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Smart Incubator with Real Time Temperature and Humidity Control

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Abstract - *The demand for non-vegetarian food has increased multiple folds in the modern world. Among this chicken stands atop. So the natural hatching process cannot even follow the demand. So the hatcheries are required to meet the demand by artificially hatching the eggs. In this project a novel incubator for eggs is designed. We have a temperature control system using a heating coil. An exhaust fan is used to circulate the hot air near the coil to all the parts of the incubator evenly so that the eggs get correct and uniform heat at all the areas. Humidity is controlled at a particular value. For this, a fan and water system is used to get the required humidity uniformly in the incubator. Provision for externally adjusting these parameters is available through a smart phone interface. The parameters of the system are logged at every interval of given time period. Tensilica ESP 8266 is the processor used in this system as it has inbuilt Wi-Fi. DHT 11 is used as temperature and humidity sensor to sense the respective values in the incubator system.*

Key Words: Tensilica ESP 8266, DHT 11, I2C Serial Interface, 12c 16x2 LCD, Temperature and Humidity Control, HTML-5

1. INTRODUCTION

The weather conditions that where once ideal for the hatching of eggs has now changed dramatically and as a result the hatching efficiency of the eggs has fallen down considerably. So it has become a problem for the farmers to get a good yield. In order to aid the hatching of eggs it is necessary to provide the proper condition to get healthy hatchings. This can be overcome by giving the exact weather conditions as required using an incubator. So we proposed a smart incubator system with real time Temperature and humidity control.

There are number of incubator systems are available in the market nowadays. But all this systems provide a predefined fixed humidity and temperature conditions inside the incubator. These incubators does not adjust the temperature and humidity conditions according to the surrounding environmental conditions. So the adjustment of these temperature and humidity values are done by direct visual inspection.

A smart incubator with real time temperature and humidity control system can resolve these issues. This system provides a wireless connection between the incubator system and a smart phone. Using this smart phone the temperature and humidity conditions inside the incubator system can be monitored and adjusted. The Tensilica ESP 8266 processor used here. This processor has an inbuilt Wi-Fi capabilities, it can act as both host and client. This is one of the cheapest processor available in the market with an inbuilt Wi-Fi facility. So that the proposed incubator system is cheaper than any other systems currently available in the market. A DHT 11 sensor is used to calculate the temperature and humidity in the system.

2. LITERATURE REVIEW

In this section topics related to a Smart Incubator with Real Time Temperature and Humidity Control are included. These provides a sampling of problems appropriate for application of Smart Incubator with Real Time Temperature and Humidity Control. The references are summarized below.

2.1 Systems of Measurement and Control of Relative Humidity in New Born Incubator [1]

This paper proposed a microcontroller-based system devoted to the new born incubator. In that incubator a precise environmental conditions are provided to the premature new borns. A control system of humidity and software that carries out the reading of the sensors used in the incubator. For the realization of the measurements, two similar new born incubators were used. In that one of the new born incubator used distilled water and other one was valued without water. The measures were collected to each 2 minutes during 96 h. The relative humidity inside of the new born incubator, with water, without control of humidity, (70.67 ± 3.71) %. The mean value of the internal temperature was of (34.33 ± 1.84) ºC. Without water had average (46.53 ± 3.84) %. The mean value of the internal temperature was of (36.58 ± 1.04) ºC. With water and with control of humidity, was inside the established belt of comfort for the standard. This paper provides details about the control of humidity inside the incubator system.

2.2 Design of Indoor Environment Monitoring System Based on Wi-Fi [2]

Nowadays the increased industrialization and urbanization badly affect the peoples living conditions. The effect of these make the indoor and outdoor environment unpredictable. In recent times indoor air quality has

attracted the attention of policy makers and researchers as an important similar to that of external air pollution. In certain sense, indoor air quality must be paid more attention than outdoor air quality as people spend more time indoors than outdoors. So this paper proposed a system, which can monitor the temperature and humidity using DHT11 sensor and the light intensity is sensed by the GY-30. The sensor data's are processed by the Arduino Uno. The wireless communication ESP 8266 (WIFI) module will transmission the collect data to the client's mobile equipment, may provide the user at any time to get the indoor environment condition. All of them are for purpose of satisfying the indoor environmental requirements.

2.3 A Low Cost Implementation of MQTT using ESP 8266 [3]

IoT (Internet of Things) is an emerging technology in the modern world. For such rapid growing technology, it is the necessity to have very light, inexpensive and minimum bandwidth protocol like Message Queuing Telemetry Transport (MQTT) Protocol. In this paper, it is shown that communication between the low power ESP8266WiFi as client with the clients on smartphones and laptop using an MQTT protocol becomes easier and more reliable. The Wi-Fi enabled ESP8266 board interfaces with DHT11 sensor and LDR sensor to monitor the ambient condition and according to the light intensity level the brightness level of 8*8 Neopixel matrix is controlled.

2.4 Weather Station Design Using IoT Platform Based on Arduino Mega [4]

Weather station is an urgent requirement due to the ever-changing weather conditions. So a remote access to the weather station can make it a lot easier for getting the conditions of a place even from a far away place. This paper proposed a design using Arduino mega 2560 as the main part and to evaluate the weather conditions, it is interfaced with some sensors. For measuring the Temperature and humidity uses a DHT22 sensor. rain detection using FC-37 rain sensor, and air pressure using BMP180 sensor. Air pressure measurement results are used to predict the weather. The measurement results of all sensors are stored in SD Card and displayed on TFT LCD 2.2 'and website using ESP8266 Wi-Fi module.

2.5 Temperature and Humidity Control with a Model Predictive Control Method in the Air-Conditioning System [5]

Nowadays the outdoor air environment is changes uncontrollably. So the indoor air environment is usually controlled for occupants comfort with an air-conditioning (A/C) system. Air conditioning (A/C) systems are widely used in small- to medium-scaled buildings to provide a specified ambient environment for occupants. Nowadays everyone are looking for the comfortable indoor living environments with specific air temperature as well as humidity which requires more complex facilities. The current variable speed drive (VSD) technology offer tremendous scope for improving indoor thermal comfort and energy efficiency for A/C systems. In such an A/C system, there are multi-inputs and multi-outputs (MIMO) which require multi-objectives to achieve during control process. Moreover, many variables are coupled together. All these factors make it difficult and challenging for the A/C system control design.

3. DESIGN OVERVIEW

The block diagram depicts the total blue print of the proposed project, A Smart Incubator with Real Time Temperature and Humidity Control. The total functioning of the project is represented in a single block diagram shown in figure 1. Tensilica ESP 8266 is the brain of this system. DHT 11 is the humidity and temperature sensor, which is connected to the ESP 8266. A 12C 16*2 LCD display is connected to the ESP 8266 to view the current temperature and humidity conditions inside the incubator.

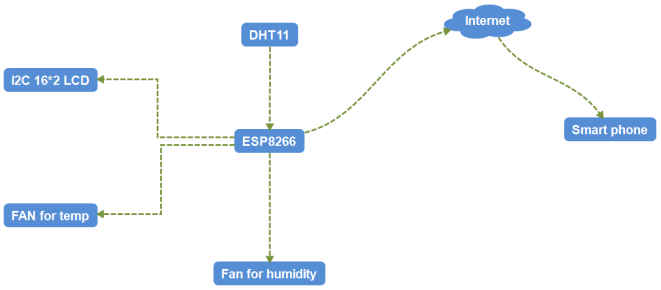

Fig -1: Block Diagram of Smart Incubator with Real Time Temperature and Humidity Control

The desired temperature and humidity of the incubator is achieved by using two separate fans in an appropriate manner, which are also interfaced with the processor. The smart phone is interfaced with ESP 8266 through Wi-Fi. Using the smart phone the reference values of temperature and humidity can be adjusted and also monitor the current values of temperature and humidity.

3.1 Tensilica ESP 8266

The ESP8266 is a low-cost Wi-Fi microchip with full TCP/IP stack and microcontroller capability produced by Espressif Systems. Using Hayes-style commands this small module allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections. The advanced versions of ESP 8266 are available in the market. The ESP8285 is an ESP8266 with 1 MiB of built-in flash, allowing for single-chip devices capable of connecting to Wi-Fi. This processor attracted every one due to its very low price and the fact that there were very few external components on the module which suggested that it could eventually be very inexpensive in volume.

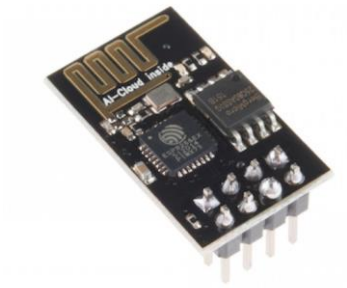

Fig-2: Tensilica ESP 8266 processor

Espressifs ESP8266EX delivers highly integrated Wi-Fi SoC solution to meet users continuous demands for efficient power usage, compact design and reliable performance in the Internet of Things industry. With the complete and self-contained Wi-Fi networking capabilities, ESP8266EX can perform either as a standalone application or as the slave to a host MCU. When ESP8266EX hosts the application, it promptly boots up from the ash. The integrated high speed cache helps to increase the system performance and optimize the system memory. The pin diagram of the Tensilica ESP 8266 is shown in figure 3.

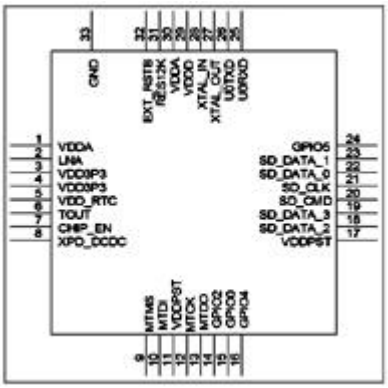

Fig-3: Pin diagram of ESP 8266

Also, ESP8266EX can be applied to any microcontroller design as a Wi-Fi adaptor through SPI / SDIO or I2C / UART interfaces. ESP8266EX integrates antenna switches, RF balun, power amplifier, low noise receive amplifier and power management modules. The compact design minimizes the PCB size and requires minimal external circuitries. Besides the Wi-Fi functionalities, ESP8266EX also integrates an enhanced version of Tensilicas L106 Diamond series 32-bit processor and on-chip SRAM. It can be interfaced with external sensors and other devices through the GPIOs. Software Development Kit (SDK) provides sample codes for various applications. Espressif Systems Smart Connectivity Platform (ESCP) enables sophisticated features including fast switch between sleep and wakeup mode for energy-efficient purpose, adaptive radio biasing for low-power operation, advance signal processing, spur cancellation and radio co-existence mechanisms for common cellular, Bluetooth, DDR, LVDS, LCD interference mitigation.

Table – 1: Hardware Specification of ESP 8266

Parameters	Specifications
CPU	32-bit Processor
Peripheral Interface	UART/SDIO/SPI/I2C/IR Remote Control GPIO/ADC/ PWM/ LED Light & Button
Operating Voltage	2.5V ~ 3.6V
Operating Current Average Value	80 mA
Operating Temperature Range	-40 ° C ~ 125° C
Storage Temperature Range	-40 ° C ~ 125° C
Package Size	QFN32-pin (5 mm x 5 mm)
Wi-Fi Mode	Station/ SoftAP/ SoftAP + Station
Security	WPA/WPA2
Network Protocols	IPv4, TCP/UDP/HTTP/FTP
User Configuration	AT Instruction Set, Cloud Server, Android/iOS App

3.2 DHT 11 Sensor

DHT11 digital temperature and humidity sensor is a composite Sensor contains a calibrated digital signal output of the temperature and humidity. Application of a dedicated digital modules collection technology and the temperature and humidity sensing technology, to ensure that the product has high reliability and excellent long-term stability. The sensor includes a resistive sense of wet components and an NTC temperature measurement devices, and connected with a high-performance 8-bit microcontroller.

Fig-4: DHT 11 sensor

The DHT 11 Humidity and Temperature Sensor consist of 3 main components. A resistive type humidity sensor, an NTC (Negative Temperature Coefficient) thermistor (to measure the temperature) and an 8-bit microcontroller, which converts the analog signals from both the sensors and sends out single digital signal. This digital signal can be read by the Tensilica ESP 8266 processor for further analysis.

Table -2: Hardware Specification of DHT 11 Sensor

Parameters	Specifications	
Relative Humidity (RH)	Resolution	16 Bit
	Repeatability	±1% RH
	Range	At 25°C ±5% RH
Relative Temperature	Resolution	16 Bit
	Repeatability	±0.2°C
	Accuracy	At 25°C ±2°C
Electrical Characteristics	Power Supply	DC 3.5～5.5V
	Supply Current	measurement 0.3mA standby 60μA
	Sampling Period	more than 2 seconds

3.3 I2C Serial Interface Module

I2C Serial to Parallel Converter for LCD Display for has PCF8574 I2C chip that converts I2C serial data to parallel data for the LCD display. It can be connected to a standard HD44780 compatible 16x2 or 20x4 Character Display Module that supports 4-bit mode. In general, LCD connection with Arduino require RS, E, and 4 data pins. I2C interface LCD adapter plates leave the flexibility to reduce these pins to only 2. Since it uses I2C mode for communication only SDA and SCL pins are needed. The I2C address is 0x3F by default, but this can be changed via 3 solder jumpers provided on the board. The I2C serial interface module is shown in figure 5.

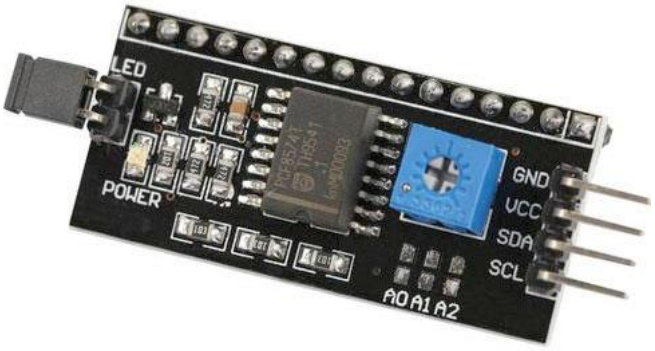

Fig – 5: I2C serial interface module

Serial I2C LCD display adapter converts parallel based 16 x 2 character LCD display into a serial i2C LCD that can be controlled through just 2 wires. Adapter uses PCF8574 chip that serves as I/O expander that communicates with Tensilica ESP 8266 or any other microcontroller by using I2C protocol. A total of 8 LCD displays can be connected to the same two wire I2C bus with each board having a different address. The default i2C address is 0X27 and may be changed to any of the following 0X20~0X27 via soldering A0 A1 A2 pins.

3.4 12c 16x2 LCD

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special even custom characters (unlike in seven segments), animations and so on. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD. The 12c 16x2 LCD display module is shown in figure 6.

Fig-6: 12c 16x2 LCD

3.5 Real Time Temperature and Humidity Control

In smart incubator system we are using two fans for maintaining the temperature and humidity. Where an aluminum heating plate is attached to the fan, which controls the temperature in the incubator. The aluminum heating plate is heated up to the required temperature range. The air passed by the fan crosses the heated aluminum plate, so temperature of the air increases. The temperature inside the incubator reaches the required value, then the fan turns off. The temperature control setup is shown in figure 7.

Fig-7: Temperature Control Setup

Humidity control in an incubator system is a difficult process. The humidity control setup is shown in figure 8.A jar is filled with water, on top of the jar one fan is fixed. By turning on the fan a vacuum is created thereby the humidity inside the incubator controlled. When the humidity reaches the required value the fan turn off. The humidity control setup shown in figure 8.

Fig-8: Humidity control setup

3.6 HTML-5

HTML5 is a mark-up language used for structuring and presenting content on the World Wide Web. HTML5 includes detailed processing models to encourage more interoperable implementations; it extends, improves and rationalizes the mark-up available for documents, and introduces mark-up and application programming interfaces (APIs) for complex web applications. For the same reasons, HTML5 is also a candidate for cross-platform mobile applications, because it includes features designed with low-powered devices in mind. Here in the Smart incubator System the temperature and humidity is controlled by a smart phone interfaced via internet. The current status of both parameters are viewed in the smart phone through a web page designed by HTML-5. The GUI of the smart phone is shown below in figure 9.

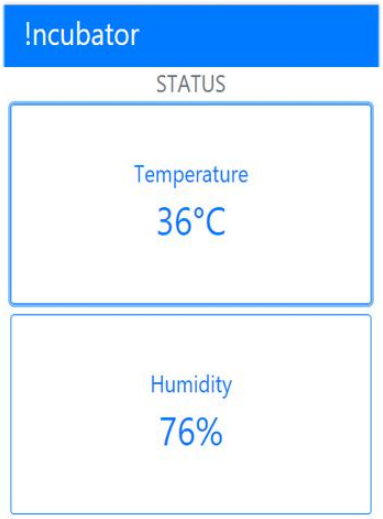

Fig -9: Smart phone GUI

In order to monitor and control the current status of temperature and humidity, some instructions are written on the browser search bar and search. It will goes to the corresponding web pages. The instruction contain the IP address of the processor Wi-Fi module. The processor Wi-Fi module act as a host device, so by properly type the username and password in the smart phone a connection established between the processor and the smartphone. To view the current temperature and humidity status of the smart incubator uses the IP : 192.168.43.70, for setting new reference values of temperature and humidity uses another instruction code IP : 192.168.43.70/set?a=36b=76. Where the variable 'a' assigned for temperature and 'b' is assigned for humidity.

3.7 POWER SUPPLY UNIT

A regulated power supply is an embedded circuit, it converts unregulated AC into a constant DC, with the help of a rectifier. Its function is to supply a stable voltage to a circuit or device that must be operated within certain power supply limits. The output from the regulated power supply may be alternating or unidirectional, but is nearly always DC. The type of stabilization used may be restricted to ensuring that the output remains within certain limits under various load conditions, or it may also include compensation for variations in its own supply source. Initial stage of every electronic circuit is power supply system which provides required power to drive the whole system. The processor requires 3.3 V. The sensors and the fan requires 5 V. 7805 voltage regulator IC is used for getting 5V supply and AP111733 voltage regulator IC for getting 3.3V supply. The power supply module shown in figure 10.

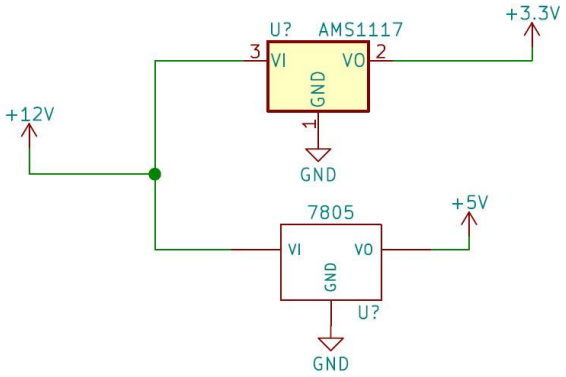

Fig -10: Power Supply Circuit for Smart Incubator

4. RESULT

Experiment using the Smart Incubator with Real Time Temperature and humidity Control is completed successfully and the results are tabulated in table 3 shown below. Figure 11, shows the final prototype of the Smart Incubator with Real Time Temperature and humidity Control.

Table -3: Result showing the accuracy of the system

Parameters	Number Of Checks	Number Of Successful Outcomes
Smart phone and Wi-Fi interfacing	20	20
Temperature Control	20	20
Humidity Control	15	15
Real Time Status of Temperature	10	10
Real Time Status of Humidity	10	10
Temperature & Humidity Control	15	15

Fig-11: Final prototype of Smart Incubator with Real Time Temperature and Humidity Control

5. CONCLUSION

The Smart Incubator with Real Time Temperature and Humidity Control has been designed and developed successfully. It gives an easy and less expensive way to implement an incubator System with a wireless status monitoring and set the required reference values. This system uses the cheapest and efficient Tensilica ESP 8266 processor. By using this processor and the DHT 11 sensor the current status of the temperature and humidity inside an incubator is monitored and controlled precisely. So this efficient smart incubator system that automatically adjust the values of temperature and humidity according to the optimum values.

6. FUTURE SCOPE

The project can be further modified to include the following functionalities.

A. Can use DSP to predict the surrounding environment.
B. It automatically turn on when object present inside
C. According to the material automatically adjust the parameters.

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