



Radiosynthesizer
Vacuum Pump
TESTBED
USER MANUAL

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CHANGE HISTORY

AUTHOR	DATE	CHANGES
Victor Amador	March 27 th , 2023	Initial Release

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1. INTRODUCTION

This manual supplies information necessary to effectively use the radiosynthesizer vacuum pump Testbed.

Used vacuum pumps may contain radioactive substances. Users must follow all applicable radiation safety measures when using this instrument.

Testbed was built completely in-house by the Molecular Imaging Core, a shared resource of the department of Diagnostic Imaging at St. Jude Children's Research Hospital.

DISCLAIMER: Deviations between the contents of this manual and the actual instrument are possible as long as they are not critical. Any change in hardware or software that is deemed critical will be documented in an updated version of the user manual to ensure this device can be validated and used for clinical purposes.

2. PHYSICAL OVERVIEW

2.1. General View



Figure 1: (1) quick-turn draw latch, (2) control panel, and (3) custom LCD bezel, (4) power plug for the pump, (5) muffler for the gas exhaust, (6) and elbow fitting pointing downwards to drain exhaust liquids.

2.2. Fluidic Connections

From facility	To Testbed	From Testbed
Argon gas P \geq 2bar (N ₂ also possible)	ARGON IN (1/8" tube OD push-in)	-
-	GAS WASTE (muffler)	Open exhaust
-	LIQUID WASTE	1/8" tube OD push-in to collection vessel

3. CONTROLS

The pushbuttons send a signal to a microcontroller to activate one of the modes of operation:



Figure 2: (1) captive panel screws and rubber vibration dampening grommets; (2) LCD mounted on the bezel; and (3) illuminated controls.

Select from the five available modes of operation by pressing on dedicated buttons on the top of the Testbed:

- **CYCLE:** runs the pump and switches the valves automatically to maintain the negative atmospheric pressure inside the pump. This helps clean the pump head internals. A PID algorithm switches the exhaust valve to maintain 65 kPa absolute in the supply line. The operator can manually increase the flow to force the removal of solvents accumulated inside the pump with the flick of the toggle switch.
- **PRESSURIZE:** increases the internal pressure of the pump. It is used to measure a leak rate or detect leaks.
- **VACUUM:** runs the pump against a closed inlet. Useful to test the quality of the vacuum.
- **HOLD:** closes all valves to measure leak rate or detect leaks.
- **VENT:** the controller opens the exhaust valve to equalize the pressure in the device and the atmosphere. This is recommended before the pump is removed from the instrument.

Additionally, two toggle switches allow the user to:

- Open a secondary gas inlet that delivers gas at a higher pressure into the system. It helps to remove deposits during the CYCLE mode.
- Toggle to another outlet, where a liquid collection container can be connected. Mild solvents can be used to clean the pump's internal surfaces. Operate the dedicated toggle switch alternate exhaust ports. Dedicated outlets reduce the possibility of an accidental spill from the outlet on the back of the instrument.

4. Logging Application

Test results can be optionally saved using a companion logging application. Its interface is organized in purpose specific pages accessible through tabs.

4.1. Comms Tab

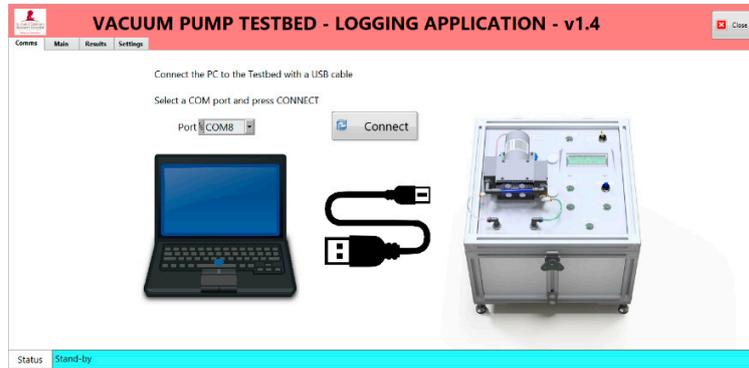


Figure 3. Communications tab.

Upon launching the application, users are prompted to select the USB port connected to the Testbed and press Connect. A successful connection will automatically switch to the Main tab.

4.2. Main Tab

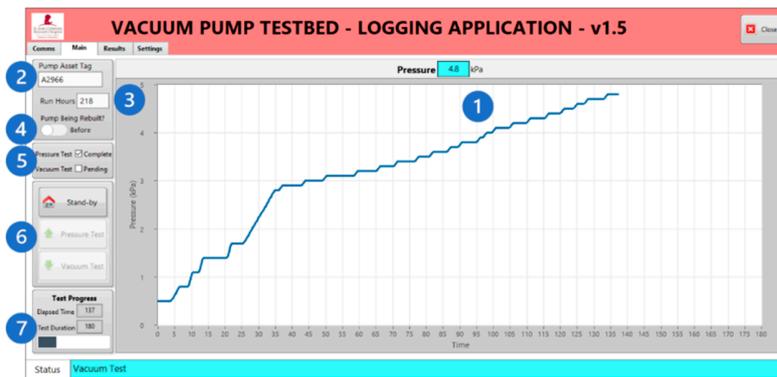


Figure 4. Main tab.

Here the user can monitor the reading from the pressure sensor and record tests results.

1. Chart Panel: shows the current pressure value and a historical graph.
2. Pump Asset Tag: type the asset tag code of the pump being tested.
3. Run Hours: type the reading from the pump's hour meter.
4. Pump Being Rebuilt?: select whether the test is conducted before or after the pump has been rebuilt.
5. Test Status Panel: automatically checks the boxes indicating if the pressure and vacuum test has been completed.

6. Mode Panel

- Stand-by: no data is being saved in this mode.
- Pressure Test: save readings to the pressurization section of the report.
- Vacuum Test: save readings to the vacuum tightness section of the report.

7. Test Progress Panel

- Elapsed Time: shows time passed since the start pressure or vacuum test.
- Test Duration: shows the duration of the pressure or vacuum test.

4.3. Results Tab

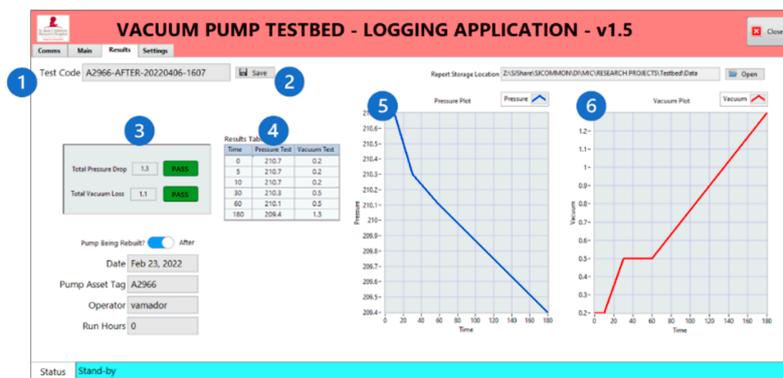


Figure 5. Results tab.

1. Test Code: a concatenated string composed from the pump asset tag code, rebuild status, date, and time the test was completed.
2. Pass/Fail Panel: summarizes the results and compares them with the acceptance criteria.
3. Save button: takes a screenshot of the Results tab and saves it to the chosen destination folder as a JPEG file with the Test Code name
4. Results Table: readings at several predefined times.
5. Pressure Plot: plots the results of the pressurization test.
6. Vacuum Plot: plots the results of the vacuum tightness test.
7. Save button: takes a screenshot of the Results tab and saves it to the chosen destination folder as a JPEG file with the Test Code name.

4.4. Settings Tab

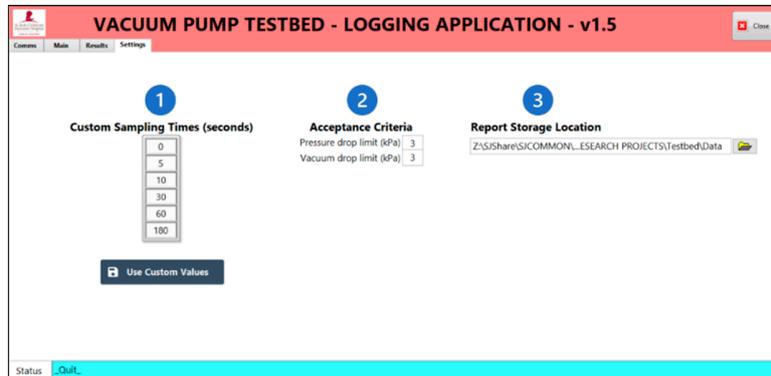


Figure 6. Results tab.

Allows users to check or change select test parameters. Values are reset to their defaults the next time the application is launched.

1. Custom Sampling Times
2. Acceptance Criteria
3. Report Storage Location.

5. OPERATION

5.1. Start Up



Figure 7: Rear view of the Testbed

1. Connect the inert gas supply line to the Testbed's GAS IN port.
2. Plug it in to the electrical outlet. There is a fused female IEC 320 connector on the back and the power supply is compatible with both 120V/60Hz and 220V/50Hz, so it can be easily adapted to any country's socket type
3. Toggle the power switch in the power entry module to the ON position and verify that the green light in the power entry module turns on.
4. Direct your attention to the LCD. After a welcome message, the current mode will be displayed along the top row. The current absolute pressure in kPa is always shown on the bottom row.

5.2. System Suitability Test

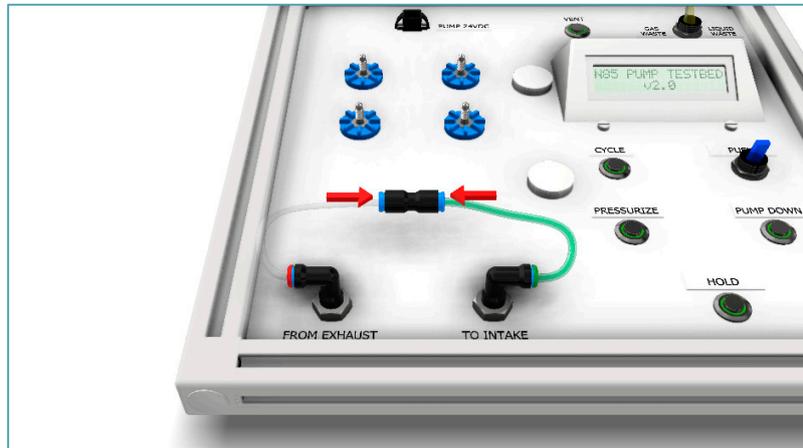


Figure 8: Connect intake and exhaust lines.

1. Connect the lines labeled TO INTAKE and FROM EXHAUST together using a female push-in coupling fitting.
2. Select PRESSURIZE
3. Verify that the pressure reading is between 205 and 220 kPa and wait until the value stabilizes.
4. Press HOLD and observe the leak rate.
5. Pressure drop shall not exceed 3 kPa in 3 minutes.

5.3. Coupling To Pump

1. Open the lid.
2. Line up the four threaded holes on the base of the pump with the captive panel fasteners.
3. Drive the captive panels fasteners until the base of the pump touches the blue vibration dampeners.
4. Close the lid and lock the latch. A gas spring keeps the lid open.
5. Connect the green 1/8" OD tube to the intake port of the pump.
6. Connect the clear 1/8" OD tube to the exhaust of the pump.
7. Connect the pump's electrical connector to the 24V DC socket.
8. Connect the Testbed to the computer with a male USB-A to male USB-B cable.
9. Turn on the computer and open the Testbed Logger application.
10. In the Communications Tab, use the drop down menu to select the correct COM port number.
11. Press CONNECT.
12. In the Main Tab, fill in the pump information fields.

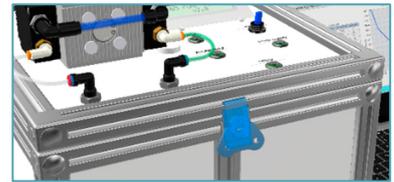


Figure 9: Quick-turn draw latch

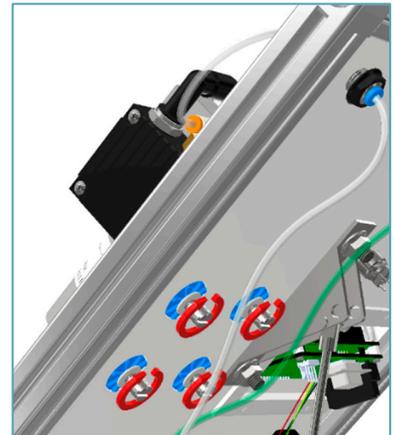


Figure 10: Captive panel fasteners

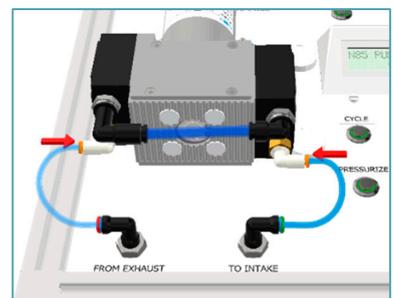


Figure 11: Intake and exhaust connections.



Figure 12: Pump power connector.

5.4. Purge the pump

1. Press CYCLE.
2. Allow the pump to circulate inert gas for at least 5 minutes. During this time, V14 should open every 2 to 5 seconds, with the pressure reading oscillating around 75kPa. Check for condensation forming in the clear tube coming from the exhaust port. If necessary, open the Testbed's lid and adjust the needle valve as shown in Figure 13 until V14 cycles every 2 to 5 seconds.

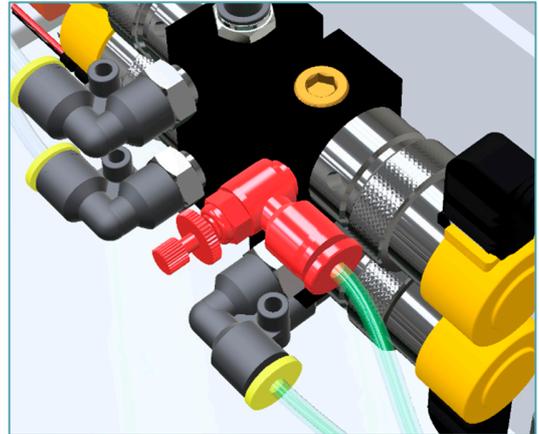


Figure 13: Loosen or tighten the knob on the fitting highlighted in red fitting to reduce or increase the flow.

3. Briefly move the PUSH toggle switch to increase the pressure. Do not exceed 120 kPa for more than 5 seconds. Larger drops may appear in the exhaust line.
4. Release the PUSH switch and let the pressure return to 75 kPa.
5. Repeat steps 16 and 17 until no condensation is visible.

5.5. Vacuum Test

1. Press VACUUM and verify that the pressure is between 0 and 6 kPa.
2. Press HOLD.
3. Press VACUUM TEST in the Main tab of the logger application to record the results.

5.6. Pressure Test

1. Once the test is completed, press PRESSURIZE and verify that pressure is between 200 and 220 kPa.
2. Press HOLD.
3. Press PRESSURE TEST in the Main tab of the logger application to record the results.
4. Once the test is completed the logger application will show the Results tab. If the leak rate is within limits, press Save to archive the results.

5.7. Shut Down

1. Press VENT to equalize pump and atmospheric pressures.
2. Power off the Testbed and unplug the power cord from the wall outlet
3. Disconnect the inert gas supply line.
4. Break gaseous and electrical connections to the pump.
5. Open the lid and loosen the captive panel fasteners to remove the pump.
6. Close the lid.

6. Maintenance

6.1. Cleaning

To prevent damage from exposure to aggressive solvents during pump testing, the Testbed should be purged and dried with inert gas.

1. Connect the lines labeled TO INTAKE and FROM EXHAUST together using a female push-in coupling fitting.
2. Press CYCLE and let gas flow for 5 minutes.
3. Press HOLD and place a container under the liquid waste port on the rear of the Testbed.
4. Move the waste mode selector to the LIQUID WASTE position.
5. Press CYCLE and let gas flow for 5 minutes.

6.2. Yearly Maintenance

1. Replace all tubing.
2. Inspect all fittings and their rubber seals for wear.
3. Disassemble all valves and check their internals.
4. Inspect wiring for loose connections and damaged components.
5. Tighten structural fasteners.
6. Calibrate or verify the pressure sensor readings are against a NIST-certified gauge.

7. TECHNICAL SPECIFICATIONS

7.1. Mechanical and inert gases

Inert Gas	2 bar maximum
Max. operating pressure	7.23 / 105 bar rel. / psi
Ultimate Vacuum	3 (mbar abs)
Delivery at atm. Pressure	6 (l/min)

7.2. Electrical Specifications

Voltage	110 – 120 Vac
Frequency	47 – 60 Hz
Power Supply Capacity	250 W
Maximum Internal Power Consumption	240 W
Overvoltage Protection	130 %
Over-current Protection	Typical: 110 %, Maximum: 140 %
Short Circuit Protection	Continuous with auto-recovery
Over Temperature Protection	85 C with auto-recovery

7.3. Environmental Specifications

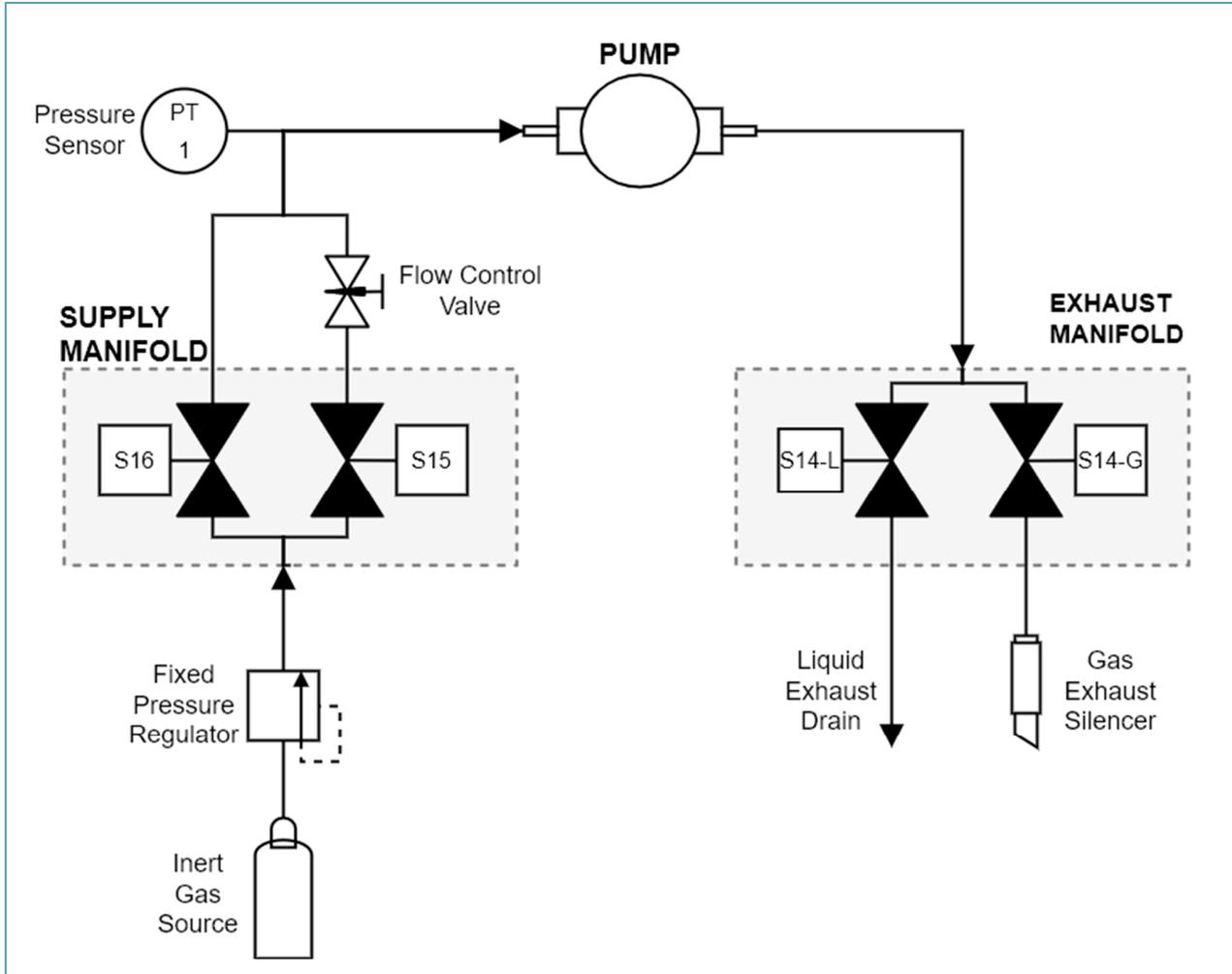
Operating Temperature	0 – 50 C
Storage Temperature	-20 – 85 C
Operating Humidity	5 – 90 % Non-condensing
Storage Humidity	5 – 95 %

7.4. Dimensions

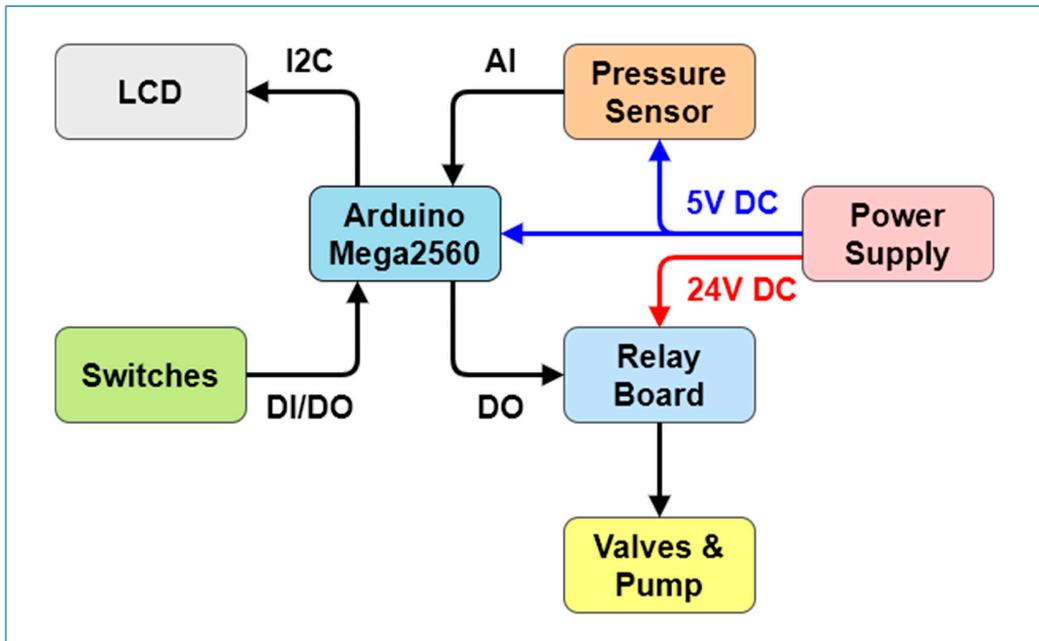
W x D x H	300 x 300 x 400 mm
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8. TECHNICAL DOCUMENTATION

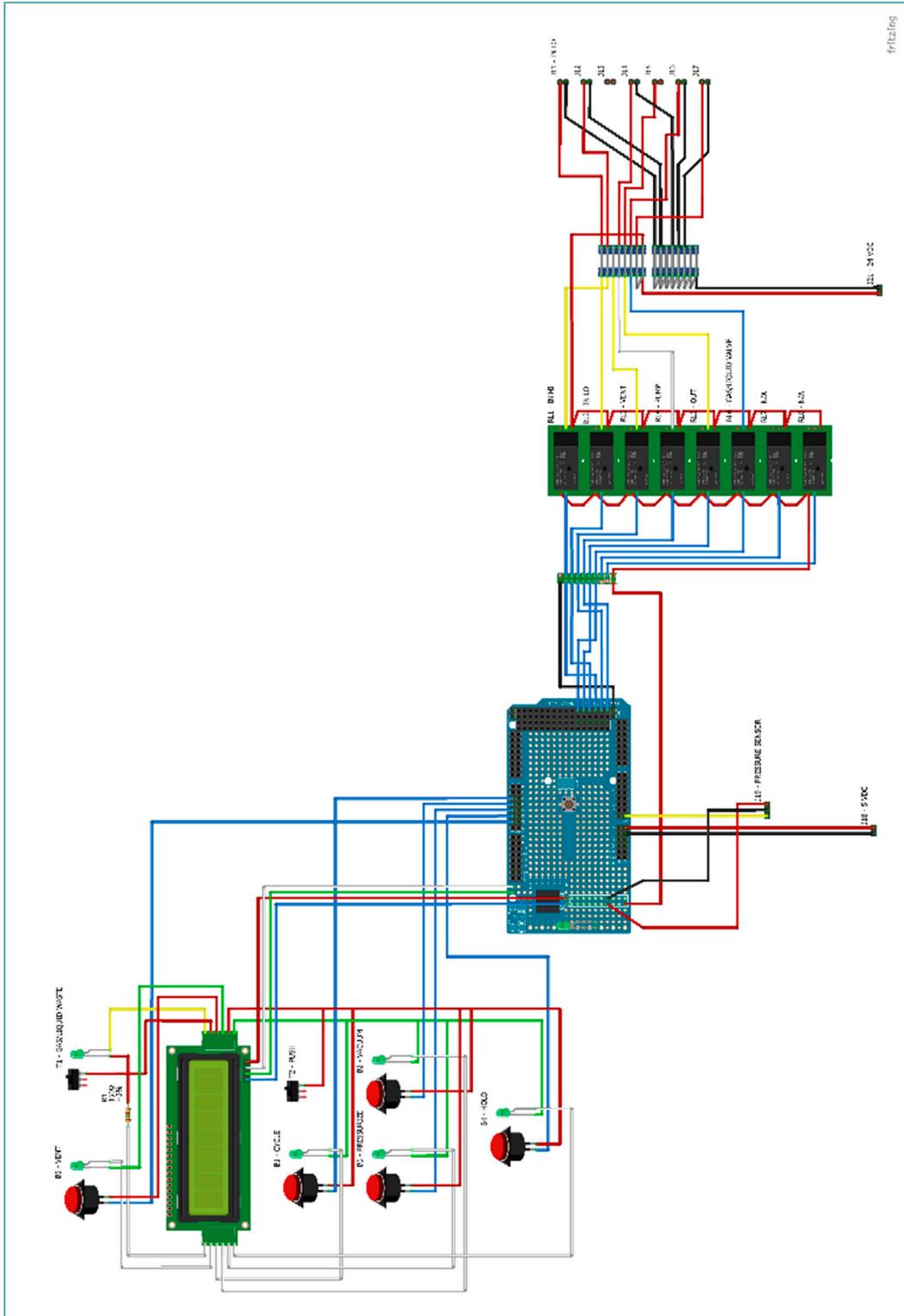
8.1. Fluidic Diagram



8.2. General Power and Signals Distribution



8.3. Detailed Wiring



9. SIMPLIFIED PARTS LIST

TYPE	DESCRIPTION	VENDOR	PART NUMBER	QTY
ENCLOSURE	240mm Aluminum T-Slotted Framing Extrusion Rail, Single Profile, 20mm Size, Solid	McMaster-Carr	5537T9	12
	120mm Aluminum T-Slotted Framing Extrusion Rail, Single Profile, 20mm Size, Solid	McMaster-Carr	5537T9	6
	3-Way Corner Bracket for 20 mm High Single Rail	McMaster-Carr	5537T289	8
	Outside Corner Bracket for 20 mm High Single Rail	McMaster-Carr	5537T286	4
	Heavy Duty Hinge for 20mm High Single Profile Aluminum T-Slotted Framing Extrusion	McMaster-Carr	5537T859	2
	Swivel Leveling Mount, Nickel-Plated Steel with 2" Long 10-32 Threaded Stud	McMaster-Carr	6111K45	4
	T-slotted Silver Surface Bracket, 1-1/2" Long for 20 mm High Rail	McMaster-Carr	5537T944	5
	18-8 Stainless Steel Hex Drive Flat Head Screw, M4 x 0.7 mm Thread, 12 mm Long	McMaster-Carr	92125A192	9
	18-8 Stainless Steel Cap Nut, M4 x 0.7 mm Thread	McMaster-Carr	94000A035	3
	Spring-Loaded Ball Fastener, M5 Thread Size for Aluminum T-Slotted Framing Extrusion	McMaster-Carr	5537T75	8
	Turn-to-Open Draw Latch, Stainless Steel, Nonlocking, 3/4" Latch Distance	McMaster-Carr	1406A46	1
	Impact-Resistant Polycarbonate Sheet, 24" x 24" x 1/8"	McMaster-Carr	8574K193	1
	Clear Impact-Resistant Polycarbonate, 12" x 12" x 1/16" Sheet	McMaster-Carr	8574K24	1
	Tie Cable Holder for 20 mm High Single Rail T-Slotted Framing	McMaster-Carr	5537T356	1
	Thumb-Screw-Head Captive Panel Screw, M4 x 0.7mm Thread Size, 22mm Long	McMaster-Carr	95536A357	4
	Vibration Damping Grommets, Ribbed, 0.17" Hole Diameter, 0.39" Overall Thickness	McMaster-Carr	9311K62	4
	Retainers for M4 x 0.7mm Thread Size Captive Panel Screws	McMaster-Carr	91065A850	4
	Compression Springs, Corrosion Resistant, 9.5 mm Long	McMaster-Carr	94125K472	4
	Spring Clip Holder for 7/8" to 1.25" Item Diameter, Nylon-Coated Steel	McMaster-Carr	1722A32	1
	Fastener Caps, Hinged, for 1/4" Thread Diameter - White	McMaster-Carr	91620A300	2
	Gas Spring, Miniature, stroke: 3.54in, compression force: 6lbs	McMaster-Carr	9417K6	1
Heavy Duty 0.16" ID Eyelet Mounting Bracket for Gas Spring	McMaster-Carr	9417K92	1	

	Nylon Plastic Washer for M3 Screw Size, 3.2 mm ID, 8 mm OD, Off-White	McMaster-Carr	95610A130	4
	Plastic Narrow Cheese Head Slotted Screws Off-White Plastic, M3 X 0.5 mm Thread, 6 mm Long	McMaster-Carr	95280A116	12
	Nylon 6/6 Male-Female Threaded Hex Standoff, 4.5mm Hex, 10mm Long, M3 x 0.50 mm Thread	McMaster-Carr	95783A057	12
FLUIDIC CONNECTIONS	Elbow 1/8" push-in to male #10-32	Clippard Minimatic	PQ-ME04N	3
	Brass Pipe Fitting with Sealant, Plug with Hex Drive, 1/8 NPT	McMaster-Carr	50785K918	2
	EV, ET, EC Series Accessories - Multi-Valve Manifold - 2 Stations	Clippard Minimatic	15481-2	2
	2-Way Normally-Closed Valves, Manifold Mount - Standard - Terminal Spades - Vac. to 105 psig+ - 24 VDC	Clippard Minimatic	ET-2M-24	4
	Flow Control Valve, Meter Out from #10-32 Male Thread to 1/8" OD Tubing	Clippard Minimatic	PQ-CV04N	1
	30 PSI Fixed-Pressure Compressed Air Regulator, Zinc Housing 300 Maximum PSI, 1/8 NPT Female	Parker	14R011FCL030	1
	Mounting Bracket Kit for Parker 10F, 14F, P3AR, 14R, 14E and 15R Series Filter/Regulator	Parker	PS417BP	1
	Push-to-Connect Tube Fitting for Air, Thru-Wall 90 Degree Elbow Connector, for 1/8" Tube OD	McMaster-Carr	5779K275	1
	Identification Ring for 1/8" Tube OD Push-to-Connect Tube Fitting for Air - Green	McMaster-Carr	5779K791	1
	Identification Ring for 1/8" Tube OD Push-to-Connect Tube Fitting for Air - Red	McMaster-Carr	5779K791	1
	Muffler, 1/8 NPT Male, Copper, 18 scfm @ 100 PSI Flow Rate	McMaster-Carr	4450K17	1
	Push-to-Connect Tube Fitting for Air, Long 90 Degree Elbow, for 1/8" Tube OD x 1/8 NPT Male	McMaster-Carr	5779K148	2
	Push-to-Connect Tube Fitting for Air, Thru-Wall Adapter, for 1/8" Tube OD x 1/8 NPT Female	McMaster-Carr	5779K267	1
	Push-to-Connect Tube Fitting for Air, Through-Wall Connector for 1/8" Tube OD	McMaster-Carr	5779K675	1
	Push-to-Connect Tube Fitting for Air, Inline Tee Adapter, for 1/8" Tube OD x 1/8 NPT Female	McMaster-Carr	5779K226	1
	Push-to-Connect Tube Fitting for Air, Wye Connector, for 1/8" Tube OD	McMaster-Carr	5779K41	1
	Firm Polyurethane Tubing for Air and Water, 1/16" ID, 1/8" OD, Clear	McMaster-Carr	5648K67	1
	Firm Polyurethane Tubing for Air and Water, 1/16" ID, 1/8" OD, Clear Green	McMaster-Carr	5648K67	1

ELECTRONICS AND POWER DISTRIBUTION	Power Supply Dual Voltage DC 24V/12V	CUI	VF-D250-D1224A-CF	1
	50 psi absolute pressure range, cable connection	Omega	PX309-050A5V	1
	Arduino MEGA 2560 Rev3	Arduino	A000067	1
	Mega protoshield for Arduino	Adafruit	192	1
	8 Channel DC 5V Relay Module	Sainsmart	20-018-102-CMS	1
	power entry module without fuse IEC320-C14	Schurter Inc.	DC11.0031.001	1
	terminal block 4pos/2cir blue miniDIN	Phoenix Contact	3000926	3
	miniDIN rail 15x5.5mm	Weidmuller	117510000	1
	terminal block 4pos/2cir grey miniDIN	Phoenix Contact	1414129	5
	terminal block fixed bridge 10 positions	Phoenix Contact	3001608	1
	terminal block end cover for 4pos grey miniDIN	Phoenix Contact	3002665	1
	terminal block 2pos/1cir grey miniDIN	Phoenix Contact	3100305	1
	Pushbutton Switch SPST-NO Anti-Vandal, Illuminated Panel Mount, Front	E-Switch	PV0H240SS-331	5
	LCD i2c alphanumeric 16x2 grey on white	Matrix Orbital	LK-162-12-GW	1
	Illuminated Toggle Switch DPDT Panel Mount - AMBER	NKK switches	TL22SDAG015D	1
	Illuminated Toggle Switch DPDT Panel Mount - AMBER	NKK switches	TL22SNAG016G	1
	USB 2.0 B Female Socket Printer Panel Mount to Right angle USB 2.0 Type-B Male Adapter Cable	Amazon	B01LRZ8GK2	1
	Rectangular Connectors - Housings Plug Black 0.098" (2.50mm), X-key, 3 positions, panel mount	TE Connectivity	1-1318116-3	1
	Connector Housing, 16 positions Black 0.100" (2.54mm)	TE Connectivity	102387-3	1
	Connector Header Through Hole 16 position 0.100" (2.54mm)	TE Connectivity	5104338-3	1