IO-Link
Smart Sensor Profile
2nd Edition

Specification

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Important notes:

NOTE 1 The IO-Link Community Rules shall be observed prior to the development and marketing of IO-Link products. The document can be downloaded from the www.io-link.com portal.

NOTE 2 Any IO-Link device shall provide an associated IODD file. Easy access to the file and potential updates shall be possible. It is the responsibility of the IO-Link device manufacturer to test the IODD file with the help of the IODD-Checker tool available per download from www.io-link.com.

NOTE 3 Any IO-Link devices shall provide an associated manufacturer declaration on the conformity of the device with this specification, its related IODD, and test documents, available per download from www.io-link.com.

Conventions:

In this specification the following key words (in **bold** text) will be used:
may: indicates flexibility of choice with no implied preference.
should: indicates flexibility of choice with a strongly preferred implementation.
shall: indicates a mandatory requirement. Designers **shall** implement such mandatory requirements to ensure interoperability and to claim conformity with this specification.

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0 Introduction

0.1 General

The Single-drop Digital Communication Interface (SDCI) and system technology (IO-Link™[1]) for sensors and actuators is standardized within IEC 61131-9 [1]. The technology is an answer to the need of these digital/analog sensors and actuators to exchange process data, diagnosis information and parameters with a controller (PC or PLC) using a low-cost, digital communication technology while maintaining backward compatibility with the current DI/DO signals as defined in IEC 61131-2.

Any SDCI compliant Device can be attached to any available interface port of an SDCI Master. SDCI compliant devices perform physical to digital conversion in the device, and then communicate the result directly in a standard 24 V I/O digital format, thus removing the need for different DI, DO, AI, AO modules and a variety of cables.

Physical topology is point-to-point from each Device to the Master using 3 wires over distances up to 20 m. The SDCI physical interface is backward compatible with the usual 24 V I/O signalling specified in IEC 61131-2. Transmission rates of 4,8 kbit/s, 38,4 kbit/s and 230,4 kbit/s are supported.

Tools allow the association of Devices with their corresponding electronic I/O device descriptions (IODD) and their subsequent configuration to match the application requirements [2].

This document describes a common part of a sensor model that should be valid for future Device profiles and a more specific part for so-called Smart Sensors.

This document follows the IEC 62390 [3] to a certain extent.

Terms of general use are defined in IEC 61131-1 or in [4]. Specific SDCI terms are defined in this part.

0.2 Patent declaration

There are no known patents related to the content of this document.

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PROGRAMMABLE CONTROLLERS —

Profile for Smart Sensor Devices according IEC 61131-9 (Single-drop Digital Communication Interface – SDCI)

1 Scope

The single-drop digital communication interface (SDCI) technology described in part 9 of the IEC 61131 series focuses on simple sensors and actuators in factory automation, which are nowadays using small and cost-effective microcontrollers. With the help of the SDCI technology, the existing limitations of traditional signal connection technologies such as switching 0/24 V, analog 0 to 10 V, etc. can be turned into a smooth migration. Classic sensors and actuators are usually connected to a fieldbus system via input/output modules in so-called remote I/O peripherals. The (SDCI) Master function enables these peripherals to map SDCI Devices onto a fieldbus system or build up direct gateways. Thus, parameter data can be transferred from the PLC level down to the sensor/actuator level and diagnosis data transferred back in turn by means of the SDCI communication. This is a contribution to consistent parameter storage and maintenance support within a distributed automation system. SDCI is compatible to classic signal switching technology according to part 2 of the IEC 61131 series.

This document defines the model of a so-called Smart Sensor. This model comprises process data structures, binary switching Setpoints and hysteresis, best practice handling of quantity measurements with or without associated units and teaching commonalities.

The overall valid Function profile Identification and Diagnosis is specified in [7].

This document contains statements on conformity testing for Smart Sensor Devices and profile specific IODD features.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61131-3*, Programmable controllers – Part 2: Programming languages*

IEC 61131-9, *Programmable controllers – Part 9: Single-drop digital communication interface for small sensors and actuators (SDCI)*

3 Terms, definitions, symbols, abbreviated terms and conventions

3.1 Common terms and definitions

For the purposes of this document, the following terms and definitions in addition to those given in IEC 61131-1 and IEC 61131-2 apply.

3.1.1
Application Specific Tag
Device parameter indicating either the role or the location of the Device

[SOURCE: IEC 61131-9, B.2.16]

3.1.2
Detailed Device Status
Device parameter providing currently pending Events

[SOURCE: IEC 61131-9, B.2.19]

3.1.3
Device
single passive peer to a Master such as a sensor or actuator

Note 1 to entry: Uppercase "Device" is used for SDCI equipment, while lowercase "device" is used in a generic manner.

[SOURCE: IEC 61131-9, 3.1.14]

3.1.4
DeviceID
DID
Device parameter containing its unique identifier per VendorID

[SOURCE: IEC 61131-9, B.1.9]

3.1.5
Device Status
Device parameter containing a number of well-defined as well as reserved Device conditions

EXAMPLE Maintenance required, out-of-specification, etc.

[SOURCE: IEC 61131-9, B.2.18]

3.1.6
dynamic parameter
part of a Device's parameter set defined by on-board user interfaces such as teach-in buttons or control panels in addition to the static parameters

NOTE 1 to entry: New wording suggested for IEC 61131-9: Device parameters which change their values triggered by Device internal processes such as a teach-in or change of status

[SOURCE: IEC 61131-9, 3.1.16]

3.1.7
Firmware Revision
Device parameter containing its vendor specific coding for the firmware revision

[SOURCE: IEC 61131-9, B.2.15]

3.1.8
ISDU
indexed service data unit used for acyclic acknowledged transmission of parameters that can be segmented in a number of M-sequences

[SOURCE: IEC 61131-9, 3.1.21]

3.1.9
manufacturer
supplier of Device or Master acting as original equipment manufacturer (OEM) with its own VendorID and responsibility for product features and quality or as supplier to third parties via brandlabeling (*vendors*)

3.1.10
Master
active peer connected through ports to one up to n Devices and which provides an interface to the gateway to the upper level communication systems or PLCs

Note 1 to entry: Uppercase "Master" is used for SDCI equipment, while lowercase "master" is used in a generic manner.

[SOURCE: IEC 61131-9, 3.1.27]

3.1.11
On-request Data
acyclically transmitted data upon request of the Master application consisting of parameters or Event data

[SOURCE: IEC 61131-9, 3.1.29]

3.1.12
PD Input Descriptor
Device parameter containing the data structure description of the input Process Data of a profile Device

[SOURCE: IEC 61131-9, B.2.6]

3.1.13
PD Output Descriptor
Device parameter containing the data structure description of the output Process Data for a profile Device

[SOURCE: IEC 61131-9, B.2.7]

3.1.14
port
communication medium interface of the Master to one Device

[SOURCE: IEC 61131-9, 3.1.31]

3.1.15
Process Data
input or output values from or to a discrete or continuous automation process cyclically transferred with high priority and in a configured schedule automatically after start-up of a Master

[SOURCE: IEC 61131-9, 3.1.33]

3.1.16
Product Name
Device parameter containing the complete product name

[SOURCE: IEC 61131-9, B.2.10]

3.1.17
Product ID
Device parameter containing the vendor specific product or type identification of the Device

[SOURCE: IEC 61131-9, B.2.11]

3.1.18
Profile Characteristic
Device parameter containing the ProfileIdentifiers (PFIDs) corresponding to its implemented profile

[SOURCE: IEC 61131-9, B.2.5]

3.1.19
Profile Parameter
reserved Indices for Device profiles within the range of 0x0031 to 0x003F

[SOURCE: IEC 61131-9, B.2.23]

3.1.20
Profile Specific Index
Index within 0x4000 to 0x4FFF, reserved for Device profiles

[SOURCE: IEC 61131-9, B.2.26]

3.1.21
static parameter
part of a Device's parameter set to be saved in a Master for the case of replacement without engineering tools

[SOURCE: IEC 61131-9, 3.1.37]

3.1.22
switching signal
binary signal from or to a Device when in SIO mode (as opposed to the "coded switching" SDCI communication)

[SOURCE: IEC 61131-9, 3.1.38, modified]

3.1.23
vendor
supplier of Devices or Masters not necessarily identical with the original equipment manufacturer thereof, providing an individual VendorID, and being responsible for product features and quality

EXAMPLE Brandlabeling

3.1.24
VendorID
VID
Device parameter containing a unique vendor identification assigned by the IO-Link Community

[SOURCE: IEC 61131-9, B.1.8]

3.1.25
Vendor Name
Device parameter containing only one of the vendor names listed for the assigned VendorID

[SOURCE: IEC 61131-9, B.2.8]

3.2 Smart sensor profile: Additional terms and definitions

3.2.1
Binary Data Channel
BDC
Function Class for binary values with a fixed set of attributes defining the switch behavior and the *Setpoints*

Note 1 to entry: This term has been defined and used in Edition 1. It has been renamed to *Switching Signal Channel* in Edition 2.

3.2.2
dynamic teach start
teach-in command to start continuous capturing of teach-in values

3.2.3
dynamic teach stop
teach-in command to terminate a dynamic teach and to evaluate the teach-in values

3.2.4
Function Block
FB
contains the inputs, outputs, processes, requirements, and constraints of a given function used in PLC systems

3.2.5
FunctionClass
FC
particular function within a Device profile identified by a 16 bit code within the range of 0x8000 to 0xBFFF

Note 1 to entry: A profile Device can use one or several FunctionClasses one or several times.

3.2.6
Gradient
rate at which a measurement value changes with respect to a changing physical quantity

3.2.7
High-active
state of "high", if a target is detected or a threshold level has been exceeded

3.2.8
Low-active
state of "low", if a target is detected or a threshold level has been exceeded

3.2.9
Measuring Data Channel
MDC
FunctionClass for measurement values with a fixed set of attributes defining the measurement and exact descriptionof the values within the Process Data

3.2.10
measuring sensor
Device comprising a transducer for continuously capturing physical quantities and a communication unit for the transmission of corresponding digital values

3.2.11
Offset
difference between a transmitted digital value and its physical quantity value

3.2.12
Programmable Logic Controller
PLC
Microcomputer embedded in or attached to a device to perform switching, timing, or machine or process control tasks

3.2.13
Process Data Variable
PDV
representation of process values

3.2.14
Profile Identifier
ProfileID
16 bit code within the range of 0x0001 to 0xBFFF identifying a particular ProfileID

Note 1 to entry: See specification of ProfileIdentifier in [7]

3.2.15
RecordItem
item within a record as part of a parameter object

[SOURCE: [2]]

3.2.16
Scale
exponent (n) of a multiplier (with a base of 10) for measurement values

EXAMPLE The multiplier for a scale of 3 is 10^3

3.2.17
sensor diagnosis
Function Class for Device diagnosis information with fixed attributes on retrievable information from a Device after incidents

[SOURCE: IEC 61131-9, clause 10.9]

3.2.18
Setpoint
SP
measurement or detection value defining one *Switchpoint* within a *Switching Signal Channel*

3.2.19
single point mode
evaluation method with one single *Setpoint* where the binary output signal changes whenever the *Switchpoint* is passed

3.2.20
SingleValue

defined name for specific parameter value derived from IODD

[SOURCE: [2]]

3.2.21
single value teach
teach-in procedure capturing the *Teachpoint* to determinate the *Setpoint*

3.2.22
switching sensors
Devices measuring physical quantities or detecting presence of an object and providing switching signals with ON/OFF states depending on one or two *Setpoint* values

3.2.23
Switching Signal Channel
SSC
FunctionClass for measurement or detection values with a fixed set of attributes defining the switching behavior and the *Setpoints* and exactly one switching signal within the Process Data

Note 1 to entry: Represents a switching signal in form of a Processdata bit.

3.2.24
Switchpoint
measurement or detection value of a sensor where the switching signal changes its value

3.2.25
Switchpoint Hysteresis
attribute of the configuration defining the difference between active and inactive transitions of the *Switchpoints* for a *Switching Signal Channel*

3.2.26
Switchpoint Logic
attribute of the configuration defining the activity state of the *switching signal* for a *Switching Signal Channel*

3.2.27
Switchpoint Mode
attribute of the configuration of a switching signal based on a measurement that can be only one out of a set of possible operational modes for binary signals such as "Deactivated", "Single Point", "Window", or "Two Point “

Note 1 to entry: Vendor specific modes are possible

3.2.28
Teach-in apply
teach-in command, applied only in context with two value teach, to trigger the evaluation of two *Teachpoints* and to calculate a derived *Setpoint*

3.2.29
teach cancel
teach-in command to cancel the current teach-in procedure without calculation of the *Setpoints* and to restore previous values

3.2.30
teach flag
indication for the successful determination of a *Teachpoint*

3.2.31
teach-in
procedure within a Device to determine *Teachpoints* and to derive *Setpoint* values for a particular switching function

3.2.32
Teach-in Select
TI Select
parameter selecting a *Switching Signal Channel* for the application of *teach-in commands*

3.2.33
Teach-in command
system command to trigger or control a technology specific teach-in procedure

3.2.34
Teach-in Result
parameter providing the indications for *teach-in flags* and *teach-in state*

3.2.35
Teachpoint
TPn
value determined during a *teach-in* procedure and serving as input for a *Setpoint* calculation

3.2.36
teach state
indication of the current state of the *teach-in* procedure

3.2.37
transducer
the measuring or detection element of the sensor

3.2.38
two point mode
evaluation method defined by two *Setpoints* where the *switching signal* only changes if the sensor measurement or detection value decreases from above the highest *Setpoint* and passes the lowest *Setpoint* or if it increases from below the lowest *Setpoint* and passes the highest *Setpoint*

3.2.39
two value teach
teach-in procedure requiring two *Teachpoints* to determine one *Setpoint*

3.2.40
unit code
attribute with standardized codes for physical units

3.2.41
window mode

evaluation method using two *Setpoints* defining a window area, inside the switching signal is active

3.3 Symbols and abbreviated terms

DI	Digital input
DO	Digital output
FC	Function class
I/O	Input / output
OD	On-request Data
PD	Process Data
PLC	Programmable logic controller
SDCI	Single-drop digital communication interface

SIO	Standard Input Output (binary switching signal)	[IEC 61131-2]
SP	Setpoint	
SP1	Setpoint 1	
SP2	Setpoint 2	
SSC	Switching signal channel	
TP1	Teachpoint 1	
TP2	Teachpoint 2	

3.4 Conventions

3.4.1 Behavioral descriptions

For the behavioral descriptions, the notations of UML 2 [4] are used, mainly state diagrams. The layout of the associated state-transition tables is following IEC 62390 [3].

Triggers are for example external requests ("calls") or internal changes such as timeouts; [guard] are Boolean conditions for exits of states; numbered transitions describe actions in addition to the triggers within separate state-transition tables.

In this document, the concept of "nested states" with superstates and substates is used as shown in the example of Figure 1.

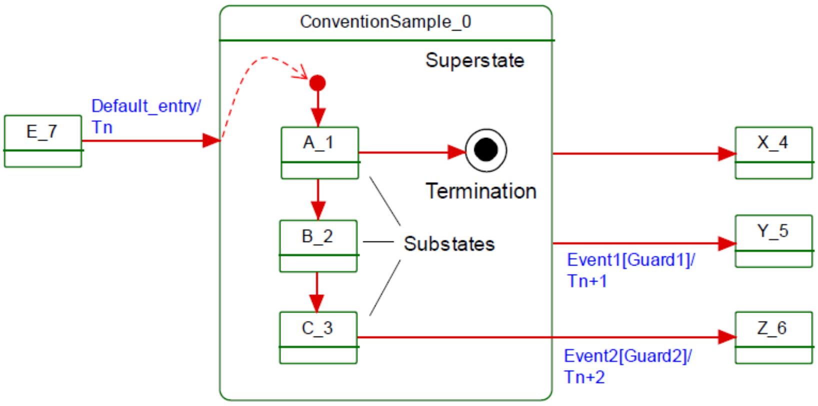


Figure 1 – Example of a nested state

UML 2 allows hierarchies of states with superstates and substates. The highest superstate represents the entire state machine. This concept allows for simplified modelling since the content of superstates can be moved to a separate drawing. An eyeglasses icon usually represents this content. Compared to "flat" state machines, a particular set of rules shall be observed for "nested states":

a) A transition to the edge of a superstate (e.g. Default_entry) implies transition to the initial substate (e.g. A_1).

b) Transition to a termination state inside a superstate implies a transition without event and guard to a state outside (e.g.X_4). The superstate will become inactive.

c) A transition from any of the substates (e.g. A_1, B_2, or C_3) to a state outside (Y_5) can take place whenever event1 occurs and guard1 is true. This is helpful in case of common errors within the substates. The superstate will become inactive.

d) A transition from a particular substate (e.g. C_3) to a state outside (Z_6) can take place whenever event2 occurs and guard2 is true. The superstate will become inactive.

The state diagrams shown in this document are entirely abstract descriptions. They do not represent a complete specification for implementation.

3.4.2 Memory and transmission octet order

Figure 2 demonstrates the order that shall be used when transferring WORD based data types from memory to transmission and vice versa (Figure 2).

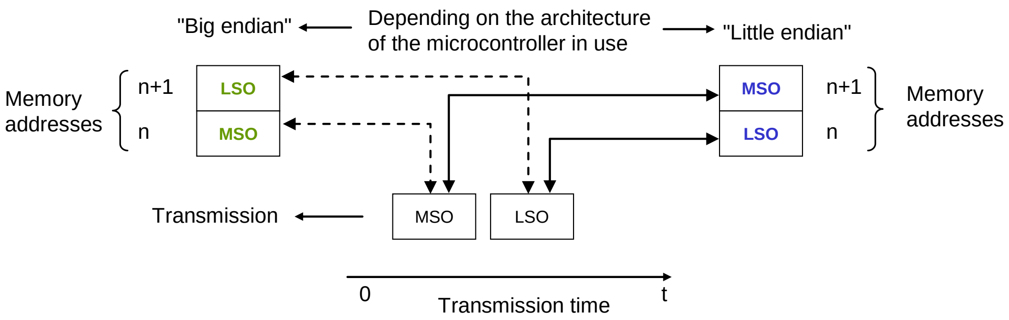


Figure 2 – Memory and transmission octet order

4 Overview of sensor devices

4.1 Smart Sensors

In factory automation, sensors nowadays are using a broad spectrum of transducers based on many different physical or chemical effects. They are converting one or more physical or chemical quantities (for example position, pressure, temperature, substance, etc.) and propagate them in an appropriate form to data processing units such as for example PLCs.

Due to the built-in microcontrollers these sensors are able to not only provide the conversion of the quantities but also to provide some preprocessing. Most of these sensors are "switching sensors". With the help of an individual parameterization or teaching process ("teach-in"), the sensors receive information on their "switching mode" and the Setpoint values. This can result in one or more binary information about the measured quantity. Depending on functionality, those sensors provide the following outputs

- Binary information to transfer a switching state and/or
- Analog information to transfer measurement values such as pressure or temperature

This widespread sensor type is called "Smart Sensor". It has been somewhat constrained so far by the conventional digital and analog interfaces defined in IEC 61131-2.

4.2 Sensors migrating to SDCI

It is the purpose of SDCI to overcome the limitations of the classic sensor interfaces DI, DO, AI, and AO via a point-to-point digital communication that allows transmitting not only binary and/or analog information but additional information also. Very often, the changes to the core sensor application ("sensor technology") are very little during the migration to SDCI. However, the user realizes a dramatic increase in comfort and flexibility through the identification, parameterization, and diagnosis features.

5 Smart Sensor profile

5.1 Objectives for the Smart Sensor profile

The user expects a common "view" on a profile Device as defined in [7] and therefore requires standardized functions. On the other hand, room for innovations is expected and the possibility of customer specific adaptations to a certain extent. With this background, Device profiles are always a challenge and they are striving for good compromises.

Objective for this Edition 2 is the definition of supplementary profiles defining a more stringent behavior for the associated complementary ProfileIDs. PLC programs shall remain unchanged when moving between different Devices supporting one particular complementary ProfileID. In case of Device replacement, only the Device identification within the port configuration needs to be changed.

While Edition 1 specifies a set of FunctionClasses from which a sensor designer can choose any combination, Edition 2 specifies a number of fixed combinations providing fixed functionality identified by an individual ProfileID.

In detail, the following requirements and objectives for the profile have been compiled:

- Manufacturer/vendor specific extensions (functions) shall always be possible.
- The profile specifies a set of standardized functions (FunctionClasses). If a manufacturer/vendor indicates particular FunctionClasses they shall be implemented and behave in the specified manner.
- Each Smart Sensor shall provide its manufacturer/vendor specific Device description file (IODD). It shall comply with the specified IODD profile template of a particular ProfileID.
- The Smart Sensor profile does not focus on particular measurement technologies such as pressure, temperature, and alike. It focuses on common technology-independent features.
- The Device model shall describe the behavior of the Smart Sensor ("Function model").
- The Smart Sensor profile specifies detailed Process Data layouts per ProfileID with accurate and substitute values to reduce the integration effort in a PLC program.
- Generic proxy function blocks for PLC programs are provided to illustrate the programming approach and to facilitate the deployment in PLC systems.
- Representation and transmission of the measurement information shall be based on Process Data Variables (PDV) and Switching Signal Channels (SSC).
- Necessary parameters for the profile shall be defined, for example setpoints, switching modes, etc.
- Uniform profile identification shall be specified (mandatory parameter objects).
- Uniform diagnosis information shall be defined.
- If appropriate a model of a PLC functionality is provided to give an example how to use the defined profile functionality from customer view.

5.2 Measurement categories for Smart Sensors

The Smart Sensor profile definitions are independent from the physical or chemical quantities to be measured. Table 1 contains a list of typical physical and chemical measurement quantities for Smart Sensors. The list is far from being complete.

Table 1 – Typical physical and chemical measurement quantities

Geometry	Movement	Force	Heat	Optic	Chemistry
Position Distance Angle Direction Strain Level	Travel Speed Rotation Displacement Acceleration Vibration	Force Pressure Tension Torque Acceleration	Temperature Heat Heat conductivity Specific heat	Refractivity Irradiance Light density Luminance Chrominance	Substances Volume fraction Mass fraction Humidity Conductivity pH value

Smart Sensors represent the measurement results in a uniform manner

- as switching information as Switching Signal Channels (SSC) or
- as measurement data information as Measurement Data Channel (MDC) or
- as Process Data Variables (PDV)

5.3 Smart Sensor object model

The Smart Sensor object model is based on the FunctionClass and ProfileID concepts defined in [7].

Each ProfileID specifies which FunctionClasses are mandatory or optional.

Devices conform to the legacy Smart Sensor Profile shall provide a list of the optional FunctionClasses in the parameter Profile Characteristic according [7].

The different types of smart sensor profiles are named with a description and can be identified by their type definition which is defined in Table 2. Subclasses are identified by an enumerator as postfix.

Table 2 – Smart Sensor Profile types

SSP types	Abbreviation	Description	Remark
SSP 0	GPS	Generic Profiled Sensor	See Annex F
SSP 1	FSS	Fixed Switching Sensor	See 6
SSP 2	AdSS	Adjustable Switching Sensor	See 7
SSP 3	DMS	Digital measuring Sensors	See 8

To distinguish the different profile sub types of the SSP types, these are numbered and a profile characteristic name is defined which shall be referenced within the Device documentation and the IODD.

6 Fixed switching sensors (FSS)

6.1 Overview

Fixed switching sensors (FSS) within the Smart Sensor Profile are Devices offering exactly one binary output signal (switching signal). The Setpoint of this switching output is predefined during the manufacturing process and is therefore fix for the application.

Support of the Profiles "Identification" and "Diagnosis" is mandatory when supporting these Profiles.

The FunctionClass "Transducer Disable" allows for switching off/on the transducer part of a sensor, for example a laser.

In addition, the Switchpoint Logic (High-active / Low-active) can be defined by the application.

Table 3 provides an overview of the FunctionClasses and the Process Data Structures for Fixed Switching Sensors. Since there are no options, only the ProfileID shall be listed in the Profile-Characteristic index, see [7].

Table 3 – Switching sensor profile types 1

Profile type	ProfileID	Profile characteristic name	Function Classes		Process Data structure (see Annex B)
			Switching signal channel a)	Transducer Disable b)	
SSP 1.1	0x0002	Fixed Switching Sensor	0x8005	–	PDI8.BOOL1
SSP 1.2	0x0003	Fixed Switching Sensor, disable function		0x800C	PDI8.BOOL1 PDO8.BOOL1

NOTE
a) See Annex A.2
b) See Annex A.6

7 Adjustable switching sensors (AdSS)

7.1 Overview

Adjustable switching sensors (AdSS) within the Smart Sensor Profile are Devices offering exactly one binary output signal (switching signal). The Setpoint of this switching output can be defined by the application either by entering a dedicated Setpoint value during configuration or with the help of a teach-in procedure.

In addition, different teach-in procedures such as single value teach, two value teach, or dynamic teach are possible thus easing the commissioning of the application. Individual combinations of these teach-in methods are permitted depending on the type of sensor.

The Switchpoint Logic (High-active / Low-active) can be defined by the application.

Support of the Profiles "Identification" and "Diagnosis" is mandatory when supporting these Profiles.

The FunctionClass "Transducer Disable" allows for switching off/on the transducer part of a sensor, for example a laser.

Table 4 provides an overview of the FunctionClasses and the Process Data structures for Adjustable Switching Sensors. Since there are no options, only the ProfileID shall be listed in the ProfileCharacteristic index, see [7].

Table 4 – Switching sensor profile types 2

<table>
<tr><th rowspan="3">Profile type</th><th rowspan="3">ProfileID</th><th rowspan="3">Profile characteristic name</th><th colspan="5">Function Classes</th><th rowspan="3">Process Data structure (see Annex B)</th></tr>
<tr><th rowspan="2">Switching Signal Channel a)</th><th colspan="3">Teach-in</th><th rowspan="2">Transducer Disable b)</th></tr>
<tr><th>Single value teach</th><th>Two value teach</th><th>Dynamic teach</th></tr>
<tr><td>SSP 2.1</td><td>0x0004</td><td>Adjustable Switching Sensor, single value teach</td><td rowspan="6">0x8006</td><td>0x8007</td><td>–</td><td>–</td><td rowspan="3">–</td><td rowspan="3">PDI8.BOOL1</td></tr>
<tr><td>SSP 2.2</td><td>0x0005</td><td>Adjustable Switching Sensor, two value teach</td><td>–</td><td>0x8008</td><td>–</td></tr>
<tr><td>SSP 2.3</td><td>0x0006</td><td>Adjustable Switching Sensor, dynamic teach</td><td>–</td><td>–</td><td>0x8009</td></tr>
<tr><td>SSP 2.4</td><td>0x0007</td><td>Adjustable Switching Sensor, single value teach, disable function</td><td>0x8007</td><td>–</td><td>–</td><td rowspan="3">0x800C</td><td rowspan="3">PDI8.BOOL1
PDO8.BOOL1</td></tr>
<tr><td>SSP 2.5</td><td>0x0008</td><td>Adjustable Switching Sensor, two value teach, disable function</td><td>–</td><td>0x8008</td><td>–</td></tr>
<tr><td>SSP 2.6</td><td>0x0009</td><td>Adjustable Switching Sensor, dynamic teach, disable function</td><td>–</td><td>–-</td><td>0x8009</td></tr>
<tr><td colspan="9">NOTE
a) See Annex A.2
b) See Annex A.6</td></tr>
</table>

7.2 Possible combinations of switching sensor profile characteristics

Table 5 shows all permitted combinations of profiles within one Device.

Table 5 – Possible switching sensor profile combinations

SSP types	ProfileIDs
SSP 2.1 + SSP 2.2	0x0004 + 0x0005
SSP 2.1 + SSP 2.3	0x0004 + 0x0006
SSP 2.2 + SSP 2.3	0x0005 + 0x0006
SSP 2.1 + SSP 2.2 +SSP 2.3	0x0004 + 0x0005 + 0x0006
SSP 2.4 + SSP 2.5	0x0007 + 0x0008
SSP 2.4 + SSP 2.6	0x0007 + 0x0009
SSP 2.5 + SSP 2.6	0x0008 + 0x0009
SSP 2.4 + SSP 2.5 +SSP 2.6	0x0007 + 0x0008 + 0x0009

7.3 Proxy Function Block (FB) for for Adjustable Switching Sensors

To ease the integration in Run-Time systems like PLCs, an appropriate FunctionBlock is specified in D.1. By using this an operator can perform the teach actions based only on the teach principle without knowledge of the used parameters or data. Also all failure reactions and specific actions were performed and the operator gets simple results. The behaviour and functionality is mapped in the view and system level of the operator.

8 Digital measuring sensors (DMS)

8.1 Overview

In principle, SDCI communication allows any data representation of measured values. As a consequence many different data structures with different data types can occur, which may lead to higher engineering costs at commissioning, maintenance (exchange of Devices) and porting of user programs from one PLC to another.

Thus, it is the purpose of this profile to standardize also the data structures for measuring sensors.

At first the number of data structures for any measuring sensor is limited. The data structures are defined without considering unit variants. This implies also some rules for the permitted value ranges and a definition of limit/substitute values for specific data types. Together with a fixed-point value an applicable scale (factor equals to 10^{scale}) is provided to allow for automatic handling of the data type in function blocks. This allows small footprint sensor applications, simple usage of the fixed point value, and also a convenient calculation by a function call within a PLC.

The data structures will be assigned to specific parameters defining the physical quantities in SI units and measuring limits of the specific Device, see annex C.6.

The highly recommended combinations of data structures and SI units are defined to reduce different interpretations of physical measurements.

In Table 6, the possible combinations of FunctionClasses for the measuring Device profile are defined. Each ProfileID represents one single combination comprising the mandatory FunctionClasses. Since there are no options, only the ProfileID shall be listed in the ProfileCharacteristic index, see [7].

Support of the Profiles "Identification" and "Diagnosis" is mandatory when supporting these Profiles.

A particular FunctionClass "TransducerDisable" allows for switching off/on the transducer of the measuring Device.

Table 6 – Measuring Device profile types 3

Profile type	ProfileID	Profile characteristic name	FunctionClasses		Process Data structure (see Annex B)
			Measurement	Transducer Disable [a)]	
SSP 3.1	0x000A	Measuring Sensor	0x800A	–	PDI32.INT16_INT8
SSP 3.2	0x000B	Measuring Sensor, high resolution	0x800B		PDI48.INT32_INT8
SSP 3.3	0x000C	Measuring Sensor, disable function	0x800A	0x800C	PDI32.INT16_INT8 PDO8.BOOL1
SSP 3.4	0x000D	Measuring Sensor, high resolution, disable function	0x800B		PDI48.INT32_INT8 PDO8.BOOL1

NOTE
a) See Annex A.6

8.2 Proxy function call for measuring sensors

To ease the integration in Run-Time systems like PLCs, an appropriate FunctionCall is specified in D.4. The FunctionCall decodes the process data from the device and provides the information in a way an operator can use directly in any PLC program. All specific decoding action is taken without any required specific knowledge of the data structure.

Annex A
(normative)
FunctionClasses

A.1 Overview

Table A.1 provides an overview of the defined or referenced FunctionClasses together with references to the Common Profile specification [7] and clauses within this document.

Table A.1 – Overview of FunctionClasses

Function-Class	Name	Reference / Clause
[0x8000]	Device Identification	[7] A.2
[0x8001]	Multi-channel, two setpoint switching sensor, type 0 Generic Profiled Sensor	F.3, [7]
[0x8002]	Process Data Variable (PDV)	[7] A.3
[0x8003]	Device Diagnosis	[7] A.4
[0x8004]	Teach Channel	F.4
[0x8005]	Fixed Switching Signal Channel	6, A.2,
[0x8006]	Adjustable Switching Signal Channel	7, A.3
[0x8007]	Teach-in single value	7, A.4
[0x8008]	Teach-in two value	7, A.4
[0x8009]	Teach-in dynamic	7, A.4
[0x800A]	Measurement Data Channel, (standard resolution)	8, A.5
[0x800B]	Measurement Data Channel, (high resolution)	8, A.5
[0x800C]	Transducer Disable	0

A.2 Fixed Switching Signal Channel – [0x8005]

A.2.1 General

The FunctionClass “Fixed Switching Signal Channel” has one predefined Setpoint, which cannot be altered by the user application. Therefore, this FunctionClass cannot be combined with teach-in FunctionClasses. The switchpoint of the switching signal is directly derived from the fixed Setpoint.

A.2.2 Switchpoint Logic

The function class provides the object SSC Config, containing the parameter Logic, which can be set to "high-active" or "low-active" according to the application requirements. This results in an inverted switching behavior of the switching signal.

High-active the switching signal is "high", if a target is detected or a threshold level has been exceeded.

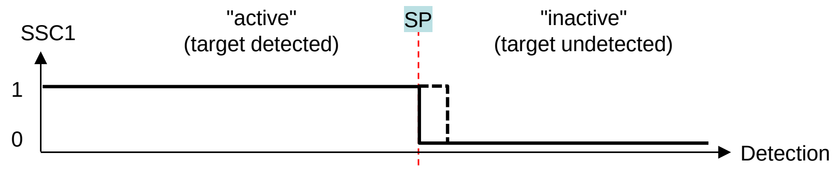
Low-active the switching signal is "low", if a target is detected or a threshold level has been exceeded.

"High-active" is the default setting.

A.2.3 Presence and quantity detection

Switching sensors generally exist in two basic categories – presence detection and quantity detection. The following figures show the differences in the switching signal behavior.

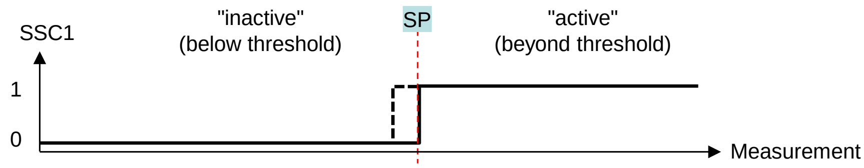
Figure A.1 demonstrates the Switching Signal for a sensor of type presence detection and configured as High-active.



NOTE Hysteresis is manufacturer specific

Figure A.1 – Switching signal – presence detection

Figure A.2 demonstrates the Switching Signal for a sensor of type quantity detection and configured as High-active.



NOTE Hysteresis is manufacturer specific

Figure A.2 – Switching signal – quantity detection

A.2.4 Mapping to SDCI communication

The mapping and coding of the parameter SSC Config - Logic is defined in Annex C.3.

A.3 Adjustable Switching Signal Channel – [0x8006]

A.3.1 General

The FunctionClass "Adjustable Switching Signal Channel" provides settings for adjustment of Setpoint and Switchpoint Logic. The switchpoint of the switching signal is directly derived from the Setpoint.

A.3.2 Setpoint

The parameter Setpoint defines the switchpoints of the switching signal. The setting can have a physical unit.

The manufacturer/vendor is responsible for the mapping of the setpoint to the observed switchpoint.

A.3.3 Switchpoint Logic

This parameter is common with the Fixed Switching Signal Channel, see definitions in Annex A.2.2.

A.3.4 Presence and quantity detection

This behaviour is common with the Fixed Switching Signal Channel, see definitions in Annex A.2.3.

A.3.5 Function Block Proxy

A corresponding Proxy Function Block is specified in D.1.

A.4 Teach-in FunctionClasses – [0x8007] to [0x8009]

A.4.1 Overview

The function classes [0x8007] to [0x8009] provide a specialized teach functionality for adjustable switching sensors (AdSS) with only one Setpoint SP:

- FunctionClass 0x8007 provides a single value Teach-in
- FunctionClass 0x8008 provides a two value Teach-in
- FunctionClass 0x8009 provides a dynamic Teach-in

The functionality of all Teach FunctionClasses corresponds to the general "Teach Channel [0x8004]" (see F.4). Main differences to "Teach Channel" are:

- Adjustable switching sensors provide only one setpoint SP, corresponding to SP1 in "Teach Channel" [0x8004]. Therefore, the teach commands for SP2 are not supported.
- Adjustable switching sensors provide only one Switching Signal Channel. Therefore, the parameter "Teach-in channel" according F.4 is not supported.

It is possible to combine the Teach FunctionClasses within a Device.

A.4.2 Teach-in commands

The "Teach-in commands" allow teaching of a teachpoint (TP) or controlling of the teach-in procedure. A subset of the Teach-in commands defined for function class "Teach Channel [0x8004]" (see F.4.3) is used. The Teach-in commands of FunctionClasses Single Point Teach-in [0x8007], Two Point Teach-in [0x8008], and Dynamic Teach-in [0x8009] are described in Table C.5.

A.4.3 Parameter "Teach-in Result"

The parameter "Teach-in Result" provides feedback on the status and the results of the teach-in activities. The parameter mapping and coding is described in Figure C.1, and Table C.6, Table C.7.

A.4.4 Teach-in behavior of the Teach FunctionClasses

A.4.4.1 General

All teach-in procedures require a sequential interaction between user program (PLC) and Device. The sequence is described herein via a Device state machine. The Device signals the actual state using the parameter "Teach-in Result"; the user program (PLC) sends teach-in commands by means of the Master.

The state machine shall be in Teach_Idle_0 in order to start a new teach-in procedure.

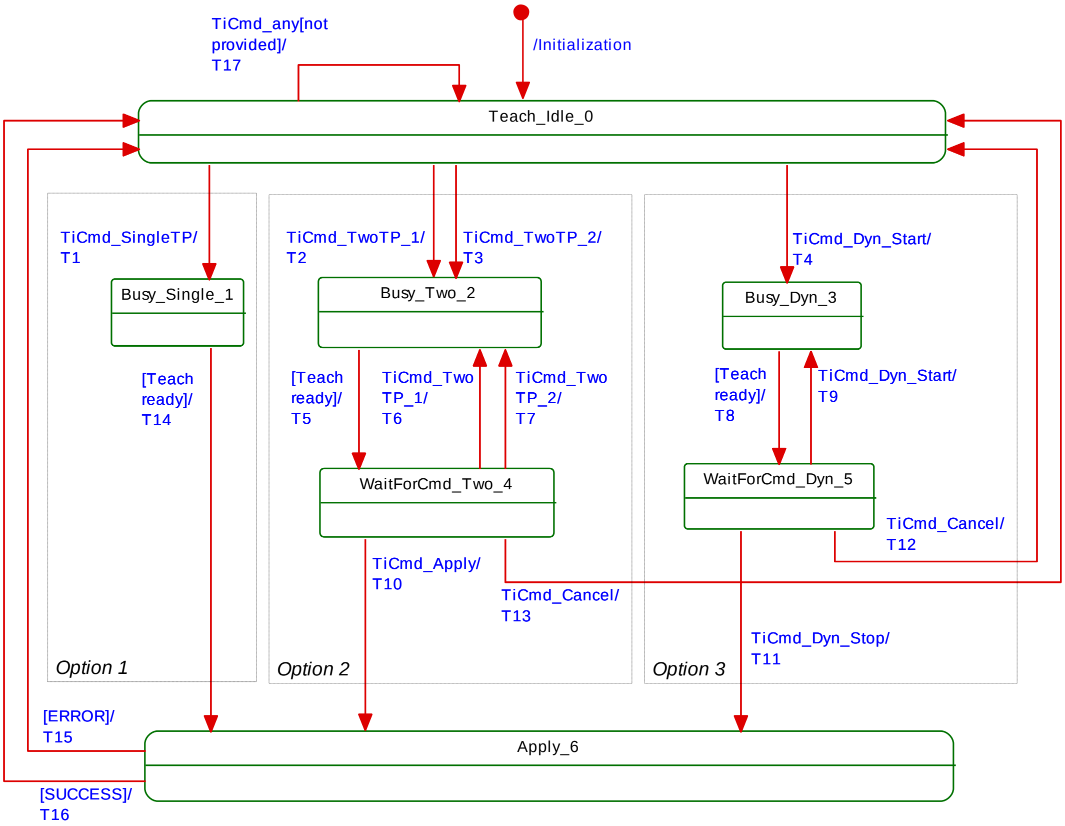
Upon communication restart, the teach-in state machine shall be reset to Teach_Idle_0. Pending actions shall be aborted in this case.

A.4.4.2 Common state machine for all three Teach FunctionClasses (Device)

Figure A.3 shows the common Device state machine for all three teach-in function class subsets. A designer can choose to implement just

- one of the options 1,2, or 3;
- any combination 1-2, 2-3, 1-3; or
- all 3 options within a Device.

Any Teach-in Command that cannot be serviced by the chosen implementation variant shall be responded by the ErrorCode "*0x8035 – Function not available*". Whenever a teach command is received in state "Busy_xxx" or "Apply_6", the command shall be rejected with ErrorCode "*0x8036 – Function temporarily unavailable*".



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653 **Figure A.3 – Common state machine for all three teach subsets**

654 Table A.2 shows the state transition tables of the teach-in procedures of the subsets.

655 **Table A.2 – State transition tables for all three teach subsets**

STATE NAME	STATE DESCRIPTION
Teach_Idle_0	In this state the Device is waiting for a requested teach-in command ("TiCmd"). The Device operates with the initial or last valid Setpoint settings for the selected teach-in channel. The reported Teach State is "IDLE", "SUCCESS", or "ERROR". All Teach Flags shall be reset.
Busy_Single_1	In this state the acquisition of Teachpoint values takes place. The Device leaves this state via transition T14 when the teach-in procedure has been accomplished. The reported Teach State is "BUSY".
Busy_Two_2	In this state the acquisition of Teachpoint values take place according to the requested Teach-in Command (see Table A.4). The Device leaves this state via transition T5, when the Device is ready to accept a new command. The reported Teach State is "BUSY".
Busy_Dyn_3	In this state the continuous acquisition of Teachpoint values is started. The Device leaves this state via transition T8, when the Device is ready to accept a new command. The reported Teach State is "BUSY".
WaitForCmd_Two_4	In this state the Device is waiting for a new teach-in command. The reported Teach State is "WAIT FOR COMMAND".
WaitForCmd_Dyn_5	In this state the Device is waiting for a new teach-in command. Parallel acquisition of teachpoint values takes place. The reported Teach State is "WAIT FOR COMMAND".
Apply_6	In this state the setpoint values are calculated and validated according to the requested Teach-in Command (see Table A.4).

STATE NAME	STATE DESCRIPTION
	By entering the state via T10 both Teach Flags must be set. Otherwise the state is left via transition T15. If the teachpoint values are valid the calculated setpoint value is stored in non-volatile memory. Upon success the Device leaves this state via transition T16. The Device then operates with the new setpoint values for the selected channel. Upon error the Device leaves this state via transition T15. The Device operates with the last valid Setpoint settings. The reported Teach State is "BUSY".

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TRANSITION	SOURCE STATE	TARGET STATE	ACTION
Initialization	–	0	Teach Flags are reset. The reported Teach State is "IDLE".
T1	0	1	This transition is performed upon reception of command "SP Single Value Teach" (0x41). This transition is provided only when FC 0x8007 is supported (see T17). The Teach Flags are reset.
T2	0	2	This transition is performed upon reception of commands "SP Two Value Teach TP1" or "SP1 Two Value Teach TP2". This transition is provided only when FC 0x8008 is supported (see T17). The Teach Flags are reset.
T3	0	2	This transition is performed upon reception of commands "SP Two Value Teach TP1" or "SP1 Two Value Teach TP2". This transition is provided only when FC 0x8008 is supported (see T17). The Teach Flags are reset.
T4	0	3	This transition is performed upon reception of command "SP Dynamic Teach Start". This transition is provided only when FC 0x8009 is supported (see T17). The Teach Flags are reset.
T5	2	4	This transition is performed when the Device is ready to accept a new command. The Teach Flags for the acquired Teachpoint is updated.
T6	4	2	This transition is performed upon reception of commands "SP Two Value Teach TP1" or "SP Two Value Teach TP2".
T7	4	2	This transition is performed upon reception of commands "SP Two Value Teach TP1" or "SP Two Value Teach TP2".
T8	3	5	This transition is performed when the Device is ready to accept a new command.
T9	5	3	This transition is performed upon reception of command "SP Dynamic Teach Start". The acquisition of a Teachpoint is restarted.
T10	4	6	This transition is performed upon reception of command "Teach Apply". Both "Teach Flags" shall be set.
T11	5	6	This transition is performed upon reception of command "SP Dynamic Teach Stop".
T12	5	0	This transition is performed upon reception of command "Teach Cancel" The Teach flags are reset. Teach state is set to IDLE.
T13	4	0	This transition is performed upon reception of command "Teach Cancel" The Teach flags are reset. Teach state is set to IDLE.
T14	1	6	This transition is performed after acquisition of Teachpoints is completed.
T15	6	0	This transition is performed after Apply_6 has failed. Teach State is set to "ERROR".
T16	6	0	This transition is performed after Apply_6 has succeeded. Teach State is set to "SUCCESS".
T17	0	0	Return ErrorCode "0x8035 – Function not available"

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INTERNAL ITEMS	TYPE	DEFINITION
Teach Flags	-	See Figure C.1
Teach State	-	See Table C.7
Teach_passed	-	Setpoint successfully calculated from Teachpoints
Teach_failed	-	Teachpoints inconsistent or Setpoint calculation impossible
Teach_ready	-	A single teach-in action has been completed

A.4.5 Mapping to SDCI communication

For the mapping to SDCI communication the corresponding parameter coding of the teach function classes [0x8007] to [0x8009] apply (see C.4.2).

A.5 Measurement Data Channel – [0x800A] to [0x800B]

A.5.1 General

The FunctionClass Measurement Data Channel provides a standardized Process data structure and some additional information how to interprete the transmitted data like physical unit or measurement limits.

A.5.2 Value range definitions

The value range of the defined data structures is split into several areas and substitute values such that PLC programmer can easily detect any specific fault or warning state. This allows reusing the special handling for these states within a PLC program. The areas are specified for all possible profile data types for measuring sensors. The profile data types can have their specific substitute values. However, the behavior of measuring sensors using a particular data type is always the same.

Figure A.4 shows the basic Process Data range including limit/substitute values and out-of-range areas which are defined in Table A.5 and Table A.6.

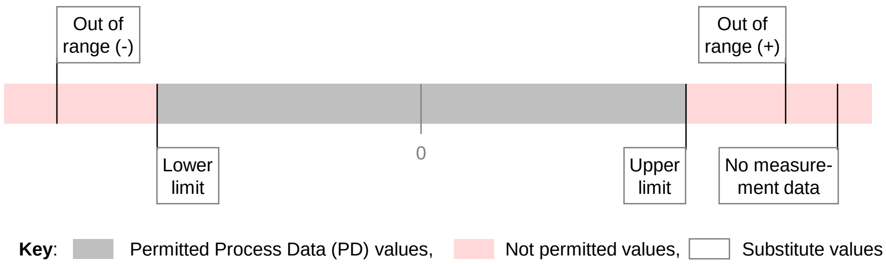


Figure A.4 – Basic Process Data ranges and limits

Table A.3 provides the definitions of the items in Figure A.4.

Table A.3 – Basic Process Data definitions

Item	Definition	Remark
Out of Range (-)	Substitute PD value reserved to signalize that the observed measurement is outside of the measurable range in the lower direction.	See Figure A.5
Out of Range (+)	Substitute PD value reserved to signalize that the observed measurement is outside of the measurable range in the upper direction.	See Figure A.5
No measurement data	Substitute PD value reserved to signalize that there is no measurement data for any unspecified reason.	
Permitted PD values	The Process Data can take any value between the Lower and Upper limit including these limit values.	See Table A.4

Item	Definition	Remark
	However, it is within the responsibility of the vendors to define the "Detection range" within the lower and upper limits. Additionally, the Process Data can provide any of the substitute values if required as specified before.	
Not permitted PD values	The Process Data cannot provide any value lower than the lower limit or higher than the upper limit with the exception of the substitute values.	See Table A.4

Figure A.5 shows the extended measurement ranges including detection range, not used and limited accuracy areas.

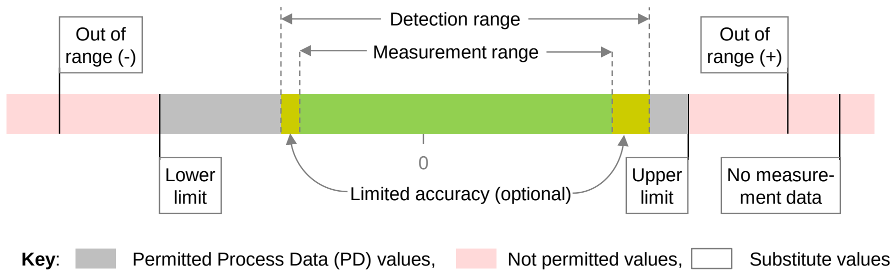


Figure A.5 – Extended measurement ranges and limits

Table A.4 provides the definitions of the items in Figure A.5.

Table A.4 – Extended Process Data definitions

Item	Definition	Remark
Detection range	The "Detection range" is the range of values in which the sensor can provide a measurement value as an output in the Process Data. This range consists of the measurement range, and optionally the "Limited accuracy" range. The "Detection range" shall be determined by the vendors. In any case, it is limited by the Lower and Upper limits.	See Table A.3
Measurement range	The vendors of measuring Devices shall define the measurement range. This is that part of the "Detection range" of the sensor, where accuracy is guaranteed.	
Limited accuracy range	The vendors of measuring Devices may optionally define "Limited accuracy" ranges. These are parts of the "Detection range" of the sensor, where the stated accuracy cannot be achieved. These ranges can be defined and used in case the vendor considers it useful to nevertheless provide a measurement value under this condition.	Optional

The permissible range of Process Data (PD) values for the Detection range is shown in Table A.5.

Table A.5 – Permissible values for the Detection range

Item	IntegerT(16)	IntegerT(32)
Lower limit	-32000	-2147482880
	0x8300	0x80000300
Upper limit	32000	2147482880
	0x7D00	0x7FFFFD00

A.5.3 Fixed special values (substitutes)

Special values – so-called substitute values – are fixed in the Process Data of the measuring sensors profile for each specified data structure. These are:

- Out of Range (-)
- Out of Range (+)
- No measurement data

The corresponding values are shown in Table A.6.

Table A.6 – Fixed special values (substitutes)

Item	IntegerT(16)	IntegerT(32)
Out of Range (-)	-32760	-2147483640
	0x8008	0x80000008
Out of Range (+)	32760	2147483640
	0x7FF8	0x7FFFFFF8
No measurement data	32764	2147483644
	0x7FFC	0x7FFFFFFC

A.5.4 Process Data value scale

The function block has no links to the IODD. Thus, the information about the necessary gradient is not available. In order to allow the function block for automatic adaptation the fixed-point process value is associated with the corresponding scale to complete the value description. Any function block can then calculate a correct unit based value even for Devices with different scales in case of wide range measurements.

This scale number is fixed for a particular Device but may vary if several different Devices are measuring the same physical quantity.

This scale information may not be referenced in the IODD UserInterface section to suppress the visibility of the static value.

For tools using the IODD the described gradient and offset shall be used as usual. The intention of the Scale is to be used by the function block defined in D.4 or any user specific function in a PLC environment.

A.5.5 Validity rule definitions

For each of the ranges, areas, and Substitute values shown in Figure A.4 the following rules apply:

a) The Process Data (PD) in the measuring Devices profile is generally used to directly transmit the measurement of the sensor or to signalize exceptionally "out of range" or "no measurement data".

b) Whenever the measurement is within the "detection range", the Process Data represents the corresponding value“, the Scale information can be used for calculating the floating point representation of the process value.

c) Whenever the measurement is outside the "detection range", the value of the Process Data will be either the substitute value "Out of Range (+)" or "Out of Range (-)" respectively.

d) Whenever the measurement cannot be performed for any reason, the Process Data will provide the (substitute) value of "No measurement data".

e) PDInvalid shall only be set when the Device is no longer able to detect even the "No measurement data" state, for example when detecting an internal fault, see [7].

A.5.6 Example

Figure A.6 shows the example of a distance measurement Device and its detailed ranges.

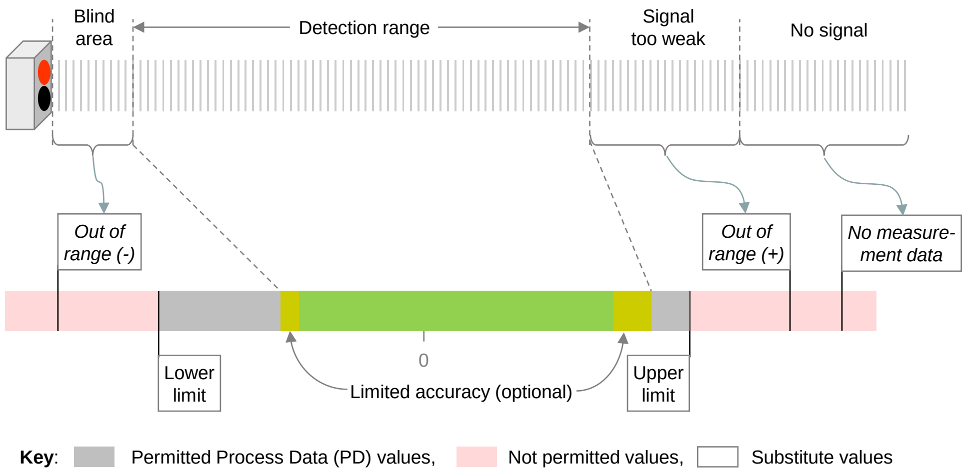


Figure A.6 – Example of a distance measurement Device

A.5.7 Units

The measuring Device profile uses a subset of the definitions in [2]. Table A.7 shows the recommended combinations of unit and data types for some physical quantities.

The following SI units with the corresponding Unit ID shall be used for the specific quantities.

Table A.7 – Recommended combinations of units and data types

Quantity	Unit (SI)	Unit Code	Data type of Measurement value
Pressure	Pa	1133	IntegerT(16)
Temperature	°C NOTE	1001	IntegerT(16)
Distance	m	1010	IntegerT(16)
Distance (high resolution)	m	1010	IntegerT(32)
Inclination	°	1005	IntegerT(16)
Velocity	m/s	1061	IntegerT(16)
Flow	m^3/h	1349	IntegerT(16)
Current	A	1209	IntegerT(16)
Voltage	V	1240	IntegerT(16)
Volume	m^3	1034	IntegerT(32)
Further combinations will be defined in the future			
NOTE °C is accepted as SI unit instead of Kelvin			

As this definition will be expanded without changing this specification document, please refer to the actual list of recommended combinations available at www.io-link.com.

A.6 TransducerDisable – [0x800C]

A.6.1 General

The Disable signal can be used to turn off the sensor transducer. Several use cases can be covered with this functionality like :

- Avoidance of mutual interference of neighbouring sensors
- Eye protection by turning off laser beams of e.g. photo electrical sensors
- Power savings (general purpose)
- Extension of life time

As this specification does not cover safety aspects, this functionality also does not cover safety aspects.

The control signal is provided by the Process Data Out channel.

A.6.2 Validity considerations

As long as the Process Data output validity is not set to the valid state by the Master sending the MasterCommand “ProcessDataOutputOperate”, the sensor transducer shall be enabled.

If the transducer is turned off the ProcessData shall provide “No measurement data”, “Target not detected”, or “Measurement below threshold” with the ProcessData marked as valid.

Annex B
(normative)

Process Data (PD) structures

B.1 Overview

The Smart Sensor Profile defines standardized Process Data structures to ease the use of the Devices following this Profile.

The ProfileID specification defines the structure which shall be used in conjunction with the profile type, see Table 3, Table 4, and Table 6.

B.2 PDI8.BOOL1

Figure B.1 shows the Process Data input structure with SSC. This structure can be filled by vendor specific data at a maximum length of 8 bits.

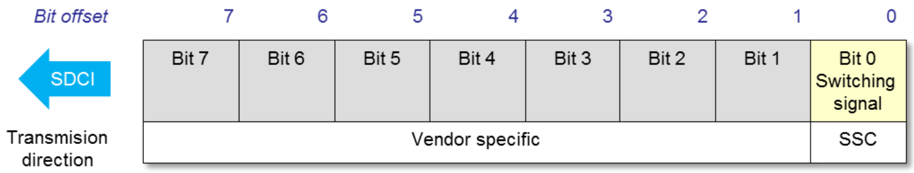


Figure B.1 – 8 bit Process Data input structure with SSC

The coding is defined in [1], Annex E.2.2 ("packed form") and in Table B.1.

Table B.1 – Coding of Process Data input (PDI8.BOOL1)

Item	Subindex	Offset	Function	Type	Value	Definition
SSC	1	0	Switching signal	BOOL	0 (FALSE)	Inactive
					1 (TRUE)	Active
Vendor specific	Vendor specific	Vendor specific	Switching sig-nals or others	Vendor specific	Vendor specific	Vendor specific

NOTE : Optionally vendor specific signals or values may be mapped. The vendor specific parts may be mapped into this range of the Process Data

NOTE : While the Device is used in SIO the physical output on C/Q may represent the activity state of the switching signal SSC. The behaviour of the sensor in SIO mode is not scope of this standard.

B.3 PDI32.INT16_INT8

Figure B.2 shows the Process Data input structure for digital measuring sensors. This structure contains the measurement value, a scale information and additional information, which can be filled by vendor specific data or defined in a later profile description.

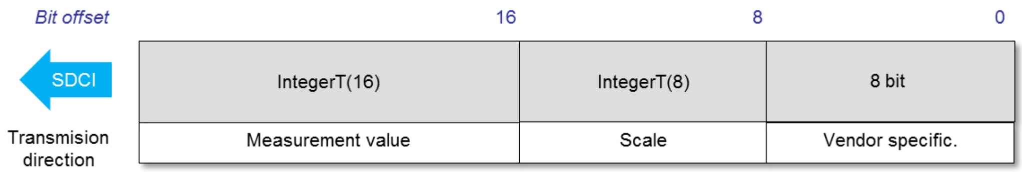


Figure B.2 – 32 bit Process Data input structure

The coding is defined in Table B.2.

Table B.2 – Coding of Process Data input (PDI32.INT16_INT8)

Item	Subindex	Offset	Function	Type	Value	Definition
Vendor specific	Vendor specific	0	Vendor specific Device data	Any 8 bit type	Vendor specific	Vendor specific
Scale	2	8	Range shifting (10^{scale})	IntegerT(8)	-128 to 127	–
Measurement value	1	16	Process Data	IntegerT(16)	-32768 to 32767	See A.5.2

NOTE : Optionally vendor specific signals or values may be mapped. The vendor specific parts may be mapped into this range of the Process Data

B.4 PDI48.INT32_INT8

Figure B.3 shows the Process Data input structure for digital measuring sensors. This structure contains the measurement value, a scale information and additional information, which can be filled by vendor specific data or defined in a later profile description.

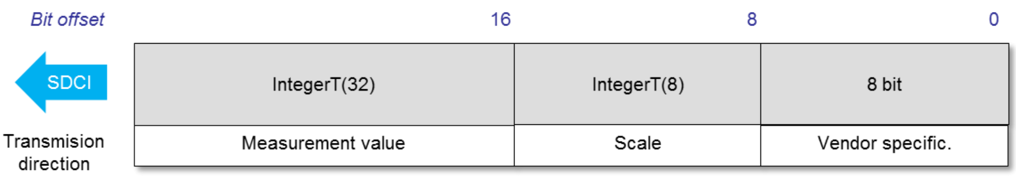


Figure B.3 – 48 bit Process Data input structure

The coding is defined in Table B.3.

Table B.3 – Coding of Process Data input (PDI48.INT32_INT8)

Item	Subindex	Offset	Function	Type	Value	Definition
Vendor specific	Vendor specific	0	Vendor specific Device data	Any 8 bit type	Vendor specific	Vendor specific
Scale	2	8	Range shifting (10^{scale})	IntegerT(8)	-128 to 127	–
Measurement value	1	16	Process Data	IntegerT(32)	-2147483648 to 2147483647	See A.5.20

NOTE : Optionally vendor specific signals or values may be mapped. The vendor specific parts may be mapped into this range of the Process Data

B.5 PDO8.BOOL1

Figure B.4 shows the Process Data output structure with "Disable". This structure can be filled by vendor specific data at a maximum length of 8 bits.

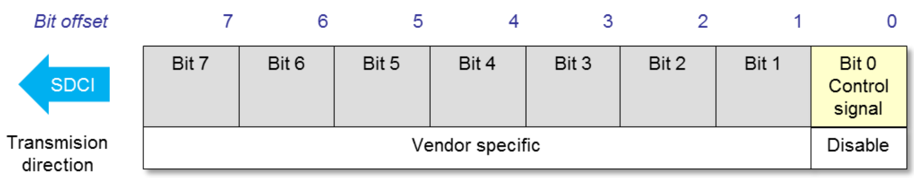


Figure B.4 – 8 bit Process Data output structure

The coding is defined in Table B.4 and contains vendor specific data.

Table B.4 – Coding of Process Data output (PDO8.BOOL1)

Item	Subindex	Offset	Function	Type	Value	Definition
Disable	1	0	Control signal	BOOL	0 (FALSE)	Active (transducer is enabled)
					1 (TRUE)	Inactive (transducer is disabled)
Vendor specific	Vendor specific	Vendor specific	Control signals or others	Vendor specific	Vendor specific	Vendor specific

NOTE : Optionally vendor specific signals or values may be mapped. The vendor specific parts may be mapped into this range of the Process Data

Annex C
(normative)

Device parameters of the Smart Sensor Profile

C.1 Overview

The manufacturer can provide Subindex access to objects with RecordItems, the Smart Sensor Profile specification does not define this behaviour. Any overall usable software shall always use the Subindex 0 access instead as this access is granted by any Device.

The persistence or volatility of the objects is stated for each object.

The SystemCommand "Restore factory settings" (0x82) will reset all Device parameters to their default value.

C.2 Device parameters of the Smart Sensor Profile

Table C.1 shows an overview of the defined Smart Sensor Profile data objects in the Index range of ISDUs.

Table C.1 – Smart Sensor Profile parameters

Index (dec)	Object name	Access	Length	Data type	M/O/C	Remark
0x0002	System-Command	W	1 octet	UIntegerT	C	Extension of SystemCommands, see [1] and C.4.3
…						
0x0038	SSC Param	R/W	2 octets	IntegerT	C	See C.4.2
0x0039	SSC Config	R/W	1 octet	IntegerT	C	See C.3 and C.4.2
0x003B	TI Result	R	1 octet	IntegerT	C	See C.4.3
…						
0x4080	MDC Descr	R	11 octets	RecordT	C	See C.5
Key M = mandatory; O = optional; C = conditional						

C.3 Device parameters for Fixed Switching Sensors (FSS)

This clause describes the specific parameter and coding for Fixed Switching Sensors (Type 1.n).

The parameter shown in Table C.2 specifies the parameter "SSC Config" which defines the logic of the switching signal channel. The object shall be stored persistent and reset to Default when performing the SystemCommand "Restore factory settings".

Table C.2 – Configuration parameter

Index (dec)	Sub-index	Offset	Access	Parameter Name	Coding	Data type
0x0039 (57)	n/a	n/a	R/W	Logic	"0" = high active (target detected or measurement value above SP) "1" = low active (no target detected or measurement value below SP) Default: "0"	BooleanT (1 bit)
Key : n/a not applicable						

C.4 Device parameters for Adjustable Switching Sensors (AdSS)

C.4.1 Overview

This clause describes the specific parameters and codings for Adjustable Switching Sensors (Type 2.n).

The parameters comprise the settings for the switching signal channel and the Teach-in channel.

C.4.2 Parameters for Switching Signal Channel

The parameter “SSC Config” to configure the logic setting reuses the definition of the parameter specified in C.3.

The parameter shown in Table C.3 specifies the parameter “SSC Param” which defines the setpoint of the switching signal channel. The object shall be stored persistent and reset to Default after “FactoryReset”.

Table C.3 –Setpoint parameter

Index (dec)	Sub-index	Offset	Access	Parameter Name	Coding	Data type
0x0038 (56)	n/a	n/a	R/W	SP	Minimum SP ≤ SP ≤ maximum SP Default: Technology specific	IntegerT16 (16 bit)
Key : n/a not applicable						

C.4.3 Parameters for Teach-in FunctionClasses

The Teach-in commands allow teaching of a teachpoint (TP) or controlling of the teach-in procedure. It uses a subset of the Teach-in commands defined for function class "Teach Channel [0x8004]" (see F.4).

The “SystemCommand” parameter is used as a vehicle to convey the "Teach-in Commands". The details are defined in Table C.4, the additional SystemCommands are specified inTable C.5. The object is volatile and not resetted by “FactoryReset”.

Table C.4 – Command parameter for Teach-in

Index (dec)	Sub-index	Offset	Access	Parameter Name	Coding	Data type
0x0002 (2)	n/a	n/a	W	System-Command	See Table C.5	UIntegerT8 (8 bit)
Key : n/a not applicable						

Table C.5 shows the "Teach-in Command" coding for the FunctionClass subsets [0x8007], [0x8008], and [0x8009]. The dynamic behavior of the teach commands are specified in A.4.4.

Table C.5 – "Teach-in Command" coding

Teach-in Command	Value	Comment	FC 8007	FC 8008	FC 8009
Teach Apply	0x40	Calculate and apply SP from Teachpoints	O	M	O
Teach SP	0x41	Determine Teachpoint 1 for Setpoint	M	O	O
Teach SP TP1	0x43	Determine Teachpoint 1 for Setpoint	O	M	O
Teach SP TP2	0x44	Determine Teachpoint 2 for Setpoint	O	M	O
Teach SP Start	0x47	Start dynamic teach-in for Setpoint	O	O	M
Teach SP Stop	0x48	Stop dynamic teach-in for Setpoint	O	O	M
Teach Custom	0x4B to 0x4E	For manufacturer specific use	O	O	O
Teach Cancel	0x4F	Abort Teach-in sequence	O	M	M
Key M Mandatory O Optional					

Figure C.1 shows the data structure of the "Teach-in Flags" and the "Teach-in State" to be used in the "Teach-in Result" coding in Table C.6.

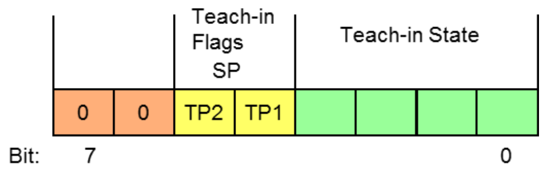


Figure C.1 – Structure of the "Teach Flags" and the "Teach State"

Table C.6 specifies the "Teach-in Result" assignment. The table references the individual coding table Table C.7. The object is volatile and reset to Default after “FactoryReset”.

Table C.6 – Result parameter for Teach-in

Index (dec)	Sub-index	Offset	Access	Parameter Name	Coding	Data type
0x003B (59)	03	5	R	Flag SP TP2	“0” = Teachpoint not aquired or not successful “1” = Teachpoint successfully aquired	BooleanT (1 bit)
	02	4	R	Flag SP TP1	“0” = Teachpoint not aquired or not successful “1” = Teachpoint successfully aquired	BooleanT (1 bit)
	01	0	R	State	See Table C.7	UIntegerT4 (4 bit)

Table C.7 shows the "Teach State" coding.

Table C.7 – "Teach State" coding

Teach State	Definition
0	IDLE
1	SUCCESS
2	Reserved
3	Reserved
4	WAIT FOR COMMAND
5	BUSY
6	Reserved
7	ERROR
8 to 11	Reserved
12 to 15	Manufacturer/vendor specific

C.5 Additional Device parameters for digital measuring sensors

This parameter contains the structure of the Process Data information within several Subindices and consists of

- Lower value measurement range
- Upper value measurement range
- Unit code,
- Scale

Table C.8 shows additional Device parameters for measuring sensors. In case of ProfileID 0x000A or 0x000C, the "Lower limit" and "Upper limit" values data type have been expanded from an IntegerT(16) to IntegerT(32); therefore the value shall be sign extended to preserve the value's sign.

Table C.8 – MDC Descr parameter

Index (dec)	Sub-index	Offset	Access	Parameter Name	Coding	Data type
0x4080 (16512)	01	56	R	Lower Limit	Lower value measurement range, see range definition in Table A.5	IntegerT32 (32 bit)
	02	24	R	Upper Limit	Upper value measurement range, see range definition in Table A.5	IntegerT32 (32 bit)
	03	8	R	Unit code NOTE	See Unit table defined in Table A.7	UIntegerT16 (16 bit)
	04	0	R	Scale	See Table B.2	IntegerT8 (8 bit)
NOTE for coding of Unit code see IODD-StandardUnitDefinitions1.1 in [2]						

Annex D
(normative)

Function Block definitions

D.1 Overview

This annex contains the proxy Function Blocks supporting the specified ProfileIDs.

The specification is based on IEC 61131-3 definitions.

As there are still some differences between the existing systems regarding the PLC system or fieldbus, the system dependent features are marked and have to be defined for each system separately.

The proxy Function Blocks can be divided into three categories of behavior,

- synchronous, which means, that the functionality is directly called and provides the results after returning from the Function Block, see D.4
- asynchronous, which means that the Function Block is triggered and after accomplishing the functionality the results are available, see D.2
- complex, which means that the proxy Function Block needs interaction between Function Block and caller to perform the desired action, see D.3

D.2 Proxy Function Block for Identification and Diagnosis

The Smart Sensor Profiles require the use of the profile for Identification and Diagnosis. The corresponding proxy Function Block is described in [7]

D.3 Proxy Function Block for Adjustable Switching Sensors

The objective for a proxy Function Block for Adjustable Switching Sensors is to provide a standardized interface and access method for parameterization of a sensor from a user application program. The FB is not running in a cyclical operation, but only on request if e.g. a setpoint is adjusted or teached.

Figure D.1 demonstrates the layout of a proxy function block for a switching sensor (AdSS) with Teach-in.

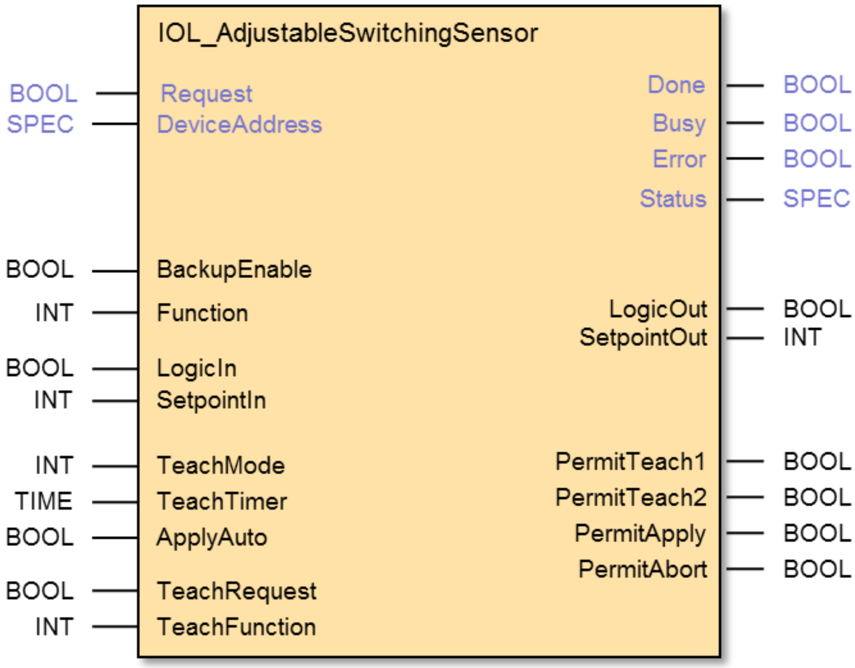


Figure D.1 – Proxy FB for AdSS

The function block provides the state machines (sequential function charts) for access to the profile specific parameters and the procedures for the three teach-in modes. The shown signals provide access to functionalities for several use cases and operation modes.

- Read switching signal channel parameter
- Write switching signal channel parameter
- Single value teach-in
- Two value teach-in
- Dynamic teach-in

The functions of the FB are controlled by the state machine by trigger signals (0→1 transistions) generated by the user application program and evaluation of the response or status information provided by the sensor.

A triggered activity of the FB is indicated with a signal Busy. As long as Busy is set all further trigger events are inhibited.

The current status of operation and all activities of the FB always provide the current values of switching signal parameters (SetpointOut, LogicOut) at the corresponding outputs. The FB is cyclically polling the Teach Result of the Device.

The structure of Process Data in and out bits is defined in annex B and the IODD and shall be mapped accordingly into the process image of the PLC. Process Data exchange is not handled in the Function Block.

The FB provides configuration and control of the Backup mechanism. Changed parameters in the device are uploaded to the master via the Data Storage mechanisms if enabled.

Table D.1 shows the variables of the AdSS proxy Function Block.

Table D.1 – Variables of the AdSS proxy FB

Variable	Data Type	Description
Inputs		
Request [a]	BOOL	A trigger causes the function selected with variable Function to be executed
DeviceAddress [a]	SPEC [b]	This variable depends on the individual fieldbus address mechanism of an SDCI Device at an SDCI Master port (see SDCI integration specification of a particular fieldbus)
BackupEnable	BOOL	This variable configures the behavior of the FB, if a parameter in the Device has been changed by the FB. "true" = enabled The backup mechanism is triggered by the FB. "false" = disabled The backup mechanism is not triggered by the FB
Function	INT	This variable selects the functionality to be triggered by a Request 0 = no_func A Request is neglected, no function is executed 1 = rd_all A Request starts the read back of current Switching Signal Channel parameter values from the sensor. These values are available at LogicOut and SetpointOut 2 = wr_conf A Request causes a previously applied value for LogicIn to be written to the sensor 3 = wr_param A Request causes a previously applied value for SetpointIn to be written to the sensor 4 = teach A Request causes the FB to enter the teach operation.
LogicIn	BOOL	This variable defines the value for a new Switchpoint to be written to the sensor on a Request with Function ‘wr_conf’, see Table C.2
SetpointIn	INT	This variable defines the value for a new Setpoint to be written to the sensor on a Request with Function ‘wr_param’, see Table C.3
TeachMode	INT	This variable defines one of the possible teach procedures: 0 = no_teach - no teach-in action 1 = single_value - single value teach-in 2 = two_value – two value teach-in 3 = dynamic - dynamic teach-in
TeachTimer	TIME	This variable defines the duration of the dynamic teach time A value of ‘0’ disables the activation of the automatic stop command. The TeachFunction ‘teach_Stop’ can always be used for triggering dynamic teach stop and thus, overwrite TeachTimer
ApplyAuto	BOOL	This variable defines the behavior for a two value teach procedure. ‘false’ = autoapply_disabled The apply function has to be triggered by the user application program in order to evaluate the gathered teach points and activate the new Setpoint ‘true’ = autoapply_enabled If two teach points have been successfully teached, the ‘apply’ function is triggered automatically, no activity from the user application program is required.
TeachRequest	BOOL	A rising edge triggers one step of teach process to be executed according to the selected function at variable TeachFunction.
TeachFunction	INT	The value applied to this variable defines the teach functionality to be executed on TeachRequest. 0 = no teach – no function selected

		1 = teach 1 – start teach step 1 functionality 2 = teach 2 – start teach step 2 functionality 3 = apply – apply two value teach results 4 = abort – abort actual teach sequence
Outputs		
Done [a]	BOOL	The signal is set, if the FB has completed a requested operation.
Busy [a]	BOOL	The signal is set, if the FB is executing a requested operation
Error [a]	BOOL	The signal is set, if an error occurred during execution of a requested operation.
Status [a]	SPEC [b]	The value represents the current status of the FB operation and executed functions. The content is system specific and contains the status information defined in Table D.2.
SetpointOut	INT[32]	This variable represents the current value of the parameter Setpoint from the sensor. The variable is updated with each termination of a teach process, a write process or on a Request signal with Function rd_all
LogicOut	BOOL	This variable represents the current value of the parameter Logic from the sensor. The variable is updated with each termination of a teach process, a write process or on a Request signal with Function rd_all, see Table C.2
PermitTeach1	BOOL	The signal is set, if according to the current state of the FB a trigger signal for teach function 'teach_1' is possible.
PermitTeach2	BOOL	The signal is set, if according to the current state of the FB a trigger signal for teach function 'teach_2' is possible.
PermitApply	BOOL	The signal is set, if according to the current state of the FB a trigger signal for teach function 'apply' is possible.
PermitAbort	BOOL	The signal is set, if according to the current state of the FB a trigger signal for teach function 'abort' is possible.
Key a: This variable name may be adapted to the PLC specific naming guide lines b: SPEC represents the applicable data type for this specific parameter, this may vary over different PLC systems		

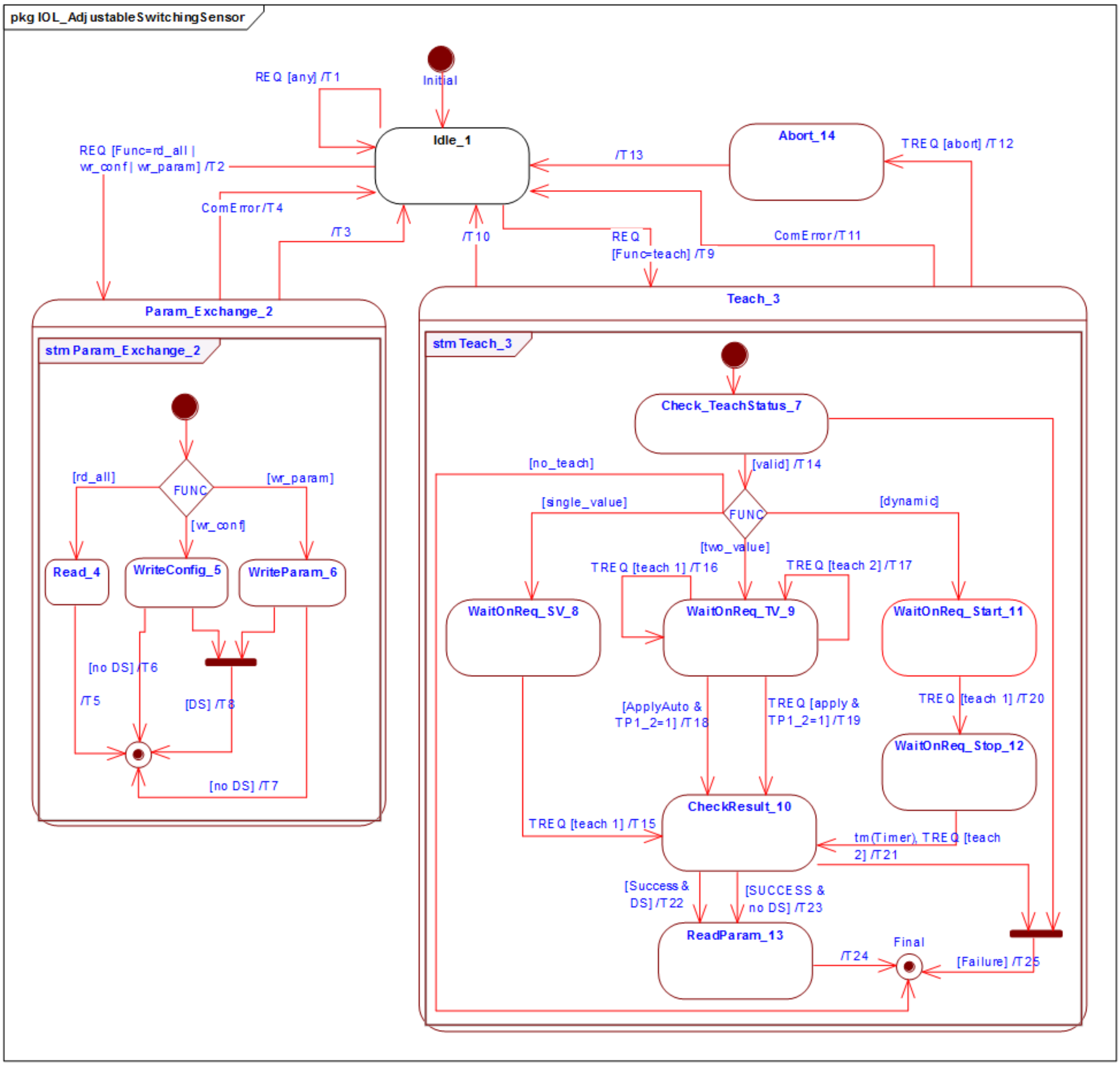
Table D.2 defines the extension of the status parameters FB status additional to the COM status of the communication functions including the reference to the Teach-in state of the Device (see Table C.7).

Table D.2 – Extension of FB Status

Definition	Teach-in State
FunctionBlock internal status	
Done, success	
Busy	
Busy reading data	
Busy writing data	
Busy Teach process	
Busy Teach process, state single value	
Busy Teach process, state two value	
Busy Teach process, state dynamic	
Busy Teach process, apply action	
Busy Teach process, abort action	
Done, error	
Additional, concurrent Teach states of the Device	

Definition	Teach-in State
Teach success / idle	Idle or success
Teach wait for command	Wait for command
Teach busy	Busy
Teach error	Error

952 Figure D.2 shows the state machine of the Adjustable Switching Sensor proxy FB



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954 **Figure D.2 – State machine of the AdSS proxy FB**

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Table D.3 shows the state transition tables for the teach-in state machine of the AdSS proxy FB

Table D.3 – State and transition table for AdSS FB

STATE NAME	STATE DESCRIPTION
Idle_1	No FunctionBlock activities. Set all Permitxx to inactive. Initial Status is “Done, success”, “Teach, success idle”
ParamExchange_2	This superstate allows all states inside to react on communication errors during the activities. Set Status to “Busy”.
Teach_3	This superstate allows all states inside to react on – communication errors – abort requests – disabling the FunctionBlock – temporarily unavailable Tach-in function requests Set Status to ”Busy Teach process”
Read_4	Read all configuration and settings parameter of the device, see Table C.2 and Table C.3 Set Status to “Busy reading data”.
WriteConfig_5	Write configuration parameter to the Device, see Table C.2 Set Status to “Busy writing data”.
WriteParam_6	Write settings parameter to the Device, see Table C.3 Set Status to “Busy writing data”.
CheckTeachState_7	At entry wait till Teach-in State is no longer busy, read Teach-in State (Table C.6), provide Teach Status information.
WaitOnReq_SV_8	At entry wait till Teach-in state is no longer busy, read Teach-in state (Table C.6), provide Status information and set Status to “Busy Teach process, state single value”. Set only PermitTeach1 to active. Wait till next step (teach_1) is requested.
WaitOnReq_TV_9	At entry wait till Teach-in state is no longer busy, read Teach-in state (Table C.6), provide Teach Status information and set Status to “Busy Teach process, state two value”. Set PermitTeach1, PermitTeach2 and PermitAbort to active. Set PermitApply active if TP1 and TP2 are active. Wait till next step (teach_1, teach_2 or apply) is requested
CheckResult_10	At entry wait till Teach-in state is no longer busy, read Teach-in state (Table C.6), provide Teach Status and Set Status to “Busy Teach process, state apply action”.
WaitOnReq_Start_11	At entry wait till Teach-in state is no longer busy, read Teach-in state (Table C.6), provide Teach Status information and set Status to “Busy Teach process, state single value”. Set only PermitTeach1 to active. Wait till next step (teach_1) is requested.
WaitOnReq_Stop_12	At entry wait till Teach-in state is no longer busy, read Teach-in state (Table C.6) and provide Status information. Set only PermitTeach2 to active. Wait till next step (teach_2) is requested.
ReadParam_13	Read back the Device parameter to update the SetpointOut and LogicOut variables, Set Status to “Busy reading data”.
Abort_14	Apply abort to Device, update Status information and perform garbage collection.

TRANSITION	SOURCE STATE	TARGET STATE	ACTION
T1	1	1	Set Status to “Done, error”
T2	1	2	-
T3	2	1	Set Status to “Done, success”
T4	2	1	Set Status to “Done, error”
T5	4	1	-

TRANSITION	SOURCE STATE	TARGET STATE	ACTION
T6	5	1	-
T7	6	1	-
T8	5, 6	1	Invoke SystemCommand “ParamDownloadStore”, see [1] B.2.2
T9	1	3	Set Status to “Teach-in success/idle” and “Busy teach process”
T10	3	1	-
T11	3	1	Set Status to “Done, error” and “Teach-in error”
T12	3	14	Invoke “Teach-in Cancel”, see Table C.5. Set Status to “Busy Teach abort”
T13	13	1	Set Status to “Done, success” and “Teach success/idle”
T14	7	8, 9, 11	-
T15	8	10	Invoke “Teach SP”, see Table C.5
T16	9	9	Invoke “Teach SP TP1” , see Table C.5
T17	9	9	Invoke “Teach SP TP2” , see Table C.5
T18	9	10	Invoke “Teach Apply” , see Table C.5
T19	9	10	Invoke “Teach Apply” , see Table C.5
T20	11	12	Invoke “Teach SP Start” , see Table C.5
T21	12	10	Invoke “Teach SP Stop” , see Table C.5
T22	10	13	Invoke SystemCommand “ParamDownloadStore”, see [1] B.2.2
T23	10	13	-
T24	13	1	Set Status to “Done, success” and “Teach success/idle”
T25	7, 10	1	Set Status to “Teach-in error”

INTERNAL ITEMS	TYPE	DEFINITION
ComError	Boolean	Any detected error during communictaion to the Device
REQ	Trigger	Rising edge of the FB Request input
Func	Integer	Selected function from Function input
DS	Boolean	State of BackupEnable input at FB
TREQ	Trigger	Detected trigger at rising edge of TeachRequest with selected TeachFunction as guard
Failure	Boolean	Result of the previous action indicates failure like teach-in failed or requested function not available

D.4 Function Block for Measurement Data Channel (MDC)

The Measurement Data Channel defines the Process Data structure, functions and representation of measuring sensors. A proxy Function Block is defined providing derived status signals and allowing a standardized interface for user application programs.

Figure D.3 demonstrates the layout of a proxy Function Block for the Measurement Data Channel of measuring Devices.

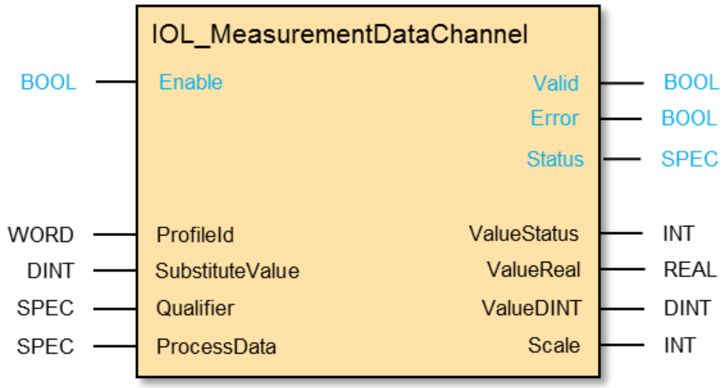

Figure D.3 – Function block for Measurement Data Channel

Table D.4 describes the signal and variables of the Measurement Data Channel Function Block.

Table D.4 – Variables of the Measurement Data Channel Function Block

Variable	Data Type	Description
Inputs		
Enable [a]	BOOL	Enables the function of the FB
ProfileID	WORD	Selected ProfileID, respectively process datalayout, see Table 6 1 = SSP 3.1 2 = SSP 3.2 3 = SSP 3.3 4 = SSP 3.4
SubstituteValue	DINT	The provided value is applied at the ValueReal and ValueDINT if ValueStatus is not equal 0
Qualifier	SPEC [b]	This signal corresponds to the ProcessDataInvalid information from the sensor. The format is system specific. 'false' = ProcessData are invalid 'true' = ProcessData are valid
ProcessData	SPEC [b]	The Process Data Input from the sensor is applied to this input. The format is system specific. NOTE: the Process Data Input width depends on the profile for the DMS (either INT16 or INT32)
Outputs		
Valid [a]	BOOL	If "true" the provided values are valid and may be used for further calculations
Error [a]	BOOL	If "true" an internal error is occurred and futher information is provided provided by the Function Block via the Status variable
Status [a]	SPEC [b]	Provides internal error codes
ValueStatus	INT	Status of process data input 0 = ok 1 = PD invalid 2 = No Data

		3 = Out of range (+) 4 = Out of range (-)
ValueReal	REAL	Process data in real format for evaluation within the PLC
ValueDINT	DINT	Process data in double integer format
Scale	INT	Process data scale factor
Key a: This variable name may be adapted to the PLC specific naming guide lines b: SPEC represents the applicable data type for this specific parameter, this may vary over different PLC systems		

The function analyses the received Process Data Input value and creates corresponding indications in case of invalid values, no data, out-of-range+, and out-of-range-. The user provides the qualifier, and a substitute value. Figure D.4 shows the calculation procedure for the measurement value and substitute values.

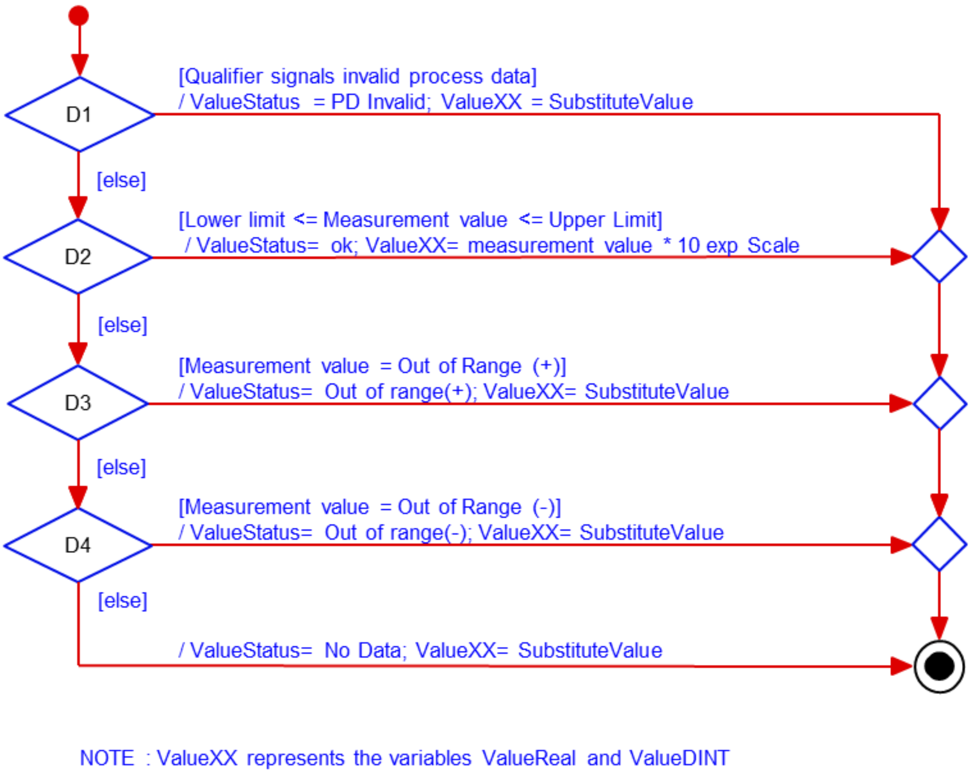

Figure D.4 – Determination of measurement value or substitute values

Annex E
(normative)

IODD definitions and rules

E.1 Overview

The objective to create the Smart Sensor Profile Ed.2 was to eliminate the optional functionalities in profiled Devices by specifying completely defined profiles. As the parameter and the behavior is specified the look and feel of the Devices should also be harmonized, otherwise the appearance of the same profile is different between different manufacturer.

To achieve a common look and feel, the IODD content has to be defined as well. This clause includes the rules for the naming conventions and menu layout.

E.2 Constraints and rules

The following naming conventions shall be considered :

- Every object name shall start with an appropriate abbreviation of the FunctionClass
  - SSC Switching Signal Channel parameter set
  - TI Teach-in parameter set
  - MDC Measurement Data Channel parameter set
- The object name shall be human-readable and can be abbreviated to shorten the name
- Commands shall be named in imperative
- A menu group shall represent the FunctionClass without abbreviation
- SingleValues shall be human-readable and are abbreviated to shorten the name
- The predefined name shall always be used in any Device specific IODD
- A vendor/manufacturer specific extension can be added to the predefined name in order to enable vendor specific explanations even in different languages, these shall be separated by “ – “
- The menu entries shall be located in the specified menu section
- The menu entries shall not be altered in layout and structure

E.3 Name definitions

E.3.1 Profile type characteristic names

The profile characteristic names (see Table 3, Table 4, Table 6) shall be used whenever the profile functionality is referenced in the IODD.

E.3.2 Parameter set for Fixed Switching Signal profile

Table E.1 specifies the name predefinitions for the SSC Config.Logic object including the predefinitions for the SingleValues, see Table C.2.

Table E.1 – SSC Config.Logic predefinitions

Variable name predefinition	SingleValue name predefinition
SSC Config - Logic	0 = High active 1 = Low active

E.3.3 Parameter set for Adjustable Switching Signal profile

The SSC Config object is defined in Table E.1.

Table E.2 specifies the name predefinitions for the SSC Param.SP object, see Table C.3.

Table E.2 – SSC Param.SP predefinitions

Variable name predefinition	SingleValue name predefinition
SSC Param - SP	n/a
Key n/a not applicable	

Table E.3 specifies the name predefinitions for the TI Result object including the predefinitions for the SingleValues, see Table C.6.

Table E.3 – TI result predefinitions

Variable name predefinition	Subindex	Parameter name predefinition	SingleValue name predefinition
TI Result	3	Flag SP TP2	0 = Initial or not ok 1 = OK
	2	Flag SP TP1	
	1	State	0 = Idle 1 = Success 4 = Wait for command 5 = Busy 7 = Error 12 .. 15 = Custom

Table E.4 specifies the predefinitions for the Teach-in commands defined for the SystemCommand object, seeTable C.5.

Table E.4 – Teach-in command predefinition

Variable name	SingleValue name predefinitions
System Command	0x40 = Teach apply 0x41 = Teach SP 0x43 = Teach SP TP1 0x44 = Teach SP TP2 0x47 = Teach SP start 0x48 = Teach SP stop 0x4B .. 0x4E = Teach Custom 0x4F = Teach cancel

E.3.4 Parameter set for Digital Measuring Sensor profile

Table E.5 specifies the predefinitions for the MDC object including the RecordItem names, see Table C.8.

Table E.5 – MDC descriptor predefinition

Variable name predefinition	Subindex	Parameter name predefinitions	SingleValue name predefinition
MDC Descr	1	Lower limit	n/a
	2	Upper limit	
	3	Unit code	
	4	Scale	
Key n/a not applicable			

E.4 IODD Menu definitions

E.4.1 Overview

Examples for layouts of Port and Device configuration tools are shown in [1] 11.7.

Within these examples the IODD defines the parameter layout of the connected device. In this clause the object and parameter layout of the different profile types are specified.

To harmonize the layout, the parameter shall be referenced in the menu. If RecordItems are available, these shall be referenced in the menu. The shown variable figures and the SingleValues are examples.

E.4.2 Menu structure of a Fixed Switching Signal

In Figure E.1 the menu structure of a Fixed Switching Signal Sensor is specified, it shall be located in the Parameter section of the menu.

- Switching Signal Channel			
	SSC Config - Logic	High Active	

Figure E.1 – Menu FSS

E.4.3 Menu structure of an Adjustable Switching Signal

In Figure E.2 the menu structure of an Adjustable Switching Signal Sensor is specified, it shall be located in the Parameter section of the menu.

- Switching Signal Channel		
SSC Param - SP	1234	
SSC Config - Logic	High Active	
- Teach-in Single Value *		
System Command **	Teach SP	
TI Result - State	Idle	
- Teach-in Two Value *		
System Command	Teach SP TP1	
System Command	Teach SP TP2	
System Command	Teach Apply	
System Command	Teach Cancel	
TI Result - Flag SP TP1	Ok	
TI Result - Flag SP TP2	Ok	
TI Result - State	Idle	
- Teach-in Dynamic *		
System Command	Teach Start	
System Command	Teach Stop	
System Command	Teach Cancel	
TI Result - State	Idle	

Figure E.2 – Menu AdSS

The presence of the parameter trees marked with an “*“ is depending on the supported Teach-in FunctionClass. The example shows a default layout.

Note ** The naming of the SystemCommand is depending on the parametrization tool.

E.4.4 Menu structure of a Digital Measuring Sensor

In Figure E.3 the menu structure of a Digital Measuring Sensor is specified, it shall be located in the Diagnosis section of the menu.

- Measuring Data Channel		
MDC Descr - Lower Limit	0	
MDC Descr - Upper Limit	1000	
MDC Descr - Scale	-1	
MDC Descr - Unit	Pa	

Figure E.3 – Menu DMS

Annex F
(normative)

Legacy Smart Sensor Profile (Edition 1)

F.1 History

F.1.1 Overview

Since publishing the Smart Sensor Profile [9] in 2011, here called Ed.1, different feedback from the customers and users of devices reached the community. This feedback is compiled in this Smart Sensor Profile Specification Ed.2.

One complain was about the missing restrictions on defining subsets of profiles. The customer cannot rely on standardized features of devices.

Not all profile aspects of Ed. 1 were transferred into Ed. 2, only the aspects for simple switching devices. Additionally measuring devices were added.

It is the objective of the community to keep the positive aspects of Ed. 1, therefore the following reworked clauses, specifying devices with more than 1 switching signal, are still valid. Nevertheless these clauses may be reworked in further releases of this specification.

F.1.2 Overview on change to Ed. 1

The following parts are adapted from Ed. 1 to fit in Ed. 2:

- Naming conventions are adapted to the new style
- The IODD representation is specified in F.6
- Overall valid profiles are moved to the ProfileGuideline in [7]

F.2 Generic Profiled Sensor

Since this previous edition of the Smart Sensor profile allows any combination of several FunctionClasses without a preference for specific combinations, the supported FunctionClass IDs shall be listed in the ProfileCharacteristic index as described in [7].

Table F.1 shows the variety of permitted FunctionClass options for ProfileID 0x0001.

Table F.1 – Generic Profiled Sensor profile types

Smart Sensor type	Identification FunctionClass [0x8000]	SSC FunctionClass [0x8001]	PDV FunctionClass [0x8002]	Diagnosis FunctionClass [0x8003]	Teach-in FunctionClass [0x8004]
"Binary" sensor	M	1 to n	–	O	O
"Analog" sensor	M	–	1 to n	O	O
"Binary + analog" sensor	M	1 to n	1 to n	O	O
Key M = mandatory O = optional – = not relevant					

The FunctionClasses Identification, PDV, Diagnosis are specified in [7].

F.3 Switching Signal Channel (former: BinaryDataChannel) – [0x8001]

F.3.1 Characteristic of the Switching Signal Channel (SSC)

The name of this FunctionClass has been "BinaryDataChannel" in Edition 1. In Edition 2, it has been changed to "Switching Signal Channel". The Process Data of this FunctionClass represent the state information of a switching signal. The FunctionClass requires configuration and parameterization via standardized profile specific parameters and their Indices.

F.3.2 Configuration and parameterization of the SSC

This profile specification defines several best-practices SSCs. Manufacturer/vendor specific linear extensions are always possible.

The following 4 parameters define the switching behavior of an SSC:

- Switchpoint Logic
- Switchpoint Hysteresis
- Switchpoint Mode
- Setpoints SP1 and SP2

These parameters are defined within the subsequent clauses.

The Setpoint parameters are defined in detail in Table F.4. The coding of the Setpoint and Switchpoint parameters is specified in Table F.6.

F.3.3 Switchpoint Logic

The parameter "Switchpoint Logic" defines whether the switching information is transmitted as “High-active” or “Low-active” signals.

F.3.4 Switchpoint Hysteresis

The parameter "Switchpoint Hysteresis" defines whether a hysteresis is associated with the Setpoints SP1 and SP2. The layout of the hysteresis in respect to SP1 and SP2, for example symmetrical, right-aligned, or left-aligned, etc. is manufacturer/vendor specific. It cannot be defined in the FunctionClass.

The interpretation of the hysteresis values (relative or absolute) is also manufacturer/vendor specific.

F.3.5 Switchpoint Modes

F.3.5.1 Overview

The parameter "Switchpoint Mode" defines how the binary state information of the switching signal is created depending on Setpoint parameters (SP1, SP2) and the current measurement value.

The Switchpoint Mode does not define the switching function itself. The different sensor types are using different switching functions depending on the various manufacturer/vendor specific technologies.

The quiescent state of sensors for presence detection (e.g. optical proximity sensors or ultrasonic sensors) is a measurement value of "infinite". An approaching object will cause the switching state of the sensor to change at the setpoint (measurement value). The departing object will cause the switching state of the sensor to switch back at a larger measurement value than the setpoint (see Figure F.1)

The quiescent state of sensors for quantity detection (e.g. pressure or temperature sensors) is a measurement value of "zero". An increasing measurement value will cause the switching state of the sensor to change at the setpoint value. A decreasing measurement value will cause the switching state of the sensor to switch back at a smaller measurement value than the setpoint value (see Figure F.2).

The associated FunctionClass comprises 4 different modes:

- Deactivated
- Single Point Mode
- Window Mode
- Two Point Mode

If a Smart Sensor implements an SSC, it shall support at least one of these Switchpoint Modes. Additional modes are optional. In case a Smart Sensor does not support any other of the additional optional modes, the general rule for not supported parameters applies (see [7]). Manufacturers/vendors can supplement the above defined modes by manufacturer specific modes.

F.3.5.2 Single Point Mode

Figure F.1 demonstrates the switching behavior in Single Point Mode. The switching state changes, when the current measurement value passes the Setpoint SP1. This change occurs with rising or falling measurement values. If a hysteresis is defined for SP1, the switching behavior shall observe the hysteresis as shown in Figure F.1. This behavior is typical for "presence detection of objects" with hysteresis in respect to SP1 and High-active switching.

Setpoint SP2 is not relevant for this mode.

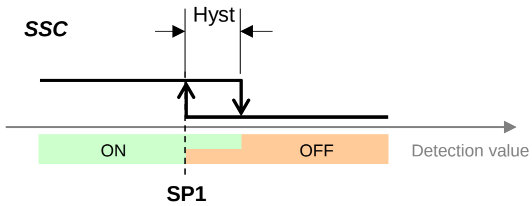

Figure F.1 – Example of a Single Point Mode for presence detection

The behavior shown in Figure F.2 is typical for "quantity (level) detection" of materials (liquids) with non-symmetrical hysteresis in respect to SP1 and High-active switching.

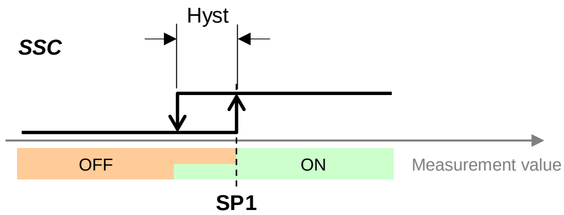

Figure F.2 – Example of a Single Point Mode for quantity detection

F.3.5.3 Window Mode

Figure F.3 demonstrates the switching behavior in Window Mode. The switching state changes, when the current measurement value passes the Setpoint SP1 and Setpoint SP2. This change occurs with rising or falling measurement values.

If hysteresis is defined for SP1 and SP2, the switching behavior shall observe the hysteresis as shown in Figure F.3. This behavior shows symmetrical hysteresis in respect to SP1 and SP2 and High-active switching.

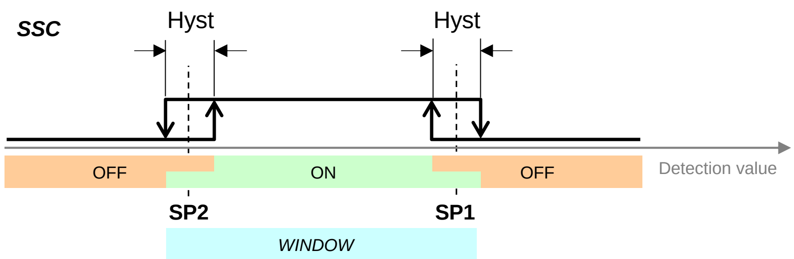

Figure F.3 – Example for the Window Mode

F.3.5.4 Two Point Mode (without hysteresis)

Figure F.4 demonstrates the switching behavior in Two Point Mode. The switching state changes, when the current measurement value passes the Setpoint SP1. This change occurs only with rising measurement values. The switching state changes also, when the current measurement value passes the Setpoint SP2. This change occurs only with falling measurement values. Hysteresis shall be ignored in this case.

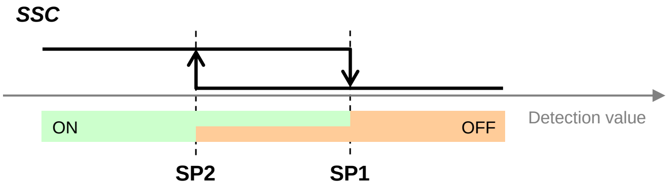

Figure F.4 – Example for the Two Point Mode of presence detection

If the detection value is in between SP1 and SP2 at power-on of the Smart Sensor, the behavior depends on the manufacturer/vendor specific design of the Device.

The behavior shown in Figure F.4 is typical for "presence detection of objects" with no hysteresis in respect to SP1 and SP2 and High-active switching.

The behavior shown in Figure F.5 is typical for "quantity (level) detection of materials (liquids)" with no hysteresis in respect to SP1 and SP2 and High-active switching.

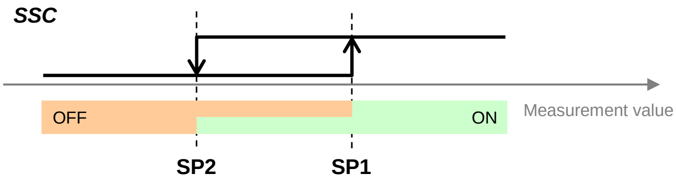

Figure F.5 – Example for the Two Point Mode of quantity detection

F.3.6 Deactivated

The switching state in the deactived mode shall be “No target detected” or “ Measurement value below Setpoint”

F.3.7 Setpoint parameters (SP1, SP2)

A Smart Sensor deploys at least the Setpoint SP1 or both Setpoints SP1 and SP2 per SSC. However, it always shall provide both Setpoint parameters of this FunctionClass SSC. That means, even if the Smart Sensor does not use SP2 in its swiching functions, it shall support read and write access to both parameters. In case a Smart Sensor does not support any parameters, the general rule for not supported parameters applies (see [7]).

The interpretation of the Setpoints SP1 and SP2 depends on the particular implementation of the manufacturer/vendor. However, if the measurement value for the definition of switching state information (SSC) is also provided as a ProcessDataVariable (PDV), the Setpoints shall be represented in the same manner, for example with Gradient and Offset and octet granular data types (≥ 1 octet). See [7] for details.

The Smart Sensor Device shall support all the necessary plausibility checks specified in clause 10 ("Device") of [1] and observe the following rules:

- Setpoint SP2 shall be outside the hysteresis range of SP1 and vice versa
- Setpoints SP1 and SP2 are within the measurement value range

In case one or more checks failed, the Smart Sensor shall behave in the following manner:

- During acyclic data exchange (via ISDU), the Device shall return a negative response and restore the previous values

- During cyclic data exchange, the Device shall send valid Process Data based on previous valid parameter data

In order to avoid inconsistent configuration data it is important to note,

- that SP1 and SP2 data are written together via Subindex 0 (one record) guaranteeing that a changed value of SP1 or SP2 cannot cause a plausibility check error, or
- that the option Block Parameter (see [1]) is used for a change of configuration guaranteeing a plausibility check and activation of the written parameters not before the termination of the entire transmission.

F.3.8 SSC mapping

F.3.8.1 Concepts

The switching signals of the SSCs are mapped into the PDinput data stream as shown in [7] (7.3.2 and Figure 8). The parameters for configuration and parameterization of the SSCs are mapped into the profile related Index space as illustrated in Appendix F.5.

F.4 Teach Channel – [0x8004]

F.4.1 Concepts for Smart Sensors

The FunctionClass "Teach Channel" defines an interface for remote teach-in functions via SDCI communication and standardized commands for the most common basic teach-in mechanisms. Thus, the Smart Sensor profile provides a uniform and flexible interface for several teach-in methods. Instead of defining all kinds of teach-in methods, this FunctionClass defines a set of universal commands that can be used in various sequences to realize many individual methods. This includes the calculation algorithms for the associated parameters such as the Setpoints SP1 and SP2. The FunctionClass provides a "music instrument"; the "music" to play is defined by the manufacturer/vendor.

Two parameters are defined to control the teach-in procedure. The "TI Select" parameter (F.4.2) allows selecting the SSC to be taught. This is required, if several SSCs are assigned to a teach-in procedure and the adjustment of the Setpoint values. It is default behavior that teach-in commands are automatically assigned to the SSC with teach-in capability defined by the manufacturer/vendor. It is highly recommended for basic Smart Sensors to assign teach-in capability to SSC1 in order to avoid explicit addressing of a SSC.

Several commands are defined for the second parameter "Teach-in Command" (F.4.3). Each individual command enables the user to start one out of several standardized teach-in procedures. The commands are described within the context of a possible application within the subsequent clauses.

The FunctionClass [0x8004] provides also feedback on the status and the results of the teach-in activities. A universal state machine with common states (Idle, Busy, Wait-on-command, Success, and Error) for the different teach-in procedures is defined in F.4.5. The parameter "Teach-in Result" holds the information about the current state of the activated teach-in procedure (F.4.4). The parameter provides two different types of information:

- Teach Flags: Feedback, whether the Device determined a certain "Teachpoint" successfully or not
- Teach State: Feedback on the current state of the particular teach-in procedure

F.4.2 Parameter 1: "Teach-in Select"

The parameter "Teach-in Select" allows addressing of the particular SSC or a set of SSCs for which the teach-in commands apply (for coding see Table F.10). A maximum of 128 SSCs can be addressed.

F.4.3 Parameter 2: "Teach-in Command"

F.4.3.1 General

The parameter "Teach-in Command" allows teaching of a teachpoint (TP) or controlling of the teach-in procedure. Manufacturer/vendor specific extensions are possible. The commands of the FunctionClass [0x8004] are described within the context of a possible application in the subsequent clauses (for coding see Table F.8).

F.4.3.2 "Single Value Teach-in"

A Setpoint is defined by one "Teachpoint" (TP). The teach-in procedure is "static", which means, the measurement value is constant during the teach-in procedure.

The associated commands “SP1 Single Value Teach” and “SP2 Single Value teach” are specified in Table F.8.

Figure F.6 illustrates an example for "Single Value Teach" in "Single Point Mode".

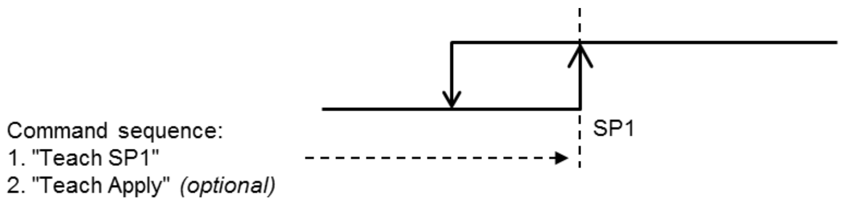

Figure F.6 – "Single Value Teach" (Single Point Mode)

Figure F.7 illustrates an example for "Single Value Teach" in "Window Mode".

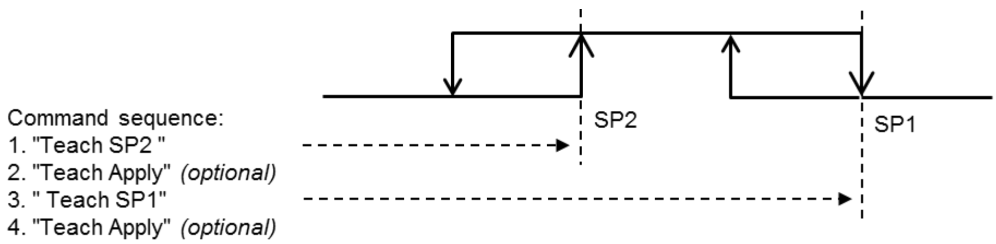

Figure F.7 – "Single Value Teach" (Window Mode)

F.4.3.3 "Two Value Teach-in"

A Setpoint is defined by two "Teachpoints" (TP).

The associated commands "Teach SPn TPm" are specified in Table F.8.

NOTE The calculation method to determine SP from TP1 and TP2 is manufacturer/vendor specific.

Figure F.8 illustrates an example for "Two Value Teach" in "Single Point Mode".

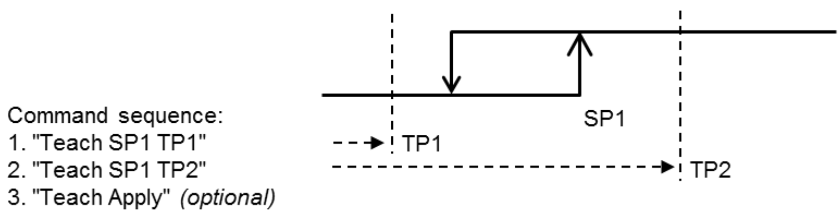

Figure F.8 – "Two Values Teach" (Single Point Mode)

Figure F.9 illustrates an example for "Two Value Teach" in "Two Point Mode".

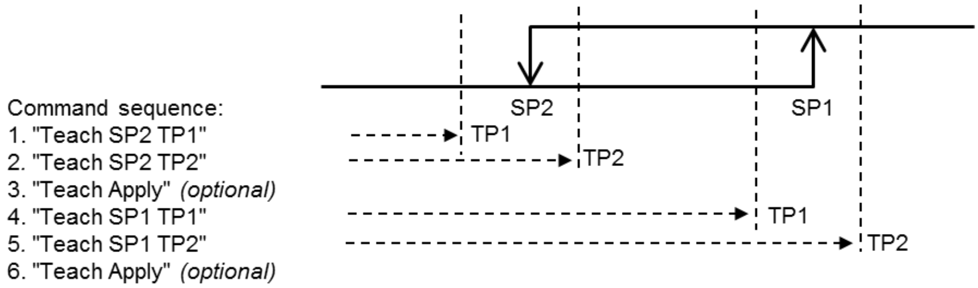

Figure F.9 – "Two Values Teach" (Two Point Mode)

F.4.3.4 "Dynamic Teach-in" (within a time period)

One single Setpoint or both Setpoints of a SSC are set-up via captured measurement values during a certain period of time. The teach-in procedure is "dynamic", which means, the measurement value is not constant during the teach-in procedure. Usually, the minimum and maximum values within this time frame are taken to define the Setpoints. The associated commands "Teach SPn Start” to “Teach SPn Stop” are specified in Table F.8.

Figure F.10 illustrates an example for "Dynamic Teach" in "Single Point Mode", where commands "Teach SP1 Start " and " Teach SP1 Stop " are used for the determination of the Setpoint SP1.

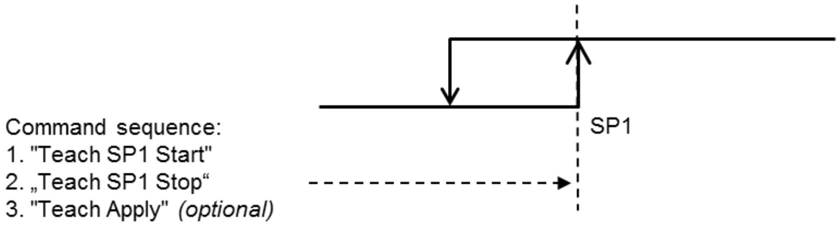

Figure F.10 – "Dynamic Teach-in" (Single Point Mode)

Figure F.11 illustrates an example for "Dynamic Teach" in "Window Mode" or “Two Point Mode” It is the responsibility of the manufacturer to describe the required commands for the "Dynamic Teach" procedure.

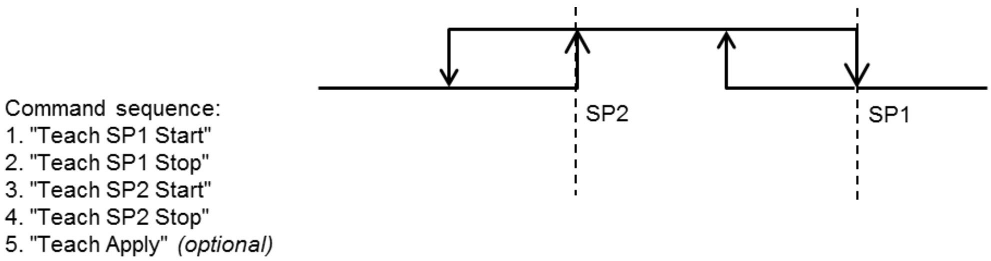

Figure F.11 – "Dynamic Teach-in" (Window Mode or Two Point Mode)

F.4.3.5 "Teach-in Apply"

The command "Teach Apply" can be used optionally to terminate the teach-in procedure with the calculation of the Setpoints. In this case, the Setpoints will be accepted only after "Teach Apply".

F.4.3.6 "Teach-in Cancel"

The command "Teach Cancel" can be used to cancel the teach-in procedure without calculation of the Setpoints. In this case, the previously taught Setpoints will be established.

F.4.4 Parameter 3: "Teach-in Result"

The parameter "Teach-in Result" provides feedback on the status and the results of the teach-in activities. This status information is split into "Teach-in State" and "Teach-in Flags" (see Figure F.13).

The following "Teach-in States" are defined:

- IDLE
- BUSY
- WAIT FOR COMMAND
- SPxSUCCESS
- ERROR

See Table F.2 for definitions of these status types reported via the "Teach-in Result" parameter, and Table F.12 for the coding of this part of the parameter. The reported status information can be manufacturer/vendor specific.

In order to differentiate the teach-in status information, particular "Teach-in Flags" are available, only indicating the result of the Teachpoint (TP) capture (Figure F.13 and Table F.11).

F.4.5 Teach-in dynamics

Figure F.12 shows the Device state machine for the common teach-in procedure.

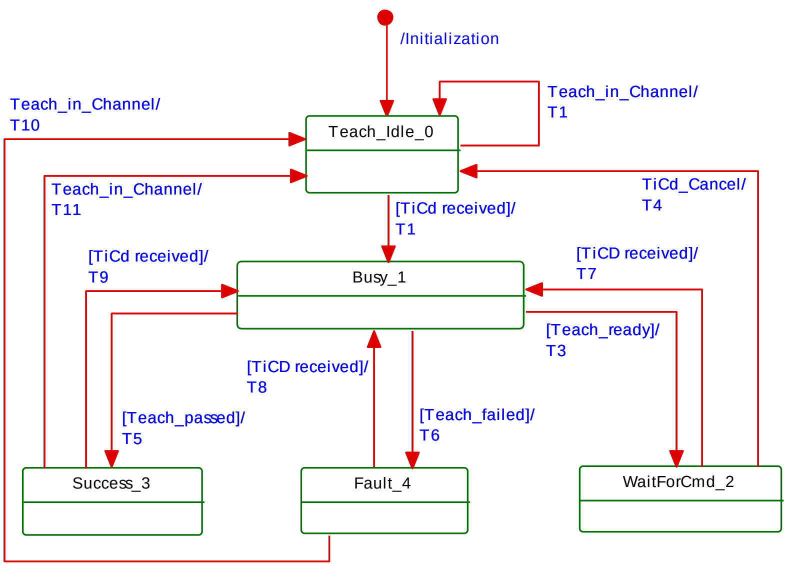

Figure F.12 – State machine of the common teach-in procedure

A taken state depends on the received particular teach-in command. Thus, a reported "Teach-in Result" depends on the actual state of the state machine for the teach-in procedure.

1334 Table F.2 shows the state transition tables of the teach-in procedure.

1335 **Table F.2 – State transition tables of the teach-in procedure**

STATE NAME	STATE DESCRIPTION
Teach_Idle_0	In this state the Device is waiting for a requested teach-in channel or a teach-in command ("TiCd"). The Device operates with the initial or last valid Setpoint settings for the selected teach-in channel.
Busy_1	In this state the acquisition of Teachpoint values and/or calculation of Setpoint values take place according to the requested Teach-in Command (see Table F.). Depending on Device implementation, acquisition of Teachpoints and calculation of Setpoints can be executed in one single sequence, without requiring further teach-in commands. In this case the Device leaves this state via transition T3.
WaitForCmd_2	In this state the Device is waiting for a new teach-in command. It moves to "Teach_Busy_1" upon receiving any teach-in command except the "Teach Cancel" command (TiCd_TeachCancel) where it moves to "Teach_Idle_0" state.
Success_3	In this state the Device operates with the newly acquired and calculated Setpoint values for the selected teach-in channel. It exits upon reception of a new requested teach-in channel or a teach-in command
Fault_4	In this state the Device operates with the last valid Setpoint settings for the selected teach-in channel. It exits upon reception of a new requested teach-in channel or a teach-in command

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TRANSITION	SOURCE STATE	TARGET STATE	ACTION
T1	0	0	The current teach-in channel value is replaced by the required value. The Teach-in Flags are reset. The reported Teach State is "IDLE".
T2	0	1	The acquisition of a single or several Teachpoints is started for the selected teach-in channel. The reported Teach-in State is "BUSY".
T3	1	2	The acquisition of a single or several Teachpoints is ready and the Device requires further teach-in commands. The Teach-in Flags for the acquired Teachpoints are set. The reported Teach-in State is "WAIT FOR COMMAND".
T4	2	0	Teach-in Flags are reset. The last valid Setpoint settings are restored. The reported Teach-in State is "IDLE".
T5	1	3	Teach-in Flags are reset. The new set point values are activated. The reported Teach-in State is "SP1SUCCESS", "SP2SUCCESS" or "SP12SUCCESS", depending on the already executed Setpoint calculations since selection of the teach-in channel.
T6	1	4	Teach-in Flags are reset. The last valid set point values are restored. The reported Teach-in State is "ERROR".
T7	2	1	The action corresponds to T2
T8	4	1	The action corresponds to T2
T9	3	1	The action corresponds to T2
T10	4	0	The action corresponds to T1
T11	3	0	The action corresponds to T1
Initialization	-	0	The teach-in channel value is initialized with the default value ("0"). Teach-in Flags are reset. The reported Teach-in State is "IDLE".

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INTERNAL ITEMS	TYPE	DEFINITION
Teach Flags	-	See Figure F.13
Teach State	-	See Table F.12
Teach_passed	-	Setpoint successfully calculated from Teachpoints
Teach_failed	-	Teachpoints inconsistent or Setpoint calculation impossible
Teach_ready	-	A single teach-in action terminated

F.5 Additional Device parameters for Generic profiled Sensors

F.5.1 Overview

Each and every SSC provides a parameter set defining its switching behavior (Configuration) and an additional parameter set defining the Setpoints.

Table F.3 shows an overview of the defined legacy Smart Sensor Profile data objects in the Index range of ISDUs.

Table F.3 – Legacy Smart Sensor Profile parameters

Index (dec)	Object name	Access	Length	Data type	M/O/C	Remark
0x0002 (2)	SystemCommand	W	1 octet	UIntegerT	C	Extension of SystemCommands, see [1] and Table F.8
…						
0x003A (58)	TI Select	R/W	1 octet	UIntegerT	C	See Table F.10
0x003B (59)	TI Result	R	1 octet	UIntegerT	C	See Table F.11
0x003C (60)	SSC1 Param	R/W	variable	RecordT	C	See Table F.4
0x003D (61)	SSC1 Config	R/W	4 octets	RecordT	C	See Table F.6
0x003E (62)	SSC2 Param	R/W	variable	RecordT	C	See Table F.4
0x003F (63)	SSC2 Config	R/W	4 octets	RecordT	C	See Table F.6
0x4000 ()	SSC3 Param	R/W	variable	RecordT	C	See Table F.4
0x4001 ()	SSC3 Config	R/W	4 octets	RecordT	C	See Table F.6
Subsequent parameters 0x4002 to 0x4079 for SSC4 to SSC127						
0x407A ()	SSC128 Param	R/W	variable	RecordT	C	See Table F.4
0x407B ()	SSC128 Config	R/W	4 octets	RecordT	C	See Table F.6
Key M = mandatory; O = optional; C = conditional						

F.5.2 Parameters for the Generic Profiled Sensor

This clause specifies the specific parameter and coding for the Generic Profiled Sensors (Type 0).

The parameter shown in Table F.4 specifies the parameter "SSCn Param", where "n" is used as an enumerator of the switching channels, further information is provided in Table F.5. The object shall be stored persistent and reset to Default after "FactoryReset".

Table F.4 – Setpoint parameter

Index (dec)	Sub-index	Offset	Access	Parameter Name	Coding	Data type
0x003C (60) or 0x003E (62) or any other ap-plicable address b)	01	See Table F.5	R/W	SP1	Setpoint 1	UIntegerT a) IntegerT a) Float32T
	02	0	R/W	SP2	Setpoint 2	UIntegerT a) IntegerT a) Float32T
Key : a) selectable data length : 8, 16, 32, or 64 bit b) any address of "SSCn Param" parameters						

As the datatype of the setpoints is not fixed the following Table F.5 contains the resulting offsets depending on the used Data types for the set points.

Table F.5 – Offset definition

Data type	Resulting offset
UIntegerT8 IntegerT8	8
UIntegerT16 INTEGERT16	16
UIntegerT32 Integer32	32
UIntegerT64 IntegerT64	48
Float32T	32

The object shown in Table F.6 specifies the parameter “SSCn Config”, where “n” is used as an enumerator of the switching channels. The object shall be stored persistent and reset to Default after “FactoryReset”.

Table F.6 – Configuration parameter

Index (dec)	Sub-index	Offset	Access	Parameter Name	Coding	Data type
0x003D (61) or 0x003F (63) or any other ap-plicable address a)	01	24	R/W	Logic	0x00 : High active Optional values: 0x01 : Low active 0x02 … 0x7F : Reserved 0x80 … 0xFF : Vendor specific	UIntegerT8 (8 bit)
	02	16	R/W	Mode	0x00 : Deactivated 0x01 : Single point 0x02 : Window 0x03 : Two point 0x04 to 0x7F : Reserved 0x80 to 0xFF : Vendor specific	UIntegerT8 (8 bit)
	03	0	R/W	Hyst	0x0000 : mandatory, if no hysteresis or vendor specific default Optional values: 0x0001 to 0xFFFF: Vendor specific defini-tion	UIntegerT16 (16 bit)
Key : a) any address of “SSCn Config” parameters						

F.5.3 Parameters for the Teach-in FunctionClasses

The Teach-in commands allow teaching of a teachpoint (TP) or controlling of the teach-in procedure.

The “SystemCommand” parameter is used as a vehicle to convey the "Teach-in Commands". The details are defined in Table F.7, the additional SystemCommands are specified in Table F.8.

Table F.7 – Command parameter for Teach-in

Index (dec)	Sub-index	Offset	Access	Parameter Name	Coding	Data type
0x0002 (2)	n/a	n/a	W	System-Command	See Table F.8	UIntegerT8 (8 bit)
Key : n/a not applicable						

Table F.8 specifies the “Teach-in command” coding for the FunctionClass Teach Channel 0x8004. The dynamic behaviour is described in F.4.5.

Table F.8 – "Teach-in Command" coding

Teach-in Command	Value	Comment	FC 8004
Teach Apply	0x40	Calculate and apply SP1,2 from Teachpoint(s)	O
Teach SP1	0x41	Determine Teachpoint1 for Setpoint1	O
Teach SP2	0x42	Determine Teachpoint1 for Setpoint2	O
Teach SP1 TP1	0x43	Determine Teachpoint1 for Setpoint1	O
Teach SP1 TP2	0x44	Determine Teachpoint2 for Setpoint1	O
Teach SP2 TP1	0x45	Determine Teachpoint1 for Setpoint2	O
Teach SP2 TP2	0x46	Determine Teachpoint2 for Setpoint2	O
Teach SP1 Start	0x47	Start dynamic teach-in for Setpoint1	O
Teach SP1 Stop	0x48	Stop dynamic teach-in for Setpoint1	O
Teach SP2 Start	0x49	Start dynamic teach-in for Setpoint2	O
Teach SP2 Stop	0x4A	Stop dynamic teach-in for Setpoint2	O
Teach Custom	0x4B to 0x4E	For manufacturer specific use	O
Teach Cancel	0x4F	Abort Teach-in sequence	O
Key M Mandatory O Optional			

Table F.9 specifies the parameter TI Select which defines the selected switching signal channel for the next teach-in procedure. The table references individual coding in Table F.10. The object is volatile and reset to Default after “FactoryReset”.

Table F.9 – Selection for Teach-in channel

Index (dec)	Sub-index	Offset	Access	Parameter Name	Coding	Data type
0x003A (58)	n/a	n/a	R/W	TI Select	See Table F.10	UIntegerT8 (8 bit)
Key : n/a not applicable						

Table F.10 shows the coding of the selectable SSC.

Table F.10 – "TI Select" coding

Teach-in channel	Definition
0	Address of the manufacturer/vendor specific pre-defined (default) SSC
1 to 128	Address of the SSC1 to SSC128
129 to 191	Reserved
192-254	Different manufacturer/vendor specific SSC sets
255	Addressing of all implemented SSCs

Figure F.13 shows the data structure of the "Teach-in Flags" and the "Teach-in State" to be used in the "TI Result" coding in Table F.11.

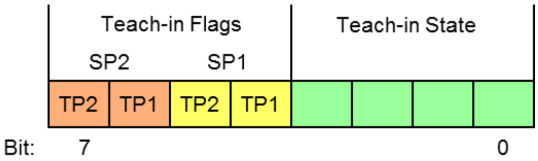

Figure F.13 – Structure of the "Teach Flags" and the "Teach State"

Table F.11 specifies the assignment of the parameter "TI Result" according to the Figure F.13 which shows the layout of the parameter. The table references individual coding in Table F.12. The object is volatile and reset to Default after "FactoryReset".

Table F.11 – Result parameter for Teach-in

Index (dec)	Sub-index	Offset	Access	Parameter Name	Coding	Data type
0x003B (59)	05	7	R	Flag SP2 TP2	"0" = Teachpoint not aquired or not successful "1" = Teachpoint successfully aquired	BooleanT (1 bit)
	04	6	R	Flag SP2 TP1		BooleanT (1 bit)
	03	5	R	Flag SP1 TP2		BooleanT (1 bit)
	02	4	R	Flag SP1 TP1		BooleanT (1 bit)
	01	0	R	State	See Table F.12	UIntegerT4 (4 bit)

Table F.12 shows the "Teach State" coding.

Table F.12 – "Teach State" coding

Teach State	Definition
0	IDLE
1	SP1 SUCCESS
2	SP2 SUCCESS
3	SP12 SUCCESS
4	WAIT FOR COMMAND
5	BUSY
6	Reserved
7	ERROR
8 to 11	Reserved
12 to 15	Manufacturer/vendor specific

F.6 IODD definitions and rules

The same rules and constraints as specified in Annex E are valid for the Generic Profiled Sensor.

F.6.1 Name definitions

Table F.13 specifies the name predefinitions for the SSC Param parameter, see Table F.4.

Table F.13 – SSC Param predefinition

Variable name predefinition	Subindex	RecordItem name predefinition	SingleValue name predefinition
SSCn Param a)	1	SP1	n/a
	2	SP2	n/a
Keys a) SSCn where n is a number from 1 to 128 n/a not applicable			

Table F.14 specifies the name predefinitions for the SSC Config parameter parameter including the predefinitions for the SingleValues, see Table F.6.

Table F.14 – SSC Config predefinition

Variable name predefinition	Subindex	RecordItem name predefinition	SingleValue name predefinition
SSCn Config a)	1	Logic	0 = High active 1 = Low active
	2	Mode	0 = Deactivated 1 = Single Point 2 = Window 3 = Two Point 0x80 .. 0xFF = Custom
	3	Hyst	n/a
Keys a) SSCn where n is a number from 1 to 128 n/a not applicable			

Table F.15 specifies the name predefinitions for the TI Select parameter parameter including the predefinitions for the SingleValues, see Table F.9.

Table F.15 – TI Select predefinition

Variable name predefinition	SingleValue name predefinition
TI - Select	0x00 = Default channel 0x01 = SSC1 … 0x80 = SSC128 0xC0 .. 0xFE = Custom 0xFF = All SSC

Table F.16 specifies the predefinitions for the Teach-in commands defined for the SystemCommand parameter, see Table F.8.

Table F.16 – Teach-in command predefinition

Variable name	SingleValue name predefinitions
System Command	0x40 = Teach apply 0x41 = Teach SP1 0x42 = Teach SP2 0x43 = Teach SP1 TP1 0x44 = Teach SP1 TP2 0x45 = Teach SP2 TP1 0x46 = Teach SP2 TP2 0x47 = Teach SP1 start 0x48 = Teach SP1 stop 0x49 = Teach SP2 start 0x4A = Teach SP2 stop 0x4B .. 0x4E = Teach Custom 0x4F = Teach cancel

Table F.17 specifies the name predefinitions for the TI Result parameter including the predefinitions for the SingleValues, see Table F.11.

Table F.17 – TI Result predefinition

Variable name predefinition	Subindex	Parameter name predefinition	SingleValue name predefinition
TI Result	5	Flag SP2 TP2	0 = Nok 1 = OK
	4	Flag SP2 TP1	
	3	Flag SP1 TP2	
	2	Flag SP1 TP1	
	1	State	0 = Idle 1 = SP1 success 2 = SP2 success 3 = SP12 success 4 = Wait for command 5 = Busy 7 = Error 12 .. 15 = Custom

F.6.2 Menu structure of a Generic Profiled Sensor

In Figure F.14 the menu structure of a Generic Profiled Sensor is specified, it shall be located in the Parameter section of the menu..

The same rules apply as defined in E.4.1

Menu	Parameter	Value
- Switching Signal Channel 1		
	SSC1 Param - SP1	1234
	SSC1 Param - SP2	1234
	SSC1 Config - Logic	High active
	SSC1 Config - Mode	Two point
	SSC1 Config - Hyst	0
+ SwitchingSignalChannel2		
- Teach-in Single Value *		
	TI - Select	SSCn
	System Command	Teach SPn
	TI Result - State	Idle
- Teach-in Two Value *		
	TI - Select	SSCn
	System Command	Teach SPn TP1
	System Command	Teach SPn TP2
	System Command	Teach Cancel
	TI Result - Flag SP2 TP1	Ok
	TI Result - Flag SP2 TP2	Ok
	TI Result - State	Idle
- Teach-in Dynamic *		
	TI - Select	SSCn
	System Command	Teach SPn Start
	System Command	Teach SPn Stop
	System Command **	Teach Apply
	TI Result - State	Idle

Figure F.14 – Menu GPS

The parameter tree of Switching Signal Channel 2 is collapsed and structural identical to the Switching Signal Channel 1.

The presence of the parameter tree marked with an "*" are depending on the supported Teach-in functionalities and may be conditional on the selected SSCn Config Mode. The example shows a default layout, non-reduced layout.

"SSCn" and "SPn TP" show the variables selected by TI Select, only one teach channel at a time is visible.

Note ** The naming of the SystemCommand is depending on the parametrization tool.

Annex G
(normative)
Profile testing and conformity

G.1 General

G.1.1 Overview

It is the responsibility of the vendor/manufacturer of a Smart Sensor profile Device to perform a conformity testing and to provide a document similar to the manufacturer declaration defined in [1] or based on the template downloadable from the IO-Link website (www.io-link.com).

G.1.2 Issues for testing/checking

- Identification complete and correct?
- Descriptors available and correct?
- All rules observed?
- Switching behavior conform to the specification?
- FunctionClasses available and correct?
  - Indices available and correct?
  - Read/write correct?
  - Data structures: Record? Value ranges?
  - Behavior of the FunctionClass conforms to the specification?
- Extract SSCs (switching functions) and MDCs (measuring data functions) from user manual or IODD and check conformity with the specification
- Checklist: checkbox "relevant" and checkbox "verified"
- IODD: see [6]

Annex H
(informative)
Information on conformity testing of profile Devices

Information about testing profile Devices for conformity with this document can be obtained from the following organization:

IO-Link Community
Haid-und-Neu-Str. 7
76131 Karlsruhe
Germany
Phone: +49 (0) 721 / 96 58 590
Fax: +49 (0) 721 / 96 58 589
E-mail: info@io-link.com
Web site: http://www.io-link.com

Bibliography

[1] IO-Link Community, *IO-Link Interface and System*, V1.1.2, July 2013, Order No. 10.002, or
IEC 61131-9, *Programmable controllers – Part 9: Single-drop digital communication interface for small sensors and actuators (SDCI)*

[2] IO-Link Community, *IO Device Description (IODD)*, V1.1, July 2011, Order No. 10.012

[3] IEC/TR 62390:2005, *Common automation device profile guideline*

[4] IEC 60050 (all parts), *International Electrotechnical Vocabulary*

NOTE See also the IEC Multilingual Dictionary – Electricity, Electronics and Telecommunications (available on CD-ROM and at <http://domino.iec.ch/iev>).

[5] IO-Link Community, *IO-Link Communication*, V1.0, January 2009, Order No. 10.002

[6] IO-Link Community, *IO-Link Test*, V1.1.2, July 2014, Order No. 10.032

[7] IO-Link Community, *IO-Link Profile Guideline*, V0.9.9, Mar 2017, Order No. 10.072

[8] IO-Link Community, *Corrigendum & Package 2015*, V1.0, February 2016, Order No. 10.122

[9] IO-Link Community, *IO-Link Smart Sensor Profile*, V1.0, October 2011, Order No. 10.042, discontinued

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