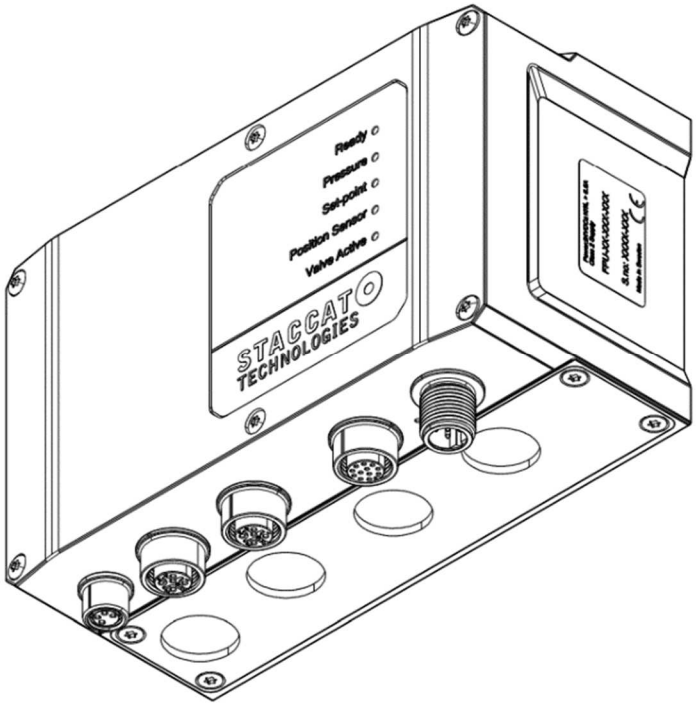
FPU-XX-XXX-XXX



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.

Key features

- Position accuracy of ± 0.5 mm
- Speed up to 1 m/s
- Force control
- Compatible with most actuators
  Available for diameters Ø20 to 320 mm and lengths between 5 mm to 5 000 mm
- Multiple input/output signals
  - Analog current, 4-20 mA
  - Analog voltage, 1-5 V and 0-10 V
  - Digital I/O
  - I/O Link
- Compatible with all 4-20 mA position sensors.

Index

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:** 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: Many sensors can be teached to reverse direction and/or to adjust the sensing range. If the sensor is teached to a new range, the new length should also be used in the settings to ensure correct reading.

Note: Positioning unit will not operate if position sensor signal is lost.

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.

Overview

The Flexible Positioning Unit is an ad on to a pneumatic actuator. Together with a position sensor, the position of the actuator can be controlled with accuracy down to 0.5 mm and speeds over 1 m/s.

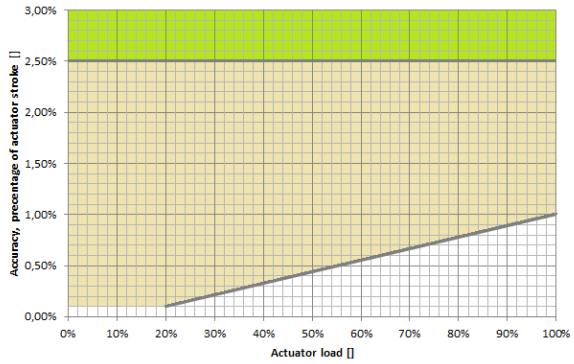
Software, electronics and valves provides closed loop controlling of an actuator. Desired set-point and actuator position is acquired and analyzed by software. With a PID controller in combination with feed forward, an appropriate valve response is calculated and actuator positioned.

At delivery, the positioning system is configured for a chosen actuator type, diameter and position sensor length. If a reconfiguration is required, this is possible through PC software and I/O Link communication. Communication software and hardware can be purchased from Staccato Technologies.

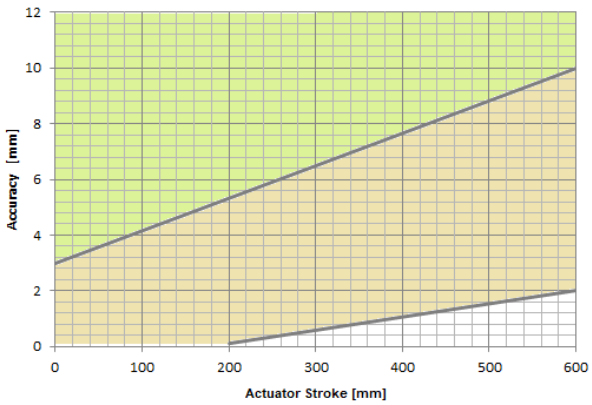
For optimal performance, it’s recommended that controller parameters are tuned specifically for your application and requirements.

Accuracy

Length of actuator and actuator load governs the accuracy possible in a system. The two graphs below illustrate possible accuracy.



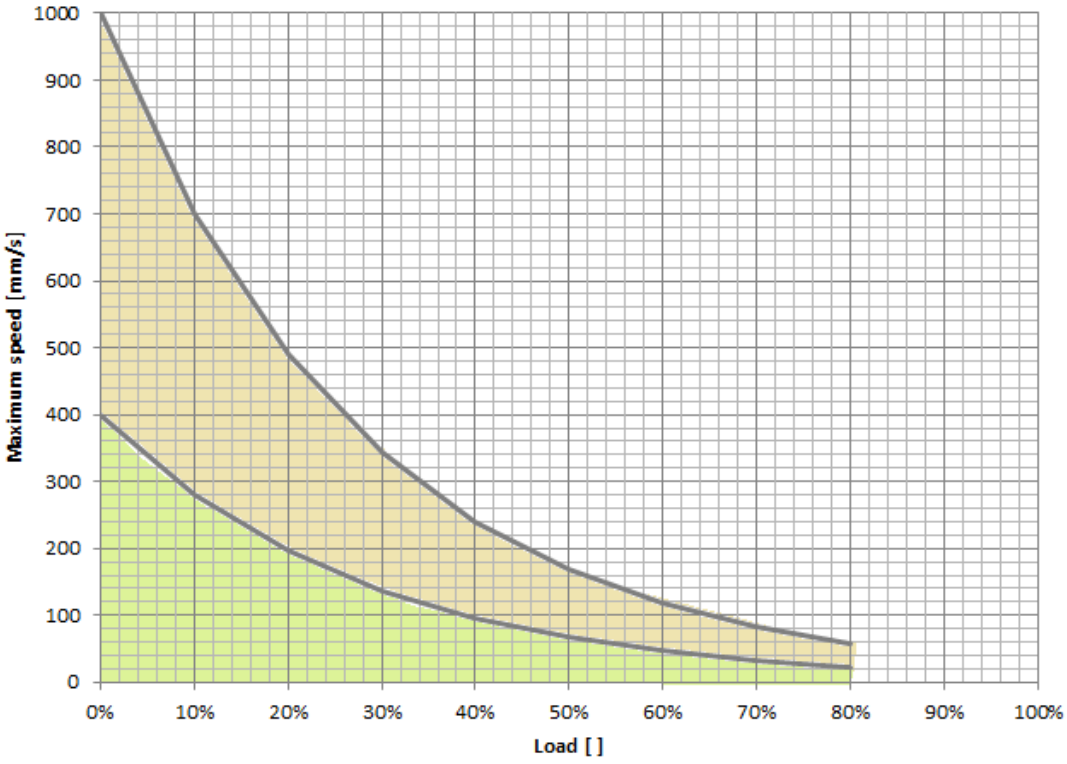
Actuator load refers to load in relation to maximum force available for actuator size and pressure (pressure x cross section area).



Green area	Recommended area.
Yellow area	Operating range, parameter settings needs to be adjusted depending on speed. Contact Staccato for support.

Maximum Speed

Following graph illustrates speed as a function of load on actuator.



Green area	Recommended area.
Yellow area	Operating range, parameter settings needs to be adjusted depending on speed. Contact Staccato for support.

Specification

General

Feature	Value	
Weight	1.8 kg	
Customs stat no.	8481209090	
Country of origin	Sweden	
Cylinder	Type	Double acting pneumatic actuators
	Stroke length	5 to 5000 mm
	Diameter	Ø 20 to 320 mm
Position sensor	4-20 mA analog position sensors.	
Mounting	Recommended with ports pointing down. Tubing length to cylinder, less than 1 m recommended for optimal performance.	
Compressed air	Operating pressure	0.4 to 0.8 MPa (4 to 8 bar)
	Proof pressure	1.5 MPa
	Air quality	- Filtered: 50 µm - Lubricated or unlubricated - For optimal performance, pressure should be stable
Pressure Sensor	Integrated in valve system for monitoring both actuator chambers.	Pressure - Sensor
Environment	Enclosure	IP67
	Operating temperature	0 to 60 °C Higher temperatures possible with conditions, please contact Staccato.
	Storage temperature	-20 to 60 °C
24 V output	I, U and POS port have voltage output for external components, maximum load of 0.5 A.	

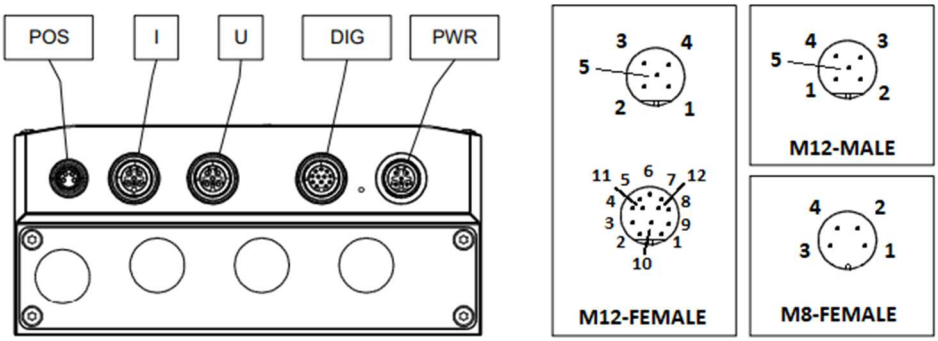
Input/output

Analog current input signal, position sensor	
General	4-20 mA current input
Pin	POS port, pin 2
Accuracy	1 % FS, linearity 0.2 % FS
Impedance	150 Ω
Analog current input signal	
General	4-20 mA current input
Pin	I port, pin 2 and 3
Accuracy	1 % FS, linearity 0.2 % FS
Impedance	150 Ω
Analog current output signal	
General	4-20 mA current output
Pin	I port, pin 4
Accuracy	1 % FS, linearity 0.2 % FS
Maximum load	500 Ω
Analog voltage input signal	
General	Analog voltage input signal, configurable 1-5 V or 0-10 V
Pin	U port, pin 2
Accuracy	1 % FS, linearity 0.2 % FS
Impedance	39 kΩ
Analog voltage output signal	
General	Analog voltage output, configurable 1-5 V or 0-10 V
Pin	U port, pin 4
Accuracy	1 % FS, linearity 0.2 % FS
Minimum load	10 kΩ
Digital output	
General	3 digital outputs, can be used as feedback signals or voltage supply to external components.
Pin	DIG port, pin 4, 5 and 6
Type	PNP
Voltage low	0 V
Voltage high	24 V
Maximum load	0.5 A(1)
Digital Input	
General	3 digital inputs
Pin	DIG port, pin 7, 8 and 9
Type	PNP, pull down
Voltage low	0-1 V
Voltage high	3-30 V
Impedance	15 kΩ

Voltage supply	
Operating voltage	24 VDC ± 10 %
Mean power consumption	10 W
Peak current	6.5 A
I/O Link	
General	I/O Link slave
Pin	DIG port, pin 10, 11 and 12.
Version	Version 1.1
Speed	COM2
Minimum cycle time	10 ms

(1) Maximal allowed 0.5 A in total, shared by all outputs.

Connections/Pinning



Electrical	Description	Contact type	Pinning	
POS	Position sensor input.	M8-4POLE-A-FEMALE	1	+24V out(1)
			2	4-20 mA(2)
			3	GND/-
			4	N.C
U	Set-point input, 0-10 V or 1-5 V analog voltage.	M12-5POLE-A-FEMALE	1	+24V out(1)
			2	Set-point, 0-10 V
			3	GND/-
			4	Position, 0-10 V
			5	GND/-
I	Set-point input, 4-20 mA analog current.	M12-5POLE-A-FEMALE	1	+24V out(1)
			2	Set-point, 4 to 20 mA, +
			3	GND/-
			4	Position, 4 to 20 mA
			5	Set-point, 4 to 20 mA, -
DIG	Digital interface.	M12-12POLE-A-FEMALE	1	CAN L(3)
			2	CAN H(3)
			3	GND/-
			4	Digital output, 1(1)
			5	Digital output, 2(1)
			6	Digital output, 3(1)
			7	Digital input, 1
			8	Digital input, 2
			9	Digital input, 3
			10	I/O Link, L+
			11	I/O Link, CQ
			12	I/O Link, GND
PWR	Power supply.	M12-5POLE-B-MALE	1	+24V
			2	GND/-(4)
			3	N.C.
			4	N.C.
			5	GND/-(4)

(1) Maximum total load of 0.5 A, shared by multiple outputs. Note that voltage level may vary ± 0.5 V, not suitable as voltage supply for sensors without electronics and voltage stabilization.

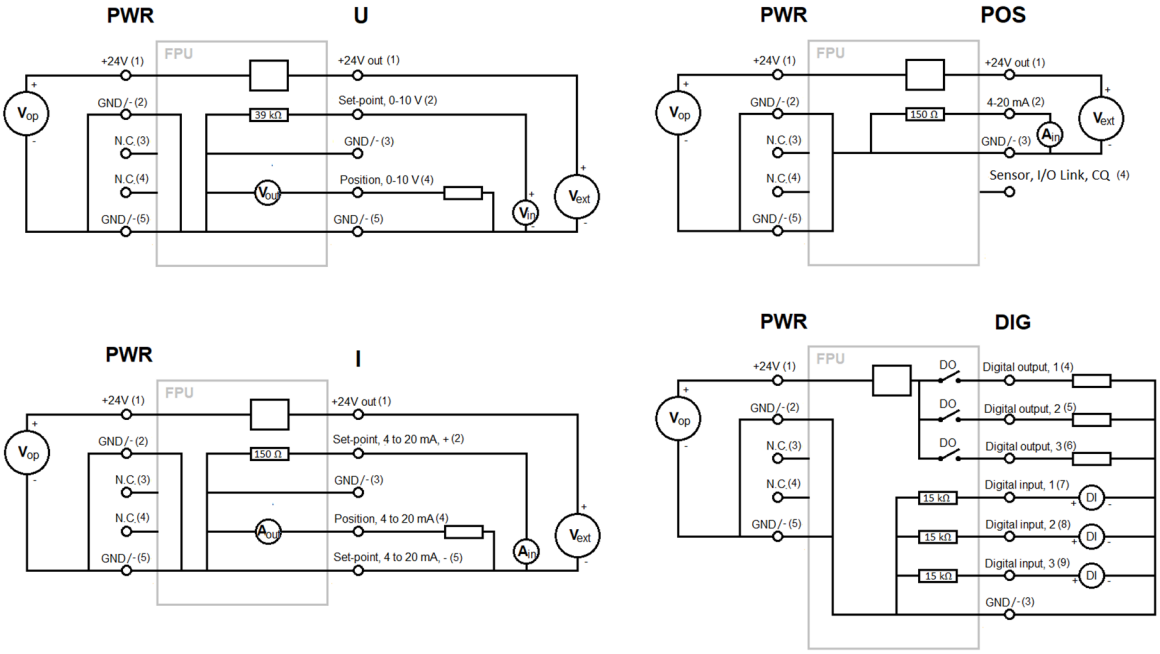
(2)Signal input does not handle 24 V.

(3)Does not handle 24 V over CAN L and CAN H.

(4)Sufficient if only one of the two GND/- is connected.

Wiring Diagram

General



Sign	Description
V_{op}	Operational voltage connected to PWR port on FPU. - 24 VDC ± 10 % required, 6.5 A
V_{ext}	Voltage supply to external component, such as sensor or valve. - Maximum load of 0.5 A.
V_{in}	Analog voltage input signal, 0 to 10 V.
V_{out}	Analog voltage output signal, 0 to 10 V.
A_{out}	Analog current output signal, 4 to 20 mA.
A_{in}	Analog current input signal, 4 to 20 mA.
DI	Digital input signal.
DO	Digital output signal. Possible to use as voltage supply for external component. - Maximum load of 0.5 A.

Position Sensor to I Input Current

A postiiono sensor can be connected to the I port to generate an 4-20 mA input signal. This can be utilized to:

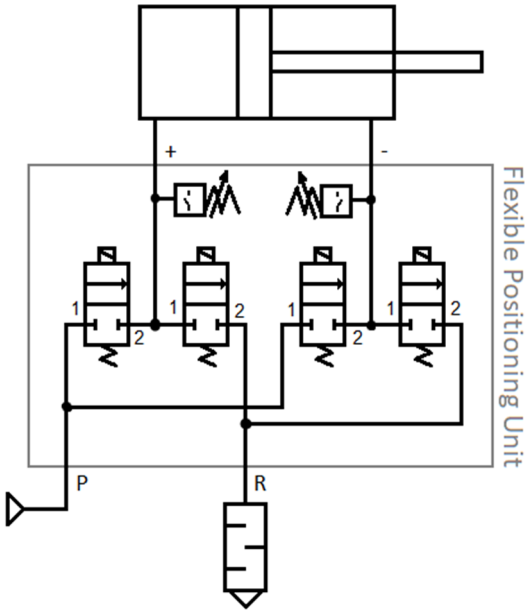
- Use signal as set-point signal, copy movement of one actuator. See page 43 for application example.
- Generate set-point signal for test purposes.

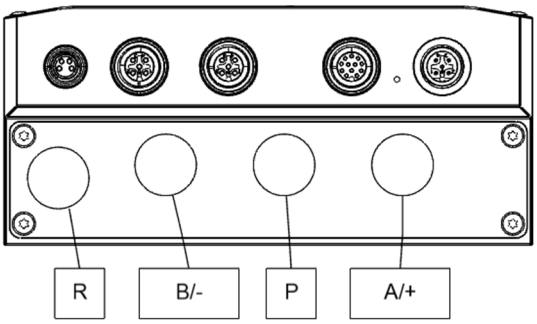
1 m cable available, order code 4354201. Connects 4-20 mA position sensor to input current signal on I port of FPU.

FPU, I port	
Pin	**No.**
+24V out	1
Set-point, 4 to 20 mA, +	2
GND/-	3
Position, 4 to 20 mA	4
Set-point, 4 to 20 mA, -	5

Position sensor, 4-20 mA	
No.	**Pin**
1	Supply voltage
2	Current Output Signal
3	N.C.
4	GND

Pneumatic Ports





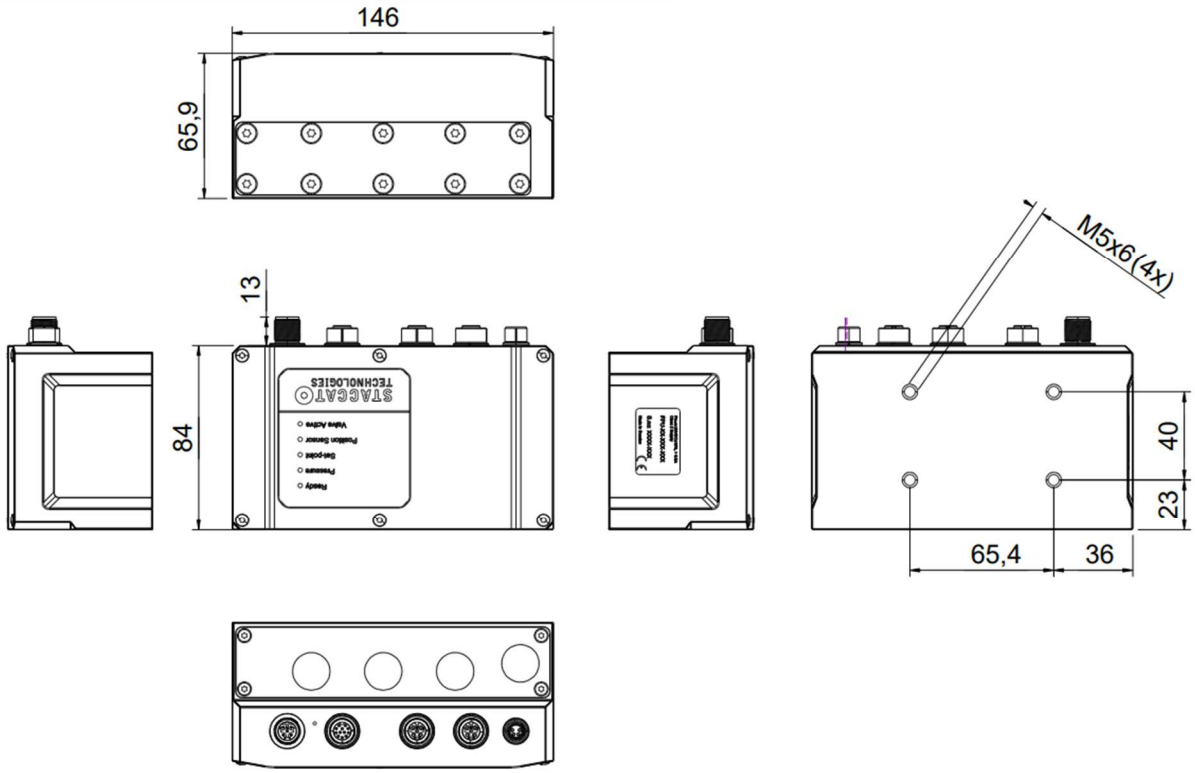
Pneumatic connections	Port type	Description
P	G3/8[2]	Supply pressure.
A/+	G3/8[2]	Actuator extension, movement in positive direction[1].
B/-	G3/8[2]	Actuator retraction, movement in negative direction[1].
R	G3/8[2]	Exhaust port.

[1] Movement in positive/negative direction refers to movement giving increasing/decreasing signal from position sensor.

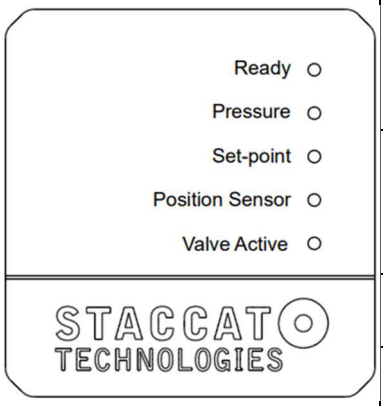
[2] Note that pneumatic ports require face seal with maximum thread depth of 8 mm, conical threads not applicable.

Note that valves in Flexible Position Unit can leak if pressure on port 2 is higher than pressure on port 1.

Dimensions

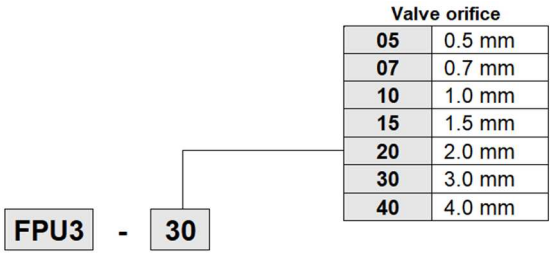


LED:s

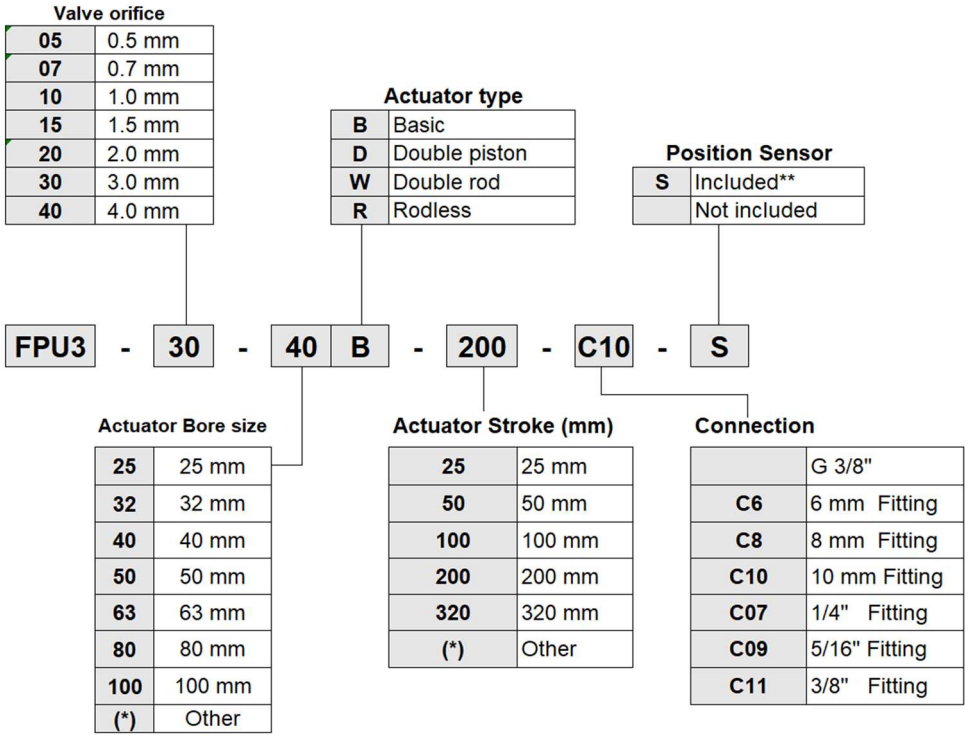
Display	Led	Description
	Ready	Led on indicates position system is functional. - Flashing 2.5 Hz, system not ready. - Flashing 0.5 Hz, valve frequency decreased due to high temperature. Restart to reset. - When system is started, system will initiate for 1 s. Led will flash during this time.
	Pressure	Led on indicates pressure in at least one of the chambers connected to + and – port over 0.1 MPa. - Flashing indicates pressure in both chambers less than 0.1 MPa, see page 49.
	Set-point	Led on indicates set-point is ok. - Flashing indicates set-point signal is not ok.
	Position Sensor	Led on indicates position sensor is ok. - Flashing indicates position sensor signal is not ok.
	Valve Active	On if any of the valves in position sensor is active.

Order code

Use the following order code for a Staccato FPU that is pre-prepared. Note that unit must be configured to dimension of cylinder in your application, this can be done with the Staccato PC application or over I/O Link.



Use the following order code for a Staccato FPU that is preconfigured to cylinder in your application.



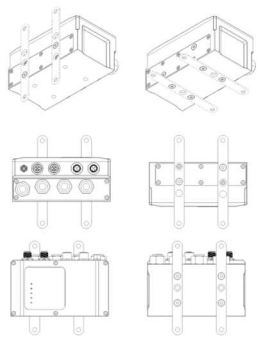
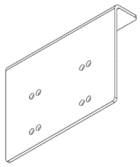
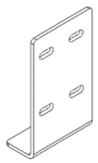
* Enter required value.

** See table of available position sensor lengths.

Note the table with available position sensors length, and that shipped position sensor may be 15 to 20 mm longer than length of cylinder according to order code. This will ensure that the complete stroke of the cylinder is within the range of the position sensor.

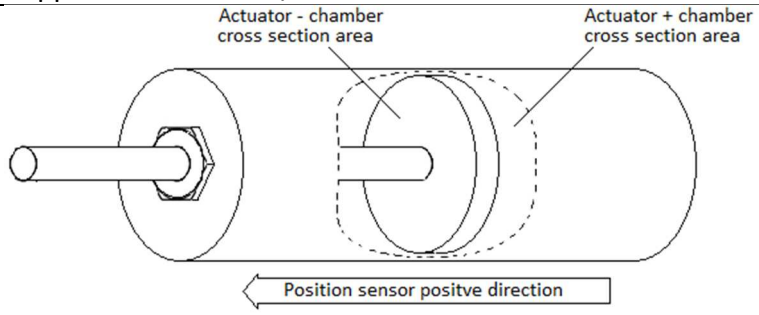
Actuator Stroke according to order code	Length of positoin sensor that will be shipped
10 - 25	25 mm
35 - 50	50 mm
85 - 100	100 mm
100 - 107	107 mm
128 - 143	143 mm
164 - 179	179 mm
185 - 200	200 mm
200 - 215	215 mm
236 - 251	251 mm
272 - 287	287 mm
303 - 323	323 mm
339 - 359	359 mm
375 - 395	395 mm
411 - 431	431 mm
447 - 467	467 mm
483 - 503	503 mm
519 - 539	539 mm
555 - 575	575 mm
591 - 611	611 mm
627 - 647	647 mm
663 - 683	683 mm
699 - 719	719 mm
735 - 755	755 mm
771 - 791	791 mm
807 - 827	827 mm
843 - 863	863 mm
879 - 899	899 mm
915 - 935	935 mm
951 - 971	971 mm
987 - 1007	1 007 mm

Accessories

Accessory	Order Code	Description/Comment
CAN adapter kit	3203001	Can Adapter, enables CAN communication between PC and positioning unit.
Mounting plate	21168401, Long 2116840, Short	 Bracket kit for side & bottom mounting
	21168402	 Mounting plate, wide, A
	21168403	 Mounting plate, wide, B
DIN-Bracket	2116841	For bottom mounting on DIN-rail
Din Rail, Aluminum	21168421	148mm (for one unit, flush mounting)
	21168422	298mm (for two positioning units)
	21168423	985.5mm
Power supply	3202001	Power supply, type F (European plug)
	3202001-AU	Power supply, type E (Australia/New Zeeland)
	3202001-N	Power supply, type B (North American plug)
	3202001-UK	Power supply, type G (UK)
	3202001-ZA	Power supply, type M (South Africa)
Silencer	2112010001	Silencer assembly, with 1 m 10 mm tubing
	2324001	Silencer, pulsating exhaust. 3/8 Specifically designed for Staccato Flexible Positioning Unit, FPU. Developed for eliminating the impact sound of pulsating exhaust noise, such as from fast valve switching.

User manual

Basic parameters

<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>Position sensor length</td><td>Position sensor gives a 4 to 20 mA signal; It’s possible to calibrate a Flexible Positioning Unit to a position sensor.
<table>
<tr><th>Calibrated</th><th>Position sensor setting</th></tr>
<tr><td>Calibrated</td><td>Set the length of the cylinder.</td></tr>
<tr><td>Not calibrated</td><td>Set length of the position sensor.</td></tr>
</table>
It’s highly recommended to calibrate sensor, calibration can be done with PC application or over I/O Link.</td></tr>
<tr><td>Actuator areas</td><td> 

FPU can control various sizes of actuator. In order for the controller software to correctly assess the amount of air that is required, piston cross section areas must be known. For a basic cylinder with positive position sensor according to image above, the piston cross sectional area of the + chamber A_+ is given by the following equation:
$$A_+ = \pi \left(\frac{D}{2}\right)^2$$
And the piston cross sectional area of the – chamber A_-:
$$A_- = \pi \left(\frac{D}{2}\right)^2 - \pi \left(\frac{d}{2}\right)^2$$
D is the bore diameter and d the piston diameter. Note that:

- The + chamber is the area that corresponds to positive direction of the position sensor.
- For double rod actuators, A_- equation is used for both chambers.
- For rod less actuators, A_+ is valid for both chambers.
- For double piston actuators, both sides should be multiplied by 2.

At delivery, it will be configured according to the order code. It’s possible to change in the PC software, by choosing actuator type and bore size, manufacturer and series or manual input.</td></tr>
</table>

Operation Modes

The FPU unit receive a set-point signal (or whish value), which it compares to the position of the actuator and adjust accordingly. The following set-point signals can be used:

<table>
<tr><th>Operation Mode</th><th>Description</th></tr>
<tr><td>Position Control 4 to 20 mA</td><td>Set-point is received from 4-20 mA signal connected to the I port.</td></tr>
<tr><td>Position Control 1-5 V</td><td>Set-point is received from 1-5 V signal connected to the U port.</td></tr>
<tr><td>Position Control 0-10 V</td><td>Set-point is received from 0-10 V signal connected to the U port.</td></tr>
<tr><td>Position Control 5-19 mA, Retract 4 mA, Extend 20 mA</td><td>Analog current with fast transfer to end positions.
Use full supply pressure for end position movement.
<table><tr><th>Current</th><th>Position</th></tr><tr><td>4 mA</td><td>Home position, fully retracted.</td></tr><tr><td>5-19 mA</td><td>Analog position.</td></tr><tr><td>20 mA</td><td>Home position, fully extended.</td></tr></table></td></tr>
<tr><td>Position Control 1-9 V, Retract 0 V, Extend 10 V</td><td>Analog voltage with fast transfer to end positions.
Use full supply pressure for end position movement.
<table><tr><th>Current</th><th>Position</th></tr><tr><td>0 V</td><td>Home position, fully retracted.</td></tr><tr><td>1-9 V</td><td>Analog position.</td></tr><tr><td>10 V</td><td>Home position, fully extended.</td></tr></table></td></tr>
<tr><td>Position Control 1-5 V (4-20 mA if no signal)</td><td>Set-point is received from 1-5 V signal connected to the U port.

If no signal is detected at U port, set-point is received from 4-20 mA signal connected to the I port.</td></tr>
<tr><td>Position Control 4-20 mA (1-5 V if no signal)</td><td>Set point is received from 4-20 mA signal connected to the I port.

If no signal is detected at I port, set-point is received from 1-5 V signal connected to the U port.</td></tr>
<tr><td>Position Control 4-20 mA (0-10 V if no signal)</td><td>Set-point is received from 4-20 mA signal connected to the I port.

If no signal is detected at I port, set-point is received from 0-10 V signal connected to the U port.</td></tr>
</table>

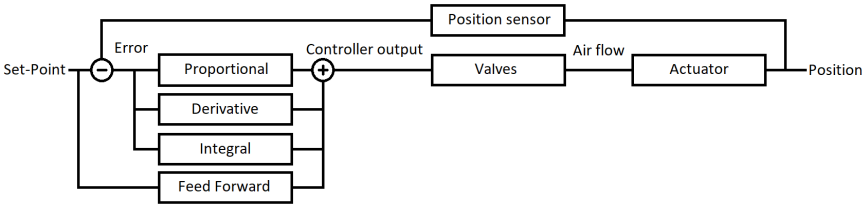
Position Control 4-20 mA. Speed Control 0-10 V	- Set-point is received from 4-20 mA signal connected to the I port. - Maximum velocity is received through a 0 to 10 V signal connected to the U port. 0 to 10 V corresponds to 0 to 2 m/s. Note that application may not reach target speed due to FPU size, controller setting and/or actuator size.
Position Control 0-10 V. Force Control 4-20 mA (+)	- Set-point is received from 0-10 V signal connected to the U port. - Maximum force in positive direction is received through 4-20 mA signal to the I port. 4-20 mA corresponds to force equivalent to 0 to 1 MPa pressure force in actuator.
Position Control 1-5 V. Force Control 4-20 mA (+)	- Set-point is received from 1-5 V signal connected to the U port. - Maximum force in positive direction is received through 4-20 mA signal to the I port. 4-20 mA corresponds to force equivalent to 0 to 1 MPa pressure force in actuator.
Position Control 0-10 V. Force Control 4-20 mA (-)	- Set-point is received from 0-10 V signal connected to the U port. - Maximum force in negative direction is received through 4-20 mA signal to the I port. 4-20 mA corresponds to force equivalent to 0 to 1 MPa pressure force in actuator.
Position Control 1-5 V. Force Control 4-20 mA (-)	- Set-point is received from 1-5 V signal connected to the U port. - Maximum force in negative direction is received through 4-20 mA signal to the I port. 4-20 mA corresponds to force equivalent to 0 to 1 MPa pressure force in actuator.
Position Control 0-10 V. Force Control 4-20 mA (Absolute)	- Set-point is received from 0-10 V signal connected to the U port. - Maximum force in both direction is received through 4-20 mA signal to the I port. 4-20 mA corresponds to force equivalent to 0 to 1 MPa pressure force in actuator.

Position Control 1-5 V. Force Control 4-20 mA (Absolute)	- Set-point is received from 1-5 V signal connected to the U port. - Maximum force in both direction is received through 4-20 mA signal to the I port. 4-20 mA corresponds to force equivalent to 0 to 1 MPa pressure force in actuator.
Preset Positioning	Preset position values assigned to digital input signals. Possible to assign up to 8 different values using the three digital input pins in DIG port.
Manual (on the fly)	Set point is manually set in the manual tab in PC software.
Jog Digital	Jog actuator with digital signal to Dig. port - + direction: Digital input, 1 - - direction: Digital input, 2
Jog Analog 1-5 V	Jog actuator with analog signal 1-5 V.
Jog Analog 4-20 mA	Jog actuator with analog signal 4-20 V.
Zero G Jog	Jog actuator with applied external force.
IO Link	Digital interface, see **Fel! Hittar inte referenskälla.** on page **Fel! Bokmärket är inte definierat.** for details.

Controller

Parameter	Description
Controller gain	Depending on the application, it's possible to choose a gain. A more aggressive gain will increase the speed but may reduce the accuracy. Too aggressive gain may cause oscillation in movement. In the Basic tab, it's possible to set accuracy and controller gain on a 10 grade scale. For advanced users, it's possible to set the P and Feed forward gain individually. This is done in the controller advanced settings in the PC software.
Accuracy	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.
Maximum speed	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. 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.

Advanced Controller Settings

Parameter	Description
Controller gain	

Position of actuator is controlled with a closed loop PID-controller combined with feed forward. PID is an acronym for proportional-integral-derivative. Input to software is position and desired set-point. Controller output from software activates valves that position the actuator.

Block	Description
Proportional	Controller output from this block is proportional to deviation between set-point and position.
Integral	Controller output from this block is proportional to integral of deviation between set-point and position. Do not change without support from Staccato.
Derivative	Controller output from this block is proportional to derivative of deviation between set-point and position. Do not change without support from Staccato.
Feed forward	Set-point is feed forward in system.

Gain of each controller block is possible to adjust individually. Each parameter can be set to a value between 0 and 100 %. There are numerous ways to tune the controller, table below show some recommendations to when to increase or decrease the gain of the different blocks.

Problem	Solution
Actuator movement is slow.	- Increase proportional factor - Increase maximum speed
Overshoot during positioning.	- Decrease proportional factor - Decrease maximum speed
Oscillation in position	- Decrease proportional factor - Decrease maximum speed
Lagging position during increase.	- Increase proportional factor

Feed forward tolerance	Set-point velocity is feed forward, if signal velocity is less than set feed forward tolerance, value is filtered out.
Two step proportional controller	Possible to set different P parameters in controller software depending on error. Increases stroke speed, reduces noise, wear and cycle time. Note that speed will still be limited by set maximum speed.
Full speed controlled brake	Possible to set full speed of actuator and controlled brake. Note that full speed will be limited by set maximum speed.

Advanced parameters

<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>Valve frequency</td><td>Staccato valves normally operates at 50 Hz, it’s possible to set valve frequency of valves in order to. Reduce frequency to Increase life time, note that reduced frequency can effect performance.</td></tr>
<tr><td>Maximum force</td><td>Possible to set maximum force for actuator. If maximum force is set, actuator movement will stop if force exceeds set maximum force.

Note that:
- Force repeatability equivalent to pressure repeatability of 0.02 MPa (0.2 bar).
- This refers to pressure force in actuator chambers, external force can differ due to friction in actuator, guides and bushings.</td></tr>
<tr><td>Load Condition Speed limit</td><td>This function reduces speed of actuator if load on actuator is higher than set limit.</td></tr>
<tr><td>Soft start</td><td>Possible to reduce speed of actuator at startup, before pressure is high in system.</td></tr>
<tr><td>Enable mode</td><td>With this function activated, a signal is required for function:
- Signal high → Normal function
- Signal low → No function

<table><tr><th>Enable Signal Low</th><th>Description</th></tr><tr><td>Closed Valves/Hard Stop</td><td>Valves passive/closed.</td></tr><tr><td>Actuator Exhausted</td><td>Actuator is exhausted.</td></tr><tr><td>Home Position, fully retracted</td><td>Actuator at home position, fully retracted.</td></tr><tr><td>Home Position, fully extended</td><td>Actuator at home position, fully extended.</td></tr></table>
Demonstration video available with QR code. Note that both home positions will go with full speed.</td></tr>
<tr><td>Pressure adjuster</td><td>Background function that will increase pressure to set value during operation.</td></tr>
<tr><td>Pressure build up</td><td>Background function that will increase pressure to set value. This can give small oscillations until pressure has reached desired value.</td></tr>
</table>

Digital outputs

Digital output functionality, each of the three digital outputs can be set to following functionality:

Function	Description
Off	Digital output not active
On	Digital output active (0.5 A maximum, shared with multiple outputs)
Position	Coupled to position value. Possible to set point- or window mode.
Position Set-Point Achieved Status	Digital output active if position is within tolerance setting in PC software.
Pressure, + Chamber	Coupled to pressure value in + chamber. Possible to set point- or window mode.
Pressure, - Chamber	Coupled to pressure value in - chamber. Possible to set point- or window mode.
Force, Positive Direction	Coupled to force in positive direction. Possible to set point- or window mode.
Force, Negative Direction	Coupled to force in positive direction. Possible to set point- or window mode.
Force, Absolute Value	Coupled to absolute value of force, will react to force in any direction. Possible to set point- or window mode.
Direction Signal, Positive	Signal for booster valve, positive direction. Compatible with: - Exhausting valve - Supply valve See page 41.
Direction Signal, Negative	Signal for booster valve, positive direction. Compatible with: - Exhausting valve - Supply valve See page 41.
External Lock Signal	Signal used to control an external lock. Signal active if position set-point is achieved. See page 42 for details.
Ready Status	Digital output active If positioning system is functional.
Position Sensor Signal Status	Digital output active if Position sensor signal is ok.
Set-Point Signal Status	Digital output active if Set-point signal is ok.

Analog outputs

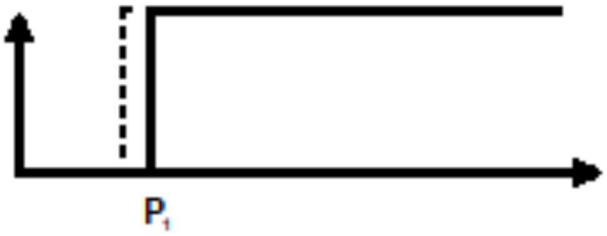
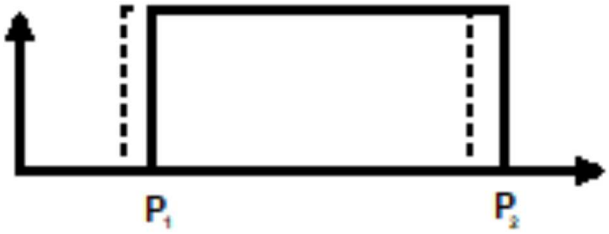
Function mode sets what value is received from analog output, as an example if Function Mode Position is set, analog signal from Flexible Position Unit will show position measured by position sensor.

Function Mode	Description
Not Active	Analog signal output not active.
Position	Position feedback.
Force	Pneumatic force feedback. Calculated pressure, based on cross sectional areas of actuator and pressure. Friction forces not included.
Pressure, +	Pressure, + chamber
Pressure, -	Pressure, - chamber

Analog output	Range
Analog Current	4-20 mA
Analog Voltage	Configurable: - 0-10 V - 1-5 V

Analog output	Scaling
Position	Signal range corresponds to full stroke of position sensor.
Force	Signal range represents 0 to force equivalent to 1 MPa.
Pressure	Signal represents 0 to 1 MPa.

Following settings are configurable for the digital outputs:

Parameter	Description
High/On or Low/Off	Signal high or signal low when active.
Time delay	Time delay applies when signal goes from not active to active. Depending on setting, time delay applies: - High/On: when signal goes from low to high - Low/Off: when signal goes from high to low.
Point mode or window mode	Possible to set digital output to, - Point mode  - Window mode  Note does not apply to status or signal function, see table above.
Hysteresis	Hysteresis of signal when setting point mode or window mode can be seen in figure above.

Jog Settings

<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>Digital Jog Speed</td><td>Jog speed in positive and negative direction, only utilized in operation mode Jog Digital.</td></tr>
<tr><td>Zero G Jog Load Detection Mode</td><td>Only utilized in operation mode Zero G Jog:
<table>
<tr><th>Load Detection Mode</th><th>Description</th></tr>
<tr><td>Automatic</td><td>When operation mode is set to Zero G Jog, pneumatic force will be detected and set.</td></tr>
<tr><td>Manual</td><td>Manually set desired pneumatic force of actuator.</td></tr>
</table>
Sets load detection mode, see Zero G Jog on page 37 for application example.</td></tr>
<tr><td>Force Tolerance</td><td>Only utilized in operation mode Zero G Jog. If external force of Force Tolerance is applied to actuator, actuator will be jogged.</td></tr>
<tr><td>Jog Speed</td><td>Jog speed in operation mode Zero G Jog.</td></tr>
<tr><td>Manual Set Force</td><td>Manual set force, if Zero G Jog Load Detection Mode is set to Manual.</td></tr>
</table>

Application examples

Preset Positioning

<table>
<tr><td>Function description</td><td>Actuation between fixed positions, digital input signal connected to DIG port.

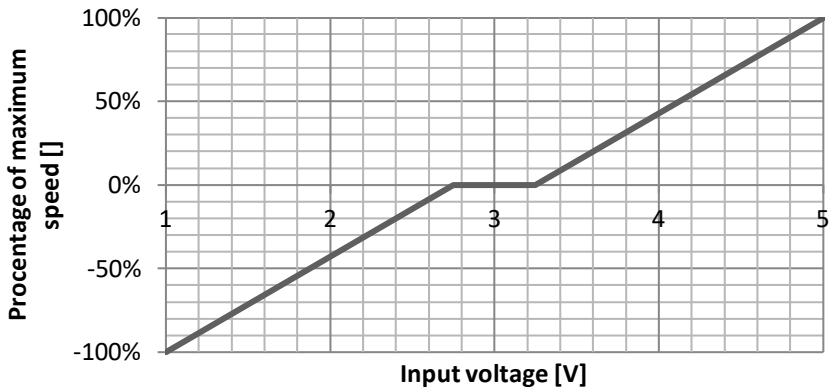
There are two different options:
- 3 different preset positions or modes like exhausting actuator, one for each digital input pins on DIG port.
- 8 different preset positions or modes like exhausting actuator. Possible by combining combinations of the three digital input pins on DIG port.</td></tr>
<tr><td>Set-up</td><td>Set-up in PC software using the Preset Positioning tab.</td></tr>
<tr><td>Input signal</td><td>Each of the digital inputs will correspond to a position or a preset mode. See table below.

<table>
<tr><th>Digital input</th><th>Set-point</th></tr>
<tr><td>DI 3</td><td>Preset 1</td></tr>
<tr><td>DI 2</td><td>Preset 2</td></tr>
<tr><td>DI 1</td><td>Preset 4</td></tr>
<tr><td>No signal or more than one signal</td><td>Hard stop (valves closed)</td></tr>
</table>

<table>
<tr><th>DI 1</th><th>DI 2</th><th>DI 3</th><th>Set-point</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>Preset 0</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>Preset 1</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>Preset 2</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>Preset 3</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>Preset 4</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>Preset 5</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>Preset 6</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>Preset 7</td></tr>
</table>

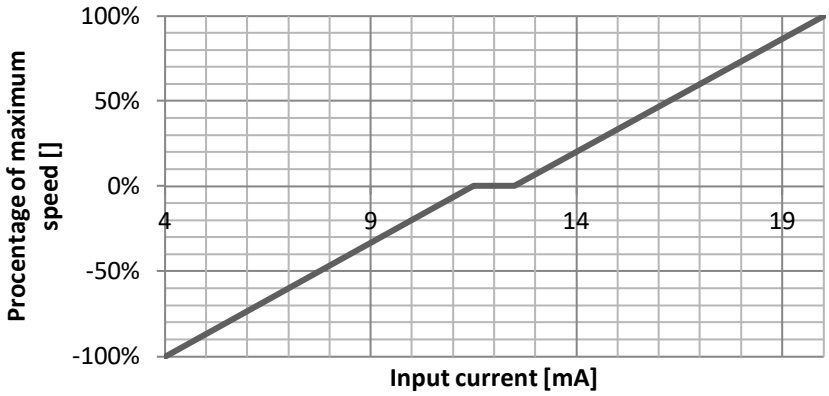
Following preset can be set:
- Position
- Hard stop (valves closed)
- Actuator exhausted
- Home position fully extended
- Home position fully retracted</td></tr>
</table>

Analog jog 1-5 V

Function description	Possible to jog position using analog voltage signal.
Set-up	Set-up in PC software: - Select analog jog in operation mode list in Basic tab. - Set up Maximum Speed, corresponding to 1 and 5 V in Basic tab. Connect set-point signal to Set-point, 0-10 V pin on U port. Note that valves will continue to activate at full frequency, even if actuator is at end point. To prevent this, maximum force in negative and positive direction can be set.
Input signal	 Analog input signal will set speed of actuator. - Speed is set to 0 in the interval 2.75 to 3.25 V. - If position sensor is connected, position will be locked with closed loop controller when speed is set to zero. If position sensor is not connected, actuator will be locked with no closed loop controller.

Analog jog 4-20 mA

Function description	Possible to jog position using analog current signal.
Set-up	Set-up in PC software: - Select analog jog in operation mode list in Basic tab. - Set up Maximum Speed, corresponding to 4 and 20 mA in Basic tab. Connect set-point signal to Set-point, 4 to 20 mA, + and - pins on I port. Note that valves will continue to activate at full frequency, even if actuator is at end point. To prevent this, maximum force in negative and positive direction can be set.

Input signal	
	Analog input signal will set speed of actuator.
	- Speed is set to 0 in the interval 11.5 to 12.5 mA.
	  ○ If position sensor is connected, position will be locked with closed loop controller when speed is set to zero. This activates position controlling.
	  ○ If position controller is not connected, valves will be closed.

Digital jog

Function description	Possible to jog position using digital signal.

Set-up	Set-up in PC software:
	- Select digital jog in operation mode list in Basic tab.
	- Set up speed, in Jog tab
	  ○ Jog speed +, speed in positive direction
	  ○ Jog speed -, speed in negative direction
	
	Note that Maximum Speed in Basic tab is still active. Jog speed will not exceed Maximum Speed set in basic tab.
	- Example: If Jog Speed + of 200 mm/s is set, and a Maximum speed of 150 mm/s is set.
	Jog speed in positive direction will be 150 mm/s.
	
	Note that speed limits activated in Advanced tab may apply as well.
	
	Connect set-point to Dig. port
	- + direction: Digital input, 2
	- - direction: Digital input, 3

Input signal	Two different digital inputs, on for movement in + and – direction.

Zero G Jog

Function description	Jog actuator with external force.

Set-up	Set-up in PC software:
	- Select operation mode Zero G Jog
	- Select load detection mode
	  ○ Automatic
	  When operation mode is set to Zero G Jog, pneumatic force will be detected and set.
	  ○ Manual
	  Manually set desired pneumatic force of actuator.
	- Set Force Tolerance
	  If an external force is applied to actuator greater than force tolerance, actuator will be jogged in the direction of force.
	- Set speed
	  The jog speed of Zero G Jog.

Input signal	No signals required, apply external force to actuator to move actuator.

On the fly speed control

Function description	Analog current input for position set-point. Maximum velocity is set with analog voltage input.
Set-up	In PC software, select desired input channel.
Input signal	I and U port are utilized: - Analog current input for position set point, 4 to 20 mA. - Analog voltage input for speed control, 0 to 10 V corresponds to 0 to 2 m/s.

On the fly force control

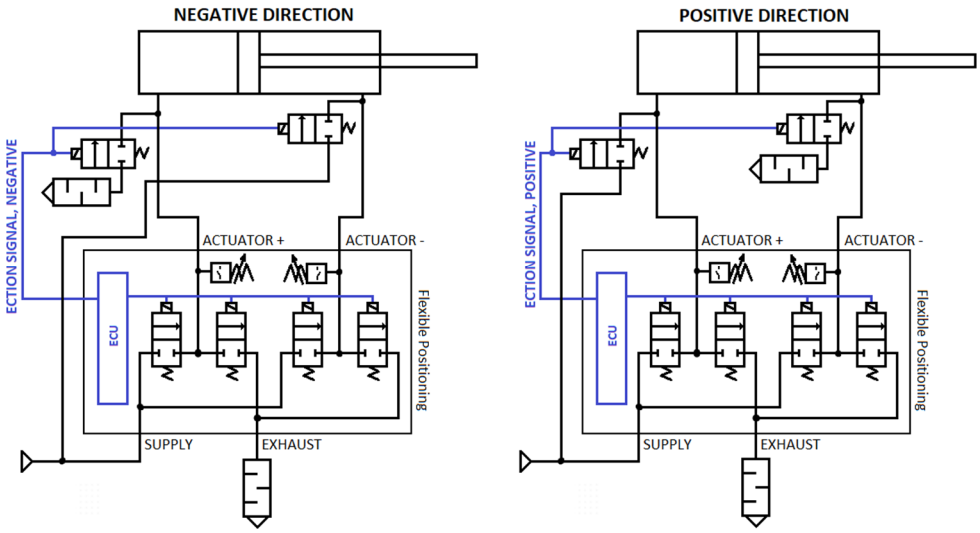
Function description	Analog voltage input for position set-point. Analog current input for pressure force.
Set-up	Set operation mode to one of the following: - Position Control 0-10 V, Force Control 4-20 mA (+) - Position Control 1-5 V, Force Control 4-20 mA (+) - Position Control 0-10 V, Force Control 4-20 mA (-) - Position Control 1-5 V, Force Control 4-20 mA (-) - Position Control 0-10 V, Force Control 4-20 mA (absolute) - Position Control 1-5 V, Force Control 4-20 mA (absolute)
Input signal	I and U port are utilized: - Analog voltage input for position set point, 0 to 10 V - Analog current input for force control 4 to 20 mA gives a pressure force corresponding to 0 to 1 MPa pressure.

Enable Function

<table>
<tr><td>Function description</td><td>For function, an enable signal must be provided.

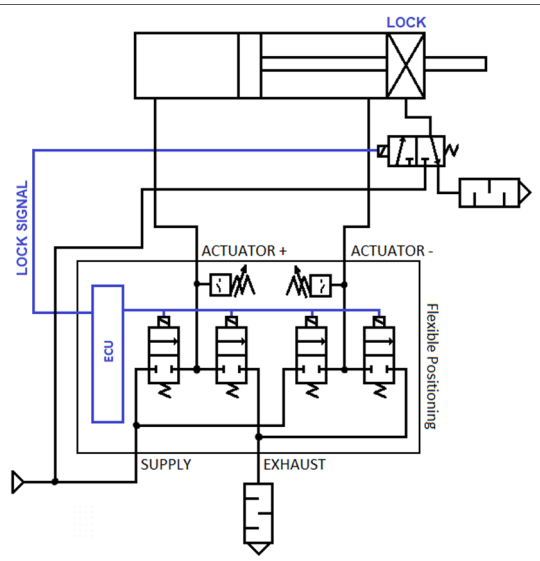
<table><tr><th>Enable signal</th><th>Function</th></tr><tr><td>Signal high</td><td>Normal function.</td></tr><tr><td>Low signal</td><td>One of the following:
- Valves passive, position locked
Note that supply pressure is required to avoid back pressure leakage, see pneumatic diagram.
- Actuator exhausted
- Home, extended position
- Home, retracted position</td></tr></table></td></tr>
<tr><td>Set-up</td><td>In advanced tab in PC software or over I/O Link interface.
- Activate enable mode
- Select function, see table above
- Select input port for enable signal
○ DIG port, Digital input 1
○ U port, Set-point, 0-10 V</td></tr>
<tr><td>Input signal</td><td>Select I or U for position set-point,
- Note that U port can be selected for enable signal, if so, U port can not be utilized for position set-point.</td></tr>
</table>

Booster Valves

Function description	Digital output is used to control a booster valve. A booster valve is used to increase speed.
Set-up	In the PC software, set a digital output as direction signal. - Any of the three digital outputs can be set as a direction signal, positive or negative direction. - It's possible to set two different digital outputs to two different directions. External booster valves must be connected. Below are examples of how 4 different valves can be used. 
Input signal	Booster valve signal compatible with all input signals for set-point.

External Lock

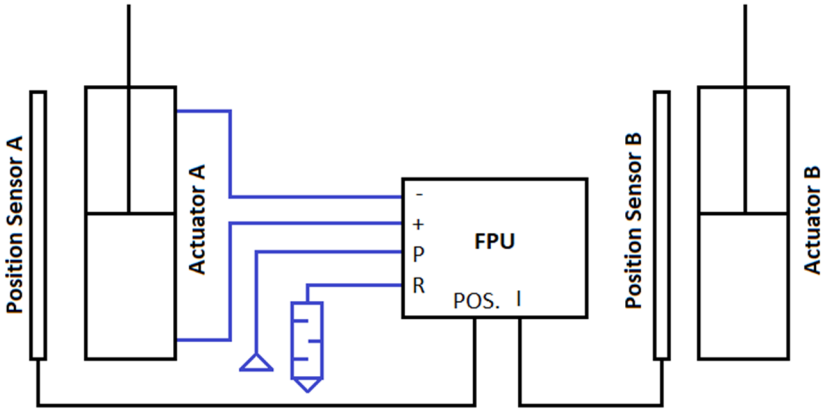
<table>
<tr><td>Function description</td><td>Digital output is used to control a lock connected to actuator.

- External lock is activated with signal from digital output when position set-point is achieved.
Note that tolerance for activation of lock is governed by set accuracy of the controller.
- When lock is activated, following three modes can be selected.
<table>
<tr><th>Mode</th><th>Description</th></tr>
<tr><td>Hard stop/Locked valves</td><td>Valves closed.</td></tr>
<tr><td>Pressure controller, preset pressure</td><td>Closed loop controlling of pressure in + and – chamber of actuator with an accuracy of 0.02 MPa. Desired pressure values are set individually for the two chambers in the in PC software.</td></tr>
<tr><td>Pressure controller, detected pressure</td><td>Closed loop controlling of pressure in + and – chamber of actuator with an accuracy of 0.02 MPa. Desired pressure value will be sampled when lock is activated.</td></tr>
</table>
- Lock signal will deactivate when position deviates from position set-point.</td></tr>
<tr><td>Set-up</td><td> 

- In the PC software, set one of the three digital outputs as External Lock.
- Set desired time delay
- Possible to set a inverted signal
- Select mode when lock is activated.
○ Set desired pressure values if</td></tr>
<tr><td>Input signal</td><td>External lock valve signal compatible with all input signals for set-point.</td></tr>
</table>

Copy Function

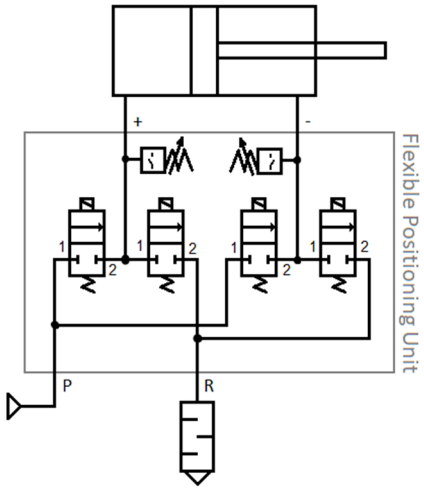
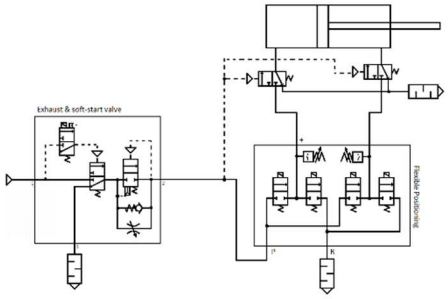
Function description	Set up actuator A to copy movement of actuator B. - Position sensor is connected to actuator B, set as set-point for movement.

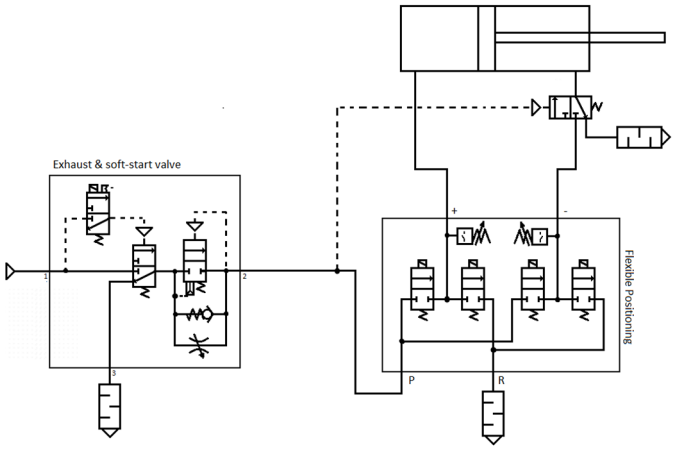
Set-up	
	- Set basic parameters of FPU for position controlling:
	  ○ Length of position sensor A
	  ○ Dimensions of actuator A
	  ○ Controller parameters
	- Set operation mode of FPU to Position Control 4-20 mA
	- Connect position sensor B to I port of FPU according to Position Sensor to I Input Current on page 14.
	- Connect position sensor A to POS. port of FPU.
	
	Movement of actuator B will be copied by actuator B. Note that movement of actuator A will be delayed, due to delays in system. Amount of delay will vary with application. Please contact Staccato for further support.

Input signal	No further input signals required for function.

Shut down & Quick exhaust

Below are some typical application examples for different behaviors during shut down, quick exhaust etc. Whole system must be considered by the designer in terms of safety and required/expected behaviors.

Type	Description
At power failure: - Movement is stopped - All valves are normally closed (NC) and will keep the actuator in position - Positioning will resume when power is returned At air supply failure: - Unit will try to position, and will reduce valve cycling to 20 Hz if the air is removed - Air in actuator can flow out backwards through P port - Positioning will resume when air is returned	
At one of following: - Power failure - Emergency stop push button activation - Use of standard 3/2 soft start exhausting valve Following functionality: - Stop of movement - All chambers exhausted Note that tubing and components should be chosen to have sufficient flow rate.	

At one of following: - Power failure - Emergency stop push button activation Following functionality: - Stop movement - Move to start position Soft-start functionality.	

Trouble shoot

Step-by step guide

<table>
<tr><th>Step</th><th>Comment</th></tr>
<tr><td>Power</td><td>Check ready led, should be on or flashing in 2,5 Hz.

If ready led flickers irregularly or is off, check power input. Note that power supply must be able to deliver:
- 6.5 A peak current
- 10 W mean power output</td></tr>
<tr><td>Power outputs</td><td>FPU has several power outputs. Check that power input is not connected to any of the power outputs.

If it’s correctly connected, all LED’s will turn off if PWR port is unplugged.</td></tr>
<tr><td rowspan="2">Position signal</td><td>Check led on position sensor, most sensors have led indicating actuator is in range. See examples below however confirm using supplier position sensor instruction manual.
<table>
<tr><th>Sensor type</th><th>Check</th></tr>
<tr><td>SMC D-MP sensors</td><td>- Blue led on, indicating power
- Yellow led on, indication actuator in range</td></tr>
<tr><td>SICK MPA and MPS sensors</td><td>- Blue led on, indicating power
- Yellow led on, indication actuator in range</td></tr>
<tr><td>Festo SDAT sensors</td><td>- Green led on, indicating ready and actuator in range</td></tr>
<tr><td>Metal Works LTS sensor</td><td>- Yellow led on, indication actuator in range</td></tr>
</table></td></tr>
<tr><td>Check position sensor led on FPU, should be on.

If position sensor led is:
- Flashing: signal error, FPU will not function.
- Note that bad signal quality can give irregular flickering of led as led switches from on mode to flashing mode.</td></tr>
</table>

Position signal mapping	For best performance, 4 mA should correspond to fully retracted actuator and 20 mA fully extended actuator. Giving a signal range of 16 mA. For very long position sensors with short actuators, signal range decreases. If signal range is less than 10 mA, a teach-in of position sensor is strongly recommended. See position sensor instruction manual for further information.
Connect pneumatic ports	Connect + and – ports to actuator. it's crucial that + port is connected to actuator chamber giving increasing position signal level and – port giving decreasing position signal level.
Set-point signal	Check Set-point led on FPU, should be on. If position sensor led is: - Flashing: signal error, FPU will not function. - Note that bad signal quality can give irregular flickering of led as led switches from on mode to flashing mode.
Pressure	Check that pressure is connected to P port. Pressure should be between 0.4 and 0.8 MPa.
Position sensor length	Check that length of position sensor is correctly set-up. - AAA in the order code corresponds to the factory set length of the position sensor, FPU2-XX-XXX-AAA. The length of the position sensor can be changed with a CAN dongle and the PC software or over I/O Link. The length of the position sensor is vital for controlling the actuator, in order to correctly access the position of the actuator.
Actuator chamber	Check that the cross sectional area of the piston is correctly set-up. - AAA in the order code corresponds to the factory set diameter of the actuator, FPU-XX-AAA-XXX. The cross sectional areas of the piston can be changed with a CAN dongle. The cross sectional areas are vital for controlling the actuator, in order to correctly access the amount of air needed.

Internal Safety

Internal high temperature guard	Description
Pressure failure	Software will detect pressure failure and reduce operating frequency of valves. This reduces temperature build up. - Valve frequency will be lowered to 20 Hz - Pressure led will flash - If pressure is not recovered after 60 s, frequency will be further decreased to 5 Hz Check: - Supply pressure is between 0.4 and 0.8 MPa. - Actuator can mechanically reach set position from controller signal output (end of stroke or other obstacles). - Maximum force setting is lower than maximum available force with supply pressure.

Internal temperature operation limit	FPU will measure temperature in unit. If high temperatures are detected:
	- Valve frequency will be decreased every 2 minutes until temperature is under control
	- Ready led will flash in 0.5 Hz
	- Valve frequency decrease will remain until unit is restarted.
	
	Review:
	- Ambient temperature in application
	- Valve frequency used, if possible reduce valve frequency
	- FPU thermal connection, improve cooling.
	  ○ Is FPU mounted in sealed box without air?
	  ○ Is FPU mounted on hot surface?
	  ○ Is FPU thermally insulated?
	
	To reset state, cycle power supply. Note that resetting state without preventive actions may cause same failure state.

Error list

Problem	Solution
No response over CAN communication.	- Check connection cable - Restart PC software - Restart FPU - Restart PC
All LED:s off	- Check if power is connected. - Check if voltage is correct.
Pressure led is flashing.	Indicates that pressure in chambers connected to + and – port is less than 0.1 MPa. Note that this can be a result of normal operation, example if set-point is set to exhaust actuator. If this isn't a result of normal operation, check: - Check if supply pressure is between 0.2 and 1.0 MPa - Move actuator between end point by changing set-point.
Position led is flashing	- Check if position sensor is connected - Check position sensor settings, see position sensor manual.
Set-point led is flashing	- Check if set point contact is connected
Actuator locked in one end position	- Check that + and – ports are correctly connected. - Check that position sensor is in range.
Digital or analog signal not operating correctly	- Check that all analog and digital signals use the same ground reference as operational voltage to FPU.