

Abstract

Generally pressure of gasses provided by anesthesia and ventilation machines is measured with an internal pressure sensor in order to avoid unsafe conditions for patients. However, in developing countries this part may not be functional and an external device may be required to monitor pressure. Engineering World Health (EWH), an organization that provides medical equipment to underserved areas of the world, is in need of a device like this. Once background research was completed, a pressure transducer design was selected, consisting of a circuit, a microcontroller, and a LED display. Testing showed that the pressure sensor was accurate to within 1%, was very precise, and was relatively inexpensive.

Background

Engineering World Health (EWH): an organization interested in making a difference in disadvantaged areas of the world by providing medical equipment

EWH Design Program: specifications set for medical devices that would be useful in underdeveloped areas, accepts design ideas, and eventually the device could be mass-produced and distributed

Motivation

- Precise and accurate pressure measurements to avoid unsafe conditions for the patients
- Lack of resources to fix malfunctioning medical equipment in third world countries



Photo with permission from Engineering World Health

Current Technology

- Pressure sensors built into anesthesia and ventilation machines
- Break easily within the machine



http://www.medgadget.com/archives/img/dr_11.jpg

Problem Statement

Our task is to develop a gas pressure meter to be used in third world countries and to be distributed by EWH. The pressure meter will be used with ventilators and anesthesia machines, and pressure leaving the machines will be measured and displayed in a digital readout.

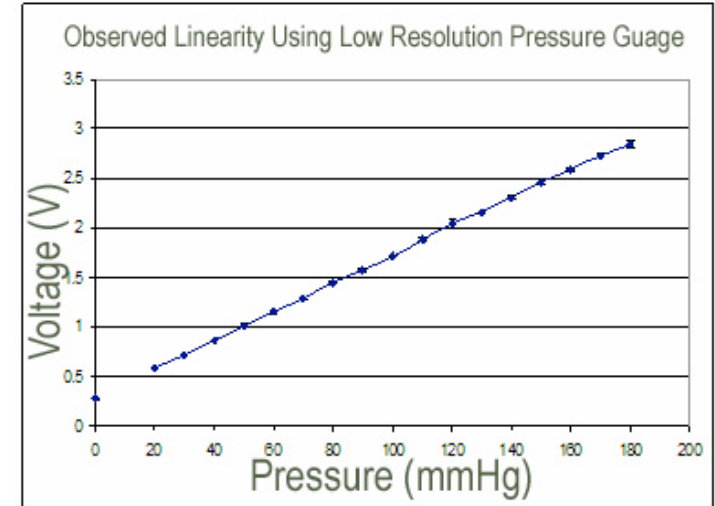
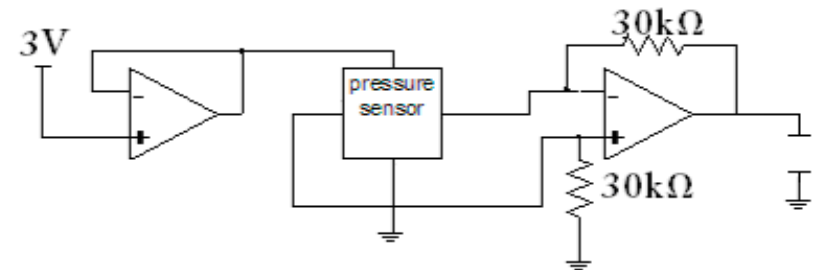
Specifications

The device must:

- Measure pressure to within at least 10% of its true value
- Have a digital readout
- Have dimensions of 4 inches by 4 inches by 1 inch for a continuous readout or 1 inch by 4 inches by 1 inch single readout device
- Read pressures between 0 and 75 mm of Hg
- Compensate for different connections to the machine
- Be reusable
- Cost less than five dollars per unit in quantities of 500, including packaging, but not including the cost of manufacturing

Prior Work

- Designed a circuit that was able to convert pressure input into voltage output
- Central component of this circuit is a strain gauge
- Linear relationship between pressure input and voltage output



This Semester's Work

■ Gas Pressure Meter

■ Circuit

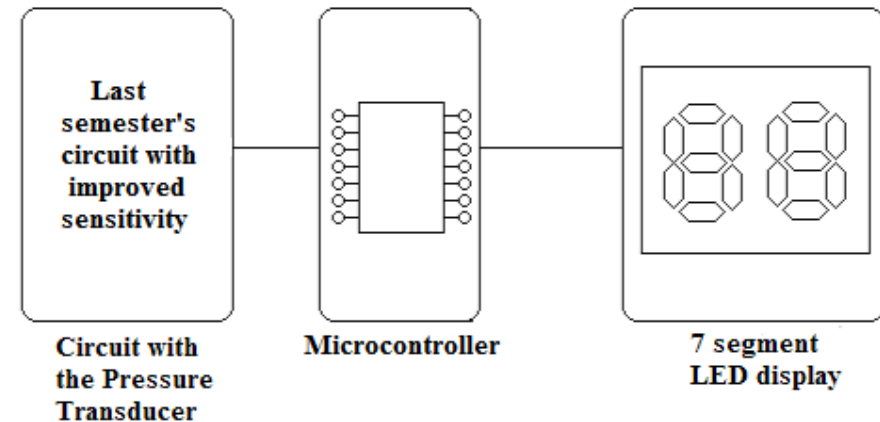
- Sensitivity of the circuit improved
- Various gas compositions tested

- Microcontroller – converts voltage output of the circuit into a digital readout corresponding to the initial pressure input

- 7-segment LED display

■ Proposal

- Submitted to EWH
- Received funding



Designs Considered:

Choosing the Microcontroller

■ Requirements:

- 14 pins
- Low power source
- Inexpensive

■ Options:

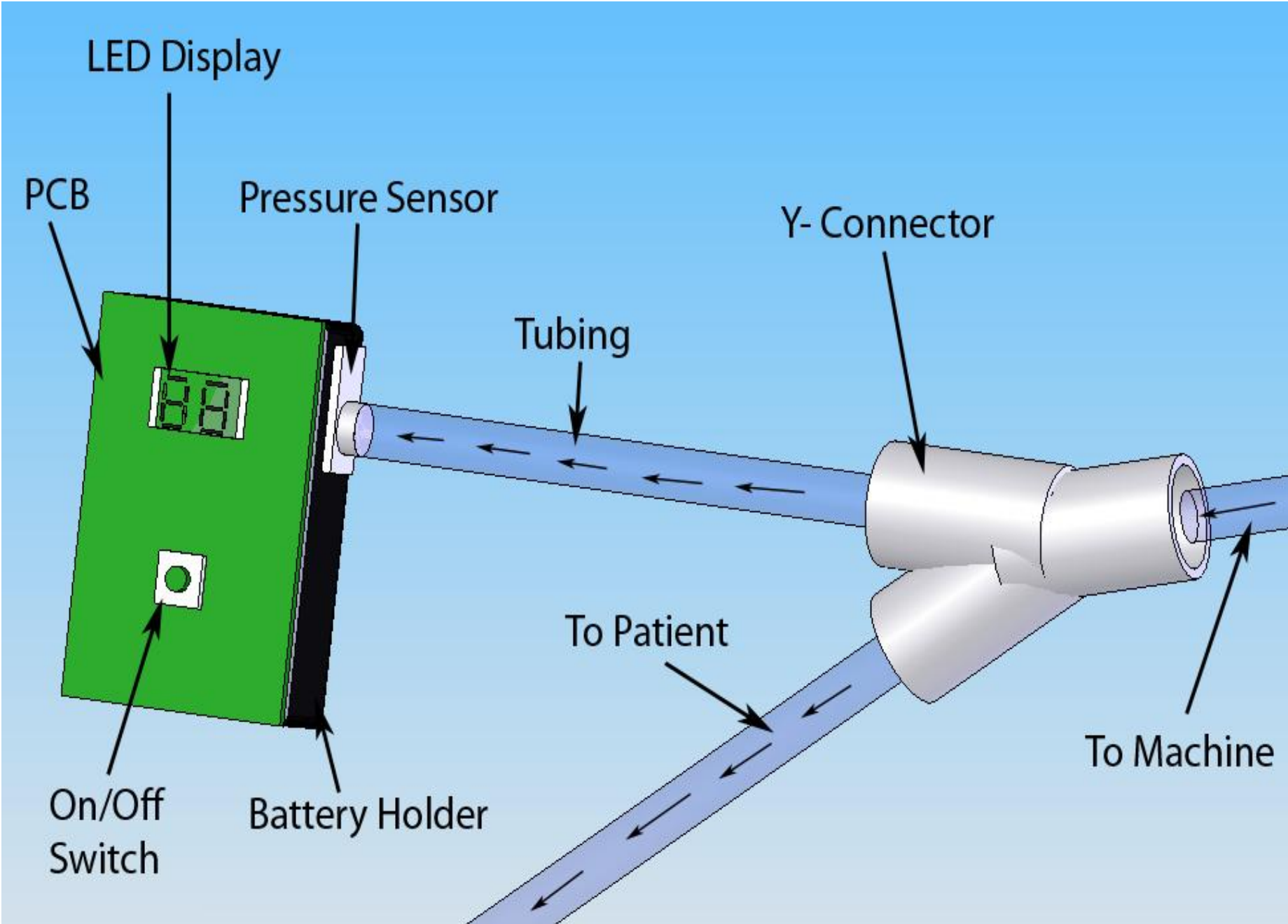
- Peripheral Integrated Circuit (PIC)
- Mixed Signal Microcontroller

Final Design

- Mixed Signal Microcontroller
 - Less expensive
 - Fewer additional parts needed
 - Programming pad purchased by Biomedical Engineering Department
- Prototype Construction
 - Sensitivity of Circuit
 - Addition of an inverting amplifier
 - Microcontroller programming
 - Testing
 - Case Construction

Budget

Part Description	Seller	Part Number	Unit Cost (per 3)	Total Cost (Unit x3)	Unit cost (per 500)	Total Cost (Unit x500)
Pressure Sensor	Electronic Goldmine	G15473	\$ 3.91	\$ 11.73	\$ 1.51	\$ 755.00
Battery Holder	All Electronics	BST-3	\$ 4.00	\$ 12.00	\$ 0.32	\$ 160.00
PCB	Express PCB		\$ 17.00	\$ 51.00	\$ 1.60	\$ 800.00
Display	Electronic Goldmine	G4031	\$ 2.66	\$ 7.98	\$ 0.24	\$ 120.00
Microcontroller			\$ 3.00	\$ 9.00	\$ 1.31	\$ 655.00
Resistors (four per unit)	Digikey	Varies Based on Size	\$ 0.80	\$ 2.40	\$ 0.12	\$ 60.00
Operational Amplifier (3 per unit)	Allied Electronics	LM358ADE4	\$ 2.43	\$ 7.29	\$ 0.33	\$ 165.00
Potentiometer	All Electronics	TPR-10K	\$ 1.60	\$ 4.80	\$ 0.16	\$ 80.00
Luer Connectors (male and female)	Cole Parmer	EW-45500-00	\$ 0.84	\$ 2.52	\$ 0.51	\$ 255.00
Button	All Electronics	PB-151	\$ 0.40	\$ 1.20	\$ 0.25	\$ 125.00
Total			\$ 36.64	\$ 109.92	\$ 6.35	\$ 3,175.00



Testing

- Linearity of the Circuit
 - Controlled input pressures
 - Recorded corresponding output voltage values
- Various Gas Compositions
 - Controlled input pressures of various gasses (O_2 and medical air – 21% O_2 and 79% N_2)
 - Recorded corresponding output voltage values
 - Observed similarity of linear relationships
 - Concluded that different gasses do not affect accuracy of the circuit

■ Sensitivity

- Added inverting amplifier in order to increase the range of output voltages of the circuit

■ Accuracy of Digital Display

- Controlled input pressure
- Observed a corresponding digital readout from LED's

Future Work

- Construct second prototype
- Transfer circuit to Printed Circuit Board
- Continue testing:
 - With anesthesia and ventilation machines
 - In different environments (humidity, temperature)
- Reduce size of device in order to maximize ease of use
- Work with EWH to have device mass-produced and distributed