International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 08 | August - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

IoT Based Continuous Positive Airway Pressure for Sleep Apnea and Unhealthy Snoring Patient

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1. Abstract

The non-invasive mechanical breathing technique known as Continuous Positive Airway Pressure (CPAP) is frequently employed in neonatology. The survival of very low birth weight preterm newborns may be impacted by the use of new therapeutic and technological advancements. The exorbitant cost of this device and its multiple add-on features, like Apnea Hypopnea Index (AHI) and flow limiting, among others, present a challenge. As a proof of concept for use in a Neonatal Intensive Care Unit (NICU), the design and fabrication of a CPAP device are the focus of this study. Methods: Electro-pneumatic circuits and signal conditioning boards of sensors have been installed in order to design the experimental CPAP device with sensory instrumentation for supplying data to a micro-controlled system and achieve optimized CPAP performance with minimal energy consumption.The Cloud Platform would store the received data.At a proof of concept level, the same might likewise be used to Sleep Apnea Subject(s).

Keywords: Continuous Positive Airway Pressure (CPAP), Sleep Apnea, Neonatal, Respiratory Distress Syndrome (RDS), Premature baby, Transpiration medical device, Internet of Things.

2. Introduction

Rapid advancements in medical technology have led to ground-breaking discoveries that have raised the standard of living for countless individuals. Continuous Positive Airway Pressure (CPAP) therapy has distinguished itself as a standout among these advancements for people with sleep apnea and other related breathing issues. The use of CPAP therapy has significantly increased potential in the future thanks to the Internet of Things (IoT) integration, which is revolutionizing sleep medicine.

CPAP therapy uses a CPAP machine to continually push compressed air through your airways while you sleep in order to keep your airways open.

1.1 Background

Obstructive sleep apnea (OSA), a sleep disorder marked by frequent breathing disruptions while sleeping, is frequently managed with continuous positive airway pressure (CPAP) therapy. In order to keep the airway open and prevent the soft tissues in the throat from collapsing, CPAP devices give a steady flow of air pressure through a mask, allowing the patient to breathe normally while sleeping.

The integration of Internet of Things (IoT) technology into many medical devices, including CPAP machines, has become increasingly popular in recent years. IoT integration is the process of connecting items to the internet so they may gather and exchange data as well as be monitored and controlled from a distance.

1.2 Objectives

The goal of this project is to open up the subject's nasal passage and throat to eliminate sleep apnea and snoring issues that are damaging over time, and to store the data on a cloud platform to track the situation.

The proposed IoT-integrated CPAP invention aims to enhance the efficacy, usability, and user experience of CPAP therapy for those with sleep apnea. The following are the main goals:

Cost-Effectiveness: Create a more cheap and cost-effective CPAP device so that it can be used by a wider group of patients, including those with low incomes.

Improved Therapy Efficiency: Use IoT technology to build a CPAP device that can automatically alter air pressure in real-time to deliver the best therapy all night long. greater treatment results and greater patient sleep are guaranteed by this dynamic pressure adjustment.

Compactness and portability: Create a CPAP equipment that is more compact, lightweight, and portable so that patients can use it outside of their homes and while traveling. A portable design promotes patient compliance by enabling ongoing therapy wherever the patient is.

A greater understanding of sleep problems, such as sleep apnea, among the general public and healthcare experts can be achieved by using IoT data. For study and instruction, it is possible to use the CPAP devices' anonymised data.

User-Friendly Interface: Make a mobile application and user interface that are simple to use so that patients can easily engage with their CPAP devices. In order to encourage patient participation and self-monitoring, the application should offer real-time access to sleep data, usage statistics, and individualized feedback.

Implement remote monitoring capabilities so that medical professionals and sleep specialists can access patient data and, if necessary, make prompt interventions. Healthcare workers may be alerted via automated notifications to device problems or material modifications in patient compliance.

Automated Firmware Updates: To keep the CPAP device up to speed with the most recent improvements, bug fixes, and security patches, enable over-the-air firmware updates. With the help of this function, patients can take advantage of new developments without having to physically replace their devices.

Privacy and Security: Ensure that dependable security measures are in place to safeguard patient privacy and adhere to laws governing the protection of healthcare data, such as HIPAA. During transmission and storage,

patient data should be encrypted, and access restrictions should be put in place to limit access to only authorized employees.
The proposed CPAP innovation with IoT integration seeks to improve CPAP therapy by meeting these goals, making it more efficient, approachable, and available to a larger population. For those who have sleep apnea, improved treatment results, higher patient compliance, and greater understanding of sleep problems all contribute to better overall health and wellbeing.

3. Literature Review

3.1. Design and Implementation of a Helmet-based, Non-invasive CPAP Devices for COVID-19

2021 3rd International Conference on Electrical & Electronic Engineering (ICEEE) | 978-1-6654-8281-3/21/$31.00 ©2021 IEEE | DOI: 10.1109/ICEEE54059.2021.9718771

To raise the oxygen level, various gadgets are employed. The design and use of a helmet-based Continuous Positive Airway Pressure (CPAP) device are covered in this study. Positive pressure is produced by a blower, and the necessary pressure is adjusted by a pressure sensor. The needed value is set using two rotary encoders, and the data is monitored on a TFT display. The real-time and user interface controllers are two Arduino boards. Proteus software is used for PCB designs and hardware simulations. In Solidworks software, the CPAP device's mechanical body was created. The CPAP is attached to a helmet that was also created in the Solidworks program. Through the pipe, compressed air that is combined with oxygen is sent to the helmet. Finally, this article also includes information about the device's price.

3.2. Design and Development of a Robust CPAP Device for Respiratory Support

2021 IEEE International Conference on Biomedical Engineering, Computer and Information Technology for Health (BECITHCON) | 978-1-6654-6621-9/21/$31.00 ©2021 IEEE | DOI: 10.1109/BECITHCON54710.2021.9893691

Since the Spanish flu pandemic, when there was only supportive care available, the COVID-19 pandemic has been a difficult moment for humanity.
The main factor in the hospitalization of COVID-19 patients was respiratory support since they had mild to severe breathing problems. Ventilators are typically used for respiratory assistance, mixing pressurized air with the necessary oxygen concentrations. An invasive mechanical ventilator (IMV) is a sophisticated computer-controlled device that supports full ventilation by providing positive pressure to the lungs through an endotracheal or tracheostomy tube. IMV is quite expensive, and specialized nurses are needed for the procedure. Non-invasive ventilation (NIV), which was judged required during the epidemic, is an alternative to IMV. CPAP, an NIV that is administered via a face mask, does not call for the assistance of specialized nurses. The COVID-19 epidemic attracted attention to CPAP because of its inexpensive cost and ease of use. The design and development of a CPAP ventilation device are discussed in this work. A microcontroller-based electro-mechanical device called a CPAP was developed to provide patients with respiratory problems with supportive therapy.

4. Problem Statement

High Price: The present CPAP equipment' high price is one of their main disadvantages. Traditional CPAP machines can be pricey, which limits their usability for those with low incomes. Some people may choose not to seek treatment due to the high expense, which could delay diagnosis and cause health issues.

Not Portable: The inability to move about is another drawback of current CPAP equipment. It might be difficult to transport or operate a traditional CPAP machine outside of the home because they are frequently quite big and heavy. Lack of portability may result in patients skipping therapy when they are out and about or traveling.

Less Awareness: The general public is not well-informed about sleep disorders and CPAP therapy. Many persons with sleep apnea may not even be aware of their illness, and those who are may not completely comprehend the possible advantages of CPAP therapy. The lack of knowledge may prevent early action and cause a delay in diagnosis.

Manual Operation: Some conventional CPAP systems call for manual pressure setting adjustments depending on a doctor's prescription. Some patients may find it difficult to effectively handle this manual process, which might result in subpar therapy results. Furthermore, manual modifications might not be adequate to accommodate changes in the patient's condition while they are sleeping.

5. Need for the Project

Given these drawbacks, the following problems may be resolved by a proposed CPAP innovation with IoT integration:
Cost-Effectiveness: The suggested CPAP device can be made more affordable by incorporating IoT technology without sacrificing any of its essential features. Integration of the Internet of Things (IoT) enables more effective manufacturing, remote diagnosis, and targeted maintenance, all of which can help bring down the overall cost of the item.

Compactness and Portability: The proposed CPAP equipment can be made to be more compact, portable, and lightweight so that patients can use it without discomfort whether traveling or on the go. A portable design enables people to continue their therapy uninterrupted and can dramatically increase patient compliance.
IoT connectivity allows the suggested CPAP equipment to gather and share anonymized data for research and analysis, which raises awareness. This information can be used to educate the public and medical professionals about sleep problems and CPAP therapy.

Automated Pressure Control: The suggested CPAP device can feature sophisticated algorithms to automatically regulate the air pressure depending on real-time data gathered during the patient's sleep thanks to IoT integration. By adjusting to the patient's shifting demands and sleep habits throughout the night, this function makes sure they get the best therapy possible.
The suggested IoT-integrated CPAP invention can assist overcome the drawbacks of the current devices and provide patients with sleep apnea with a more affordable, portable, and user-friendly option. By utilizing IoT technology, it is now possible to improve patient compliance, treatment outcomes, and ultimately the overall quality of life for those who have sleep apnea.

6. Proposed Methodology

The suggested system attempts to overcome the drawbacks of the current CPAP machines by providing a number of benefits through cutting-edge technologies and Internet of Things integration.
1. Less Expensive: The main benefit of the suggested approach is that it is less expensive. The suggested method is more affordable than genuine CPAP equipment, making it more available to a larger spectrum of patients, including those with limited resources.

2. Portable and Simple to Recharge: Patients can use the suggested CPAP system both at home and while traveling because it is made to be portable. Due to its small size and light weight, users may easily carry the device. The system also features a reliable rechargeable power supply, which lessens the need for conventional power outlets.

3. Controlled Pressure Air Flow System (CPAFS): Using a CPAFS guarantees that the air pressure is maintained at a healthy level during the course of the treatment. By providing the right pressure needed to keep the airways open while you sleep, this feature improves the efficacy of CPAP therapy.

4. There are two ways to work:
The suggested system has two operating modes: Auto mode and Timer mode (also known as Manual mode). In Auto mode, the device continuously delivers tailored therapy by automatically adjusting the air pressure based on real-time data. Patients can choose to manually choose their desired pressure settings in Timer mode.

5. Smart Mode for Decent Life: The suggested system's inclusion of Smart Mode guarantees that the device has a respectable operating life. The CPAP machine's performance and use are optimized in this mode, extending the device's total lifespan.

6. Continuous Data Monitoring and Cloud Storage: The suggested system continuously tracks patient sleep information, including usage trends and therapeutic success. The gathered information is safely kept in the cloud. As a result, patients and healthcare professionals can remotely access the data and learn more about the patient's progress and the efficiency of their treatments.

7. Monitoring System Based on Mobile Apps: The system includes a user-friendly mobile application that enables patients to conveniently communicate with their CPAP machine. The app gives users immediate access to sleep information, therapeutic data, and customized feedback. Through the smartphone app, patients may keep tabs on their development and check their adherence to therapy.

6.1 Software Requirements

Arduino IDE

6.2 Hardware Requirements

S.NO:	Component Name	Quantity
01.	Atmega328 microcontroller	1
02.	Potentiometer	1
03.	Sound sensor	2
04.	Air flow tube	1
05.	Air filter	
06.	Air blowing controlled motor	
07.	Motor Controlling unit	
08.	Keypad	1
09.	Liquid Crystal Display	1
010	Bluetooth	1

6.3 Benefits

The cost of the treatment is reduced, making it more accessible and affordable.

Patients can utilize the gadget conveniently while traveling or away from home thanks to its portability.

By maintaining ideal air pressure levels, the Controlled Pressure Air Flow System makes sure that therapy is effective.

In treatment settings, the Auto and Timer (Manual) modes offer flexibility and customization.

The CPAP device's lifetime is increased by Smart Mode.

Cloud storage and ongoing data monitoring enable remote access to patient data for tracking healing and therapy progress.

The mobile app-based monitoring system encourages patient participation and therapy self-management.

These benefits are provided by the proposed CPAP system with IoT integration, which seeks to improve sleep apnea therapy by making it more efficient, user-friendly, and affordable for a larger patient base.

6.4 Block Diagram

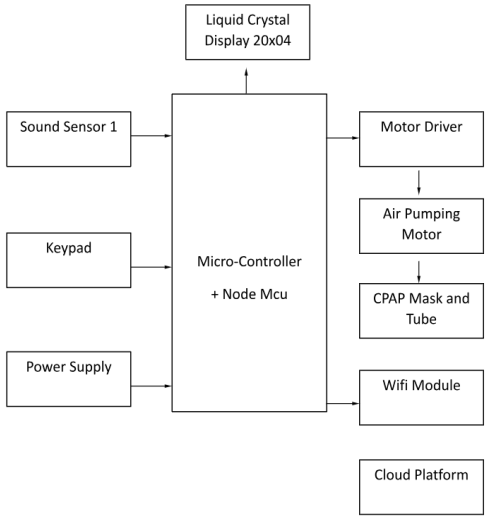

Fig: Block diagram

7. Result & Discussion

Improved Therapy Adherence: The ability to increase patient adherence to therapy is one of the major advantages of IoT-integrated CPAP devices. Patients are more likely to adhere to recommended therapy schedules when real-time data monitoring and remote feedback mechanisms are used to keep them informed about their treatment progress.

Enhanced Data Collection and Analysis: IoT integration enables the gathering of enormous volumes of CPAP machine data, including usage patterns, mask fit, and pressure settings. Insights on patient sleep behavior, treatment effectiveness, and therapy optimization can be gained by analyzing this data. Healthcare practitioners may make better decisions as a result of the data-driven approach.

IoT-enabled CPAP machines allow for the customization of treatment strategies to meet the demands of each patient. Based on real-time data, the devices may automatically alter pressure levels, mask fit, and other factors to ensure the most comfortable and effective therapy possible.

IoT-connected CPAP systems have the ability to send alarms and messages in the event of therapeutic problems or mask leaks during the night. These alerts can be received by healthcare professionals, who can then act quickly to treat possible issues before they worsen.

Telehealth and remote monitoring are made possible by IoT integration, enabling healthcare providers to keep track of patient progress without having to make regular in-person visits. Patients with restricted mobility or those who live in rural places can especially benefit from this.

Improved User Experience: IoT integration frequently results in more user-friendly CPAP device control options and interfaces. Through user-friendly mobile applications, patients may access their therapy data, modify settings, and get individualized feedback, improving their entire treatment experience.

Data Security and Privacy: As with every IoT device, data security and privacy are major issues. To avoid unwanted access, it is crucial to maintain strong encryption and protection of the sensitive health data that CPAP machines collect.

Interoperability: Achieving seamless interoperability might be difficult given the variety of CPAP device vendors and IoT platforms. To ensure that CPAP devices can efficiently interface with diverse healthcare systems and platforms, standardization activities are required.

Cost and Accessibility: The cost of IoT-integrated CPAP devices may be higher than that of conventional CPAP machines, raising questions about accessibility and affordability, particularly for patients with limited financial resources or those residing in poor nations.

Training and Support: To guarantee that healthcare professionals and patients can properly use and interpret the data produced by these devices, further training may be needed for both groups of people after IoT technology is integrated into CPAP equipment.

Long-Term Impact on Patient Outcomes: Although the theoretical advantages of IoT integration hold out a lot of promise, further research is required to determine how these advancements will actually affect patient outcomes, therapy compliance, and general quality of life.

8. Conclusion

The management of sleep apnea could be revolutionized through CPAP innovation with IoT integration, and patient outcomes could be enhanced. To be adopted and widely used, these technologies must, however, successfully overcome issues with data privacy, compatibility, and cost. The advantages of IoT-integrated CPAP therapy will likely be improved and expanded in the future with continued research and development.

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