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Research

LabVIEW BASED TEMPERATURE CONTROL SYSTEM FOR NEONATAL INCUBATOR

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ABSTRACT

This system used to monitor and control the sudden change in temperature in neonatal incubator depending on two parts: first is the microcontroller which is a compact integrated circuit designed to run a specific operation in an embedded system, and LabVIEW which is engineering software used for applications that require test, measurement, and control with rapid access to hardware and data insights. those two important parts along with other components (heaters, fans, data acquisition cards) will be used to design the desired system.
This system has the properties of being cheap, easy to use, able to deal with many units as possible at the same time and finally can be operated automatically or by one person. this system will give a temporary solution for a period of time till the responsible person would fix the main problem.

Keywords: Neonatal incubator; LabVIEW; Microcontroller; Temperature control system; Embedded system

1. INTRODUCTION

According to the WHO report in 20216 [1], The first 28 days of their life is the most in danger time for a child's survival, which called the neonatal period, where globally almost 2.6 million children die in the first month of life, with roughly 7,000 newborns dying daily, most occur within the first week of their life.

In developing countries, because the economic situation is very low; the cost of medical devices should be kept low. so there is a need to develop low-cost incubators with monitoring and control which provides the facilities required for the infants[2].

Al-Sawaff Z. H. et al [3] designed a fully automated monitoring system for neonatal incubators by using a new generation of microcontrollers and GSM systems for pre-warning the change of temperature at a fixed setpoint using the (LT35) thermos sensor [4]-[5].

Mathew et al. [6] described the design and implementation of a fully digital and programmable temperature system for the Baby Incubator. The transmitter circuits were also designed and implemented for all the variables of the incubator that are used as control signals like the air temperature sensor (thermistor), baby skin temperature sensor (probe) [7]-[8].

The neonatal incubator is a piece of equipment commonly used in pediatric hospitals, birthing centers, and neonatal intensive care units. although the unit may serve several specific functions, it is generally used to provide a safe and stable environment for newborn infants, especially for those who were born prematurely or with an illness or disability that makes them especially vulnerable for the first several months of their life [9].

The main process of the incubator is to produce healthful micro-environment in order to reduce newborn's (heat loss, humidity, and oxygen levels) by controlling the temperature inside the incubator with other important parameters like humidity and oxygen levels [10]. Temperature is one of the most important factors which needed to be maintained with minimum changes. But only temperature control is not enough to provide a comfortable decision about the environment [11].

A neonatal incubator Fig. 1, consists of a rigid box built-in fiber and steel, where an infant may be kept in a controlled environment for medical care.

The device includes an AC-powered heater, an electrical motor fan to circulate the warmed air, a water container to add humidity, a mechanical filter through which the oxygen flows, and an access port for nursing care; The electric motor allows the air to circulate into the neonatal incubator through an air inlet at the bottom of the equipment [12].

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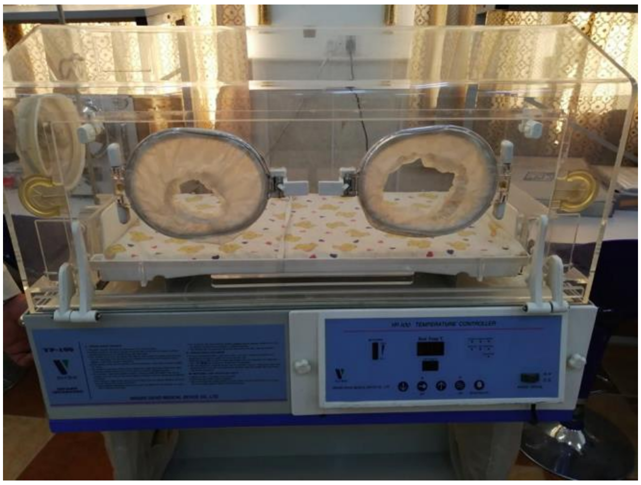

Figure 1. Infant Incubator

The microcontroller is considered as a free hardware platform consisting of an integrated circuit through which instructions can be recorded, where these instructions are written with a special programming language that allows the user to set programs that interact with electronic circuits [13].

The Arduino is an open-source board that has all the elements used to connect peripherals to the inputs and outputs of the microcontroller. as in Fig. (2) [13].

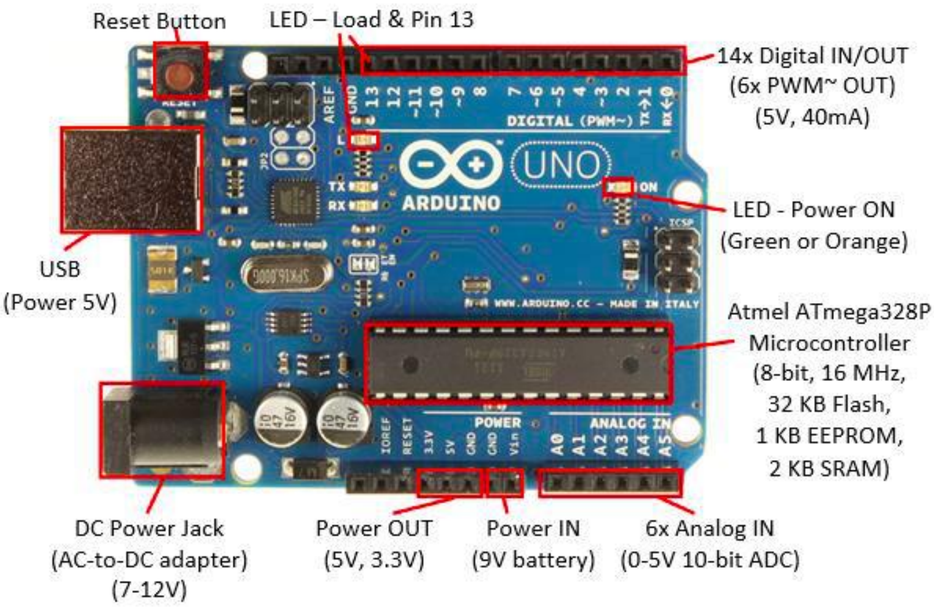

Figure 2. Arduino Uno Schematic [13]

LabVIEW is a graphical programming language that uses icons instead of lines of text to create applications. In contrast to text-based programming languages, where instructions determine program execution, LabVIEW uses dataflow programming, where the flow of data determines execution [14]. LabVIEW can build a user interface program with a set of tools and objects. The user interface program is known as the front panel. then adding codes using graphical representations of functions to control the front panel objects [15].

LabVIEW [16], which is stands for Laboratory Virtual Instrumentation Engineering Workbench, is a graphical computing environment for instrumentation, system design, and signal processing. LabVIEW is a development environment that has been built specifically for engineers and scientists with the intent of making them more productive and ensuring that they have all the tools they need to prototype, design, and build their applications. LabVIEW makes users more productive because it provides all the tools engineers need in a single environment and ensures that they all work and can be used together. The key is guaranteed compatibility between engineering tools.

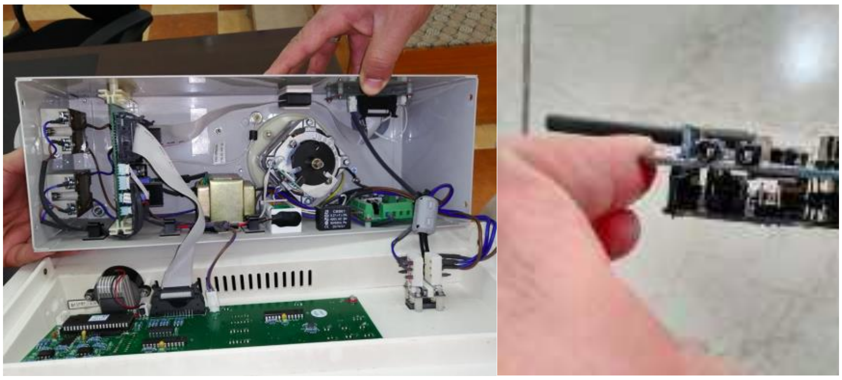

Figure 3. System electronic parts of the tested incubator along with the microcontroller

Fig. (3) shows the electronic parts of the tested neonatal incubator along with the microcontroller attached to it, where the figure shows the location of the microcontroller would be added inside the incubator.

The use of a microcontroller with the help of the LabView program made the monitoring and controlling very easy and fast in comparison with the ordinary method using only the control system already came with the incubator, and could be considered as a second control unit for more safety.

The layout and also the execution approach defines the procedure's ingredients of the mooted system along with the interactions between these ingredients. The circuit diagram representation of the developed model is shown in Fig. 4. The scope of normal values is set before the system starts taking any readings, where all the ingredients required to take the readings of the temperature are initialized, then the monitoring system now starts its work in an unending loop until it is manually halted. The mooted system will read the temperature in analog data, then the analog to digital converter (ADC) will convert these data to digital format, then converted format will be compared to the present values [17].

If the read value is within the present scope the value will be transmitted to the local server where it will be displayed in tabular format and display results. If the read value is outside the scope, a warning is sent to the doctor and the nurses, with sound alarm in the incubator [18].

At the same time, a warning signal will be sent to the LabView control system, this system will check the change of the temperature according to the set point which already been adjusted; the program will decide if there was a decrease or increase of the temperature then it will give the suitable order to start the fan or the heater till the temperature reaches to the same value of the set point [19].

The LabView program will give the right solution which will help to minimize the risk on the infant until the in-charge person fixes the whole problem.

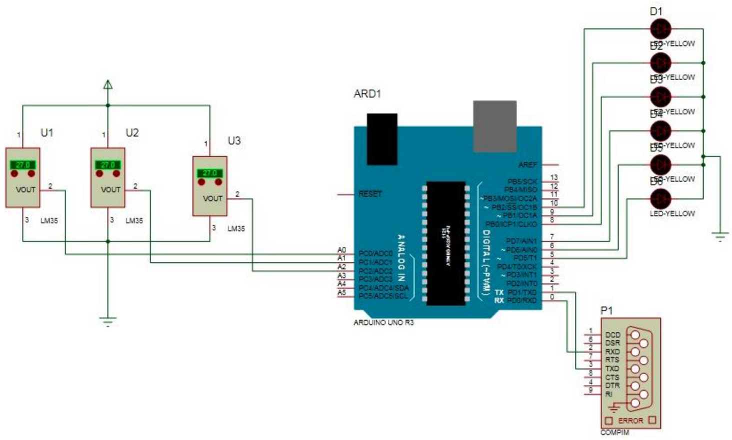

Figure 4. Microcontroller system block diagram

After completion of signals acquisition and comparison with preset values, the microcontroller then constructs the SMS messages as well as emails and packs the data samples in these messages to the desired length, it then communicates with the mobile phone using at-commands on its serial port to send the message(s). The device records temperature data continuously. When a temperature reading exceeds the present values, an alarm is triggered, and an email and an SMS message was sent to the in-charge doctor, then, the measured values are sent to the local web server and displayed on the website of the hospital in a tabular format; this assists the doctor(s) in taking correct decisions based on the accurate data; as shown in the flowchart below (Fig. 5). the connection between the Arduino monitoring system and LabView controlling system will be done in wireless connection mode, this mode will give many advantages for the system like less wiring and fast response.

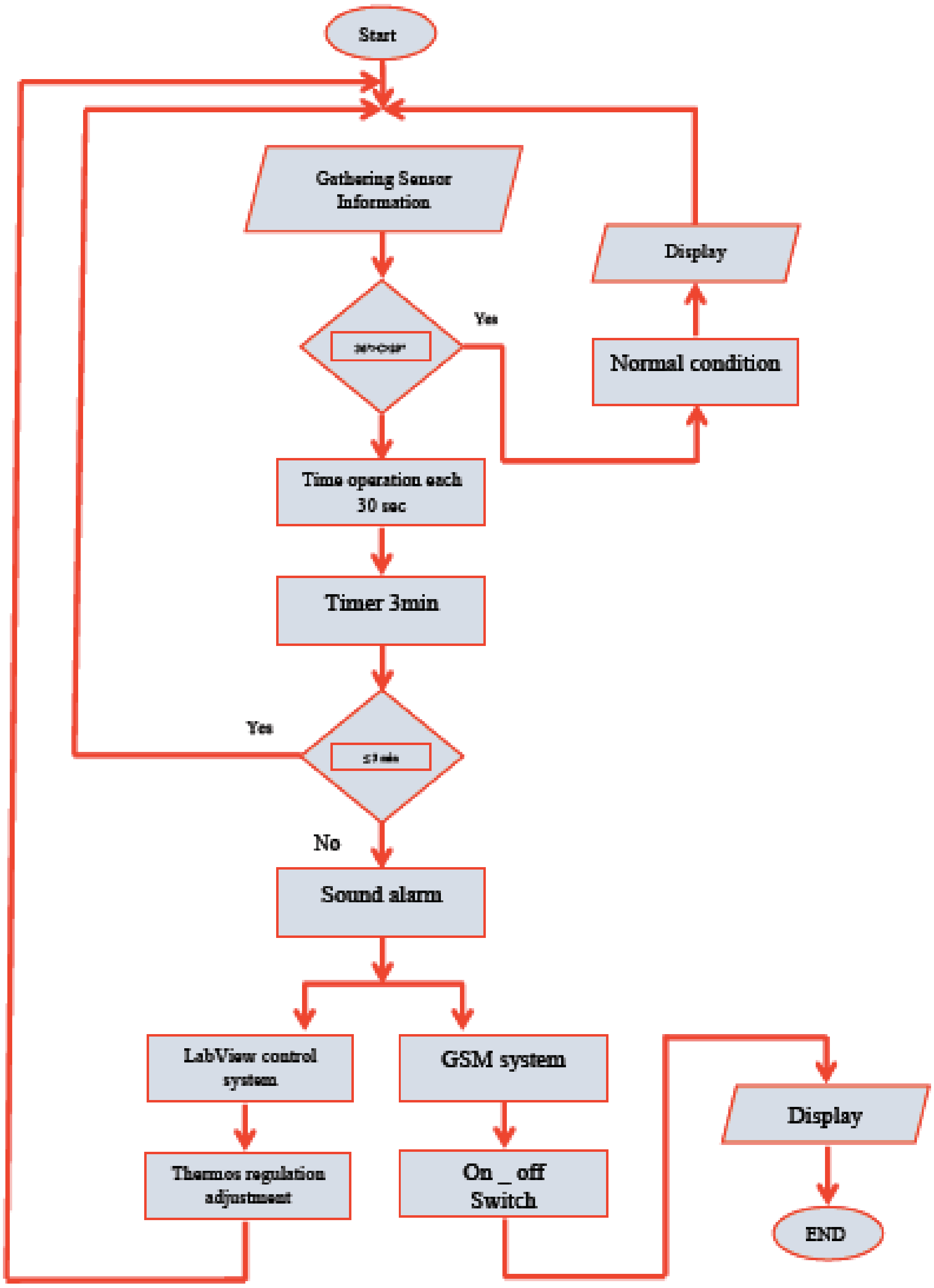

Figure 5. System flowchart

2. RESULTS AND CONCLUSIONS

The results obtained were tested and confirmed under normal temperature and dustless environment and agreed with the expected results which were displayed on the (LCD) attached with the controlling system.

The results obtained were compared and tabulated as shown in Table 1. which shows the results taken by using the original monitoring system found in the incubator and compared with the results and readings taken from the tested control system established by the microcontroller and the LabView programming system.

From the result, it was seen that there was little or no variation in the patient's readings from the clinical thermometer and all monitored units.

The system was designed to deal with only three units of neonatal incubators, the tests were done for seven samples (Table 1) under normal conditions (samples: A, B, D, and I) and different conditions (Samples: C, E, and F) to see the speed or the fast response of the alarm system along with the new tested device.

From these 7 samples, only three ideal results were taken (Samples A, B, and D) to make the final system

It's worth mentioning that the results obtained from the incubator were done under normal conditions and with the help of a dummy patient which provided with the needed tools and sensors for temperature under the same conditions of the actual patients.

Table 1. Readings results comparison between the incubator thermos sensor and the microcontroller sensor

Subject	Readings from Clinical Thermometer (C°)	Readings from infant body using microcontroller sensor (C°)
Sample A	33.6	34.1
Sample B	36.5	37.5
Sample C	35.6	35.4
Sample D	37.1	37.9
Sample E	38	37.6
Sample F	34.4	33
Sample I	39.2	36.8

A controlling system using the microcontroller and LabView system were used to ease the work of doctors in hospitals suffering from less number of staff, and in remote areas. The designed system was capable of helping the medical staff to make the right decision at the right time. The system is also appropriate for the monitoring of day-to-day activities in places like server rooms, hospital rooms, etc.

From the results were taken practically from different patients, the accuracy of the designed system was acceptable and the efficiency of the system was very high.

The designed system is very easy to use and manufacture, and the cost of manufacturing is rather reasonable, on the other hand, the size of the designed system is small and can be reduced to a minimum size depending on the size of the microcontroller used.

This system was designed to monitor and control more than one infant incubator at the same time (in our case three infant incubators were used), the total number we can control using this system can be increased till 10 units all controlled with the same LabView program as in Fig.5 and Fig.6.

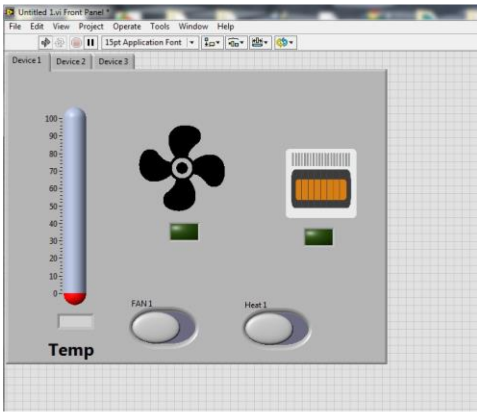

Figure 5. LabView system control panel

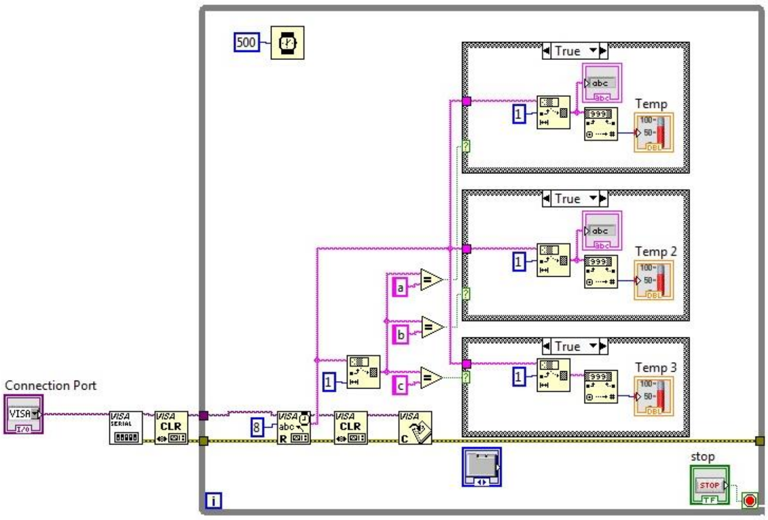

Figure 6. 3-units control system

As a future scope, different types of sensors can be added to monitor and control other variables like Humidity, oxygen levels, and Atmospheric pressure values, which are very easy and suitable for the microcontroller used in this system due to the presence of suitable sensors with less error.

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