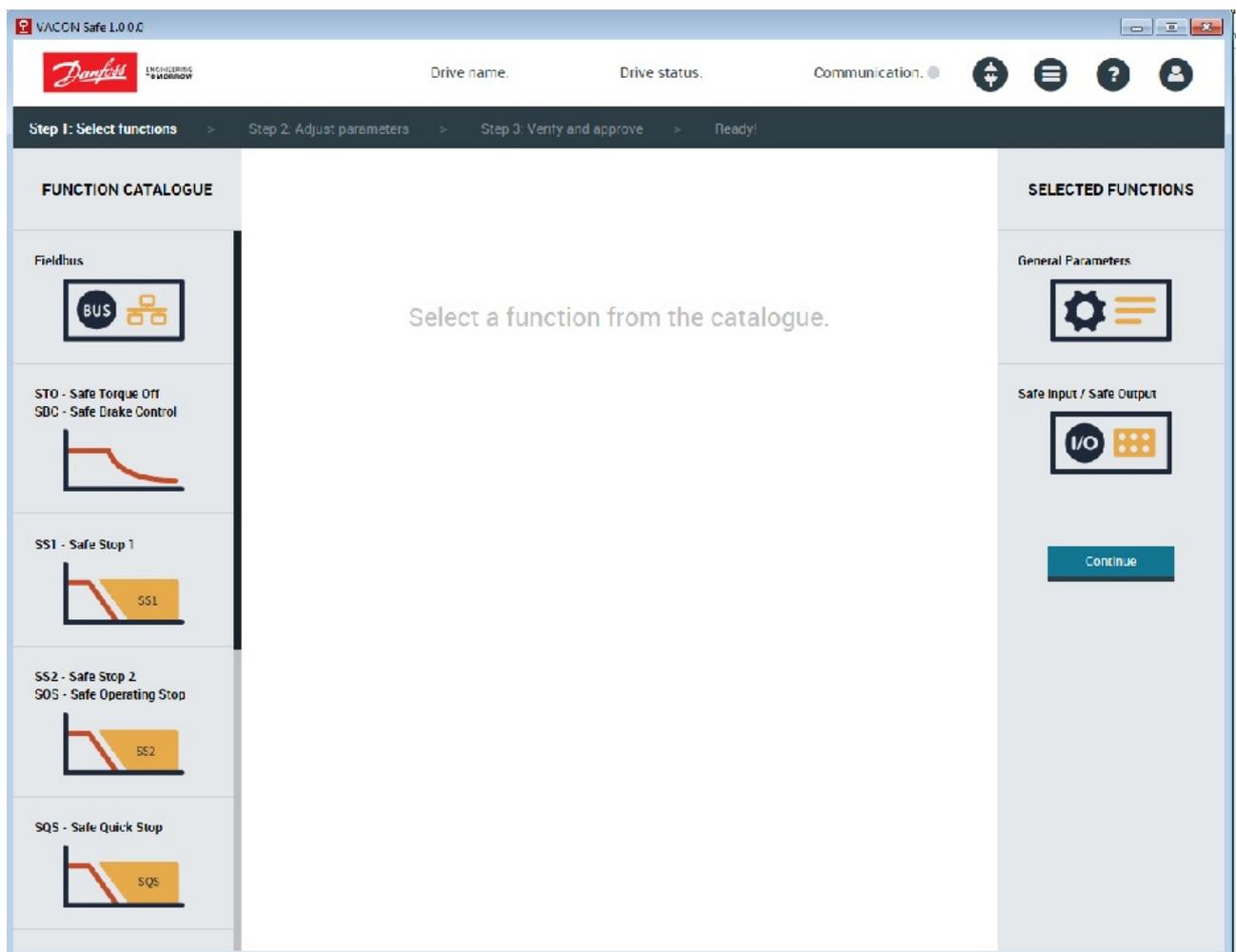


Figure 7. Starting the configuration process

On the left, there are all the functions that can be configured to OPTBL (and OPTBM and OPTBN). Click on *Fieldbus*, and then click *Add*, click on *STO*, and then click *Add*, click *SMS*, and then click *Add*, click *SQS*, and then click *Add*. *SQS* is added because monitoring functions use it as a violation response function. Leave the safety functions *SMS* and *SQS* out if you do not have a speed sensor available. All the added functions are moved to the list of selected functions on the left side. To continue, click *Continue* at the end of the list on the left side.

The following screen appears.

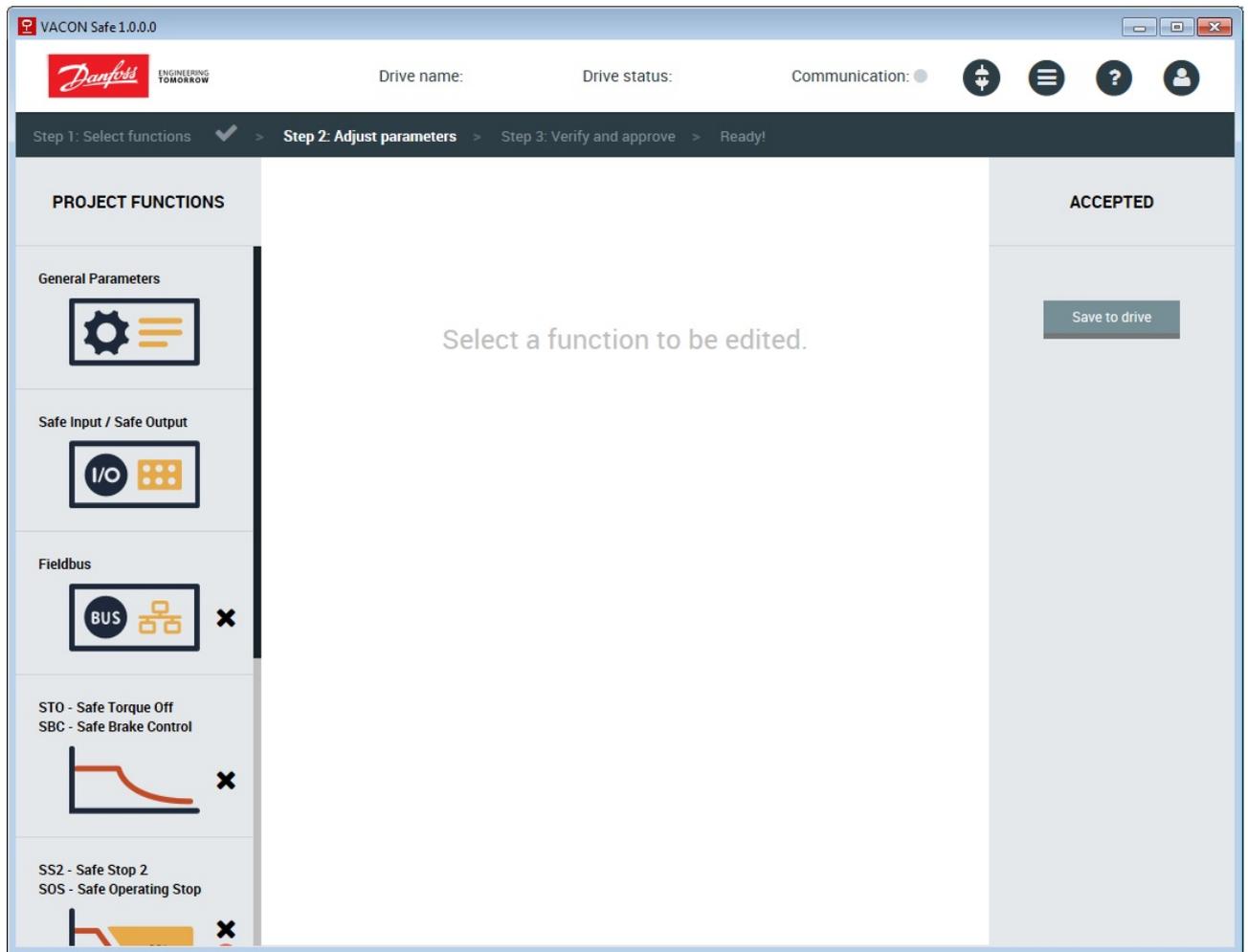


Figure 8.

You now need to edit the parameters of the selected functions. To start, click *General Parameters*. Fill out *File Name*, *File Creator*, *Company Name*. At this stage, you can put anything in these fields, but in production systems, the parameterization and installation is done by qualified persons who fill these fields with correct values.

In *Acknowledgement Mode (Start-Up)*, select *Automatic*. This will enable drive operation after a successful start-up without a separate acknowledgement.

As the speed monitoring safety function is configured, the encoder type used for speed measurement must be set up. In *Encoder Type*, select *Proximity switch and estimated speed*. Set all other fields according to your proximity switch. To correctly configure proximity sensors, see the VACON® Advanced Safety Options Operating Guide. This part can be skipped if you did not include *SMS* and *SQS* in your project.

All the other fields can be left to default values. Click *Accept* at the bottom of the parameter list. *General parameters* is moved to the list of accepted functions on the right side.

Next, click *Safe Input / Safe Output*. If you want to use the digital inputs or outputs of OPTBL, they can be configured in this screen. As the safety fieldbus is used for safety function activations, these can be left out. To continue, click *Accept*.

Then, click *Fieldbus* and configure the individual fields as shown in Figure 9.

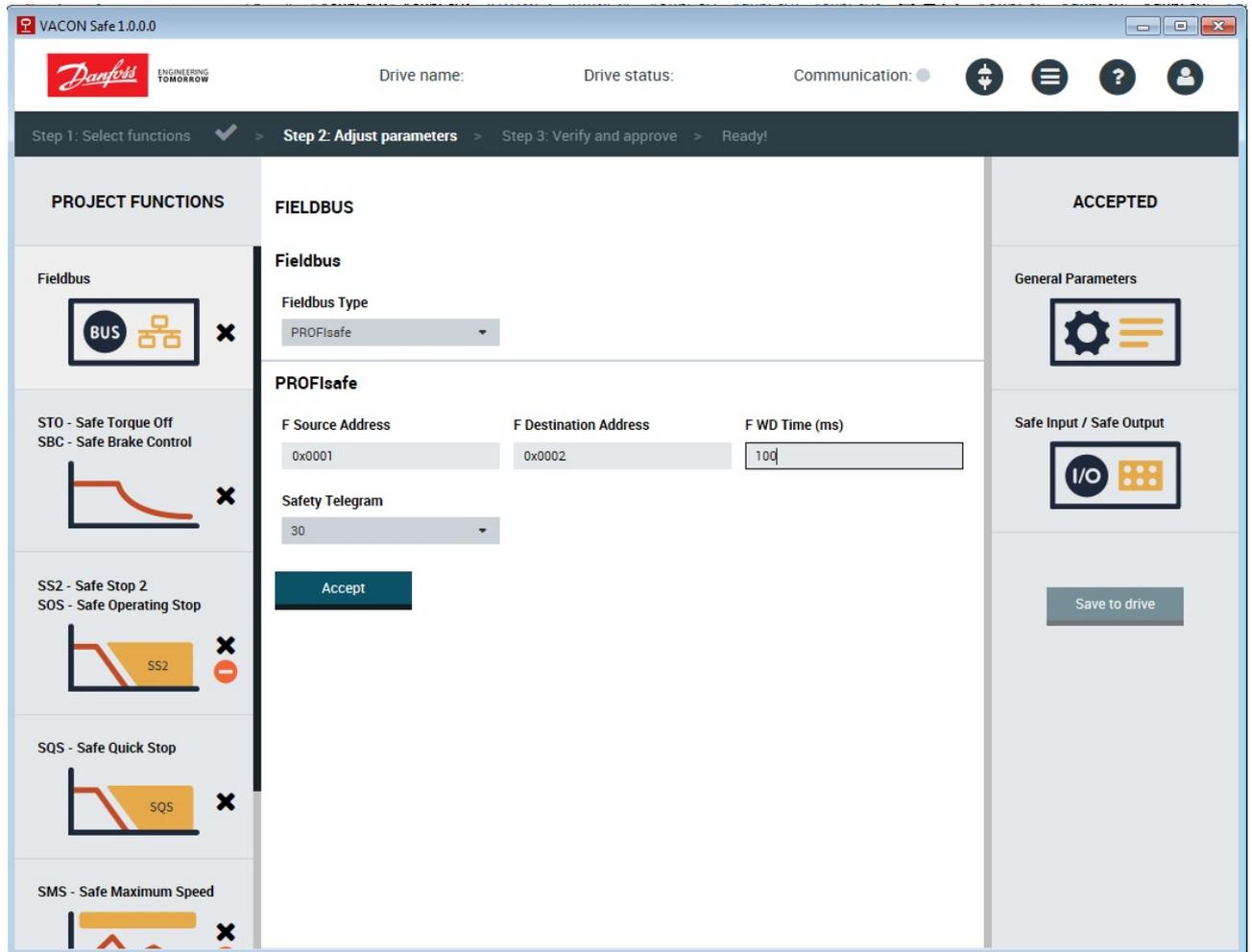


Figure 9.

Observe that the *F source address / F destination address* must be unique in the same network. In case there are several devices, you must use different values for every device. *F WD Time* can be the same in all the devices. It sets the watchdog time for the safety fieldbus. Setting *F WD Time* to lower than 20 ms is not recommended as it can cause unnecessary watchdog faults. The correct value depends on the safety assessment of the whole system. *Safety Telegram* is set to ST30. If you use a different telegram, change this field to match the PLC program.

All the values shown in this screen are needed later in the PLC configuration. The values must be the same in the drive and PLC configuration. Click *Accept*.

Then click *STO* to configure the STO safety function. Set *Acknowledgement Mode* to *Automatic*. This way no other acknowledgement is needed to disable this safety function. Click *Accept*.

Then click *SQS*. Set *SQS* to use automatic acknowledgement and *SQS Type* to *STO*. Click *Accept*.

Then click *SMS*. When the *SMS* function is activated, it will monitor the motor speed using the encoder attached to the motor. If it detects that the motor is moving faster than the set limits, it will activate the *SQS* function and stop the motor. Set *Acknowledgement Mode* to *Automatic* and *SMS Limit Plus* to 1000 rpm. *SMS Limit Minus* is set to -1000 rpm. Click *Accept*. Click *Save to Drive* at the end of the list of accepted functions.

Connect a serial cable to the connector of the drive control panel and click *Scan*. When your drive is detected, select it and click *Connect*. Type the password (the default is "admin") and click *Save to drive*. This will save the parameters to the drive and load them back for verification. Make sure that the parameters match and click *Approve* at the end of the parameter list for all functions listed on the left side. Once this is done, click *Continue* at the end of the list on the right side.

Check the box to agree with the statement shown and then click *OK*. After VACON® Safe has successfully stored the parameters the following screen appears.

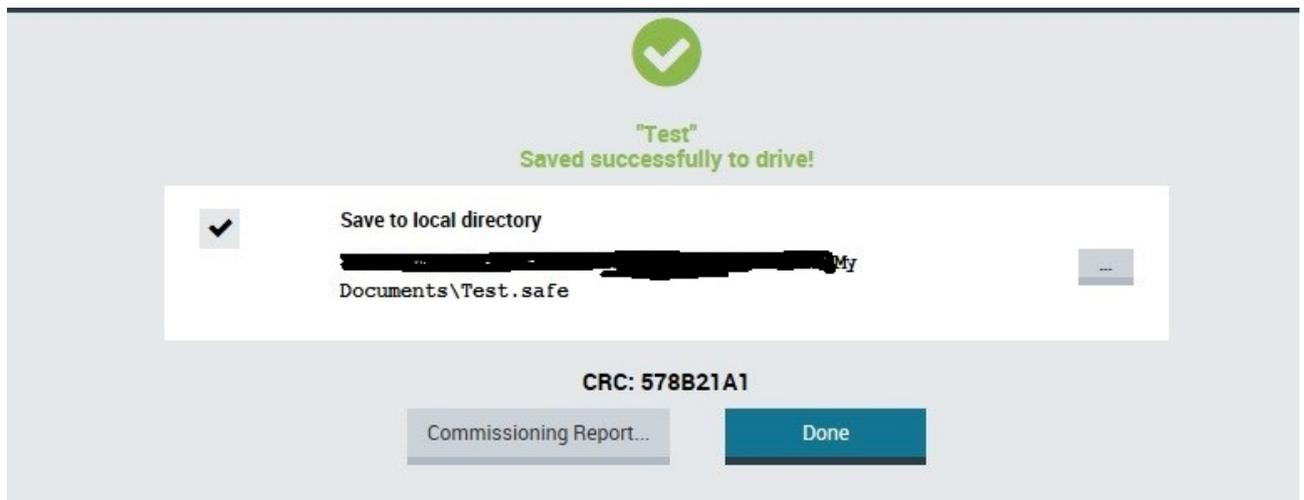


Figure 10.

Take a note of the *CRC* value shown on the screen. It is also used in the PLC configuration together with other PROFIsafe parameters.

5.3 PLC CONFIGURATION

Start a new project in TIA Portal. Open the *Devices & Networks* view and drag and drop the controller type you have to the work area in the center of the screen. Drag and drop the VACON® OPTEA device to the same place. VACON® OPTEA can be found In *Other Field Devices* -> *PROFINET IO* -> *Drives* -> *VACON* -> *VACON Drives*. Assign OPTEA to the controller. Your HW configuration should look like in Figure 11.

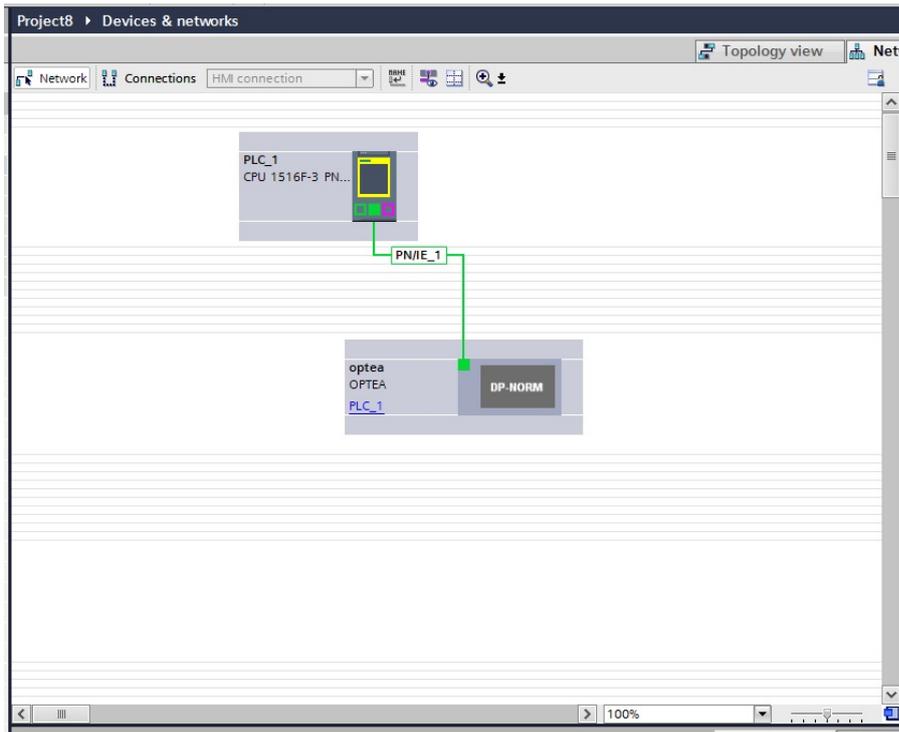


Figure 11.

Double-click on the OPTEA device to configure it. The available modules are shown in the right-side catalog. Plug in module ST1 from PROFIDRIVE folder to slot 1. Plug in module ST30 from the safety folder to slot 2 as shown in Figure 12.

Device overview							
...	Module	Rack	Slot	I address	Q address	Type	...
	optea	0	0			OPTEA	...
	Interface	0	0 X1			optea	...
	ST1_1	0	1	0...3	0...3	ST1	...
	ST30_1	0	2	4...9	4...9	ST30	...

Figure 12.

The view shows the *I address* and *Q address* values that will be needed with the PROFIsafe function blocks later.

By selecting the *Interface* in the upper screen, you can configure the PROFINET IO connection (name of station, IP address etc.). Remember to do those as well. For more information, refer to the VACON® OPTEA Installation Manual.

Select the *ST30_1* module and find its *Properties*. Select *PROFIsafe*.

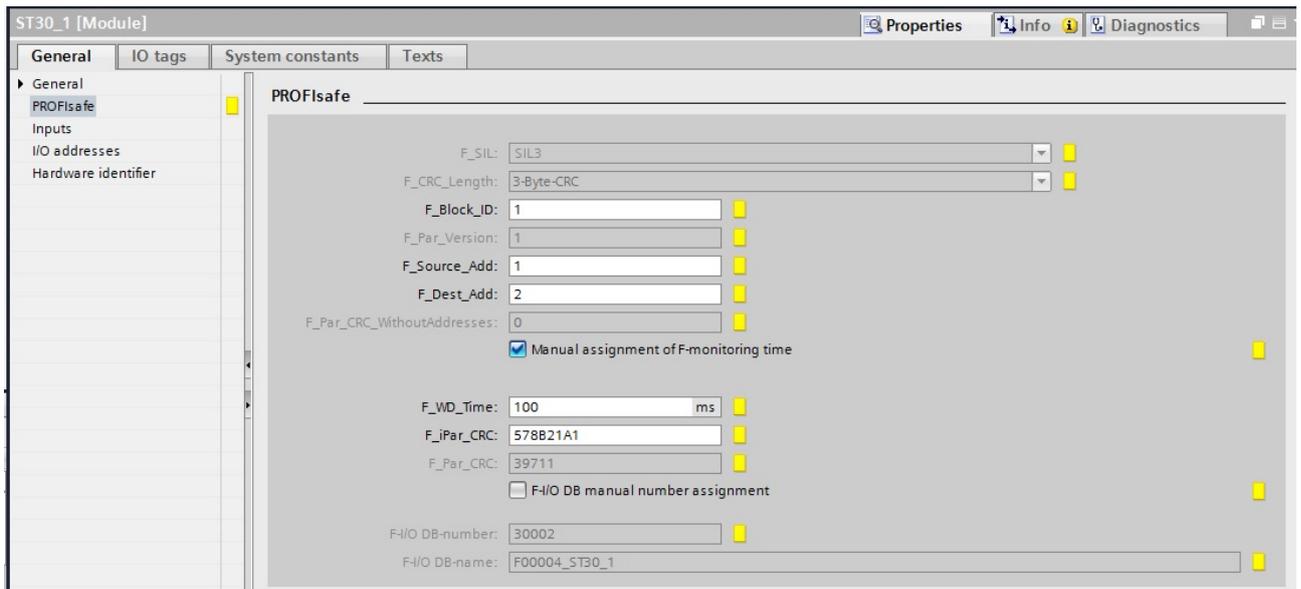


Figure 13. The Properties list

F_Block_ID can be left as it is. Fill out the other fields to have the same values as which were configured with VACON® Safe. *F_iPar_CRC* is the CRC value that VACON® Safe gives after a successful configuration.

5.3.1 F-Cycle time configuration for S1500 PLCs

Finally, set the *F-runtime group 1* cycle time to match the PROFIsafe watchdog time. You can edit it by double-clicking the *FOB_RTG1* program block. You can find it from the project tree.

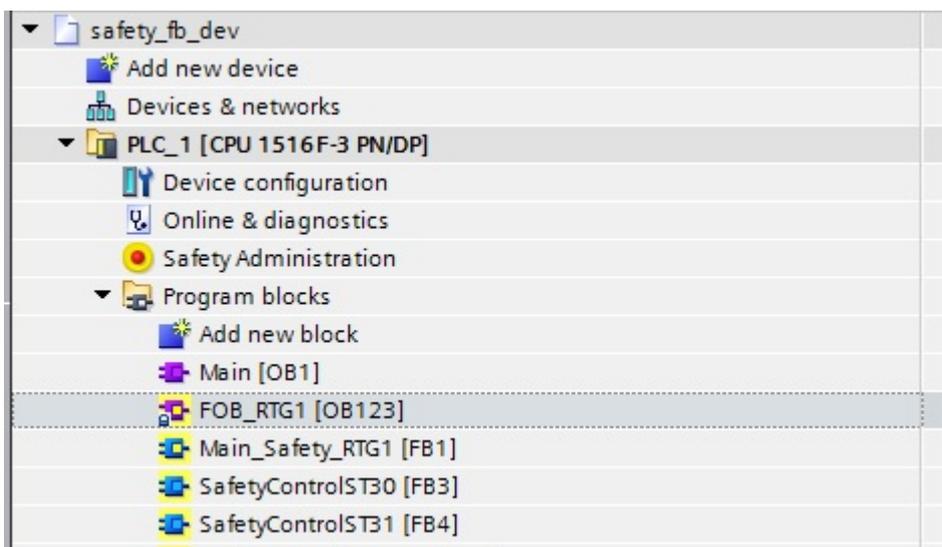


Figure 14. Location of the the *FOB_RTG1* program block

The properties of *FOB_RTG1* become visible.

F-runtime group 1 [RTG1]

Fail-safe organization block

Name:

Event class:

Number:

Cycle time: μs

Phase shift: μs

Priority:

calls →

Main safety block

I-DB:

F-runtime group parameters

Warn cycle time of the F-runtime group: μs

Maximum cycle time of the F-runtime group: μs

DB for F-runtime group communication:

F-runtime group information DB:

Figure 15.

Set the *Cycle time* to a value that is 1/10 of F_WD_time . If this value is too close to F_WD_time , there is risk of triggering PROFIsafe watchdog and the drive will enter a fail-safe state unnecessarily.

5.4 PLC PROGRAMMING

To add the PROFIsafe function blocks to your program, drag and drop the correct function blocks from the library to your project as shown in Figure 16.

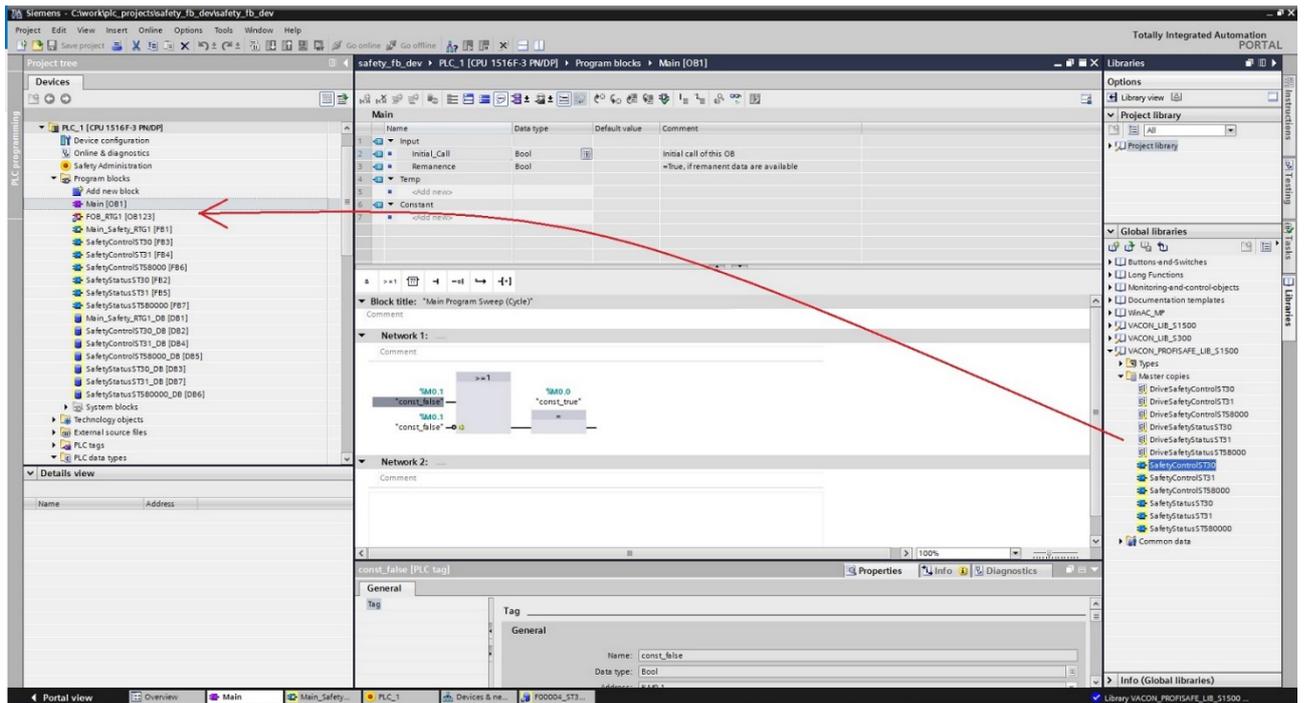


Figure 16.

In the screenshot, all the blocks are copied to *Program blocks*. This is not necessary, and in this example, only function blocks *SafetyControlST30* and *SafetyStatusST30* are needed.

Drag and drop the PLC data types to your project. They go under *PLC data types*, see Figure 17.

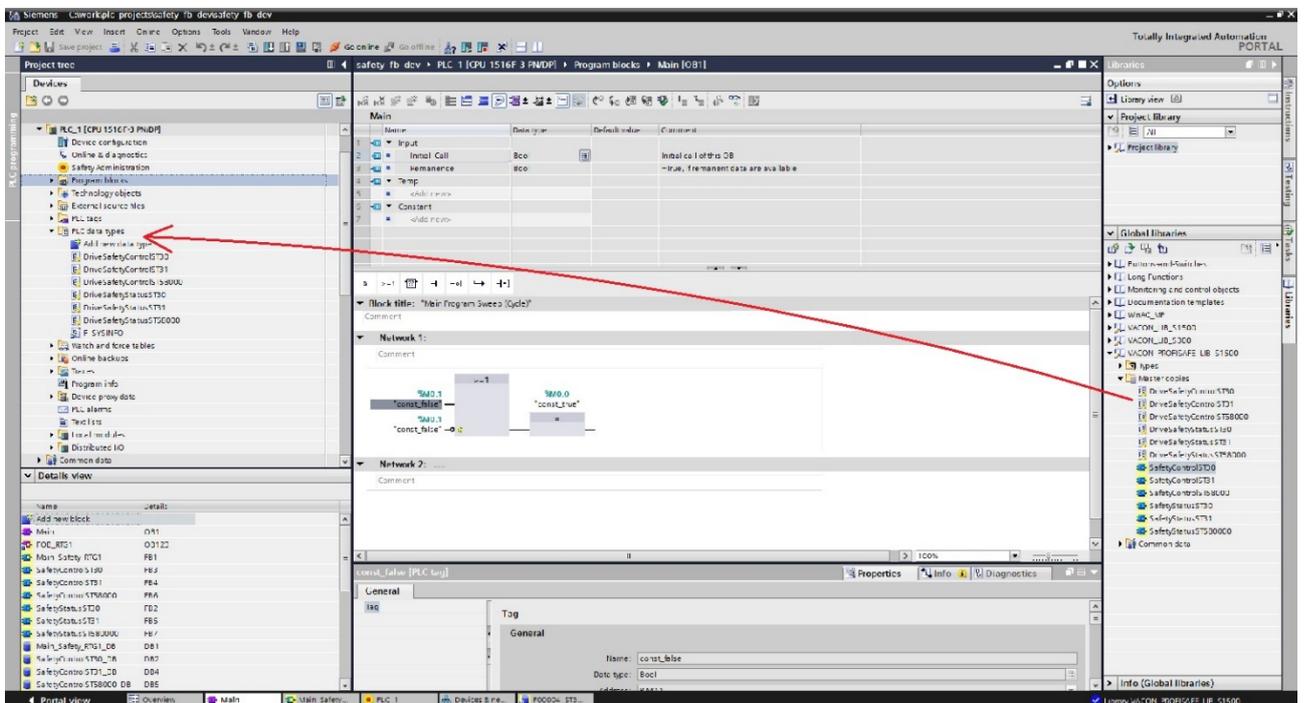


Figure 17.

5.4.1 F-IO data blocks

All the safety telegrams present in the PLC project have an F-IO data block attached to them. This block is used to check and control different signals related to the safety telegram.

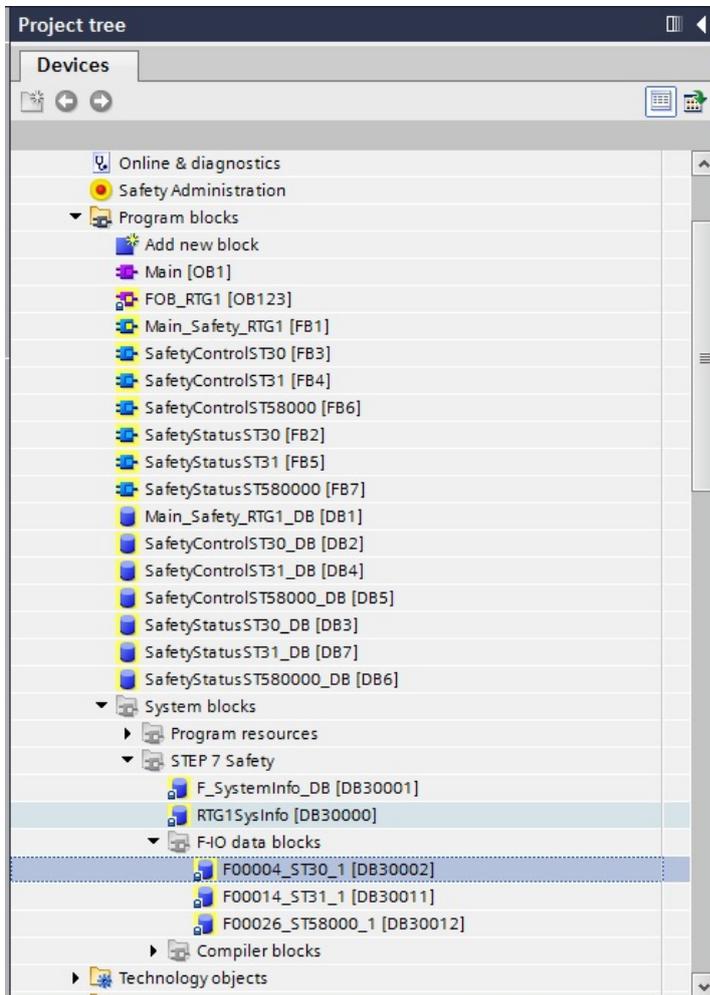


Figure 18. Location of the F-IO data blocks

At present, the most important signals are *ACK_REQ* and *ACK_REI*. Other signals that could be important are *QBAD*, which signals that the device is in fail-safe state, *PASS_OUT*, which signals that the device is passivated, or *PASS_ON*, which is used to passivate the device. Passivation means that the device is in fail-safe state and cannot operate.

ACK_REQ signals that the device has detected a communication fault, and before it can be operated it must be activated via *ACK_REI* signal. A simple automatic acknowledgement can be achieved by the network shown in Figure 19.

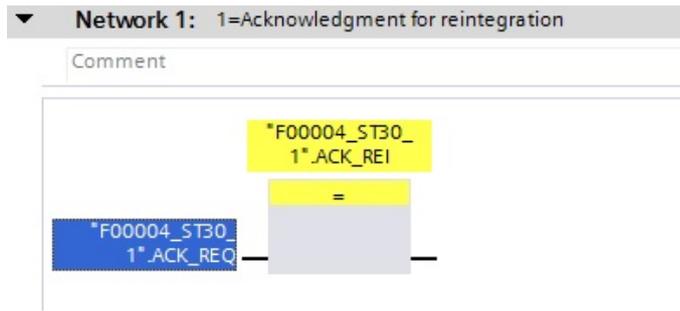


Figure 19.

If you do not want to use automatic acknowledgement, you must assign, for example, a Remote IO to control this signal.

5.4.2 PROFIsafe function block configuration

Create the tags for the data types used by PROFIsafe function blocks.

	Name	Tag table	Data type	Address	Retain	Visibl...	Acces...	Comment
1	const_true	Default tag table	Bool	%M0.0	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
2	const_false	Default tag table	Bool	%M0.1	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
3	dummy	Default tag table	Bool	%M0.2	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
4	PROFIsafeControlST30_Drive1	Default tag table	*DriveSafetyControlST30*	%Q4.0	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
5	PROFIsafeStatusST30_Drive1	Default tag table	*DriveSafetyStatusST30*	%I4.0	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
6	PROFIsafeControlST31_Drive2	Default tag table	*DriveSafetyControlST31*	%Q14.0	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
7	PROFIsafeStatusST31_Drive2	Default tag table	*DriveSafetyStatusST31*	%I14.0	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
8	PROFIsafeControlST58000_Drive3	Default tag table	*DriveSafetyControlST58000*	%Q26.0	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
9	PROFIsafeStatusST58000_Drive1	Default tag table	*DriveSafetyStatusST58000*	%I26.0	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
10	Tag_1	Default tag table	Bool	%M10.0	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
11	<Add new>				<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	

Figure 20. Example of data type tags

Notice the address assignment for tags *PROFIsafeControlST30_Drive1* and *PROFIsafeStatusST30_Drive1*. They are assigned the values *%Q4.0* and *%I4.0* respectively, and the values correspond to the addresses in the module configuration that was done earlier. Same mapping must be done for all devices that are controlled by the function blocks in the library.

Next, create an instance of both *SafetyControlST30* and *SafetyStatusST30* and map their signals to whatever is needed in your program.

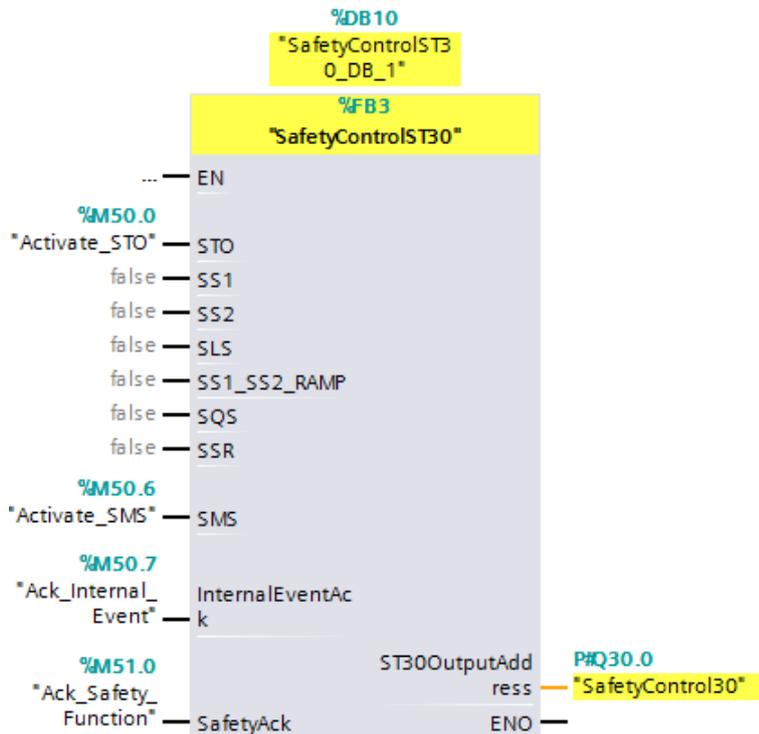


Figure 21. Example mapping of SafetyControlST30

In this example, the signals are mapped to memory variables. This way they can be controlled via an online connection to PLC. Usually they should be mapped to, for example, remote IO (E-Stop buttons etc.). Remember to map the unused safety function inputs to constant *false*.

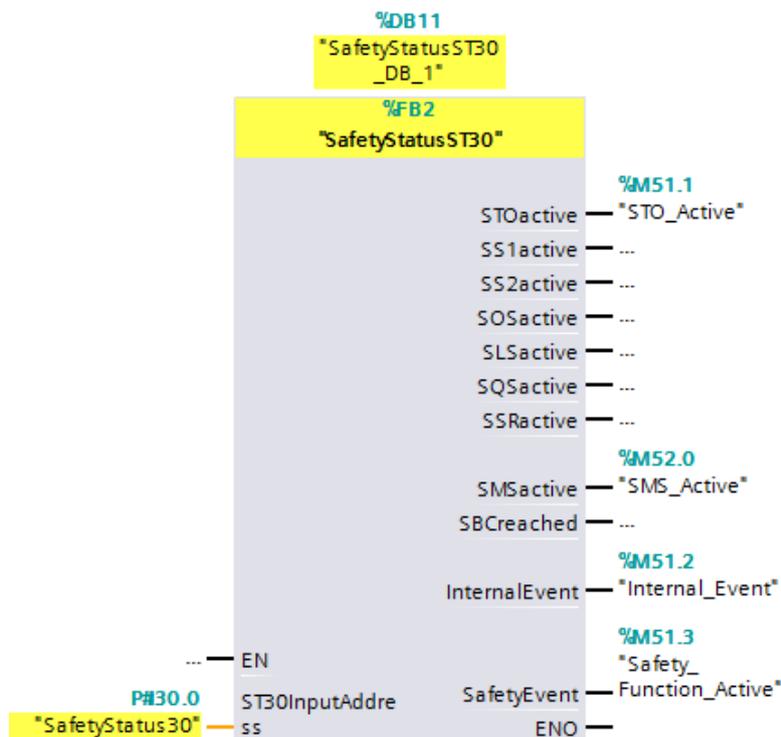


Figure 22. Example mapping of SafetyStatusST30

Now you can compile and download the program to the PLC.

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Vacon Ltd
Member of the Danfoss Group
Runsorintie 7
65380 Vaasa
Finland

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