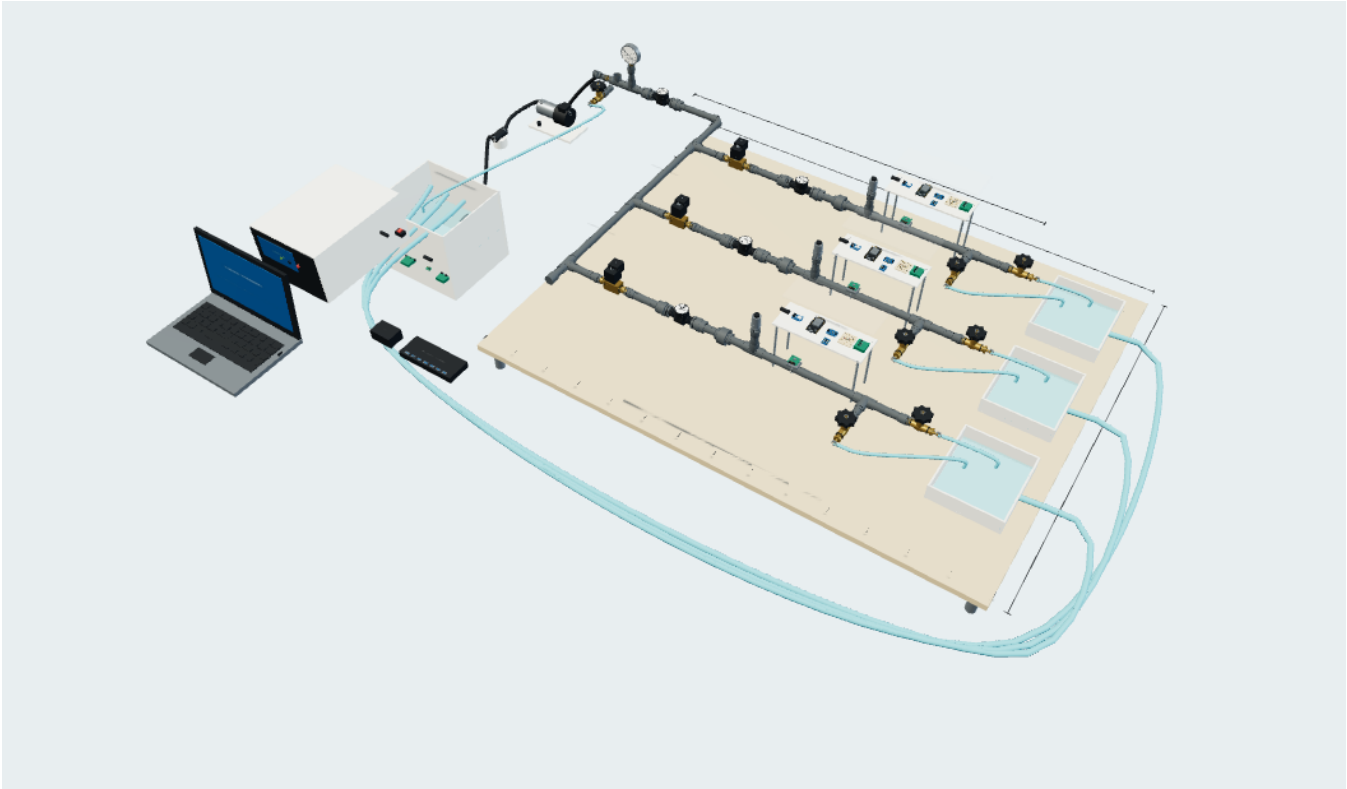


A real-parts reference your team can inspect.

R1 - 20 October 2026 | 3-zone laboratory prototype



Included	Scope
Interactive 3D + GLB	Offline HTML with named parts, exact endpoint tables and selectable wires/joints. GLB uses metres and includes part metadata.
303 component / material instances	135 external electrical connections and 201 plumbing connection records. Repeated boards, passive parts, reducers, seals and clamps are separate items.
Manufacturer geometry	STEP-derived meshes for Adafruit 1085, Adafruit 5648 and Tameson NLB-014. Other shapes are reconstructed or custom.

This is a reference design, not a physically validated fabrication release. You have not supplied the actual purchased part labels or photos. Use the listed reference variants, complete the open fit checks, and validate one zone before copying it three times.

Start by opening `Leak_Finder_Reference_Model.html` in a desktop browser. It contains its own 3D library and images and needs no internet connection.

01 / BUILD REFERENCE

How to use the package

File	What it does
Leak_Finder_Reference_Model.html	Open locally in Chrome, Edge, Firefox or a browser with WebGL. Rotate, zoom, choose a part, click a wire or joint ID, and inspect named endpoints. No installation or server is required.
Leak_Finder_Reference_Assembly.glb	Import into Blender or another glTF 2.0 viewer. Units are metres, Y is up. Nodes carry part IDs, manufacturer references and geometry status. It is a mesh assembly, not editable feature-based CAD.
electrical_connections.csv	Every external electrical connection, from component and pin to component and pin. USB and adapter cords are manufactured cable assemblies.
plumbing_connections.csv	Every named wet joint, its two ports, joining method and remaining fit check.
bill_of_materials.csv	Reference manufacturer numbers and modeled counts. Small pipe spans are not cut lengths or stock purchase quantities.
reference_design.json	Canonical project data used to generate the HTML, guide and tables. Teammates can inspect or revise the design from this file.

Find any connection

Open Wire by wire or Pipe joints. Filter a circuit or zone. Click E001, J001 or any other ID to return to 3D with both endpoints identified. The same IDs appear in the appendices below.

Find the laptop connection

Use the Laptop -> hub -> ESP32s view. One cable runs from the laptop USB port to the UH700 USB 3 Micro-B HOST port. Three separate Type-A-to-Micro-USB data cables connect hub ports 1-3 to ESP32 nodes A-C. Firmware upload and serial data use these USB connectors, not GPIO pins.

Work in layers

Start with Complete rig, then One zone, Local electronics, ESP32 header close-up or the socket section. Electrical harness is a visibility control. Explode layers is an inspection aid; the displaced parts and fixed cable paths are not an assembly position.

The viewer exports the complete GLB even when a focused view is selected. Its PNG button saves the rendered canvas; labels in the inspector remain in the HTML and this PDF.

02 / BUILD REFERENCE

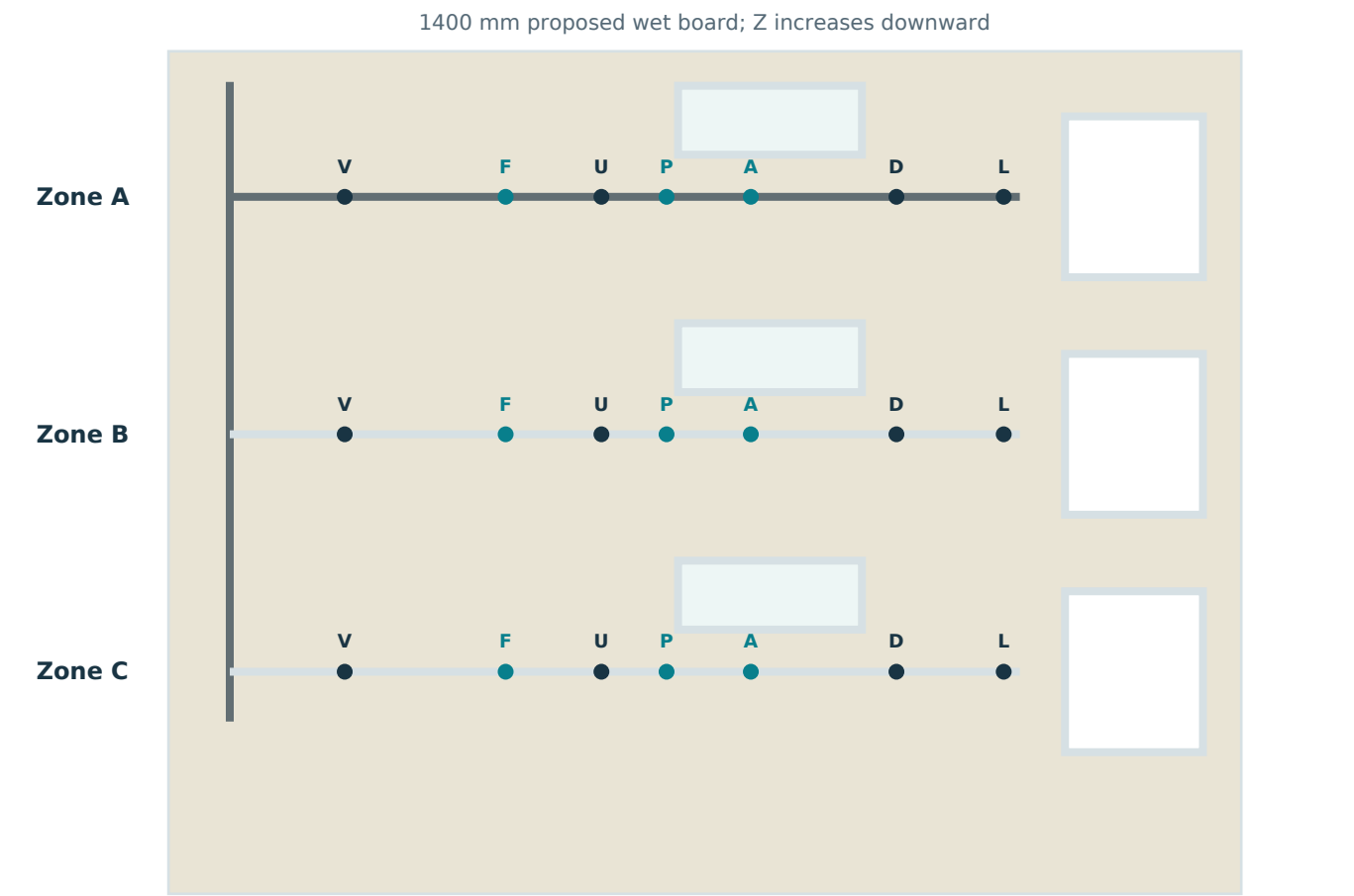
The reference parts that matter

Qty	Exact reference	Purpose / restriction
3	Espressif ESP32-DevKitC V4, WROOM-32E	Classic 38-pin board. USB powers each node. The specified header numbers do not apply to arbitrary ESP32 clones.
3	ADI EVAL-ADXL355-PMDZ	SPI vibration sampling. P1 numbering is authoritative. Mount to a rigid pipe saddle, without drilling into the water path.
3	Adafruit 1085 ADS1115, STEMMA QT revision	Pressure ADC. VIN 3.3 V, ADDR to GND, I2C address 0x48. Use A0, not the A+ power rail.
3	Adafruit 757 BSS138 level converter	Translate NPN flow pulses: HV 5 V, LV 3.3 V, common GND; zone OUT to B1, A1 to GPIO34. Node A also uses B2/A2 for F0.
4	DFRobot SEN0550	One main and three zone flow meters. G1/2 male, 5 V supply in this design, nominal 150 pulses/L. This replaces the earlier SEN0217 concept.
3	DFRobot SEN0257, 0-16 bar version	5 V supply, nominal 0.5-4.5 V output. Bare G1/4 port used in the adapter chain. Verify the range label.
3	Burkert 6013 article 125300 + plug 314802	12 V DC NC isolation valve; G1/4 female, 0-6 bar. Select the plain Form A plug. Use 9 W cold-coil power for sizing.
3	Adafruit 5648 MOSFET Driver	Purchased driver with AO3406, flyback protection and 10k IN pull-down. 1.5 A continuous rating exceeds the 0.75 A reference coil current.
7	Tameson NLB-014	Three leak needles, three normal-demand needles and one upstream manual bypass. The bypass is not an independent relief device.
1	Pentair SHURflo SLV10-AA40	12 V intermittent-duty diaphragm pump; confirm exact SKU label and pressure curve. Nominal 40 psi demand shutoff.
1	TP-Link UH700 V5 + included adapter	Powered USB hub with USB 3 Micro-B HOST input, 7 Type-A outputs and supplied 12 V/2 A adapter.

A complete reference bill, including all fitting codes, appears in Appendix A and the CSV. Custom supports, seals and commodity items are distinguished from confirmed manufacturer SKUs.

03 / BUILD REFERENCE

Scale, layout and space



Dimension	Reference value / meaning
Wet support board	1400 x 1100 x 18 mm proposed board. Reserve additional dry space for reservoir, pump, supply and laptop; overall illustrated envelope is about 2200 x 1700 mm.
Zone centre lines	A: Z=190 mm; B: Z=500 mm; C: Z=810 mm. Pitch is 310 mm. Main header X=80 mm.
Straight pipe height	100 mm from board top to horizontal pipe centre line. Supports and heavy valve mounts are custom.
Branch X positions	Isolation 230; flow 440; union 565; pressure 650; vibration 760; demand tee 950; leak needle 1090 mm.
Pipe dimensions	GF 161017106: OD 20.0, wall 1.5, ID 17.0 mm. Small stubs use d16 and d12 metric GF pipe. Do not substitute 1/2-inch ASTM pipe.
ESP32 grid	27.94 mm core width; 48.26 mm core length plus 6.04 mm antenna extension. Header row spacing 25.40 mm; pin pitch 2.54 mm.

Do not cut from the coordinates. A pipe span between fitting faces needs actual socket insertion added at both ends. Nested reducing bushes, thread engagement, adapter sealing seats and clamp clearance must be measured on the received parts.

04 / BUILD REFERENCE

How the water circuit joins

Water path: open reservoir -> suction strainer -> pump -> upstream bypass tee -> gauge -> F0 -> dead-ended 20 mm header -> three independent branches. The bypass takeoff is before F0, so bypass return does not count as zone inlet flow.

Interface	Complete reference adapter chain
20 mm pipe to G1/4 female valve	20/16 bush GF 721900334 -> 16/12 bush 721900331 -> 12 mm pipe stub 161017104 -> 12 mm socket/G1/4 female instrument adapter 721916204 -> sealed G1/4 male/male nipple FL2S-M-B-014G -> valve female port. Repeat on the other valve side.
20 mm pipe to G1/2 male flow sensor	20/16 bush 721900334 -> 16 mm stub 161017105 -> 16 mm socket/G1/2 female instrument adapter 721916206 -> matched flat seal -> SEN0550 male port. Repeat at the outlet. Follow the molded flow arrow.
Pressure sensor branch	20 mm tee 721200106 -> 20/16 bush -> 16/12 bush -> 12 mm stub -> GF G1/4 instrument adapter -> bare SEN0257 G1/4 male port with approved seal. Supplied G1/2 adapter is not used in this chain.
Leak or demand needle	20 mm branch -> same G1/4 adapter chain -> sealed male/male nipple -> NLB-014 female inlet. Its outlet receives a G1/4 male x 6 mm barb -> clamped 6 mm ID pressure hose -> free discharge with visible air gap.
Removable union	Solvent-weld the two d20 tail sockets only. Keep the centre nut and EPDM O-ring clean. The nut is a mechanical service joint, not a glued connection.

Joining methods

Deburr, clean and mark each actual PVC socket depth. Use the pipe system-approved cleaner/cement, assembly time and full cure time. Use the manufacturer seal method at each G/BSPP port; do not rely on thread size alone. Do not force NPT, Rp or mismatched inch pipe into this system.

Open returns

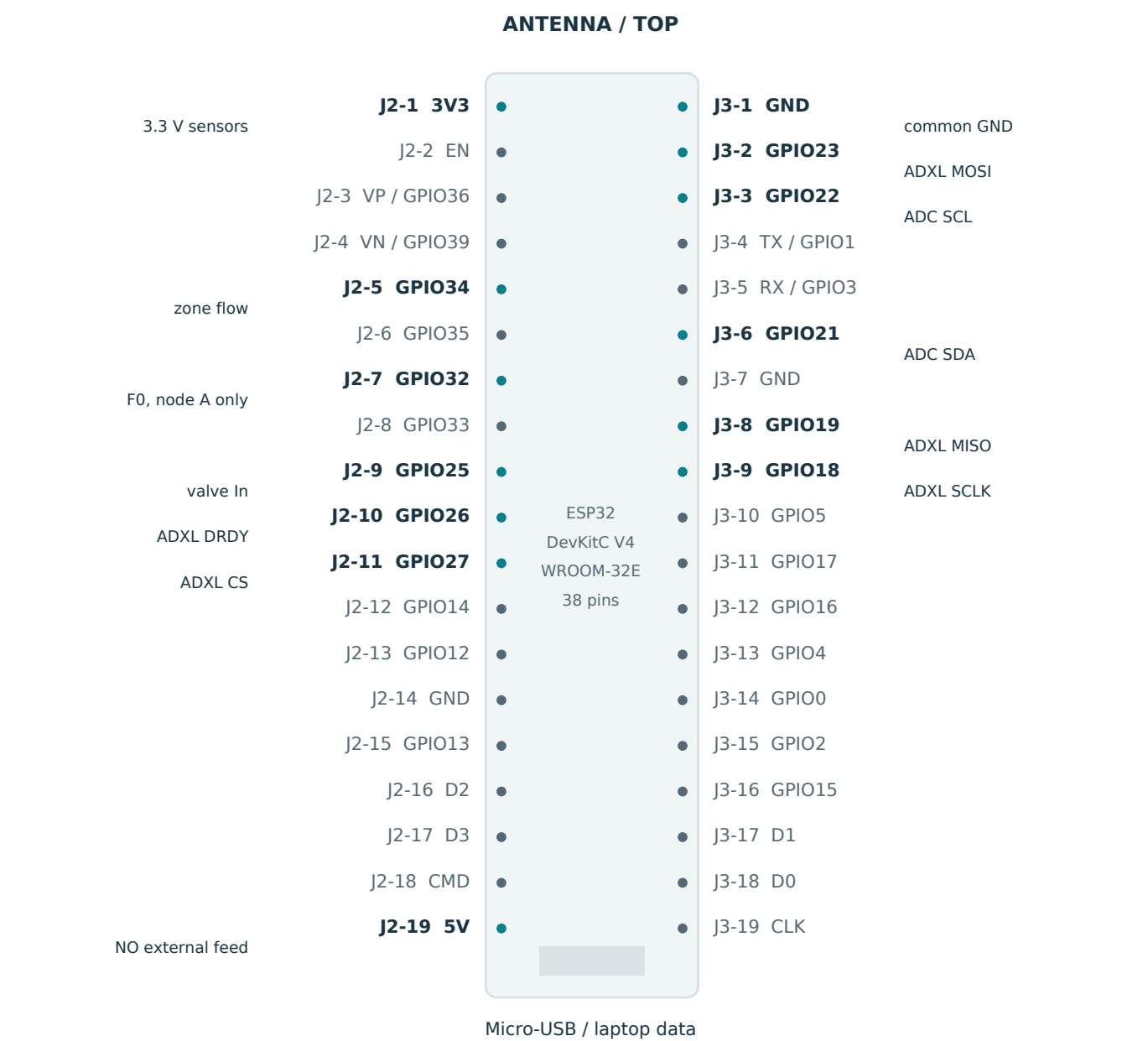
Leak and demand outlets discharge separately to open trays. Each tray drain falls continuously to the lower, vented reservoir. Keep return discharge above reservoir water level and leave visible air gaps. No shared pressurized outlet pipe connects the zones.

Supplier seat checks remain open for the G1/2 flow mating pair and G1/4 sensor/nipple adapters. Those checks are needed even though the documented nominal thread sizes match.

05 / BUILD REFERENCE

ESP32: the pin map to follow

Top view, antenna at the top and Micro-USB at the bottom. This is the 38-pin Espressif DevKitC V4 / WROOM-32E reference. Use the header number and signal name together; confirm the board before wiring.



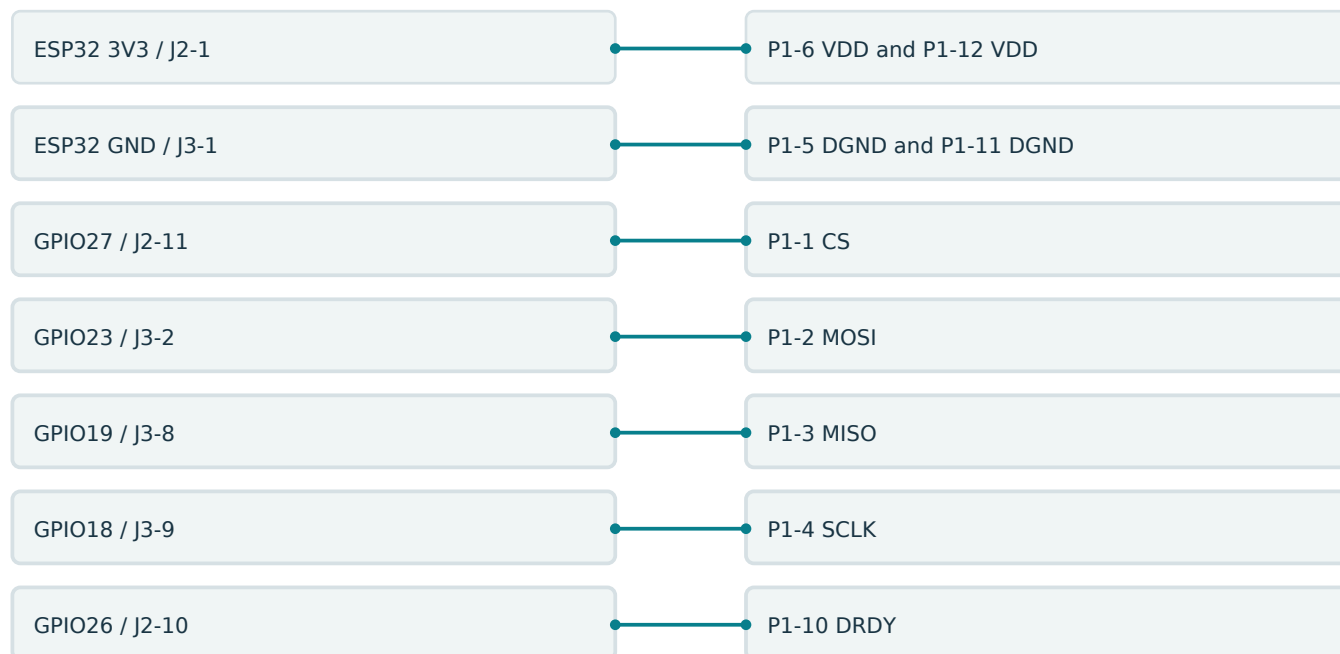
USB is the board power input in this design. Leave J2-19 5V unconnected to the external sensor rail. GPIO34 is input-only. Node A alone uses GPIO32 for main inlet meter F0. All other nodes use the same local sensor and valve mapping.

Source: Espressif DevKitC V4 guide and mechanical drawing. Header span is 18 intervals x 2.54 = 45.72 mm; row spacing is 25.40 mm.

06 / BUILD REFERENCE

Accelerometer: exact P1 connections

Repeat for each local zone node



Mechanical connection

Clamp a rigid saddle around the straight 20 mm pipe and secure the EVAL-ADXL355-PMDZ board to it. Support the board without stressing its PCB. There is no water port and no hole through the pipe. Do not put foam between the sensing board/saddle and pipe.

Connector orientation

Identify P1 pin 1 from the board mark and Analog Devices documentation. Pins 7 INT1, 8 NC and 9 INT2 are unused. Do not infer pin numbering from the perspective of the reconstructed board body.

Keep the measurement local

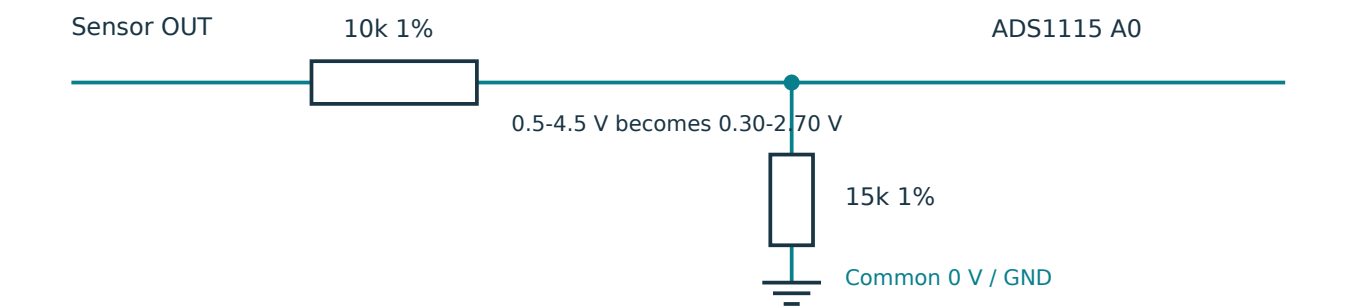
Target a short local SPI harness, about 100-150 mm, and verify actual signal quality. Each zone has its own ESP32; there is no long shared SPI bus across the whole rig. Rigid coupling and repeatable clamp torque affect the result.

ADXL355 has not been proven to distinguish leaks on your selected PVC rig. Collect no-leak, pump-only, normal-demand and controlled-leak samples before choosing detection thresholds or claiming accuracy.

07 / BUILD REFERENCE

Pressure: divider and ADS1115

SEN0257 pressure output -> 0.60 divider



From	To
SEN0257 VCC / GND	External regulated +5 V / common 0 V
SEN0257 OUT	10k top resistor -> junction P
Junction P	15k bottom resistor -> GND; also wire to ADC A0
ESP32 3V3 / J2-1	Adafruit 1085 VIN
ESP32 GND / J3-1	ADC GND
GPIO21 / J3-6	ADC SDA
GPIO22 / J3-3	ADC SCL
ADC ADDR	ADC GND for I2C address 0x48

Use the correct ADC revision

The reference is Adafruit 1085 with STEMMA QT, not an unspecified ADS1115 module. This board has I2C pull-ups to VIN. Supply VIN with 3.3 V. A+ and A- are power rails on this revision; A+ is not a signal input. ALRT and A1/A2/A3 are unused.

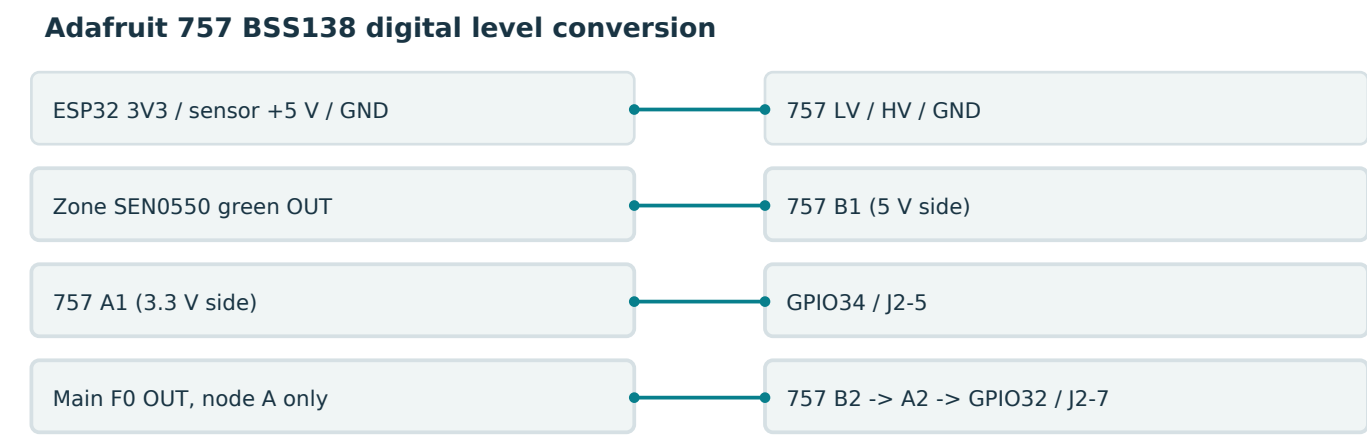
Convert, then calibrate

Use PGA +/-4.096 V for the 0.30-2.70 V input span. That gain setting does not allow A0 above the ADC supply. Raw sensor voltage = ADC volts / 0.60. For the stated 0-16 bar sensor, nominal pressure in bar = (raw volts - 0.50) x 4. Apply calibration against a reference gauge.

The stated 0.5-1% full-scale accuracy corresponds to 0.08-0.16 bar on a 16 bar sensor. Small pressure changes on a low-pressure rig may need a better-suited sensor. Do not treat ADC resolution as sensor accuracy.

08 / BUILD REFERENCE

Flow: translate the NPN pulse levels



Flow input	Translated output endpoint
Zone A flow FA	A-F OUT -> A-LEVEL B1; A-LEVEL A1 -> A-ESP J2-5 GPIO34
Zone B flow FB	B-F OUT -> B-LEVEL B1; B-LEVEL A1 -> B-ESP J2-5 GPIO34
Zone C flow FC	C-F OUT -> C-LEVEL B1; C-LEVEL A1 -> C-ESP J2-5 GPIO34
Main inlet F0	F0 OUT -> A-LEVEL B2; A-LEVEL A2 -> A-ESP J2-7 GPIO32

Sensor harness

For SEN0550, red is VCC, black is GND and green is pulse OUT. Supply it from the external regulated 5 V rail. Join sensor grounds to local signal ground. The 757 uses LV=3.3 V, HV=5 V and common GND; connect signals by A/B labels, not a guessed header order. Unused channels remain open.

Why a level converter

The sensor is specified as an NPN pulse output. The selected BSS138 board includes 10k pull-ups and supports slow digital signals. This avoids depending on an unspecified output pull-up when loading the signal with a resistor divider. At the stated maximum flow, nominal pulse frequency is 50 Hz. Verify the actual 3.3 V-side high/low levels and edge quality before connecting GPIO34. Do not use this converter for analog pressure.

Count and calibrate

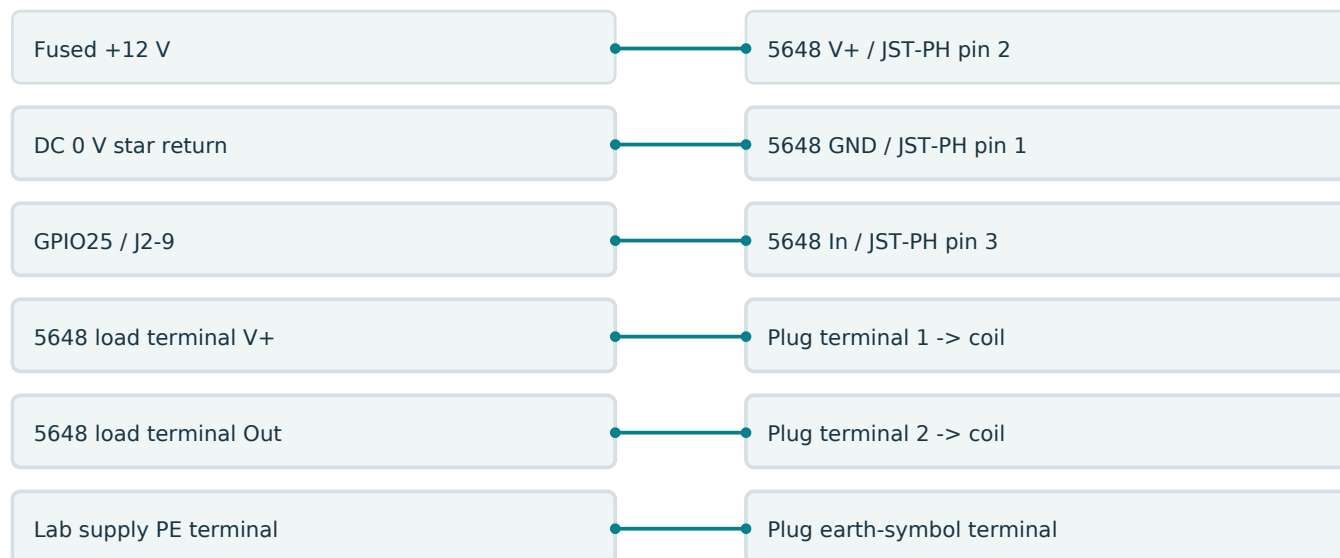
Reference factor is 150 pulses per litre. Nominal flow L/min = frequency Hz x 60 / 150. Measure a timed collected volume and fit each meter independently. Zero pulses do not prove zero leakage. Stated flow range is 30-1200 L/h (0.5-20 L/min); confirm low-flow performance experimentally.

The 1 GPM pump family loses flow as pressure rises. Do not assume three zones will all stay above 0.5 L/min at once. Establish the operating point with one branch, then measure each additional branch.

09 / BUILD REFERENCE

Valve: use the assembled driver

Adafruit 5648 -> Burkert 125300 + plain 2518 plug



Why this driver

The selected coil is 9 W at 20 C, about 0.75 A at 12 V. Burkert also lists 8 W warm-coil power. Size for the 9 W case. The Adafruit 5648 board is rated 1.5 A continuous, accepts 3.3 V control and contains the MOSFET, flyback diode and 10k input pull-down. Those are internal board components, not extra parts to assemble.

How to attach the wires

Use a correctly pinned 3-wire JST-PH harness for V+, GND and In, or the matching labeled board pads with suitable rated soldered connections. Use the two output terminals marked V+ and Out for the valve cable. Follow the terminal-block wire preparation instructions. A charge/data cable connector cannot replace this harness.

PE and polarity

The plain DC coil is not polarized, but use terminal 1 as positive and terminal 2 as the switched return consistently with this drawing. The driver flyback path is polarized. The plug earth symbol connects to the lab earth terminal, separately from DC negative. Do not put earth on Out. An LED/rectifier/suppressed plug needs a new wiring review.

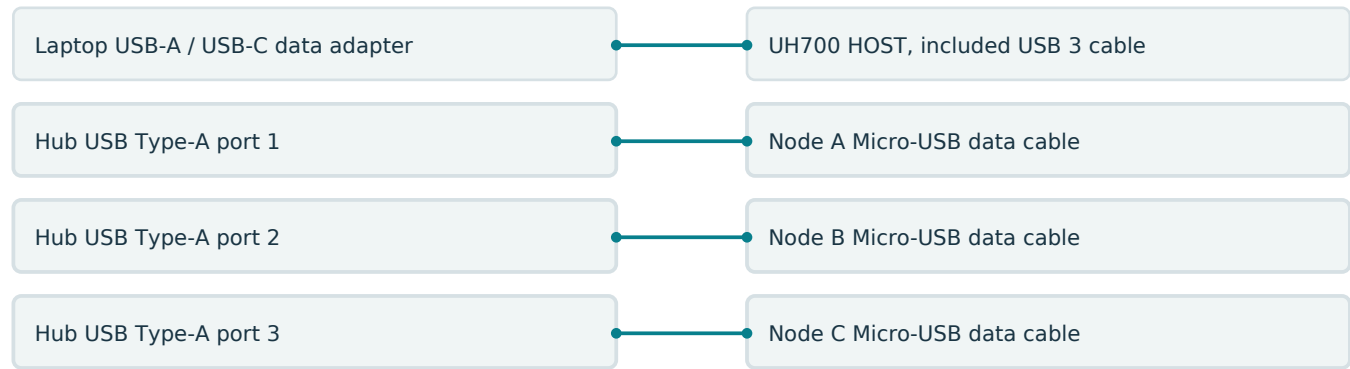
HIGH at GPIO25 opens the normally closed valve. LOW closes it. Confirm that boot/reset leaves the valve closed and measure current before wet operation. Support the heavy brass valve separately; do not load the plastic sensor threads.

10 / BUILD REFERENCE

Power, grounds and laptop cables

Circuit	Connection / reference
Load source	RIGOL DP811A lab supply, 20 V/10 A range, set to 12.0 V with output initially OFF. Use current limiting and OVP appropriate to the verified loads.
Pump branch	12 V -> 5 A fuse -> manual DC motor-rated switch -> pump positive. Pump negative -> star 0 V on a dedicated return. SLV family manual calls for 16 AWG or larger, depending on voltage drop.
Three valve branches	One 1 A time-delay fuse per 0.75 A cold-coil reference branch, subject to actual current and wire protection. Each driver load return runs directly back to star 0 V, outside the thin logic harness.
Sensor branch	12 V -> 0.5 A fuse -> Pololu D24V5F5 VIN. GND -> star 0 V. VOUT -> sensor 5 V terminal block. Leave SHDN open to enable; do not connect it to an ESP32.
Node power	Hub USB -> ESP32 USB input. ESP32 3V3 -> local ADXL355 and ADS1115. External sensor +5 V has no connection to the ESP32 5V header.
Grounds	Join sensor ground, ADC ground, ESP32 ground, buck ground and driver 0 V to a common signal reference. Keep pump/coil currents on their own load wires. PE remains a separate protective conductor.
Hub power	Use the UH700 V5 supplied 12 V / 2 A adapter. Its upstream connector is USB 3 Micro-B. It is not the ESP32 Micro-USB connector and is not powered from the pump branch.

USB: plug into the USB connectors, not GPIO



Use suitable length data cables for the measured physical route; the 3D cable bends are schematic. For the first bench test, connect one ESP32 directly to the laptop. Each attached board appears as its own serial port. Identify and label the ports before simultaneous logging.

11 / BUILD REFERENCE

Build in a sequence you can verify

1. Identify the hardware

Read the labels on ESP32, sensors, valve coil, driver and hub. Match the reference list; photograph any differences before assembly.

2. Start with one dry node

Connect one ESP32 to the laptop with a USB data cable. Install Arduino IDE and the Espressif ESP32 board package; select the correct serial port. Verify a basic serial sketch first.

3. Build the low-voltage harness

Make labeled terminal blocks. With output OFF, set the lab supply to 12.0 V. Fit pump 5 A, valve 1 A time-delay and buck 0.5 A branches. Keep PE, 0 V, 5 V and 12 V labels distinct.

4. Verify the 5 V rail

Connect the Pololu regulator VIN/GND. Measure VOUT before attaching sensors. Never connect this 5 V rail to the USB-powered ESP32 5V header.

5. Condition pressure and flow correctly

Pressure: solder 10k top and 15k bottom, output at their junction; a 5.0 V test input gives about 3.0 V. Flow: connect Adafruit 757 LV to 3V3, HV to 5V, GND common; sensor OUT to B1 and A1 to GPIO34. Node A also uses B2/A2 for F0.

6. Connect SPI and I2C

Follow the exact endpoint table. Power accelerometer and ADS1115 from 3V3, not 5 V. ADDR to GND selects 0x48. Read sensor identity/data before attaching the assembly to water.

7. Test one isolation valve dry

Connect Adafruit 5648 V+ to its fused 12 V branch, GND to star return and In to GPIO25. Output V+ goes to coil terminal 1, Out to terminal 2, PE to earth. Verify reset leaves the valve closed.

Do the dry electrical tests before routing water. Power USB logic first, then the external sensor/load rail; remove the external rail before unplugging USB. Verify that no powered sensor output drives an unpowered MCU/ADC input.

12 / BUILD REFERENCE

Assemble and test the water model

8. Lay out the plumbing

Mark a proposed 1400 x 1100 mm board and 310 mm zone pitch. Dry-fit all named reducers, stubs, nipples, seals and unions. Support heavy brass parts independently; do not hang their weight from PVC sensors.

9. Cut, join and cure

Measure each pipe between actual sockets including insertion. Deburr, clean, mark depth and use the GF-compatible solvent system and cure time. Keep union seals/nuts clean; use the specified face seals on G threads.

10. Commission one water zone

Keep all boards dry. Fill and vent reservoir; open bypass and demand. Start pump briefly, check flow arrow and leaks, then verify shutoff within the pump specification. Stop immediately for blocked flow or abnormal pressure/current.

11. Calibrate flow and pressure

Collect a measured volume over time for every flow sensor; 150 pulses/L is only nominal. Compare pressure against a suitable calibrated reference. Zero no-flow signals before baseline capture.

12. Collect contrasting test runs

Log pump state, normal-demand setting and leak volume for pump-off/no-leak, pump-on/no-leak, normal demand, and controlled leak. Test one change at a time. Firmware and dashboard still need implementation.

13. Expand to three zones

Repeat the validated node, assign unique zone labels/serial ports and connect through the powered UH700. Prove flow balance and valve isolation before making detection claims.

Commission at controlled pressure

The pump reference has a nominal 40 psi (about 2.8 bar) demand shutoff. Verify the exact label and operation; it does not turn the manual bypass into a safety valve. Use clean, room-temperature water, keep the bypass open for initial runs, and keep the operating point inside every real component rating. Stop for abnormal pressure, blocked flow or unexpected cycling.

No independent pressure-relief SKU has been validated in this package. If the lab requires one, select a water-rated relief device and discharge arrangement for the actual pump flow, pressure setpoint and local lab requirements before operating.

13 / BUILD REFERENCE

Software work and a useful demonstration

Stage	Concrete result to show
ESP32 bring-up	Board identity confirmed; serial output works; selected GPIOs documented. Firmware starts with valve output LOW and reports its zone ID.
Sensors separately	SPI accelerometer communication and stable samples. ADS1115 0x48 detected and pressure voltages read. Flow pulse count changes when a measured volume passes.
Timestamped logging	One stream per node: time, zone, pulse count/window, raw ADC volts, calibrated pressure, valve command, pump state and demand setting. Record pump/demand state manually in this reference.
Baseline runs	Pump OFF/no leak; pump ON/no leak; normal demand only; controlled leak with measured collected volume. Repeat runs and keep test conditions comparable.
Rules before a classifier	Check calibrated inlet/zone balance, pressure response and vibration changes. Define repeatable features/windows. Treat valve closure as a controlled confirmation experiment, not proof by itself.
Detection evaluation	Split training and evaluation by separate test runs. Report false alarms for pump/demand changes and missed low-flow leaks. State the tested pipe, pressure, clamp position and leak conditions.

Software choices

Arduino IDE with the official Espressif ESP32 board package for firmware. SPI for the ADXL355; Wire/I2C for ADS1115; pulse counters or suitable interrupts for flow. Python with pySerial can collect the USB streams. Use a timestamped CSV first; add a local dashboard afterward.

There is no working firmware, live dashboard or trained detection model inside this mechanical/electrical package. The model and drawings are design deliverables. Project completion percentage should describe actual demonstrated work, not a guessed research percentage.

14 / BUILD REFERENCE

Fit checks before purchase or release

1. Confirm actual owned ESP32 is the 38-pin DevKitC V4/WROOM-32E reference before following header numbers.
2. Confirm G1/2 flow-sensor sealing face mates with GF 721916206; order the matching flat washer. Thread agreement alone does not prove a seal.
3. Confirm all G1/4 nipple/adaptor/sensor shoulder seals with supplier; choose seal dimensions and tightening torque from actual mating parts.
4. Choose supplier codes for 9.5 mm suction strainer, inlet barb, rated hoses, clamps, fuse holders and gauge configuration.
5. Dry-fit nested bushes and instrument adapters; derive pipe cuts from measured insertion depths. This model is not a released fabrication drawing.
6. Verify pump exact SKU label, 12 V current/startup, 40 psi shutoff, intermittent duty, mounting and pressure-flow curve before commissioning.
7. Confirm the supplied valve plug is plain 314802 and coil is 12 V DC article 125300; a suppression/LED plug changes polarity details.
8. Have the lab technician verify PE continuity and DC wiring before wet operation. PE is not the blue/black DC return conductor.
9. Test one zone first: available pump flow may not keep three SEN0550 sensors above 0.5 L/min simultaneously.
10. Validate vibration-based leak discrimination experimentally. The model does not prove detection accuracy, pressure transient behavior or field performance.

Accuracy of this package

Three manufacturer CAD models are used as published. The ESP32 header grid, Adafruit PCB pad locations and named electrical nets are documented. Sensor bodies, adapters, plug, pump, gauge and supports include reconstructed geometry. No tolerance stack, final interference check or pressure qualification can be claimed from these reconstructions.

If your team already has different components, change the reference part entry, port definitions and affected nets together. Do not silently substitute a board revision, thread standard, sensor pulse factor or valve voltage.

15 / BUILD REFERENCE

Appendix A: full reference BOM

Counts are modeled instances, not necessarily retail pack quantities. For pipe and hose, choose stock only after actual cut planning. Tameson nipples/barbs may be sold in packs. Confirm that the selected college-lab supply and instruments are available before buying substitutes.

Co unt	Part	Manufacturer / specification	Assembly detail
3	38-pin ESP32 development board	ESP32-DevKitC V4 / ESP32-WROOM-32E	27.94 mm core width, 48.26 mm core length plus 6.04 mm antenna extension; header pitch 2.54 mm; row spacing 25.40 mm. Do not substitute C3/S3 or a 30-pin clone without remapping.
3	SPI accelerometer evaluation board	EVAL-ADXL355-PMDZ	P1 numbers govern connections; 25 x 25 mm board envelope reconstructed. Rigid saddle is a custom part.
3	4-channel ADC breakout	1085, ADS1115 STEMMA QT revision	VIN = 3.3 V. A+ is a power rail, not an analog input. A0 is the pressure input.
3	Flow pulse logic level converter	757, BSS138 4-channel converter	LV = ESP32 3V3; HV = sensor 5V; GND common. B1 -> A1 is zone flow, B2 -> A2 is main F0 on node A. Unused channels remain open. This is for digital pulses, not analog pressure.
3	Assembled 1.5 A continuous valve driver	5648, MOSFET Driver STEMMA	AO3406 and flyback diode are on the board. Built-in 10 kohm IN-to-GND pull-down verified in Eagle schematic. Supply this driver with 12 V, not ESP32 3V3.
4	G1/2 pulse flow sensor	SEN0550	80 x 47 x 37 mm published envelope. 5 V; 150 pulses/L nominal; 0.5-20 L/min stated range. New selection replaces SEN0217.
3	5 V analog pressure sensor	SEN0257, 0-16 bar version	Use the bare G1/4 port in this design; remove the supplied G1/2 adapter only as the supplier permits. Verify shipped range on its label.
3	12 V DC normally closed isolation valve	6013, article 125300	G1/4 female; 0-6 bar; 3 mm orifice; 32 mm coil. Size for 9 W at 20 C = 0.75 A. Datasheet distinguishes 8 W warm / 9 W cold.
3	Plain DIN Form A coil plug	2518, article 314802	Plain connector without LED, rectifier or suppression. Follow molded terminal numbers. PE is separate from DC return.
7	Brass G1/4 needle valve	NLB-014	42 mm face-to-face body; 40 bar product rating. Use for demand, controlled leak and manual bypass. Bypass is not a safety relief valve.
25	GF PVC-U pressure pipe, 20 mm OD	161017106	Wall 1.5 mm; ID 17.0 mm; PN16 at 20 C; supplied in 5 m lengths. Cut after dry fitting.
8	GF PVC-U pressure pipe, 16 mm OD	161017105	Wall 1.2 mm; ID 13.6 mm. Small stubs only; cut after dry fitting.

Co unt	Part	Manufacturer / specification	Assembly detail
18	GF PVC-U pressure pipe, 12 mm OD	161017104	Wall 1.1 mm; ID 9.8 mm. Small stubs only; cut after dry fitting.
11	GF equal tee, 20 mm sockets	721200106	Published centre-to-socket-end L=27 mm, z=11 mm. Model uses 16 mm socket engagement for this tee.
1	GF 90-degree elbow, 20 mm sockets	721100106	Published L=27 mm, z=11 mm.
3	GF removable union, 20 mm sockets	721510106, EPDM	43 mm union nut diameter from catalogue. Nut and O-ring are never solvent welded.
1	GF 20 mm pressure end cap	721960106	Published body diameter 27 mm, length 24 mm.
26	GF 20 mm spigot x 16 mm socket bush	721900334	Short reducing bush, L=16 mm. Nested reducers require actual dry fit.
18	GF 16 mm spigot x 12 mm socket bush	721900331	Short reducing bush, L=14 mm.
18	GF 12 mm socket x G1/4 female instrument adapter	721916204	Published L=27 mm. Seal seat must match the actual male fitting. This is G, not Rp.
8	GF 16 mm socket x G1/2 female instrument adapter	721916206	Published L=36 mm. Use matching flat seal for SEN0550; verify mating seat before ordering.
13	Brass G1/4 male/male nipple	FL2S-M-B-014G	Require compatible flat/bonded seals at both female faces; sealing-seat fit remains an open purchase check.
7	Brass G1/4 male x 6 mm hose barb	FL2S-MH-B-014G-06-I	Use pressure-rated 6 mm ID hose and matched hose clamps. Seal at the threaded shoulder as approved by supplier.
1	Pump discharge transition	SPEC: G1/4 male x 9.5 mm barb	Exact purchasing code and seat dimensions must be selected; use pressure-rated water fitting with correct G seal.
1	Pump suction strainer	SPEC: inline 50-mesh, 9.5 mm barbs	Do not order Pentair 255-313 as a direct fit: it is 1/2 NPSM, not the SLV 3/8-inch barb.
1	Pentair SHURflo diaphragm pump	SLV10-AA40	12 V; 3/8-inch (9.5 mm) built-in barbs; 40 psi nominal demand shutoff; intermittent duty. Family drawing approx 173 x 100 x 81 mm; exact SKU fit check required.
1	WIKA mechanical pressure gauge	111.10, NS63, bottom G1/4 B, 0-4 bar	Visual reference only. Confirm this exact configuration with supplier; body geometry is reconstructed.
1	RIGOL lab DC supply	DP811A	Reference lab equipment: set output to 12.0 V on 20 V / 10 A range. Use current limiting and OVP. Earth socket bonds PE conductors; never substitute DC 0 V for PE.

Co unt	Part	Manufacturer / specification	Assembly detail
1	Pololu 12 V to 5 V buck regulator	2843 / D24V5F5	5 V / 500 mA. VIN, GND, VOUT, SHDN pins. Leave SHDN open for enabled operation; built-in pull-up.
1	TP-Link powered 7-port USB hub	UH700 V5	165 x 65.5 x 17.5 mm. USB 3 Micro-B upstream. Use included 12 V / 2 A adapter; not the pump supply.
1	Custom wet support board	CUSTOM / SPEC	1400 x 1100 x 18 mm proposed layout; not a manufacturing drawing.
3	Custom dry electronics shelf and splash shield	CUSTOM / SPEC	240 x 90 mm support; position above and beside pipe. Maintain access to USB and terminals.
3	Custom rigid sensor saddle	CUSTOM / SPEC	Match 20 mm OD pipe; rigid contact, no foam. Model is an envelope, not a released STL.
3	Open collection tray	CUSTOM / SPEC	180 x 210 x 45 mm layout envelope; open discharge air gaps.
1	Open water reservoir	CUSTOM / SPEC	Vented container below tray drain outlets; no sealed return manifold.
5	Labeled distribution terminal block	CUSTOM / SPEC	Distinct +12 V, +5 V, 0 V and PE terminals; do not bridge positive rails.
5	DC inline fuse holder + fuse	CUSTOM / SPEC	Main pump 5 A per SLV family manual; each valve 1 A time-delay starting choice, confirm actual current and wire ampacity; sensor branch 0.5 A.
1	DC manual pump switch	CUSTOM / SPEC	Rated at least 12 V / 5 A motor load with suitable startup rating; keep dry.
3	Custom perfboard pressure divider carrier	CUSTOM / SPEC	One 10 kohm / 15 kohm divider per analog pressure signal; solder and label each net. Flow pulses use a separate Adafruit 757.
3	10 kohm, 1%, 0.25 W resistor	10k 1%	Metal film, axial. One top resistor per divider.
3	15 kohm, 1%, 0.25 W resistor	15k 1%	Metal film, axial. One bottom resistor per divider.
7	SPEC: pressure-rated 6 mm ID water hose	CUSTOM / SPEC	Required minimum working rating 6 bar at intended water temperature; choose actual hose supplier; length measured on assembled rig.
3	SPEC: reinforced 9.5 mm ID pump hose	CUSTOM / SPEC	Suction side must resist collapse; pressure side minimum 6 bar. Exact supplier and cut lengths pending.
3	SPEC: 12 mm ID gravity drain hose	CUSTOM / SPEC	Open gravity return; continuous downhill route to reservoir, no kinks or backpressure.
38	SPEC: G1/4 compatible face/bonded seal	CUSTOM / SPEC	Select material and dimensions for actual shoulder/port seat. Supplier confirmation required.
8	SPEC: G1/2 compatible flat seal	CUSTOM / SPEC	Match SEN0550 to GF instrument adapter seat; supplier confirmation required.

Co unt	Part	Manufacturer / specification	Assembly detail
12	SPEC: stainless hose clamp	CUSTOM / SPEC	Choose clamp range for actual hose OD, not hose ID. One at each retained barb.
1	UH700 supplied power adapter	CUSTOM / SPEC	Use the adapter packaged with this hardware revision. Keep mains and adapter dry.
1	User laptop	CUSTOM / SPEC	Illustrative 320 x 220 mm laptop. USB data / serial, no connection to a GPIO pin.

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Appendix B: every electrical connection

Each E ID is selectable in the offline viewer. Manufactured cables represent complete cable assemblies. Internal PCB copper, coil contacts and built-in protection components are not loose wires to add. All unlisted GPIOs and unused ADC/accelerometer signals remain unconnected.

Wire	From / pin	To / pin	Net name	Assembly note
E001	SUPPLY +12	DIST +12	LOAD_12V	12.0 V; adequately rated leads
E002	SUPPLY 0V	DIST 0V	LOAD_RETURN	ground
E003	SUPPLY PE	DIST PE	PROTECTIVE_EARTH	PE binding post, separate from DC negative
E004	DIST +12	FUSE-P IN	PUMP_FUSED_IN	power
E005	FUSE-P OUT	SW-P IN	PUMP_FUSED_12V	power
E006	SW-P OUT	PUMP +	PUMP_SWITCHED	16 AWG or larger, SLV family manual
E007	PUMP -	DIST 0V	PUMP_RETURN	Motor current return; not through ESP32 jumpers
E008	DIST +12	FUSE-S IN	SENSOR_BUCK_FEED	power
E009	FUSE-S OUT	BUCK VIN	BUCK_12V	power
E010	DIST 0V	BUCK GND	BUCK_RETURN	ground
E011	BUCK VOUT	S5 +5	SENSOR_5V	5v
E012	BUCK GND	S5 0V	SENSOR_RETURN	ground
E013	LAPTOP USB-A	HUB HOST	USB_HOST	Included USB 3 Type-A to Micro-B upstream cable; laptop USB-C needs compatible data adapter
E014	HUB-PSU DC	HUB DC	HUB_SUPPLY	Manufacturer supplied 12 V/2 A adapter only
E015	A-P OUT	A-R10-P IN	A_P_RAW	Raw 5 V domain, do not connect directly to MCU/ADC
E016	A-R10-P OUT	A-R15-P IN	A_P_0V6	Soldered junction; divider ratio 0.60

Wire	From / pin	To / pin	Net name	Assembly note
E017	A-R15-P OUT	A-TB 0V	A_P_RETURN	ground
E018	A-R10-P OUT	A-ADC A0	A_P_0V6	analog
E019	A-TB +5	A-P VCC	A_P_5V	5v
E020	A-TB 0V	A-P GND	A_P_GND	ground
E021	A-ESP J2-1 3V3	A-LEVEL LV	A_LEVEL_3V3	3v3
E022	A-TB +5	A-LEVEL HV	A_LEVEL_5V	5v
E023	A-TB 0V	A-LEVEL GND	A_LEVEL_GND	ground
E024	A-F OUT	A-LEVEL B1	A_A-F_5V_PULSE	High-voltage B side, do not connect raw pulse to GPIO
E025	A-LEVEL A1	A-ESP J2-5 IO34	A_A-F_3V3_PULSE	Low-voltage A side, 3.3 V pulse
E026	A-TB +5	A-F VCC	A_A-F_SUPPLY	5v
E027	A-TB 0V	A-F GND	A_A-F_RETURN	ground
E028	F0 OUT	A-LEVEL B2	A_F0_5V_PULSE	High-voltage B side, do not connect raw pulse to GPIO
E029	A-LEVEL A2	A-ESP J2-7 IO32	A_F0_3V3_PULSE	Low-voltage A side, 3.3 V pulse
E030	A-TB +5	F0 VCC	A_F0_SUPPLY	5v
E031	A-TB 0V	F0 GND	A_F0_RETURN	ground
E032	A-ESP J2-1 3V3	A-ACC 6	A_ACC_3V3	3v3
E033	A-ESP J3-1 GND	A-ACC 5	A_ACC_GND	ground
E034	A-ESP J2-11 IO27	A-ACC 1	A_ACC_CS	spi
E035	A-ESP J3-2 IO23	A-ACC 2	A_ACC_MOSI	spi

Wire	From / pin	To / pin	Net name	Assembly note
E036	A-ESP J3-8 IO19	A-ACC 3	A_ACC_MISO	spi
E037	A-ESP J3-9 IO18	A-ACC 4	A_ACC_SCLK	spi
E038	A-ESP J2-10 IO26	A-ACC 10	A_ACC_DRDY	spi
E039	A-ACC 6	A-ACC 12	A_ACC_3V3	3v3
E040	A-ACC 5	A-ACC 11	A_ACC_GND	ground
E041	A-ESP J2-1 3V3	A-ADC VIN	A_ADC_VIN	3v3
E042	A-ESP J3-1 GND	A-ADC GND	A_ADC_GND	ground
E043	A-ESP J3-6 IO21	A-ADC SDA	A_ADC_SDA	i2c
E044	A-ESP J3-3 IO22	A-ADC SCL	A_ADC_SCL	i2c
E045	A-ADC ADDR	A-ADC GND	A_ADDR_LOW	ADS1115 address 0x48; other ADC channels unused
E046	A-ESP J3-1 GND	A-TB 0V	A_LOGIC_GROUND	Signal reference; route valve current directly back to star, not through this lead
E047	S5 +5	A-TB +5	A_SENSOR_FEED	5v
E048	DIST 0V	A-TB 0V	A_LOCAL_RETURN	ground
E049	DIST +12	A-FUSE IN	A_VALVE_FEED	power
E050	A-FUSE OUT	A-DRIVER V+	A_VALVE_12V	Adafruit JST-PH pin 2 / V+; 22 AWG load-rated harness
E051	DIST 0V	A-DRIVER GND	A_DRIVER_RETURN	Adafruit JST-PH pin 1, separate load return
E052	A-ESP J2-9 IO25	A-DRIVER IN	A_VALVE_CONTROL	Adafruit JST-PH pin 3. HIGH opens NC valve; LOW closes
E053	A-DRIVER LOAD+	A-PLUG 1	A_COIL_PLUS	Driver terminal marked V+ -> plug terminal 1
E054	A-DRIVER OUT	A-PLUG 2	A_COIL_SWITCHED	Driver terminal marked Out -> plug terminal 2

Wire	From / pin	To / pin	Net name	Assembly note
E055	DIST PE	A-TB PE	A_PE_FEED	earth
E056	A-TB PE	A-PLUG PE	A_VALVE_PE	Molded earth symbol; do not connect to Out or DC 0V
E057	HUB USB1	A-ESP USB	A_USB_DATA_POWER	USB Type-A to Micro-B data cable. ESP32 5V header remains unconnected
E058	B-P OUT	B-R10-P IN	B_P_RAW	Raw 5 V domain, do not connect directly to MCU/ADC
E059	B-R10-P OUT	B-R15-P IN	B_P_0V6	Soldered junction; divider ratio 0.60
E060	B-R15-P OUT	B-TB 0V	B_P_RETURN	ground
E061	B-R10-P OUT	B-ADC A0	B_P_0V6	analog
E062	B-TB +5	B-P VCC	B_P_5V	5v
E063	B-TB 0V	B-P GND	B_P_GND	ground
E064	B-ESP J2-1 3V3	B-LEVEL LV	B_LEVEL_3V3	3v3
E065	B-TB +5	B-LEVEL HV	B_LEVEL_5V	5v
E066	B-TB 0V	B-LEVEL GND	B_LEVEL_GND	ground
E067	B-F OUT	B-LEVEL B1	B_B-F_5V_PULSE	High-voltage B side, do not connect raw pulse to GPIO
E068	B-LEVEL A1	B-ESP J2-5 IO34	B_B-F_3V3_PULSE	Low-voltage A side, 3.3 V pulse
E069	B-TB +5	B-F VCC	B_B-F_SUPPLY	5v
E070	B-TB 0V	B-F GND	B_B-F_RETURN	ground
E071	B-ESP J2-1 3V3	B-ACC 6	B_ACC_3V3	3v3
E072	B-ESP J3-1 GND	B-ACC 5	B_ACC_GND	ground
E073	B-ESP J2-11 IO27	B-ACC 1	B_ACC_CS	spi

Wire	From / pin	To / pin	Net name	Assembly note
E074	B-ESP J3-2 IO23	B-ACC 2	B_ACC_MOSI	spi
E075	B-ESP J3-8 IO19	B-ACC 3	B_ACC_MISO	spi
E076	B-ESP J3-9 IO18	B-ACC 4	B_ACC_SCLK	spi
E077	B-ESP J2-10 IO26	B-ACC 10	B_ACC_DRDY	spi
E078	B-ACC 6	B-ACC 12	B_ACC_3V3	3v3
E079	B-ACC 5	B-ACC 11	B_ACC_GND	ground
E080	B-ESP J2-1 3V3	B-ADC VIN	B_ADC_VIN	3v3
E081	B-ESP J3-1 GND	B-ADC GND	B_ADC_GND	ground
E082	B-ESP J3-6 IO21	B-ADC SDA	B_ADC_SDA	i2c
E083	B-ESP J3-3 IO22	B-ADC SCL	B_ADC_SCL	i2c
E084	B-ADC ADDR	B-ADC GND	B_ADDR_LOW	ADS1115 address 0x48; other ADC channels unused
E085	B-ESP J3-1 GND	B-TB 0V	B_LOGIC_GROUND	Signal reference; route valve current directly back to star, not through this lead
E086	S5 +5	B-TB +5	B_SENSOR_FEED	5v
E087	DIST 0V	B-TB 0V	B_LOCAL_RETURN	ground
E088	DIST +12	B-FUSE IN	B_VALVE_FEED	power
E089	B-FUSE OUT	B-DRIVER V+	B_VALVE_12V	Adafruit JST-PH pin 2 / V+; 22 AWG load-rated harness
E090	DIST 0V	B-DRIVER GND	B_DRIVER_RETURN	Adafruit JST-PH pin 1, separate load return
E091	B-ESP J2-9 IO25	B-DRIVER IN	B_VALVE_CONTROL	Adafruit JST-PH pin 3. HIGH opens NC valve; LOW closes
E092	B-DRIVER LOAD+	B-PLUG 1	B_COIL_PLUS	Driver terminal marked V+ -> plug terminal 1

Wire	From / pin	To / pin	Net name	Assembly note
E093	B-DRIVER OUT	B-PLUG 2	B_COIL_SWITCHED	Driver terminal marked Out -> plug terminal 2
E094	DIST PE	B-TB PE	B_PE_FEED	earth
E095	B-TB PE	B-PLUG PE	B_VALVE_PE	Molded earth symbol; do not connect to Out or DC 0V
E096	HUB USB2	B-ESP USB	B_USB_DATA_POWER	USB Type-A to Micro-B data cable. ESP32 5V header remains unconnected
E097	C-P OUT	C-R10-P IN	C_P_RAW	Raw 5 V domain, do not connect directly to MCU/ADC
E098	C-R10-P OUT	C-R15-P IN	C_P_0V6	Soldered junction; divider ratio 0.60
E099	C-R15-P OUT	C-TB 0V	C_P_RETURN	ground
E100	C-R10-P OUT	C-ADC A0	C_P_0V6	analog
E101	C-TB +5	C-P VCC	C_P_5V	5v
E102	C-TB 0V	C-P GND	C_P_GND	ground
E103	C-ESP J2-1 3V3	C-LEVEL LV	C_LEVEL_3V3	3v3
E104	C-TB +5	C-LEVEL HV	C_LEVEL_5V	5v
E105	C-TB 0V	C-LEVEL GND	C_LEVEL_GND	ground
E106	C-F OUT	C-LEVEL B1	C_C-F_5V_PULSE	High-voltage B side, do not connect raw pulse to GPIO
E107	C-LEVEL A1	C-ESP J2-5 IO34	C_C-F_3V3_PULSE	Low-voltage A side, 3.3 V pulse
E108	C-TB +5	C-F VCC	C_C-F_SUPPLY	5v
E109	C-TB 0V	C-F GND	C_C-F_RETURN	ground
E110	C-ESP J2-1 3V3	C-ACC 6	C_ACC_3V3	3v3
E111	C-ESP J3-1 GND	C-ACC 5	C_ACC_GND	ground

Wire	From / pin	To / pin	Net name	Assembly note
E112	C-ESP J2-11 IO27	C-ACC 1	C_ACC_CS	spi
E113	C-ESP J3-2 IO23	C-ACC 2	C_ACC_MOSI	spi
E114	C-ESP J3-8 IO19	C-ACC 3	C_ACC_MISO	spi
E115	C-ESP J3-9 IO18	C-ACC 4	C_ACC_SCLK	spi
E116	C-ESP J2-10 IO26	C-ACC 10	C_ACC_DRDY	spi
E117	C-ACC 6	C-ACC 12	C_ACC_3V3	3v3
E118	C-ACC 5	C-ACC 11	C_ACC_GND	ground
E119	C-ESP J2-1 3V3	C-ADC VIN	C_ADC_VIN	3v3
E120	C-ESP J3-1 GND	C-ADC GND	C_ADC_GND	ground
E121	C-ESP J3-6 IO21	C-ADC SDA	C_ADC_SDA	i2c
E122	C-ESP J3-3 IO22	C-ADC SCL	C_ADC_SCL	i2c
E123	C-ADC ADDR	C-ADC GND	C_ADDR_LOW	ADS1115 address 0x48; other ADC channels unused
E124	C-ESP J3-1 GND	C-TB 0V	C_LOGIC_GROUND	Signal reference; route valve current directly back to star, not through this lead
E125	S5 +5	C-TB +5	C_SENSOR_FEED	5v
E126	DIST 0V	C-TB 0V	C_LOCAL_RETURN	ground
E127	DIST +12	C-FUSE IN	C_VALVE_FEED	power
E128	C-FUSE OUT	C-DRIVER V+	C_VALVE_12V	Adafruit JST-PH pin 2 / V+; 22 AWG load-rated harness
E129	DIST 0V	C-DRIVER GND	C_DRIVER_RETURN	Adafruit JST-PH pin 1, separate load return
E130	C-ESP J2-9 IO25	C-DRIVER IN	C_VALVE_CONTROL	Adafruit JST-PH pin 3. HIGH opens NC valve; LOW closes

Wire	From / pin	To / pin	Net name	Assembly note
E131	C-DRIVER LOAD+	C-PLUG 1	C_COIL_PLUS	Driver terminal marked V+ -> plug terminal 1
E132	C-DRIVER OUT	C-PLUG 2	C_COIL_SWITCHED	Driver terminal marked Out -> plug terminal 2
E133	DIST PE	C-TB PE	C_PE_FEED	earth
E134	C-TB PE	C-PLUG PE	C_VALVE_PE	Molded earth symbol; do not connect to Out or DC 0V
E135	HUB USB3	C-ESP USB	C_USB_DATA_POWER	USB Type-A to Micro-B data cable. ESP32 5V header remains unconnected

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Appendix C: every plumbing joint

Each J ID is selectable in the offline viewer. The schedule specifies interfaces and methods; it does not verify actual seal-seat compatibility or release final pipe cuts. An OUT label on an adapter identifies that named port, not a claim that water can flow only in that direction.

Join t	First component / port	Second component / port	Join method	Required detail
J001	TANK PICKUP	HS1 IN	Submerged pickup; reservoir open	
J002	HS1 OUT	STRAIN IN	9.5 mm barb + clamp	
J003	STRAIN OUT	HS2 IN	9.5 mm barb + clamp	
J004	HS2 OUT	PUMP IN	9.5 mm barb + clamp	
J005	PUMP OUT	HD1 IN	9.5 mm barb + clamp	
J006	HD1 OUT	IN-BARB IN	9.5 mm barb + clamp	
J007	IN-AD-R20 OUT	IN-AD-R16 IN	Nested solvent sockets	20-to-16 and 16-to-12 bushes; do not thread or force
J008	IN-AD-R16 OUT	IN-AD-STUB IN	12 mm solvent socket	
J009	IN-AD-STUB OUT	IN-AD-AD IN	12 mm solvent socket	
J010	IN-BARB OUT	IN-AD-AD OUT	G1/4 matched face seal	Supplier sealing seat check required
J011	IN-AD-R20 IN	IN-TEE IN	20 mm solvent socket / measured stub	
J012	BYP-AD-R20 OUT	BYP-AD-R16 IN	Nested solvent sockets	20-to-16 and 16-to-12 bushes; do not thread or force
J013	BYP-AD-R16 OUT	BYP-AD-STUB IN	12 mm solvent socket	
J014	BYP-AD-STUB OUT	BYP-AD-AD IN	12 mm solvent socket	
J015	IN-TEE SIDE	BYP-AD-R20 IN	20 mm solvent socket / measured stub	
J016	BYP-AD-AD OUT	BYP-NIP IN	G1/4 face/bonded seal	

Join t	First component / port	Second component / port	Join method	Required detail
J017	BYP-NIP OUT	BYPASS IN	G1/4 face/bonded seal	
J018	BYPASS OUT	BYP-BARB IN	G1/4 face/bonded seal	
J019	BYP-BARB OUT	BYP-HOSE IN	6 mm barb + clamp	
J020	BYP-HOSE OUT	TANK RETURN	Free discharge above water	
J021	F0-IN-AD THREAD	F0 IN	G1/2 flat face seal	Parallel threads locate; correct seal makes the water seal. Seat confirmation required.
J022	F0-IN-AD SOCKET	F0-IN-STUB IN	16 mm solvent socket	
J023	F0-IN-STUB OUT	F0-IN-R OUT	16 mm solvent socket	
J024	F0-OUT-AD THREAD	F0 OUT	G1/2 flat face seal	Parallel threads locate; correct seal makes the water seal. Seat confirmation required.
J025	F0-OUT-AD SOCKET	F0-OUT-STUB IN	16 mm solvent socket	
J026	F0-OUT-STUB OUT	F0-OUT-R OUT	16 mm solvent socket	
J027	IN-TEE OUT	MAIN-P1 IN	20 mm solvent socket	
J028	F0-OUT-R IN	MAIN-P2 IN	20 mm solvent socket	
J029	MAIN-P2 OUT	MAIN-ELB IN	20 mm solvent socket	
J030	MAIN-ELB OUT	A-HEADER IN	20 mm solvent socket	
J031	A-HEADER OUT	A-TEE IN	20 mm solvent socket	
J032	A-V-IN-R20 OUT	A-V-IN-R16 IN	Nested solvent sockets	20-to-16 and 16-to-12 bushes; do not thread or force
J033	A-V-IN-R16 OUT	A-V-IN-STUB IN	12 mm solvent socket	

Join t	First component / port	Second component / port	Join method	Required detail
J034	A-V-IN-STUB OUT	A-V-IN-AD IN	12 mm solvent socket	
J035	A-V-IN-AD OUT	A-V-IN-NIP IN	G1/4 face/bonded seal	
J036	A-V-IN-NIP OUT	A-V IN	G1/4 face/bonded seal	
J037	A-V-OUT-R20 OUT	A-V-OUT-R16 IN	Nested solvent sockets	20-to-16 and 16-to-12 bushes; do not thread or force
J038	A-V-OUT-R16 OUT	A-V-OUT-STUB IN	12 mm solvent socket	
J039	A-V-OUT-STUB OUT	A-V-OUT-AD IN	12 mm solvent socket	
J040	A-V-OUT-AD OUT	A-V-OUT-NIP IN	G1/4 face/bonded seal	
J041	A-V-OUT-NIP OUT	A-V OUT	G1/4 face/bonded seal	
J042	A-TEE SIDE	A-P1 IN	20 mm solvent socket	
J043	A-P1 OUT	A-V-IN-R20 IN	20 mm solvent socket	
J044	A-F-IN-AD THREAD	A-F IN	G1/2 flat face seal	Parallel threads locate; correct seal makes the water seal. Seat confirmation required.
J045	A-F-IN-AD SOCKET	A-F-IN-STUB IN	16 mm solvent socket	
J046	A-F-IN-STUB OUT	A-F-IN-R OUT	16 mm solvent socket	
J047	A-F-OUT-AD THREAD	A-F OUT	G1/2 flat face seal	Parallel threads locate; correct seal makes the water seal. Seat confirmation required.
J048	A-F-OUT-AD SOCKET	A-F-OUT-STUB IN	16 mm solvent socket	
J049	A-F-OUT-STUB OUT	A-F-OUT-R OUT	16 mm solvent socket	
J050	A-V-OUT-R20 IN	A-P2 IN	20 mm solvent socket	

Join t	First component / port	Second component / port	Join method	Required detail
J051	A-P2 OUT	A-F-IN-R IN	20 mm solvent socket	
J052	A-F-OUT-R IN	A-P3 IN	20 mm solvent socket	
J053	A-P3 OUT	A-UNION IN	20 mm solvent socket	
J054	A-UNION OUT	A-P4 IN	20 mm solvent socket	
J055	A-P4 OUT	A-PTEE IN	20 mm solvent socket	
J056	A-PRESS-R20 OUT	A-PRESS-R16 IN	Nested solvent sockets	20-to-16 and 16-to-12 bushes; do not thread or force
J057	A-PRESS-R16 OUT	A-PRESS-STUB IN	12 mm solvent socket	
J058	A-PRESS-STUB OUT	A-PRESS-AD IN	12 mm solvent socket	
J059	A-PTEE SIDE	A-PRESS-R20 IN	20 mm solvent socket / measured stub	
J060	A-PRESS-AD OUT	A-P WATER	G1/4 matched face seal	Bare sensing thread, without shipped G1/2 adapter
J061	A-PTEE OUT	A-TEST IN	20 mm solvent socket	
J062	A-TEST OUT	A-DTEE IN	20 mm solvent socket	
J063	A-DEM-R20 OUT	A-DEM-R16 IN	Nested solvent sockets	20-to-16 and 16-to-12 bushes; do not thread or force
J064	A-DEM-R16 OUT	A-DEM-STUB IN	12 mm solvent socket	
J065	A-DEM-STUB OUT	A-DEM-AD IN	12 mm solvent socket	
J066	A-DTEE SIDE	A-DEM-R20 IN	20 mm solvent socket / measured stub	
J067	A-DEM-AD OUT	A-DEM-NIP IN	G1/4 face/bonded seal	
J068	A-DEM-NIP OUT	A-DEMAND IN	G1/4 face/bonded seal	

Join t	First component / port	Second component / port	Join method	Required detail
J069	A-DTEE OUT	A-P5 IN	20 mm solvent socket	
J070	A-LEAK-R20 OUT	A-LEAK-R16 IN	Nested solvent sockets	20-to-16 and 16-to-12 bushes; do not thread or force
J071	A-LEAK-R16 OUT	A-LEAK-STUB IN	12 mm solvent socket	
J072	A-LEAK-STUB OUT	A-LEAK-AD IN	12 mm solvent socket	
J073	A-P5 OUT	A-LEAK-R20 IN	20 mm solvent socket	
J074	A-LEAK-AD OUT	A-LEAK-NIP IN	G1/4 face/bonded seal	
J075	A-LEAK-NIP OUT	A-LEAK IN	G1/4 face/bonded seal	
J076	A-DEMAND OUT	A-DEMAND-BARB IN	G1/4 face/bonded seal	
J077	A-DEMAND-BARB OUT	A-DEMAND-HOSE IN	6 mm barb + clamp	
J078	A-DEMAND-HOSE OUT	A-TRAY DEMAND	Visible air gap, free discharge	Divert LEAK into a measuring jug for calibration
J079	A-LEAK OUT	A-LEAK-BARB IN	G1/4 face/bonded seal	
J080	A-LEAK-BARB OUT	A-LEAK-HOSE IN	6 mm barb + clamp	
J081	A-LEAK-HOSE OUT	A-TRAY LEAK	Visible air gap, free discharge	Divert LEAK into a measuring jug for calibration
J082	A-TRAY DRAIN	A-DRAIN IN	Gravity drain, secured hose	
J083	A-DRAIN OUT	TANK RETURN-A	Free discharge above reservoir water	
J084	A-TEE OUT	B-HEADER IN	20 mm solvent socket	
J085	B-HEADER OUT	B-TEE IN	20 mm solvent socket	
J086	B-V-IN-R20 OUT	B-V-IN-R16 IN	Nested solvent sockets	20-to-16 and 16-to-12 bushes; do not thread or force

Join t	First component / port	Second component / port	Join method	Required detail
J087	B-V-IN-R16 OUT	B-V-IN-STUB IN	12 mm solvent socket	
J088	B-V-IN-STUB OUT	B-V-IN-AD IN	12 mm solvent socket	
J089	B-V-IN-AD OUT	B-V-IN-NIP IN	G1/4 face/bonded seal	
J090	B-V-IN-NIP OUT	B-V IN	G1/4 face/bonded seal	
J091	B-V-OUT-R20 OUT	B-V-OUT-R16 IN	Nested solvent sockets	20-to-16 and 16-to-12 bushes; do not thread or force
J092	B-V-OUT-R16 OUT	B-V-OUT-STUB IN	12 mm solvent socket	
J093	B-V-OUT-STUB OUT	B-V-OUT-AD IN	12 mm solvent socket	
J094	B-V-OUT-AD OUT	B-V-OUT-NIP IN	G1/4 face/bonded seal	
J095	B-V-OUT-NIP OUT	B-V OUT	G1/4 face/bonded seal	
J096	B-TEE SIDE	B-P1 IN	20 mm solvent socket	
J097	B-P1 OUT	B-V-IN-R20 IN	20 mm solvent socket	
J098	B-F-IN-AD THREAD	B-F IN	G1/2 flat face seal	Parallel threads locate; correct seal makes the water seal. Seat confirmation required.
J099	B-F-IN-AD SOCKET	B-F-IN-STUB IN	16 mm solvent socket	
J100	B-F-IN-STUB OUT	B-F-IN-R OUT	16 mm solvent socket	
J101	B-F-OUT-AD THREAD	B-F OUT	G1/2 flat face seal	Parallel threads locate; correct seal makes the water seal. Seat confirmation required.
J102	B-F-OUT-AD SOCKET	B-F-OUT-STUB IN	16 mm solvent socket	
J103	B-F-OUT-STUB OUT	B-F-OUT-R OUT	16 mm solvent socket	

Join t	First component / port	Second component / port	Join method	Required detail
J104	B-V-OUT-R20 IN	B-P2 IN	20 mm solvent socket	
J105	B-P2 OUT	B-F-IN-R IN	20 mm solvent socket	
J106	B-F-OUT-R IN	B-P3 IN	20 mm solvent socket	
J107	B-P3 OUT	B-UNION IN	20 mm solvent socket	
J108	B-UNION OUT	B-P4 IN	20 mm solvent socket	
J109	B-P4 OUT	B-PTEE IN	20 mm solvent socket	
J110	B-PRESS-R20 OUT	B-PRESS-R16 IN	Nested solvent sockets	20-to-16 and 16-to-12 bushes; do not thread or force
J111	B-PRESS-R16 OUT	B-PRESS-STUB IN	12 mm solvent socket	
J112	B-PRESS-STUB OUT	B-PRESS-AD IN	12 mm solvent socket	
J113	B-PTEE SIDE	B-PRESS-R20 IN	20 mm solvent socket / measured stub	
J114	B-PRESS-AD OUT	B-P WATER	G1/4 matched face seal	Bare sensing thread, without shipped G1/2 adapter
J115	B-PTEE OUT	B-TEST IN	20 mm solvent socket	
J116	B-TEST OUT	B-DTEE IN	20 mm solvent socket	
J117	B-DEM-R20 OUT	B-DEM-R16 IN	Nested solvent sockets	20-to-16 and 16-to-12 bushes; do not thread or force
J118	B-DEM-R16 OUT	B-DEM-STUB IN	12 mm solvent socket	
J119	B-DEM-STUB OUT	B-DEM-AD IN	12 mm solvent socket	
J120	B-DTEE SIDE	B-DEM-R20 IN	20 mm solvent socket / measured stub	
J121	B-DEM-AD OUT	B-DEM-NIP IN	G1/4 face/bonded seal	

Join t	First component / port	Second component / port	Join method	Required detail
J122	B-DEM-NIP OUT	B-DEMAND IN	G1/4 face/bonded seal	
J123	B-DTEE OUT	B-P5 IN	20 mm solvent socket	
J124	B-LEAK-R20 OUT	B-LEAK-R16 IN	Nested solvent sockets	20-to-16 and 16-to-12 bushes; do not thread or force
J125	B-LEAK-R16 OUT	B-LEAK-STUB IN	12 mm solvent socket	
J126	B-LEAK-STUB OUT	B-LEAK-AD IN	12 mm solvent socket	
J127	B-P5 OUT	B-LEAK-R20 IN	20 mm solvent socket	
J128	B-LEAK-AD OUT	B-LEAK-NIP IN	G1/4 face/bonded seal	
J129	B-LEAK-NIP OUT	B-LEAK IN	G1/4 face/bonded seal	
J130	B-DEMAND OUT	B-DEMAND-BARB IN	G1/4 face/bonded seal	
J131	B-DEMAND-BARB OUT	B-DEMAND-HOSE IN	6 mm barb + clamp	
J132	B-DEMAND-HOSE OUT	B-TRAY DEMAND	Visible air gap, free discharge	Divert LEAK into a measuring jug for calibration
J133	B-LEAK OUT	B-LEAK-BARB IN	G1/4 face/bonded seal	
J134	B-LEAK-BARB OUT	B-LEAK-HOSE IN	6 mm barb + clamp	
J135	B-LEAK-HOSE OUT	B-TRAY LEAK	Visible air gap, free discharge	Divert LEAK into a measuring jug for calibration
J136	B-TRAY DRAIN	B-DRAIN IN	Gravity drain, secured hose	
J137	B-DRAIN OUT	TANK RETURN-B	Free discharge above reservoir water	
J138	B-TEE OUT	C-HEADER IN	20 mm solvent socket	
J139	C-HEADER OUT	C-TEE IN	20 mm solvent socket	

Join t	First component / port	Second component / port	Join method	Required detail
J140	C-V-IN-R20 OUT	C-V-IN-R16 IN	Nested solvent sockets	20-to-16 and 16-to-12 bushes; do not thread or force
J141	C-V-IN-R16 OUT	C-V-IN-STUB IN	12 mm solvent socket	
J142	C-V-IN-STUB OUT	C-V-IN-AD IN	12 mm solvent socket	
J143	C-V-IN-AD OUT	C-V-IN-NIP IN	G1/4 face/bonded seal	
J144	C-V-IN-NIP OUT	C-V IN	G1/4 face/bonded seal	
J145	C-V-OUT-R20 OUT	C-V-OUT-R16 IN	Nested solvent sockets	20-to-16 and 16-to-12 bushes; do not thread or force
J146	C-V-OUT-R16 OUT	C-V-OUT-STUB IN	12 mm solvent socket	
J147	C-V-OUT-STUB OUT	C-V-OUT-AD IN	12 mm solvent socket	
J148	C-V-OUT-AD OUT	C-V-OUT-NIP IN	G1/4 face/bonded seal	
J149	C-V-OUT-NIP OUT	C-V OUT	G1/4 face/bonded seal	
J150	C-TEE SIDE	C-P1 IN	20 mm solvent socket	
J151	C-P1 OUT	C-V-IN-R20 IN	20 mm solvent socket	
J152	C-F-IN-AD THREAD	C-F IN	G1/2 flat face seal	Parallel threads locate; correct seal makes the water seal. Seat confirmation required.
J153	C-F-IN-AD SOCKET	C-F-IN-STUB IN	16 mm solvent socket	
J154	C-F-IN-STUB OUT	C-F-IN-R OUT	16 mm solvent socket	
J155	C-F-OUT-AD THREAD	C-F OUT	G1/2 flat face seal	Parallel threads locate; correct seal makes the water seal. Seat confirmation required.
J156	C-F-OUT-AD SOCKET	C-F-OUT-STUB IN	16 mm solvent socket	

Join t	First component / port	Second component / port	Join method	Required detail
J157	C-F-OUT-STUB OUT	C-F-OUT-R OUT	16 mm solvent socket	
J158	C-V-OUT-R20 IN	C-P2 IN	20 mm solvent socket	
J159	C-P2 OUT	C-F-IN-R IN	20 mm solvent socket	
J160	C-F-OUT-R IN	C-P3 IN	20 mm solvent socket	
J161	C-P3 OUT	C-UNION IN	20 mm solvent socket	
J162	C-UNION OUT	C-P4 IN	20 mm solvent socket	
J163	C-P4 OUT	C-PTEE IN	20 mm solvent socket	
J164	C-PRESS-R20 OUT	C-PRESS-R16 IN	Nested solvent sockets	20-to-16 and 16-to-12 bushes; do not thread or force
J165	C-PRESS-R16 OUT	C-PRESS-STUB IN	12 mm solvent socket	
J166	C-PRESS-STUB OUT	C-PRESS-AD IN	12 mm solvent socket	
J167	C-PTEE SIDE	C-PRESS-R20 IN	20 mm solvent socket / measured stub	
J168	C-PRESS-AD OUT	C-P WATER	G1/4 matched face seal	Bare sensing thread, without shipped G1/2 adapter
J169	C-PTEE OUT	C-TEST IN	20 mm solvent socket	
J170	C-TEST OUT	C-DTEE IN	20 mm solvent socket	
J171	C-DEM-R20 OUT	C-DEM-R16 IN	Nested solvent sockets	20-to-16 and 16-to-12 bushes; do not thread or force
J172	C-DEM-R16 OUT	C-DEM-STUB IN	12 mm solvent socket	
J173	C-DEM-STUB OUT	C-DEM-AD IN	12 mm solvent socket	
J174	C-DTEE SIDE	C-DEM-R20 IN	20 mm solvent socket / measured stub	

Join t	First component / port	Second component / port	Join method	Required detail
J175	C-DEM-AD OUT	C-DEM-NIP IN	G1/4 face/bonded seal	
J176	C-DEM-NIP OUT	C-DEMAND IN	G1/4 face/bonded seal	
J177	C-DTEE OUT	C-P5 IN	20 mm solvent socket	
J178	C-LEAK-R20 OUT	C-LEAK-R16 IN	Nested solvent sockets	20-to-16 and 16-to-12 bushes; do not thread or force
J179	C-LEAK-R16 OUT	C-LEAK-STUB IN	12 mm solvent socket	
J180	C-LEAK-STUB OUT	C-LEAK-AD IN	12 mm solvent socket	
J181	C-P5 OUT	C-LEAK-R20 IN	20 mm solvent socket	
J182	C-LEAK-AD OUT	C-LEAK-NIP IN	G1/4 face/bonded seal	
J183	C-LEAK-NIP OUT	C-LEAK IN	G1/4 face/bonded seal	
J184	C-DEMAND OUT	C-DEMAND-BARB IN	G1/4 face/bonded seal	
J185	C-DEMAND-BARB OUT	C-DEMAND-HOSE IN	6 mm barb + clamp	
J186	C-DEMAND-HOSE OUT	C-TRAY DEMAND	Visible air gap, free discharge	Divert LEAK into a measuring jug for calibration
J187	C-LEAK OUT	C-LEAK-BARB IN	G1/4 face/bonded seal	
J188	C-LEAK-BARB OUT	C-LEAK-HOSE IN	6 mm barb + clamp	
J189	C-LEAK-HOSE OUT	C-TRAY LEAK	Visible air gap, free discharge	Divert LEAK into a measuring jug for calibration
J190	C-TRAY DRAIN	C-DRAIN IN	Gravity drain, secured hose	
J191	C-DRAIN OUT	TANK RETURN-C	Free discharge above reservoir water	
J192	C-TEE OUT	HEADER-END IN	20 mm solvent socket	

Join t	First component / port	Second component / port	Join method	Required detail
J193	HEADER-END OUT	HEADER-CAP IN	20 mm solvent socket	
J194	MAIN-P1 OUT	GAUGE-TEE IN	20 mm solvent socket	
J195	GAUGE-TEE OUT	GAUGE-P2 IN	20 mm solvent socket	
J196	GAUGE-P2 OUT	F0-IN-R IN	20 mm solvent socket	
J197	GAUGE-AD-R20 OUT	GAUGE-AD-R16 IN	Nested solvent sockets	20-to-16 and 16-to-12 bushes; do not thread or force
J198	GAUGE-AD-R16 OUT	GAUGE-AD-STUB IN	12 mm solvent socket	
J199	GAUGE-AD-STUB OUT	GAUGE-AD-AD IN	12 mm solvent socket	
J200	GAUGE-TEE SIDE	GAUGE-AD-R20 IN	20 mm solvent socket / measured stub	
J201	GAUGE-AD-AD OUT	GAUGE WATER	G1/4 matched face seal	

18 / BUILD REFERENCE

Appendix D: manufacturer sources

Accessed 20 October 2026. These are the sources for the reference selection. Verify revision, regional configuration, delivered labels and current manuals. Manufacturer names identify parts and do not imply endorsement.

Espressif DevKitC V4 guide and mechanical drawing

https://docs.espressif.com/projects/esp-dev-kits/en/latest/esp32/esp32-devkitc/user_guide.html

Espressif DevKitC V4 dimensions, mm

https://dl.espressif.com/dl/schematics/esp32_devkitc_v4_dimensions.pdf

Analog Devices EVAL-ADXL355-PMDZ connector P1

<https://wiki.analog.com/resources/eval/user-guides/circuits-from-the-lab/eval-adxl355-pmdz>

Adafruit ADS1115 pinouts, current STEMMA QT revision

<https://learn.adafruit.com/adafruit-4-channel-adc-breakouts/pinouts>

Adafruit 757 BSS138 4-channel logic converter

<https://www.adafruit.com/product/757>

Adafruit 1085 manufacturer CAD, MIT

https://github.com/adafruit/Adafruit_CAD_Parts/tree/main/1085%20ADS1115%20ADC

Adafruit 5648 MOSFET Driver pinouts

<https://learn.adafruit.com/adafruit-mosfet-driver/pinouts>

Adafruit 5648 manufacturer CAD, MIT

https://github.com/adafruit/Adafruit_CAD_Parts/tree/main/5648%20MOSFET%20Driver

DFRobot SEN0550, G1/2, dimensions and pulse factor

<https://www.dfrobot.com/product-2608.html>

DFRobot SEN0257, current 0-16 bar version

<https://www.dfrobot.com/product-1675.html>

Burkert 6013, article 125300, 12 V DC, NC, G1/4

<https://www.burkert.in/en/products/solenoid-valves/general-purpose-2-2-solenoids/125300>

Burkert 6013 datasheet, dimensions and cold-coil power

<https://www.burkert.com/en/Media/plm/DTS/DS/ds6013-standard-eu-en.pdf2>

Burkert 2518 plain Form A connector, article 314802

<https://www.burkert.in/en/products/solenoid-valves/accessories/cable-plugs/314802>

Tameson NLB-014 brass needle valve, G1/4

<https://tameson.com/products/nlb-014-g1-4inch-brass-needle-valve-nbr-40-bar>

Tameson NLB-014 downloadable STEP

<https://storage.tameson.com/asset/Products/CAD/nlb-014.zip>

Tameson FL2S-M-B-014G double nipple, G1/4

<https://tameson.com/products/fl2s-m-b-014g-g-1-4inch-brass-double-nipple-16-bar-5-pieces>

Tameson G1/4 male x 6 mm hose barb

<https://tameson.com/products/fl2s-mh-b-014g-06-i-g-1-4inch-male-x-6mm-brass-hose-barb-16-bar-5-pieces>

GF industrial catalogue: printed pages 66, 72-77, 83-87, 92

<https://www.gfps.com/content/dam/gfps/au/product-ranges/gfps-au-industrial-catalogue-en.pdf>

Pentair SHURflo SLV10-AA40 exact reference model

https://www.pentair.com/en-us/products/business-industry/water-supply-pumps/spray-pumps/slv_series_diaphragm_pumps/sku/slv10-aa40.html

SHURflo SLV installation manual, 911-565 Rev G

<https://www.pentair.com/content/dam/extranet/web/nam/shurflo/manuals/911-565-slv-series-industrial-pumps-iom.pdf>

Pololu 2843, D24V5F5, regulated 5 V / 500 mA

<https://www.pololu.com/product/2843>

RIGOL DP800 User Guide: DP811A 20 V / 10 A range, earth terminal

https://www.rigol.com/dam/global/downloads/brochures/en/user-manual/dc-powers/DP800_UserGuide_EN.pdf

TP-Link UH700 V5: Micro-B upstream, 7 Type-A ports

https://static.tp-link.com/upload/product-overview/2025/202505/20250515/UH700%28UN%295.0_datasheet.pdf

WIKA 111.10 pressure gauge family

https://www.wika.com/en-en/111_10_111_12.WIKA

GF catalogue: pipe dimensions on printed page 66; metric elbow/tee/cap/reducing bushes on pages 72-77; instrument adapters on page 86; union on page 92. PN ratings are referenced at 20 C and do not release the assembled rig for those pressures.

Adafruit CAD and Three.js are MIT-licensed; full notices are included in LICENSES.txt and embedded in the HTML. Tameson needle geometry is derived from its public manufacturer product STEP. Custom geometry and connection data are supplied for the project team to inspect and adapt.