Journal of Technical Science & Technologies; ISSN: 2298-0032; e-ISSN:2346-8270; Volume 8, issue 2, 2024

Pressure Difference Measuring System for Clean Rooms

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Abstract

This article presents the development and implementation of a pressure difference measuring system tailored for clean rooms, essential in medical facilities to control airflow and reduce nosocomial infections. The study evaluates various pressure sensors, leading to the selection of intelligent sensors that meet specific performance criteria. Key features and operating principles of the system are outlined, including sensor types, measurement techniques, and system architecture. A detailed comparison of sensors such as BMP180 and BMP280 highlights their suitability based on parameters like resolution, power consumption, and communication interfaces.

The system's structure includes dual pressure sensor units connected to a main control unit, enabling real-time pressure monitoring across different room zones. The sensors, equipped with a microcontroller for initial data processing, relay information to the control unit for further analysis and display. Designed with a calibration feature, the system ensures measurement accuracy by allowing recalibration under identical atmospheric conditions. Operating on low voltage, the system provides safe and reliable performance with applications extending to isolation rooms and environments requiring precise pressure regulation.

Integrating the measuring system with ventilation systems significantly mitigates the risk of airborne disease transmission, contributing to the maintenance of sterile environments. The article concludes that this cost-effective, intelligent pressure monitoring solution not only enhances safety in healthcare settings but also supports regulatory compliance and improves overall infection control measures in high-risk areas.

Keywords: Measurement system, ventilation, atmospheric pressure, isolation room.

Introduction

The emergence of the severe acute respiratory syndrome coronavirus (SARS-CoV-2) has led to a global pandemic and public health crisis. The virus's mode of transmis-

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sion and high virulence have introduced new challenges for the design of rooms in medical facilities to prevent nosocomial (hospital-acquired) transmission.

Modern studies show that, even in the world's leading clinics, nosocomial infections affect 1-2% of patients. This percentage can be significantly higher when proper preventive measures are not strictly followed, and it surged during the COVID-19 pandemic due to the high transmissibility of the virus. Effective prevention of diseases like aspergillosis, other fungal infections, tuberculosis, and airborne viral diseases is possible in clinics that adhere to proper guidelines. One of the critical methods for preventing airborne diseases in healthcare facilities is controlling airflow by managing pressure differences between rooms, which is achieved through the use of differential pressure sensors.

General Recommendations on Differential Pressure

When designing and constructing rooms where pressure differences are measured, it is recommended to maintain a pressure range of 10-20 Pa (Pascals) between adjacent rooms of different classes, with an optimal level of around 15 Pa. The accuracy of differential pressure control should generally be within ±5 Pa. Therefore, a pressure difference below 10 Pa between different classes of rooms may not guarantee reliable performance. Conversely, a pressure difference above 20 Pa usually does not enhance cleanliness and is typically only necessary in isolation rooms.

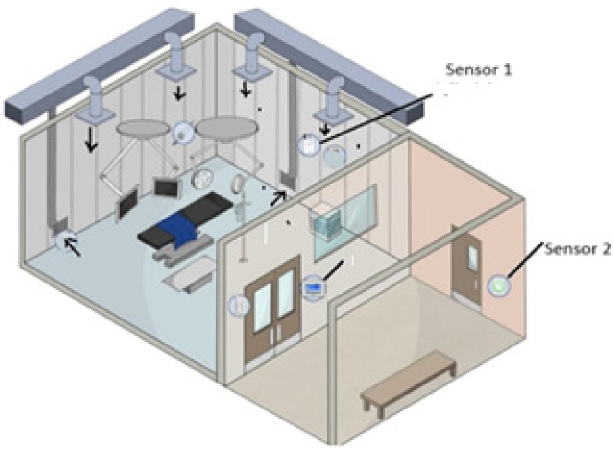

Fig. 1. Locations of components of the pressure difference measuring system located in medical rooms

The airtightness of rooms where pressure differences are controlled should be sufficiently high, but not excessive. As room volume increases and airflow loss occurs, maintaining consistent pressure becomes more challenging. Fig. 1 illustrates the placement of pressure sensor blocks and the main control unit within the measuring system.

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A brief overview of atmospheric pressure sensors

A pressure sensor is a device that alters its physical parameters based on the pressure of the medium it measures, whether it be liquid, gas, or steam. In these sensors, the ambient pressure is converted into a unified pneumatic or electrical digital code or signal. Such devices contain sensitive elements that respond to changes in environmental pressure, making them essential tools for precise measurement [3].

BOSCH is a global leader in automotive and consumer pressure sensors. Below is an overview of some popular sensor modules from BOSCH's atmospheric pressure sensor family:

- **BMP280 Intelligent Pressure Sensor**: This sensor is an advanced version of the BMP085, BMP180, and BMP183 sensor family. The BMP280 chip offers low power consumption, enhanced temperature stability, and 20-bit DCS resolution for both temperature and pressure. It is part of the GY-BMP280-3.3 sensor module, which operates based on the piezoresistive method. It provides high-precision atmospheric pressure measurement, with an absolute error margin of ±0.12 hPa (hectopascal), and an absolute temperature error margin of ±0.1 °C. This sensor can also calculate altitude by converting pressure data.

- **RKP-GY-BMP280-3.3 Digital Sensor**: This sensor can function as an altimeter, with an accuracy of ±1 meter. It is often used in applications such as flight controllers (multicopters, quadcopters, balloons, probes, and hang gliders), as well as stand-alone altimeters and GPS/GLONASS-enabled altitude and weather tracking devices.

- **GY-BMP280-3.3 Module**: Featuring both I2C and SPI data exchange interfaces, this module can be easily connected to Arduino family platforms, making it versatile and user-friendly for various projects.

- **BMP180 Intelligent Sensor**: Included in the GY-68-3.3 sensor module, this low-cost and high-precision sensor enables accurate measurement of atmospheric pressure and ambient temperature. It is frequently utilized in hydrometeorological mobile stations for environmental monitoring.

Table 1 below provides a comparison of the parameters of these sensors, which aids in selecting the most suitable sensor module for specific applications.

Table 1. Comparison of parameters of intelligent pressure sensors

parameters	Sensor BMP180	Sensor BMP280
Dimensions of occupied space	3.6 × 3.8 mm.	2.0 × 2.5 mm.
Minimum VDD	1.80 V.	1.71 v.
Minimum VD _ DIO	1.62 V.	1.20 v.

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Power consumption, @3 Pa rms. while making noise	12 Mka	2.7 Mka
RMS value of the noise	3 Pa	1.3 Pa
pressure resolution	1 Pa	0.16 Pa
temperature resolution	0.1°C	0.01°C
Data exchange interface	I²C	I²C & SPI (3 or 4 lines , mode '00' or '11')
Measurement modes	Only P or T, forced	P&T, forced or periodic
measurement frequency	120 hertz	157 Hz
Filter options	does not have	Five driving lanes

Structural scheme of the measuring system

Fig. 2 shows the structural diagram of the developed pressure difference measuring system. It contains the following blocks: 1,2 - two identical pressure measuring sensor blocks, 3 - main control block (leading controller), 4 - digital indicator, 5 - power supply block

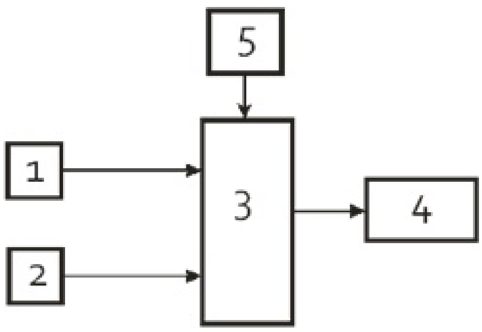

Fig. 2. Structural scheme of the proposed measuring system
1,2 - two identical pressure measuring sensor units, 3 - main control unit (leading controller), 4 - digital indicator, 5 - power supply unit

The device operates as follows: the main control unit (3) of the measuring system receives digitally converted data from two identical pressure-measuring sensor units (1 and 2). Each sensor unit contains a pressure sensor, a microcontroller, and a synchronization scheme to ensure smooth data transfer. The microcontroller handles the initial processing of parameters and constants from the factory-calibrated pressure sensor, performs statistical analysis of the measurement data, and transfers the processed information to the main controller, which can be located several tens or even hundreds of meters away.

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The pressure readings from sensor units 1 and 2, positioned in different locations, are transmitted to the main control unit, which serves as the leading controller. This main unit processes the received data and displays the pressure difference on a digital indicator. Additionally, when the pressure difference is negative, the control unit can optionally generate an analog or digital output signal.

For enhanced safety, the entire system operates on low voltage (5V), with the transformer placed externally to the system. To improve measurement accuracy, the device offers a calibration feature. To perform operational calibration, all three components of the measuring system should be placed together in the same room, ensuring that both pressure sensor units experience the same atmospheric pressure. These units are then connected to the main unit using short-length connecting cables provided with the system. After a period of 10-15 minutes (to allow temperature equilibrium to be reached), a button on the front panel is used to reset the device's display to "0," completing the calibration process.

Figure 3 shows a photo of the practical implementation of the described measurement system, including the sensor units and communication cables in working condition.

Fig. 3. realized and working Photo of a laboratory sample of the measurement system with sensor blocks and communication cables

Conclusion

In summary, following an extensive analysis of pressure sensors, an intelligent pressure sensor that meets the required specifications has been selected. A structural diagram and operational algorithm for the pressure difference measurement system have also been developed. To enhance measurement accuracy, the system includes statistical processing of measurement data and calibration to compensate for any static errors. Additionally, each sensor block can be positioned several tens or even hundreds of meters from the main control unit. Integrating this measuring system with a ventilation system can effectively reduce the risk of infectious disease transmission and contribute to maintaining a sterile working environment.

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References

Sammy Al-Benna //Negative pressure rooms and COVID-19. Journal: Journal of Perioperative Practice 2020 p (18–23) ((last transcribed 6.07.2021)

Azmaifarashvili, Z, Tomaradze, O. Sensors and intelligent measuring devices. Technical University Publishing House 2017. 498 p. ISBN: 978-9941-20-754-9

A. Frangishvili, T. Dzagania, Z. Azmaifarashvili, E. Butskhrikidze, M. Meskhia. differential pressure monitoring system medical for institutions . automated control systems . works # 1(33), Vol. 1.1 2022, pp . 5-12

Menabde, T., Otkhozoria, N., & Otkhozoria, V. (2024). Use of the theory of measurement uncertainty in procedures for data processing and results obtained by checking-calibration gas flow meters. International Science Journal of Engineering & Agriculture, 3(2), 40–46.https://doi.org/10.46299/j.isjea.20240302.03

Chkheidze, I., Otkhozoria, N., & Narchemashvili, M. (2021). Evaluation of Measurement Quality uding the Monte-Carlo Method. Universum, 65-70. doi: DOI: 10.32743/UniTech.2021.84.3-4.65-70

Otkhozoria, N., Otkhozoria, V., Narchemashvili, M. (2021) Fractality Of Measurements Of Quantities And Real Processes. International Trends In Science And Technology, Engineering Sciences June 2021 Doi: https://doi.org/10.31435/rsglobal_conf/30062021/7620