

DAR ES SALAAM INSTITUTE OF TECHNOLOGY



PROJECT TITLE:DESIGN AND IMPLEMENTATION OF AN OXYGEN PURITY MONITORING SYSTEM IN OXYGEN CONCENTRATORS FOR PATIENT SAFETY.

MODULE:PROJECT CONCEPTUALIZATION

PROJECT TYPE: PROBLEM SOLVING

CLASS :BENG22 ETE

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BACKGROUND OF THE PROJECT

Oxygen concentrators are widely used in medical care to supply oxygen with purity levels above 90%. However, oxygen purity can fluctuate during operation, and many existing systems lack continuous real-time monitoring of purity. This makes it difficult to promptly detect performance changes, which may compromise reliable and safe delivery of medical-grade oxygen. Continuous monitoring of oxygen purity is therefore essential to ensure consistent and dependable operation.

PROBLEM STATEMENT

Many oxygen concentrators do not provide continuous real-time monitoring of oxygen purity, relying instead on periodic checks.

This can fail to detect sudden purity drops caused by operating conditions or component wear, leading to unsafe oxygen delivery and potential risks to patient safety.

OBJECTIVES

MAIN OBJECTIVE:

To design and implement a system for continuous and real-time monitoring of oxygen purity in an oxygen concentrator.

OBJECTIVES

SPECIFIC OBJECTIVES:

1. To design and implement the sensing unit.
2. To design and implement safety mechanism.
3. To develop the control unit for data processing and system management.
4. To design and implement power supply for all system components.
5. To design and implement real-Time User Feedback and Communication.
6. To design the system prototype and testing.

LITERATURE REVIEW

S.No	Author(s)	Year	Technique Used	Strengths	Weakness / Limitation
1.	Shivalinga, Jayaraj & Paul	2024	Air pressure sensor + Arduino for measuring flow & <i>indirect purity</i> in portable concentrators	Low-cost and real-time monitoring; easy to build	Indirect estimation of purity (pressure proxy) not direct O ₂ sensing
2.	Ardiansyah & Sujiwa	2025	Silica gel filtration analysis to measure oxygen concentration changes	Practical evaluation of media effects on purity	Not a direct sensor method; purity results depend on filtering materials
3.	Santos et al. (in MDPI study)	2025	Pressure Swing Adsorption (PSA) parametric optimization measuring oxygen %	Empirical validation of PSA purity performance	Not a dedicated sensing technique, more operational measurement
4.	Intelligent OC closed-loop system	2025	MAX30100 feedback + PID control to modulate concentrator based on SpO ₂	Automated adjustment of oxygen level	Relies on blood SpO ₂ (patient), not direct gas purity sensor

LITERATURE REVIEW

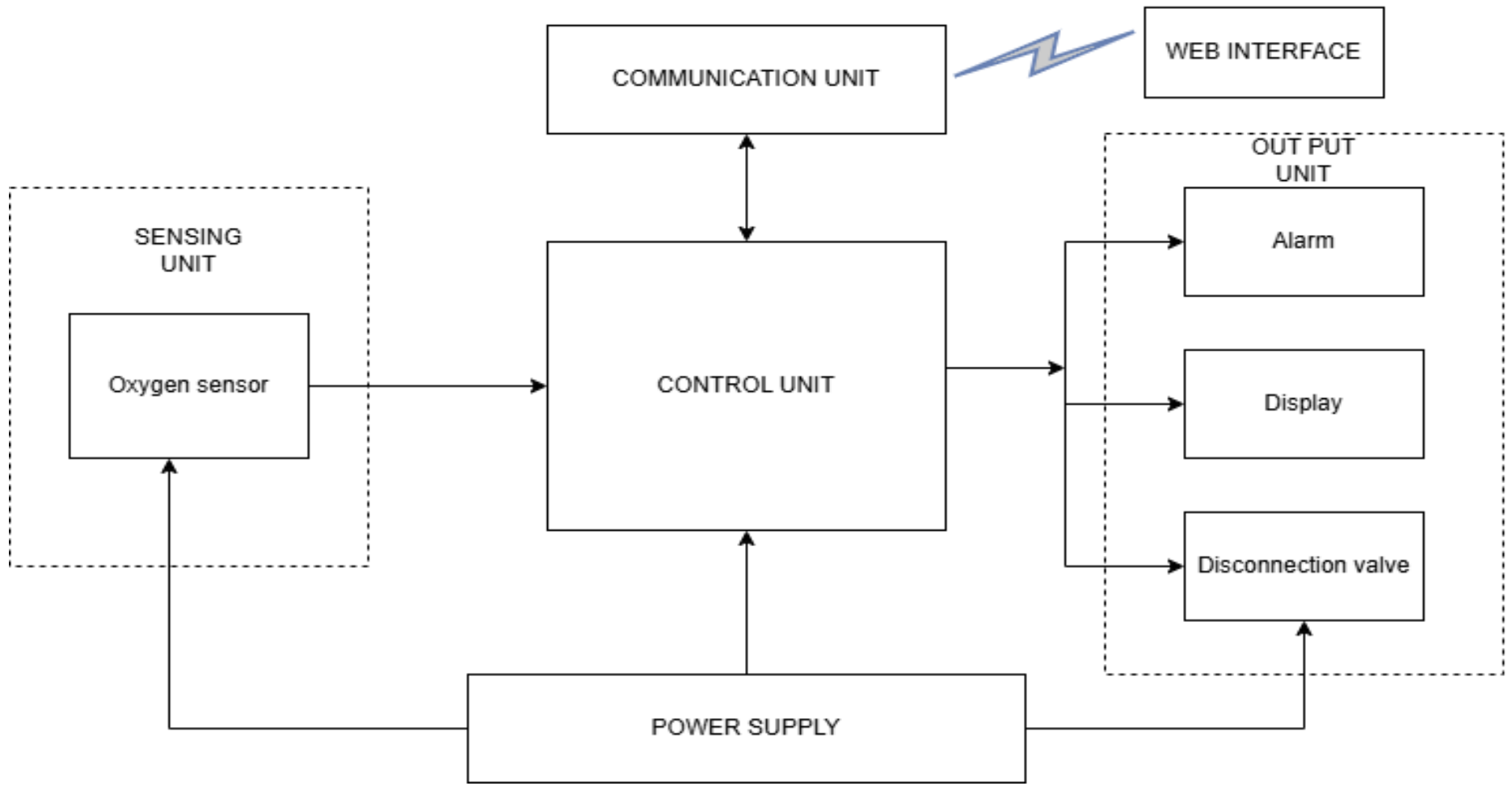
Existing Limitations:

- Current existing systems mainly use standalone oxygen analysers.
- Indirect oxygen purity estimation methods.
- Offline or periodic oxygen purity evaluation.
- Patient SpO₂-based oxygen control systems.

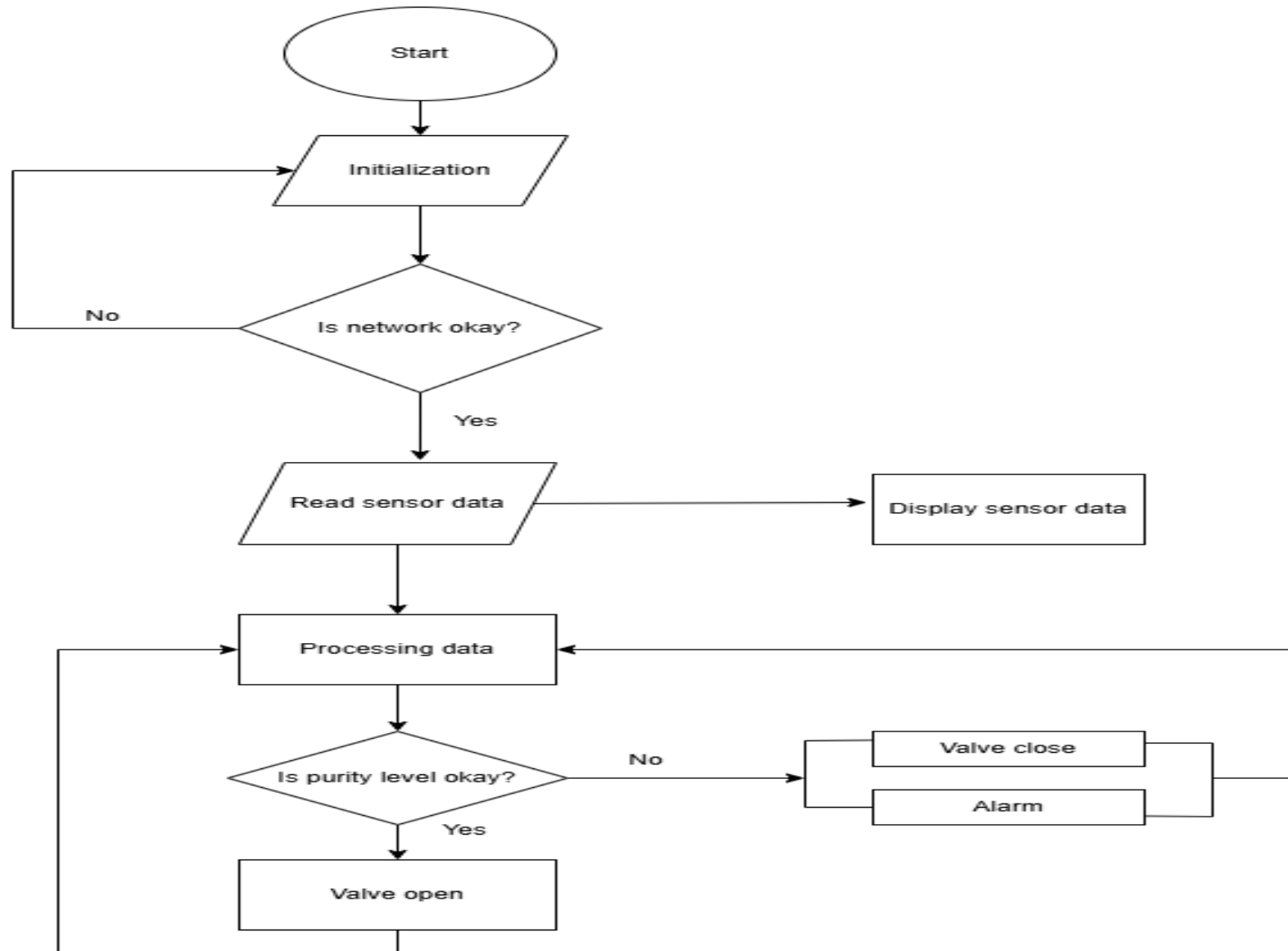
Proposed system:

- It is to integrate real-time oxygen purity detection.
- Safety alerts and user interface integrated

BLOCK DIAGRAM OF A PROPOSED SYSTEM



FLOW CHART



DATA COLLECTION

Primary data

Primary data was collected using structured questionnaires administered to medical staff and technicians to understand real-world challenges in monitoring oxygen purity and oxygen concentrator performance as well as observation.

The aim was to identify conditions under which changes in oxygen purity may go unnoticed and to determine the types of alerts and monitoring features required to enhance patient safety.

DATA COLLECTION

Primary Data

QN NO	Question	Response choice	Responses
1.	What is your role?	a) Technician b) Nurse c) Doctor d) Biomedical Eng. e) Other	a) 38 b) 2 c) 8 d) 46 e) 11
2.	What oxygen flow rate is commonly used?	a) 1–2 L/min b) 3–4 L/min c) 5 L/min d) Not sure	a) 14 b) 40 c) 26 d) 24
3.	Have you observed oxygen purity fluctuations during concentrator operation?	a) Yes b) No c) Not sure	a) 82 b) 8 c) 14

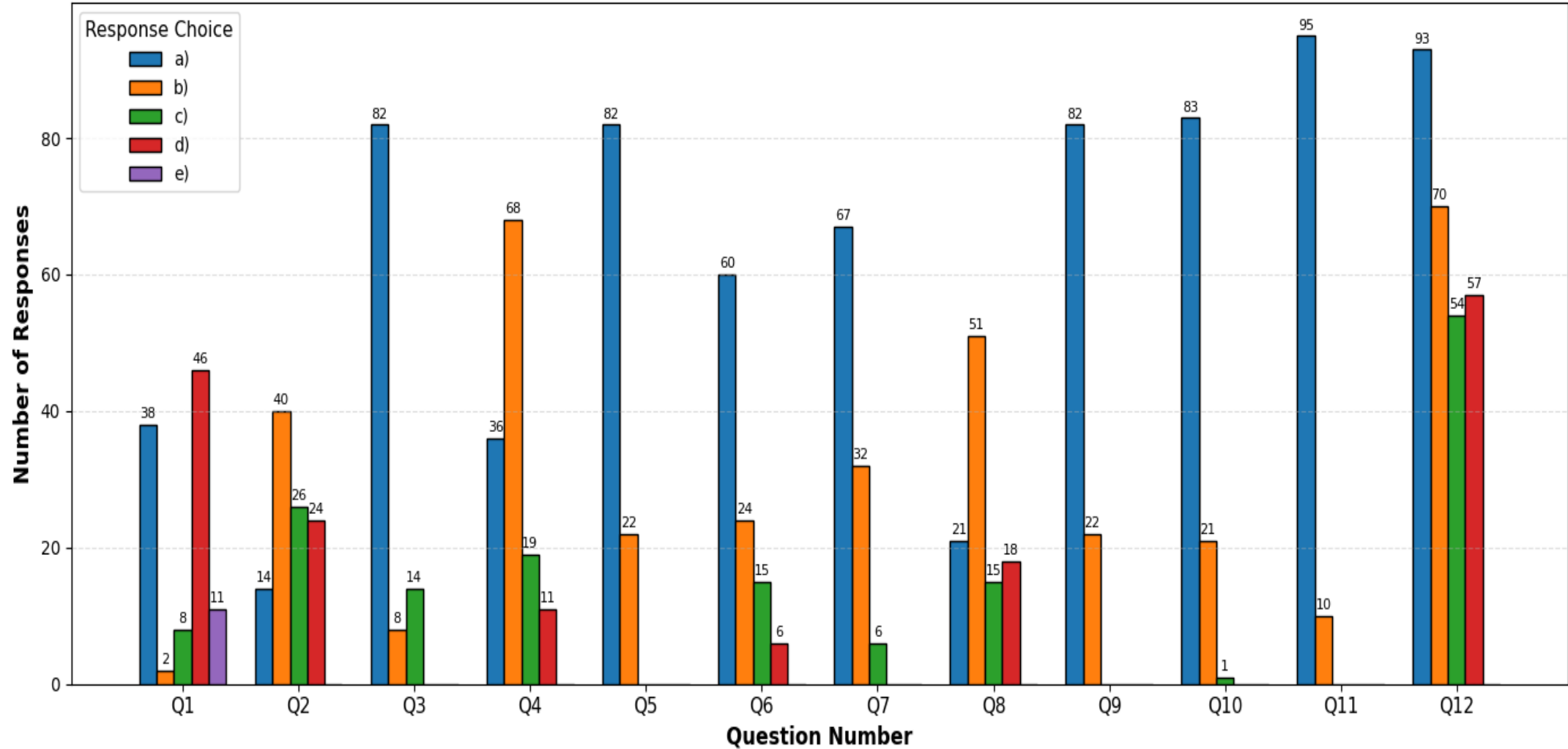
QN NO	Question	Response choice	Responses
4.	How do you normally know the oxygen purity level?	a) Display on the concentrator b) External oxygen analyzer c) During servicing d) We do not check	a) 36 b) 68 c) 19 d) 11
5.	Have you ever experienced a delay in identifying low oxygen purity levels?	a) Yes b) No	a) 82 b) 22
6.	Has delayed detection of low oxygen purity ever posed a risk to patient safety?	a) Yes, serious risk b) Yes, minor risk c) No risk observed d) Not applicable	a) 60 b) 24 c) 15 d) 6

QN NO	Question	Response choice	Responses
10	Do you think continuous real-time oxygen purity monitoring is necessary for patient safety?	a) Strongly agree b) Agree c) Neutral d) Disagree	a) 83 b) 21 c) 1 d) 0
11.	Would a web-based interface for real-time oxygen purity monitoring be useful in your facility?	a) Yes b) No	a) 95 b) 10
12.	Which features would be most important in a web-based oxygen purity monitoring system?	a) Real-time oxygen purity display b) Visual and audible alerts c) Data logging and history tracking d) Remote access by clinicians/technicians	a) 93 b) 70 c) 54 d) 57

QN NO	Question	Response choice	Response
7.	In your opinion, can failure to detect low oxygen purity lead to critical or catastrophic patient outcomes?	a) Strongly agree b) Agree c) Neutral d) Disagree	a) 67 b) 32 c) 6 d) 0
8.	On average, how many hours per day is the oxygen concentrator used?	a) Less than 4 hours b) 4–8 hours c) 8–12 hours d) More than 12 hours	a) 21 b) 51 c) 15 d) 18
9.	Does the oxygen concentrator provide an alarm when oxygen purity falls below safe levels?	a) Yes b) No	a) 82 b) 22

PRIMARY DATA VISUALIZATION

Primary Data Visualization (Questionnaire Responses)



OBSERVATION



PRIMARY DATA

Interpretation

- Approximately 50% response confirms that existing monitoring approaches are not sufficiently reliable, justifying the need for a system that continuously evaluates oxygen purity rather than relying on periodic check or assumptions.
- Users value early detection of abnormal oxygen purity conditions since more than 57% of the majority supports proactive monitoring rather than reactive intervention where patient's safety is at risk.
- Lack of real time monitoring web interface has delay in monitoring oxygen purity. 90% of respondents reflect a strong belief that patient safety depends on reliable oxygen purity monitoring.

Conclusion

Primary data were collected through structured questionnaires to understand user needs and safety concerns related to oxygen concentrators.

Secondary data were obtained from USAID/PATH guidelines, World Bank concentrator manuals, and relevant literature to define technical and operating requirements. Overall, the collected data sufficiently supported the design of the proposed real-time oxygen purity monitoring system.

DATA COLLECTION

Secondary data

Data was collected through a review of documented information from recognized health and engineering authorities related to oxygen concentrator operation, safety standards, and performance requirements.

The data focused on the following system units:

- Sensing unit
- Control unit
- Communication unit
- Output unit
- Dashboard/web interface
- Power unit

OXYGEN SENSING UNIT

Parameter	Requirements	Basis for Selection
Measurement range	21% – 100% O ₂	Medical oxygen application
Minimum acceptable purity	≥ 90%	WHO medical oxygen standard
Accuracy	±2%	Literature review (2019–2024)
Response time	< 15 seconds	Real-time monitoring requirement
Output type	Analog voltage	Compatibility with microcontroller
Operating temperature	0–50°C	Hospital environment

CONTROL UNIT

Parameter	Requirements	Design Justification
ADC resolution	≥ 10 -bit	Accurate oxygen percentage conversion
Processing capability	≥ 16 MHz	Real-time data processing
Operating voltage	3.3V / 5V	Sensor compatibility
Memory	≥ 32 KB	Program storage
Communication support	Wi-Fi capable	Remote monitoring
Power consumption	Low	Continuous operation

COMMUNICATION UNIT

Parameter	Requirements	Purpose
Network type	Wi-Fi (2.4 GHz)	Hospital compatibility
Data update interval	1–5 seconds	Near real-time monitoring
Communication protocol	HTTP / MQTT	Web dashboard integration
Indoor coverage	≥ 20 meters	Ward coverage

ALARM SYSTEM

Parameter	Requirements	Purpose
Warning threshold	$O_2 < 90\%$	Safety alert
Critical threshold	$O_2 \leq 85\%$	Emergency condition
Alarm type	Audible + Visual	Immediate notification
Response time	< 2 seconds	Rapid detection

DISCONNECTION VALVE

Parameter	Requirements	Purpose
Valve type	Solenoid valve	Automatic shut-off
Operation mode	Normally open	Allows oxygen flow when safe
Operating voltage	12V DC	Reliable control
Pressure rating	≥ 30 psi	Compatible with concentrator output

POWER SUPPLY

Parameter	Requirements	Purpose
Input	220V AC	Hospital standard
Output	5V DC / 12V DC	Component supply
Regulation tolerance	$\pm 5\%$	Stable operation
Protection	Overcurrent & surge protection	Safety

DISPLAY UNIT

Parameter	Requirements	Technical Justification
Display Type	16x2 or 20x4 Alphanumeric LCD	Sufficient to display oxygen % and status messages
Operating Voltage	5V DC	Compatible with microcontroller
Current Consumption	≤ 20 mA (without backlight)	Low power requirement
Interface Mode	4-bit or I2C Serial Interface	Reduces number of MCU pins used
Operating Temperature	0°C – 50°C	Suitable for indoor clinical settings
Response Time	< 1 second refresh	Real-time monitoring requirement
Displayed Parameters	Oxygen % value + Status (Normal/Warning/Critical)	User-friendly monitoring

Conclusion

The findings from the secondary data were used to derive technical requirements and form the basis for the system design.

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