Application Note

FESTO

IO-Link parameter description

A brief explanation of the contents
- identification
- parameter and commands
- block parameterization
- teach-In
- process data
- using different pressure units
- diagnosis

SPAE-.....
pressure sensor

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1 Components/Software used

Type/Name	Version Software/Firmware	Date of manufacture
SPAE-...	general	operative from 2015

Table 1.1: 1 Components/Software used

Note

You can find detailed specifications on the product, the instruction manual and the declaration of conformity at:

➔ www.festo.com

Detailed information on the IO-Link specification V1.1 und the Smart sensor profile at:

➔ www.io-link.com

The device description file IODD at:

➔ www.festo.com/sp

2 IO-Link operating mode

In the IO-Link operating mode, programmed switching signals and the continuously measured pressure values (digitally coded analogue values) are transferred.

– Data transmission is serially and digitally coded in the IO-Link protocol.
– Usage of unshielded standard cables up to 20 m length is possible.
– Process data: 14 bit for the pressure measurement value and 2 bit for the binary channels.
– Parameters and functions in accordance with Smart-Sensor Profile.
– There are two binary channels available, which can be individually programmed as threshold comparator, hysteresis comparator or window comparator.
– Each binary channel is adjustable as normally closed (NC) or normally open (NO).
– The continuously measured pressure values are always transferred parallel and independent of the binary channels.
– Support of optional functions Block Parameterisation and Data Storage.
– Display IO-Link operation: LEDs are inverted every 2 seconds for the period of 0,1 seconds.
– The key is locked during a parameter access, afterwards the device returns automatically into the RUN mode.
– Device description file IODD for every pressure range and for every physical pressure unit.

3 Technical data

3.1 General specification

IO-Link	
Protocol	IO-Link
IO-Link, Protocol version	Device V1.1
IO-Link, Profile	Smart Sensor Profile
IO-Link, Function classes	Binary data channel, Process data variable, Identification, Diagnosis, Teach channel
IO-Link, Communication mode	COM2 (38,4 kBaud)
IO-Link, Port class	A
IO-Link, Process data length OUT	0 byte
IO-Link, Process data length IN	2 bytes
IO-Link, Process data content IN	Pressure monitoring BDC1 (Binary Data Channel 1) Pressure monitoring BDC2 (Binary Data Channel 2) Pressure measured value PDV 14 bit (Process Data Variable)
IO-Link, Min. cycle time	3 ms
IO-Link, Data storage required	0,5 kByte
IO-Link, Device ID	see chapter *3.3.1 Identification parameters*

Table 3.1:

3.2 Communication features

- Preoperate: Frame type 1_V, OD-capability 8 bytes
- Operate: Frame type 2_V, OD-capability 2 bytes
- ISDU will be supported
- Data storage will be supported
- Block parameterisation will be supported

3.3 On demand data

The detailed description of these parameters can be found in the IO-Link specification, in the IODD, in the IO-Link test und Smart sensor profile. The default values and the respective valid range of these parameters are listed in the IODD xml file.

3.3.1 Identification parameters

Vendor ID 333 d / 01 4D h
Device ID see the following table

Device ID [dec]	Device ID [hex]	Order Code
126	00 00 7E	SPAE-P025R-...
127	00 00 7F	SPAE-V025R-...
128	00 00 80	SPAE-P05R-...
129	00 00 81	SPAE-V05R-...
130	00 00 82	SPAE-P1R-...
131	00 00 83	SPAE-V1R-...
132	00 00 84	SPAE-B2R-...
133	00 00 85	SPAE-P2R-...
134	00 00 86	SPAE-P6R-...
135	00 00 87	SPAE-P10R-...
136	00 00 88	SPAE-B11R-...

Table 3.2:

Index	Subin-dex	Name	Value	Access[1]			Length	Format
				U	M	S		
0x0010	0	Vendor Name	Festo AG & Co. KG	R	R	R	11 bytes	String
0x0011	0	Vendor Text	http://www.festo.com	R	R	R	20 bytes	
0x0012	0	Product Name	Order code, e.g. SPAE-P10R-Q4-PNLK-2.5K	R	R	R	64 bytes	
0x0013	0	Product ID[2]	e.g. 1234567	R	R	R	7 bytes	
0x0014	0	Product Text	Pressure sensor	R	R	R	15 bytes	
0x0015	0	Serial Number	YMP12345[3]	R	R	R	8 bytes	
0x0016	0	Hardware Revision	0000	R	R	R	4 bytes	
0x0017	0	Firmware Revision	V00.42.01.24	R	R	R	12 bytes	
0x0018	0	Application Specific Tag[4]	***	R	R/W	R/W	32 bytes	

1) Authorisation group: U = user, M = maintenance, S = specialist; access: R = read, R/W = read and write; , – = no access
2) Festo-part number
3) **Y**ear**M**onth (coded date of manufacture) **P**=consecutively numbered 5 digits test number
4) Value defined by user

Table 3.3:

3.3.2 Standard IO-Link parameters und commands

Index	SubIn-dex	Name	Value	Access[1]			Length	Format
				U	M	S		
0x0002	0	System command	➔ Table 3.5				1 byte	UInterger8
0x000C	0	Device access Locks[2]	0 = unlocked 1 = locked	R	R/W	R/W	2 bytes	Record
0x0020	0	Error count	0	R	R	R	2 bytes	UInterger16
0x0024	0	Device status	0	R	R	R	1 byte	UInterger8
0x0025	0	Detailed device status	➔Table 3.14[3]	R	R	R	192 bytes	Array of 3 byte records
0x0028	0	Process data input	➔ Table 3.11	R	R	R	2 bytes	Record

1) Authorisation group: U = user, M = maintenance, S = specialist; access: R = read, R/W = read and write; , – = no access

2) Bit 0: lock Parameter Write Access; Bit1: lock data storage; Bit3: lock local user interface (key)

3) maximal 5 different Device status are available

Table 3.4:

Value dec	Value hex	Access[1]			Command	Note	Format
		U	M	S			
128	0x80	–	W	W	Reset device	Device warm start	UInterger8
130	0x82	–	W	W	Restore Factory Settings	Sets the factory settings operative again	
160	0xA0	W	W	W	Reset InA1 min	Reset the minimal measurement value storage	
161	0xA1	W	W	W	Reset InA1 max	Reset the maximal measurement value storage	
65	0x41	–	W	W	P1 Single Value Teach	Determines Teachpoint for Setpoint P1	
66	0x42	–	W	W	P2 Single Value Teach	Determines Teachpoint for Setpoint P2	
67	0x43	–	W	W	P1 Two Value Teach TP1	Determines Teachpoint 1 for Setpoint P1	
68	0x44	–	W	W	P1 Two Value Teach TP2	Determines Teachpoint 2 for Setpoint P1	
75	0x4B	–	W	W	One Action Teach	Device specific Teach-In	
79	0x4F	–	W	W	Teach Cancel	Cancels the Teach-In sequence	

1) Authorisation group: U = user, M = maintenance, S = specialist; access: R = read, R/W = read and write; , – = no access

Table 3.5:

3.3.3 Smart-sensor profile parameter

Index	Subin-dex	Name	Value	Access [1]			Length (byte)	Format
				U	M	S		
0x000D	0	Profile characteristics		R	R	R	12	Array of UInteger16
	1	Device profile ID	0x0001: SmarteSensor profile	R	R	R	2	UInteger16
	2	Function class ID	0x8000: Device identification	R	R	R	2	
	3	Function class ID	0x8001: Binary data channel	R	R	R	2	
	4	Function class ID	0x8002: Process data variable	R	R	R	2	
	5	Function class ID	0x8003: Diagnosis	R	R	R	2	
	6	Function class ID	0x8004: Teach channel	R	R	R	2	
0x000E	0	PDInput descriptor		R	R	R	6	Array of OctetString3
	1	BDC1, BDC2	0x01, 0x02, 0x00	R	R	R	3	OctetString3
	2	Process data value	0x02, 0x0E, 0x02	R	R	R	3	OctetString3
0x003A	0	Teach-in channel	0 - default BDC1 (OutA) 1 - BDC1 (OutA) 2 - BDC2 (OutB)	-	R/W	R/W	1	UInteger8
0x003B	0	Teach-in status	0	-	R	R	1	Record
	1	Teach flag P2 TP2	0 - not taught, 1 - taught	-	R	R	1	BooleanT
	2	Teach flag P2 TP1	0 - not taught, 1 - taught	-	R	R	1	
	3	Teach flag P1 TP2	0 - not taught, 1 - taught	-	R	R	1	
	4	Teach flag P1 TP1	0 - not taught, 1 taught	-	R	R	1	
	5	Teach state	0	-	R	R	1	UInteger4
BDC1, Pressure monitoring OutA								
0x003C	1	Setpoint P1	164 ... 16219, default 11468	R	R/W	R/W	2	UInteger16
	2	Setpoint P2	164 ... 16219, default 9830				2	
0x003D	1	Switchpoint logic	0 – normally open, default 1 – normally closed				1	UInteger8
	2	Switchpoint mode [2]	1 – single point mode (F0) 2 - Window mode (F3) 3 – Two point mode (F2) 0x80 - Two teach point (F1)				1	
	3	Switchpoint hysteresis	0 ... 1621, default 82				2	UInteger16
BDC2, Pressure monitoring OutB								
0x003E	1	Setpoint P1	0 ... 16382, default 6553	R	R/W	R/W	2	UInteger16
	2	Setpoint P2	0 ... 16382, default 3277				2	
0x003F	1	Switchpoint logic	0 – normally open, default 1 – normally closed				1	UInteger8
	2	Switchpoint mode [2]	1 – single point mode (F0) 2 - Window mode (F3) 3 – Two point mode (F2) 0x80 - Two teach point (F1)				1	
	3	Switchpoint hysteresis	0 ... 14746, default 82				2	UInteger16

1) Authorisation group: U = user, M = maintenance, S = specialist; access: R = read, R/W = read and write; , – = no access

2) default 1 – single point mode (F0)

Table 3.6:

3.3.4 IO-Link Teach-In

The remote teach-in procedure via IO-Link is the same as the manual one. Instead of key pressing the teaching points are taught by the corresponding commands from IO-Link Smart sensor profile.
The teaching sequence does not matter too.

In case of an over-pressure event every teach command causes ISDU error “function temporarily unavailable” 0x8036 and the teach-in procedure is cancelled. If the teach-in mode was not yet started, then the device will remain in the run mode.

A survey on the teach-in commands ➔ Table 3.5

The “P1 single value teach” command 0x41 teaches the teaching point TP1 in the modes F0, F2 and F3.

The “P2 single value teach” command 0x42 teaches the teaching point TP2 in the modes F2 and F3.

The “P1 two value teach TP1” and the “P1 two value teach TP2” commands 0x43 and 0x44 teach the teaching points TP1 and TP2 in the mode F1.

In contrast to the manual Teach-in procedure a teach point can be repeatedly set with the commands 0x41, 0x42, 0x43 and 0x44 regardless of the sequence of applying the teach pressure TP1 and TP2.

In case an invalid command, respective to the current switching / teach mode, is sent, the device will signal the ISDU error “function not available” 0x8035.

The mode F0 has only one teach point and causes no reaction on the display.

In the other modes, once any teach point command is activated, the sensor starts the Teach-in procedure. It sets the corresponding teach point, the teach flags and teach state and waits for the second command. The display shows the currently measured process value. One LEDs blink intact to signal the remote Teach-In state. The key is locked between the first and the second teach command.

If the first teach command comes once more before the second one, then the currently measured process value will be used again for the first teach point. The second teach point is set after the second teach command, and the remote Teach-In procedure ends in the same way as manual Teach-in.

All Teach-in commands are in format UInterger8. They should be sent with the index 0x0002 (system command) sub index 0.

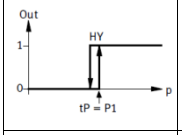
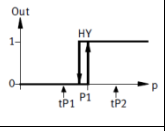
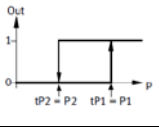
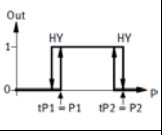
➔ **note**

There is also a specific teach command 0x4B, which is used in IODD to simulate key pressing in IODD device tool. This command reflects the logic of the manual Teach-in using key pressing.
Additionally this command can ease the use of the Teach-in functions provided by IO-Link for customer applications.

- In mode F0 this command equates to the “P1 single value teach” command 0x41.
- In mode F1 the first sending of this command equates to the “P1 two value teach TP1” commands 0x43 and the second sending equates to the “P1 two value teach TP2” commands 0x44.
- In modes F2 and F3 the first sending equates to the “P1 single value teach” command 0x41 and the second equates to the “P2 single value teach” commands 0x42.

For more information see IO-Link Smart Sensor Profile.

Survey of the Teach-In command sequence

					Mode			
					F0	**F1**	**F2**	**F3**
					Single Point Mode	Single Point Mode	Two Point Mode	Window Mode
								
					Threshold value comparator	Thresh-oldvalue comparator	Threshold value comparator	Window-comparator
No.	**Action**	**Out**	**Index**	**Sub-Index**	**Data**			
1	If necessary choose the appro-priate switching function[1)]	A	0x003D	0x02	0x01	0x80	0x03	0x02
		B	0x003F	0x02				
2	Choose BDC	A	0x003A	0x00	0x01			
		B	0x003A	0x00	0x02			
i	Single value Teach-In				✓		✓	✓
	Two value Teach-In					✓		
3	Apply the first teach pressure							
4	P1 Single value teach		0x0002	0x00	0x41		0x41	0x41
	P1 Two value teach (tP1)		0x0002	0x00		0x43		
5	Apply the second teach pressure							
6	P2 Single value teach		0x0002	0x00			0x42	0x42
	P1 Two value teach (tP2)		0x0002	0x00		0x44		
i	Canceling Teach-In		0x0002	0x4F	is always possible			

1) By changing the switching function an inconsistent set of parameters for Fx, P1, P2, HY could occur which prevents the switching function to be changed. An appropriate error message is shown. In this case to restore the factory settings is recommended. With the factory settings a free choice of a switching function is always possible.

Table 3.7:

➔ **Note**

The Teach-apply command 0x40 is not used during Teach-in process. All successfully calculated switching points will be immediately taken over.

3.3.5 Block parameterisation

With this feature the sending of invalid parameters to a device can be prevented. Individually sent parameter values are as the case may be not compatible to the parameter values already stored in the device.

The parameters transmitted as a block will be simultaneously accepted and activated.

For SPAE there are two blocks of parameters:

Block parameterisation for **BDC1**

Index	Sub-Index	Name
0x003C	1	Setpoint P1
	2	Setpoint P2
0x003D	2	Switch mode
	3	Hysteresis

Table 3.8:

Block parameterisation for **BDC2**

Index	Sub-Index	Name
0x003E	1	Setpoint P1
	2	Setpoint P2
0x003F	2	Switch mode
	3	Hysteresis

Table 3.9:

3.3.6 Device specific parameter

Index	SubIndex	Name	Value	Access[1]			Length	Format
				U	M	S		
0x0182	0	Filter response time InA (τ=1ms x 2^n)	0 = Filter Off , default value 1 = 2 ms 2 = 4 ms 3 = 8 ms 4 = 16 ms 5 = 32 ms 6 = 64 ms	-	-	R/W	2 Bytes	UInteger16
0x01E2	0	Display brightness	1 = min. .... 5 = max. brightness default value: 4	R	R/W	R/W		
0x01E8	0	Display duration [di]	0 – permanent on / 1 ... 20 min Default value: 0	R	R/W	R/W		
0x01E9	0	Display orientation [do] / [op]	0 - standard, 1 - reversed Default value: 0	R	R/W	R/W		
0x01EA	0	Lock code	0 - no lock / 1...99 – code default value: 0	R	R/W	R/W		
0x2005	0	[Lo] InA minimal meaured pressure value (volatile)	0 ... 2^{14} - 1	R	R	R		
0x2006	0	[Hi] InA maximal meaured pressure value (volatile)	0 ... 2^{14} - 1	R	R	R		

1) Authorisation group: U = user, M = maintenance, S = specialist; access: R = read, R/W = read and write; , – = no access

Table 3.10:

3.4 Process data IN

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Significance	MSB													LSB		
Process data	Process Data Variable (PDV)														BDC2	BDC1
Data content	14-bit measured value (pressure measurement value InA)														OutB	OutA
Index	0x0028															
Sub-Index	1														2	3
Data type	UInteger14														BooleanT	

Table 3.11:

3.5 Conversion factor for the parameters Process data value, Process data value min, Process data value max and Switching points P1, P2

The conversion factors, necessary for the correct representation of the measurement values and the switching points in different physical units in the control unit, are:

Range		**Units**								
[bar]		**mbar**	**bar**	**kPa**	**MPa**	**psi**	**mmHg**	**inchHg**	**inch$H_2$0**	**kgf/cm²**
0 ... 0,25 P025	G[1)]	0,015259720442	0,000015259720	0,001525972044	0,000001525972	0,000221323933	0,011445736434	0,000450619545	0,006126319966	0,000015560337
	O[1)]	0	0	0	0	0	0	0	0	0
0 ... -0,25 V025	G	-0,015259720442	-0,000015259720	-0,001525972044	-0,000001525972	-0,000221323933	-0,011445736434	-0,000450619545	-0,006126319966	-0,000015560337
	O	0	0	0	0	0	0	0	0	0
0 ... 0,5 P05	G	0,030519440884	0,000030519441	0,003051944088	0,000003051944	0,000442647867	0,022891472868	0,000901239089	0,012252639932	0,000031120674
	O	0	0	0	0	0	0	0	0	0
0 ... -0,5 V05	G	-0,030519440884	-0,000030519441	-0,003051944088	-0,000003051944	-0,000442647867	-0,022891472868	-0,000901239089	-0,012252639932	-0,000031120674
	O	0	0	0	0	0	0	0	0	0
0 ... -1 V1	G	-0,061038881768	-0,000061038882	-0,006103888177	-0,000006103888	-0,000885295733	-0,045782945736	-0,001802478179	-0,024505279863	-0,000062241348
	O	0	0	0	0	0	0	0	0	0
0 ... 1 P1	G	0,061038881768	0,000061038882	0,006103888177	0,000006103888	0,000885295733	0,045782945736	0,001802478179	0,024505279863	0,000062241348
	O	0	0	0	0	0	0	0	0	0
0 ... 2 P2	G	0,122077763535	0,000122077764	0,012207776354	0,000012207776	0,001770591467	0,091565891473	0,003604956357	0,049010559727	0,000124482695
	O	0	0	0	0	0	0	0	0	0
0 ... 6 P6	G	0,366233290606	0,000366233291	0,036623329061	0,000036623329	0,005311774400	0,274697674419	0,010814869072	0,147031679180	0,000373448086
	O	0	0	0	0	0	0	0	0	0
0 ... 10 P10	O	0,610388817677	0,000610388818	0,061038881768	0,000061038882	0,008852957334	0,457829457364	0,018024781786	0,245052798633	0,000622413477
	G	0	0	0	0	0	0	0	0	0
-1 ... 1 B2	G	0,122077763535	0,000122077764	0,012207776354	0,000012207776	0,001770591467	0,091565891473	0,003604956357	0,049010559727	0,000124482695
	O	-1000	-1	-100	-0,1	-14,5038	-750,062	-29,53	-401,47	-1,0197
-1 ... 10 B11	G	0,671427699445	0,000671427699	0,067142769944	0,000067142770	0,009738253067	0,503612403101	0,019827259965	0,269558078496	0,000684654825
	O	-1000	-1	-100	-0,1	-14,5038	-750,062	-29,53	-401,47	-1,0197

1) G = Gradient, O = Offset

Table 3.12:

3.6 Conversion factor for the hysteresis

Range		Units								
[bar]		mbar	bar	kPa	MPa	PSI	mmHg	inchHg	inchH_20	kgf/cm²
0 ... 0,25 P025	G[1)]	0,015259720442	0,000015259720	0,001525972044	0,000001525972	0,000221323933	0,011445736434	0,000450619545	0,006126319966	0,000015560337
	O[1)]	0	0	0	0	0	0	0	0	0
0 ... -0,25 V025	G	0,015259720442	0,000015259720	0,001525972044	0,000001525972	0,000221323933	0,011445736434	0,000450619545	0,006126319966	0,000015560337
	O	0	0	0	0	0	0	0	0	0
0 ... 0,5 P05	G	0,030519440884	0,000030519441	0,003051944088	0,000003051944	0,000442647867	0,022891472868	0,000901239089	0,012252639932	0,000031120674
	O	0	0	0	0	0	0	0	0	0
0 ... -0,5 V05	G	0,030519440884	0,000030519441	0,003051944088	0,000003051944	0,000442647867	0,022891472868	0,000901239089	0,012252639932	0,000031120674
	O	0	0	0	0	0	0	0	0	0
0 ... -1 V1	G	0,061038881768	0,000061038882	0,006103888177	0,000006103888	0,000885295733	0,045782945736	0,001802478179	0,024505279863	0,000062241348
	O	0	0	0	0	0	0	0	0	0
0 ... 1 P1	G	0,061038881768	0,000061038882	0,006103888177	0,000006103888	0,000885295733	0,045782945736	0,001802478179	0,024505279863	0,000062241348
	O	0	0	0	0	0	0	0	0	0
0 ... 2 P2	G	0,122077763535	0,000122077764	0,012207776354	0,000012207776	0,001770591467	0,091565891473	0,003604956357	0,049010559727	0,000124482695
	O	0	0	0	0	0	0	0	0	0
0 ... 6 P6	G	0,366233290606	0,000366233291	0,036623329061	0,000036623329	0,005311774400	0,274697674419	0,010814869072	0,147031679180	0,000373448086
	O	0	0	0	0	0	0	0	0	0
0 ... 10 P10	O	0,610388817677	0,000610388818	0,061038881768	0,000061038882	0,008852957334	0,457829457364	0,018024781786	0,245052798633	0,000622413477
	G	0	0	0	0	0	0	0	0	0
-1 ... 1 B2	G	0,122077763535	0,000122077764	0,012207776354	0,000012207776	0,001770591467	0,091565891473	0,003604956357	0,049010559727	0,000124482695
	O	0	0	0	0	0	0	0	0	0
-1 ... 10 B11	G	0,671427699445	0,000671427699	0,067142769944	0,000067142770	0,009738253067	0,503612403101	0,019827259965	0,269558078496	0,000684654825
	O	0	0	0	0	0	0	0	0	0

1) G = Gradient, O = Offset

Table 3.13:

3.7 Diagnosis

Error-code	Mode	Type	Malfunction	Possible cause	Remedy
0x5000	(Dis)appear	Error	Display [Er] / [01]	Device defective	• Replace device
0x8C10	(Dis)appear	Warning	Display flashes in the RUN mode	Measuring range exceeded	• Stay within measuring range
0x5111	(Dis)appear	Error	Display [Er] / [17]	Undervoltage	• Apply permissible operatingvoltage
0x4210	(Dis)appear	Error	Display [Er] / [20]	Temperature error	• Check operating conditions • Replace device
0x1815	(Dis)appear	Error	Display [Er] / [21]	Short circuit of OutA	• Eliminate short circuit

Table 3.14: