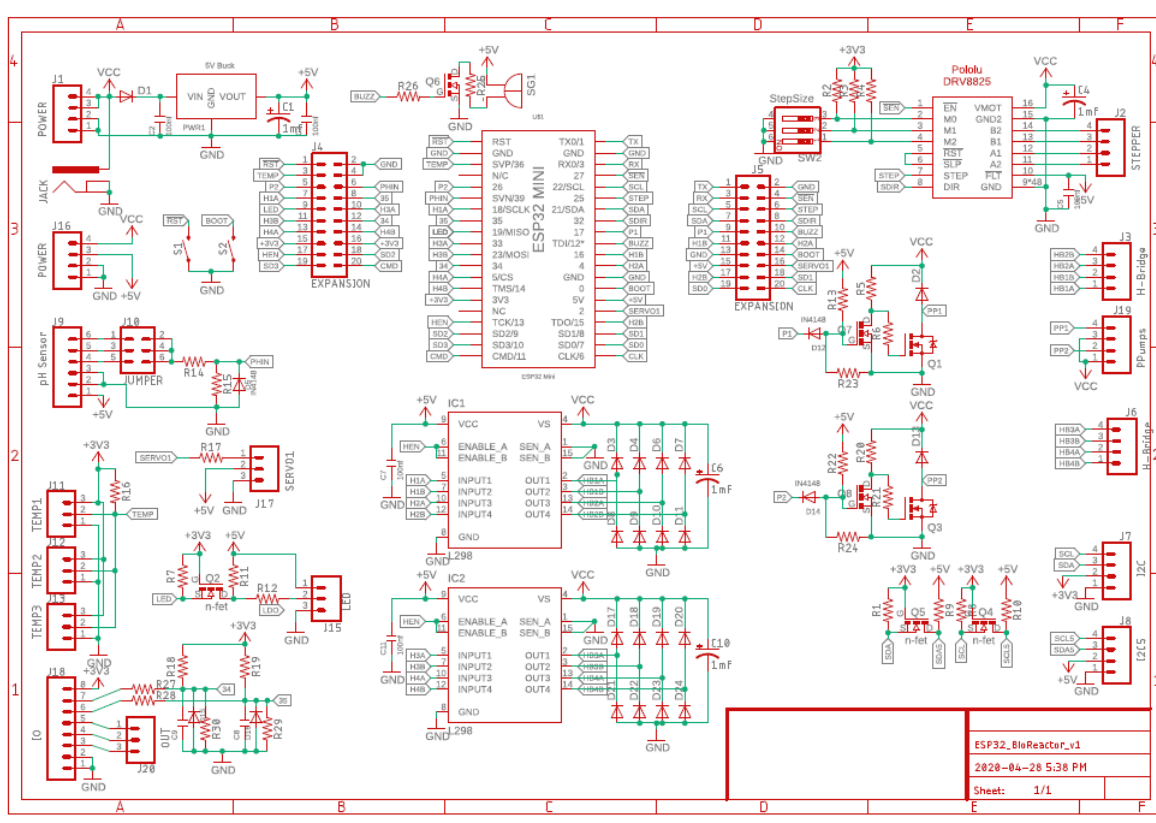


ESP32_BioReactor_v1 PCB :: Description

PCB v1 Revision Description

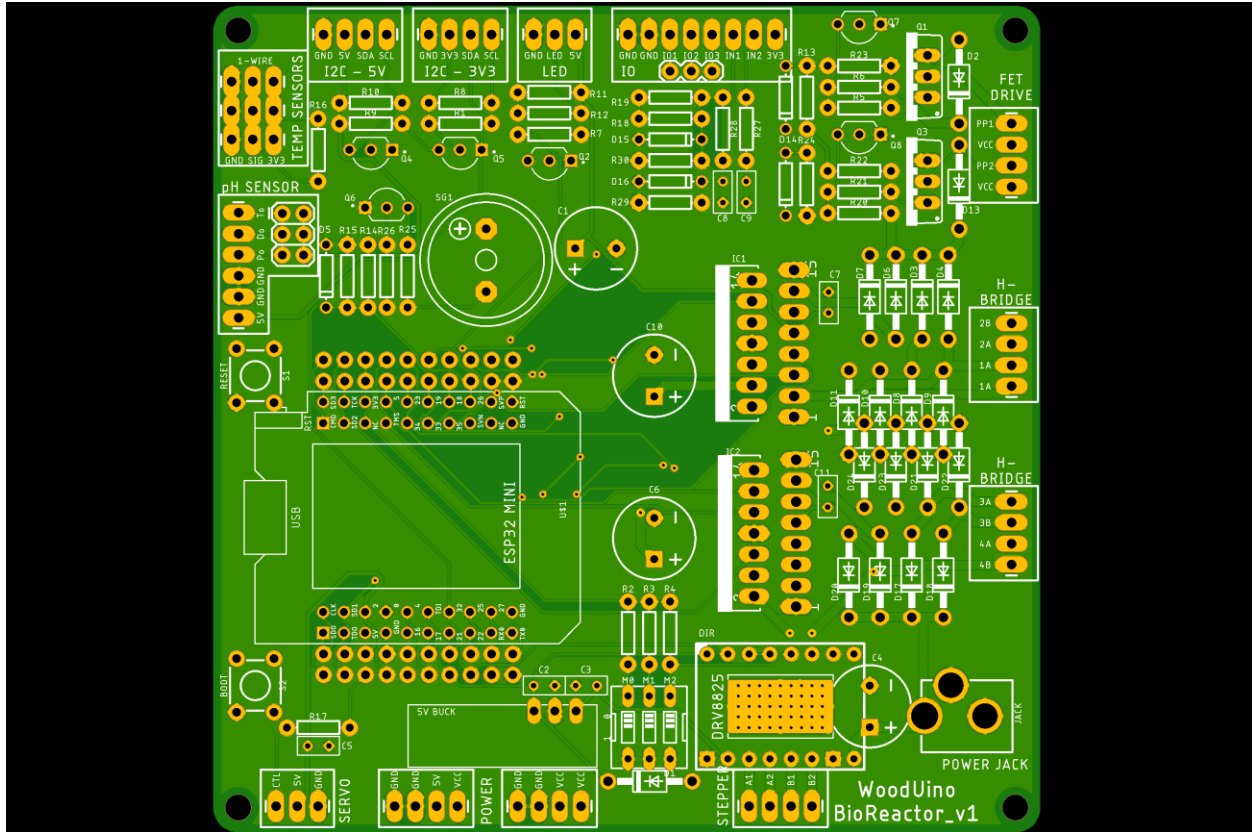
The initial version of the board is designed as a prototype consolidation of the functions necessary to run a small, low-cost reagent manufacturing machine. The following is the circuit schematic and an image of the 100mm x 100mm double-sided PCB.

The board contains an ESP32 D1 Mini Module to control on-board driver and interface circuits for the machine.



ESP32_BioReactor_v1 Schematic

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ESP32_BioReactor_v1 Circuit Board Layout

This version of the PCB includes support for the following features:

1. Rocking Mechanism

The rocking mechanism consists of a tray that can be moved in one plane from side to side to keep the chemicals agitated. Two designs are included to allow the control of this rocking motion to be performed by either a stepper motor or a servo.

STEPPER MOTOR: The DRV8825 stepper motor driver is the popular low-cost dual inline module used to control NEMA 17 motors often found in small drawing machines and 3D printers. The ESP32 controls the motor's STEP [25] and DIRECTION [32], and includes an ENABLE [27] to activate (0) / deactivate (1) the motor power.

The stepper driver module is powered directly from the main supply voltage (typically 12V) delivered to the board. A 4-pin connector [STEPPER: A1, A2, B1, B2] allows direct connection to a typical NEMA 17 dual-phase stepper motor. In addition, three DIP switches on the board set the micro-stepping feature from FULL-STEP to 1/16th STEP for fine control of the motor speed and power as follows.

STEP SIZE	M0	M1	M2
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FULL	0	0	0
HALF STEP	1	0	0
QUARTER STEP	0	1	0
EIGHTH STEP	1	1	0
SIXTEENTH STEP	1	1	1

The module contains a small trimpot that allows the user to set the supply current necessary to operate the particular stepper motor being used. To minimize power dissipation, this trimpot should be adjusted to operate the stepper motor just above its stall current.

In addition, it is important to note that the A4988 Stepper Driver Module is a pin-for-pin compatible device and can be substituted with no code or hardware changes.

SERVO MOTOR: A servo motor connection [2] is provided to control a MG995 or similar power servo from the 5V supply. If a larger servo motor is to be used, it is recommended that it is connected to its own supply voltage.

2. Peristaltic Pumps, Air Pumps and Heater Drivers

The board consists of two high-power dual H-bridges and two power-FETs to control the array of peristaltic pumps, air pumps and heater/cooler systems that may be present. While the design requirements of the machine may change, these power drivers are not dedicated to operate specific external devices, allowing the user to mix-and-match them as needed. The functionality provided is as follows:

H-BRIDGES: Two dual H-Bridge drivers – using the L298N - are included to provide 4 independent bi-directional pulse-width modulated (PWM) 12V outputs. The L298N has been around for many years and is robust, reliable and easy to heatsink, if necessary. Both devices share a common ENABLE [13] pin to activate (1) / deactivate (0) all four of the outputs.

Each of the H-Bridge drivers uses two inputs to control its two output pins. The pins used are as follows:

H-BRIDGE	INPUT A	INPUT B	CONNECTOR OUTPUT
H1	H1A [18]	H1B [16]	HB1A, HB1B
H2	H2A [4]	H2B [15]	HB2A, HB2B
H3	H3A [33]	H3B [23]	HB3A, HB3B
H4	H4A [5]	H4B [14]	HB4A, HB4B

In operation, one INPUT can be used as a FORWARD (REVERSE) DIRECTION while the other INPUT pin can be used to control power through PWM. Note that the “value” of the PWM will depend on the polarity of the DIRECTION input.

POWER FETS: Two power n-channel FETs are included to provide unidirectional control to two independent 12V devices, each connected between VCC and the OUTPUT. These connections can

ESP32_BioReactor_v1 PCB :: Description

ON/OFF control 12V devices directly, and mains-operated devices using an external opto-coupled solid-state relay (SSR) or relay. In addition, the power delivered to each OUTPUT can be controlled using PWM.

The power FETs are controlled by P1 [17] and P2 [26] and output on connections PP1 and PP2. The pre-driver circuitry for each power FET allows the user to change the power-on state of the output through component population choices, as follows:

POWER FET	POWER-ON STATE	POPULATE	DEPOPULATE	CONNECTOR OUTPUT
P1	OFF (DEFAULT)	R13, D12 (fwd)	R23	PP1, VCC
P1	ON	R23, D12 (rev)	R13	
P2	OFF (DEFAULT)	R22, D14 (fwd)	R24	PP2, VCC
P2	ON	R24, D14 (rev)	R22	

3. I2C OLED [LCD] Display & Sensors

The board offers two I2C communication ports, one at 3.3V and the other at 5V, to connect displays, sensors, real-time clocks and other I2C connected devices. The I2C uses the ESP32's default pins for SCL [22] and SDA [21]. The logic levels from the ESP32 are also shifted to run at 5V using discrete FET bidirectional level converters to allow lots of flexibility.

4. Addressable LED Array / Panel

The board sports a single serial OUTPUT [19] to connect one or more addressable LEDs, based on the WS2812B NEOPIXEL. The logic levels from the ESP32 are shifted to run from the 5V using a discrete FET bidirectional level converter to allow the driving of standard strips or panels of these LEDs. Suitable libraries (Adafruit, FastLED) offer simple control of the red, green and blue (rgb) LEDs of the WS2812B chips, while also providing more sophisticated support for using hue, saturation and light intensity (HSV) and other colour models.

The on-board 5V supply is capable of supplying up to 1.5A, so a good 'rule-of-thumb' would be to limit the number of WS2812B NEOPIXELS to ~64. If more are required – for increased coverage or intensity, for instance – it will be necessary to power them with an external 5V supply.

5. Temperature Sensors

Provision on the board is made to support three DS18B20 temperature sensors that run on 3.3V and use the Dallas Semiconductor "1-WIRE" protocol [36]. While there are three separate output connectors, the simple protocol allows this number to be increased to support more devices, if needed.

6. pH Sensor

An INPUT connection is provided [39] to support a pH Sensor and its associated control module. As the pH module is powered from the 5V supply, a resistor voltage divider is provided (R14, R15) – along with

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a 3.3V Zener for protection – to limit the analogue input range to ~3V. In addition, three jumpers are provided allowing selectable connection to the three pH sensor module analogue outputs.

7. Alert Buzzer

A single buzzer is provided [12] to allow for audible feedback. A small-signal FET is used to provide power to the buzzer through a current limiting resistor (R25), which can be selected based on the audible level required.

8. Expansion Port

A small expansion port is provided to allow the connection of two INPUTs [34 and 35] which are protected with resistor pull-up (R18, R19 respectively), pull-down (R30, R29, resp.), voltage dividers (R27 || R30 and R28 || R29, respectively) for flexibility. 3.3V Zener diodes are also provided for protection and the optional 0.1uF capacitors (C9, C8) can be used for simple low-pass filtering and button debouncing. 3.3V and GND connections are also provided.

In addition, connections to 3 INPUT/OUTPUTs are also provided. These are undedicated and can be 'jumped' to any unused IO pins. All signals are 3.3V

9. Power In/Out

Main power (typically 12V) can be connected to the board through a standard 5.5/2.1mm power jack or through pairs of connector pins. An additional set of power pins is also provided for connections to 12V, 5V and GND for off-board power.

10. Miscellaneous

The board also features a reset switch – to restart the ESP32 - and a boot switch that may be needed when new software is being downloaded to the ESP32.

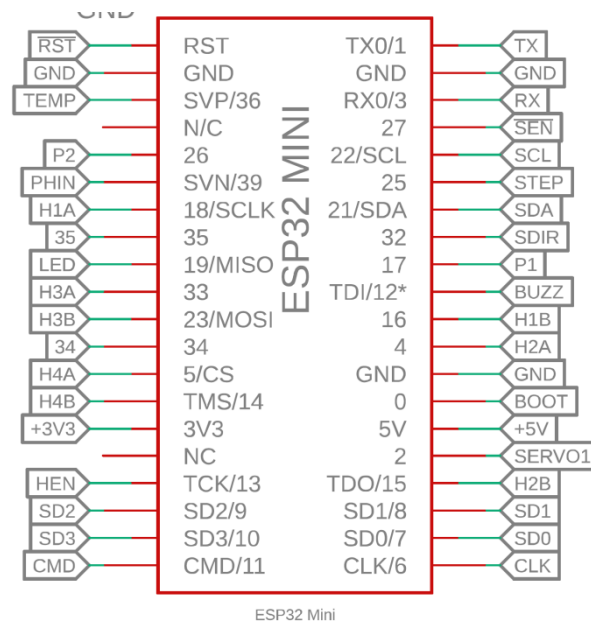
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ESP32 D1 Mini Pin Connections

The following table shows the ESP32 D1 Mini connections used:

ESP32 Pin	Function
!RST	ESP32 Reset
GND	Supply 0v
36 / TEMP	Temp sensors I/P
26 / P2	Power FET 2 O/P
39 / PHIN	pH sensor I/P
18 / H1A	H-Bridge 1A
35	General purpose I/P
19 / LED	LED O/P
33 / H3A	H-Bridge 3A
23 / H3B	H-Bridge 3B
34	General purpose I/P
5 / H4A	H-Bridge 4A
14 / H4B	H-Bridge 4B
3V3	3.3V OP
13 / HEN	H-Bridge Enable O/P
SD2	<i>Internal FLASH</i>
SD3	<i>Internal FLASH</i>
CMD	<i>Internal FLASH</i>

ESP32 Pin	Function
1 / TXD	Transmit Data (USB)
3 / RXD	Receive Data (USB)
27 / !SEN	Stepper !ENABLE
22 / SCL	I2C SCL
25 / STEP	Stepper STEP
21 / SDA	I2C SDA
32 / SDIR	Stepper DIRECTION
17 / P1	Power FET 1 O/P
12 / BUZZ	Buzzer O/P
16 / H1B	H-Bridge 1B
4 / H2A	H-Bridge 2A
0 / BOOT	ESP32 Boot / Flash
5V	5V Power I/P
2 / SERVO1	Servo CTL O/P
15 / H2B	H-Bridge 2B
SD1	<i>Internal FLASH</i>
SD0	<i>Internal FLASH</i>
CLK	<i>Internal FLASH</i>



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Bill Of Materials (BOM)

The following is a Bill of Materials for the board.

Qty	Value	Device	Parts
7	100nf	CERAMIC DISC - 0.1" (14)	C2, C3, C5, C7, C8, C9, C11
4	1000uF	1000UF RADIAL 5MM 25V 20% (15)	C1, C4, C6, C10
20	10K	10K 1/4W 1% Axial	All others ***
5	4K7	4K7 1/4W 1% Axial	R21,R6, R26, R16,R15
1	3K3	3K3 1/4W 1% Axial	R14
5	200Ω	200 1/4W 1% Axial	R12, R17, R25, R27, R28
19	1N4001/Schottky	1N4001 / 1N5819 (5)	D1, D2, D13, D3-D11, D17-D24
2	IN4148 / IN914	Small signal Axial (4)	D12, D14
3	ZENER	3V3 Zener Axial (3)	D5, D15, D16
6	N-FET	2N7000 T092 (11)	Q2, Q4, Q5, Q6, Q7, Q8
1	5V BUCK	5VBUCK (1)	5VBUCK
1	POLOLU-DRV8825	POLOLU-DRV8825 (6)	DR1
1	ESP32 D1 MINI	ESP32 D1 MINI (7)	U1
1	BUZZER	12085 BUZZER (2)	SG1
2	N-Power FET	IRF540 / FQP50N06 TO220 (8)	Q1, Q3
1	JUMPER	CONN_03X2FEMALE 0.1"	J10
2	L298N	L298 ZIP-15 (9)	IC1, IC2
2	SWITCH	MOMENTARY SPST 6.0MM (12)	S1, S2
1	POWER_JACK	POWER_JACKPTH_LOCK (13)	JACK
1	STEPS Switch	SW_DIP-3 (10)	SW2

Note that several of the resistors listed as 10K (R18, R19, R29, R30) may have their value changed or not be populated (R13, R23, R22, R24) depending on the use of that part of the circuit.

11. Buying Notes

The following are some suggestions for purchasing the components used on the board. In many cases, substitutions are acceptable.

1. 5V Buck Converter Power Supply Module: <https://www.aliexpress.com/item/32326346960.html>
2. Passive buzzer 12A05 2KHz: <https://www.aliexpress.com/item/4000133619336.html>
3. 3.3V Zener diode (1N4728A 3V3): <https://www.aliexpress.com/item/33036174099.html>
4. 1N4148 small signal diode: <https://www.aliexpress.com/item/33035453991.html>
5. 1N4001 / 1N5819 Schottky diode: <https://www.aliexpress.com/item/32854074561.html>
6. DRV8825 Polulu stepper driver: <https://www.aliexpress.com/item/1000005739591.html>
7. ESP32 D1 Mini board: <https://www.aliexpress.com/item/4000650306925.html>
8. 50N06 N-Power FET: <https://www.aliexpress.com/item/32823515287.html>
9. L298N ZIP-15: <https://www.aliexpress.com/item/32867965978.html>
10. Slide Toggle 3-way DIP switch: <https://www.aliexpress.com/item/32892007978.html>

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11. 2N7000 N-ch MOSFET: <https://www.aliexpress.com/item/4000515871375.html>
12. 6mm Momentary tactile switch: <https://www.aliexpress.com/item/32961272650.html>
13. 5.5mm 2.1mm Power Jack: <https://www.aliexpress.com/item/32730260523.html>
14. 100nF (0.1") ceramic cap.: <https://www.aliexpress.com/item/32868001945.html>
15. 1000uF 25V electrolytic cap.: <https://www.aliexpress.com/item/32506590473.html>