

Real Time Monitoring And Control Of Neonatal Incubator Using LabVIEW

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ABSTRACT

This paper proposes an implementation of a real time web-based system for monitoring Temperature, Humidity, Weight and Physical condition of infant and also to control temperature and humidity. Redundant Sensing for the critical parameter, temperature has been incorporated using Triple Modular Redundancy. Continuous Oxygen supply is ensured. The algorithm is written such that the data is acquired continuously and compared with the Lower and Upper Limits in case of temperature and window comparison technique is used for Humidity. The proposed design model is simulated using LabVIEW 2011 software and hardware implementation was done with Compact Field Point Acquisition module for monitoring and controlling with sensors and actuators. Neonate activities in Incubator and Incubator parameters were monitored using Camera and Vision Assistant software with the help of Web Publishing tool of LabVIEW 2011 software which helps to monitor and control Incubator parameters from remote location also.

Keywords: LabVIEW, Infant, Compact Field Point, Temperature, Humidity

1. INTRODUCTION

The incubator is considered as an air conditioned room with special specification which we can control it with respect to the condition of baby in incubator Incubators are designed to provide an optimal environment for newborn babies with growth problems (premature baby) or with illness problems. The incubator is an isolated area environment with no dust, bacteria, and has the ability to control temperature, humidity, and oxygen to remain them in acceptable levels such as (36°C-38°C) for temperature,(70%-75%) for humidity [1], [2]. Newborn babies with growth problems usually have a net body area greater than normal babies from the same age. This in turn makes their heat loss greater than normal babies. Moreover, their net mass is less than the normal babies and makes them unable to keep their body temperature to the required level. With regard to sick babies, they usually can't control their body temperature without an external aid. The newness put in the incubator about 28 days after his born and he has the clinical care in the incubator from special window in the incubator to have his food, recording his weight, take care of him and make the small operations. Several types of control systems including microcontroller, ANN etc. were used to control the incubator internal environment to keep the premature baby safe [3]. Most of these controllers can deal with abnormal conditions, and fails to respond when an unexpected error like sensor failure or occurrence of short circuit.

This paper presents a new technique for controlling these parameters even under unexpected failure of sensors and protects the infant from short circuit. Instead of microcontroller, LabVIEW is used to control the real time incubator for which data is acquired through Compact Field Point. Temperature is of primary importance when it comes to incubator control and hence redundancy is applied for the temperature. Triple Modular Redundancy (TMR) is being used to ensure that incubator control works even when 2 out of the 3 temperature sensors fail. When a short circuit is detected a warning message is displayed and immediately Logic OFF will be sent to all the Final Control Elements (here Cooler, Heater, Humidifier) to protect baby from short circuit. A camera fit into the incubator acquires images of the baby continuously so that the environment is not disturbed by frequent visits. Neonate activities in Incubator and Incubator parameters were monitored using Camera and Vision Assistant software with the help of Web Publishing tool of LabVIEW 2011 software which helps to monitor and control Incubator parameters from remote location also [4].

2. IMPLEMENTATION

2.1. Temperature Sensor

K-type thermocouple is used to measure the temperature of both the baby and incubator. The choice is justified since other temperature sensors either have non linear relationships or Produce heat which may affect the environment and in turn the baby. Also thermocouple is an active device which reduces load on power supply. It has a very broad range and can tolerate stresses in very high magnitudes. It is made up of Chromel and Alumel with a sensitivity of approximately 41 $\mu\text{V}/^\circ\text{C}$ [5].

The relationship between voltage and temperature in thermocouple is given by:

$$E = S (T_h - T_l)$$

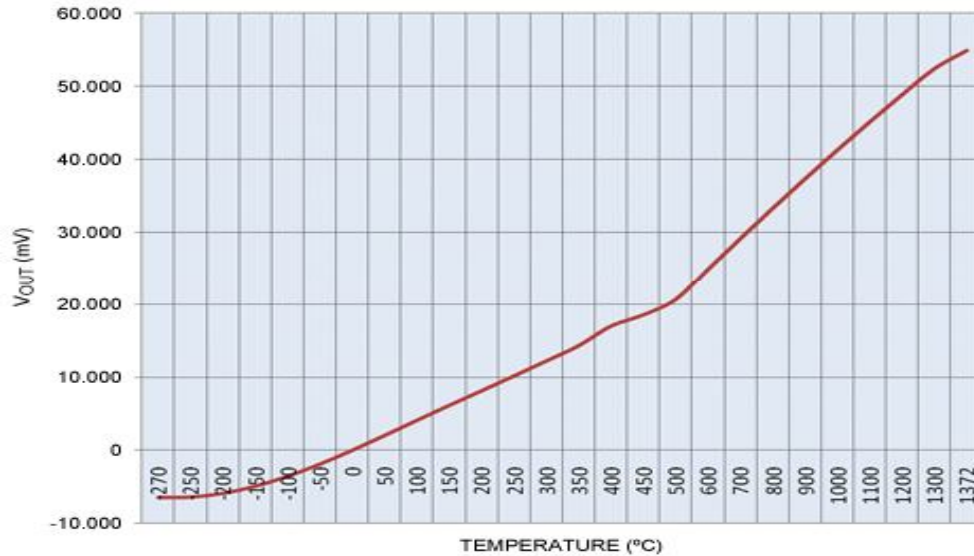


Figure 1 Temperature Vs Millivolt Charactersitics Of K-type Thermcouple

TMR is used to get a Fault Tolerant Condition for Temperature Sensors where in Sensor testing will be done continuously for Connectivity and working and if any sensor fails it is isolated , intimated to the user and the value is discarded. The temperature data is acquired to the PC through TC-120 Module .

2.2. Humidity Module

The Humidity Module GY-HRTM203 is used to sense the humidity levels. When the Relative Humidity falls below 70%, a Humidifier is turned ON and when it exceeds 75%, dehumidifier is turned ON.

The table 1shows the relationship between output voltage and % RH .

2.3. Oxygen Sensor

Alpha Sense- AAN 005 Oxygen Sensor is used to sense the oxygen concentration. When the oxygen concentration falls below 25% , oxygen is supplied from the cylinder.

2.4. LabVIEW controller

LabVIEW, a graphical programming tool is used to control the process inside the incubator. The data from Temperature, Humidity, Short circuit detector and Strain Guage Modules is acquired using Compact Field Point. Temperature Acquisition Module (TC-120) gets the signals from temperature sensors & Analog Input/Output (AIO-610) module get the signals from Humidity,Short circuit Detector and Strain Guage Modules. The control algorithm is written such that Sensor values are acquired continuously and compared if they are in specified limits. Window Comparison Technique is being used to Control Humidity for faster response.

The strain gauge output is calibrated to display the weight of the baby. Periodically Oxygen Supply is Turned ON/OFF to ensure baby has adequate Oxygen. The camera is attached to the incubator and is programmed to acuire images of baby continuously using LabVIEW with the help of Vision Assistant. All these parameters along with the image can be viewed and controlled remotely[6] ,[7].

Table 1 Relationship between Output Voltage and %RH

%RH	25	30	35	40	45	50	55	60
Output(V)	1.35	1.50	1.65	1.80	1.90	2.00	2.10	2.20
%RH	65	70	75	80	85	90		
Output(V)	2.30	2.40	2.49	2.56	2.65	2.74		

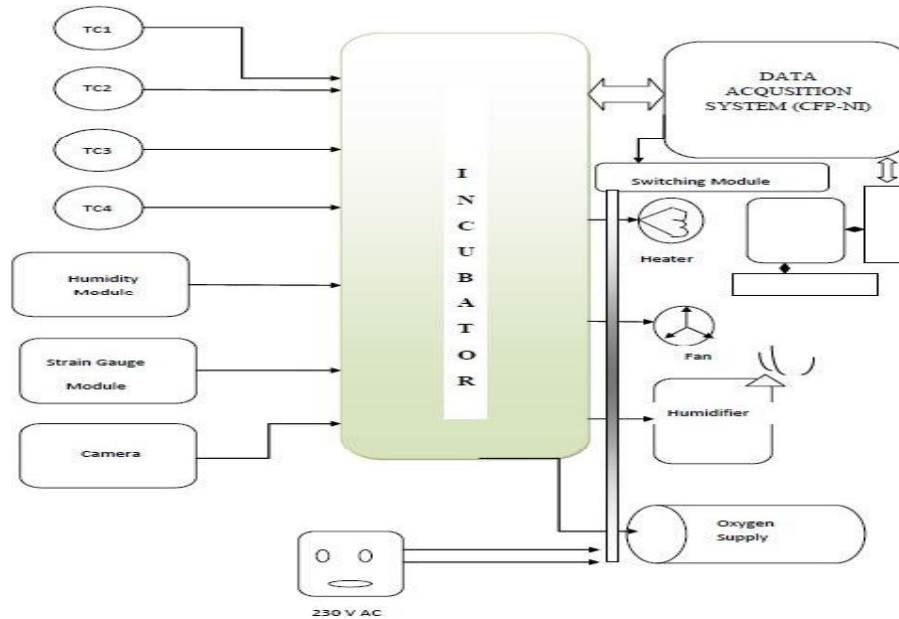


Figure 2 Block Diagram Of Neonatal Incubator System

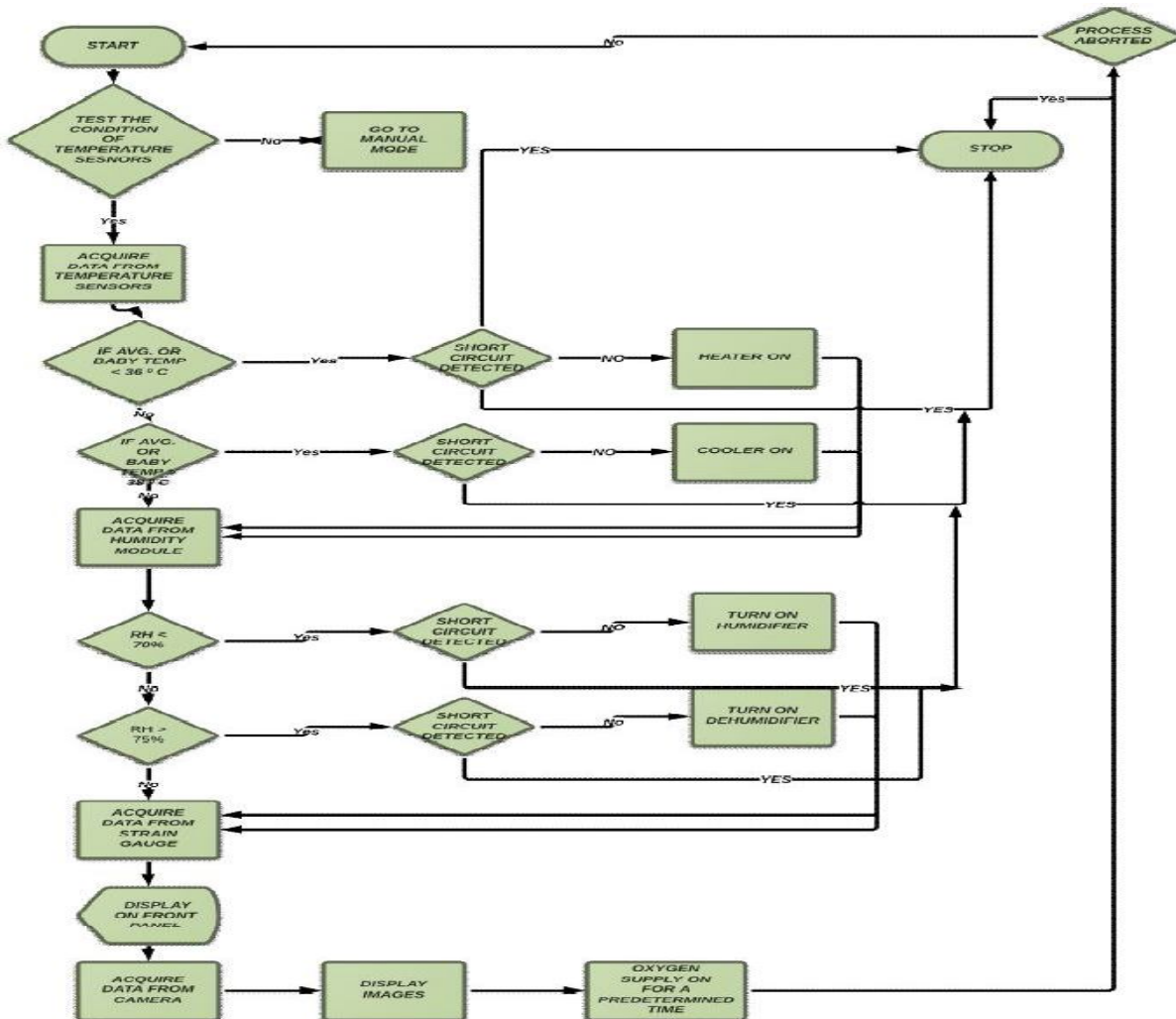


Figure 3 Flow Chart depicting the Incubator Control Action

3. EXPERIMENTAL RESULTS AND DISCUSSIONS:

The data is acquired from all the sensors and also interfaced to the control elements. When a thermocouple disconnects it's value will be discarded and also alerts the user. When temperature of the incubator or baby falls less than 36⁰C , Heater turns ON. When it raises above 38⁰C, Cooler is turned ON. When RH falls below the lower limit Humidifier is turned ON and when it goes beyond upper limit Dehumidifier is turned ON. When one or two of the sensors get disconnected, the value from that particular sensor gets discarded and the warning message gets displayed. The process still works according to the required specifications of the parameters.

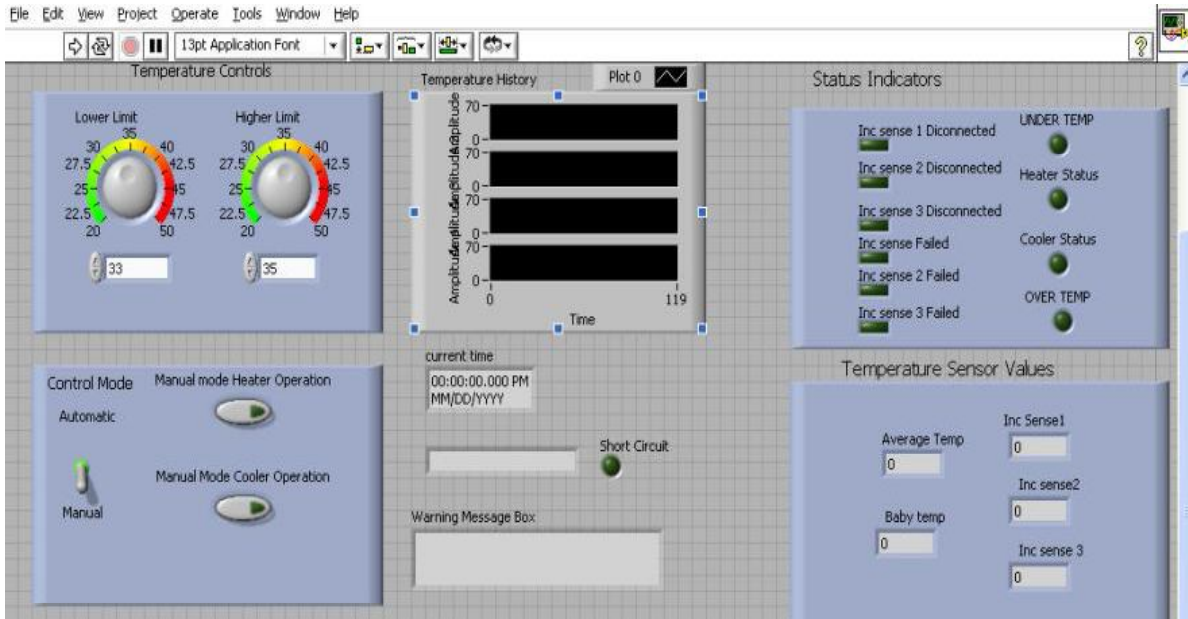


Figure 4 Temperature Controls and Indicators

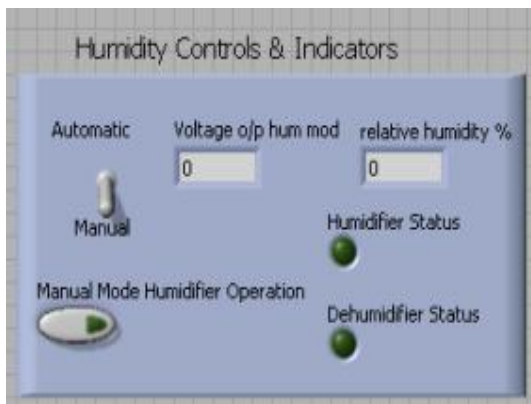


Figure 5 Humidity Controls and Indicators



Figure 6 Weight Indicator

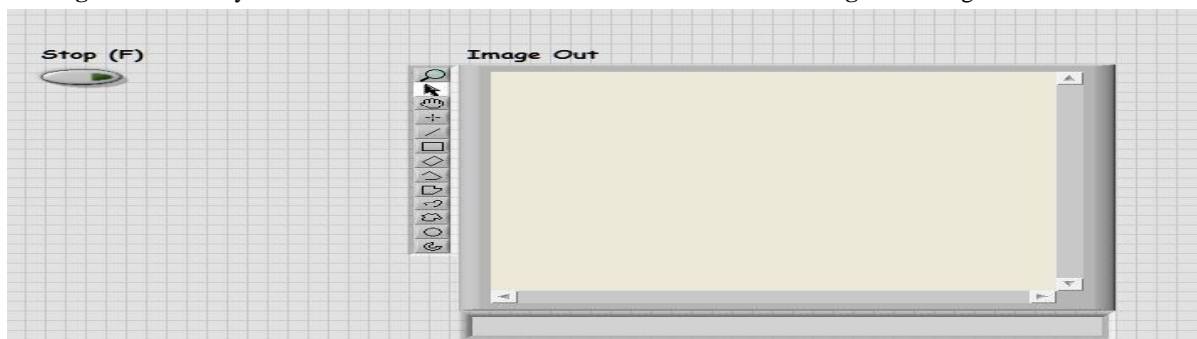


Figure 7 Continuous Monitoring through Digital Camera

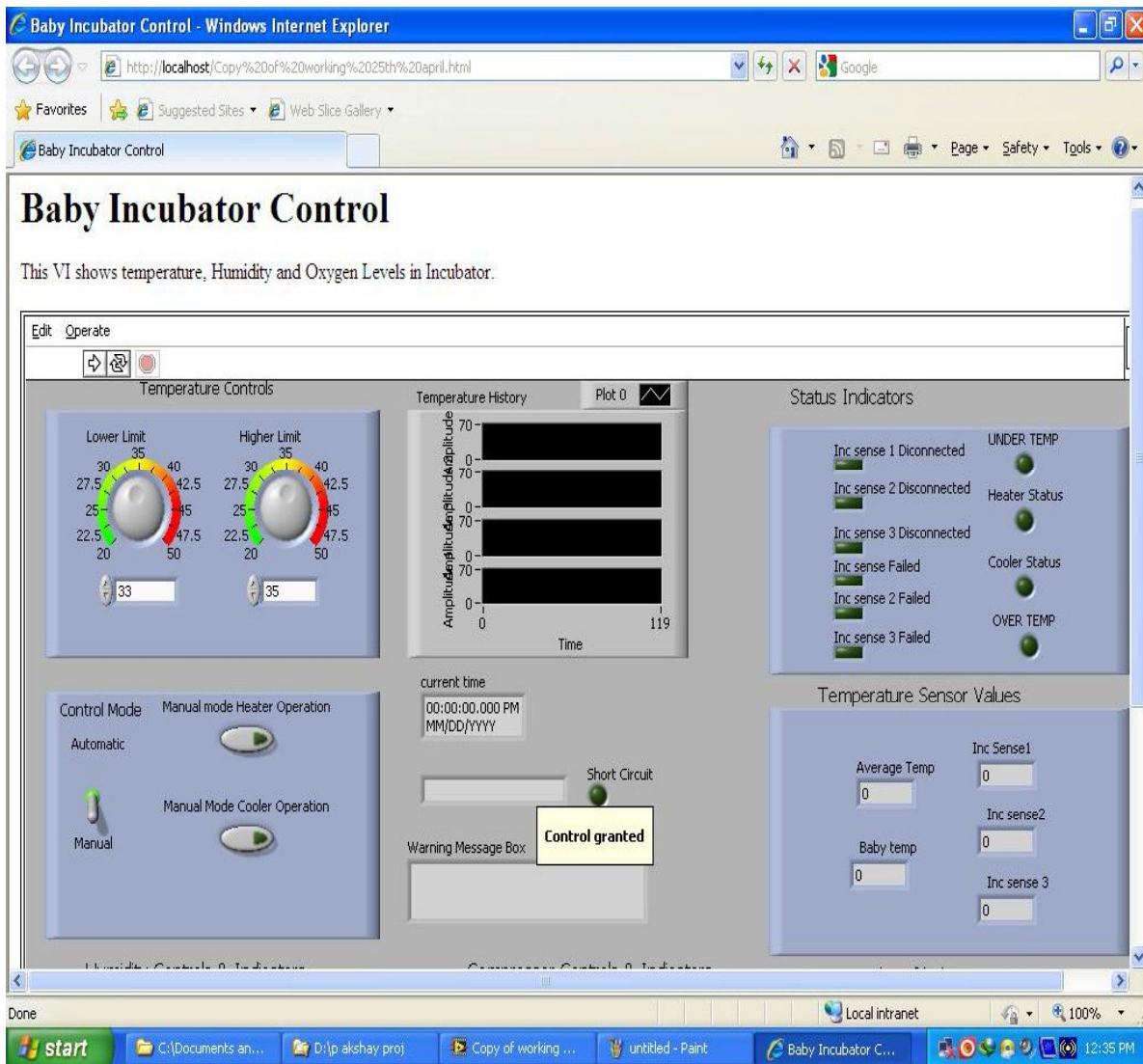


Figure 8 Frontpanel when published onto Web

Table 2 Table of results Desired and achieved

S.No	Parameter	Value	Desired Action	Achieved Action
1.	Temperature	<36	Heater ON	Heater ON
2.	Temperature	>38	Cooler ON	Cooler ON
3.	Humidity	<70% RH	Humidifier ON	Humidifier ON
4.	Humidity	>75% RH	Dehumidifier ON	Dehumidifier ON
5.	Weight	-	Display Weight	Displayed Weight
6.	Image	-	Acquire Images	Images Displayed on Front panel
7.	Short Circuit Detection	-	Disconnect Every device from Mains	Disconnect Every device from Mains

4. CONCLUSION:

Real time parameters like temperature, Humidity, Weight, images etc can be acquired and even fault tolerant conditions can be implemented to save the life of infant. More sensors can be included to reduce noise, Vibrations etc. By

replacing the fieldpoint Data Acquisition Board with minor ones it can be implemented for transport incubators. Remote monitoring and control of parameters is useful especially in case of transport incubators and also remote treatment of babies where proper medical facilities are not available. The cost incurred is the equipment cost and the effect is life saving one.

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