Real time Indoor Monitoring of relative humidity and temperature using Radio Frequency with SMS warning for production area of Amkor Technology Philippines

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CHAPTER 1

DESIGN BACKGROUND AND INTRODUCTION

In a semiconductor company, it is important to have a controlled environment to maintain the quality of the semiconductors that they will produce therefore parameters are controlled such as the relative humidity and temperature. Our client monitors these parameters manually by using the Honeywell's circular chart recorder. Additionally, this process is done manually by the person-in-charge of the production area. So, if the person-in-charge misses the periodical checking of the parameter, it can cause a problem with the quality of the semiconductors. To address this problem, a wireless monitoring system using the Radio frequency technology will record the relative humidity and temperature periodically and notify the person in charge through sending a SMS messages of the changes with the parameters, to take the appropriate actions needed.

Customer

The client of this design is the Amkor Technology located at Km. 22, 559 E Service Rd, Cupang, Muntinlupa, and Metro Manila. The company is the world's leading supplier of outsourced semiconductor interconnect services. They focus on providing their clients with semiconductor packaging and test services. They operate in different countries such as Korea, China, Taiwan, Singapore and here in the Philippines.

Need

Semiconductor fabrication plant might appear to be a low hazard facility, but it is not. The facility houses a large quantity of combustible liquids, flammable liquids and flammable gases used in the process, and the plastic construction materials in process equipment, ductwork and containers present an appreciable combustible loading. The potential of losing millions of pesos in the semiconductor facilities is huge. The facility must Develop and implement preventive maintenance schedules for all facilities in the fabrication plant. The personnel must consider the temperatures and chemicals that could expose each piece of the equipment. Equipment exposed to higher temperatures or corrosive materials may require more frequent maintenance. The monitoring of both temperature and humidity is greatly needed by the fabrication plant to avoid the potential damages or accidents that can occur at the production area.

Solution

To comply with the requests of the client, a humidity and temperature detection device for production area of semiconductors is proposed. The prototype design is composed of four parts, temperature and humidity data acquisition module, wireless transmission module, temperature and humidity data processing module and the SMS/alarm module. The control core of the data acquisition module is the PIC16F877A microcontroller this transfers the temperature and humidity electrical signals collected by the SHT11 which can measure both values. After the data acquisition the next would be the transmission of the readings

through the ATX-34 module for the RF transmitter circuit and with the ARX-34D will serves as the RF receiver circuit module. To program the PIC, PIC C-Compiler is used. The data transmission from the PIC to the RF receiver is evaluated and transmitted to the computer via USB to TTL. After the computer receive and record the data, it will send an SMS notification to the personnel for any changes in the monitored parameters.

Objectives

The main objective of the design is to monitor the relative humidity and temperature of the production area of the company.

Specific Objectives

a. To install monitoring device that records the relative humidity and temperature of the facility.
b. To use radio frequency for wireless communication system in sending recorded data through the laptop.
c. To notify the changes of the monitored parameters through SMS with the person in charge of the production area.

A. Scopes and Delimitations

The monitoring system will cover the 500 sq. meter production area and it will utilize the RF technology to communicate the device with the computer which covers about 200 m and operates at a frequency of 433MHZ for each receiver and transmitters. The proposed sensors will have approximately 350 sq. meters of coverage each, and the group will put the three sensors

to strategical location to cover the given production area. The scope of the device is to monitor the temperature that ranges from 22ºC to 29ºC and the relative humidity ranges from 55% to 65%. Once the device records the parameters periodically and there are changes in the parameters it will send a SMS notification to the personnel in charge. The device does not cover static measurement such as physical contact and any other sources.

Differentiation

In Table 1.1, shows the differentiation of the "Design of the environmental temperature and humidity wireless monitoring system" by Sun Hao, Chi Zongtao to our proposed design "Real time Indoor Monitoring of relative humidity and temperature using Radio Frequency with SMS warning". To differentiate the technology, functionality and the features of the proposed design.

Table 1.1 Differentiation from the existing patented design

	Design Solution	**Nearest Similarity**
Technology	The system uses RF (radio frequency) to transmit measured data into a computer. Equipped with ATX-34 module for the RF transmitter circuit and	The use of temperature and humidity sensors. The use of radio frequency to transmit data. It uses the NRF24LOI transceiver for transmitting and

	with the ARX-34D will serves as the RF receiver circuit module. It is also capable of SMS and alarm notification.	receiving radio frequencies.
Functionality	Real-time monitoring of temperature and humidity. (Digital presentation of values) Gives more precise values. Automated Temperature and humidity levels. Smart notification feature for maintenance team	Realtime monitoring of temperature and humidity. (Digital presentation of values) Gives more precise values. Automated Temperature and humidity levels.
Features	Wireless Monitoring System	Wireless Monitoring System

	Automatic Detection System for temperature and humidity. Lower cost and is widely used technology (radio frequency). Equipped with 3 pair of temperature and humidity sensor SMS and alarm notification system	Automatic Detection System for temperature and humidity. Lower cost and is widely used technology (radio frequency). Equipped with single pair of temperature and humidity sensor

Benefits

With the implemented design of "Real time Indoor Monitoring of relative humidity and temperature using wireless and database system for production area of Amkor Technology Philippines", the company will be implementing the project once it is finished since it is a very important device for their production area. The design would provide the client to be well informed about the temperature and the relative humidity of the Production area with the help of the SMS notification feature. This ensures that the maintenance team will be notified as soon as possible when emergency situations are present. The design will utilize the usage of mobile phones and maximize the ways of reaching the maintenance team in case of emergency.Additionally, the system is equipped with alarm in cases of failure of the SMS notification to reached the personnel. This will help the client to minimize unnecessary damage to its devices including the semiconductors by providing the temperature levels and the relative humidity.

CHAPTER 2

REVIEW OF RELATED LITERATURE

This chapter presents the following studies that were related with the group's proposed design and can served as a source of reference to be able to continue the process presented from the previous chapter. This will also present the ideas behind the existing programs and design technologies that will be used in the proposed design.

Relative Humidity

Water is the most common causes of electrical circuit problems because of the electrically conductive and corrosive nature. A less known effect is the water vapor which reacts with the temperature and pressure of the atmosphere in a given volume. The presence of water vapor can be differentiated into three: Absolute Humidity, Relative Humidity and Air (dry) temperature. Relative humidity is the ratio of water vapor density to the water vapor density at the saturation vapor pressure expressed in percentage. (Drexhage, 2016). This means the effect of humidity in electrical circuits can reduced blocking voltage because of the composition of semiconductor with its chip is covered with silicone-based gel that can accumulate moisture that can disrupt the electric fields. Another effect is the

corrosive property of the semiconductors. Since a semiconductor composes of an silicone component, Figure 2.1 shows that the silicon gel absorbs water molecules driven when condensation occurs.

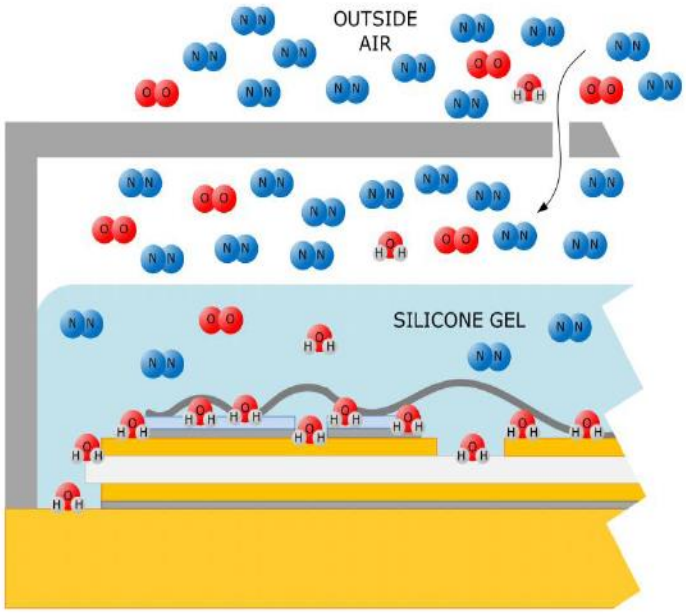

Figure 2.1 Water molecules absorb by the silicone gel

Temperature

Temperature plays an important role in understanding the different aspect and functionality of a semiconductor. Different properties such as energy gap, carrier densities, mobility, carrier diffusion, velocity saturation, current density, threshold voltage, leakage current, interconnect resistance, electronic migration and conductance can be affected by the temperature. Generally, temperature is in control to different circumstances that includes the electron and hole transport mechanism (G. Palai, 2014). So increasing the temperature can reduce the band gap of a semiconductor. If the band gap of a semiconductor decrease due to the

increase of temperature can also consider as a increase of the energy of the electron in the material. Breaking down the bond needs lesser energy.

Early warning monitoring system

Early warning monitoring system (EWMS) can be used in different situations, it can deliver timely useful information that enables an individual or group that are threatened by a hazard and to prepare an appropriate action to reduce the possible harm or loss (Henriksen, H.J., International Journal of Disaster Risk Reduction, 2018). To develop a monitoring system three modular configuration is necessary: first is the human-machine interaction (HMI) in which serves as the central module that display and collect data on other modules. Next is the electric power metering module that is connected in to the central module via wireless connection. Lastly, is the inner sensing module that is also connected to the central module, that send data using Serial Peripheral Interface (SPI) (Sousa, 2015).

SHT1x (RH/T)

Sensirion's SHT1x series is consist of a cheap version of previous version such as SHT10 humidity sensor, a standard version of SHT11 and a SHT15. That is likely to be calibrated with digital output. SHT1x humidity sensor used a sensor element and a signal processing in a small footprint to have a digital output. The relative humidity is measured through a unique capacitive sensor while the

temperature is used a band gap sensor. The humidity sensor used a coupled 14-bit-analog-to-digital converter and a serial interface circuit. There is different version of SHT1X which varies with the accuracy of the recording the RH% and the Temperature. The first variation is the SHT10 which has an accuracy of RH% ±4.5 and temperature reading of ±0.5. Next is the SHT11 with ±3 RH% accuracy and ±0.4 temperature reading. Lastly is SHT15 which the high-end type of sensor and has the most accurate RH% reading of ±2 and ±0.3 temperature reading.

Figure 2.3 SHT1x (RH/T) sensor

PIC16F87X

PIC16F series is one of the most used microcontrollers since it has the largest code library that is on the internet. PIC16F877 can be upgraded to a new schematic with the use of PIC16F887 because of the cheaper cost. It also has the same layout and peripherals that will run without modification. The microcontroller's feature is a high-performance RISC CPU. It only have 35 single

word instruction, which utilized a single cycle instruction except a program branch which are two cycle. Its memory can range from 8K x 14 words of FLASH program memory, 368 x 8 bytes of RAM and 256 x 8 bytes of EEPROM Data memory. The pinout compatible to this microcontroller is PIC16C73B/74B/76/77. On the other hand, the peripherals of the microcontroller featured a three timer which composes 8-bit timer/counter with 8-bit prescaler and 16-bit timer/counter with prescaler that can be incremented SLEEP via crystal/clock and an 8-bit timer/counter with an 8-bit period register, prescaler and postscaler. A 10-bit multi-channel Analog-to-Digital converter, Synchronous Serial Port (SSP) with SPI (Master mode) and I2C™ (Master/Slave), Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection, Parallel Slave Port (PSP) 8-bits wide, with external RD, WR and CS controls (40/44-pin only), Brown-out detection circuitry for Brown-out Reset (BOR).

Figure 2.4 PIC16F87X Microcontroller

Chapter 3

DESIGN PROCEDURES

A. Hardware Development

Design Process Flow

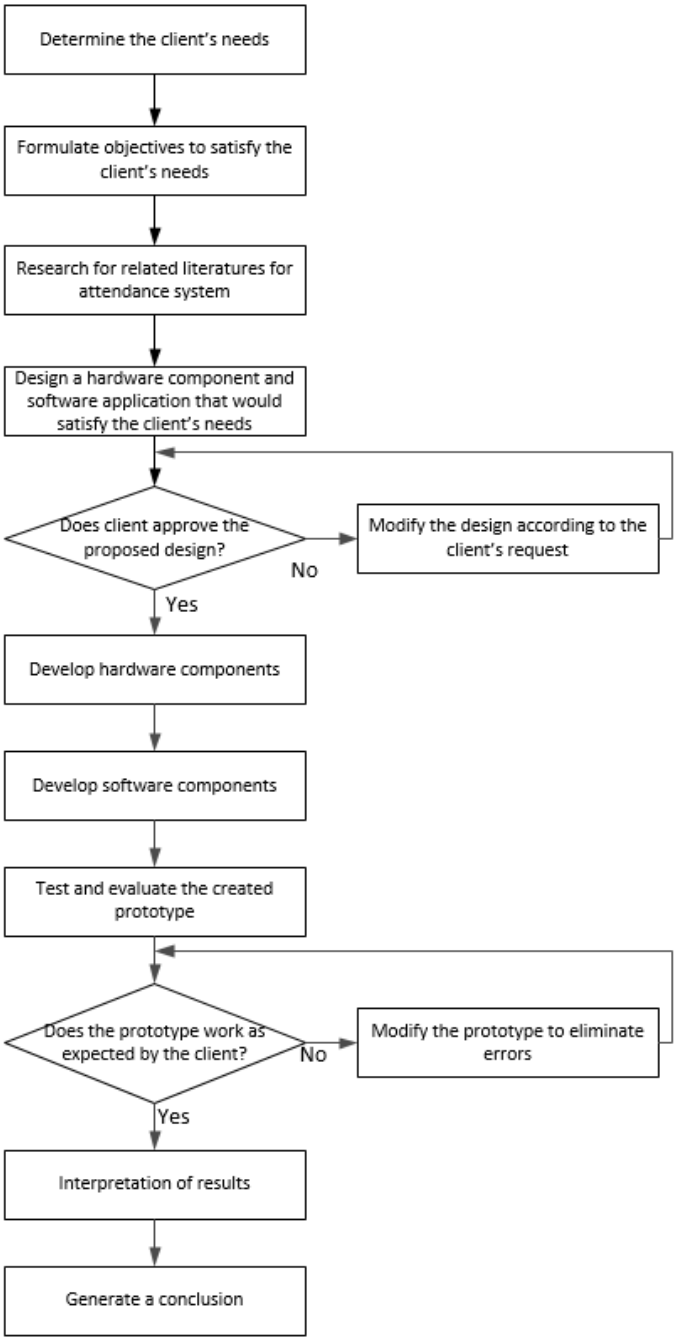

Figure 3.1 Design Procedure of Real time Indoor Monitoring of relative humidity and temperature using wireless and database system for production area of Amkor Technology Philippines

The initial step in the design procedure is to determine the client's needs. A set of objectives is then formulated based on the client's needs. To have a well-established basis, a research for related literatures on attendance systems is conducted by the group. A design proposal for the hardware and software is then submitted to the client. After the client conforms to the proposed design, the development of software and hardware components is done. Testing and evaluation of the created prototype is performed after the development. Lastly, interpret results and generate conclusion after the client accepts the results of the created prototype

Conceptual Framework

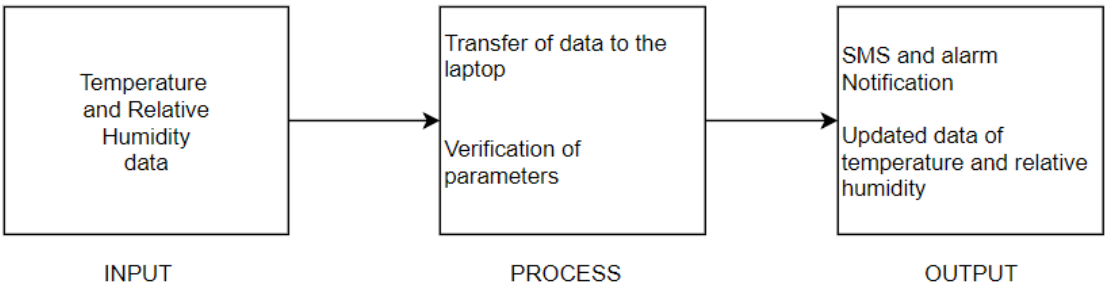

Figure 3.2 Conceptual Framework for Real time Indoor Monitoring of relative humidity and temperature using wireless and database system for production area of Amkor Technology Philippines

Figure 3.2 shows the conceptual framework of the proposed solution. The temperature and the relative humidity data that are gathered by the SHT11 sensor will serves as the input of the system. The gathered data will then be sends to the laptop by the radio frequency via transmitter and receiver module. In the laptop, the data will be compared to the desired parameters to the recorded data, if the recorded data is not in the range of the monitored parameters the device will send an SMS notification to the person with the updated data to of the parameters and will notify the surroundings with an alarm.

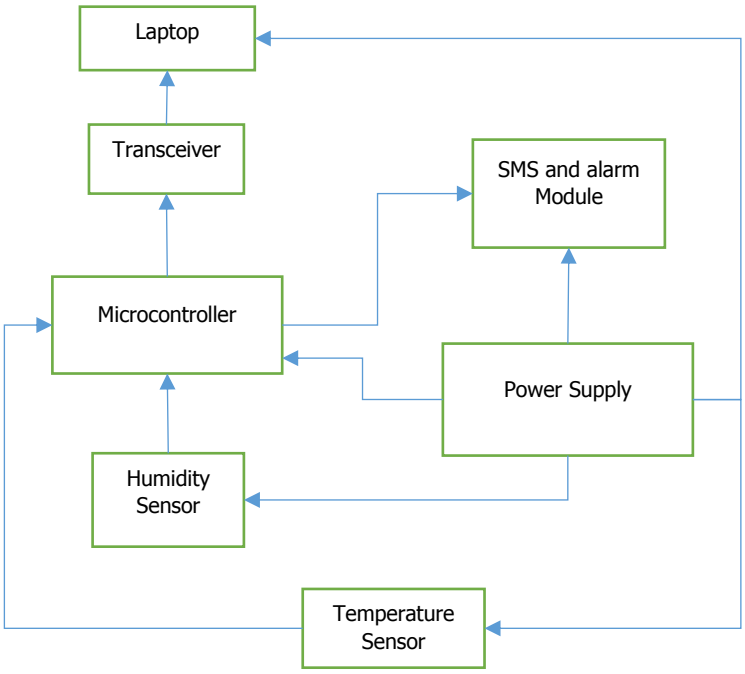

Figure 3.3 System Block Diagram of Real time Indoor Monitoring of relative humidity and temperature

Figure 3.3 shows the block diagram of the implemented system, Detection humidity and temperature detection device for production area of semiconductors. The humidity and temperature sensors would be used to detect the humidity and temperature levels of the production area. Then the microcontroller will be the one to collect the gathered data and send these data through the transmitter into the Laptop. The Laptop will then begin to analyze the data received and processed the inputs and check if it exceeds the maximum or lower than the minimum level of

the recommended humidity and temperature levels. The SMS module will send a notification to the personnel in charge and notify the people with an alarm.

Procedure:

1. Identify the required materials to fulfill the objective stated by the client.
2. Determine different methods to comply the needs of the client and the different component's specification to construct the monitoring system
3. Design the conceptual framework of the system to organize the ideas and to determine what will the systems input data, the processes involved with the data and the output which results with that process.
4. Conceptualize the system's block diagram in order to determine the connection of the different components of the proposed monitoring system.
5. The input data to the SHT11 sensors for the system is consist of temperature and relative humidity which is directly connected to the PIC16F877A.
6. The process to be done by the system is through the transmitter and the receiver which transfer and receive the data from the sensor to the laptop. The laptop also checks the parameters if it is in the preferred range in maintaining the area's parameter.

7. The output of the system can be seen in the LCD on the device and the recorded data is saved in the laptop. The monitoring system also sends the updated data to the personnel in charge in the area and alarm the other people in the area.

Schematic Diagram

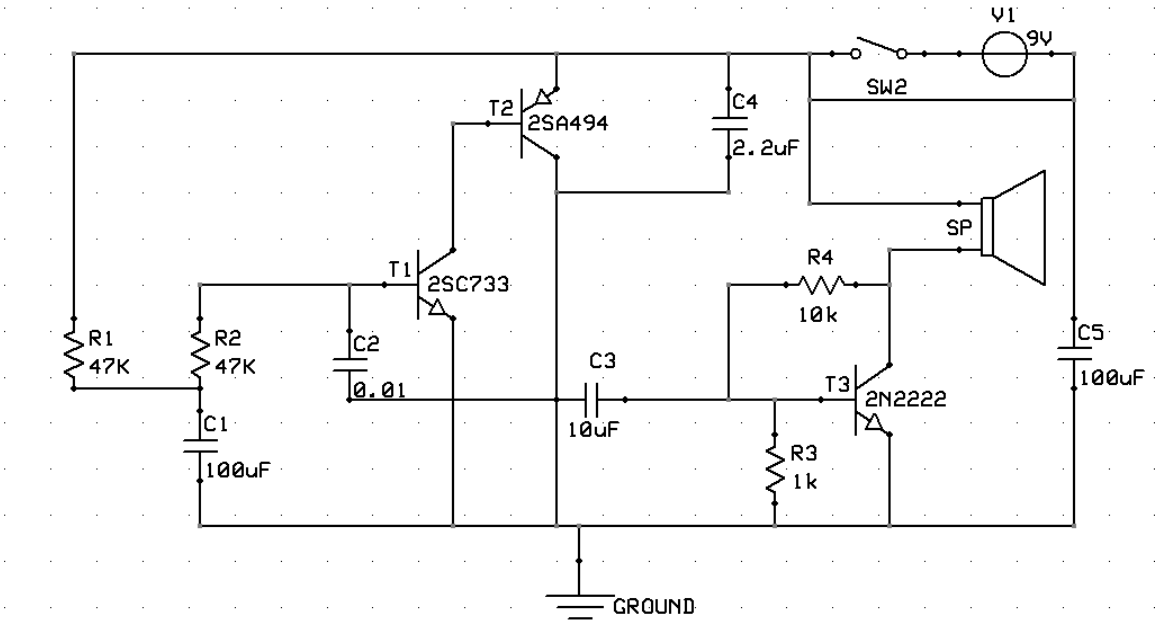

Figure 3.4 Schematic diagram of the alarm

Figure 3.4 shows the schematic diagram of the alarm for the proposed system. It is composed of two transistor which can be operated by a 9V battery. The two transistor is biased in order to attain the base of T1 in the RC circuit. It is also equipped with an amplifier circuit to increase the sound of the alarm of the device.

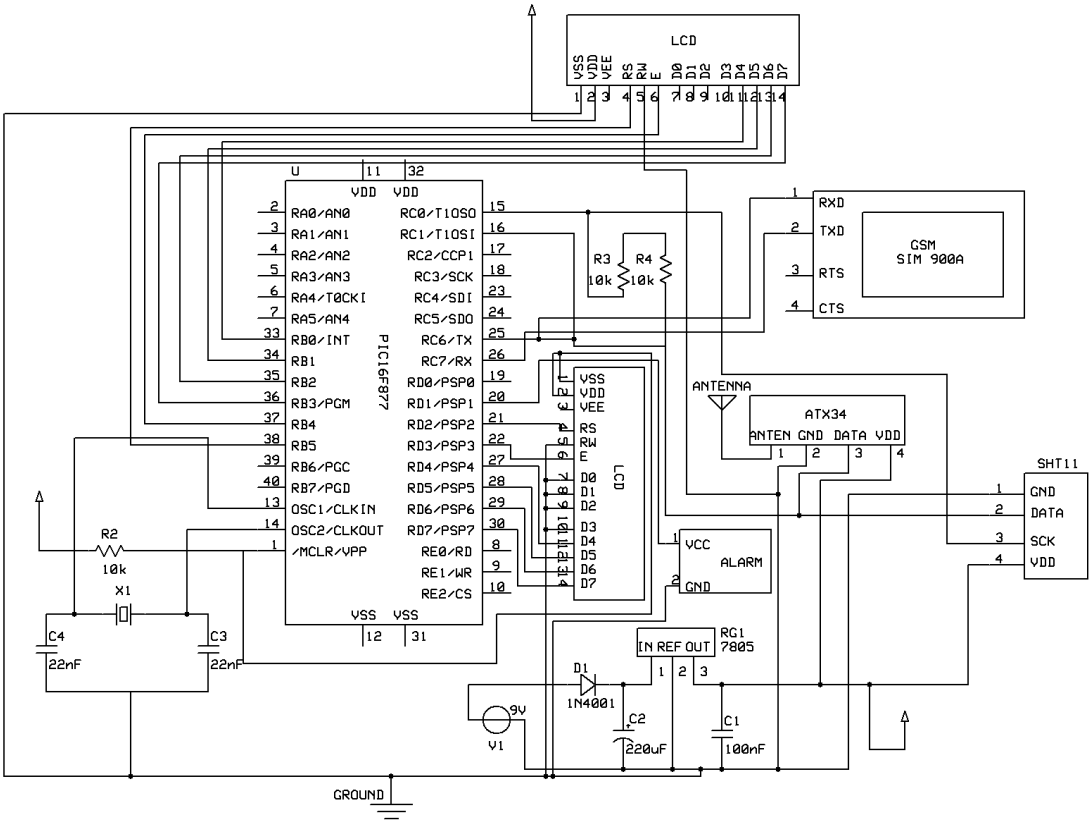

Figure 3.5 Schematic diagram of the transmitter circuit

Figure 3.5 shows the schematic diagram of the transmitter circuit. The circuit will function as the accumulator of the relative humidity and temperature, then the PIC16F877A is directly connected to the LCD in order to display the data that it gathered. The LCD and the microcontroller is powered by a 9V power source. The transmitter module used a Ultra high frequency band (UHF) for its high frequency stability, low power consumption and physical size for the close distance transmission application. Additionally, an antenna is used to widen the range of the data transmission. The Alarm is connected to the microcontroller to initiate the device to alarm when the parameters are not in the desired range.

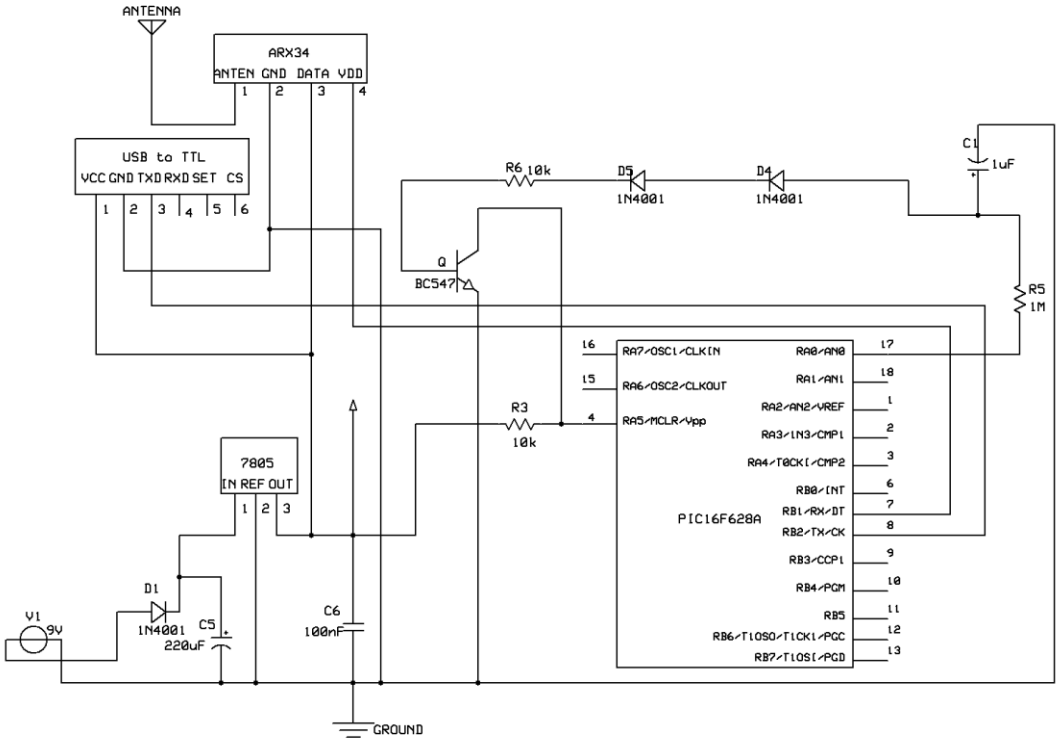

Figure 3.6 Schematic diagram of the receiver circuit

Figure 3.6 shows the schematic diagram of the receiver circuit. It uses the PIC16F628A microcontroller and powered by a 9V power source. The data that will be transmitted by the transmitter circuit will be obtain by the RF receiver module and the microcontroller will send data to the laptop via USB to TTL converter module. Additionally, the circuit also operates in a UHF the same as the transmitter and uses an antenna, used by the transmitter circuit.

B. Software Development

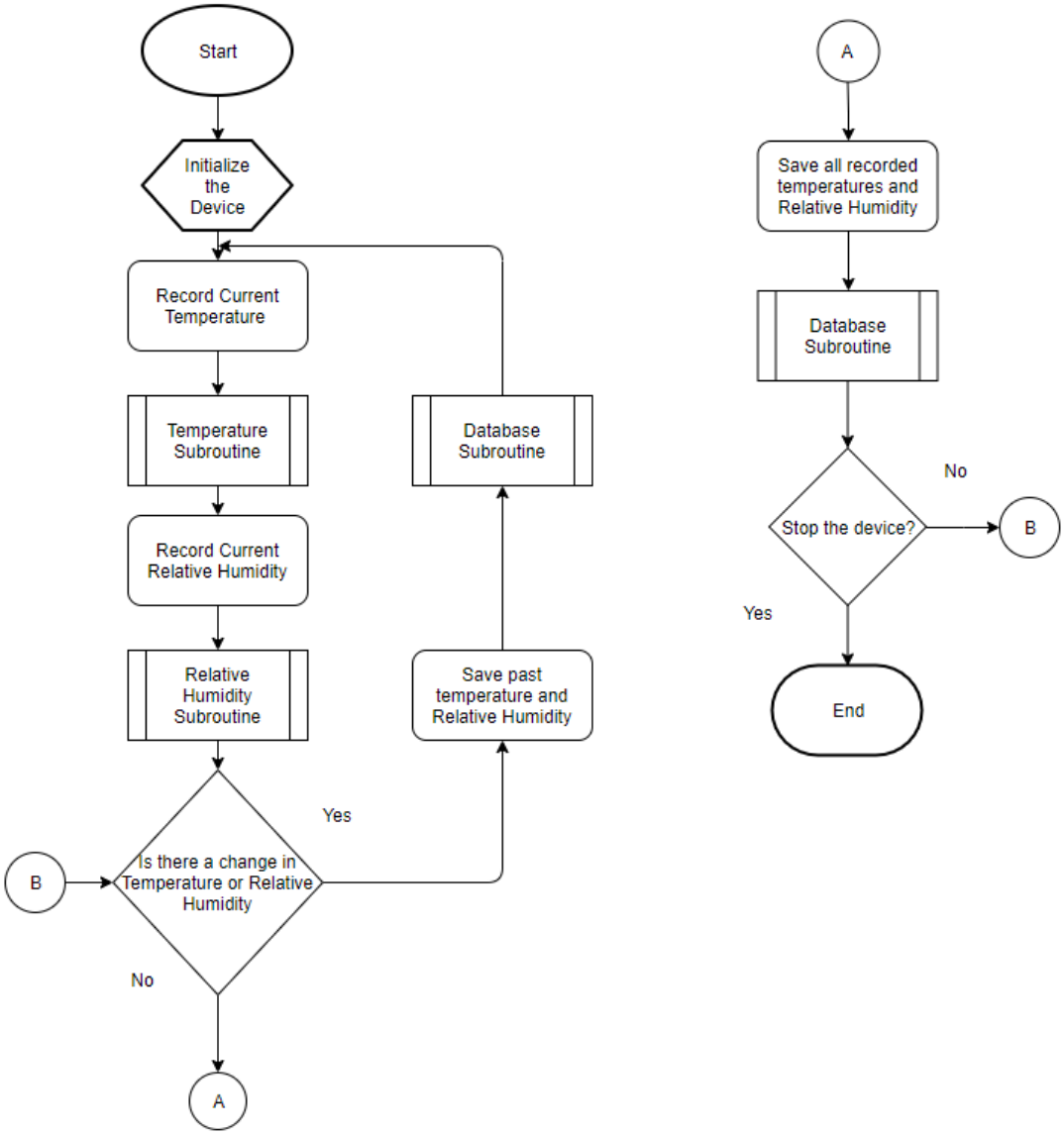

Figure 3.7 System Flowchart of Real time Indoor Monitoring of relative humidity and temperature

The Figure 3.6 shows a simple system records the temperature then analyzes it if it is the desired range of the user. If in case it does not, it initiates a SMS and Alarm function that alerts the user that something is wrong. The user can view the current temperature in the laptop. After that the relative humidity will be recorded, if something is wrong again, it will initiate the SMS and Alarm function once more and the recorded humidity is now seen in the laptop. The accuracy of the recorded temperature and relative humidity is assured since they are modules provided on the market and tested for accuracy and precision. If nothing is wrong, it still recorded and saved and will continue to record data unless terminated by the user/s.

Procedure:

1. The program will start the initialization of the device.
2. The device will record the initial temperature and relative humidity of the area.
3. To check the initial temperature, the device will record the current temperature of the area.
4. If the temperature is below 22ºC or above 29ºC the device will initiate the SMS and Alarm function that will notify the personnel in charge in the area
5. After notifying the personnel, the device will send the data and record it in the database.

6. To check the initial relative humidity, the device will record the current relative humidity of the area.
7. If the relative humidity is below 55ºC or above 65ºC the device will initiate the SMS and Alarm function that will notify the personnel in charge in the area
8. After notifying the personnel, the device will send the data and record it in the database.
9. If there will be changes in temperature and relative humidity within the specified range it will be transfer to the database subroutine for records.
10. The database subroutine will collect all data collected at a certain time of temperature or humidity then initiate transfer
11. Once the laptop receives the data, it will provide timestamp for record purposes.
12. After the database subroutine, it will initiate another cycle for the next data collection.
13. The device will continue to function since in the production area needed a 24/7 monitoring system to maintain the parameters.

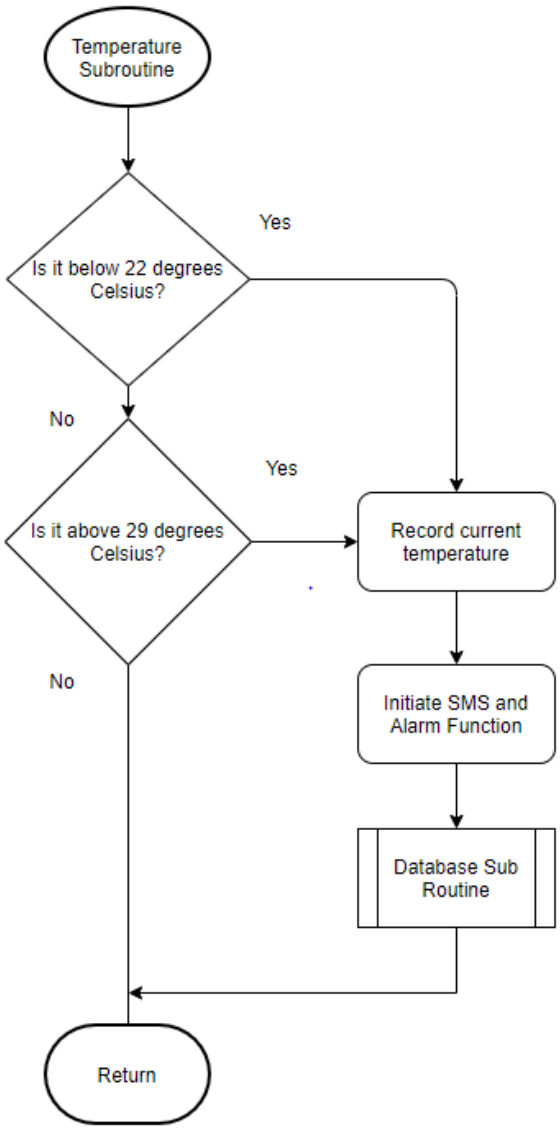

Figure 3.8 Temperature Sub-routine

The Figure 3.8 shows a predefined range given by the client/ user. It said that these is the best temperature for the semiconductors in the production area. We can see here that after initiating the SMS and Alarm function, the data is still recorded and saved. Then if nothing is wrong in the temperature it is returned to the main function to initialize the rest of the functions.

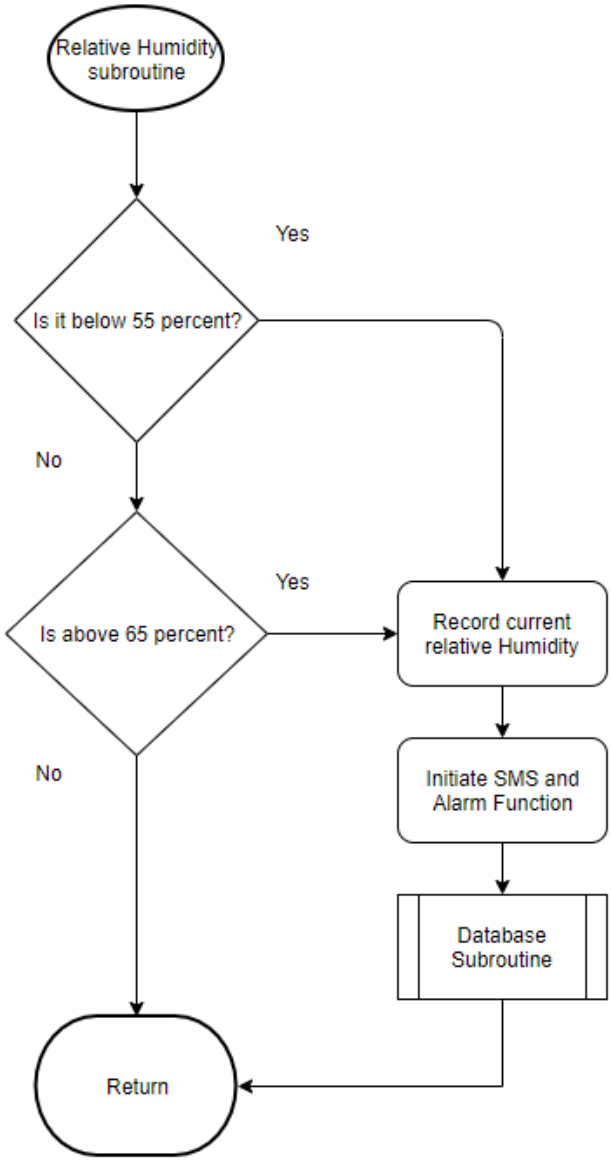

Figure 3.9 Relative Humidity Sub-routine

The relative humidity is important to measure since it tells you the moisture in the air or the amount of vapor in the air, a damp environment is not good for the semiconductors. In this module, the recorded relative humidity is then assessed, as if it is in the desirable range and if it is too dry (below minimum range) or too wet (above maximum range) then it will initiate the SMS and Alarm function. The

measured relative humidity is also recorded and saved. If nothing is wrong, it will return to the main function to continue other functions.

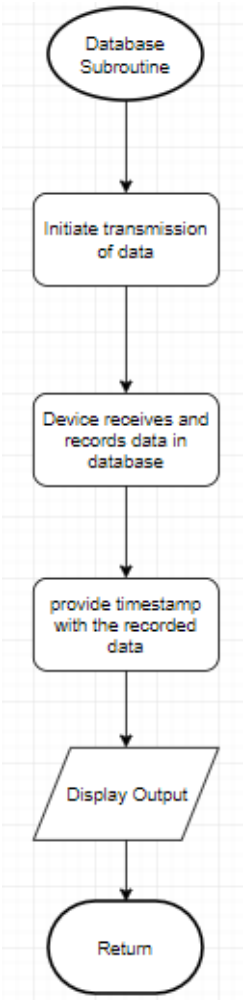

Figure 3.10 Database Sub-routine

The database module is responsible for recording and putting timestamp on the data recorded, this will serve as reference for future activity. This also ensures that data are recorded, and functions are working since at the end of each module, they pass the record/s to the database module. The data is transmitted to the laptop and once the laptop receives the data, it will display the data for the end user/s.

Data Flow Diagram

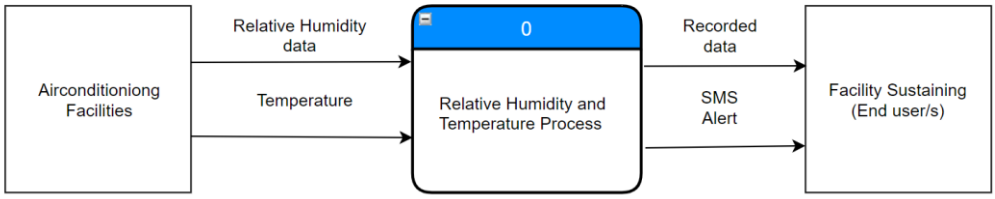

Figure 3.11 Context-Level Data flow diagram of the Monitoring system

The temperature and relative humidity readings are obtained in the air-conditioning facilities which are adjusted from time to time which is then given to be checked if under desired range. After which, the recorded data are transmitted to the Facility sustaining for record purposes. In case of data which are under or above the desired range, a SMS is directly given to the person/s in charge to alert immediately for said changes which are harmful for semiconductors, also there is an Alarm function to alert the people around the premises.

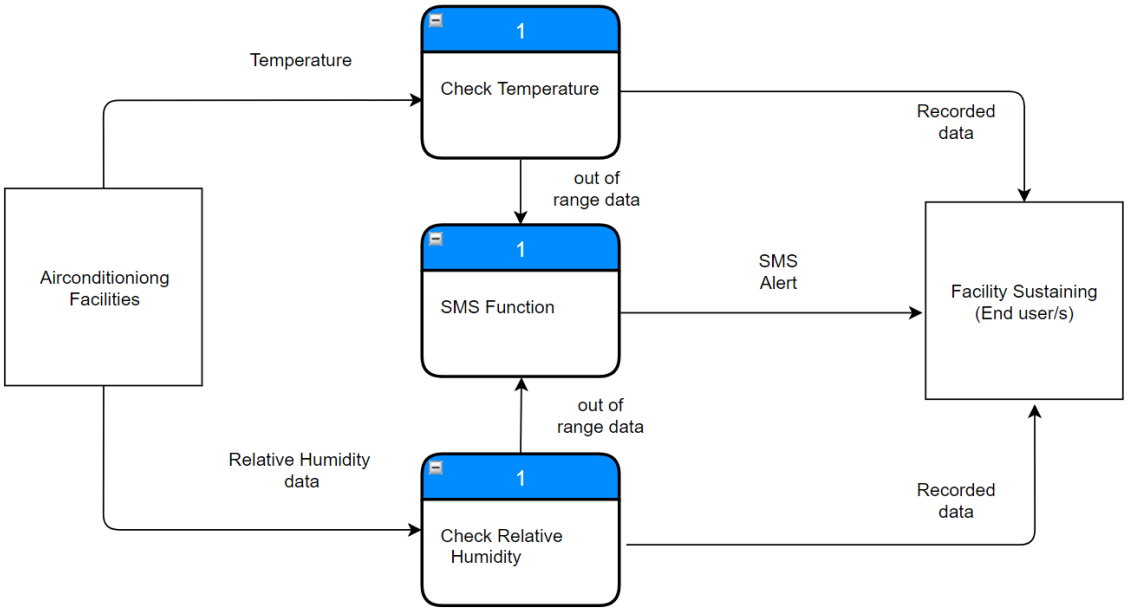

Figure 3.12 Level 1 Data flow diagram of the Monitoring system

The ideal range of relative humidity for semiconductor provided by the client is between 55 to 65 percent, once it is below or above the desired range, it is then transferred to the SMS function which is then sent to the end user/s or the facility sustaining department. The ideal temperature for semiconductor provided by the client is between 22 to 29 degree Celsius and if it is below or above the desired range, a SMS will also be sent to the facility sustaining department. Additionally, an Alarm function is to set off also in the premises of the device to ensure that proper attention is given. Normal temperature and relative humidity within the desired range are still sent to the facility sustaining for future reference and acts as verification that the modules are working.

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