

# Low-cost Respiratory Flowmeter and Monitoring System

## Princeton Open Ventilation Monitor Collaboration

**Introduction:** We have developed an inexpensive respiratory flowmeter system that is based on readily available commercial components. The system is designed for use in conjunction with non-invasive ventilator systems, such as the Covid 19 Helmet developed by Sea-Long Medical Systems, LLC,<sup>1</sup> but is modular and can be used in other systems. The system comprises one or more flow and pressure sensors and a central station that can be used to remotely monitor up to 20 patients. The system reports flow, pressure and clinically relevant metrics including respiratory rate, tidal volume, PIP, PEEP and I:E ratio.

**Hardware:** The flow-sensor assembly shown in Fig. 1, consists of a differential pressure sensor that measures the pressure drop across a flow channel and a second sensor that measures the pressure in the sensor relative to atmosphere. Signals from these sensors are processed by a Raspberry Pi (RPi) based interface box connected via an RJ-45 jack.

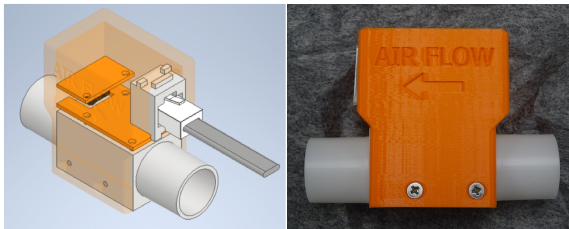


Figure 1: Flow-sensor assembly. The electronic sensor elements are mounted on circuit boards that connect to an external RPi controller via a standard RJ-45 jack.

Fig. 2 shows the interface box. The RPi converts the raw signals to flow and pressure readings, which are logged and made available to a remote monitoring station over a network. The RPi scans flow and pressure information and sets off alarms when patients experience difficulties. An LCD displays basic information and a rotary encoder is used to set alarm

thresholds. Colored LEDs and a piezoelectric buzzer announce alarms.

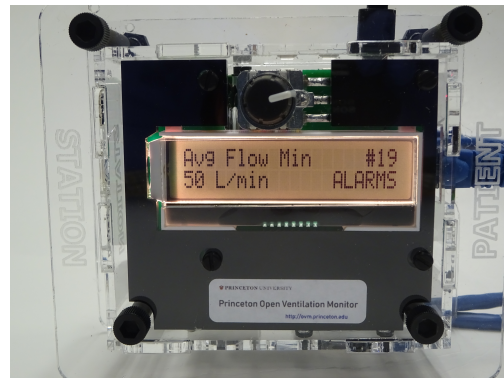


Figure 2: The Raspberry Pi based interface box.

A networked remote monitoring station shown in Fig. 3 displays more detailed information from up to 20 interface boxes. In addition to alarm status, the system also displays respiratory rate, tidal volume, PEEP, PIP, and I:E ratio. The system has a touch screen interface with multiple views to either show all patients simultaneously or to show details of a single patient.

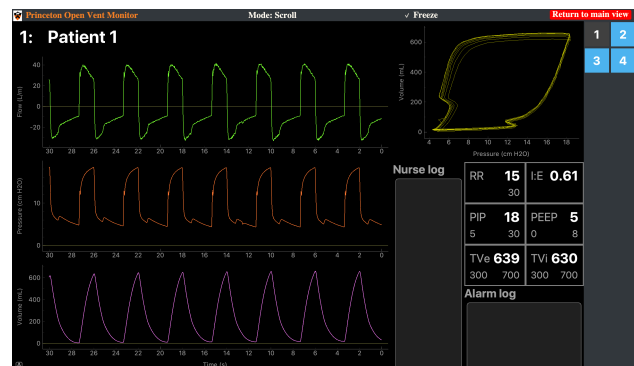


Figure 3: Monitoring station display. Data obtained using a ventilator and Ingmar ASL5000 test lung.

<sup>1</sup>see URL: <https://www.sea-long.com/>