Title: VentMon: and Open Source Inline Ventilator Test Fixture and Monitor

Authors: Robert Read, Lauria Clarke

Affiliations: Public Invention with support from the *Protocol Labs* and the *Mozilla Foundation*

Contact email: read.robert@gmail.com

Abstract: A device that plugs into the airway circuit and measures the parameters of an operating ventilator that are carefully controlled by clinicians.

Keywords: COVID-19, open source medical device,

Specifications table:

Hardware name	VentMon
Subject area	Educational Tools and Open Source Alternatives to Existing Infrastructure
Hardware type	Field measurements and sensors, Electrical engineering and computer science
Open source license	MIT License, CERN-OHL-S
Cost of hardware	$280
Source file repository	*DOI URL to an approved source file repository: Mendeley Data, the OSF, or Zenodo (instructions). For example: https://doi.org/10.5281/zenodo.3346799* *If there is no external repository write " Available in the article "*

1. Hardware in context

The Coronavirus pandemic has created a global shortage of ventilators. Ventilators are expensive to manufacture and during uncertain times supply chains can be disrupted increasing the cost and scarcity of these devices. Since the beginning of the pandemic in March, there has been a large movement to develop cheaper, more supply chain resilient ventilator. The urgency and goals of this movement have shifted as the global understanding of the virus has evolved. Regardless of the current state of this movement, however, the use of open source medical devices in resources limited emergency situations – common during a global pandemic – is a topic that has come to the forefront of may conversations about preparedness and treatment. Medical devices require rigorous testing before they can be used on the general public. Open source medical devices require the same level, if not more scrutiny. If an open source movement is to succeed in this field, the tools to test and validate medical devices should also be community based. The goal of VentMon is to provide an equally open source, community based verification solution to increase the efficiency and accuracy of the development process for teams making open source ventilator devices.

2. Hardware description

- ...
- ...
- ...

3. Design files

TODO Need to make hyperlinks colored in *Location of File* column

3.1 Design Files Summary

Design file-name	**File type**	**Open source license**	**Location of the file**
Embedded Firmware	C++ Source Code	MIT License	VentMon Firmware
PIRDS Data Viewer	HTML Source Code	MIT License	Vent Display
PIRDS Data Logger	C Source Files	MIT License	PIRDS Logger
VentMon T0.3 PCB	PCB Design Files	MIT License	VentMon PCB
Pressure Sensor and Airway Adaptor	STL File	MIT License	VentMon Adaptors
PIRDS Data Standard			

For each design file listed above, include a short description of the file here (one or two sentences)

4. Bill of materials

Current Link: VentMon HardwareX BOM

- BOM needs to be converted to PDF and uploaded per instructions:
  For a complex Bill of Materials, the complete Bill of Materials (editable spreadsheet file e.g., ODS file type or PDF file) can be uploaded in an open access online location such as the Open Science Frameworks repository. Include the link here. Alternatively, the Bill of Materials can be uploaded at the time of submission on the online Elsevier submission interface as supplementary material.

5. Build instructions

Two versions of VentMon can be assembled depending on availability of parts and time. The most physically robust and complete version of VentMon requires the purchase and manufacture of a custom PCB as well as a number of 3D printed plastic parts. This version of the device requires the least amount of time to assemble and contains fewest discrete components. Due to the high cost of PCB manufacture and assembly, VentMon can also be created using off the shelf components readily available from DIY electronics suppliers. This version requires significantly more assembly time. Both assembly procedures are outlined below.

5.1 PCB Based VentMon

This version of VentMon requires two 3D printed parts – one encapsulated an on-board pressure sensor and one is an airway adaptor – as well as a PCB assembly. Before beginning the assembly process make sure that you have manufactured those three parts.

1. PCB Assembly

1.1 Add standoffs to PCB

1.1.1 take hardware and put it in the holes

1.2 Mount sensor enclosure for BME280 pressure sensor

1.2.1 Insert plastic part into mounting holes on PCB to check fit and alignment. The barb should face toward the outer edge of the PCB.

1.2.2 Apply glue to bottom edge and mounting pegs of plastic.

1.2.3 Insert plastic back into holes being careful not to get any glue on the sensor.

1.2.4 Allow 24 hours for glue to cure before attaching a hose to the barb.

2. Enclosure
3. Flow Sensor Assembly
4. Oxygen Sensor Assembly
5. Final Assembly

5.2 COTS Based VentMon

1. Qwiic Shield Assembly
2. Enclosure
3. Flow Sensor Assembly
4. Oxygen Sensor Assembly
5. Final Assembly