

QA Smart Mini Syringe Pump SMSP1 – Instructions (2020-12-08/QA)

Key Features

High Volumetric Performance

- Wide Speed Range 1:50000 (0.01...500 µl/s with 1 ml syringe)
- Various Syringe Volume Options 0.5 ml...100 ml (tbd)
- Volumetric Accuracy < 1.0% (of Full Syringe Range)
- Volumetric Reproducibility < 0.1% (of Full Syringe Range)
- Smooth, Pulsation-Free and Oscillation-Free Dispensing (<0.05% of Full Syringe Range)
- Slow, Pulsation-Free and Oscillation-Free Volume Rate
- Miniaturized and Weight Optimized Design (470 g with 1 ml syringe)

Smart Control

- Integrated Microcontroller and Motor Control
- Smooth, pulsation-free 1/256 Micro Stepping Control
- Various Control and Interfacing Options:
 - USB (via adapter)
 - UART (RS232/QSB)
 - pulse frequency/direction input
 - flexible digital/analog expansion interface e.g. for retrofit options*
- OEM and Retrofit Compatibility Modes

Smart Self Monitoring Options

- Status Indicator (LED)
- Acoustic status/configuration and fault indicator
- Movement Precision Self Monitoring
- Motor Overload Monitor (Current/Temperature*)
- Pressure Monitor*
- Performance Memory / Error Counter
- Run Time Data
- Fault Prediction / Aging Monitor
- Acoustic Fault Signaling
- All Parameters accessible and configurable via USB/UART

Smart Extension Options*

- Pressure Sensors
- Temperature Sensors
- Reagent Thermostat
- Flow Rate Sensors
- Fluidic Valves, including bipolar pulse control
- Syringe Pump Cascading (e.g. 2 pumps tandem or parallel)

*) optional, available upon request



Reliability

- Optimized Service/Maintenance Intervals
- Extended Lifetime (MTBF), typ.:
 - Syringe (no leakage): 5 years@500 cycles/day typ. (liquid), 2.5 years@500 cycles/day typ. (air)
 - Pump/Mechanics: 5 years@500 cycles/day typ.

Applications

- High Precision/Accuracy Volumetric Dispensing
- High Precision Volumetric Flow Cytometry (FCM), Microscopic Slide Flow Analyzer (MSFA), Microscopic Slide Analyzer (MSA), Slow Flow FCM
- OEM Applications / OEM Instrument Integration
- Loop Type Sample/Reagent Fluidics Support
- High Throughput Sample Automation (e.g. pocketSPU)
- Retrofit for FCM Syringe Pumps (QA, ...)

SMPS1 Variants

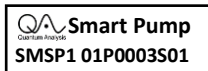
SMSP1 is available in variants S (small), M (medium) and L (large) with support for various syringe sizes and volumes (see table). For a given variant, supported syringes are user exchangeable by means of a separately available syringe adapter set.

SMSP1 Variant	SMSP1-S	SMSP1-M	SMSP1-L
Supported Syringe			
Max. Dispension Volume/Cycle (Full Range Syringe Volume), FR	ml		
S1000	1.0	+	+
S1500	1.5	+	+
S10K	10	+	+
S100K	100		+

Table 1: SMPS1 variants vs. syringe volume. Other syringe volumes optional upon request.

Product Label

For reference and quality control traceability, SMPS1 carries a product identification label with serial number. Please provide serial number in case of support requests.



Safety Precautions and Warnings

- Module intended for system integration only. Not intended for standalone use.
- Integration and connection only to recommended systems within specifications.
- Operation, maintenance and service by trained personnel, only.
- Connect connectors and tubing securely.
- Do not disassemble.
- Do not modify or use for other than intended purposes.
- Make sure to be properly trained for maintenance or service.



Caution: Moving parts! Keep hands away to avoid injuries!

Technical Specifications

Variant	Unit	SMSP1-S			
		S1000	S1500	S10K	S100K
Max. Dispension Volume/Cycle (Full Range Syringe Volume), FR	ml	1.0	1.5	10	100
Max. Syringe pressure	hPa	2000	2000	1,000	500
Dispensing Pressure (max.) *1)	hPa	2000	2000	500 tbd	250 tbd
Aspiration Pressure (min.) *1)	hPa	-1000	-1000	-500 tbd	-250 tbd
Chemical Compatibility (Fluids)	-	see separate table			
Volumetric Aspiration/Dispensing Rate (min)	µl/s	0.01	0.01	1	10
Volumetric Aspiration/Dispensing Rate (max)	µl/s	500	750	5000	10,000
Volume Accuracy	% FR	<0.5	<0.5	tbd	tbd
Volume Reproducibility (similar cycle)	% FR	<0.1	<0.1	tbd	tbd
Volume Rate Pulsation	µl	<0.1	<0.1	tbd	tbd
Volume Rate Oscillation	%	<1.0	<1.0	tbd	tbd
Power Supply	V	12+-5%	12+-5%	12+-5%	12+-5%
Typ. Current Consumption (max.) *2)	A	0.4	0.4	1	2
Max Current Consumption (max.) *3)	A	0.6	0.6	1	2
Failure Current (max.) *4)	A	2	2	2	2
Reposition Time (min) (@50% FR)	s	1	1	tbd	tbd
Life Time (MTBF), Pump Mechanics, typ. *5)	cycles	500,000	500,000	tbd	tbd
Life Time (MTBF), Syringe, typ. *5)	cycles	200,000	200,000	tbd	tbd
Media	-	water, air, cleaning solution	water, air	water, air	water, air
Air/Fluid Outlet Connector	-	Flexible Tubing ID 1 ...3 mm	Flexible Tubing ID 1 ...3 mm		
Environmental Conditions (operation)	-	10...45°C non condensing	10...45°C non condensing		
Environmental Conditions (storage) (recommended)	-	0...50°C non condensing	0...50°C non condensing		
Dimensions	mm	150 x 40 x 40	150 x 40 x 40	tbd	tbd
Weight (including syringe)	g	470	470	tbd	tbd
Standards: developed and manufactured according to ISO 9001:2015, CE, RoHS *6)		+	+	+	+

1) Relative to environmental pressure.

2) @10% of max. aspiration/dispensing rate / 20% of max. pressure load (without extensions)

- 3) @max. speed/pressure load (without extensions)
- 4) Limit by self-resettable fuse
- 5) Full range cycles with reference medium (QA Sheath Fluid) @50% of max. dispensing rate, T = 25°C
- 6) Directive 2011/65/EU and delegated Directive (EU) 2015/863 - Restriction of the use of certain hazardous substances (RoHS).

Note: All specifications verified for reference fluid: QA Sheath Fluid / QA Carrier Fluid, T = 20...25°C.
Also valid for compatible clean, non-corrosive aqueous solutions with similar properties.

Media Compatibility (examples):

Media	Note
Air	dust free / particle filtered < 2 µm
Pure Water	particle free
Carrier Fluid: QA Carrier Fluid	for MSFA/MSA systems
Sheath Fluid: QA Sheath Fluid Sysmex Partec Sheath Fluid Biomérieux ChemSol S	particle filtered < 20 µm
Cleaning Solutions: QA Cleaning Blue QA Cleaning Green	Daily Rinsing by Sheath Fluid or Pure Water Required
Buffers: PBS	Daily Rinsing by Sheath Fluid or Pure Water Required

Note: For use with other fluids, contact QA.

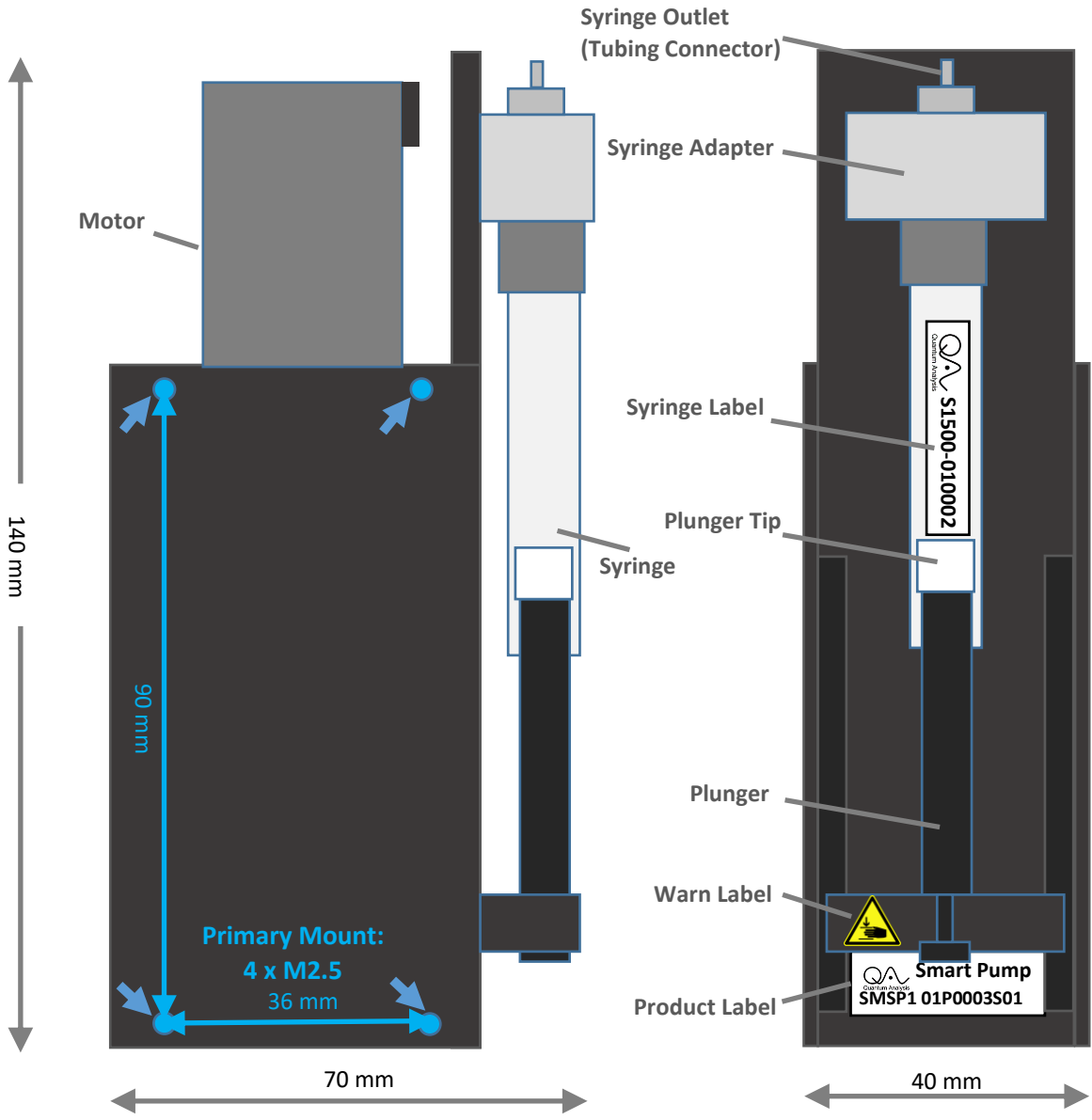


Warning: Leakage Risk! Do not allow dissolved adds (buffers, detergents, ...) within syringe to dry and crystallize! Syringe lifetime may be significantly degraded and sealing may damage and start leaking!

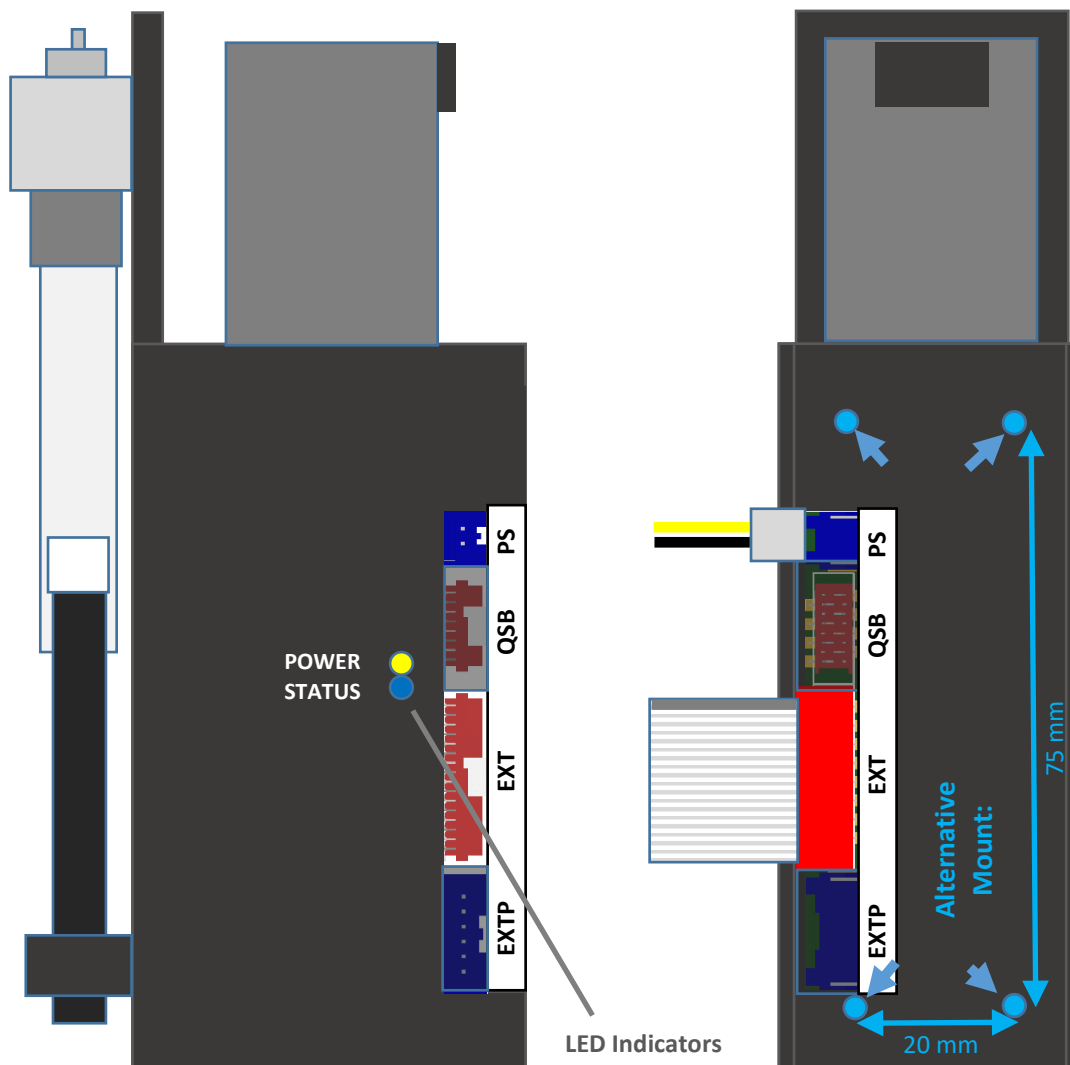


Warning: Pressure! Make sure overpressure provision is available in system! When used with liquid, syringe pump may generate excessive pressure, especially when used with liquid in syringe, if no external provision of overpressure protection is implemented! This may damage syringe pump or sealing and cause liquid to enter syringe pump or spread around system!

Overview



SMSP1 (shown variant S with S1500 syringe): Tubing outlet and electrical connections, Left: alternative mount positions 4 x M2.5. Right: top view with SMSP1 product label and syringe label.



SMSP1 (shown variant S): Electrical connections, LED indicators. Right: bottom plate side, mounting thread positions 4 x M2.5.

Mount

SMPS1 should be mounted via primary mount (after removal of side plate; recommended). In case primary mount cannot be used due to mechanical restrictions, use alternative mount.

Orientation: For using syringe with air, any orientation, vertical (syringe outlet towards top) or horizontal (syringe on top or side) is possible. When used with fluids, syringe outlet should be towards top to ensure proper priming and release of air.

Note: When used with fluids, avoid mounting with syringe horizontally on top, as potential syringe leakages may enter syringe pump and cause damages.

Note: Make sure to use screws with proper length: available thread depth in SMPS1: 4 mm. Screws too long may destroy internal parts, too short will prevent proper fixation or destroy mounting threads.

Electrical Connectors:

PS: Power Supply +12 V (note: power supply rated > 0.7 A available recommended).

QSB: Communication interface (serial COM/QSB). For PC USB connection, use QA USB-UART adapter.

Note: QSB = Quantum Serial Bus.

EXT: Extension connector, e.g. for external sensors or other extensions.

EXTP: Power extension connector, e.g. for switched fluidics valve control or thermostat.

SM (no label): Stepper motor connector.

Note: Depending on intended operation mode and extensions, not all connectors will need to be used. E.g. for Mode 1 (Step/Dir) or Mode 3 (Mode DC), only PS (12 V) and EXT (for communication) are sufficient. QSB provides a serial interface available for Mode 2 (COM) and (for all modes) service inspections (to access run time data, error memory, ...).

Note: Separate firmware manual for COM commands.

Smart Pump Messages

The device can communicate status messages by sending sequences of LED flashes and/or beeps (“telegrams”). See table in appendix for details.

LED Indicators

POWER (yellow): continuously on when connected to power supply.

STATUS (blue): flashes with smart code to indicate operation mode, status, fault prediction and errors (see separate table).

Note: In case POWER remains off after starting the system, check power supply (12 V) and proper cabling. In case POWER remains off with correct power supply, SMPS1 will require service.

Beep Indicator

Beeps with smart code to indicate operation mode, status, fault prediction and errors (see separate table).

Fault Prediction

After extended use, when reaching the end of life, volumetric precision and mechanical movement may become unreliable. SMPS1 will early self-detect upcoming expected imprecisions or faults and indicate these by associated fault prediction message status codes (LED/Beep messages, see table).

According to type of fault prediction (e.g. syringe, motion, ...) proper preventative maintenance or service action is recommended at next opportunity to avoid failure (remaining 25% of run time before failure expected).

Error Self Detection

In case SMPS1 will detect errors, e.g. positioning errors, smart control will indicate error by repeated associated message status codes (LED/Beep messages, see table). Message will repeated as long as retries to recover will fail.

According to type of error (e.g. positioning error, ...) proper maintenance or service may be required.

Errors

In addition to error self-detection, the following symptoms indicate an error or upcoming fault:

- excessive movement noise
- repeated error indication (even if recoverable)
- leaking fluid or non-expected pressure drop

Maintenance

Syringe Replacement

The syringe may start leaking when reaching end of its lifetime. The syringe set may be replaced by the operator (maintenance), if proper training has been provided. The syringe may also be replaced to another type (volume), if required. To replace the syringe set:

- Make sure system is switched off and unplugged from line power supply
- Unscrew syringe from syringe adapter (counterclockwise) by hand
- Remove complete syringe set, including plunger
- Insert new syringe and screw to syringe adapter (clockwise) by hand (“hand-tight”)
- When operating new syringe, confirm tightness (e.g. now liquid leakage)
- Confirm proper function by Status Codes (LED/Beep message, see table) and build-in software self-test (e.g. repositioning cycle after software start).

Notes:

Only replace complete syringe sets! Keep syringe set mounted!

Do not remove plunger from syringe. Plunger tip is very sensitive and may become damaged (leaking or with significantly reduced lifetime) when reinserting. Syringe set factory-serviceable only!

Service

After extended use, upon fault prediction or when repeatedly showing error symptoms or errors, SMSP1 may require service or repair.

For service, repair or refurbish (e.g. cleaning, spindle replacement, ...), it is recommended to return SMSP1 to factory. For uninterrupted operation, a spare syringe pump module should be used. At factory, service will be carried out by well-trained personnel. Full reconditioning and function test with special equipment will ensure continued performance and reliability.

Resetting Lifetime Data

After maintenance or service (e.g. syringe or spindle replacement/requalification), SMSP1 runtime data can be reset (by factory) via USB/QSB interface cable (separate COM control manual).

Lifetime Considerations

Note: Data exemplary for typical “model” reference cycle:

- cycle range: 2 x 10 mm / cycle= 20 mm/cycle
- 2 cycles per sample (e.g. including cleaning cycle)

Spindle/Spindle Nut Lifetime (Service)

Expected and rated lifetime of spindle/nut combination (MTBF, mean time before failure) (replacement required):

- Travel endurance 10 km (10,000,000 mm) @50% full speed/1000 hPa
- Lifetime => 10,000,000 mm / 20 mm/cycle => 500,000 cycles => 250,000 samples

	Samples	Samples/day	Samples/year (@200 days/year)	Expected Service Time (Years)
p < 1000 hPa	250,000	100	20,000	(>10)
		250	50,000	5
		500	100,000	2.5
		1000	200,000	1.25

Expected Service Time (Spindle/Nut Replacement) for typical use (MTBF)

Note: Lifetime spindle/nut combination reached, when:

- mechanical axial play nut/spindle > 0.2 mm or
- spindle/nut combination generating excessive noise.

Syringe Lifetime (Maintenance)

Expected and rated lifetime of syringe (MTBF):

Liquid: Travel endurance 10 km (10,000,000 mm) @50% full speed/1000 hPa

Air: Travel endurance 4 km (4,000,000 mm) @50% full speed/1000 hPa

Lifetime =>

- a) liquid: 10 km (10,000,000 mm) @ 50% full speed => 500,000 cycles => 250,000 samples
- b) air: 4 km (4,000,000 mm) @ 50% full speed => 200,000 cycles => 100,000 samples

Note: Syringe lifetime limit reached, when:

a) liquid: external leakage or leakage rate > 0.01 µl/s @ 1000 hPa (current measurement limit)

b) air: leakage rate > 0.1 µl/s @ 1000 hPa

Use	Samples	Samples/day	Samples/year (@200 days/year)	Expected Service Time (Years)
Liquid	250,000	100	20,000	(>10)
		250	50,000	5
		500	100,000	2.5
		1000	200,000	1.25
Air	100,000	100	20,000	5
		250	50,000	2
		500	100,000	1
		1000*)	200,000	0.5

Expected Maintenance Time (Syringe Replacement) for typical use (MTBF)

*) Not recommended (tbd.).

Note: Lifetime expectations supported by experimental data (QA).

Appendix: SMSP1 Smart Code Table

Category	Indicator (long beep sequence)	Status	Beep Code	LED Code	Note
Init	-		- <t>	- <t>	at startup completed
		Ready: Mode 1 (Step/Dir)	- .	- .	
		Ready: Mode 2 (COM)	- ..	- ..	
		Ready: Mode 3 (Mode DC)	- ...	- ...	
Operation	none		<t>	<t>	
		Standby (Idle)	/	..~	
		Repositioned	
		Aspirating	/	..~	
		Dispensing	/	...~	
Fault Prediction	--		-- <t> 3x	-- <t> 3x	- Beep/LED: following init - LED: during Standby/Idle
		Positioning Imprecisions/Error Counter	-- . 3x	-- . 3x	
		Overload Counter	-- .. 3x	-- .. 3x	
		Syringe Service *)	-- ... 3x	-- ... 3x	→ syringe should be replaced (maintenance)
		Spindle Service *)	-- 3x	-- 3x	→ module service recommended
Error	---		--- <t>3x~	--- <t>3x~	repeated after retry, as long as error remains If error remains → service required
		Positioning Error	--- .. 3x~	--- .. 3x~	
		Overload	--- ... 3x~	--- ... 3x~	
		Liquid Leak	--- 3x~	--- 3x~	

*) Activated upon fault prediction indications (e.g. repeated positioning imprecisions) or when a predefined lifetime parameter (e.g. 90% of expected minimum lifetime, cycle count or total travel range) is exceeded.

Symbol Legend:

Symbol	Bearing
/	no telegram
.	short code element: 0.2 s on/0.2 s off
..	2 short
..	2 short, separated by long 0.5 s pause
-	long code element: 0.5 s on/0.5 s off
3x	repeat telegram 3x,
~	repeat indefinitely (until status change)
<t>	tag code (see table below)

Note:

Message: A single Telegram or a small number (say 2) of combined Telegrams

Telegram: A Smart Code consisting of a Beep Code and/or LED Code. Each smart code consists of a small number (up to 12) short or long signals (beeps, LED flashes), followed by telegram separator (1 s).

Modes:

SMSP1 can operate in various modes:

Mode 1 (Step/Dir): Control by (volume) step and direction signal

Mode 2 (COM): Smart Control via QSB or USB serial interface. See separate manual for commands.

Mode 3 (Mode DC): Emulation of DC Motor Syringe Pump

Note: SMSP1 automatically switches to appropriate mode when started (depending on associated connections and/or communication).

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