Quick User Guide

Original instructions - September 2017

LSPone syringe pump

Advanced Microfluidics SA

LSPone

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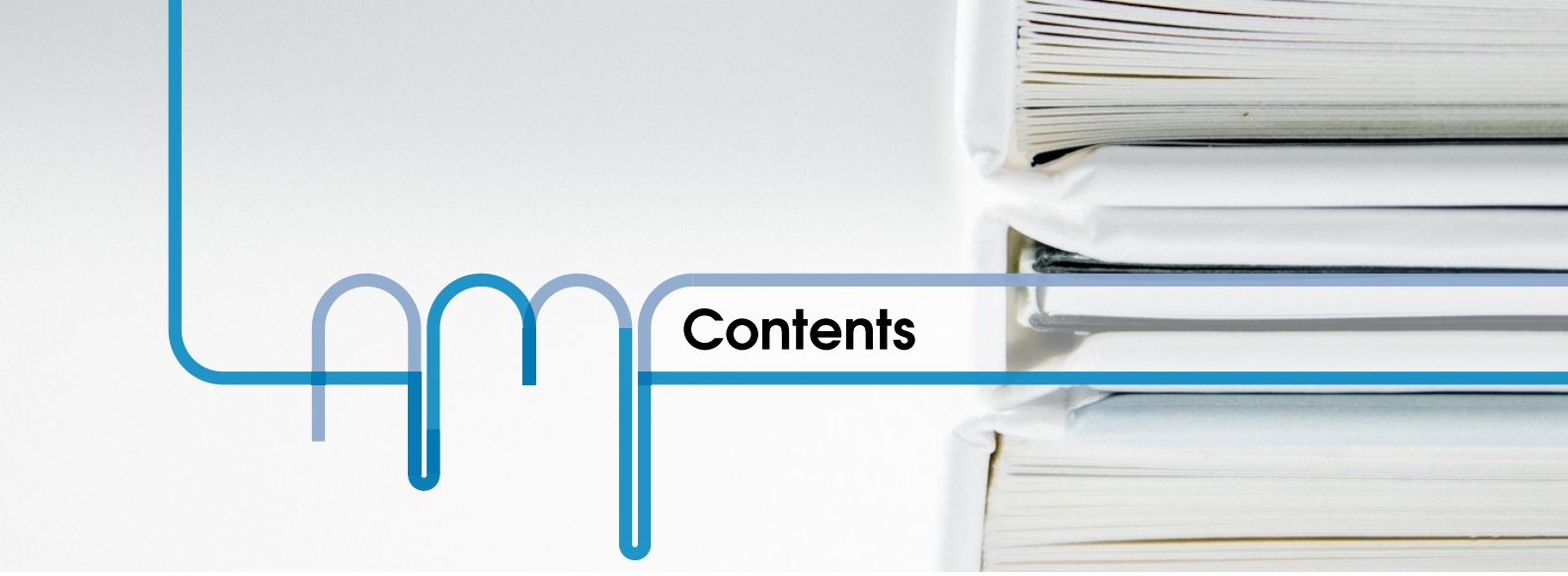

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1. Regulatory Considerations

1.1 English - Regulatory Considerations

1.1.1 Description

The LSPone is a general laboratory module. It is not intended for medical purposes therefore not subject to FDA regulatory approval.

The LSPone must not be used as a medical device or for medical purposes.

1.1.2 CE

CE certification is valid for the LSPone product. This does not apply to prototypes that are lent for evaluation.

1.1.3 Equipment ratings

Environment	
Use & Operation	Indoor
Operating temperature	5 to 40°C (41 to 104°F)
Storage temperature	-20 to 70°C (-4 to 158°F)
Humidity range	20 to 80% non condensing
Altitude	0 to 2000 m
Mechanical Data	
Weight	2.2 kg
Dimensions (L x W x H)	143 x 85 x 245 mm
Shipping weight	3.4 kg
Shipping dimensions (L x W x H)	413 x 301 x 125 mm
Electrical Data	
Power requirements	90 to 260 VAC, 1A max, 50/60 Hz
Power rating	18 VDC, 2.2A, 40 W
Interfaces	
USB (mini connector)	1.1, 2.0 and 3.0
Serial	RS282 and RS485

TABLE 1.1 – Equipment ratings

EC Declaration of Conformity

According to EC directive 2006/42/EC on machinery (Annex II A)

The equipment which accompanies this declaration is in conformity with EU Directive(s):-
2006/42/EC Machinery Directive
2006/95/EC Low Voltage Directive
2004/108/EC Electromagnetic Compatibility Directive

This declaration relates exclusively to the machinery in the state in which it was placed on the market, and excludes components which are added and/or operations carried out subsequently by the final user. The declaration is no more valid if the product is modified without agreement

Manufacturer:
Advanced Microfluidics SA
Chemin de la Dent d'Oche 1A
1024 Ecublens
Switzerland

A copy of the Technical file for this equipment is available from:
Remy Rysman
Advanced Microfluidics SA
Chemin de la Dent d'Oche 1A
1024 Ecublens
Switzerland

Description of Equipment: LSP one Syringe Pump
Model/type: LSP ONE

The following harmonized standards have been used:-
EN 61326-1:2013, IEC 61326-1:2012 (ed2.0)
EN 61010-1
EN ISO 14121-1

Only for EN 61326-1:2013, IEC 61326-1:2012 (ed2.0):
A sample of this machinery has been presented to Notified Body number STS 0024.
Electrosuisse, Montena EMC, route de Montena 75, 1728 Rossens, *who have issued an EC type-examination certificate Number* ***16-MO-0065.E01*** *dated 2016.11.23.*
The equipment in respect of which this declaration is made conforms to the example to which that certificate relates, and that certificate remains valid.

Authorized signatory of manufacturer:

Ecublens, 23.11.2016	Barraud, Antoine / CEO	
Place, Date	*Surname, First name and function of the signatory*	*Signature*

2. Safety Considerations

2.1 English - Safety considerations

For proper handling and care of the LSPone, it is essential that the operating personnel follow the general safety procedures and safety instructions described in this manual.

2.1.1 Environment of use

- The LSPone syringe pump should only be used within the limits given by the equipment ratings
- The LSPone syringe pump is intended for indoor use only
- The LSPone syringe pump should not be used in an explosive atmosphere or with potentially explosive substances
- Transportation, storage or operation of the devices below 0°C with water in the fluid passages may cause damage to the modules
- Always work in a clean and open area to ease manipulation and avoid risk of injury

2.1.2 Intended use & operation

The LSPone syringe pump is designed for precise pipetting, diluting and dispensing operations in the 0.1 μL to 1 mL range. Any other use is considered improper and may result in damage to the pump and/or unreliable test results.
Only the original approved parts and accessories may be used with the LSPone syringe pump. Any alterations or modifications to the instrument may be dangerous and will void the warranty.

2.1.3 Operating the LSPone

- When using the LSPone, Good Laboratory Practices (GLP) should be observed
- Users should wear protective clothing, safety glasses and protective gloves, especially if working with radioactive, biohazardous or harsh chemicals
- During the operation of the LSPone syringe pump, stand clear of moving parts
- Do not block moving parts
- Never try to remove valves, syringes or tubings when the pump or the valve is moving
- Never move the LSPone while it is in operation

2.1.4 Electrical safety

- The LSPone syringe pump must be disconnected from the power source when removing or replacing any mechanical components
- Use the provided power supply with the LSPone syringe pump (GSM40A18-P1J)

- Never use a damaged power cord
- Do not try to open the housing
- Do not power a device with a damaged housing

2.1.5 Precautions with radioactive, biohazardous or harsh chemicals

Please use great care when manipulating any chemical that is potentially damaging to your health.

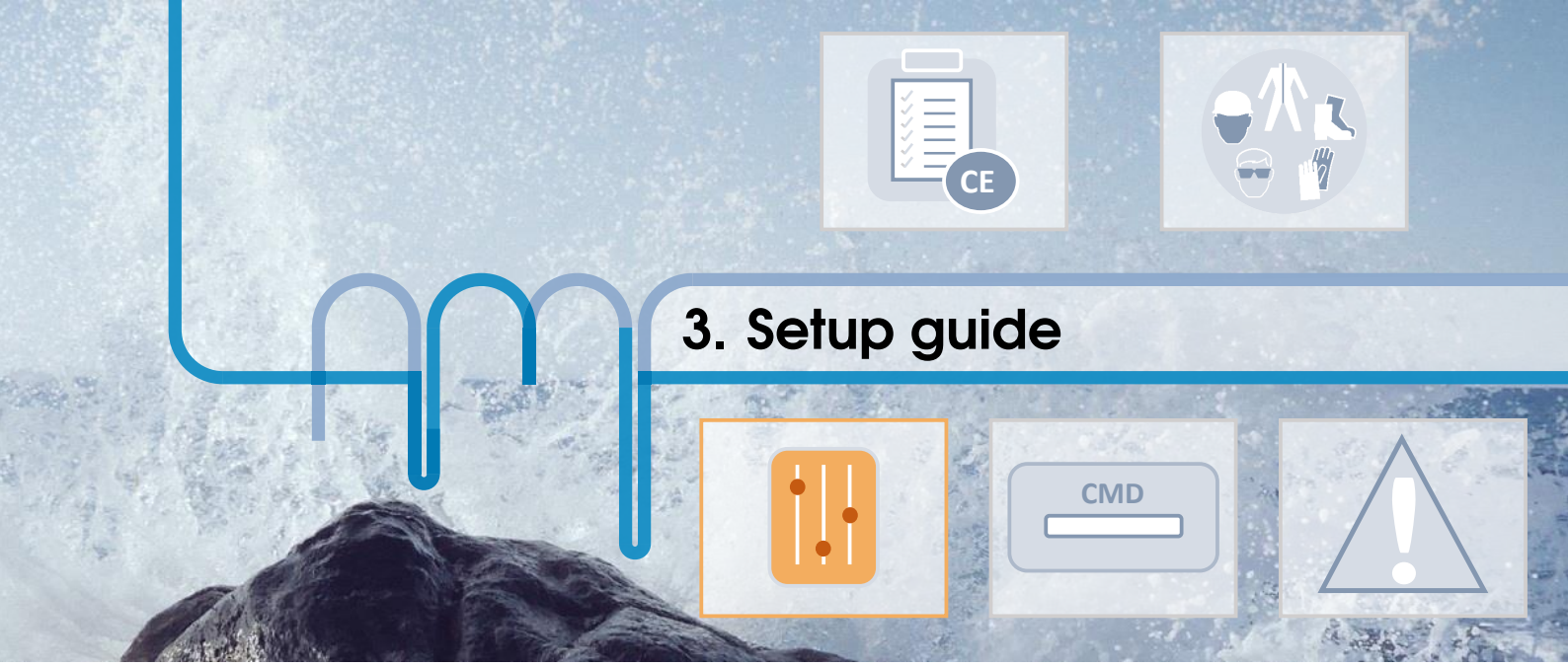
The LSPone syringe pump does not provide any user protection against radioactive, biohazardous or harsh chemicals

- Always wear protective clothing, safety glasses and protective gloves
- Clean the fluid passages (including valve and syringe) immediately after using radioactive, biohazardous or harsh chemicals
- Make sure that the fittings are correctly tightened to avoid undesired leakage
- Make sure that the glass syringe is not damaged and correctly tightened

Any liquid output can produce a squirt of liquid if the pump is programmed to push liquid through this very output at a high flow rate. Do not forget to protect yourself.

Should an accidental spill occur, turn off the instrument and wipe it down with the appropriate disinfectant or chemical. Remember to take into account the nature of the spill and the necessary safety precautions.

II Setup



3. Setup guide

3.1 GUI - quick start

In order to quickly setup up the provided software, you should execute the following steps:

1. Copy the content of the USB key on your computer
2. Connect the LSPone to the power supply
3. Connect the LSPone to your computer via USB
4. Install *LSPoneQuick* and launch it. A detection panel should appear.
5. Turn the pump off and on again for automatic detection, or select the COM port manually
6. Click on the Reset button to initialize the pump
7. Select the correct syringe volume
8. Start experimenting!

3.2 Serial communication - quick start

If you wish to connect to the pump directly using a serial communication, execute the following steps:

1. Copy the content of the USB key on your computer
2. Connect the LSPone to the power supply
3. Connect the LSPone to your computer via USB
4. Open the serial connection with the parameters:
   - baudrate: 9600, parity: none, data bits: 8, stop bits: 1, flow control: none
   - termination character: /CR
5. Send "/1ZR" to initialise the pump
6. Check the communication protocol in the following section for other commands to control the pump.
7. Start experimenting!

3.3 Additional information

For additional information, please refer to the operating manual, the website or even the brochure.

III Commands & Errors

4. List of commands

4.1 LSPone Command Set

The LSPone simplifies your microfluidic automation thanks to a wide and well-tried command set. Many of the commands have default values; however, the default values may not provide the optimal settings for your application. Therefore it would be advantageous to spend some time exploring the many possibilities offered by the pump.

4.1.1 Command Execution Guidelines

- All commands, apart from report commands and from the abort command T, must be followed by the character [R] to be run.
- During the execution of a command, no new command is accepted, except for interrupt and report commands.
- The pump answers immediately after a command was sent. If an invalid command has been sent in the command string, the pump reports an error immediately.
- To reduce wear, avoid running the plunger dry in the glass cylinder.
- Keep your fingers out of the syringe slot for safety reasons.

4.1.2 Pump & Valve Configuration Commands

Command	Operand Range	Default Operand	Power Up Default	Operand Description	Command Description
@ADDR=<n>	1..9 or A..E	1		1-character address	Pump address, "_" is broadcast address
!80<n>	4 or 6	6		Number of valve positions	Valve configuration
!17					Reset valve motion counter

4.1.3 Control Commands

Command	Operand Range	Default Operand	Power Up Default	Operand Description	Command Description
R	N/A	N/A			Execute command string
X	N/A	N/A		No trailing [R]	Re-execute last executed command string
G<n>	0...60000	0		0 = Loop forever	Repeat command sequence
g	N/A	N/A		Loop depth = max 10	Mark the start of a repeat sequence
M<n>	0..86400000			Milliseconds	Delay command execution
H	N/A	N/A		No trailing [R]	Halt command - Pause the sequence after finishing the current move. The paused sequence will resume with "/1R<CR>" or alternatively the user can send a new command. The command H can also be integrated in a sequence to introduce a pause before the execution of the remaining commands
T	N/A	N/A		No trailing [R]	Hardstop - Interrupt the current move and suppress it from the sequence. The interrupted sequence will resume with "/1R<CR>" after the interrupted command or alternatively the user can send a new command
@POWEROFF	N/A	N/A			Shut down the pump

Example 4.1 "/1gP2000D2000G3R<CR>" will trigger 3 back-and-forth 2000-step moves from the plunger.
"/1P2000HD2000R<CR>" will trigger a pick-up move of 2000 steps. The pump will then wait for "/1R<CR>" before executing the 2000-step dispense. The Halt command can also be executed on the fly. ■

4.1.4 Initialization Commands

Command	Operand Range	Default Operand	Power Up Default	Operand Description	Command Description
Z<n>	(void) or 0..2	0		0 or (void)= full force, 1= half force, 2=third force	Initialize the plunger drive (with full, half other third plunger force) and home the valve
Y<n>	(void) or 0..2	0		0 or (void)= full force, 1= half force, 2=third force	Initialize the plunger drive (with full, half other third plunger force) and home the valve

We strongly advise using third force only for initialization when a small volume syringe (25, 50 or 100 µL) is used. Half force can be used for syringe of 250 and 500 µL. Full force is adapted to 1 mL-syringe and for applications exhibiting high fluidic resistance.

4.1.5 Valve Commands

Command	Operand Range	Default Operand	Power Up Default	Operand Description	Command Description
O<n>	1..6	N/A		Counter-clockwise plug movement (valve seen from above)	Move to valve port
I<n>	1..6	N/A		Clockwise plug movement (valve seen from above)	Move to valve port. Port numbering has been configured so that incrementing the argument of I by 1 triggers a plug rotation of 60 degrees only
B<n>	1..6	N/A		Shortest plug movement	Move to valve port with shortest path clockwise direction preferred

Example 4.2 "/1M10000I2R<CR>" will be sent to wait 10 seconds before moving the plug to port 2 in a clockwise direction. In return, the pump will answer with "/0@<ETX><CR><LF>"

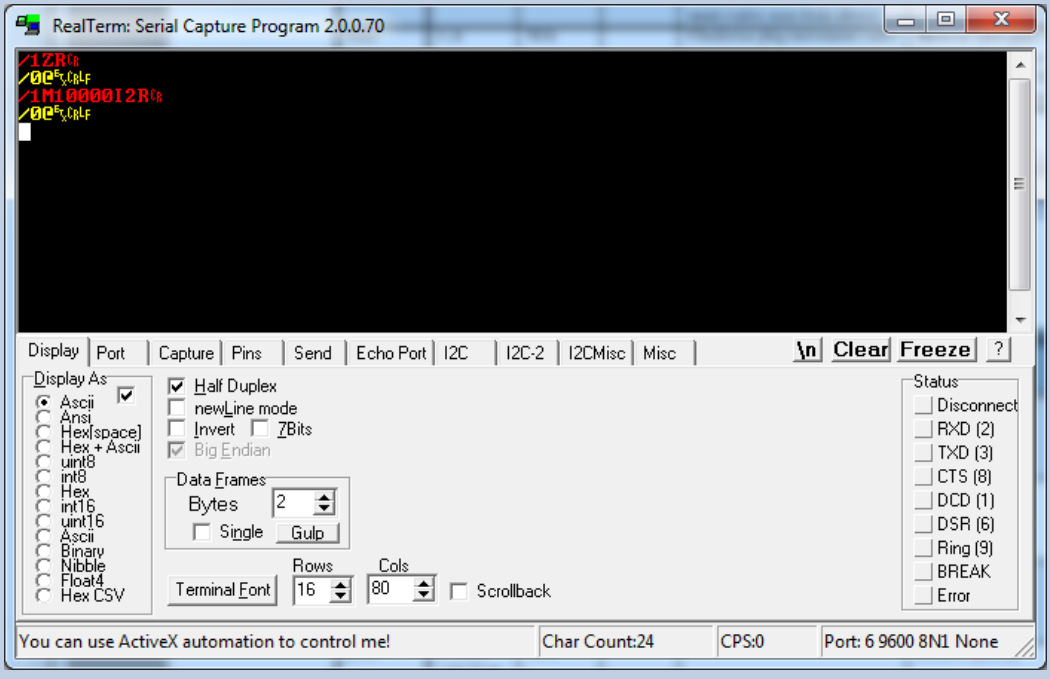


FIGURE 4.1 – Sending command via the terminal after starting the pump

Note in this example that the pump requires a homing command after power up.

4.1.6 Plunger Movement Commands

Command	Operand Range	Default Operand	Power Up Default	Operand Description	Command Description
A<n>	0..3000 with N=0 0..24000 with N=1	N/A			Absolute Position
a<n>	0..3000 with N=0 0..24000 with N=1	N/A			absolute Position
P<n>	0..3000 with N=0 0..24000 with N=1	N/A			Relative Pickup
p<n>	0..3000 with N=0 0..24000 with N=1	N/A			Relative pickup
D <n>	0..3000 with N=0 0..24000 with N=1	N/A			Relative Dispense
d<n>	0..3000 with N=0 0..24000 with N=1	N/A			Relative dispense

4.1.7 Set Commands

Command	Operand Range	Default Operand	Power Up Default	Operand Description	Command Description
V<n>	1..1600	N/A	150	Peak speed (Pulses/sec)	Set peak speed
S<n>	10..40	N/A	22	See Table 4.1	Set speed
N<n>	0..1	0		<0> = Microstep 0.01 mm resolution <1>= Microstep 0.00125 mm resolution	Scaling of dispense/pickup arguments. The motor is always driven in microstep mode

Example 4.3 "/1N1R<CR>" will be sent to choose the 0.00125 mm resolution microstepping mode. In return, the pump will answer with "/0‘<ETX><CR><LF>"

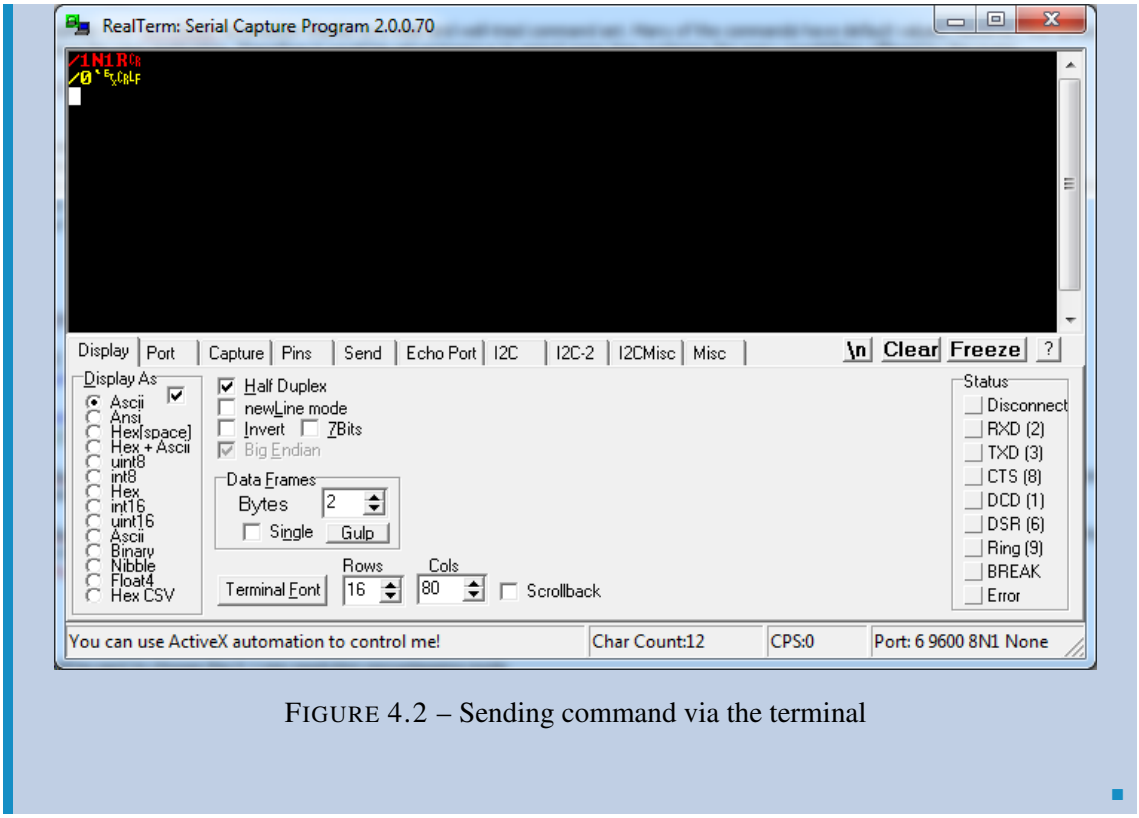


FIGURE 4.2 – Sending command via the terminal

The speed setting is a delicate process since it is highly dependent on the microfluidics setup. Tubings of small inner diameter will act as restrictions for the flow and pushing liquids at high speed through such tubings will lead to high pressure in your microfluidic circuit.

High pressure will increase the leakage in the circuit and could even block the pump as too much force would be required to dispense the syringe content. Last but not least, high pressure can blow up the weakest part of a microfluidic setup. Therefore we recommend choosing speeds according to a pressure estimation.

Speed Code	**Value** (pulses/sec)	**Seconds/stroke** (N=0, N=1)
10	1600	1.885
11	1400	2.15
12	1200	2.5
13	1000	3
14	800	3.75
15	600	5
16	400	7.5
17	200	15
18	190	15.79
19	180	16.665
20	170	17.645
21	160	18.75
22	150	20
23	140	21.43
24	130	23.075
25	120	25
26	110	27.275
27	100	30
28	90	33.335
29	80	37.5
30	70	42.855
31	60	50
32	50	60
33	40	75
34	30	100
35	20	150
36	18	166.665
37	16	187.5
38	14	224.235
39	12	250
40	10	300

TABLE 4.1 – Speed code for plunger movement

To better understand the relations between the motor speed, flow rate, plunger displacement and volume dispense, please refer to the appendix called “Resolution” in the user manual.

4.1.8 Report Commands

These commands do not need a trailing [R] character.

Command	Description
Q	Current status
? or ?0	Report absolute plunger position
?2	Report maximal speed
?4	Report actual position of plunger
?6	Report valve position
?12	Report number of backlash increments
?17	Report number of valve movements
?18 or %	Report number of valve movements (since last report)
?20 or #	Report firmware checksum
?23 or &	Report firmware version
?26	Report pump address
?28	Report current mode (fine positioning or microstep)
?29	Same as Q (query, status and error bytes)
?76	Report pump configuration
$	Internal reset
*	Report supply voltage (x0.1 V)
?9000	Unique ID
?9100	Detailed status of the pump
?9200	Detailed status of the valve

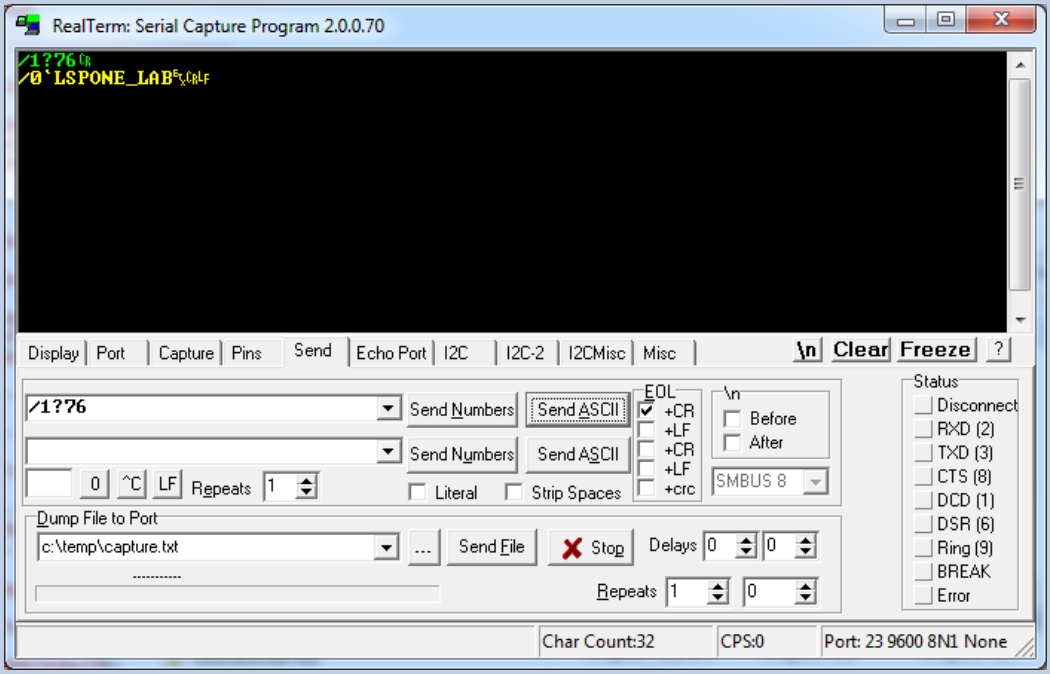


FIGURE 4.3 – Asking for the pump configuration

Example 4.4 ■

5. Debugging software problems

5.1 Visual feedback to the user

A very simple check when writing a sequence for the LSPone syringe pump can be obtained by looking at the Power-On button.

- When the blue LED is on, the pump is ready to receive commands.
- When the LED is blinking at 2 Hz, the pump is busy and the command required is being completed.
- When the LED is blinking at 5 Hz, an error has been encountered.

The fast blinking rate is the first step to debug any problem the user is facing when using the pump.

Before looking in more detail at what caused an unexpected behavior of the pump, please make sure that:

- *The pump is correctly powered. If the Power-On button emits no light at all, please check the power supply and the electrical connections.*
- *Check the hardware situation. The valve, the syringe and the plunger must be correctly tightened in their respective position.*
- *Make sure that you have sent an initialization command before running any other instructions.*

- *Do not forget to address the command to the pump by writing "/1<command>" (if the pump has the address "1", in case you are not sure of the pump address, use "_" which is the broadcast address) otherwise the pump will not be affected by the message.*

After checking these first level errors, it is possible to explicit the error message using the report commands.

5.2 Error Codes and Pump Status

The pump reports immediately after it receives a command. This principle allows to check whether the command was accepted or not by the pump or whether it encountered any problem during the task.

> **Note — Coding best practice.** A good coding practice when using this communication protocol is to check the pump status and catch possible errors with the [Q] command after each instruction.

5.2.1 Error Byte description

The error code has a length of 1 byte, i.e. 8 bits. The bit 5 is the status bit and serves for indicating whether the pump is busy or not. The error code is included in bits 0-3.

Bit	7	6	5	4	3	2	1	0
Value	0	1	Status Bit	0	Error Code			

TABLE 5.1 – Detail of the error byte as returned after a query "/1Q"

> **Note — Interest of the (Q) query.** The answer block which is automatically sent by the pump features a status bit. However the status bit should not be used to know whether the pump is busy or not. A [Q] command is the only mean to know the current status of the pump.

5.2.2 Status bit description

Status Bit 5	Description
X=0	The pump will only accept report commands or terminate command [T]
X=1	The pump is ready to accept new instructions

TABLE 5.2 – Status bit description

Error Byte	Symbol ASCII		Error	
7 6 5 4 3 2 1 0	if Bit 5 = 0	if Bit 5 =1	Code	Description
0 1 X 0 0 0 0 0	@	‘	0	No Error
0 1 X 0 0 0 0 1	A	a	1	Initialization
0 1 X 0 0 0 1 0	B	b	2	Invalid command
0 1 X 0 0 0 1 1	C	c	3	Invalid operand
0 1 X 0 0 1 0 0	D	d	4	Missing trailing [R]
0 1 X 0 0 1 1 1	G	g	7	Device not initialized
0 1 X 0 1 0 0 0	H	h	8	Internal failure (valve)
0 1 X 0 1 0 0 1	I	i	9	Plunger overload
0 1 X 0 1 0 1 0	J	j	10	Valve overload
0 1 X 0 1 0 1 1	K	k	11	Plunger move not allowed
0 1 X 0 1 1 0 0	L	l	12	Internal failure (plunger)
0 1 X 0 1 1 1 0	N	n	14	A/D converter failure
0 1 X 0 1 1 1 1	O	o	15	Command overflow

TABLE 5.3 – Error codes

5.2.3 Error Types

Immediate errors include Error 2 and 3. The automatic answer block sent after an instruction will feature the error character. No [Q] query is required to get a description of the error.

> **Example 5.1** “/1O14R<CR>” will trigger the following answer “/0c<ETX><CR><LF>” which means that an invalid operand has been used in the instruction. Here port “14” which does not exist on the valve. ■

To get detailed information about other errors, the user has to send the [Q] command and analyze the subsequent answer. **Initialization errors** appear when the initialization could not be performed. Therefore the pump cannot be used until the error was cleared and a successful initialization completed.

Command overflow errors are caused by a Move command, a Set command (except [V]), or a Valve command being sent while the plunger is moving. The pump ignores the command and issues an error 15. The user should use the [Q] query to be informed when additional commands can be sent.