DESIGNING AND PROTOTYPING OF OXYGEN ANALYZER

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ABSTRACT

A cost-effective project aims to design an oxygen analyzer using an ultrasonic flow sensor to reduce reliance on imported oxygen analyzers in developing countries. It has been validated against industry standards that demonstrate high accuracy in measuring oxygen concentration and flow rates, offering a portable, cost-effective solution to enhance healthcare systems in regions such as Nepal, India, Bangladesh, etc.

INTRODUCTION

- The oxygen analyzer measures oxygen concentration and flow rate for safety and quality control in medical equipment.
- Ensure proper oxygen level and flow rate for patients and monitor air quality.
- Ultrasonic sensor needs less maintenance and have a longer life compared to electrochemical sensors.

METHODOLOGY

The oxygen analyzer project collects essential parameters like oxygen concentration, flow rate, temperature, pressure, and volume from a ventilator and oxygen concentrator. Data acquisition was performed using the NL-PD10NF40 ultrasonic sensor, which measures oxygen concentration, flow rate, and temperature. An Arduino Nano microcontroller manages data processing, controlling the system, and acquiring sensor data. Results are displayed on a 0.98-inch OLED screen. Sensor data is further validated by comparing the Ultra-max O2 Oxygen Analyzer and Fluke Biomedical Gas Flow Analyzer VT-900A. The system's architecture includes power supply units, sensor interface circuitry for signal processing, and firmware for calibration and communication. The user interacts with the device via a simple interface, enabling efficient monitoring and control. Housed in a protective enclosure, the oxygen analyzer is built to be durable, ensuring safety, reliability, and portability, making it suitable for real-time monitoring in demanding environments.

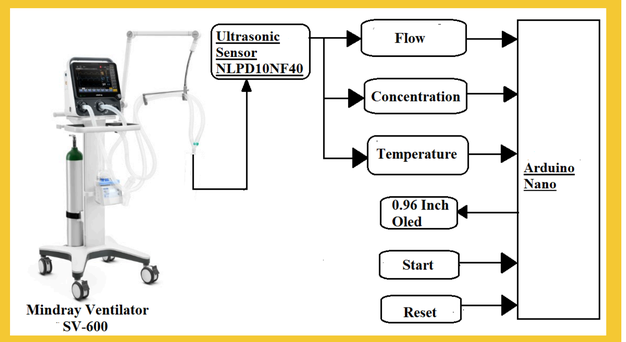

Fig1 : Block Diagram Of Oxygen Analyzer

RESULTS

Three oxygen analyzers were used to gather data: the VT 900 Gas Analyzer from Fluke Biomedical, the Ultramax Oxygen Analyzer, and our project's oxygen analyzer. The results are shown below in Table 1 & 2:

- The ventilator was set to concentrations of 21% to 100% with an increment of 5%. After each concentration was set, the three devices were used to measure the actual percentage at each setting, and the readings were recorded in an Excel sheet. The VT 900 Gas Analyzer was used first, followed by our project's analyzer, and finally, the Ultramax Oxygen Analyzer.

- After recording the data, absolute errors between the standard ventilator values and the VT 900 Gas Analyzer, project analyzer, and Ultramax Oxygen Analyzer readings were calculated. The mean absolute errors for each dataset were then computed. To analyze the accuracy of each analyzer, the data collected from each concentration setting was compared to the standard value and plotted.

Set FiO2 at ventilator	Achieved FiO2 at VT 900	Error (VT900)	Achieved FiO2 at Oxygen Analyzer	Error (Oxygen analyzer)	Achieved FiO2 at Ultra Max O2 Analyzer	Error(Ultra Max O2 Analyzer)
21	21.29	0.29	21	0	20.1	0.9
25	25.04	0.04	23	2	23.8	1.2
30	30.075	0.075	30.5	0.5	28.4	1.6
35	35.06	0.06	37.3	2.3	33.3	1.7
40	40.23	0.23	43.3	3.3	37.81	2.19
45	45.075	0.075	49.4	4.4	42.5	2.5
50	50.35	0.35	53.4	3.4	47	3
55	55.375	0.375	57.5	2.5	51.6	3.4
60	60.77	0.77	61.9	1.9	56.1	3.9
65	66.025	1.025	66.2	1.2	60.9	4.1
70	70.69	0.69	70.3	0.3	65.42	4.58
75	75.67	0.67	75.5	0.5	69.9	5.1
80	80.8	0.8	78.8	1.2	74.2	5.8
85	85.9	0.9	82.5	2.5	78.61	6.39
90	90.14	0.14	87.3	2.7	82.8	7.2
95	94.14	0.86	92.32	2.68	87.3	7.7
100	99.45	0.55	95.6	4.4	91.45	8.55
ERROR		0.464705882		2.104705882		4.106470588

Table1 : Oxygen Concentration

Set Flow from Ventilator (L/min)	Achieved Flow L/min at VT-900A	Error at VT-900A	Achieved Flow (L/min) at Oxygen Analyzer	Error at Oxygen Analyzer	Achieved Flow (L/min) at Ultramax O2 Analyzer	Error at Ultra Max O2 Analyzer
0	0	0	0	0	0	0
1	1.9	0.9	1.9	0.9	1.9	0.9
2	2.3	0.3	2.5	0.5	2.6	0.6
3	3.7	0.7	3.8	0.8	3.8	0.8
4	4.9	0.9	4.8	0.8	4.8	0.8
5	5.8	0.8	5.7	0.7	5.88	0.88
6	6.5	0.5	6.7	0.7	6.7	0.7
7	7.5	0.5	7.95	0.95	7.95	0.95
8	8	0	8.2	0.2	8.3	0.3
9	9.5	0.5	9.5	0.5	9.5	0.5
10	10.23	0.23	10.4	0.4	10.4	0.4
Error		0.484545455		0.58636364		0.620909091

Table2 : Oxygen Flowrate

- The slope of the line between the measured and standard values was calculated to assess the accuracy. These data show the largest error value of approximately 0.9 L/M at the setting points of 1 L/M and the smallest error value of 0.2 L/M at the setting point of 8 L/M.

- From these data, the largest error value is approximately 5 percent at the setting points of 40 and 100 percent and the smallest error value is 0.3 percent at the setting point of 70 percent.

- Similarly, for the flow rate measurement, the oxygen concentrator was set from 0L\M up to 10L\M. In each set point all three devices were used to measure the flow rate from the concentrator one after another in each set point.

- All the data that was obtained was recorded. The VT 900 Gas Analyzer was used first, followed by our project's analyzer, and finally, the Ultramax Oxygen Analyzer.

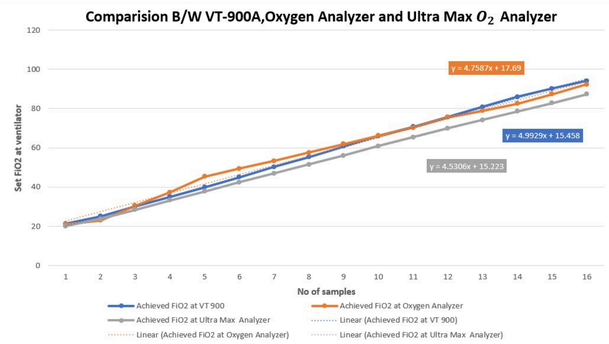

Fig2 : Graph Of Oxygen Concentration

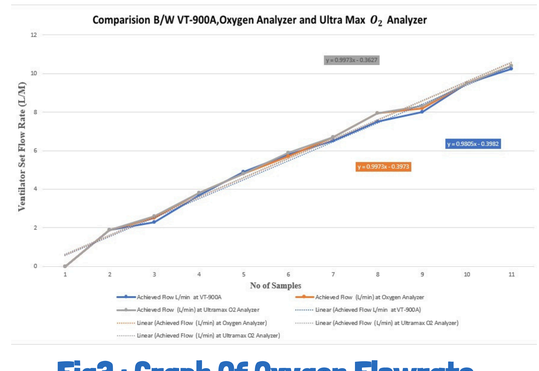

Fig3 : Graph Of Oxygen Flowrate

CONCLUSION

1. ACCURATE AND RELIABLE: OXYGEN ANALYZER PROVIDES PRECISE MEASUREMENTS OF OXYGEN CONCENTRATION AND FLOW RATE.

2. LOCAL INNOVATION: DEVELOPED IN NEPAL, THIS DEVICE ADDRESSES A CRITICAL HEALTHCARE NEED.

3. PROMISING FUTURE: FUTURE IMPROVEMENTS AND COLLABORATIONS WILL EXPAND THE ANALYZER'S IMPACT

REFERENCE

- N. A. RODRÍGUEZ-OLIVARES, L. NAVA-BALANZAR AND L. BARRIGA-RODRÍGUEZ, "DIFFERENTIAL PRESSURE SPIROMETRY FOR MECHANICAL VENTILATION USING DICHOTOMIC SEARCH," IN IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT, VOL. 70, PP. 1-10, 2021, ART NO. 4007610, DOI: 10.1109/TIM.2021.3116307.
- TOMIZUKA, M.; SUN, L. SIMPLIFIED REALIZATION OF ZERO PHASE ERROR TRACKING. JOURNAL OF DYNAMIC SYSTEMS, MEASUREMENT, AND CONTROL 2021, 143(3), P.031008. HTTPS://DOI.ORG/10.1115/1.4049391
- PUTRA, ADE, TRI BOWO INDRATO, AND LILIEK SOETJIATIE. "TOOLS TO MEASURE OXYGEN CONCENTRATION AND OXYGEN FLOW RATE IN CONTINUOUS POSITIVE AIRWAY PRESSURE." JOURNAL OF ELECTRONICS, ELECTROMEDICAL ENGINEERING, AND MEDICAL INFORMATICS 1.1 (2019): 6-10.
- I. D. G. H. W. TRIWIYANTO AND B. U. S NUMBER, "OXYGEN CONCENTRATION DETECTOR IN THE CONTINUOUS POSITIVE AIRWAY PRESSURE FOR SLEEP APNEA THERAPY BASED ON IOT TECHNOLOGY," 2021 INTERNATIONAL SEMINAR ON APPLICATION FOR TECHNOLOGY OF INFORMATION AND COMMUNICATION (ISEMANTIC), SEMARANGIN, INDONESIA, 2021, PP. 156-160, DOI: 10.1109/ISEMANTIC52711.2021.9573207.