Final Year Design Project Showcase
Batch-2022
Year 2025

Department: Polymer & Petrochemical Engineering Programme: Polymer & Petrochemical Engineering	
1	**Project Title** Indigenous Design and Development of a Smart Oxygen Concentrator.
2	**Project Idea** The project aims to design and develop a cost-effective, indigenous smart oxygen concentrator capable of producing medical-grade oxygen from ambient air. The system integrates pressure swing adsorption (PSA) technology with IoT-enabled monitoring, allowing real-time observation of oxygen purity, flow rate, pressure, operating temperature, and maintenance alerts. The objective is to reduce dependence on imported medical equipment while providing an affordable and reliable oxygen supply for hospitals, clinics, and home healthcare.
3	**Process** • Literature review on oxygen concentrator technologies and PSA systems. • Design and selection of adsorption columns, compressors, valves, molecular sieves, and control systems. • Development of an indigenous PSA-based oxygen generation unit. • Integration of sensors for oxygen concentration, pressure, temperature, and flow measurement. • Development of a microcontroller-based smart monitoring system with IoT connectivity. • Fabrication, assembly, testing, calibration, and performance evaluation. • Comparison of the developed system with commercially available oxygen concentrators.
4	**Outcome** • Successfully developed an indigenous smart oxygen concentrator. • Achieved medical-grade oxygen purity (90–95%). • Real-time monitoring of oxygen purity, flow rate, pressure, and system health. • IoT-based remote monitoring and maintenance alerts. • Lower production cost compared to imported units. • Improved accessibility of oxygen therapy in hospitals and remote areas.
5	**Evidence (Theoretical Basis)** This project presents the indigenous design, development, and parametric performance evaluation of a smart, portable medical oxygen concentrator (POC) tailored to address the lack of localized production and high cost of imported medical hardware in Pakistan. The engineered system operates on the principles of Rapid Pressure Swing Adsorption (RPSA) utilizing high-performance Lithium-exchanged X (LiX) zeolite molecular sieves

	to selectively adsorb atmospheric nitrogen under transient pressure bounds, generating medical-grade oxygen. The scientific methodology was divided into structural sizing, electronics automation, and empirical execution. Using a pair of lightweight polymer-matrix adsorption columns loaded with a total of 3.2 kg of LiX zeolite (1.6 kg per bed), an operating matrix was configured to run a continuous 4-step cyclical loop containing pressurization, adsorption, blowdown, and purge phases. Mechanical system control was achieved using an automated Arduino Uno microcontroller platform coupled to a calibrated array of high-switching-frequency 3/2-way AirTAC solenoid valves. Real-time composition tracking was sustained using an electro-galvanic oxygen sensor coupled with a high-precision 16-bit ADS1115 analog-to-digital converter to output real-time purity measurements onto an I2C-backplane 16x2 LCD layout. Comprehensive mathematical modeling and multi-scenario validations were executed at an optimized feed air flow rate of 106 Liters per Minute (LPM) and a target operating pressure of 3.2 bar. At a continuous discharge flow of 5 LPM, analytical and experimental verification data demonstrated. 95% Peak Output: Attained an experimental oxygen recovery efficiency (R) of 21.28% alongside a verified output purity (P) of 94.73%.
6	**Competitive Advantage or Unique Selling Proposition** (Cost Reduction, Process improvement, Attainment of any SDG (Sustainable Development Goal), increase of market share or capturing new market or having superior performance over a competitor. In summary, any striking aspect of the project that compels the industry to invest in FYP or purchase it. Some detailed description is required in terms of how, why when what. You can select one or more from the following dropdown and delete the rest of them). Please keep relevant options, delete the rest of them, and correct the sequence
a	**Attainment of any SDG** (e.g. How it is achieved and why it is necessary for the region) SDG#3: Good Health and Well being SDG#9: Industry Innovation and Infrastructure SDG#12: Responsible Consumption and Production
b	**Any Environmental Aspect** (e.g. carbon reduction, energy-efficient, etc.) The concentrator produces oxygen directly from ambient air without requiring oxygen cylinder transportation, reducing fuel consumption, carbon emissions, and environmental impact. It is also designed to be energy-efficient.
c	**Cost Reduction of Existing Product** Local manufacturing and the use of readily available components significantly reduce production and maintenance costs compared to imported oxygen concentrators.
d	**Process Improvement which Leads to Superior Product or Cost Reduction, Efficiency Improvement of the Whole Process** (e.g. What is the issue is current process and what improvement you suggests)

	The integration of IoT-based monitoring enables predictive maintenance, continuous performance monitoring, automatic fault detection, and improved reliability compared to conventional oxygen concentrators.	
e	**Expanding of Market share** (e.g. how it expand and what is the problem with the current market	
f	**Capture New Market** (e.g. Niche market or unaddressed segment)	
g	**Any Other Aspect**	
7	**Target Market** (Industries, Groups, Individuals, Families, Students, etc) Please provide some detail about the end-user of the product, process, or service ☐ Government and private hospitals ☐ Clinics and diagnostic centers ☐ Home healthcare providers ☐ Rural healthcare facilities ☐ Emergency medical services ☐ Disaster relief organizations ☐ Military medical units ☐ NGOs involved in healthcare ☐ Medical equipment manufacturers	
8	**Team Members** (Names along with email address)	Wajiha Tufail PP-22004 wajihatufail3@gmail.com Laiba Khursheed PP-22016 laibakhursheed001@gmail.com Abdullah Qazi PP-22030 m.abdullahqazi024@gmail.com Mursaleen Khan PP-22043 mursaleennaveedkhan108@gmail.com
10	**Supervisor Name** (along with email address)	**Supervisor:** Prof. Dr. Riaz Uddin Director ORIC | PI of Haptics, Human-Robotics & Condition Monitoring Lab, NCRA Email: riazuddin@neduet.edu.pk **Co-Supervisor** Dr. Rafiq Ahmed Assocciate Professor Email: ahmedr@neduet.edu.pk
11	**Video (If any)**	NA

Pictures (to be pasted below)

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1. Process/Control Flow

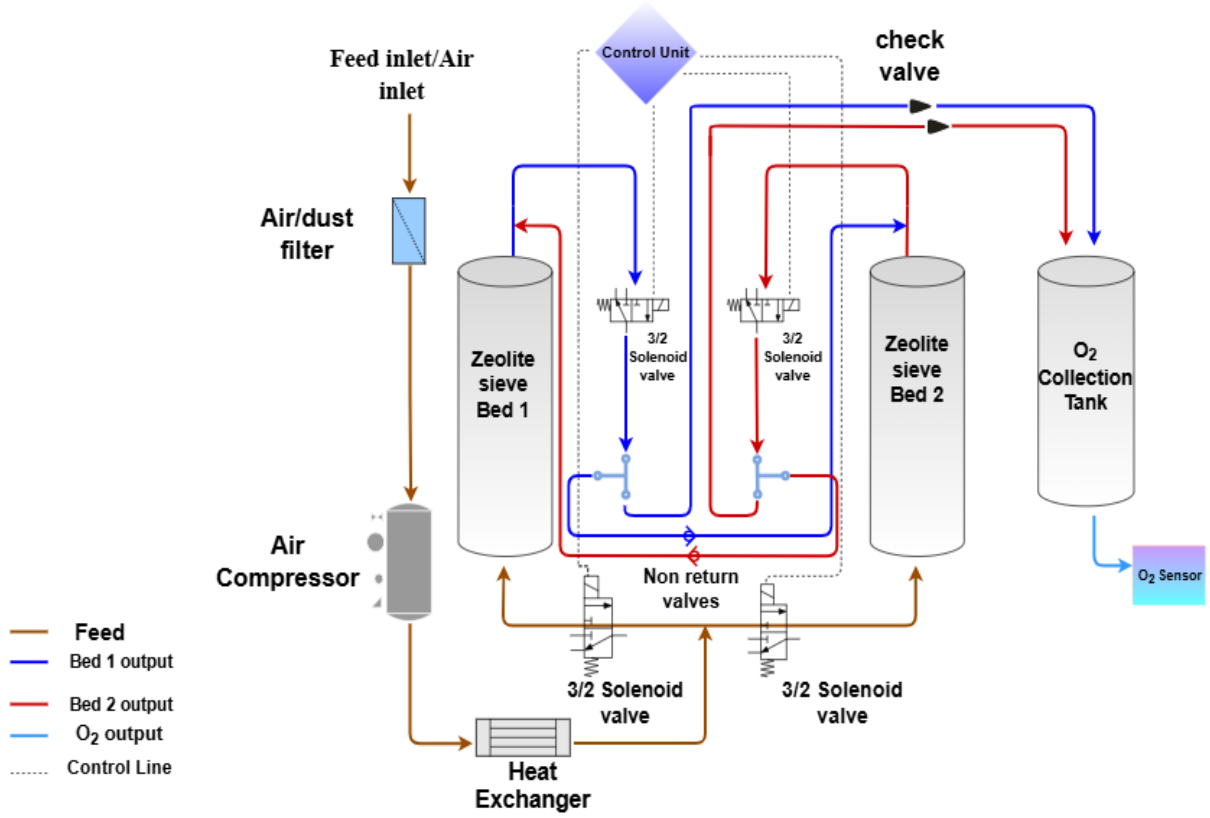


Figure 1: Control flow mechanism of Oxygen Concentrator

Figure 2: Air filter

Figure 31: Air compressor

Figure 4: Heat Exchanger

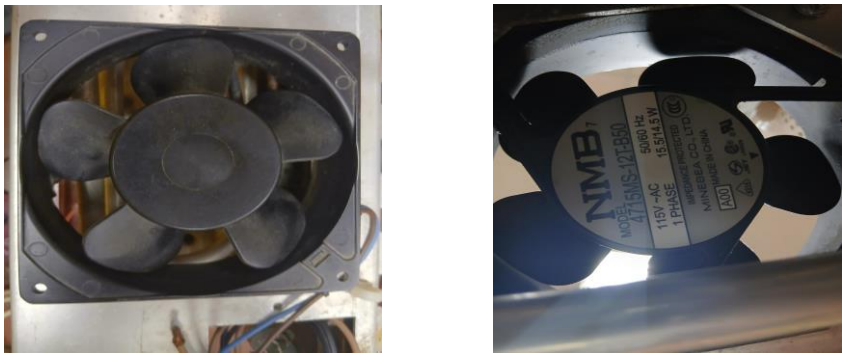


Figure 5: Cooling Fan

Figure 6: Molecular Sieve Bed

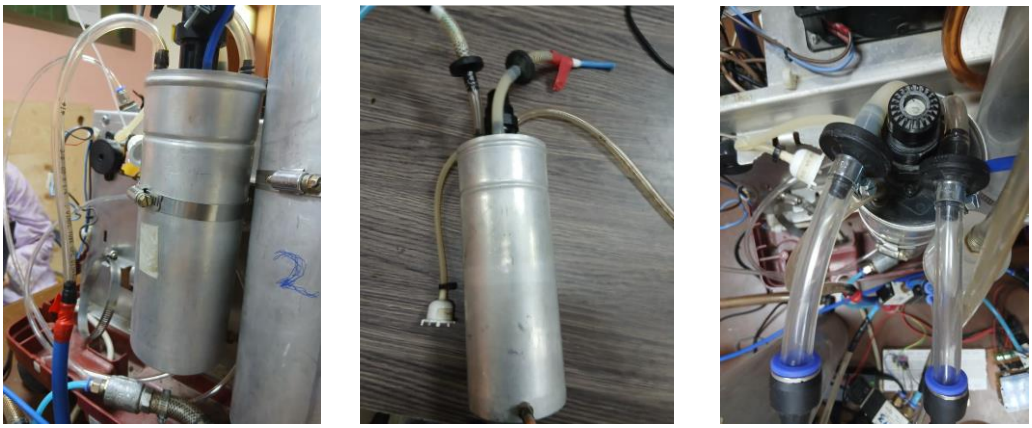


Figure 7: Storage Tank

Figure 8: Oxygen Sensor

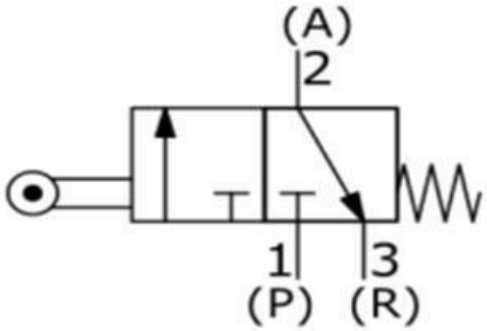


Figure 9: 3/2-way solenoid valve of AIRTAC

Figure 10: Circuit Function of a 3/2 way AIRTAC valve normally closed

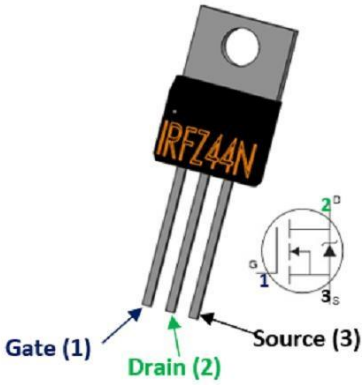


Figure 21: IRFZ44N N-Channel Power MOSFET Pin out

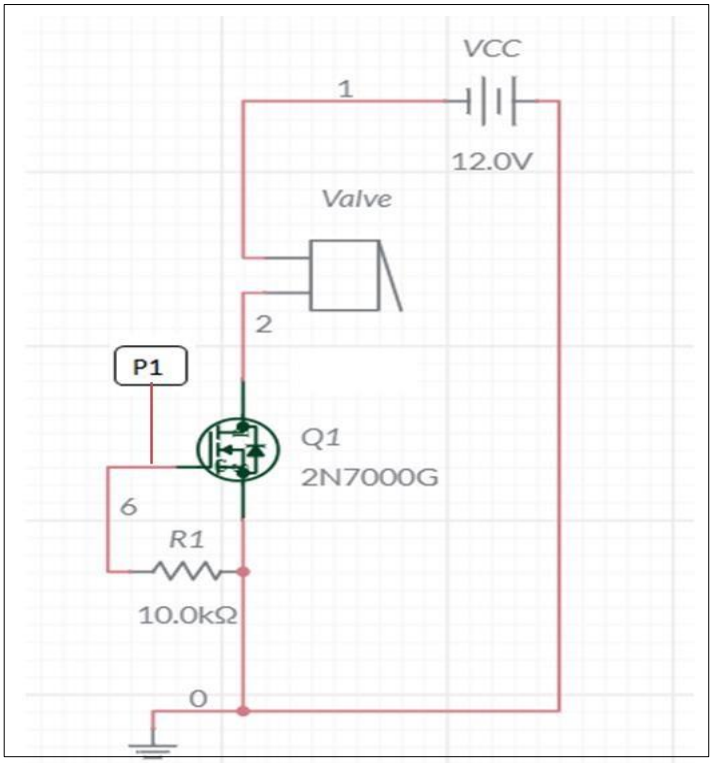


Figure 12: Single-valve Control Circuit

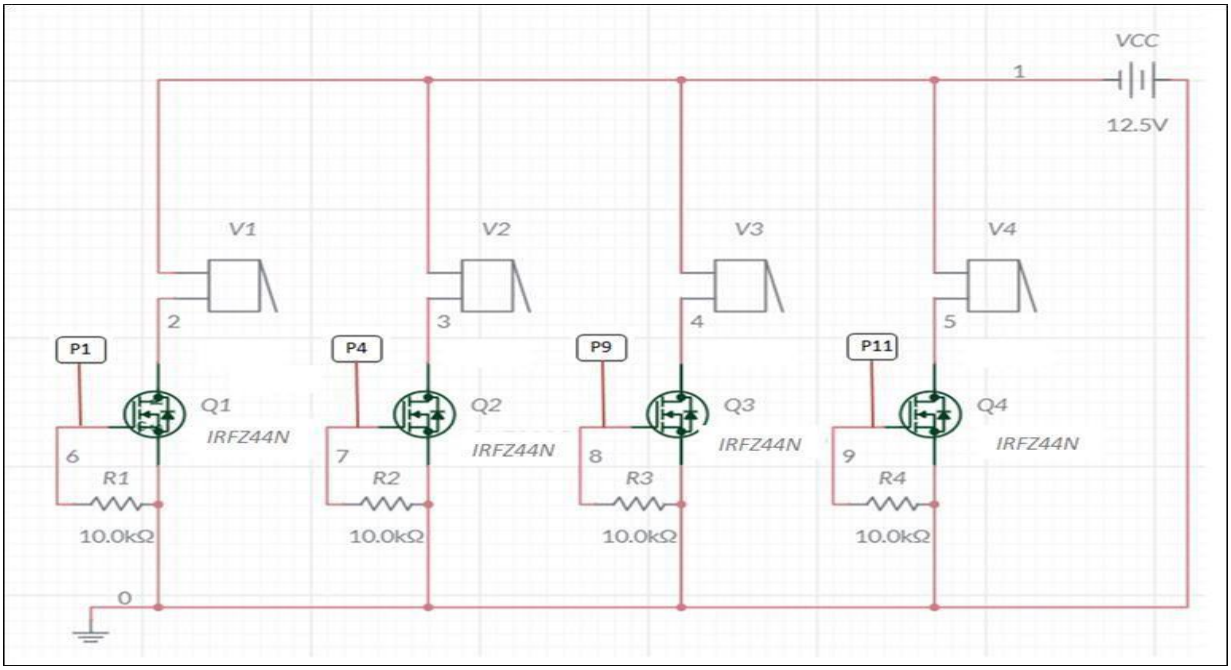


Figure 13: Four 3/2-way valve control circuitry on Multisim

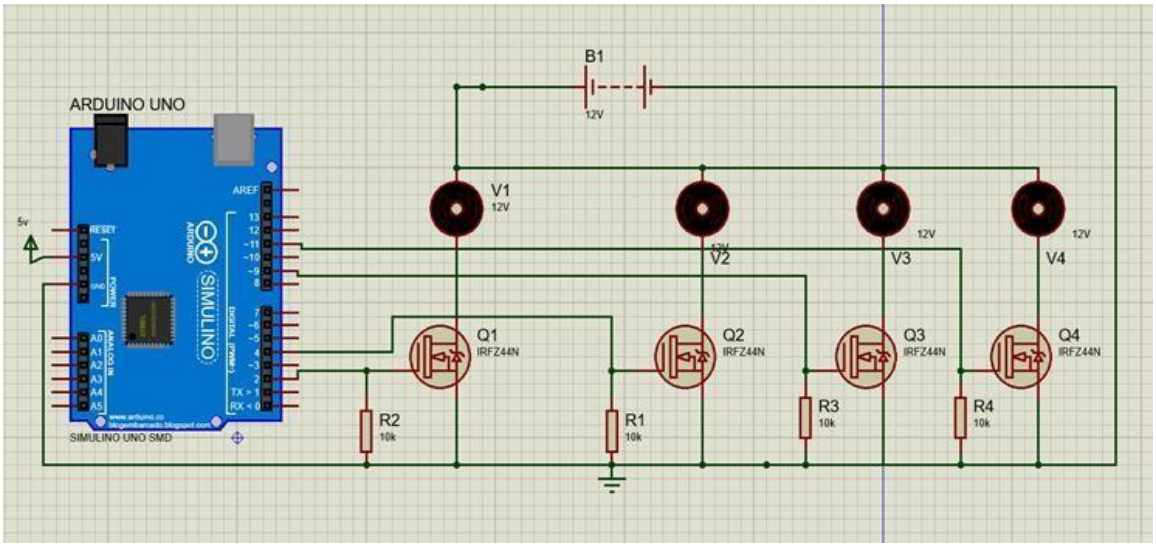


Figure 14: Four 3/2-way valve control circuitry on Proteus

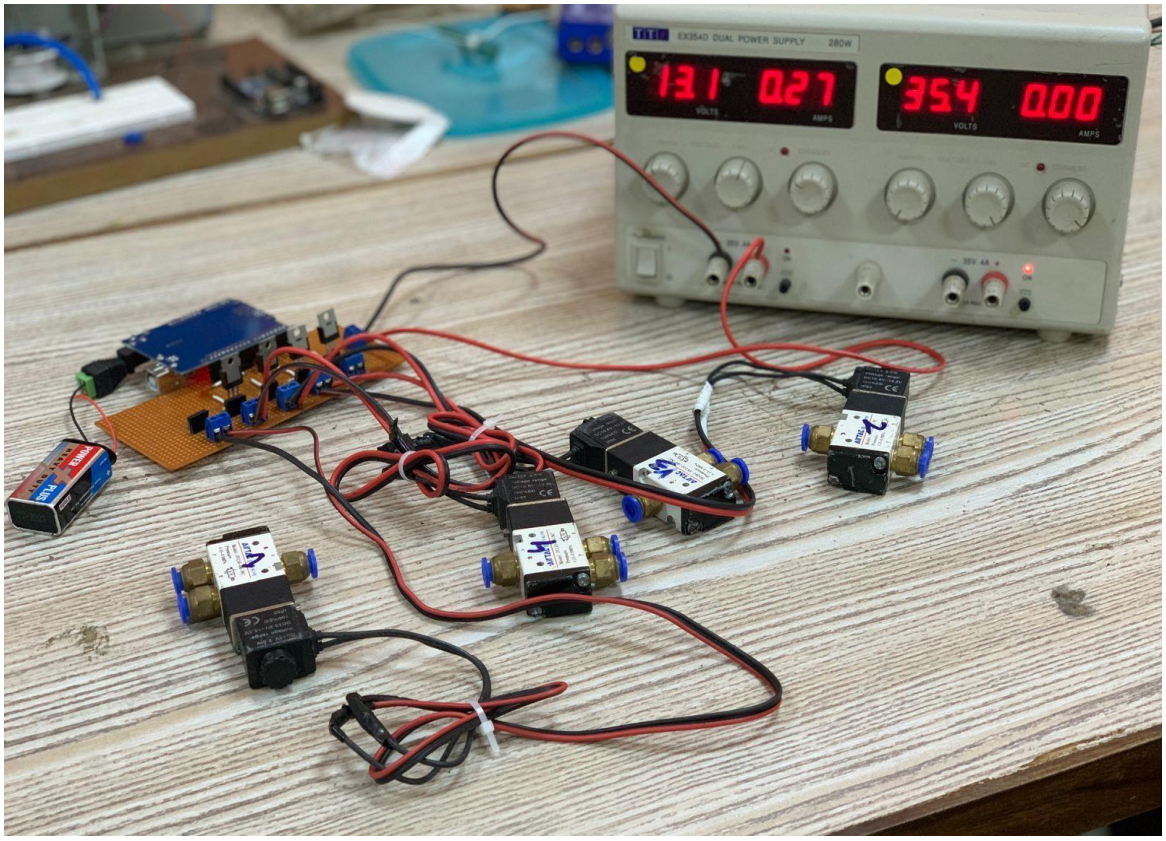


Figure 15: Valve Switching Circuit

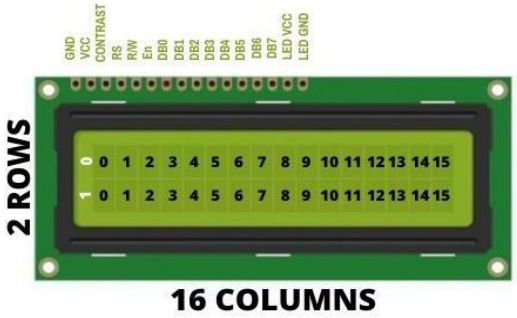


Figure 16: LCD configuration Diagram

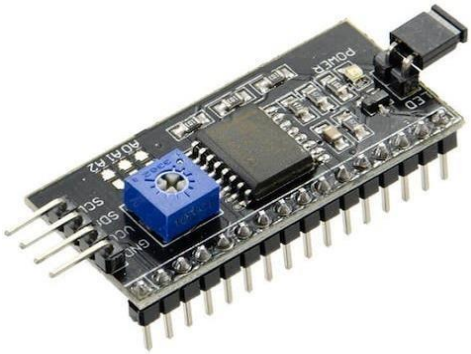


Figure 16:12C 16X2 LCD with Arduino UNO

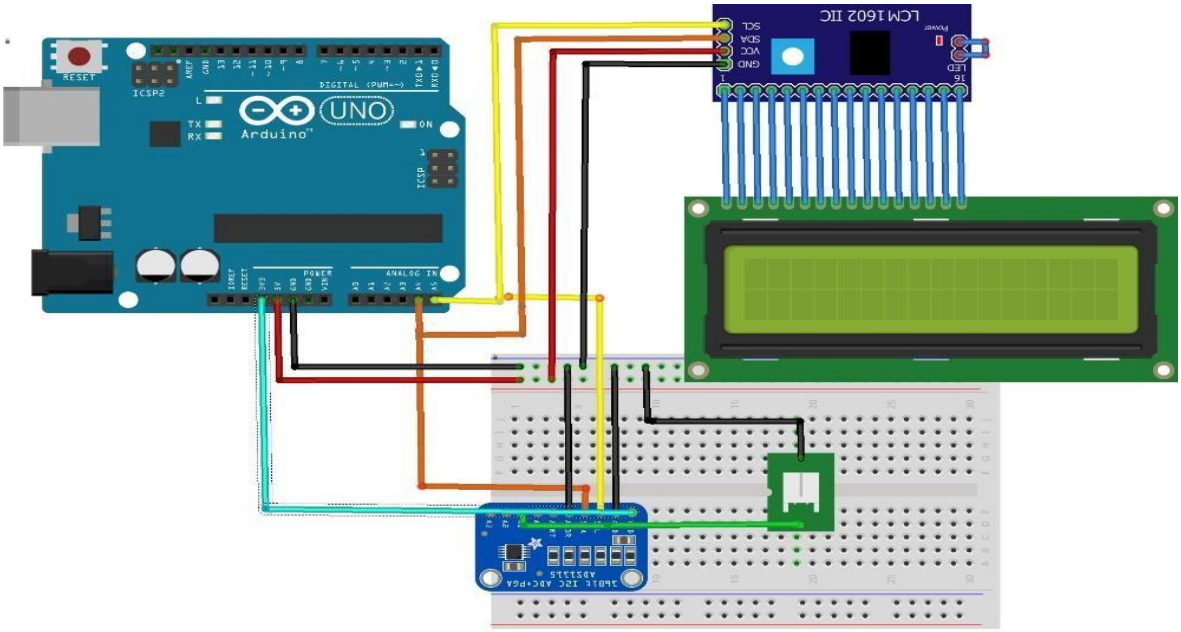


Figure 17: Connection Diagram of LCD with Arduino along with Sensor Connection terminal

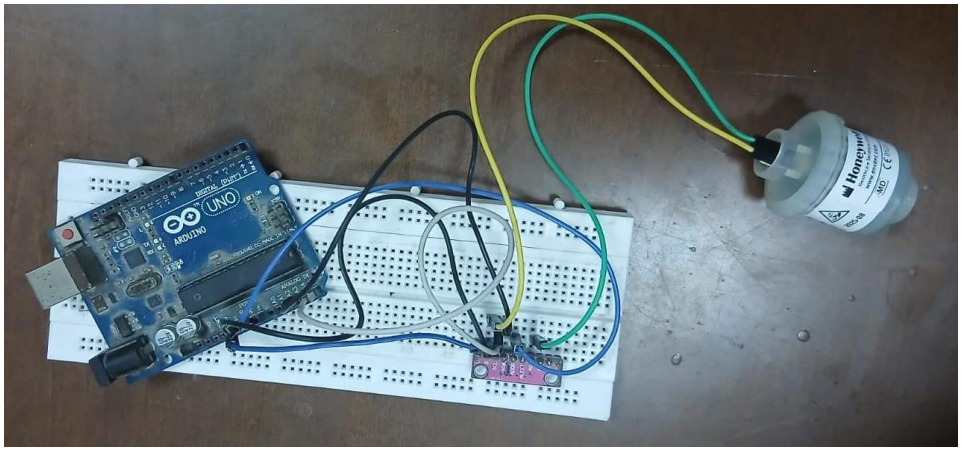
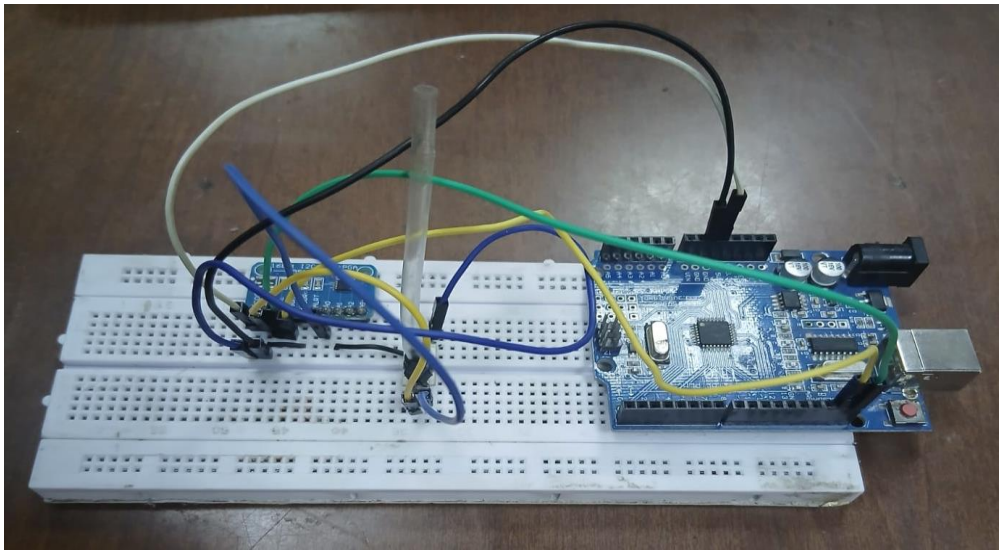


Figure 18: Oxygen Sensor Circuit



Figur19 : Pressure Sensor Circuit

Figure 30: Temperature Sensor