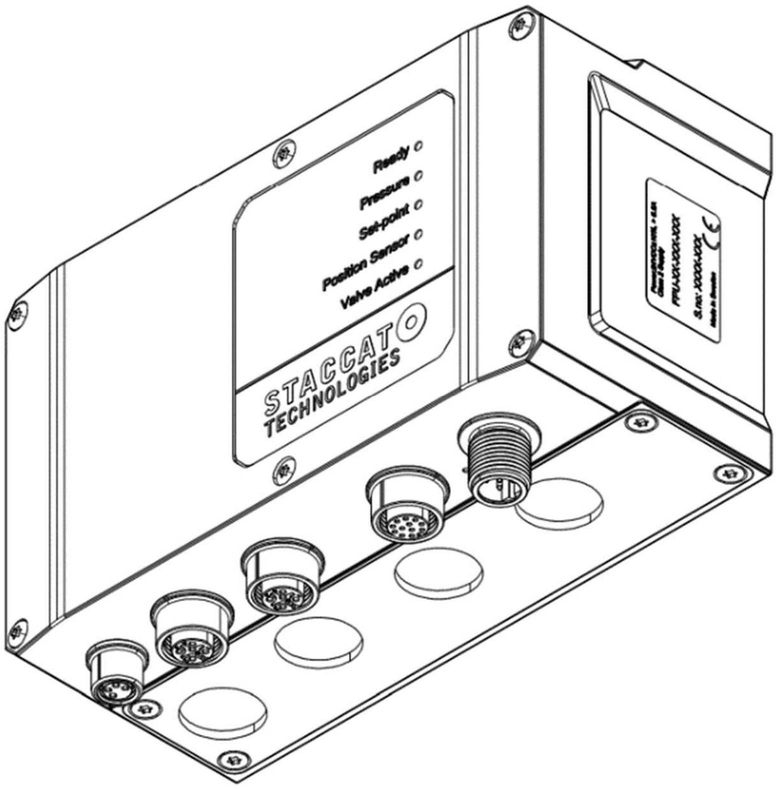
1 FPU-XX-XXX-XXX



FPU (Flexible Positioning Unit) is a control unit for pneumatic cylinders. Connect the FPU to a pneumatic cylinder together with position sensor to get 0.5 mm accuracy with speeds up to 1 m/s

This document describes the I/O Link protocol of the FPU. Note that this document is not a standalone document, please read the manual of the FPU (500-211 8200) to fully utilize this document.

⚠ **Warning:** This document only describes I/O Link protocol, read manual (document 500-2118200) before operating the FPU.

1 Index

2 Warning and Precautions!

⚠ **Warning: E**quipment with compressed air can be dangerous for people and equipment. Design, use and maintenance should only be done by trained personnel with relevant competence. Care should always be taken to avoid risks. Can be, but is not limited to; uncontrolled movements, trapped air, pinching & crushing forces, noise etc. Systems should always be designed with considerations to safety.

⚠ **Warning:** This document only describes I/O Link protocol, read manual (document 500-2118200) before using the FPU.

⚠ **Warning:** The positioning unit uses normally closed 2-port valves internally. Consider application and user safety when designing systems to consider implications with trapped air. Ensure that trapped air is exhausted prior to doing maintenance.

⚠ **Warning:** movement against empty actuator chambers can cause uncontrolled (fast) movements, consider application and user safety when designing systems to consider implications with fast movements.

⚠ **Warning:** Oscillating movement can occur if setting is too aggressive for application. Setup system in a safe manner and avoid borderline settings on speed and controller gain.

⚠ **Warning:** Ruptured tubing can cause uncontrolled movement.

⚠ **Caution:** When using external locks, consider implications of failed signals and pressure loss.

⚠ **Caution:** When using booster valves, consider implications of failed signals and pressure loss.

⚠ **Caution:** Incorrect setting may cause unwanted behavior in application.

⚠ **Caution:** Undesired exhaust may cause uncontrolled movement, consider potential risks when using Exhausting functions.

⚠ **Caution:** Supply pressure loss may cause the system to exhaust the air when trying to compensate for pressure loss.

⚠ **Caution:** Leakage may cause impaired function, uncontrolled movement, and increased noise levels.

⚠ **Caution:** Incorrect position sensor signal may cause undesired function

⚠ **Caution:** Incorrect set position signal may cause undesired function

Note: long tubing and/or tubing with restricted flow may delay response and impair function

Note: Too low force/pressure setting may restrict actuator movement

Note: On first start-up after exhausted chambers, a few cycles of movement may be needed to build up pressure (depending on application).

Note: Actuator may get stuck in an end position if position sensor signal is reversed or out of range.

3 Overview

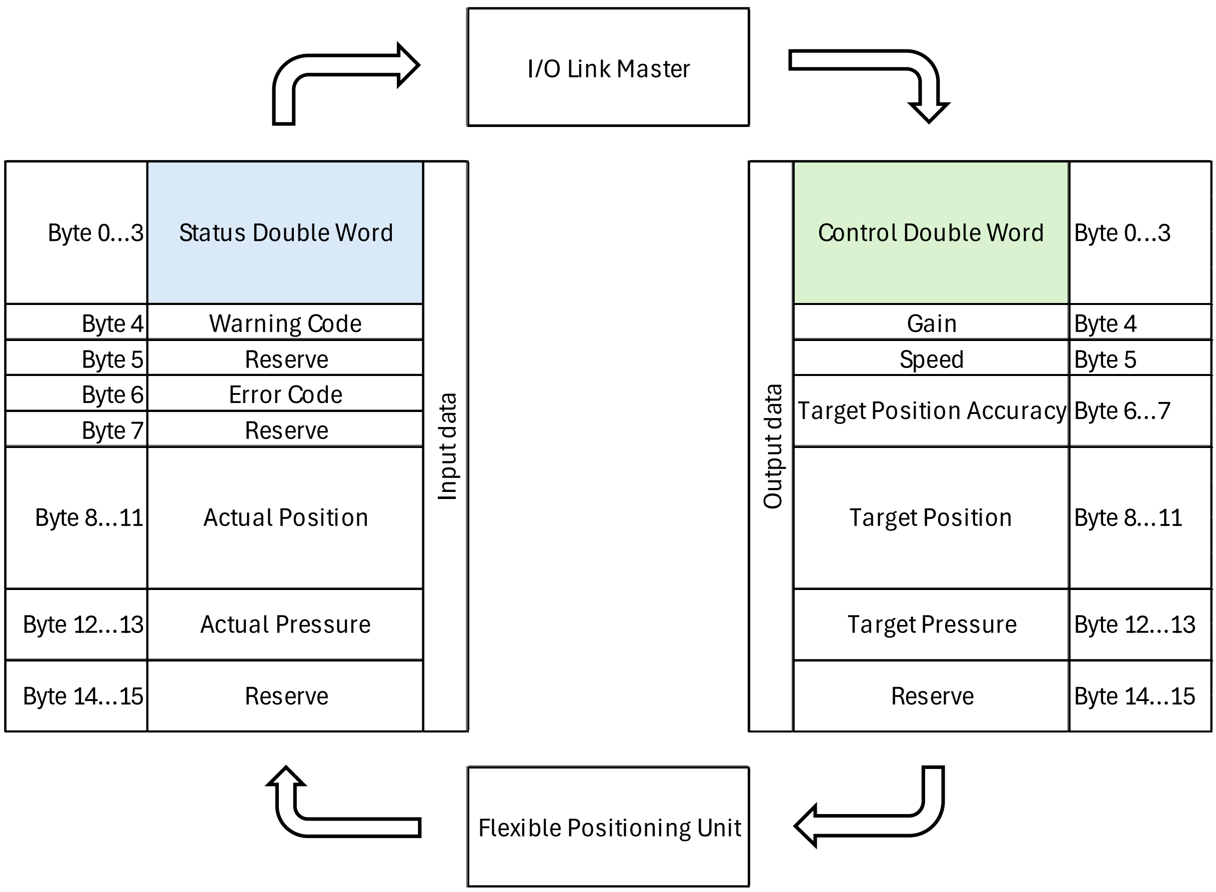


Figure above shows cyclic I/O Link data traffic between I/O Link Master and FPU. In total, 16 bytes are sent from the FPU to the I/O Link master and 16 bytes are sent back. Note in the figure above that some of the bytes are grouped together. The following key principles apply when operating the FPU over I/O Link:

- To operate a cylinder, a Control Double word is sent from I/O Link master to FPU. Depending on which of the bits that are high, different functions are activated. See 13.1 with list of all bits, and 6 for functions that are available.
- Depending on function, additional cyclic data must be sent.
  As an example, to activate function Move to Absolute Position, Gain, Speed, Target Position Accuracy and Target Position must also be transmitted. See 6, to see what cyclic data is required for specific functions.
- FPU will transmit the following to the I/O Link master with each cyclic message:
  - Status Double Word with status bits, as an example if end position is reached, End Position Reached status bit will be high. See 13.2 for list status bits.
  - Additional cyclic data with information such as Actual Position measured by position sensor is transmitted by FPU. See 7.1 for detailed descriptions.

Note that the FPU will start in an error state. Before operational readiness can be achieved, and a cylinder be operated by the FPU. The error must be acknowledged. See 4 for description.

Following key configurations must be made on the FPU to obtain basic operation:

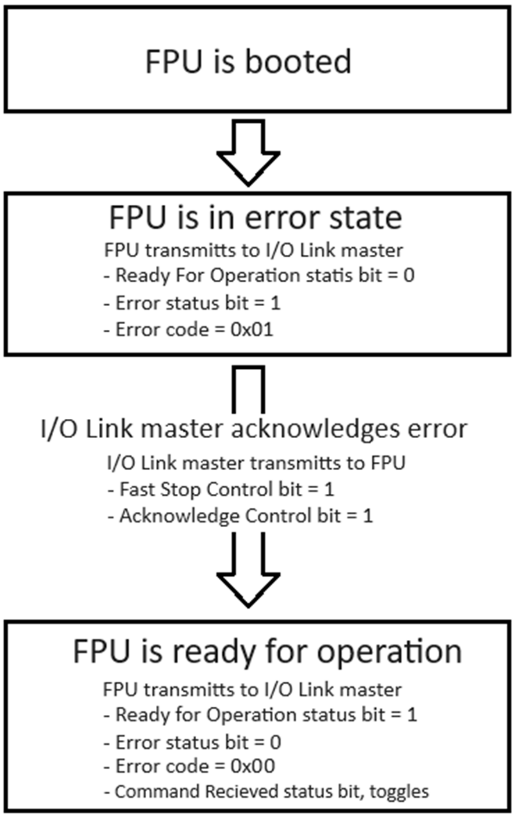
- Cylinder dimension
  This information is vital, in order to for the controller software to correctly calculate the amount of air needed to operate the cylinder in the desired way.
- Position sensor stroke
  This information is vital for the controller software to correctly interpret the position sensor signal.

Additional configurations are available to obtain optimal performance. Please see manual 500-211 8200 for all configuration options and functions that are available in the FPU. All settings and configurations can be done using register data, see 9. In addition, all settings are available with the Staccato PC Application.

4 Startup

When booting, FPU will start in an error state. This is to prevent unintended movement. From this state, operational readiness can be achieved by acknowledging error state. This is done with the Control Double Word in cyclic data.

Before starting, check that *Control Fieldbus Authority status bit is 1*. This indicates that FPU is set to I/O Link mode. This setting can be changed with register data (see 9.1) or with the PC Application.



Once the FPU is ready for operation, don’t forget to set Acknowledge control bit to 0 when activating functions.

Please note:

- From error state, it’s still possible to activate function Exhaust, see 6.4 for description of Exhaust function.
- If additional errors exist, FPU will not leave error state. In this case, please check error code.

5 Function activation

5.1 Overview

The FPU operates by activating specific functions, each designed to control a particular behavior of the pneumatic system. A function triggered using the appropriate Control Bit in the Control Double Word.

- Each function corresponds to a unique Control Bit
- Only one function can be activated at the same time

The different functions are described in chapter 6.

5.2 To Activate a Function

To activate a function, use the corresponding Control Bit in the Control Double Word.

- Function triggers at the positive flank of the Control Bit
- A function is active until another function is activated
- To deactivate a function, activate the function Close All Valves. This will close all valves.

Message no.	Message	Response from FPU
1	Control bits: - Fast Stop=1 - Fully Retract=0	The FPU receives no function activation. Note that Fast Stop control bit is 1.
2	Control bits: - Fast Stop=1 - Fully Retract=1	The Control Bit Fully Retract goes from 0 to 1, this activates the function Fully Retract.
3	Control bits: - Fast Stop=1 - Fully Retract=0	The function Fully Retract will still be activated, even after the Control Bit goes from 1 to 0.
4	Control bits: - Fast Stop=1 - Close All Valves=1	The function is deactivated, when a different function is activated. Close All Valves is an appropriate function to use.

There are more examples in 13.3 that can be helpful to see.

Also note:

- Fast Stop control bit must be 1 when operating the FPU. If the value is 0, the FPU will go to error state Fast Stop. Please see 6.1 for further details.
- It’s possible to use Repeat Command Toggle to deactivate a function, see 13.3 for details.
- Each function requires specific cyclic values, see 6 for required cyclic data for each function.

6 Functions

6.1 Fast Stop

Function description	Sets FPU in error state. All valves will be closed, and air trapped inside. Please see manual 211 8200 for description of implication. Note that the control bit value is inverted compared to other control bits, this is for safety reason. A high value on signal is required to ensure that the FPU can be operated.
Function trigger	Fast Stop control bit = 0
Additional cyclic data	None
Function finish	None
Feedback from FPU	- Fast Stop status bit = 1 - Error Code status bit = 1 - Error Code = 0x01 - Ready For Operation status bit = 0

6.2 Acknowledge

Function description	Acknowledges errors in FPU. See 4, for example on how this function is used at startup.
Function trigger	Positive flank on Acknowledge control bit.
Additional cyclic data	None
Function finish	None
Feedback from FPU	- Command Received status bit will toggle. - Error codes will be reset, note that error code can reappear if cause of error code is still there.

6.3 Jog Mode Negative/Positive

Function description	Jogs cylinder in negative or positive direction depending on which of the control bits Jog Mode Negative/Positive that are activated. Speed of movement is governed by Speed.
Function trigger	Jog Mode Negative or Jog Mode Positive control bit set to high. Note that cylinder will be jogged as long as control bit is high.
Additional cyclic data	- Speed
Function finish	Set Jog Mode Negative/Positive control bit to zero.
Feedback from FPU	Command Received status bit will toggle for each change of the Jog Mode Negative/Positive control bit.

6.4 Exhaust

Function description	Exhausts cylinder, leaving zero pressure in both chambers.
Function trigger	Positive flank on Exhaust control bit.
Additional cyclic data	None
Function finish	- Toggle Repeat Command Toggle control bit with all other control bits set to zero. - Activate different function.
Feedback from FPU	- Exhausted status bit will be set to 1 when cylinder is exhausted.

6.5 Calibrate

Function description	Calibrates position sensor, note that this function will move the cylinder to the two end points. This function requires a position sensor.
Function trigger	Positive flank on Calibrate control bit.
Additional cyclic data	None
Function finish	- Toggle Repeat Command Toggle control bit with all other control bits set to zero. - Activate different function.
Feedback from FPU	- Calibrated status bit will set to 0 when function is activated. - Calibrated status bit will set to 1 when calibration is completed.

6.6 Fill Both Chambers

Function description	Fills both chambers with system pressure.
Function trigger	Positive flank on Fill Both Chambers control bit.
Additional cyclic data	None
Function finish	- Toggle Repeat Command Toggle control bit with all other control bits set to zero. - Activate different function.
Feedback from FPU	No feedback from FPU.

6.7 Move to Absolute Position

Function description	Move cylinder to target Position. This function requires a position sensor.
Function trigger	Positive flank on Move to Absolute Position control bit.
Additional cyclic data	- Target Position - Target Position Accuracy - Gain - Speed
Function finish	- Toggle Repeat Command Toggle control bit with all other control bits set to zero. - Activate different function.
Feedback from FPU	- Position Reached status bit will set to 1 once the Target Position has been reached within the Target Position Accuracy.

6.8 Move to Relative Position

Function description	Move cylinder relative to current position. This function requires a position sensor.
Function trigger	Positive flank on Move to Relative Position control bit.
Additional cyclic data	- Target Position - Target Position Accuracy - Gain - Speed
Function finish	- Toggle Repeat Command Toggle control bit with all other control bits set to zero. - Activate different function.
Feedback from FPU	- Position Reached status bit will set to 1 once the Target Position has been reached within the Target Position Accuracy.

6.9 Fully Retract

Function description	Fully retracts cylinder. This is done by exhausting A/+ chamber and applying system pressure to B/- chamber.
Function trigger	Positive flank on Fully Retract control bit.
Additional cyclic data	None
Function finish	- Toggle Repeat Command Toggle control bit with all other control bits set to zero. - Activate different function.
Feedback from FPU	- End Position status bit = 1

6.10Fully Extend

Function description	Fully extends cylinder. This is done by applying system pressure to A/+ chamber and exhausting B/- chamber.
Function trigger	Positive flank on Fully Retract control bit.
Additional cyclic data	None
Function finish	- Toggle Repeat Command Toggle control bit with all other control bits set to zero. - Activate different function.
Feedback from FPU	- End Position status bit = 1

6.11Pressure Push

Function description	Pushes cylinder in direction set by Direction control bit with set pressure difference set by Target Pressure.
Function trigger	Positive flank on Pressure Push control bit.
Additional cyclic data	- Direction control bit - Target Pressure
Function finish	- Toggle Repeat Command Toggle control bit with all other control bits set to zero. - Activate different function.
Feedback from FPU	- Pressure Difference Reached status bit = 1

6.12Close All Valves

Function description	Closing all valves. This will trap the air inside the actuator, see manual 211 8200 for further information.
Function trigger	Positive flank on Close All Valves control bit.
Additional cyclic data	None
Function finish	- Toggle Repeat Command Toggle control bit with all other control bits set to zero. - Activate different function.
Feedback from FPU	- All Valves Closed status bit = 1

7 Cyclic data

7.1 Cyclic data transmitted from I/O Link master to FPU

7.1.1 Control Double Word

	Word	Byte	Bit	
0	0	0	0	Fast Stop
			1	
			2	Acknowledge
			3	
			4	
			5	
			6	Repeat Command Toggle
			7	Direction
		1	8	Jog Mode Negative
			9	Jog Mode Positive
			10	Exhaust
			11	Calibrate
			12	Fill Both Chambers
			13	
			14	
			15	
	1	2	16	Move to Absolute Position
			17	Move to Relative Position
			18	Fully Retract
			19	Fully Extend
			20	Pressure Push
			21	
			22	Close All Valves
			23	
		3	24	
			25	
			26	
			27	
			28	
			29	
			30	
			31	

Each bit activates a function, only one function can be activated at once. As an example, if bit corresponding to Fully Extend is high, function Fully Extend will be activated, see 6 for description of functions that can be activated.

FPU will react to positive flanks control bits, see 5 for detailed description of how functions can be activated.

Also, note that:

- “Fast stop” bit is reversed, must be 1 for function. As soon as fast stop bit is 0, FPU will be set to error state. This will have priority over other functions. See 6.1 for further details.
- “Repeat command toggle” can be used to activate function without the need to toggle the control bit. See 13.3 for detailed description.

7.1.2 Gain

Gain factor for position controller. Value 1 to 10, where 1 gives controller with low gain and 10 a controller with high gain.

Format	Unsigned, 8 bit
Physical unit	-
Value range	1…10

7.1.3 Speed

Speed factor, value between 1 and 10. Value 1 corresponds to target speed of 1 mm/s and 10 to a target speed of 1 000 mm/s. Note that lowest and highest speed can be limited by the size of the FPU in combination with bore size of cylinder.

Format	Unsigned, 8 bit
Physical unit	-
Value range	1…10

7.1.4 Target Position Accuracy

Accuracy value for controller in µm.

Format	Unsigned, 16 bit
Physical unit	Micrometer, µm
Value range	500…16000

7.1.5 Target Position

Target position value.

Format	Signed, 32 bit
Physical unit	Micrometer, µm
Value range	-5 000 000…5 000 000

7.1.6 Target Pressure

Target pressure difference over cylinder.

Format	Unsigned, 16 bit
Physical unit	Millibar, mbar
Value range	500…8 000

7.2 Cyclic data transmitted from FPU to I/O Link master

7.2.1 Status Double Word

	Word	Byte	Bit	
0	0	0	0	Ready for Operation
			1	Control Authority Fieldbus
			2	
			3	Not Feasible
			4	Sensor Calibrated
			5	Command Recieved Toggle
			6	Warning
			7	Error
		1	8	All Valves Closed
			9	Exhausted
			10	
			11	
			12	
			13	
			14	
			15	
	1	2	16	Position Reached
			17	
			18	
			19	
			20	
			21	
			22	
			23	
		3	24	Pressure Difference Reached
			25	End Position Reached
			26	
			27	
			28	
			29	
			30	
			31	

Status Double Word is transmitted from FPU to I/O Link master at each cycle. This enables easy access to status bits when programing PLC. List of Status Bits can be found in 13.2.

7.2.2 Warning

Warning code, see 11 for table of warning codes.

Format	Unsigned, 8 bit
Physical unit	-
Value range	0…255

7.2.3 Error

Error code, see 10 for table of error codes.

Format	Unsigned, 8 bit
Physical unit	-
Value range	0…255

7.2.4 Actual position

Actual position, measured by position sensor.

Format	Signed, 32 bit
Physical unit	Micrometer, µm
Value range	-

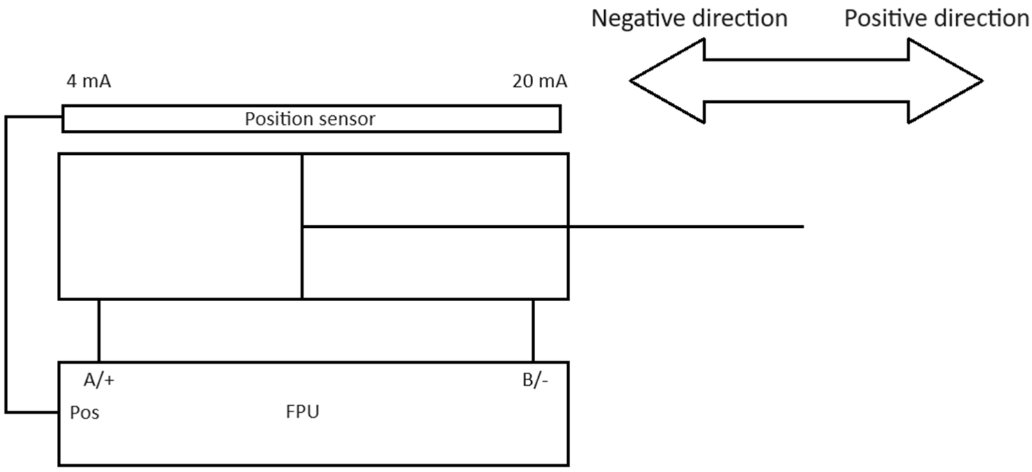
7.2.5 Actual pressure

Actual pressure difference in cylinder. Pressure on side connected to A/+ minus pressure on side connected to B/-.

Format	Signed, 16 bit
Physical unit	Millibar, mbar
Value range	-

8 Definitions

8.1 Positive/negative direction



Cylinder moves in positive direction when A/+ port is filled and B/- port is exhausted. It’s recommended that position sensor is connected so that 4 mA corresponds to position with minimized A/+ chamber.

Direction Control bit is set to that:

- 1: Positive direction
- 0: Negative direction

9 Register data

Following settings can be configured over the I/O Link interface. The FPU can be configured over the I/O Link interface and operated using other signals. Note that operation mode must be in I/O Link mode in order to receive process data over I/O Link interface and that changes in register data made over the I/O Link interface can take up to 10 s to register in eeprom.

9.1 Basic parameters

<table>
<tr><th>Parameter</th><th>R/W</th><th>Index</th><th>Size</th><th>Unit</th><th>Description</th></tr>
<tr><td>Operation Mode</td><td>R/W</td><td>65</td><td>8 bit unsigned</td><td>NA</td><td>Set following value for different operation modes.
<table>
<tr><td>3</td><td>Position Control 4 to 20 mA</td></tr>
<tr><td>4</td><td>Position Control 1 to 5 V</td></tr>
<tr><td>7</td><td>Position Control 0 to 10 V</td></tr>
<tr><td>10</td><td>Position Control 5-19 mA, Retract 4 mA, Extend 20 mA</td></tr>
<tr><td>11</td><td>Position Control 1-9 V, Retract 0 V, Extend 10 V</td></tr>
<tr><td>2</td><td>Position Control 1-5 V (4-20 mA if no signal)</td></tr>
<tr><td>1</td><td>Position Control 4-20 mA (1-5 V if no signal)</td></tr>
<tr><td>5</td><td>Position Control 4-20 mA (0-10 V if no signal)</td></tr>
<tr><td>12</td><td>Position Control 4-20 mA, Speed Control 0-10 V</td></tr>
<tr><td>13</td><td>Position Control 0-10 V, Force Control 4-20 mA (+)</td></tr>
<tr><td>20</td><td>Position Control 1-5 V, Force Control 4-20 mA (+)</td></tr>
<tr><td>14</td><td>Position Control 0-10 V, Force Control 4-20 mA (-)</td></tr>
<tr><td>21</td><td>Position Control 1-5 V, Force Control 4-20 mA (-)</td></tr>
<tr><td>22</td><td>Position Control 0-10 V, Force Control 4-20 mA (absolute)</td></tr>
<tr><td>23</td><td>Position Control 1-5 V, Force Control 4-20 mA (absolute)</td></tr>
<tr><td>9</td><td>Preset Digital Position Control</td></tr>
<tr><td>0</td><td>Manual mode</td></tr>
<tr><td>16</td><td>Jog Digital</td></tr>
<tr><td>17</td><td>Jog Analog 1-5 V</td></tr>
<tr><td>18</td><td>Jog Analog 4-20 mA</td></tr>
<tr><td>19</td><td>Zero G Jog</td></tr>
<tr><td>15</td><td>I/O Link mode</td></tr>
</table>
For operation over I/O Link, set to mode 15, I/O Link Mode.</td></tr>
<tr><td>Area, +</td><td>R/W</td><td>66</td><td>16 bit unsigned</td><td>mm²</td><td>Cross section area of actuator, on side connected to + port.</td></tr>
<tr><td>Area, -</td><td>R/W</td><td>67</td><td>16 bit unsigned</td><td>mm²</td><td>Cross section area of actuator, on side connected to - port.</td></tr>
</table>

Position sensor length	R/W	68	32 bit unsigned	mm	Position sensor gives a 4 to 20 mA signal; correctly set position length that corresponds to span of position sensor signal. If position sensor is taught, insert the taught length.

9.2 Controller Parameters

Parameter	R/W	Index	Size	Unit	Description
Maximum Speed	R/W	169	16 bit Unsigned	Mm/s	Speed limit of controller, reduces maximum speed of actuator during operation. Note that this sets the speed limit, not the speed. If controller parameters are set at a low gain in combination with a high speed limit, the actuator will not reaches the speed limit. Set maximum speed will have no impact. And if controller parameters are set at a high gain in combination with a low speed limit, the speed will be limited. Set high gain will have no impact.
Tolerance	R/W	73	16 bit Unsigned	µm	If the difference between desired set-point and measured position is less than tolerance, valves are deactivated. This reduces power and air consumption, noise and gives longer life.
P	R/W	69	16 bit Unsigned		Proportional part of PID controller, set from 0 to 100.
I	R/W	70	16 bit Unsigned		Integral part of PID controller, set from 0 to 100.
D	R/W	71	16 bit Unsigned		Derivative part of PID controller, set from 0 to 100.
FF	R/W	72	16 bit Unsigned		Feed forward of set-point signal, set from 0 to 100.
Feed forward tolerance	R/W	111	16 bit Unsigned	mm/s	Filters out feed forward velocity less than set tolerance.
P2 active	R/W	74	8 bit Unsigned		Set following value for following functions: 1 – Function deactivated 2 – Full Speed, Controlled Brake 3 – Two Step Proportional Controller See manual 211 8200 for details.
P2 limit	R/W	75	32 bit Unsigned	µm	During a movement, when the distance to the set-point is larger than this limit: - Full speed controlled brake: full speed. - Two Step Proportional Controller: P2 will be used as proportional gain instead of P. When distance is small a gain P will be used. Note that full speed will be limited by set maximum speed. See manual 211 8200 for details.
P2	R/W	76	16 bit Unsigned		Proportional part of PID controller, if in Two Step Proportional Controller.

9.3 Monitor Signals

Input signals, output signals and sensor values.

Parameter	R/W	Index	Size	Unit	Description
Position feedback	R	86	32 bit Signed	um	Measured position from position sensor.
Position Set-point	R	87	32 bit Unsigned	um	Desired value for position.
Pressure feedback, +	R	91	16 bit Unsigned	mbar	Measured pressure in + chamber.
Pressure feedback, -	R	92	16 bit Unsigned	mbar	Measured pressure in - chamber.
Pressure force feedback	R	93	32 bit Signed	N	Pressure force, calculated from pressure and cross section area of the two chambers. Note that force on rod can differ due to aspects as friction on piston, guides and bushings.
Position sensor value	R	88	16 bit Unsigned	mA	Measured analog input current from position sensor, (4-20 mA pin, POS port)
Input signal U	R	89	16 bit Unsigned	mV	Measured analog input voltage (Set-point, 0-10 V pin, U port)
Input signal I	R	90	16 bit Unsigned	mA	Measured analog input current (Set-point, 4 to 20 mA, + pin, I port)
Output signal I	R	94	16 bit Unsigned	mA	Analog current output signal (Position, 4 to 20 mA pin, I port)
Output signal U	R	95	16 bit Unsigned	mV	Analog voltage output signal (Position, 0-10 V pin, U port)
Digital input, 1 signal	R	96	8 bit Unsigned		Measured digital signal (Digital input, 1 pin, DIG port)
Digital input, 2 signal	R	97	8 bit Unsigned		Measured digital signal (Digital input, 2 pin, DIG port)
Digital input, 3 signal	R	98	8 bit Unsigned		Measured digital signal (Digital input, 3 pin, DIG port)
Digital output, 1 signal	R	99	8 bit Unsigned		Digital output signal (Digital output, 1 pin, DIG port)
Digital output, 2 signal	R	100	8 bit Unsigned		Digital output signal (Digital output, 2 pin, DIG port)
Digital output, 3 signal	R	101	8 bit Unsigned		Digital output signal (Digital output, 3 pin, DIG port)

9.4 Advanced settings

9.4.1 Valve Frequency

Parameter	R/W	Index	Size	Unit	Description
Valve frequency	R/W	77	8 bit Unsigned	ms	Frequency of valves and controller, see manual 211 8200 for details. Note that format is time period corresponding to frequency.

9.4.2 Maximum Force

Parameter	R/W	Index	Size	Unit	Description
Max force, positive direction	R/W	84	32 Bit Signed	N	If maximum force in positive direction is set, actuator movement in positive direction will stop if force exceeds set maximum force.
Max force, negative direction	R/W	85	32 Bit Signed	N	If maximum force in negative direction is set, actuator movement in negative direction will stop if force exceeds set maximum force.

- To deactivate function, set a value of 0.
- Force tolerance equivalent to pressure tolerance of 0.02 MPa.
- Negative values can be set, two's notation.
- Force refers to pressure force in actuator chambers, external force can differ due to friction in actuator, guides and bushings.

9.4.3 Maximum Pressure Difference

Parameter	R/W	Index	Size	Unit	Description
Max pressure difference	R/W	172	32 Bit Unsigned	mbar	Limits pressure difference in + and – chamber. Set 0 to deactivate function. Tolerance of 0.05 MPa.

9.4.4 Load Condition Speed Limit

Parameter	R/W	Index	Size	Unit	Description
Load Limit	R/W	170	16 bit Unsigned	N	If pneumatic force exceeds set limit, maximum speed is restricted to set value below. Set to 0 to disable function.
Speed Limit	R/W	171	16 bit Unsigned	mm/s	Speed limit if pneumatic force exceeds set limit.

9.4.5 Soft Start

Parameter	R/W	Index	Size	Unit	Description
Pressure limit	R/W	78	16 bit Unsigned	mbar	Limits maximum speed if pressure is below limit. For speed limit to be enforced, pressure must be below limit in both chambers. Set to 0 to disable function.
Speed Limit	R/W	79	16 bit Unsigned	mm/s	Speed limit if criteria is fulfilled.

9.4.6 Pressure Build Up/Pressure Adjuster

Parameter	R/W	Index	Size	Unit	Description
Pressure Adjuster	R/W	81	16 bit Unsigned	mbar	During operation of positioning unit, pressure will be adjusted by controller. Value sets maximum pressure limit for function.
Pressure Build Up	R/W	80	16 bit Unsigned	mbar	When positioning unit is initiated, pressure will be increased to set value. Note that this function can give some movement of actuator at initiation.

- To deactivate function, set a value of 0.

9.4.7 Enable

Parameter	R/W	Index	Size	Unit	Description
Enable Mode	R/W	82	8 bit Unsigned		Set following value for following functions: 0 – Function off 1 – Valves closed/Hard Stop 2 – Actuator Exhausted 3 – Home position, fully retracted 4 – Home position, fully extended See manual for details.
Input Chanel	R/W	83	16 bit Unsigned	mbar	Set following value for following functions: 0 – Digital input, 1 1 – Analog voltage in, U port See manual for details.

9.5 Jog Settings

9.5.1 Jog speed

Parameter	R/W	Index	Size	Unit	Description
Jog speed, negative direction	R/W	164	16 bit Unsigned	mm/s	Jog speed in negative direction if jog digital.
Jog speed, positive direction	R/W	165	16 bit Unsigned	mm/s	Jog speed in positive direction if jog digital.

9.5.2 Zero G jog

Parameter	R/W	Index	Size	Unit	Description
Zero G jog, Load Detection Mode	R/W	102	8 bit Unsigned		Set following value for following functions: 0 – Automatic Mode 1 – Manual Mode See manual 211 8200 for details.
Manual set force	R/W	103	32 bit Signed	N	If Zero G Jog function mode is set to manual mode, force is set with this value.
Force Tolerance	R/W	104	16 bit Unsigned	N	Only utilized in operation mode Zero G Jog. If external force of Force Tolerance is applied to actuator, actuator will be jogged.
Jog Speed	R/W	105	16 bit Unsigned	mm/s	Jog speed in operation mode Zero G Jog

See manual 211 8200 for application example.

9.6 Analog Output

Parameter	R/W	Index	Size	Unit	Description
Analog current Function Mode	R/W	118	8 bit Unsigned		Set following value for following functions: 0 – Not Active 1 – Position 2 – Force 3 – Pressure, + 4 – Pressure, -
Analog current Function Mode	R/W	119			
Analog volt, range	R/W	120	8 bit Unsigned		Set following value for following functions: 0 – 1 to 5 V 1 – 0 to 10 V

9.7 Digital Output

Parameter		R/W	Index	Size	Unit	Description
Function Mode	Digital out, 1	R/W	121	8 bit Unsigned		Set following value for following functions: 0 Off 13 On 11 Position 4 Position Set-Point Achieved 7 Pressure, + Chamber 8 Pressure, - Chamber 9 Force, Positive Direction 12 Force, Negative Direction 10 Force, Absolute Value 5 Direction Signal, Positive 6 Direction Signal, Negative 14 External Lock 1 Ready 3 Set-Point Signal Status 2 Position Sensor Signal Status See manual 211 8200 for details.
	Digital out, 2	R/W	122			
	Digital out, 3	R/W	123			
Invert Signal	Digital out, 1	R/W	124	8 bit Unsigned		Depending on setting, signal is high or low when active. 0 High/On 1 Low/Off See manual 211 8200 for details.
	Digital out, 2	R/W	125			
	Digital out, 3	R/W	126			
Time Delay	Digital out, 1	R/W	166	16 bit Unsigned		Time delay for digital output. Setting applies when Signal goes from not active to active. When set to: - High/On when signal goes from low to high - Low/Off when signal goes from high to low See manual 211 8200 for details.
	Digital out, 2	R/W	167			
	Digital out, 3	R/W	168			
Mode	Digital out, 1	R/W	127	8 bit Unsigned		Set following value for following functions: 0 Point Mode Digital output signal active when value higher than lower limit. 1 Window Mode Digital output signal active when value higher than lower limit and lower than upper limit. Note that this setting only applies to Function modes corresponding to numerical values such as Position, Pressure, Force etc... Does not apply to non numerical Function Modes such as Ready or Position Sensor Signal Status. See manual 211 8200 for details.
	Digital out, 2	R/W	128			
	Digital out, 3	R/W	**129**			
ErrorLower Limit	Digital out, 1	R/W	130	32 bit Signed		Utilized in Point Mode and Window mode. Sets limit for digital output signal activation. Unit varies with Function Mode. - Position: µm - Pressure: mbar - Force: N
	Digital out, 2	R/W	131			
	Digital out, 3	R/W	132			

Upper Limit	Digital out, 1	R/W	133	32 bit Signed		Utilized in Window Mode. Sets limit for digital output signal deactivation. Same unit as lower limit.
	Digital out, 2	R/W	134			
	Digital out, 3	R/W	135			
Hysteresis	Digital out, 1	R/W	136	16 bit Unsigned		Hysteresis for Point and Window mode, digital signal will toggle at the following points: - Lower Limit - Lower Limit – Hysteresis - Upper Limit - Upper Limit – Hysteresis Utilized in Point Mode and Window Mode, same unit as Lower Limit and Upper Limit.
	Digital out, 2	R/W	137			
	Digital out, 3	R/W	138			
Direction signal, speed limit		R/W	139	16 bit Unsigned	mm/s	If controller output desired speed higher than set limit, direction signal is activated. Setting only utilized in Direction Signal. See manual 211 8200 for application example with booster valves.
Direction signal, error limit		R/W	140	32 bit Unsigned	µm	If difference between Position and Position Set-point is higher than set limit, direction signal is activated. Setting only utilized in Direction Signal. See manual 211 8200 for application example with booster valves.
External lock, function mode		R/W	141	8 bit Unsigned		Set following value for following functions: 0 – Automatic Detection 1 – Preset Pressure 2 – Closed Valves/Hard Stop See manual 211 8200 for application example with external lock.
External lock, pressure +		R/W	142	16 bit Unsigned	mbar	Desired pressure level in + chamber, if External lock, function mode is set to Preset Pressure.
External Lock, pressure -		R/W	143	16 bit Unsigned	mbar	Desired pressure level in - chamber, if External lock, function mode is set to Preset Pressure.

10 Error codes

Error code	Decode	Description
0x01	FAST_STOP	Error state, may be set due to: - Fast Stop function is activated, 6.1. - FPU was rebooted. Note that FPU will boot in this state. See 4 for startup procedure.
0x02	CALIBRATION_FAILED	Calibration of position sensor failed, see for further information about calibration of position sensor 13.5.

11 Warning codes

Warning code	Decode	Description
0x81	SPEED_VALUE_INVALID	Cyclic data, speed value out of range. See 7.2.3.
0x82	GAIN_VALUE_INVALID	Cyclic data, gain value out of range. See 7.2.2.
0x83	TARGET_ACCURACY_VALUE_INVALID	Cyclic data, gain value out of range. 7.2.4.
0x84	TARGET_POSITION_VALUE_INVALID	Cyclic data, gain value out of range. 7.2.4.
0x85	TARGET_PRESSURE_VALUE_INVALID	Cyclic data, gain value out of range. 7.2.5.
0x86	EXECUTION_NOT_FEASIBLE	Function not possible to execute, one reason could be that more than one function is activated. See 5 for description on how to activate function.
0x87	NOT_CALIBRATED	Position sensor not calibrated, 13.5.
0x88	NO_POSITION_SENSOR_CONNECTED	Position sensor not connected.

12 Compatibility Table

There have been changes in I/O Link manuals and interface, this table shows which manual should be used.

Firmware Version	I/O Link manual document number
A74 and earlier	500-211 8200-09-A1
A78 and later	This document.

13 Miscellaneous

13.1Control Double Word

Cyclic data bits transmitted by I/O Link master to control the FPU. See 3 for overview.

Control bit	Description
Fast Stop	Control bit to activate Fast Stop function, see 6.1. Note that this bit is reversed, must be high to avoid triggering Fast Stop function and set FPU to error state.
Acknowledge	Control bit to Acknowledge function, see 6.2. This function is used to acknowledge error state.
Repeat Command Toggle	Toggle bit to activate function, reduces number of I/O Link messages to operate FPU. See 13.4 for details.
Direction	Direction signal, used for some functions. See 8.1 for definition of direction signal.
Jog Mode Negative	Control bit to activate Jog Mode Negative function, see 0.
Jog Mode Positive	Control bit to activate Jog Mode Positive function, see 0.
Exhaust	Control bit to activate Exhaust function, see 6.4.
Calibrate	Control bit to activate Calibrate Function, see 0.
Fill Both Chambers	Control bit to activate Fill Both Chambers function, see 6.6.
Move To Absolute Position	Control bit to activate Move to Absolute Position function, see 0.
Move To Relative Position	Control bit to activate Move to Relative Position function, see 6.8.
Fully Retract	Control bit to activate Fully Retract function, see 0.
Fully Extend	Control bit to activate Fully Extend function, see 6.10.
Pressure Push	Control bit to activate Pressure Push function, see 6.11.
Close All Valves	Control bit to activate Close All Valves function, see 6.12.

13.2Status Double Word

Cyclic data bits transmitted by the FPU to the I/O Link master. See 3 for overview.

Control bit	Description
Ready for operation	High when FPU is ready for operation.
Control Authority Fieldbus	High when FPU is set to operate with I/O Link mode. If low, FPU will not operate cylinder over I/O Link protocol.
Not Feasible	High if command from I/O Link master is not feasible, this will turn high if multiple functions are triggered with same message or required cyclic data is out of range.
Sensor Calibrated	High if position sensor is calibrated, see 13.5 calibration of position sensor.
Command Received Toggle	FPU will toggle this when receiving I/O Link message.
Warning	High if warning code, see 11 for warning codes.
Error	High if error code, see 10 for error codes.
All Valves Closed	High if all valves are closed, see manual 500-211 8200 for further information.
Exhausted	High if cylinder is exhausted.
Position Reached	High if Target Position is reached. Note that this status bit only is active for some of the functions and requires a position sensor.
Pressure Difference Reached	High if Target Pressure is reached. Note that this status bit only is active for some of the functions.
End Position Reached	High if cylinder is at end position. Note that this status bit requires a position sensor.

13.3Repeat Command Toggle

The Repeat Command Toggle allows you to activate the same function multiple times without needing to toggle the corresponding function bit (e.g., turning it off and on again). This simplifies communication by reducing the number of cycles required.

Example: Below a list of functions.

Message no.	Message	Response from FPU
1	Control bits: - Fast Stop=1 - Move To Relative Position=0 - Repeat Command Toggle = 0 Target Position=10000	None, no function has been activated.
2	Control bits: - Fast Stop=1 - Move To Relative Position=1 - Repeat Command Toggle = 0 Target Position=10000	Function Move to Relative Position is activated, as a result position will increase with 10 mm.
3	Control bits: - Fast Stop=1 - Move To Relative Position=1 - Repeat Command Toggle = 0 Target Position=10000	None, function is already activated.
4	Control bits: - Fast Stop=1 - Move To Relative Position=0 - Repeat Command Toggle = 0 Target Position=10000	None, no positive flank on function control bit.
5	Control bits: - Fast Stop=1 - Move To Relative Position=1 - Repeat Command Toggle = 0 Target Position=10000	Function Move to Relative Position is activated, as a result position will increase with 10 mm.

Example: In this example, the number of messages required is minimized by utilizing the Command Repeat Toggle.

Message no.	Message	Response from FPU
1	Control bits: - Fast Stop=1 - Move To Relative Position=0 - Repeat Command Toggle = 0 Target Position=10000	None, no function has been activated.
2	Control bits: - Fast Stop=1 - Move To Relative Position=1 - Repeat Command Toggle = 0 Target Position=10000	Function Move to Relative Position is activated, as a result position will increase with 10 mm.
3	Control bits: - Fast Stop=1 - Move To Relative Position=1 - Repeat Command Toggle = 1 Target Position=10000	Function Move to Relative Position is activated, as a result position will increase with 10 mm.
4	Control bits: - Fast Stop=1 - Move To Relative Position=1 - Repeat Command Toggle = 0 Target Position=10000	Function Move to Relative Position is activated, as a result position will increase with 10 mm.
5	Control bits: - Fast Stop=1 - Move To Relative Position=1 - Repeat Command Toggle = 1 Target Position=10000	Function Move to Relative Position is activated, as a result position will increase with 10 mm.

13.4 Command Received status bit

Status bit, indicates that command have been received by the FPU. Note that this status bit confirms that a command has been received, not that the command is approved and a function is triggered.

13.5Position Sensor Calibration

When commissioning the FPU, position sensor length should be set. This can be done with the following:

- Ensure that the order code of the FPU matches the length of the cylinder that you are using. If so, no action is required.
- Configure the length of the cylinder, using register data. See 9.1.
- Configure the length of the cylinder using the PC application. See manual 500-211 8200 for further details.

Calibrate the position sensor before use. Calibration is done by running the function Calibrate, see 0. The calibration function will:

1. Ensure the following:
    a. System pressure of 0.4-0.8 MPa
    b. Position sensor is connected, and the complete stroke of the cylinder is within position sensor range.
2. Cylinder will be jogged to fully extended position.
3. Position sensor value corresponding to fully extended position will be measured.
4. Cylinder will be jogged to fully retracted position.
5. Position sensor value corresponding to fully retracted position will be measured.
6. If sequence is successful, position sensor values will be saved. Feedback from FPU will be:
    a. Calibrated status bit =1
    b. Warning code indicated not calibrated will disappear.

Out of the box, note the following:

- FPU will not be calibrated. This can be seen on the following:
    - Warning code, indicating that position sensor has not been calibrated
    - Status bit Calibrated will be low.
- The FPU will be configured so that 4 mA corresponds to 0 mm and 20 mA to full length of the cylinder.

If position sensor is changed, please recalibrate the FPU to the new position sensor.

13.6Examples

<table>
<tr><th>Example</th><th>Input data</th></tr>
<tr><td>Startup</td><td>Following illustrates message that needs to be sent to FPU in order to achieve operational readiness.
<table>
<tr><th>Message no.</th><th>Message</th><th>Response from FPU</th></tr>
<tr><td>1</td><td>Control bits:
- Fast Stop=1
- Acknowledge=1</td><td>FPU will achieve operational readiness, this is indicated by the following response.

Status bits:
- Ready for Operation = 1
- Control Authority Fieldbus=1
Error Code=0x00</td></tr>
<tr><td>2</td><td>Control bits:
- Fast Stop=1
- Acknowledge=0</td><td>FPU will start.

Status bits:
- Ready for Operation = 1
- Control Authority Fieldbus=1
Error Code=0x00</td></tr>
</table>
Note that Control Authority Fieldbus status bit is 1 when FPU is operated over I/O Link. If this status bit is 0, FPU is operated by other signal. To operate the FPU over I/O Link, ensure that Operation mode is I/O Link. This can be done using register data, see 9.1.</td></tr>
<tr><td>Move cylinder to 100 mm</td><td>Provided that the steps in Startup have been completed and operational readiness have been achieved. The following message can be used to move a cylinder to a position of 100 mm.
<table>
<tr><th>Message no.</th><th>Message</th><th>Response from FPU</th></tr>
<tr><td>1</td><td>Control bits:
- Fast Stop=1
- Move to Absolute Position=1
Gain=3
Speed=5
Target Position Accuracy=1000
Target Position=100 000</td><td>FPU will trigger the function Move to Absolute Position and move cylinder to a position of 100 mm.

Status bits:
- Ready for Operation = 1
- Control Authority Fieldbus=1
- Command Received Toggle will toggle, compared to previous value.
- Position Achieved=0
Actual position will be transmitted.
Actual pressure will be transmitted.

Once the position reaches the target position of 100 ± 1 mm, Position Achieved status bit will set to high.</td></tr>
</table>
The message above will command the FPU to move cylinder to a position of 100 ± 1 mm.</td></tr>
</table>