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Medical Humidifier

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Abstract: *The DL-2605 Medical Humidifier is an advanced respiratory support device designed to deliver precisely humidified oxygen for enhanced patient safety and comfort. It incorporates three patient categories, adult, pediatric, and neonatal, with dedicated clinical condition settings to accurately control temperature and humidification levels. The system supports three different oxygen delivery methods, allowing use across various treatment needs. A key feature of the device is its integrated overheating protection function, which ensures safe operation and prevents thermal damage during therapy.*

Keywords: Condensation, ATmega168, Respiratory

I. INTRODUCTION

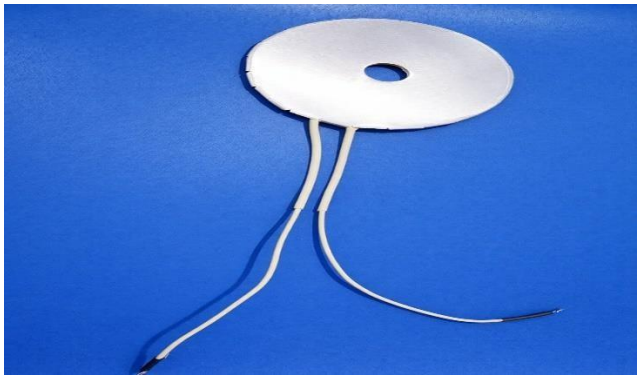
The DL-2605 Respiratory Support Humidifier is a controlled medical device designed to warm and humidify breathing gases delivered through ventilators and other positive-pressure systems. It helps prevent hypothermia, airway dryness, bronchospasm, atelectasis, and airway obstruction by maintaining adequate moisture in the respiratory tract. The device is suitable for adult, pediatric, and neonatal patients, including patients with bypassed upper airways (e.g., endotracheal or tracheostomy cases) It supports invasive, non-invasive, and HFNC modes with preset temperature and humidity ranges for different clinical conditions. The system features three patient types with selectable clinical conditions to accurately control temperature and humidification, along with an overheating protection function for safety.

The humidifier operates using a heated chamber system and includes a main frame, humidification chamber, breathing circuit, probes, and heater wire assembly. It complies with IEC 60601-1 safety standards and is classified as a Class IIb medical device. The device provides audio-visual alarms for high humidity, heater status, and probe disconnection to ensure safety. Designed for hospital environments, it must be operated by trained healthcare professionals. With reliable performance, a user-friendly interface, and controlled humidification, the DL-2605 enhances respiratory care and patient comfort

II. HARDWARE DESCRIPTION

Materials we used in design of hardware are:

A. Heating Coil:



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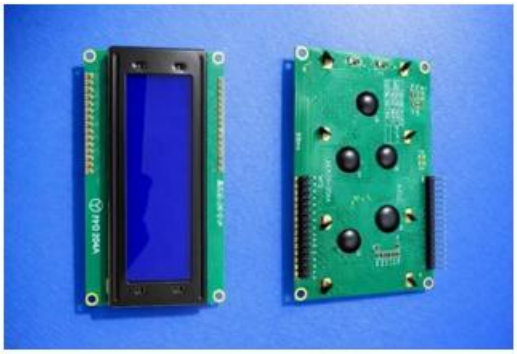
This is heater plate/heating coil element used in a medical humidifier to warm the water inside the humidification chamber. It is placed under the water chamber and transfers heat evenly to maintain the required temperature. The coil works by converting electrical energy into heat energy when current passes through the resistive element. It is designed to provide uniform heating to avoid overheating or hotspots in the chamber. In medical humidifier, this heating coil helps maintain controlled temperature and humidity levels for different patient types (adult, pediatric, neonatal). It is usually connected to the temperature sensor and control circuit for accurate regulation. The material is typically insulated and sealed for safety, durability and protection against moisture exposure.

B. GLCD



This is a 20x4 GLCD (Graphical Liquid Crystal Display) module used as the display unit in the medical humidifier. The front side shows the screen where important parameters like temperature, humidity, patient type (Adul, Pediatric, Neonatal), and operating mode (Invasive / non-invasive / HFNC) are displayed clearly. It provides real-time monitoring of chamber temperature airway temperature, and humidity values.

The back side contains the control PCB with driver ICs and interface pins that connect the display to the main control board of the humidifier. It works by receiving digital signals, from the microcontroller and converting them into visible text and graphical output. The GLCD ensures clear visibility, stable performance, and accurate display of alarms and system status. It plays a key role in helping healthcare professionals monitor and control the humidifier safely and effectively.

C. Main PCB

These PCBs are the main control board of the medical humidifier, and they act as the brain of the system. The front side contains the microcontroller, relays, power components, voltage regulators, and connectors for sensors, heater plate, probes, and display. The microcontroller processes inputs from temperature and humidity sensors and controls the heating coil accordingly. The PCB regulates the power supply, converts voltage to the required levels, and drives

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the heater safely using relays or driver circuits. It also manages alarms for high temperature, probe disconnection and system faults. The back side contains circuit tracks, solder joints, and supporting component for signal routing and stability. Overall this PCB controls, monitors, and ensures safe operation of the medical humidifier.

D. SMPS:

This device is a SMPS (Switched Mode Power Supply), and it is used in the medical humidifier to provide stable regulated DC power to the system. It converts the hospital AC mains supply (typically 230V AC) into low-voltage DC output required by the humidifier circuits. In a medical humidifier, the SMPS powers the main PCB, microcontroller, GLCD display, sensors, relays and control circuits. It ensures constant voltage output even if the input voltage fluctuates. The heater plate may be powered directly or controlled through circuits supplied by this SMPS. SMPS is preferred because it is efficient, compact, lightweight, and generates less heat compared to linear power supplies. It also provides protection features like overload, short- circuit, and over-voltage protection, which are very important for safe operation in medical devices.

E. Humidifier Chamber:

Humidifier Chamber

The humidifier chamber is an important component of the medical humidifier where sterile water is filled to generate moisture for respiratory therapy. It is placed on the heater plate or heating coil, which warms the water to control temperature. As the water heats, it produces warm moisture that mixes with the oxygen or breathing gas supplied to the patient. The chamber is designed to provide uniform heating and efficient humidification without causing overheating. It usually has inlet and outlet ports to connect the breathing circuit and temperature probes. The material is medical-grade, heat-resistant, and transparent to monitor water level easily. Proper cleaning and disinfection of the chamber are essential to maintain hygiene and patient safety.

III. SOFTWARE DESCRIPTION

The Medical Humidifier software is developed using Microchip Studio to control and monitor the device's core operations efficiently. It manages temperature and humidity levels through sensor data acquisition and precise control algorithms. The program ensures safe operation by continuously monitoring system parameters and activating protection mechanisms when necessary. The software is designed to provide reliable performance, user-friendly control, and real- time response for medical-grade humidification.

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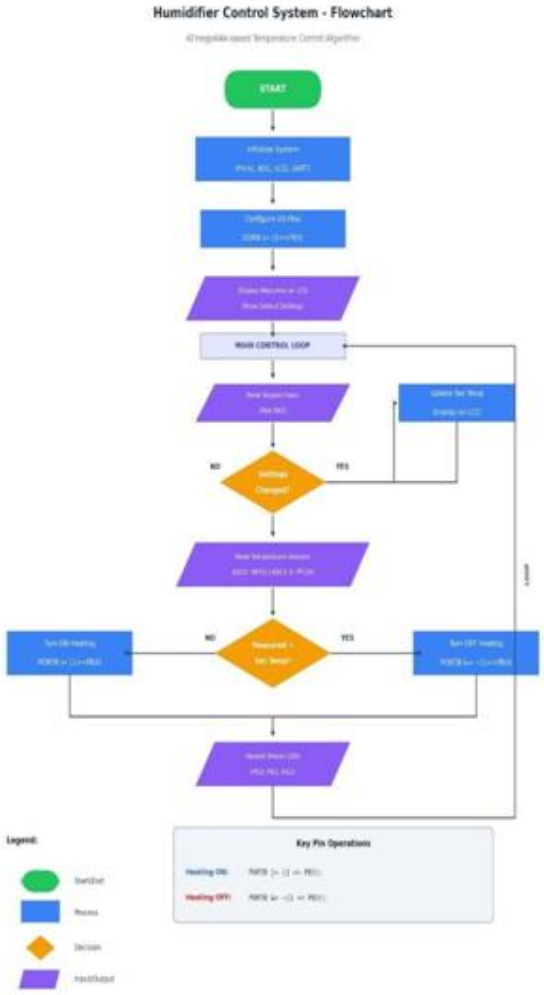
IV. FLOWCHAT



This flowchart illustrates the control algorithm of our ATmega64A-based medical humidifier system. After initializing the system and displaying default settings, the controller continuously reads keypad input and temperature sensors (MF52, PT100). It compares the measured temperature with the set value and automatically turns the heating element ON or OFF accordingly. The system updates the LCD display and status LEDs in a continuous loop to maintain the desired humidification temperature.

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V. RESULT

1. The figure shows the actual setup of medical humidifier.

VI. CONCLUSION

The DL-2605 Respiratory Support Humidifier is designed to warm and humidify medical gases during invasive and non-invasive ventilation, ensuring airway protection and patient comfort.

It supports adult, pediatric, and neonatal patients with controlled temperature and humidity settings, along with built-in safety alarms and overheating protection.

The device complies with IEC60601-1 standards and is intended for use in hospital environments by trained healthcare professionals.

With proper maintenance, cleaning, and monitoring, it enhances respiratory care by preventing airway dryness, obstruction, and related complications.

VII. ACKNOWLEDGEMENT

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