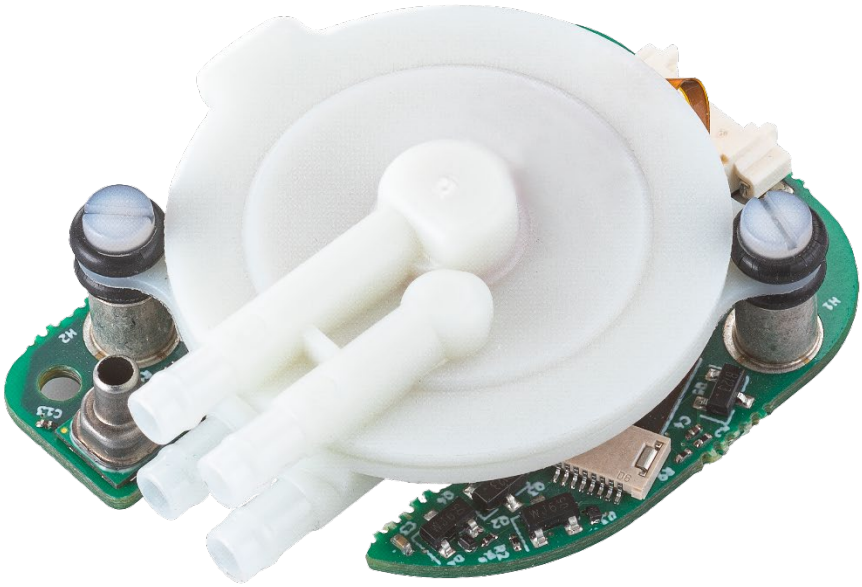
SMART PUMP MODULE (UxxCxxxxxxxx)

USER MANUAL



THE LEE COMPANY

www.theleeco.com

SMART PUMP MODULE (UxxCxxxxxxx)
USER MANUAL

1. DISCLAIMER

This resource is provided "as is" and without any warranty of any kind, and its use is at your own risk. The Lee Company does not warrant the performance or results that you may obtain by using this resource. The Lee Company makes no warranties regarding this resource, express or implied, including as to non-infringement, merchantability, or fitness for any particular purpose. To the maximum extent permitted by law, The Lee Company disclaims liability for any loss or damage resulting from use of this resource, whether arising under contract, tort (including negligence), strict liability, or otherwise, and whether direct, consequential, indirect, or otherwise, even if The Lee Company has been advised of the possibility of such damages, or for any claim from any third party.

2. SPECIAL NOTICES

Throughout this User Manual, special notices relating to the safe and correct operation of the Smart Pump Module are formatted and highlighted as follows:

CAUTION

Instructions to ensure correct operation of the equipment and/or for avoiding damage to the equipment.

WARNING

Instructions relating to the safety of the operator and avoiding injury.

3. INTRODUCTION

3.1.Piezoelectric Disc Pump

The Lee Company's piezoelectric disc pumps are a multi-award-winning technology which makes use of advances in the field of non-linear acoustics to offer the following unique features:

- silent operation
- ultra-smooth flow
- millisecond responsiveness
- compact form factor
- high-precision controllability

In contrast to conventional air pumping mechanisms (such as diaphragm and piston pumps), the disc pumps do not rely on the bulk compression of air within a cavity. Instead, the disc pumps generate a high amplitude, high frequency acoustic standing wave within a specially designed acoustic cavity. The operating frequency varies part-to-part and with pump operating conditions (e.g. temperature, pressure, etc). A dedicated drive circuit is therefore required to identify and track this frequency over time.

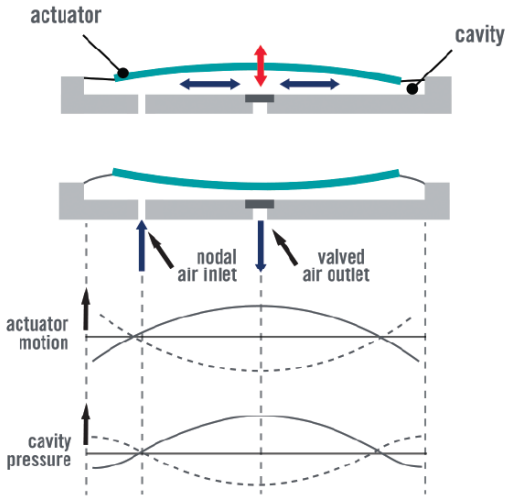


Figure 1. A schematic of the disc pump

Figure 1 shows a simplified schematic: the out-of-plane motion of the actuator drives in-plane (radial) motion of the gas in the cavity and creates a standing pressure wave, resulting in the oscillating cavity pressure shown. The motion of the actuator is highly exaggerated: there is virtually no net volume change of the cavity during operation and at any given point in time there exists both a region of compression and a region of rarefaction within the cavity.

Rectification of the alternating cavity pressure is the key to delivering useful pump performance and device lifetime. The Lee Company has addressed this need by developing a family of innovative valve designs based on lightweight polymer valve flaps.

The disc pump technology is protected by a portfolio of both patent applications and granted patents.

3.2.The Smart Pump Module

The Smart Pump Module combines a piezoelectric disc pump of your choice with drive electronics and pressure sensing in a tightly-integrated package. Its simple control interface, with digital and analog control options, makes the replacement of conventional pumps straightforward. This simplifies the design-in process, allowing OEMs to take advantage of the key benefits of the disc pumps, including silent operation and exceptional performance.

The Smart Pump Module offers standalone high-precision pressure and vacuum regulation, benefiting from the pulsation-free output, wide dynamic range and rapid response speed of the pump. The module can be fitted with any of the BL, XP, LT and HP Series pumps. Note that the Smart Pump Module is not compatible with US Series Disc Pump.

For the avoidance of doubt, the disc pumps can only pump air and similar gases directly; it cannot pump fluids directly. The disc pumps can however be employed in a wide range of liquid applications using the principle of pressure-driven flow. Please see Application Note: ‘AN002: Microfluidics - Disc Pump Application Note’ for more information.

This document provides details of the operation of the Smart Pump Module.

4. SAFETY

WARNING

The equipment described in this document is intended for use by skilled and competent personnel only. Further, the equipment is provided in a 'bare' format enabling users to integrate it into test fixtures, prototypes and product assemblies.

The user should satisfy themselves that the equipment is, and remains fit for, the intended use. The user accepts that The Lee Company shall not be held responsible or liable for any injury, damage or loss to property, person or otherwise, resulting from use of the equipment.

To aid in safety assessment of use of the equipment, the following indicative electrical data are provided:

A.C. voltage on the PCB: 120 Vpp max. (at 20 – 22 kHz)

D.C. voltage on the PCB: 60 V max.

All disc pumps emit ultrasound in operation. The following data are provided for operation at maximum power (1.4W) at a distance of 30cm:

Sound pressure level: 70-80 dB SPL @ 30 cm typ. (at 20-22 kHz)[1]

1. Equivalent to <10 phon per ISO 226:2003 and related studies, 30 cm equivalent measurement distance

WARNING

Take care during use of the Smart Pump Module not to create short circuits between exposed conductive parts of the PCBs. Short circuits may lead to malfunctioning and heating.

5. MODULE OVERVIEW

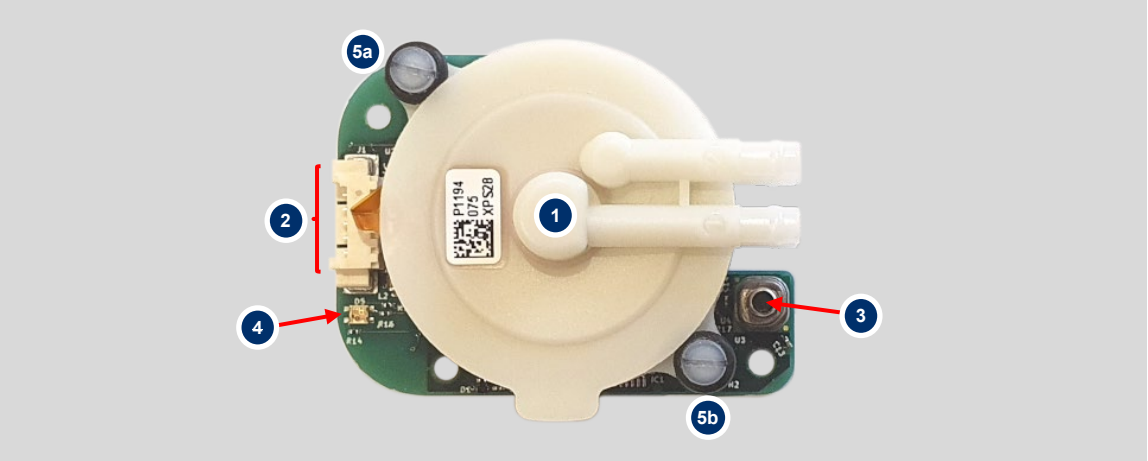
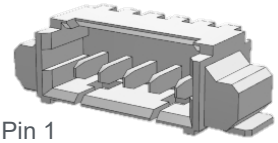


Figure 2. Smart Pump Module components

Item	Description	Details
1	Disc Pump	The Smart Pump Module can be ordered with BL, XP, LT and HP Series Disc Pumps. It is not compatible with US Series Disc Pumps.
2	Five-wire electrical interface	 Pin 1 Pin 5 The SPM has a 5 pin, 1 Row, 1.25mm pitch Header (53261-0571) https://tinyurl.com/5ekymmev Pinout: 1 - VCC - 3.5 to 5.5 V supply 2 - UART RX / I2C SDA (3.3V) 3 - UART TX / I2C SCL (3.3V) 4 - Ground 5 - 0 to 3.3 V Analog In

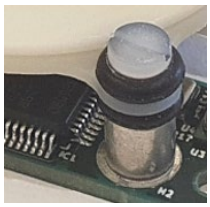
<table>
<tr><td>3</td><td>On-board pressure sensor</td><td>Supports greater than -400 mBar to +600 mBar (gauge)

12-bit resolution

Update rate approx. 60 Hz.</td></tr>
<tr><td>4</td><td>Indicator LED</td><td>Firmware versions 6.16 and above:

<table><tr><th>Colour / indication</th><th>Module status</th></tr><tr><td>Green*, breathing</td><td>Idle</td></tr><tr><td>Green*</td><td>Pump running</td></tr><tr><td>Red and green*, flashing</td><td>Module in error</td></tr></table>*The default green colour of the Status LED adjusted via the PC application. This can be helpful when running multiple pumps to give a visual indication of which tab of the PC application corresponds to which pump.

Firmware version before 6.16:

<table><tr><th>Colour / indication</th><th>Module status</th></tr><tr><td>Green, breathing</td><td>Idle</td></tr><tr><td>Orange</td><td>Pump running</td></tr><tr><td>Red, flashing</td><td>Module in error</td></tr></table></td></tr>
<tr><td>5</td><td>Pump mounts</td><td> 
Note use of O-rings and nylon bolts to isolate high-frequency vibration and prevent audible noise.</td></tr>
</table>

The Smart Pump Module can be controlled through the Disc Pump Control App on its own or connected to the Development Kit motherboard. The Development Kit can control either a single SPM via UART (serial) or up to four SPMs via I2C (additional mains power supply is required).

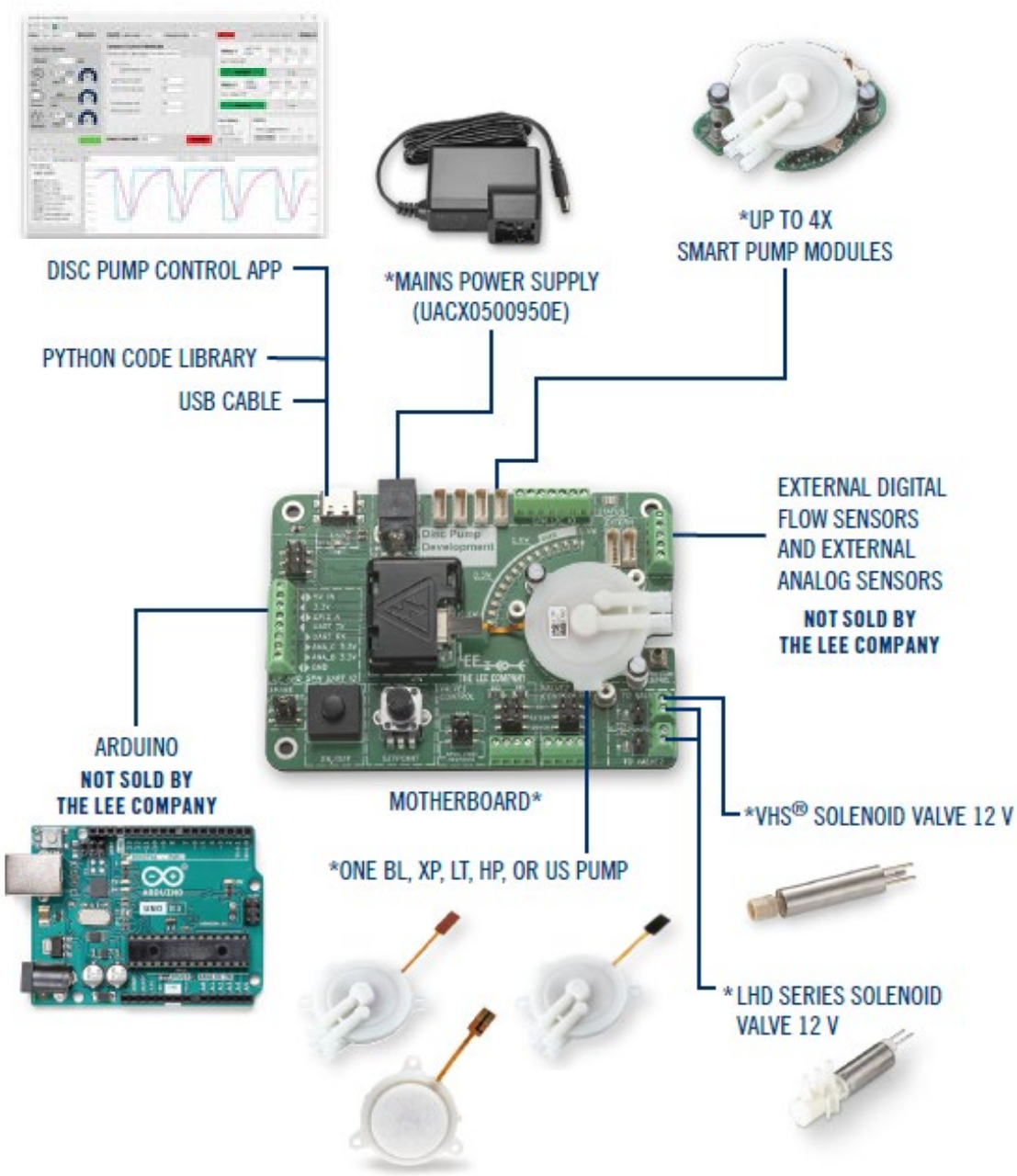


Figure 3. Disc Pump Development Kit connectivity for disc pumps/modules, solenoid valves, external sensors and microprocessors.

6. INSTALLATION

6.1.Mechanical - SPM Mounting

The SPM PCB has three 2.2 mm diameter mounting holes provided, as shown below. In order to isolate high-frequency vibration and prevent audible noise, it is recommended that the SPM is mounted using nylon M2 screws, using nylon washers or standoffs to maintain a clearance to the underside of the PCB.

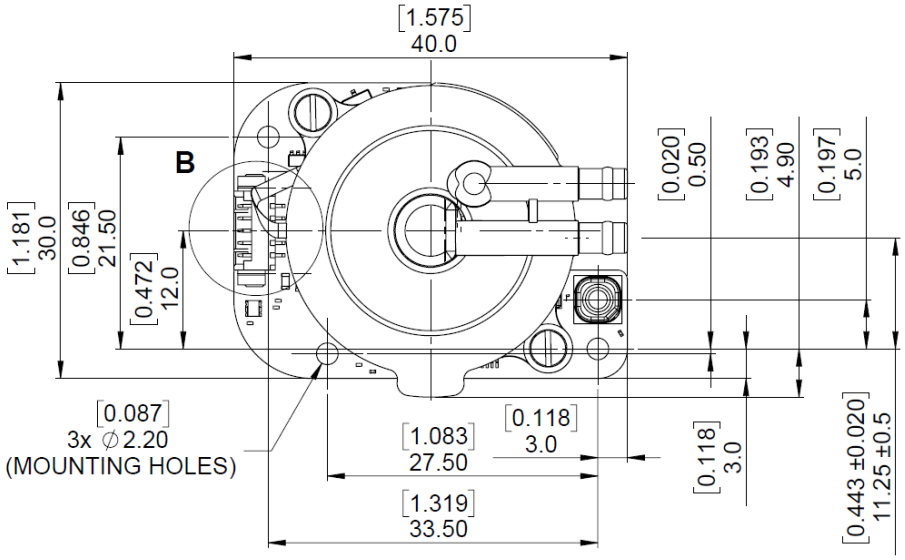


Figure 4: SPM Geometry. Dimensions in mm [inches]

6.2.Pneumatic - Pump manifolding

6.2.1. Inlet filtration requirements

TAKE NOTE

All disc pumps should be operated with an inlet filter to prevent ingestion of debris that might otherwise shorten the operational life of the pump. The Lee Company recommends that a non-shedding filter with a pore size less than 3 microns is used.

6.2.2. BL/XP/LT Series pumps

- Take note of the pump configuration according to the pump labelling:

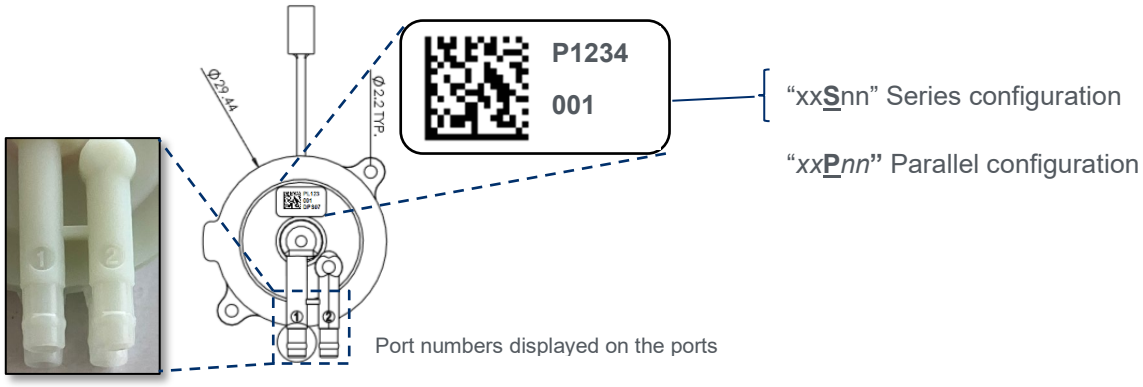


Figure 5. Pump labelling to distinguish between series and parallel configuration pumps

6.2.2.1.BL/XP/LT Series pumps - series configuration pumps

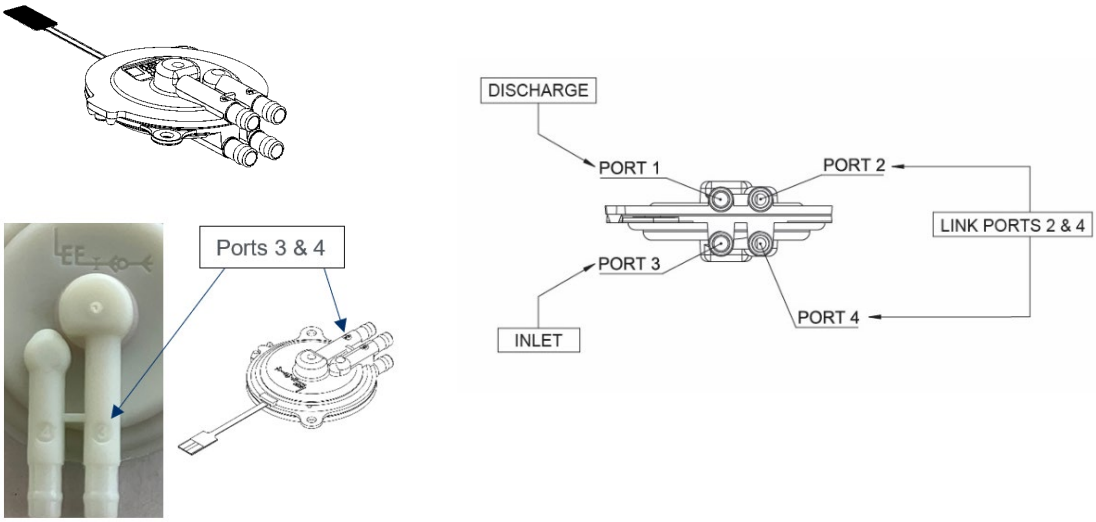


Figure 6. BL/XP/LT Series, series configuration pumps - port numbering

For series configuration pumps:

- Ports 2 and 4 must be linked (see the pump Accessories for suggested coupler)
- Port 3 is inlet
- Port 1 is discharge

Positive pressure regulation

Where the user intends to use the module to regulate pressure or vacuum, an additional connection should be made to the onboard pressure sensor.

For positive pressure regulation, connect Port 1 to the pressure sensor and the downstream system using a ‘T’ or ‘Y’ connector.

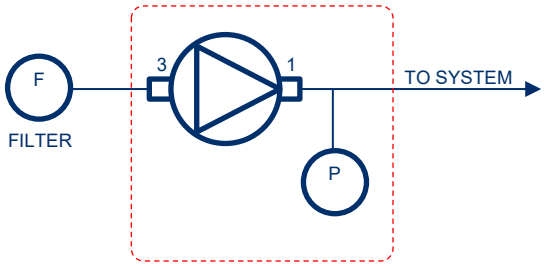


Figure 7. Schematic for connecting a series configuration pump for positive pressure regulation

The optional extra SPM Prototype Pneumatic Adapter Kit (UACX0500600H) can be purchased for prototyping and development purposes. This kit includes a 'C' coupler, 'Y' coupler and right-angled pressure sensor pipe for convenient connection between the pump and pressure sensor. Note that these components are fabricated by SLA and are therefore not recommended for use in mass-produced products.

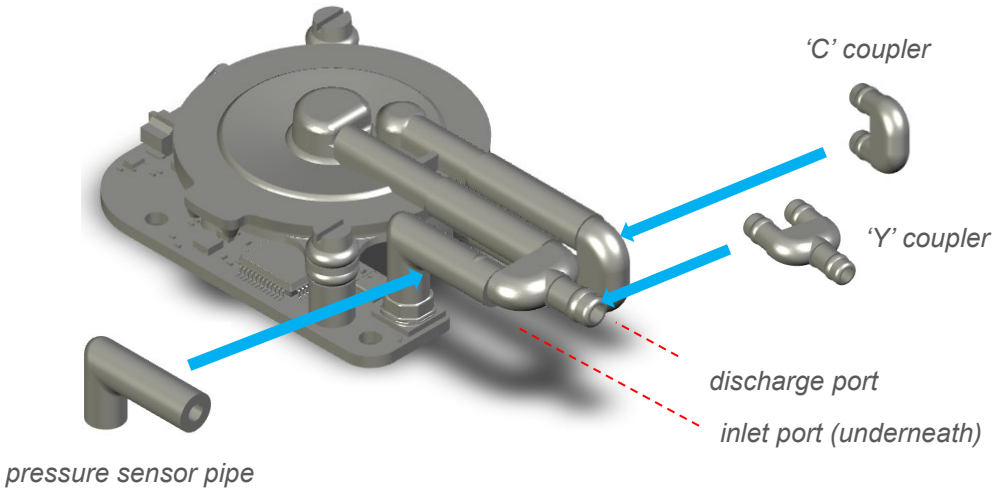


Figure 8. Connecting a series configuration pump for positive pressure regulation with the prototype connectors supplied with the optional SPM Prototype Pneumatic Adapter Kit (UACX0500600H)

Vacuum pressure regulation

For vacuum pressure regulation, connect Port 3 to the pressure sensor and the upstream system using a ‘T’ or ‘Y’ connector.

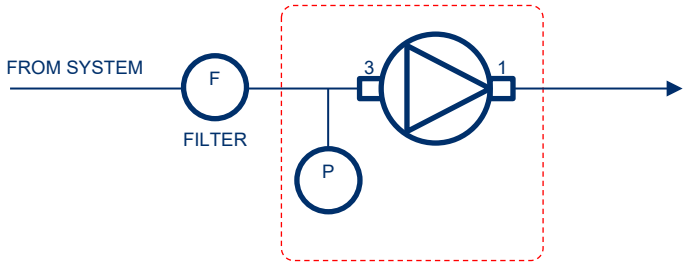


Figure 9. Schematic for connecting a series configuration pump for vacuum pressure regulation

The optional extra SPM Prototype Pneumatic Adapter Kit (UACX0500600H) can be purchased for prototyping and development purposes. This kit includes a right-angled ‘Y’ coupler and right-angled pressure sensor pipe for convenient connection between the pump and pressure sensor. Note that these components are fabricated by SLA and are therefore not recommended for use in mass-produced products.

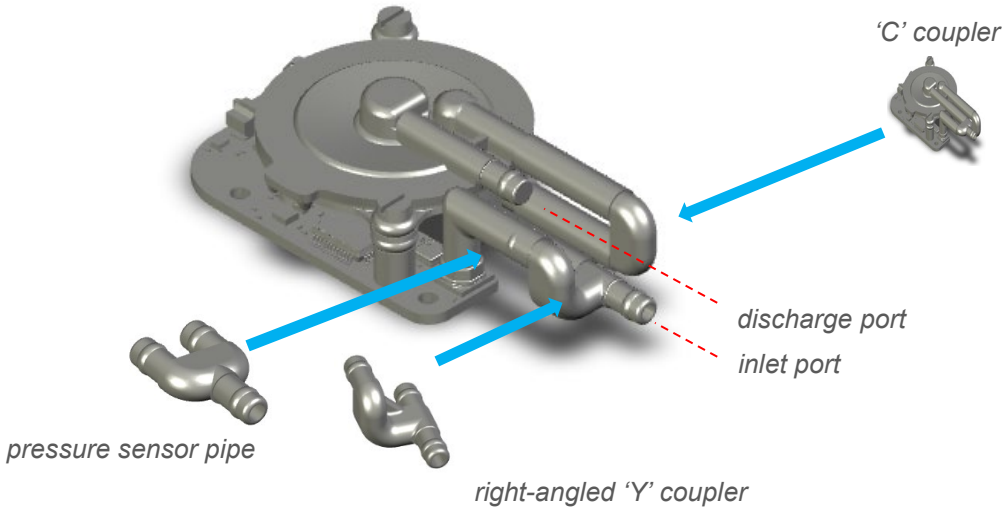


Figure 10. Connecting a series configuration pump for vacuum pressure regulation with the prototype connectors supplied with the optional SPM Prototype Pneumatic Adapter Kit (UACX0500600H)

6.2.2.2.BL/XP/LT Series pumps – parallel configuration pumps

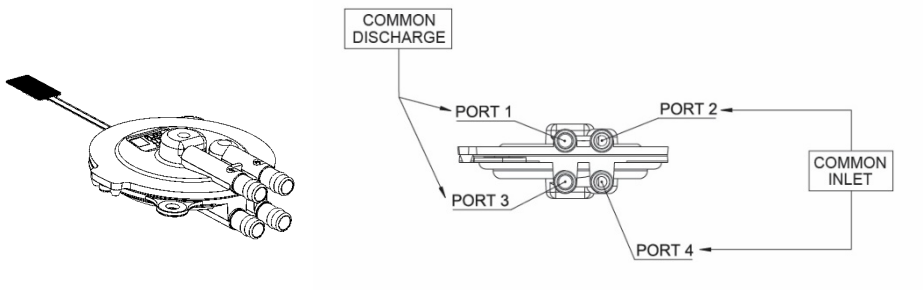


Figure 11. BL/XP/LT Series, parallel configuration pumps - port numbering

For parallel configuration pumps:

- Ports 2 and 4 are the common inlet and should be linked*
- Ports 1 and 3 are the common discharge and should be linked *

* (see the pump Accessories for suggested coupler)

Positive pressure regulation

Where the user intends to use the module to regulate pressure or vacuum, an additional connection should be made to the onboard pressure sensor.

For positive pressure regulation, connect Port 1 and Port 3 to the pressure sensor and the downstream system using a 'T' or 'Y' connector.

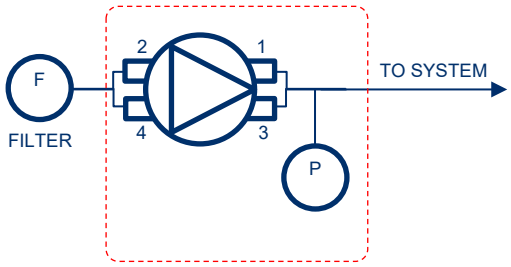


Figure 12. Schematic for connecting a parallel configuration pump for positive pressure regulation

The optional extra SPM Prototype Pneumatic Adapter Kit (UACX0500600H) can be purchased for prototyping and development purposes. This kit includes a positive pressure adapter (identified with a single circular dot on top of the part) and right-angled pressure sensor pipe for convenient connection between the pump and pressure sensor. Note that these components are fabricated by SLA and are therefore not recommended for use in mass-produced products.

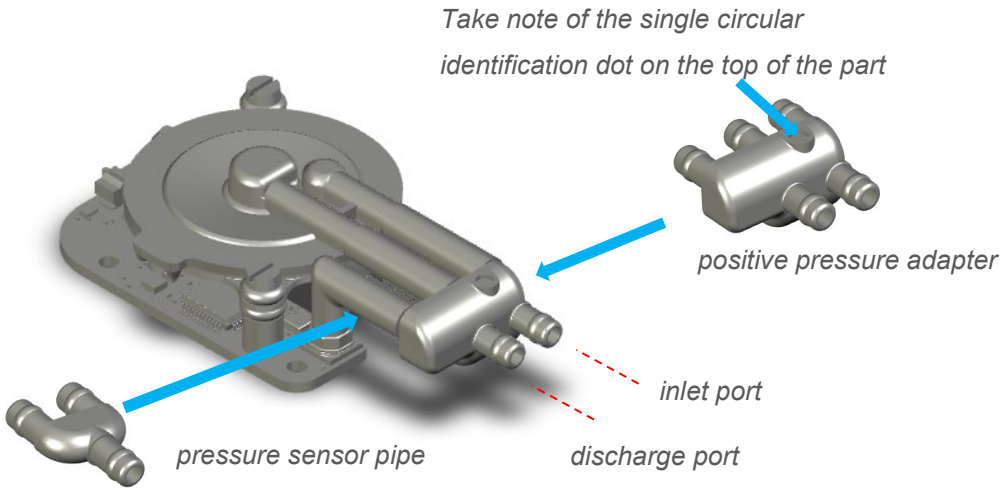


Figure 13. Connecting a parallel configuration pump for positive pressure regulation with the prototype connectors supplied with the optional SPM Prototype Pneumatic Adapter Kit (UACX0500600H)

Vacuum pressure regulation

For vacuum pressure regulation, connect Port 2 and Port 4 to the pressure sensor and the upstream system using a 'T' or 'Y' connector.

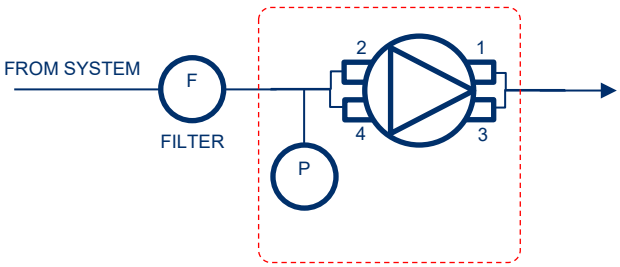


Figure 14. Schematic for connecting a parallel PDC pump for vacuum pressure regulation

The optional extra SPM Prototype Pneumatic Adapter Kit (UACX0500600H) can be purchased for prototyping and development purposes. This kit includes a vacuum adapter (identified with two circular dots on top of the part) and right-angled pressure sensor pipe for convenient connection between the pump and pressure sensor. Note that these components are fabricated by SLA and are therefore not recommended for use in mass-produced products.

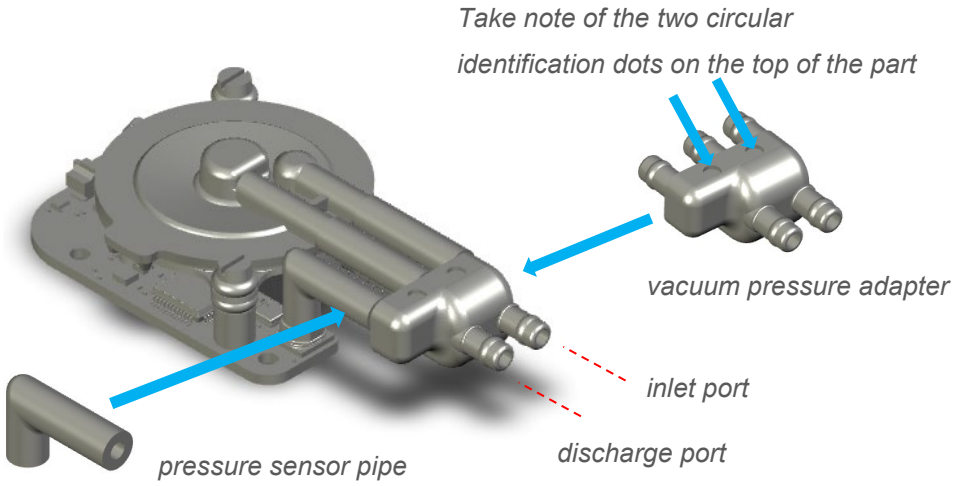


Figure 15. Connecting a parallel configuration pump for vacuum pressure regulation with the prototype connectors supplied with the optional SPM Prototype Pneumatic Adapter Kit (UACX0500600H)

6.2.3. High Pressure (HP) Series pumps

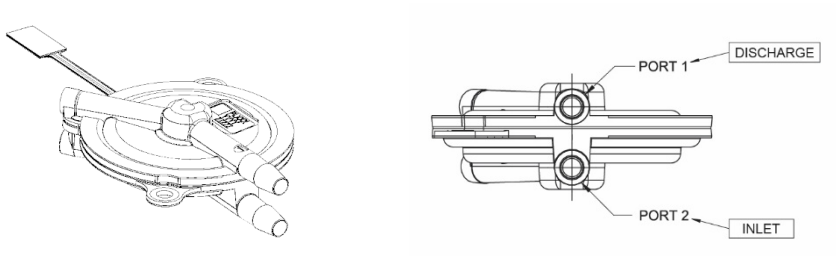


Figure 16. HP Series pumps - port numbering

For HP Series pumps:

- Ports 2 is the inlet
- Ports 1 is the discharge

Positive pressure regulation

Where the user intends to use the module to regulate pressure or vacuum, an additional connection should be made to the onboard pressure sensor.

For positive pressure regulation, connect Port 2 to the pressure sensor and the downstream system using a ‘T’ or ‘Y’ connector.

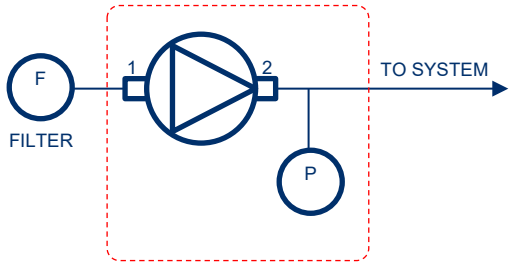


Figure 17. Schematic for connecting an HP Series pump for positive pressure regulation

The optional extra UACX0500600H SPM Prototype Pneumatic Adapter Kit can be purchased for prototyping and development purposes. This kit includes a 'Y' coupler and right-angled pressure sensor pipe for convenient connection between the pump and pressure sensor. Note that these components are fabricated by SLA and are therefore not recommended for use in mass-produced products.

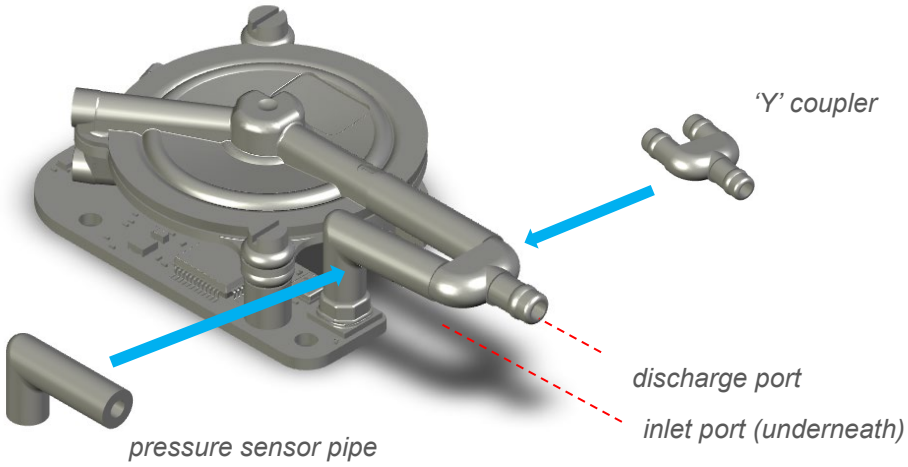


Figure 18. Connecting an HP Series pump for positive pressure regulation with the prototype connectors supplied with the optional SPM Prototype Pneumatic Adapter Kit (UACX0500600H)

Vacuum pressure regulation

For vacuum pressure regulation, connect Port 1 to the pressure sensor and the upstream system using a 'T' or 'Y' connector.

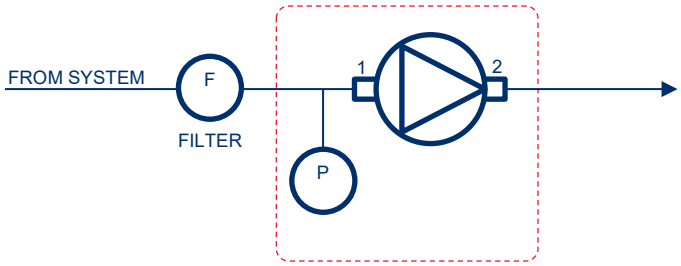


Figure 19. Schematic for connecting an HP Series pump for vacuum pressure regulation

The optional extra SPM Prototype Pneumatic Adapter Kit (UACX0500600H) can be purchased for prototyping and development purposes. This kit includes a right-angled 'Y' coupler and right-angled pressure sensor pipe for convenient connection between the pump and pressure sensor. Note that these components are fabricated by SLA and are therefore not recommended for use in mass-produced products.

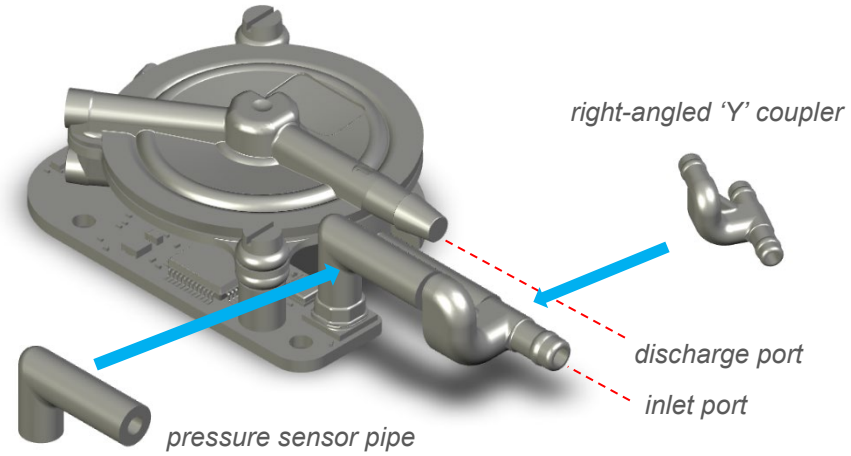
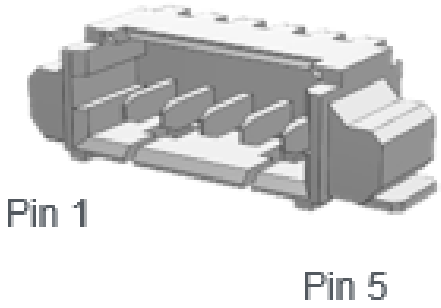


Figure 20. Connecting an HP Series pump for vacuum pressure regulation with the prototype connectors supplied with the optional SPM Prototype Pneumatic Adapter Kit (UACX0500600H)

6.3.Electrical - SPM Connector

The connector on the SPM is a 5 pin, 1 Row, 1.25mm pitch Header (53261-0571):
https://tinyurl.com/5ekymmev



The pinout is as follows

1 - VCC - 3.5 to 5.5 V supply

2 - UART RX / I2C SDA (3.3V)

3 - UART TX / I2C SCL (3.3V)

4 – Ground

5 – 0 to 3.3 V Analog In

The Power and Communication Cable (UACX0500400E) is an optional extra that can be purchased from The Lee Company (~2m in length). The Power and Communication Cable enables Smart Pump Module devices to be connected by USB to provide power and Serial Communications. It also allows the SPM to connected to the Disc Pump Control App.

7. SYSTEM OPERATION

7.1.Preparing the system for first use

- Remove the module from protective ESD bag.
- Connect the pump ports (see Section 6.2).
- Connect the electrical supply and communications (see Section 6.3).

7.2.System control interfaces

The system provides two control interfaces: 0 to 3.3 V analog control; and digital serial control. The default configuration of all Smart Pump Module when shipped is analog control of pump drive power, as described in Section 7.2.1.

7.2.1. Analog control

Pin 5 of the Smart Pump Module connector is a 0 to 3.3 V analog input (see Section 6.3). The analog input can be configured to control pump drive power (“open-loop” control) or to set the target pressure flow when using the module for standalone pressure or vacuum regulation (“closed-loop” PID control).

The default configuration of all Smart Pump Modules when shipped is analog control of pump drive power:

0 to 3.3 V input = 0 to 1 W pump drive power

It is possible to remap the analog input, such that 0 to 3.3 V input maps to an arbitrary output power range, e.g.

0 to 3.3 V input = 0.3 to 0.7 W pump drive power

This mapping can be configured via the digital serial interface either UART or I2C. Refer to The Lee Company Technical Guide ‘TN003 Serial Communications Guide’ for more information. Additionally, the Disc Pump Control App can be used to configure this mapping. See Section 8.3.3.1 and Section 8.3.3.2 for more information.

7.2.2. Digital serial control

The Smart Pump Module implements both UART and I2C interfaces to enable digital serial control. Refer to The Lee Company Technical Guide 'TN003 Serial Communications Guide' for more information on the configuration and command set of these two control options.

7.2.3. UART / I2C auto-detection

The Smart Pump Module has an auto-detection function that runs on start up to establish whether the module is connected to an I2C bus, or directly to a master device via UART. The module does this by checking whether a strong pull-up resistor (≤10 kOhm) is connected to the UART TX / I2C SCL line. The SPM attempts to pull this line down weakly. If it succeeds, the UART interface is selected; otherwise, the I2C interface is selected.

The auto-detect functionality can be disabled, and the SPM can be set to operate only in UART or only in I2C mode by modifying one of the board settings and rebooting the board. This can be done using the Board settings menu in the Disc Pump Control App (see Section 8.8 and The Lee Company Technical Guide 'TN003 Serial Communications Guide' for more information on the configuration of these options). The process for setting the SPM in I2C only mode is described in Section 7.2.4.

For a UART connection, the SPM expects the UART TX line (pin 3 on the connecter – see Section 6.3) to be connected to a high impedance input, although a pull-up resistor can be used providing the value is greater than 100 kOhm. Alternatively, a pull-down resistor can be fitted.

For an I2C connection, the SPM expects the I2C SCL line (pin 3 on the connecter – see Section 6.3) to have pull-up resistor of 10 kOhm or lower fitted. If multiple SPMs are connected in parallel it is recommended to use lower value resistors due to the extra capacitance on the bus. E.g. with two SPMs in parallel use 4.7 kOhm and with four use 2.2 kOhm.

Figure 21 presents a schematic of the two configuration options required for the UART / I2C auto-detection function.

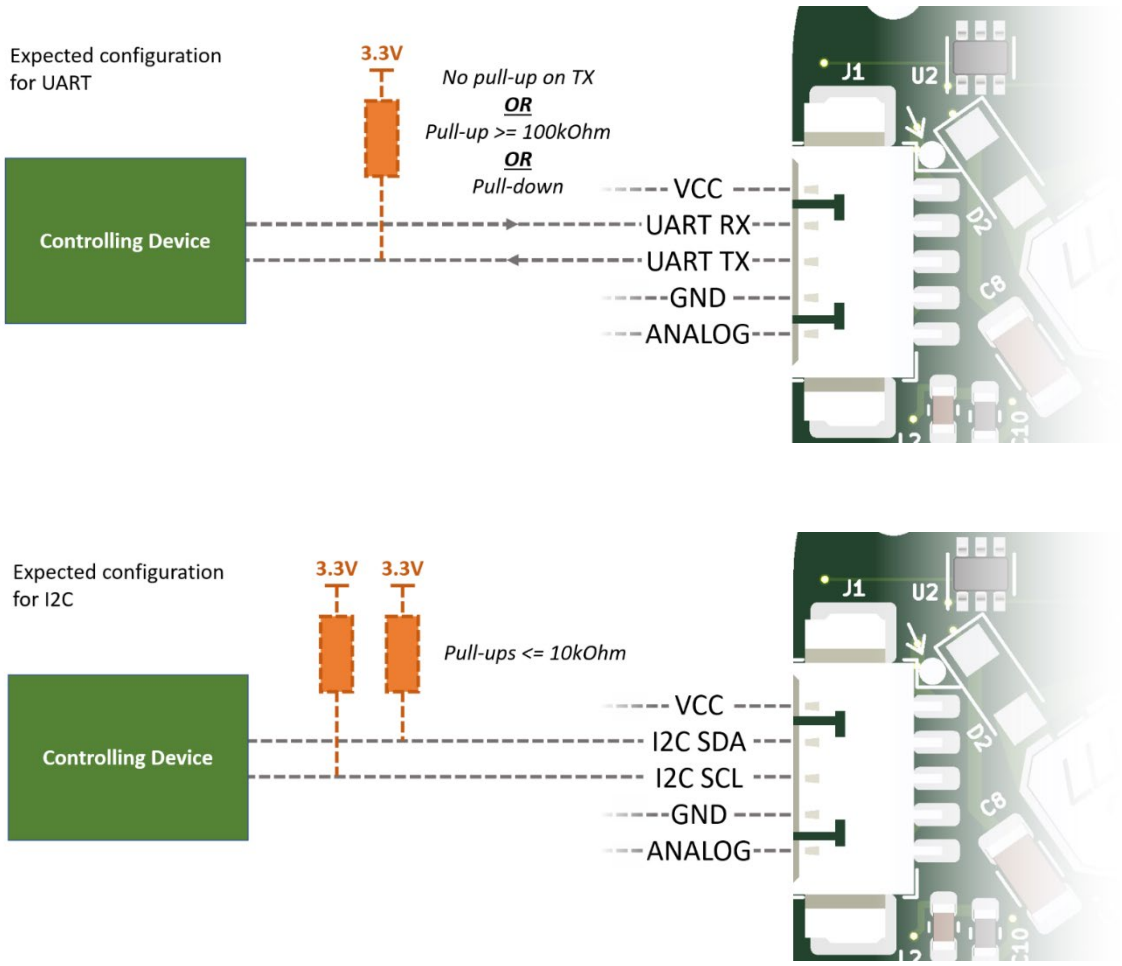


Figure 21. Expected pull-up resistor configurations required for UART / I2C auto-detection function

7.2.4. Configuration of multiple Smart Pump Modules via I2C

When multiple Smart Pump Modules are connected via I2C the following settings need to be configured:

- Connect one of the Smart Pump Module to Development Motherboard and connect it to the Disc Pump Control App. Open the settings menu as shown in Figure 22 step 1.
- Give the Smart Pump Module a unique I2C address by writing the address to register 42 I2C Adress as shown in Figure 22 step 2.
- Set the Smart Pump Module to I2C only mode by writing 1935 to register 43 I2C/UART Selection as shown in Figure 22 step 3. Note that this is only available with the Smart Pump Module Firmware version 5.6 and above.

- Save the settings to the Smart Pump Module by clicking the Use Current Settings on Startup button as shown in Figure 22 step 4. You will be prompted to confirm that you want to use the settings on startup, click Yes.
- Restart the Smart Pump Module by powering down the Development Motherboard and reconnecting it to power.
- Repeat the setup steps (with a different I2C address) for the following Smart Pump Modules as shown in as shown in Figure 22 steps 5 through 8.

For more information see Section 8.8 for setting menu. The range of values and further information can be found in the 'TG003: Communications Guide'.

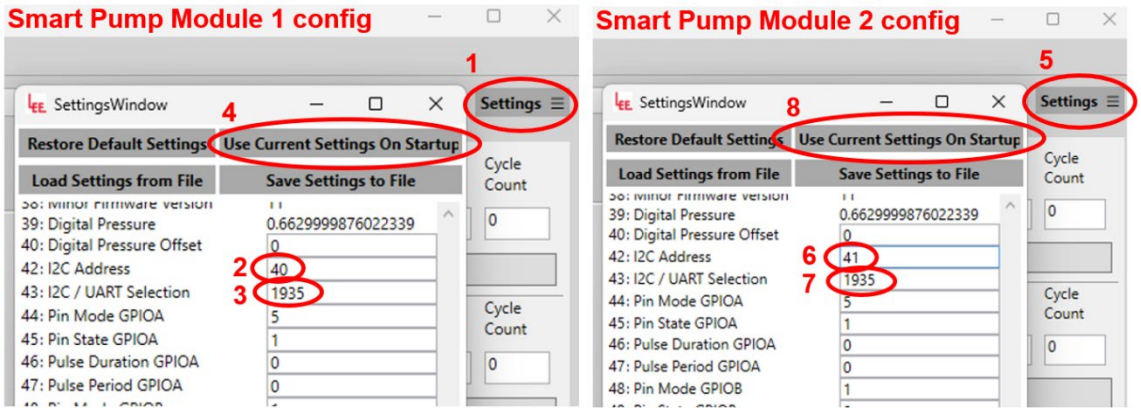


Figure 22. Configuring two Smart Pump Modules to be used at the same time over I2C. Note that Smart Pump Module needs to be restarted after acknowledging the Use Current Settings on Startup (step 4 and 8).

Note that controlling multiple pumps may cause performance issues on some computers. The typical performance issues are low framerate on the application or the graph appearing blocky. One way of mitigating the low framerate is to hide some of the plot tabs, reduce the number of variables that are plotted or reduce the Plot time axis as described is Section 0. The graph appearing blocky can happen with Smart Pump Modules connected over I2C, if the Smart Pump Module is using an old Firmware version (before v6.16). If this is the case, contact your local Lee representative for further information on how to upgrade the Firmware version. This plotting artifact can also happen if too many Smart Pump Modules are connected over I2C.

7.3.Configuring/controlling the Smart Pump Module

7.3.1. Power and Comms Cable

The Power and Communication Cable (UACX0500400E) is an optional extra that can be purchased from The Lee Company (~2m in length). The Power and Communication Cable enables Smart Pump Module devices to be configured and controlled with the Disc Pump Control App.

Figure 23. A Smart Pump Module connected to the Power and Communication Cable.

7.3.2. The Disc Pump Development Kit

The Smart Pump Module can be connected to the Development Kit motherboard via UART (serial) or I2C. By default, the Smart Pump Module autodetects the communications protocol so it could be connected to both. Both connections allow the full functionality of the module and can be used with third party automation such as Python, but there are a few key differences:

- UART requires only USB power while I2C requires the mains power supply.
- UART can use the setpoint dial to control pump power.
- I2C can connect to multiple Smart Pump Modules at once with a single communications line (e.g. a single USB cable). Note that using multiple modules requires an additional setup step explained in Section 7.2.4.

7.3.2.1. Disc Pump Development Kit - Smart Pump Module via UART

Remove the General Purpose driver from the Development kit motherboard and connect the Smart Pump Module to the SPM UART connector.

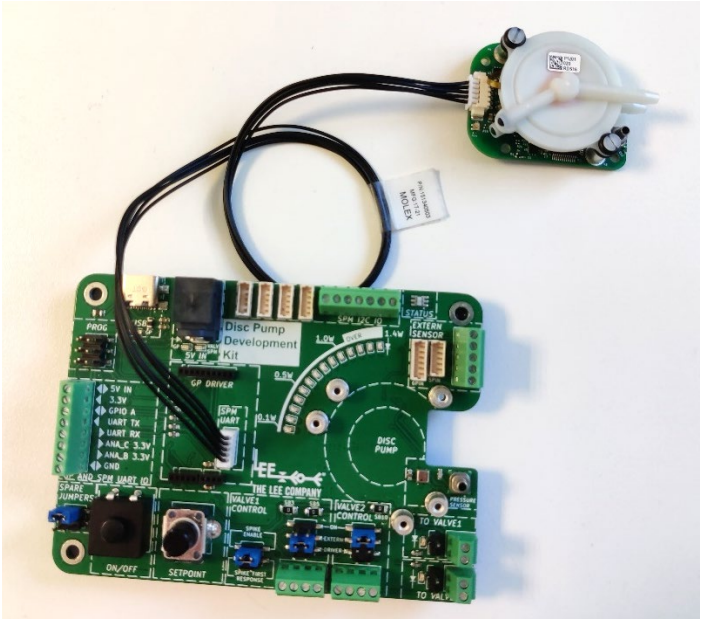


Figure 24. Smart Pump Module connected over UART to Development Motherboard

The Smart Pump Module will automatically connect via UART* and can be controlled by the:

- SETPOINT dial on the Development kit motherboard (default Smart Pump Module behaviour).
- UART R/TX connections on the GP AND SPM UART IO screw terminal.
- Disc Pump Control App as described in Section 8.

** Note: Sometimes if the Development Kit motherboard is powered with the Smart Pump Module already connected it will fail to automatically select UART. To fix this unplug and plug the Smart Pump Module into the already powered on Development Kit motherboard or see Section 7.2.3 for disabling the autodetection of I2C/UART and setting the module to only one protocol.*

7.3.2.2. Disc Pump Development Kit - Smart Pump Module via I2C

Connect the Smart Pump Module to the SPM I2C connector. Connect the mains power supply to the Development Kit motherboard.

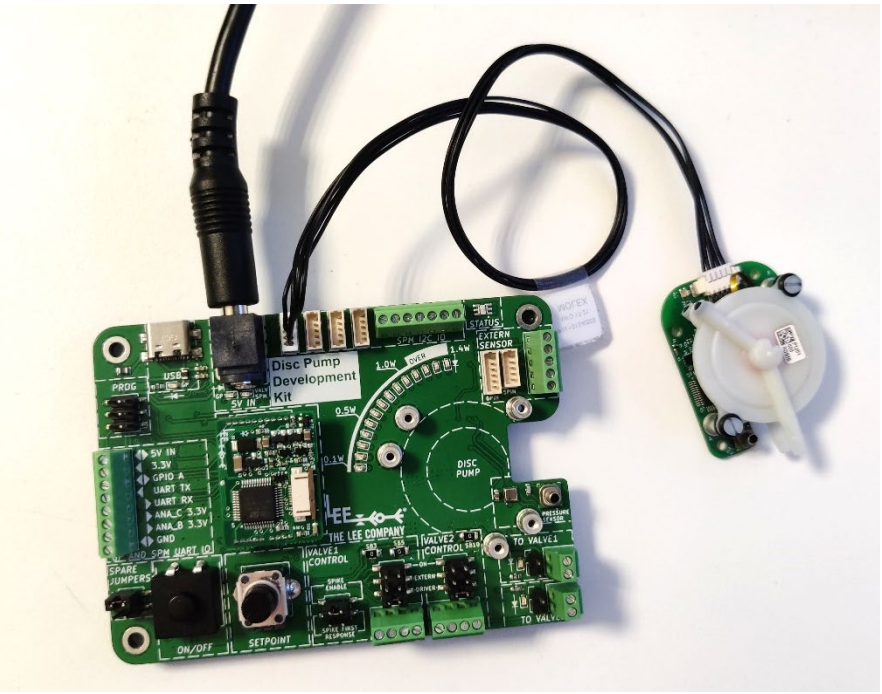


Figure 25. Smart Pump Module connected over I2C to the Development Motherboard. Mains power supply connected.

The Smart Pump Module will automatically connect via I2C* and can be controlled by the:

- Analog input from on the SPM I2C IO screw terminal (default Smart Pump Module behaviour).
- I2C SDA/SCL connections on the SPM I2C IO screw terminal.
- Disc Pump Control App as described in Section 8.

** Note: Sometimes if the Development Kit motherboard is powered with the Smart Pump Module already connected it will fail to automatically select I2C. To fix this unplug and plug the Smart Pump Module into the already powered on Development Kit motherboard or see Section 7.2.4 for disabling the autodetection of I2C/UART and setting the module to only one communication protocol.*

8. DISC PUMP CONTROL APP

8.1.The new Disc Pump Development App version 2.0

The new version (v2.0) of the Disc Pump Development App introduces a number of improvements:

- Improved plotting of pump measurements
- Controlling multiple pumps
- Improved logging of data
- Selecting pressure measurement units and access to all board settings

If you are looking for the old version on the Disc Pump Control App and its companion Smart Pump Module user manual, speak to your local Lee sales engineer. Note that the old version of the Disc Pump Control App is depreciated and will not receive subsequent updates.

8.2.Setup

To configure the PCB, a bespoke application (Disc Pump Control App) is on The Lee Company website - https://www.theleeco.com/disc-pumps/. Note that the app is only supported on Windows.

To download the relevant drivers:

- Ensure the PC is connected to the internet.
- Connect the PCB to the PC with the USB cable.
- If the PC is running Windows 7 or later, all drivers should automatically be downloaded and installed.
- Drivers for the Development kit can be downloaded from https://www.microchip.com/en-us/product/mcp2200
- Drivers for the SPM Power and Comms cable or the old Evaluation kit can be download from here: https://ftdichip.com/drivers/vcp-drivers/
- If Microsoft .NET framework is not installed then running the app may result in an error message like the one below. Usually, the prompt automatically opens the download page for the relevant .NET version. Alternatively .NET can be downloaded from there (if in doubt about the required version, install the latest version): https://dotnet.microsoft.com/en-us/download/dotnet. Note that this installation requires admin privileges on the computer.

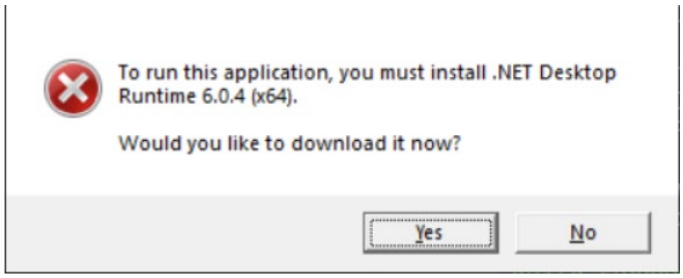


Figure 26. Error message when running the Disc Pump Control app if the required version of .NET is not installed.

CAUTION

Ensure that the driver installation process has completed successfully before proceeding

8.3.Getting started

8.3.1. Connecting the SPM

With the SPM connected to the PC via the Power and Communication Cable or through the Disc Pump Development kit (either via UART or I2C), double click on the “Disc Pump Control App.exe” executable file.

- Select the appropriate COM port from the top-left dropdown menu and click connect as shown in Figure 27. The COM port can easily be found by plugging and unplugging the kit and observing which COM port appears and disappears.
- If using a Smart Pump Module connected over I2C click the Scan I2C button on the top left. Once the scan is completed you can access the I2C devices from the Port dropdown menu and click connect as shown in Figure 27.
- Click on the “+” button to create a plot tab as shown in Figure 28.
- The application should now be connected and display all the current settings on the GUI as shown in Figure 29.

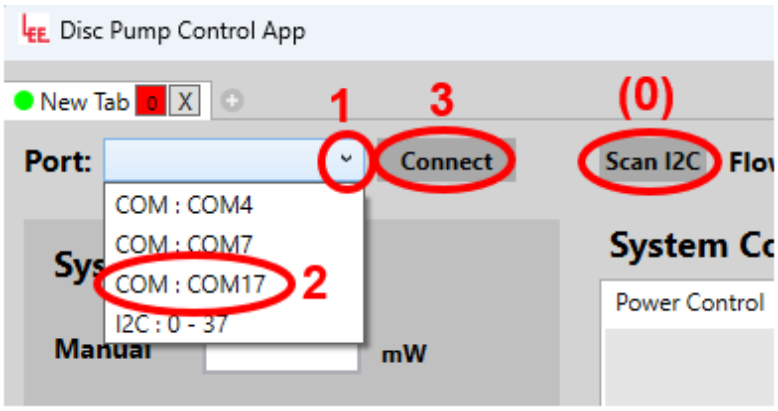


Figure 27. Connecting a driver board to the Disc Pump Control App

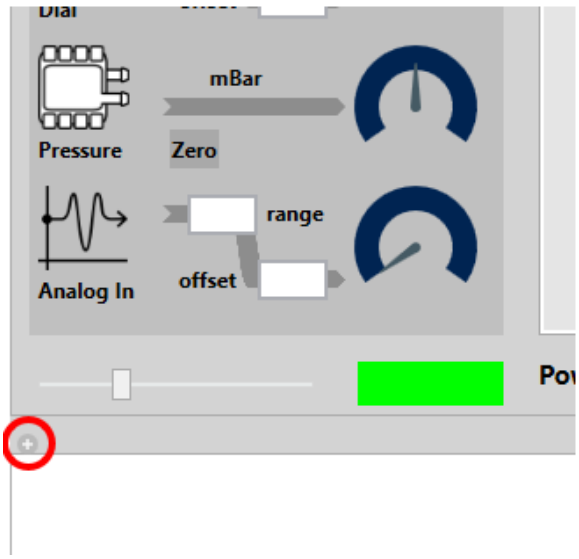


Figure 28. Creating a plot window.

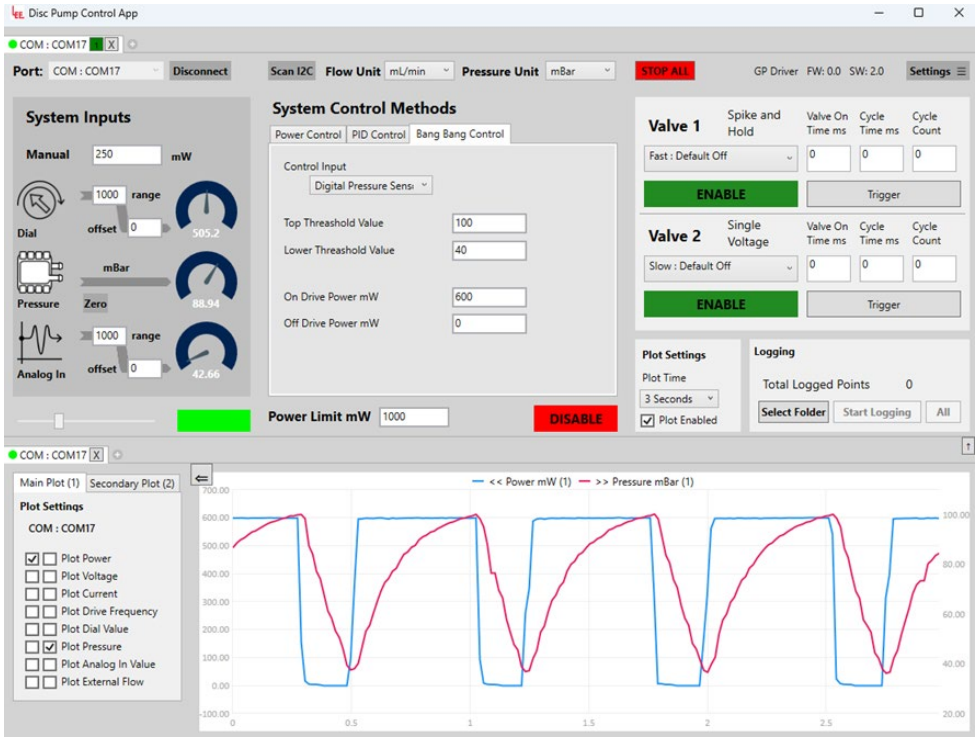


Figure 29. Disc Pump Control App GUI

8.3.2. System inputs

The user interface has a panel displaying the System Inputs on the left-hand side as shown in Figure 30 – these are:

- A manual setpoint entered via the software.
- The setpoint dial is not available for the SPM module (only the Development Kit and Evaluation kit).
- The digital pressure sensor.
- A 0 to 3.3V analog input signal (this is connected to the Dial on the Development Motherboard if the SPM is connected to it via UART).

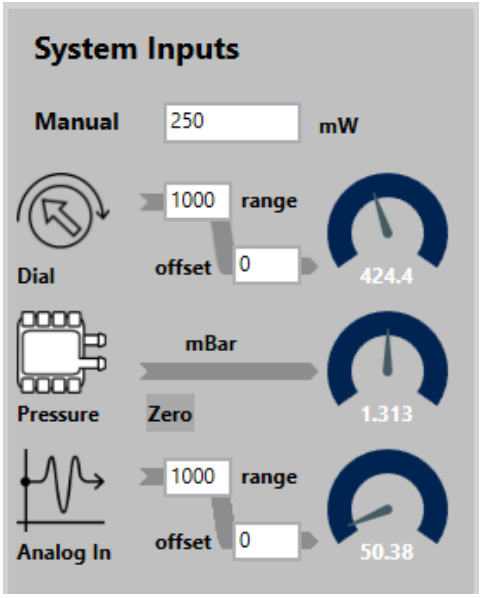


Figure 30. System inputs

The values for these inputs are displayed under the dials on the user interface.

The analog in inputs has a range and an offset associated with them. This allows the input to be arbitrarily mapped to power and pressure setpoint variables.

8.3.3. System control methods

In the centre of the user interface is the System Control Methods panel. There are three control modes:

- Power Control,
- PID pressure control,
- Bang-bang pressure control.

8.3.3.1. Power control mode

Power Control mode controls the drive power supplied to the pump.

- Select the Power Control tab.
- Select the target power source from the dropdown menu:
- **Manual**: the power target is entered manually into the “System Input” section. The units are milliwatts.
- **Dial**: not available for SPM modules (this is a feature of the Evaluation/ Development Kit)
- **Analog Input**: the power target is controlled by the 0 to 3.3V analog input supplied via pin 5 of the five-wire electrical interface (this is connected to the Dial on the Development Motherboard if the SPM is connected to it via UART).
- Note that the analog in control input value is displayed in the “System Inputs” section of the PC application. It has a range and offset associated with it, allowing the mapping of the input to the target power to be configured. Example mappings:

Desired full-scale range mapping	Range	Offset
0 to 1000 mW	1000	0
0 to 500 mW	500	0
200 to 400 mW	200	200

Table 1: Example mappings of the Range and Offset variables

- Click the “Enable/Disable” button on the GUI to toggle the pump output.
- Tick the “Plot Power” check box to observe the drive power supplied to the pump.

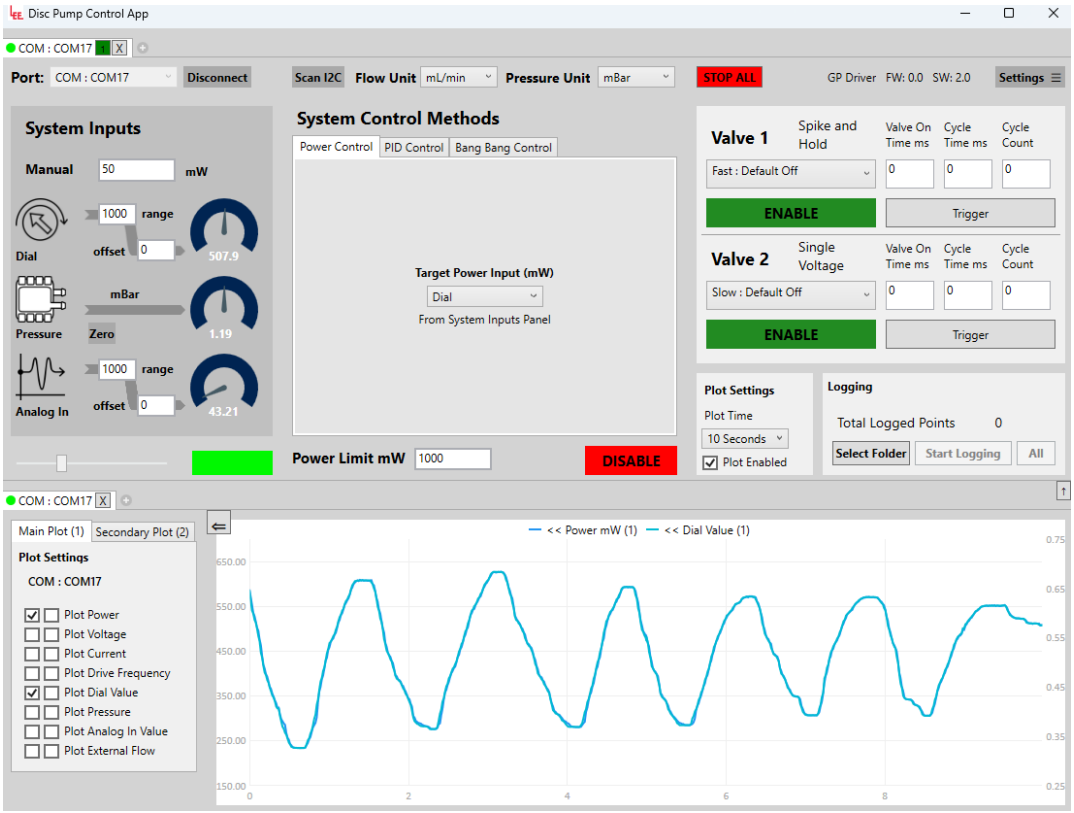


Figure 31. Power controlled to a target controlled by the SETPOINT dial on the Development motherboard.

8.3.3.2.PID control mode

PID Control mode adjusts the pump drive power until a target pressure/vacuum is reached.

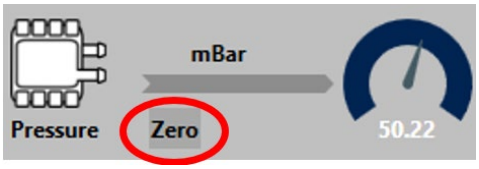
TAKE NOTE

Connect the pressure sensor to the circuit according to Section 6.2.2 and Section 6.2.3 prior to using pressure/vacuum regulation.

For positive pressure control, connect the pressure sensor to the outlet of the pump. Within the control app, use positive pressure setpoint targets and positive values for the P, I and D coefficients which determine the behaviour of the PID control loop.

For negative pressure control, connect the pressure sensor to the inlet to the pump. Within the control app use negative pressure setpoint targets and negative values for the P, I and D coefficients which determine the behaviour of the PID control loop.

The pressure sensor reading can be zeroed by clicking the “Zero” button next to the pressure sensor icon. Pressure reding must zeroed when changing pressure units.



- Select the PID Control tab.
- Select the pressure control setpoint from the dropdown menu:
- **Manual:** the pressure target is entered manually into the “System Input” section
- **Dial:** not available for SPM modules (this is a feature of the Evaluation/ Development Kit)
- **Analog Input**: the power target is controlled by the 0 to 3.3V analog input supplied via pin 5 of the five-wire electrical interface (this is connected to the Dial on the Development Motherboard if the SPM is connected to it via UART).
- Note that the analog control input value is displayed in the “System Inputs” section of the PC application. It has a range and offset associated with it, allowing the mapping of the input to the target pressure to be configured. Example mappings for the analog input control are:

Desired full-scale range mapping	Range	Offset
0 to 100 mmHg	100	0
0 to 200 mmHg	200	0
100 to 200 mmHg	100	100

Table 2: Example mappings of the Range and Offset variables

- **Input:** Select 'Digital Pressure Sensor' from the drop-down list
- Click the "Enable/Disable" button on the GUI to toggle the pump output.
- Tick the "Plot Pressure" check box to observe the pressure measured by the sensor.
- The P, I and D coefficients should be configured to optimise performance of the loop for the customer's specific setup. Factors such as the volume of the pneumatic circuit need to be considered when tuning the pressure control loop.

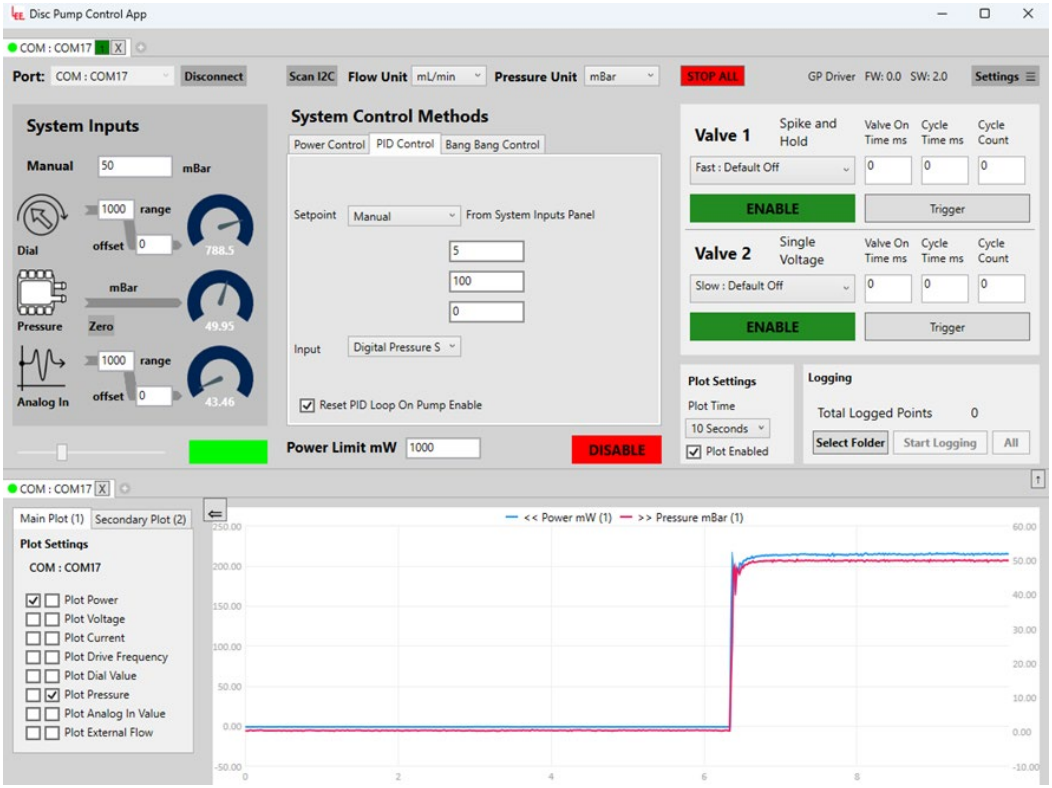


Figure 32. Pressure controlled to 50 bar under PID control mode

8.3.3.3.Bang Bang control mode (positive pressure only)

"Bang Bang" control mode is a simple on-off controller that switches the pump on and off to control the output pressure between two defined pressure limits. Bang bang control is not possible in the vacuum regulation setup with the SPM.

TAKE NOTE

Connect the pressure sensor to the circuit according to Section 6.2.2 and Section 6.2.3 prior to using pressure regulation.

- Select the Bang Bang Control tab.
- Enter the top pressure limit in the Top Thresh field.
- Enter the lower pressure limit in the Low Thresh field.
- Enter a value for On Drive Power mW – this is the drive power supplied to the pump when it is on (after the lower threshold value is reached); if in doubt, start with 1000 mW, but reduce it if the pressure overshoots above the top threshold is an issue, or to reduce the rate of inflation.
- Enter a value for Off Drive Power mW – this is the drive power supplied to the pump when it is off (after the top threshold value is reached); if in doubt, start with 0 mW, but increase it if the pressure undershoots above the lower threshold is an issue, or to reduce the rate of deflation.
- Click the "Enable/Disable" button on the GUI to toggle the pump output. Alternatively, use the ON/OFF button on the motherboard.
- Tick the "Plot Pressure" check box to observe the pressure measured by the sensor.

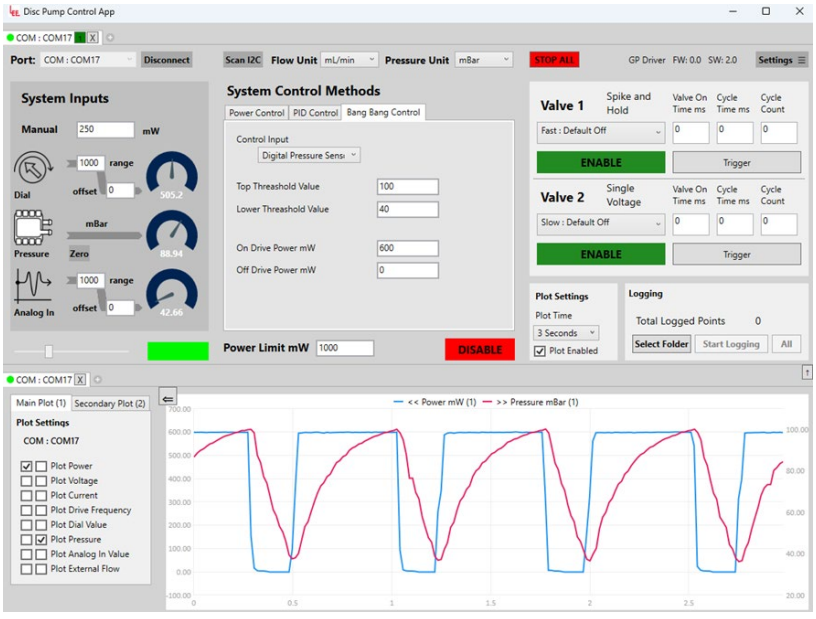


Figure 33. Pressure cycling between two limits under bang-bang control

8.3.4. Power limit

The driver board has a function to limit the drive power supplied to prevent damage to the pump. The "Power Limit mW" field allows this limit to be set. Initially, we recommend that this limit is set to 1000 mW. For intermittent (i.e. non-continuous) use, higher limits can be used up to a maximum of 1400 mW. Intermittent use is defined as having:

- Mean power ≤ 1000 mW
- A duty cycle period of less than 20 s.

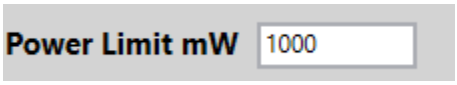


Figure 34. Pump power limit

8.3.5. Measurement units

The SPM module can be configured to report pressure and flow in a variety of measurement units. This option can be accessed from the two dropdown menus on the top of the application. Note that this functionality is supported on the Smart Pump Module only for Firmware versions 6.16 and above.

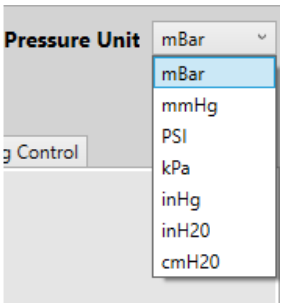


Figure 35. Selecting measurement units for pressure

The pressure must be zeroed after changing the Pressure Unit.

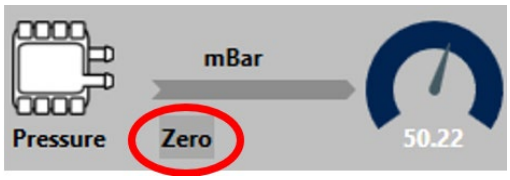


Figure 36. Zeroing the pressure sensor

Note that the choice of pressure / flow unit affects the PID values required for good control. The PID calculation is dimensionless, and so will treat a change of 1mBar (when measuring pressure in mBar) as equivalent to a change of 1PSI (when measuring pressure in PSI) because they are both changes of “one unit of pressure”. Therefore, the values of P, I and D need to be set appropriately for the pressure units used.

For example, a P value of 10 is used when the system was controlling to pressure in mBar. If the system is switched to use pressure in PSI, P needs to be set to 69 * 10 = 690 (as 1PSI = 69mBar) to achieve the same response.

8.4.Plotting

Click on the “+” button to create a plot tab as shown in Figure 37. Note that when a plot tab is created it is tied to the last active pump control tab (the last one that was clicked on) and therefore will display the output of that pump.

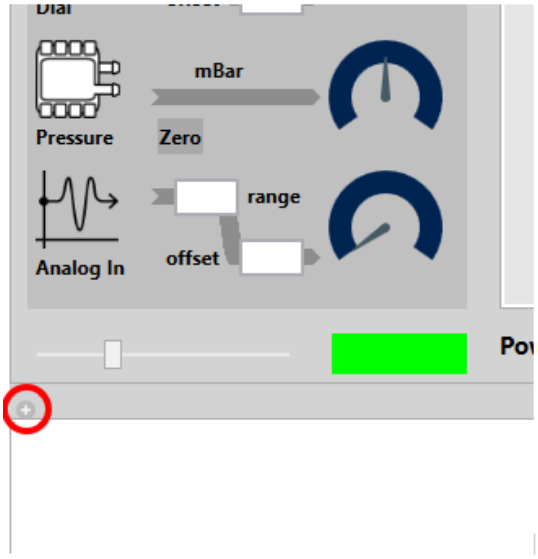


Figure 37. Creating a plot window

8.4.1. Plotting data from a single pump

Various parameters can be plotted on the graph presented in the PC application.

- Tick the check boxes on the left to confirm the values to be plotted. The left most column of tick boxs corresponds to plotting the data on the left Y axis and the right hand column of tick boxs corresponds to plotting the data on the right Y axis (as shown in Figure 38).
- On the top of the graph there is a legend of all data sets plotted. The legend contains arrows next to each data set to indicate whether it is plotted on the left or right Y axis.
- It is possible to zoom on the graph by scrolling whilst hovering over it with the mouse cursor.
- Panning up and down the Y axis is possible by clicking and dragging up and down.
- The value at a given point for a given curve on the graph can be displayed by rolling over the point with the mouse cursor.

Note that plotting data from Smart Pump Modules connected over I2C may appear blocky or in steps. This can happen if the Smart Pump Module is using an old Firmware version (before v6.16). If this is the case, contact your local Lee representative for further information on how to upgrade the Firmware version. This plotting artifact can also happen if too many Smart Pump Modules are connected over I2C).

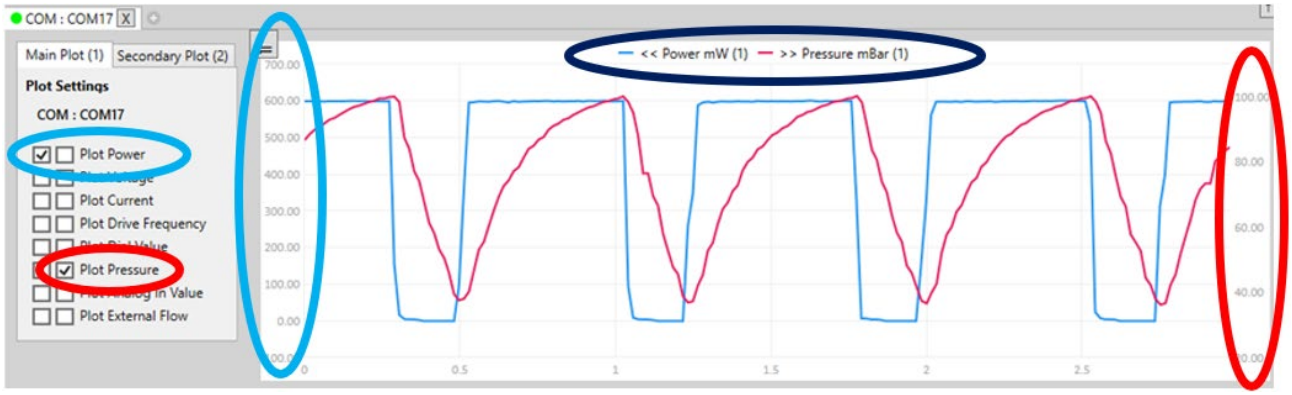


Figure 38 Plot with two axis. Plot power on the left Y axis in blue and pressure on the right Y axis in red

The plot can be paused by clicking on the Plot Enable tick box. The X time axis resolution can be set by the dropdown menu Plot Time.

.

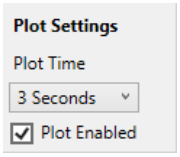


Figure 39 Plot settings - pausing the plot and setting the plot time axis

Figure 40 Showing and hiding the plot settings

8.4.2. Plotting data from multiple pumps

The data from two pumps can be plotted on the same graph.

- Connect a second pump as explained in Section 8.6.
- Select the Secondary plot settings menu on the left.
- Select the second pump that should be plotted from the drop-down menu. Tick the check boxes for the values to be plotted.
- At the top of the graph there is a legend of all data sets plotted. The legend contains a (number) next to each data set to indicate whether it is data from the main (1) or secondary (2) pump as shown in Figure 41.

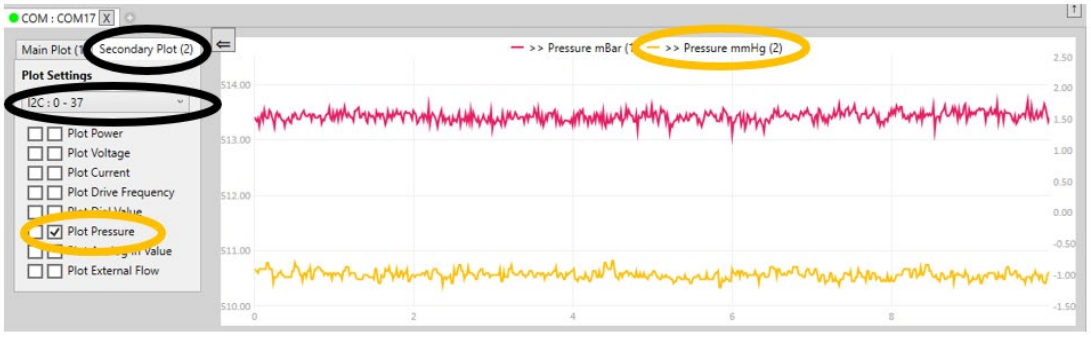


Figure 41 Plotting data from multiple pumps. Data from the main pump is plotted in red and data from the secondary pump is plotted in orange.

Note that controlling multiple pumps may cause performance issues on some computers. The typical performance issues are low framerate on the application or the graph appearing blocky. One way of mitigating the low framerate is to hide some of the plot tabs, reduce the number of variables that are plotted or reduce the Plot time axis as described is Section 8.4. The graph appearing blocky can happen with Smart Pump Modules connected over I2C, if the Smart Pump Module is using an old Firmware version (before v6.16). If this is the case, contact your local Lee representative for further information on how to upgrade the Firmware version. This plotting artifact can also happen if too many Smart Pump Modules are connected over I2C.

8.5.Using the Analog Input

The analog input can be used in a variety of ways to control of pump performance. This can be useful for initial system integration work, for example.

To control pump power	The analog input can be used to variably control the pump drive power. See Section 8.3.3.1 for further details.
To 'gate' the pump drive for short pulse control	The analog input is sampled at around 1kHz, enabling the pump to be switched on and off quickly to any desired power level using power control mode (see Section 8.3.3.1). This feature can be used to deliver a short pulse of air, e.g. for microfluidic control applications.
To control the output pressure setpoint	The analog input can be used to provide the target pressure for the on-board PID control loop, with the on-board pressure sensor being used to monitor the actual pressure. See Section 8.3.3.2 for further details.
As an input from an external pressure sensor	The analog input can be used as an input from an external pressure sensor to the on-board PID control loop, with the target pressure set manually or via the software. See Section 8.3.3.2 for further details.

8.6.Multi-pump control

The Disc Pump Control application can control multiple pumps at once. Each pump can either be individually connected to the host computer (a Smart Pump Module with USB-serial cable, Development or Evaluation kit) or multiple Smart Pump Modules can be connected through one Development kit (see Section 7.2.4 for how to configure multiple Smart Pump Modules).

To add controls for additional pumps, click on the plus button on the top left. This will generate a new pump control tab. Tabs can also be closed with the X button.

Figure 42. Adding and removing additional pump control tabs.

Pump control tabs work similarly to browser tabs in Google Chrome or Microsoft Edge. They can be dragged out to create new windows, dragged in to bring in a new window back as a tab or be rearranged. This functionality is supported for both the pump control tabs and the plot tabs. Note that when a plot tab is created it is tied to the last active pump control tab (the last one that was clicked on) and therefore will display the output of that pump.

Note that controlling multiple pumps may cause performance issues on some computers. The typical performance issues are low framerate on the application or the graph appearing blocky. One way of mitigating the low framerate is to hide some of the plot tabs, reduce the number of variables that are plotted or reduce the Plot time axis as described is Section 8.4. The graph appearing blocky can happen with Smart Pump Modules connected over I2C, if the Smart Pump Module is using an old Firmware version (before v6.16). If this is the case, contact your local Lee representative for further information on how to upgrade the Firmware version. This plotting artifact can also happen if too many Smart Pump Modules are connected over I2C

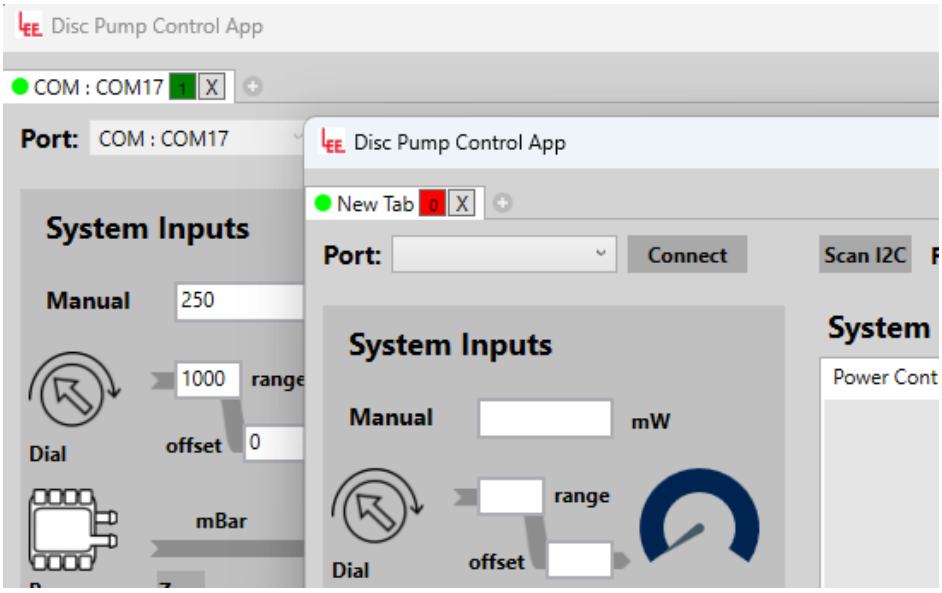


Figure 43. Dragging out tabs in separate windows.

When a pump control tab is in a standalone window as shown in Figure 44, the plot area is left empty and a plot can be created either through the "+" button (similar to how it is created when first starting the application) or by dragging in a plot window. Similarly, for plot tabs in standalone windows there is a "+" button on the top to generate a pump control tab or one can be dragged in.

Figure 44. Multiple pump control tabs and multiple plot tabs. Pump control tab with a plot tab (left), a standalone pump control tab (middle) and a standalone plot tab (right).

To help identify which tab corresponds to which pump, the colour of each tab can be changed with the slider on the left. This causes the tab circle in the application and the board status LED on the device to change colour accordingly. Note that the LED and screen colour may differ slightly due to variations in the

monitor and LED colour accuracy. Note that LED colour change on the Smart Pump Module is supported in firmware versions 6.16 and above. Additionally, tabs can be renamed by right-clicking on the tab name or the colour indicator.

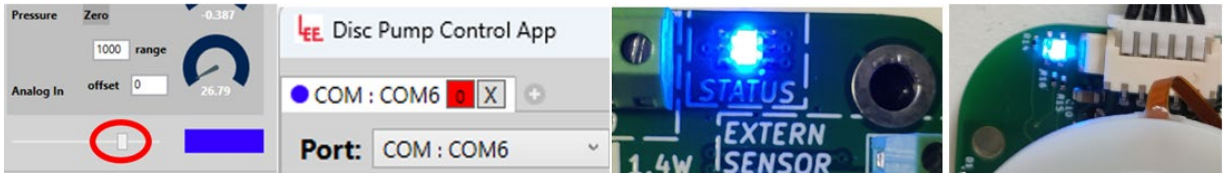


Figure 45. Colour changing of tabs and status LED

Controlling multiple pumps at once works in the same way as controlling a single pump. There are a few additional controls to make this task simpler.

- The STOP ALL button turns all connected pumps off and resets all valves to their default states.
- Each pump can be turned on/off without opening the relevant tab by clicking the little red/green square on the tab header. 1 (green) indicates the pump is on and 0 (red) indicates the pump is off

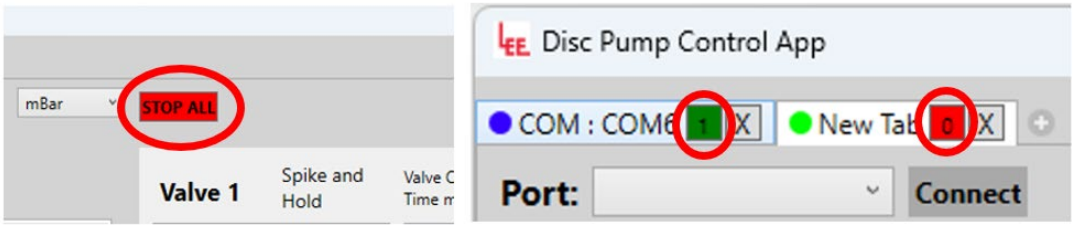


Figure 46. Stop all button (left) and pump on/off control from tab title (right).

8.7.Logging

Data can be logged to a CSV file for offline analysis.

- In the “Logging” panel, click the “Select Folder“ button as shown in Figure 47. This will prompt a folder selection where the data will be generated.
- Once the folder is selected the interface will indicate the new location as shown in Figure 48. When the logging is started the app will automatically create a .CSV log file in the target folder.
- Click the Start Logging button to initiate the logging. The interface shows the name of the created file and the number of logged points going up as shown in Figure 48. Once sufficient data is obtained click the Stop Logging data.
- Data from multiple pumps connected to the app can be logged simultaneously. The ALL button will do the same as pressing the normal logging button on all tabs simultaneously (i.e. if it says stop logging the all button will stop all tabs logging). Start all will not restart any tabs already logging but Stop will stop logging all, not just the tabs started by start all.

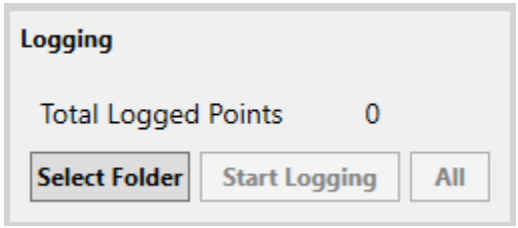


Figure 47. Data logging interface

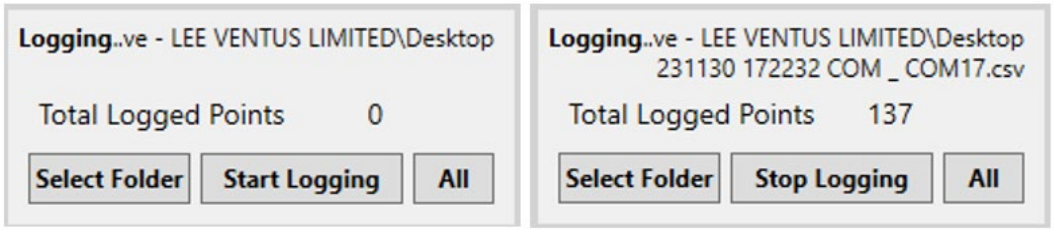


Figure 48. Data logging interface when target folder is selected (left). Data logging interface while data logging is active (right).

8.8.Board settings menu

All writable settings of the Smart Pump Module and the General Purpose Drive PCB can be accessed via the “Settings” button on the top right of the window. This brings out a separate window which lists the register ID, register name and has a field for editing the value. Consult the ‘TG003: Communications Guide’ for full information on registers functionality and appropriate values.

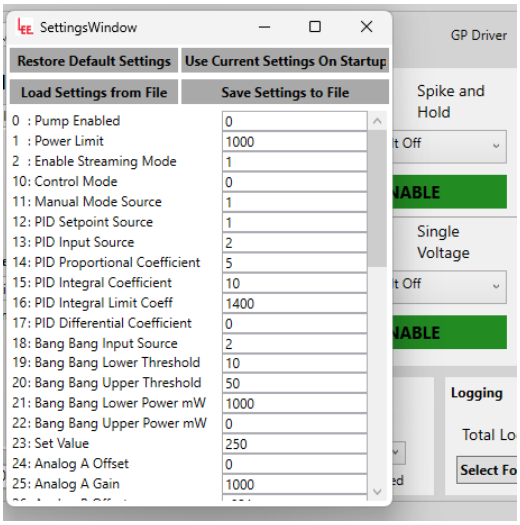


Figure 49. Settings menu.

The board settings can be saved to be used at start-up (otherwise the settings are lost upon rebooting the board). To do this use click on the “Use Current Settings On Startup”. This is required for setting some registers as they only take effect after rebooting the board.

The board settings can also be saved and loaded from a file which can be useful for transferring settings between multiple boards or when troubleshooting the system with the Lee customer support. This functionality can be accessed through the “Save / Load Settings from File buttons”.

Finally, the default board settings can be restored to factory defaults through the Restore Default Settings button. Note that the settings will be erased on rebooting unless they are saved to be used at start-up.

9. ACCESSORIES

The following accessories are available for the SPM:

9.1.UACX0500400E (USB Power and Communications Cable)

The UACX0500400E USB Power and Communication Cable is an optional extra that can be purchased from The Lee Company. The Power and Communication Cable enables SPM Smart Pump Module devices to be configured and controlled with the Disc Pump Control App.

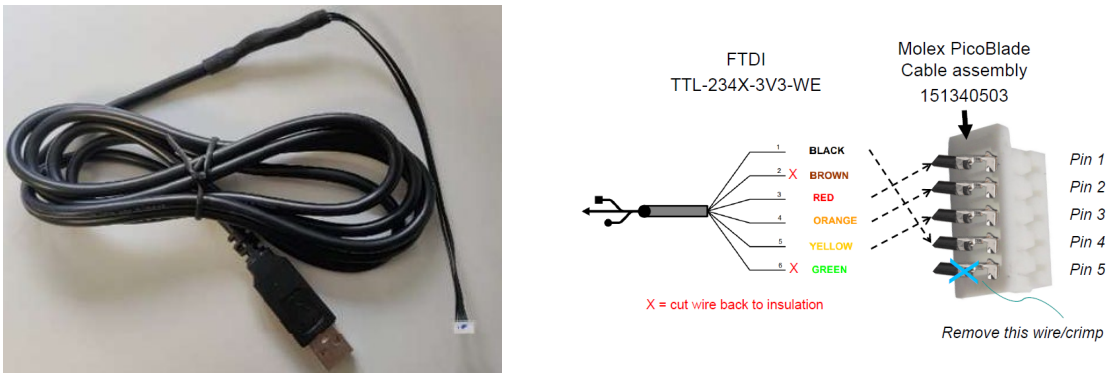


Figure 50. Part UACX0500400E

Notes:

- Connector 1: USB A
- Connector 2: 5 pin Molex PicoBlade Cable Assembly
- Length: 2 m

9.2.UACX0500600H (SPM Prototype Pneumatic Adaptor Kit)

The adaptor kit provides a number of connectors to provide a convenient method for linking ports in a range of SPM prototype systems.

ITEM NO.	DESCRIPTION
1	Manifold - PDC (-) pressure
2	Manifold - PDC (+) pressure
3	Manifold - SDC & HP (-) pressure
4	L tube
5	Y Coupler
6	SPM Silicone Tube - Pre Cut
7	C Coupler

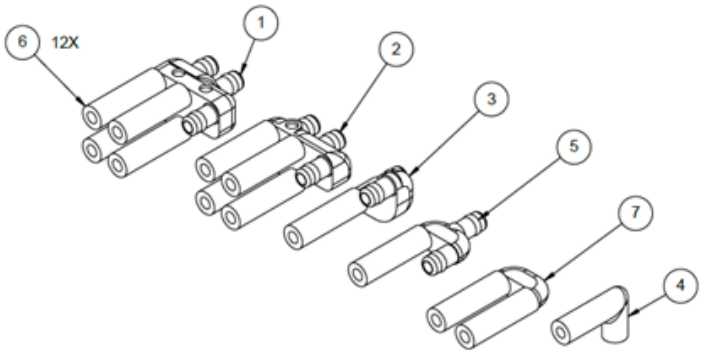


Figure 51. Part UACX0500600H

Materials: Accura Extreme Polymer and Silicone

Notes: Note that these prototype components are fabricated by SLA and are therefore not recommended for use in mass-produced products. The Lee Company make no guarantees concerning the performance of this component with respect but not limited to:

- Burst pressure
- Working pressure
- Materials/environmental compatibility
- UV exposure

9.3.UACX0500850H Soft Silicone Y coupler (pack of 10)

The Soft Y-coupler provides a convenient method for linking ports in the parallel configuration pumps.

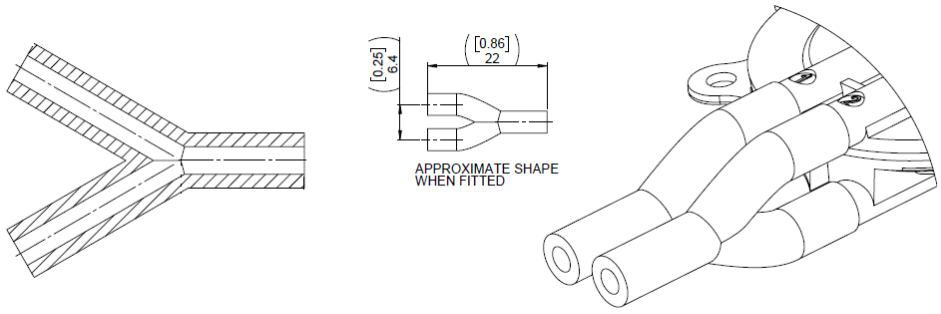


Figure 52. Part UACX0500850H

Notes:

- Pneumatically links two pump ports (for BL, XP and LT Series Pumps with the parallel configuration) and presents a 2mm ID, 4mm OD tube for connection the customers system.
- Each pump may require two couplers.
- Product comes as a pack of x10 individual couplers.

9.4.UACX0500800H Silicone V coupler (pack of 10)

The Soft V-coupler provides a convenient method for linking ports in the series configuration pumps.

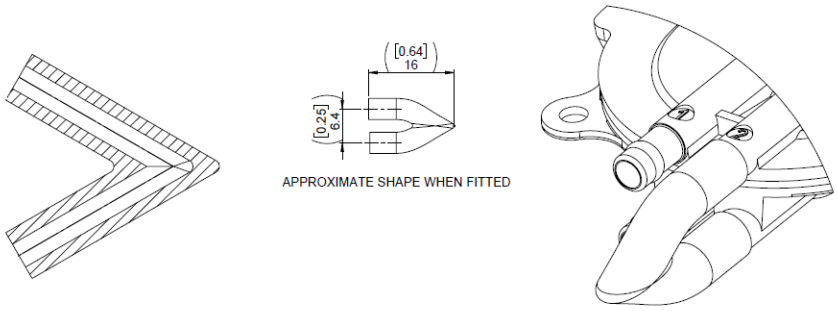


Figure 53. Part UACX0500800H

Notes:

- Pneumatically links two pump ports (for BL, XP or LT Series Pumps with a series configuration)
- Product comes as a pack of x10 individual couplers

9.5.UACX0500900H Silicone L coupler (pack of 10)

The Soft L-coupler provides a convenient method for the pressure sensor to a union to the inlet or exhaust of the pump if not using the pneumatic adapter kit.

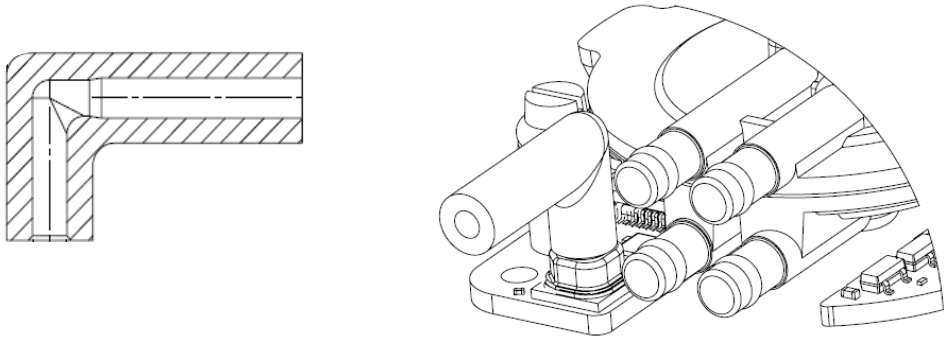


Figure 54. Part UACX0500900H

9.6.UACX0500750H (Filter)

It is recommended that the pump inlet is connected to a filter with a pore size of <3 µm to prevent ingress of debris which may reduce the performance of the pump.

Notes:

- 30 mm HPLC Syringe Filter
- Non-sterile
- Pore size of 1.2 µm

Figure 55. Part UACX0500750H

Materials: Polypropylene Housing, Glass Microfibre membrane

10.SUPPORT

The Lee Company website http://www.theleeco.com/discpumps provides technical information, FAQs, troubleshooting and documentation for download.

For additional technical support, including advice on testing of the products, please contact your Lee Sales Engineer.

11. CERTIFICATE OF CONFORMITY & PRODUCT SAFETY / DECLARATION OF INCORPORATION

THE LEE COMPANY

LEE Ventus Limited
Melbourn Science Park
Melbourn
Hertfordshire SG8 6EE
United Kingdom

EC and UKCA Declaration of Conformity

CE UKCA

Products:	Piezoelectric disc pumps and related modules, drive electronics and accessories
Models:	
Piezoelectric disc pumps	UBLB5xxxxxxx (BL Series Disc Pumps) , UXPB5xxxxxxx (XP Series Disc Pumps), UHPB5xxxxxxx (HP Series Disc Pumps) , UUSB5xxxxxxx (US Series Disc Pumps), ULTB5xxxxxxx (LT Series Disc Pumps)
Piezoelectric disc pump modules	UxxC5xxxxxxx (Smart Pump Modules incorporating any of the XP, BP, LT or HP Pump Series)
Drive electronics and accessories	UEKA0300000A (General Purpose Disc Pump Driver), UEKA0300050A (Evaluation Kit Motherboard), UEKA0300100A (Development Kit Motherboard), UACX0500100E (Breakout Board), UACX0500400E (SPM Communication Cable)
Serial numbers:	See label on product
Manufacturer:	LEE Ventus Ltd, Melbourn Science Park, Royston, Herts, SG8 6EE, UK
EU Authorised Representative:	The Lee Company Scandinavia AB, Stormbyvägen 2-4, 163 55 Spånga, Sweden

We hereby declare that the products above comply with all relevant provisions of the following directives:

- Restriction of Hazardous Substances Directive 2011/65/EU
- The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012 No. 3032

The products have been evaluated in accordance with the following harmonised standards:

- EN IEC 63000:2018

A technical file for each product is retained at the manufacturer's address.

Signed ……

Name: Tom Harrison

Position: Managing Director

P-2-056 Declaration of Conformity v03

LEE Ventus Limited
Melbourn Science Park
Melbourn
Hertfordshire SG8 6EE
United Kingdom

Product Installation and Safety

Products: **Pump drive PCBs and Accessories**

Models:

Drive PCBs
UEKA0300000A (General Purpose Pump Drive PCB),
UEKA0300050A (Evaluation Kit Motherboard),
UEKA0300100A (Development Motherboard)

Accessories
UACX0500100E (General Purpose Pump Drive PCB Breakout Board),
UACX0500400E (USB Power and Comms Cable)
UACX0500950E (ACDC Adapter 5V dc Output, 5A Output with Plug Set)

Manufacturer: LEE Ventus Ltd, Melbourn Science Park, Royston, Herts, SG8 6EE, United Kingdom

General Product Safety Information:

- Products should only be used and mounted in accordance with the relevant User Manual.
- Do not disassemble products. If damage is evident, do not operate affected product.
- Do not operate products outside of their rated operating conditions. Operation outside these ratings may result in malfunction, excessive heating and/or noise emission.
- Electronic products may emit electromagnetic radiation. The customer should evaluate the emissions of the end product(s) to assess conformity with relevant limits.

UEKA0300000A (General Purpose Drive PCB):

- The General Purpose Drive PCB can produce up to 60Vdc (120Vpp) under normal conditions, and >80Vdc (160Vpp) in a fault condition. Care must be taken when operating the General Purpose Drive PCB and in the design of products incorporating it to avoid exposure to electrical connections.
- Components on the board may become hot during use. This should be considered at the product design stage.
- The General Purpose Drive PCB emits electromagnetic radiation. The customer should evaluate the emissions of end product(s) incorporating the General Purpose Drive PCB to assess conformity with the relevant limits.
- Do not operate the General Purpose Drive PCB in an explosive atmosphere or where flammable materials are present.

UACX0500950E (ACDC Adapter 5V dc Output, 5A Output with Plug Set)

- The power adaptor should be used in accordance with the supplier manual, which can be found on the supplier's website or on request from The Lee Company

THE LEE COMPANY

Declaration of Incorporation

Products:	Piezoelectric disc pumps and related modules
Models:	
Piezoelectric disc pumps	UBLB5xxxxxx (BL Series Disc Pumps), UXPB5xxxxxxx (XP Series Disc Pumps), UHPB5xxxxxx (HP Series Disc Pumps), ULTB5xxxxxxx (LT Series Disc Pumps), UUSB5xxxxxxx (US Series Disc Pumps)
Piezoelectric disc pump modules	UxxC5xxxxxxx (Smart Pump Modules incorporating any of the XP, BP, LT or HP Pump Series)
Serial numbers:	See label on product
Manufacturer:	LEE Ventus Ltd, Melbourn Science Park, Royston, Herts, SG8 6EE, UK
EU Authorised Representative for CE Marking:	The Lee Company Scandinavia AB, Stormbyvägen 2-4, 163 55 Spånga, Sweden

Installation and use:

- Pumps and pump modules are classified as partly completed machinery intended for development of and integration into customer products by competent personnel.
- Products should only be used in accordance with the relevant user manual.
- The customer must ensure that voltages applied to the electrical connections are within the specified ratings.
- The customer should ensure that the products are mounted in accordance with the relevant user manual and are not subject to forces which may distort the assembly.
- The customer should ensure good electrical, mechanical, and pneumatic installation to prevent malfunction, leaks, noise generation, or the products becoming loose during operation.
- Product performance may degrade over time. Customers must carry out adequate testing to ensure that the performance of the products in their particular application is sufficient to meet requirements over the life of the end products.

Warnings:

- Do not disassemble products. If damage is evident, do not operate affected product.
- Do not operate products outside of their rated operating conditions. Operation outside these ratings may result in malfunction, or excessive heating or and/or noise emission.
- Pumps operate at ultrasonic frequencies and can generate ultrasound levels up to around 80 dB SPL at 0.3m when operated at 1.4W input power. Care must be taken during testing and product design to comply with applicable ultrasound exposure limits.
- Pumps and pump modules contain lead titanium zirconium oxide (CAS number 12626-81-2).
- Pumps and pump modules contain piezoelectric elements which may store and/or generate electromechanical energy. Appropriate assessment must be carried out by the customer prior to use in explosive or flammable environments or for applications requiring Intrinsic Safety.
- Pump modules can produce up to 60Vdc (120Vpp / 50 Vrms) under normal conditions, and >100 Vdc (200Vpp / 90 Vrms) in a fault condition. Care must be taken when operating pump modules and in the design of products incorporating them to avoid exposure to electrical connections.
- The pump modules emit electromagnetic radiation. The customer should evaluate the emissions of the end product(s) to assess conformity with relevant limits.
- Parts of the pump or pump module may become hot (>70 C) during normal operation, including certain electrical components. Customers must take appropriate care when handling pumps and pump modules and ensure that end users of products that incorporate these devices are protected when in operation.

Declaration of Incorporation of partly completed machinery.

According to The Machinery Directive (2006/42/EC) and Supply of Machinery (Safety) Regulations 2008 (S.I. 2012:3032) the products above are classified as partly completed machinery. These products are intended to be incorporated into or assembled with other items to form the final machinery.

It is the responsibility of the customer to ensure that the final machinery into which these products are incorporated have been declared in conformity with the relevant directives before being put into service.

A technical file for each product is retained at the manufacturer's address which has been compiled according to the Machinery Directive 2006/42/EC part B Annex VII. The technical file is available in electronic form on reasoned request by responsible authorities.

Name: Tom Harrison

Position: Managing Director

Signed: Tom Harrison
cn=Tom Harrison, o=LEE Ventus, email=harrisont@theleeco.uk, c=GB
2024.03.19 10:27:44 Z

LEE Ventus Ltd | P-2-070 Product Safety and Declaration of Incorporation v03 | Page 2 of 2

12.REVISION HISTORY

Revision	Date	Details
V05	31st Jan 2025	Added Declaration of Incorporation, more detail on port numbering and addition of accessories
V04	28 Oct 2024	Updated CE certificate, add Installation and Safety guidance and Declaration of Incorporation and pump port images.
V03	March 2024	Updated with the new version of the Disc Pump Control App (version 2.0) along the release of Firmware version 6.16. Updated guidance on connecting and configuring multiple SPMs over I2C.
V02	Feb 2024	Updated indicator LED behaviour with the introduction of Firmware version 6.16 Updated EK-03-0052 SPM Prototype Pneumatic Adapter Kit to new Lee number UACX0500600H
V01	June 2023	Branding changes inclusion of accessories and certificate of conformity
220608	8 June 2022	Select Digital Pressure Sensor on the Input drop down list for PID control
220425	25 April 2022	Added guidance on UART / I2C auto-detection and further details on EK-03-0052 SPM Prototype Pneumatic Adapter Kit
220414	14 April 2022	Various: UART/I2C voltage, connector pin identity, SLA advice update, U and I versions no longer applicable.
220304	4 March 2022	Initial release.