Webserver Based Smart Monitoring System Using ESP8266 Node MCU Module

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Abstract— The term internet of things (IOT) is considered as an important and popular technology aspect nowadays. Life style controllability based on (IOT) became considerably simpler and easier especially in the communicating approaches among the smart devices. The methodology of (IOT) allows accessing and controlling the devices anywhere and anytime. The tendency of this aspect is to communicate among various devices with respect to ESP8266 Node MCU module. The devices even can be controlled with respect to the employed ESP stations. The adeptness of data transfer among the proposed remote locations depends mainly on the behavior of the system while the security and the applicability of the system are considered more efficient. This work shares the information of air quality, Temperature and Humidity in three food stores at three remote locations with each other based on ESP module through webserver. In addition, two control actions are taken automatically in accordance with temperature and air purity output results. First, the air cooler is turned ON to cool the foods in the stores and second the air puller is turned ON to pull the contamination out of the proposed locations. Furthermore, these control actions even can be applied manually by webserver administrative person. Finally, the ESP based system is classified as inexpensive project comparing to GSM module.

Index Terms— Smart Monitoring System, Control Based ESP8266 Node MCU, Control system design, Automatic Control.

1. Introduction

The high internet speed has given humans throughout the universe more and more chances to be interconnected. Internet of things (IoT) methodology communicates both humans and the devices electronically with respect to control module [1]. The relative low cost of Wi – Fi magnified the dependency on (IoT) trends. Internet of things (IoT) aims to connect several devices and sensors through a specific network and restore the realized data from the sensors that located in various places through webpage server where the data can be reconstructed and analyzed to create the corresponding information accordingly. In the proposed webpage the admin can show and represents the data in various ways. Weather monitoring systems are considered an illustrative example on the aspects of (IoT). Weather prediction is too important in real life for different reasons like taking the required measurements in case of natural disasters such as tempests, floods, and rainstorms, etc. It is worth mentioning that weather prediction can immediately report those disasters and warn people to take the required precautions to face any disaster. Weather is important for the farmers to plant the seeds in appropriate climate conditions [2, 3]. Moreover, the climate conditions effects on the decisions regarding the different activities such as navigation, transportation, sport matches, etc. In addition, weather awareness is important for sailor and pilots who they work in transportation activities. In transportation fields, exact decisions are taken to change the navigation or sailing tactics whether to fly, sail, or ride. For this reason, the weather observation and monitoring approaches are considered too important in various fields.

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A great challenge starts by realizing the real information from the weather conditions due to the considerable dependency of the climate on the atmospheric pressure circumstances, thunderstorm, hurricanes, temperature and humidity [2, 4]. The whole module in this work acts based on (IoT) concept is a critical foundation which is the vision of smarter planet realization. The farming field is considered the ultimate argument of this paper where planting operation is the first objective then keeping the crops in the same weather condition after harvest is the second objective. In this work, the corps represented by foodstuffs are reserved in stores with appropriate environment conditions. The required and appropriated conditions were reached by modeling a control system based on a modern low cost module identified by ESP8266 Node MCU. The MCU module was applied as Wi-Fi based client station that is connected to local access point AP (server) at the proposed location. This module is equipped at three locations and the information of each individual location based on Net Pie web server.

2. System Components

The system is mainly constructed of several components unveiled as follows:

1. ESP8266 Node MCU.
2. DHT11 Sensor Module.
3. MQ-2 Gas sensor module.
4. 9 Volt Batteries.

2.1. ESP8266 Node MCU

Arduino Company started working on developing of a new microcontroller recently. This struggle succeeded when a new MCU was created and popularly called ESP8266 Node MCU module. The module was created regardless AVR processors and used partially as same as Arduino MCU [5]. Hence, the module works based on

ISSN 2229-5518

Arduino IDE C++ compiler. New specifications were added to the ESP8266 module in order to shrink the amount the components and the shields that are required to perform a specific task. The company configured this new MCU with respect to Arduino Uno board manager and SAM core. The term 'Core' was given to the group of software units that are needed to compile the Arduino C++ headers by using MCU language. The new Arduino module is considered creative design and configuration due to developing Arduino core under the domination of ESP8266 Wi – Fi that is widespread at the webpage of GitHub ESP8266 core. The MCU is assigned to be as one of the most learning software platform with respect to the combination of ESP8266 and NodeMCU firmware. The module shown in Fig.1 works under the supervision of 802.11n and 802.11b networks. This means that it can serves as an Access Point AP, Wi – Fi station or both station and AP together [6].

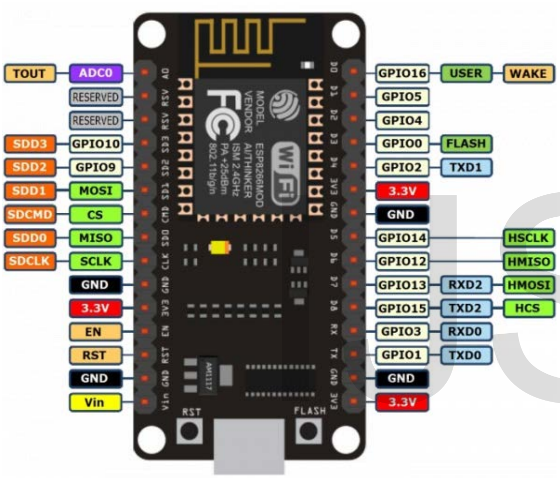

Fig.1. ESP8266 Node MCU Module

2.2. DHT11 Sensor Module

The Temperature – Humidity sensor is denoted by DHT11, measures both the temperature and humidity in an individual distinctive model. Temperature (T) and Humidity (H) Sensor features (T) and (H) sensor complex with a calibrated digital signal output. The module ensures high reliability and excellent long term stability due to the exclusive digital signal acquisition with respect to the sensing technology. This sensor includes a resistive type humidity measurement component and an NTC temperature measurement component, connected to a high performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost effectiveness [7]. DHT sensor measures both (T) and (H) which hands the readings through ESP8266 module with respect to webpage based control unit. The proposed sensor as shown in Fig.2 contains three pins identified by Vcc, Data, and Gnd. It is worth mentioning that data pin of DHT11 acts well when mapped with digital Arduino Uno pins. The schematic connection of the sensor shows that the VCC pin of DHT11 must be provided by 5V from ESP8266 MCU, the data is chosen to be connected to the digital pin D5 of ESP8266, and the Gnd terminal of the sensor is connected to the Gnd pin of ESP8266 board.

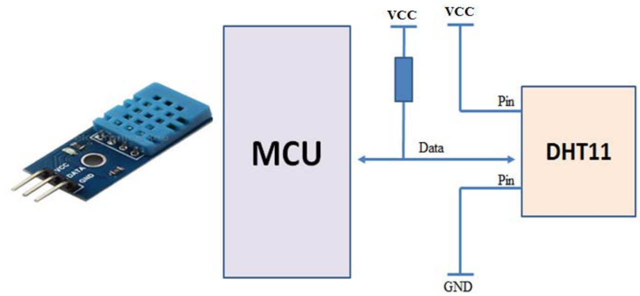

Fig.2. Temperature – Humidity (DHT11) Module

For more details regarding design limitation of DHT11, it is intended to show the specification of the module as shown in Table 1.

TABLE 1
DHT11 ITEMS SPECIFICATIONS

ITEMS	CONDITION	MIN	TYPICAL	MAX
HUMIDITY				
Resolution		1%RH	1%RH	1%RH
			8 Bit	
Repeatability			±1%RH	
Accuracy	25°C		±4%RH	
	0-50 °C			±5 % RH
Interchangeability	Fully Interchangeable			
Measurement Range	0°C	30%RH		90%RH
	25°C	20%RH		90%RH
	50°C	20%RH		80%RH
Response Time (Seconds)	1/e(63%)25° C, 1m/s Air	6 S	10 S	15 S
Hysteresis			±1%RH	
Long – Term Stability	Typical		±1%RH/year	
Temperature				
Resolution		1°C	1°C	1°C
		8 Bit	8 Bit	8 Bit
Repeatability			±1%RH	
Accuracy		±1 °C		±2 °C
Measurement Range		0°C		50°C
Response Time (Seconds)	1/e (63%)	6 S		30 S

2.3. MQ-2 Gas Sensor Module

The Liquefied Petroleum Gas (LPG) or the sensitive material of MQ-2 gas sensor is SnO2 shows lesser conductivity in the clean air. The conductivity of the sensor shown in Fig. 3 gets higher in case of higher gas concentration. The sensitivity of MQ-2 sensor is considered exceptionally higher to propane, LPG, hydrogen, methane, and the other steams. Furthermore, sensor cost limitations are suitable for numerous applications [8, 9]. The module senses the existence of the flammable gas due to temperature elevation that is realized by the heating components inside the module. As a working principle, when gas leak is detected the conductivity of the sensor rises proportionally with gas concentration raising.

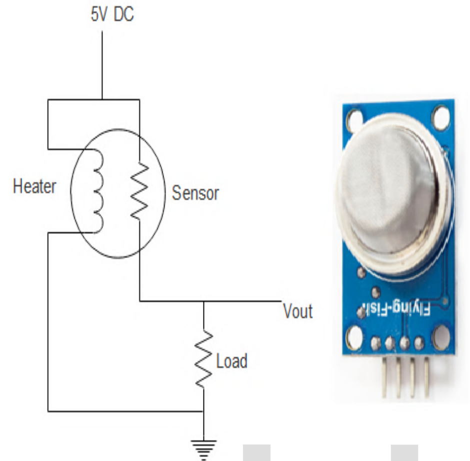

Fig.3. Schematic Gas Sensor Module

The performance of the proposed sensor can be improved using an appropriate load resistance RL by fulfilling the following equation:

$$P_S = \frac{Vc^2 * R_S}{(R_S + R_L)^2} \quad (1)$$

Where,
P_S: Sensitive power of the body.
Vc: Loop voltage.
R_S: Sensing resistance.
R_L: Load resistance.
The proposed gas sensor module can be employed to detect gas leaks and to compute air quality as follows:

$$\text{Gas Leak} = \text{Concetration} \leq \text{Gas Spread} \leq 1023 \quad (2)$$
$$\text{Air Quality} = \text{Gas leak} - 1023 \quad (3)$$

Where, the value 1023 represents the maximum range of the analog read with respect to the mapping condition between the gas sensor and Node MCU module. The restriction of load resistance value does not make any sense particularly when the output voltage is realized over the RL with respect to the point at the output and Gnd as shown in Fig.4. However, the value of the chosen RL is preferred to be around 2 – 47 KΩ, meaning that the lower value offers less sensitivity, the higher value offers less accuracy.

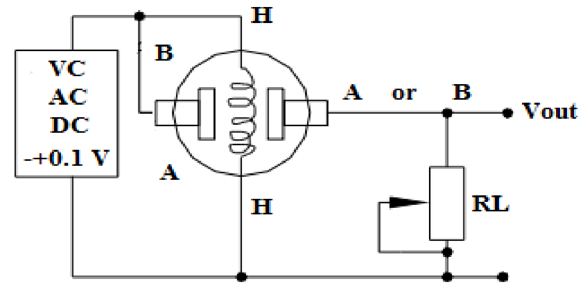

Fig.4. Gas Sensor Interior Construction

Meanwhile, the calibration procedure of the sensor for 1000 ppm – LPG or butane concentration in the air can be performed by choosing R_L = 20KΩ [8, 10]. For more clarity, the connection relation between MQ-2 gas sensor and the ESP8266 module is demonstrated in Table 2.

TABLE 2
CONNECTION BETWEEN NODE MCU AND MQ – 2

ESP8266	MQ – 2 GAS SENSOR
Digital pin	D_{out}
Analog pin	A_{out}
5 V	V_{CC}
GND	GND

3. Scope of Work

This monitoring approach of the project was designed to be serving as a webpage based monitoring system that exposes the situation of an environment via ESP8266 module. Under this scope, the system can monitor and apply control actions in specific cases. The system is constructed of different sensors employed to record the required data of the proposed locations in order to analyze the situation of the environment wisely. The proposed locations are chosen to be store management sites allocated at three remote places. These stores are used to keep foodstuffs in a specific and limited weather condition. Hereby, the proposed system was designed to realize weather elements and organize the situation accordingly. The status of the environments is recorded by using DHT11 sensor to realize Temperature – Humidity degrees and the purity of the air by using MQ2 gas sensor. In this work, the amount of data realized in each location can be appreciated periodically based on a website denoted by WBCMS Webpage Based Control Monitoring System. The WBCMS is proposed to be equipped in the three locations with respect to ESP8266 Wi-Fi station. This paper assigns the characters A, B, and C to represent the sites of the stores that are connected wirelessly based on the proposed webpage. The webpage is named Net Pie where it is opened and activated by signing in processes using a user name and password. It is worth mentioning that each individual WBCMS module is constructed of an ESP8266 Node MCU, DHT11, and LPG gas sensor as shown in the block diagram in Fig.5.

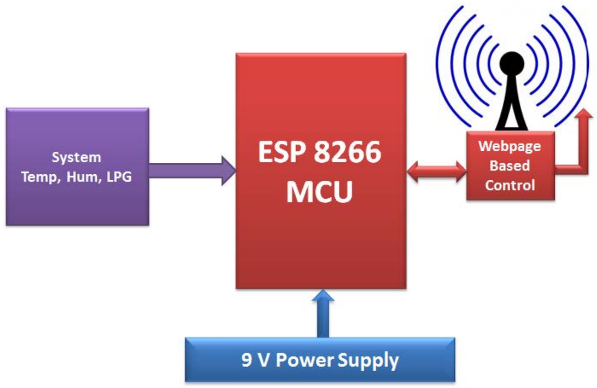

Fig.5. Webpage Based Control Monitoring System

Moreover, the data can be gathered from the three locations based on WBCMS approach with respect to the employed sensors by creating what is called Data Accumulation Center (DAC). Data accumulation center (DAC) works under the supervision of webpage control monitoring system, which assigns a spot network based on (IoT) to share the data of the locations and demonstrate the information regarding the environmental status in the stores as exposed in Fig.6.

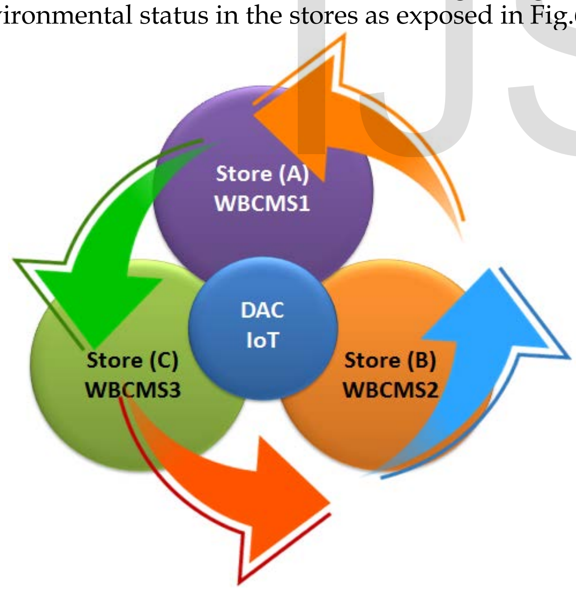

Fig.6. Data Accumulation Center (DAC) Sharing Unit

Furthermore, DAC based control action will be applied on the environment in a specific conditions. The control action can be activated automatically or intentionally with respect to the environmental conditions. Each store is equipped by two devices identified by air cooler and air puller. The controller is designed such that it activates the cooler whenever the temperature elevates more than 25oC whereas the puller can be activated when the system detects that the purity of the air is under the desired range, which is considered in this work to be assigned by 70%. Finally, it is intended to communicate among the three proposed locations with respect to ESP8266 Node MCU and Net Pie webpage server as shown in Fig.7.

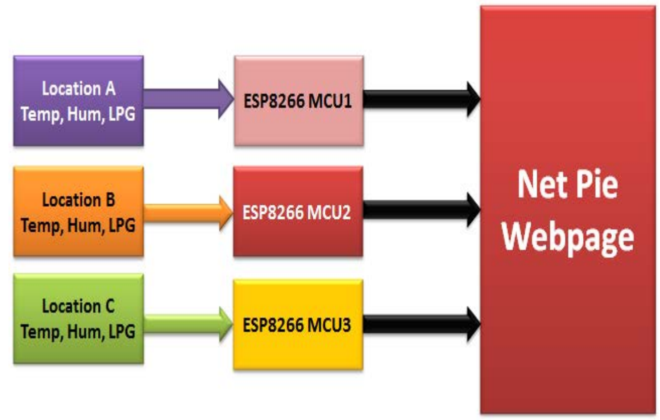

Fig.7. The Entire System Combination

4. Control System Design

As mentioned before, the control system is designed to satisfy the actions automatically or based on a decision by the observer person. The actions based automatic control are considered controllable since the actions do not violates controllability conditions. The block diagram in Fig.8 shows that the uncontrolled environment G_1 is the plant that allows all possibilities of events occurrences. The term S_{dis} represents a disturbance signal that can conquer the system to undesired situation, which represents the elevation in temperature degrees or the contamination in the quality of the air. The sensors of the system are represented by G_2 , which upgrades the system and provides the microcontroller with required information as a feedback in order to apply specific actions accordingly.

Last but not least, the term H represents the feedback system controller that represses the environment in the stores to the preferred situation.

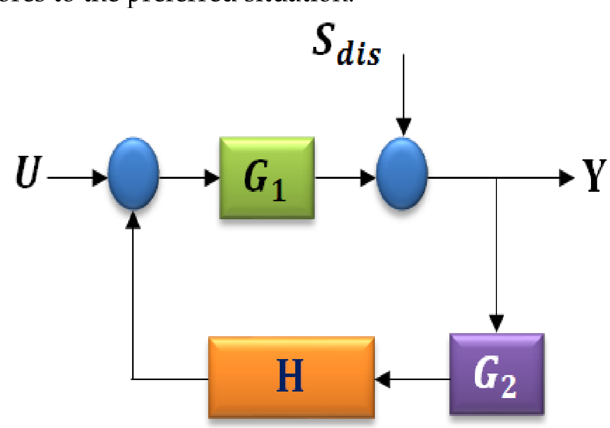

Fig.8. Control Action Processes

The plant represents the environments situation of the stores that are dominated by the Wi-Fi based controller. The schematic assembly of the module is shown in Fig. 9, which was modeled such that the system can fulfill the desired behavior of the system. The desired behavior is satisfied by covering the specification of the system regarding the occurrence of the events respectively. It is worth mentioning that the system can perform two tasks to control the system in the worst cases.

Firstly, the control action will be taken into consideration through relay1 with respect to the air puller in order to pull the contaminated air out when the purity of the air in percentage was decreased to be less than 70%.

Whereas, the second action will be applied whenever the temperature elevates more than 25oC by turning the air cooler ON through relay 2 in order to return the environment back to its desired situation.

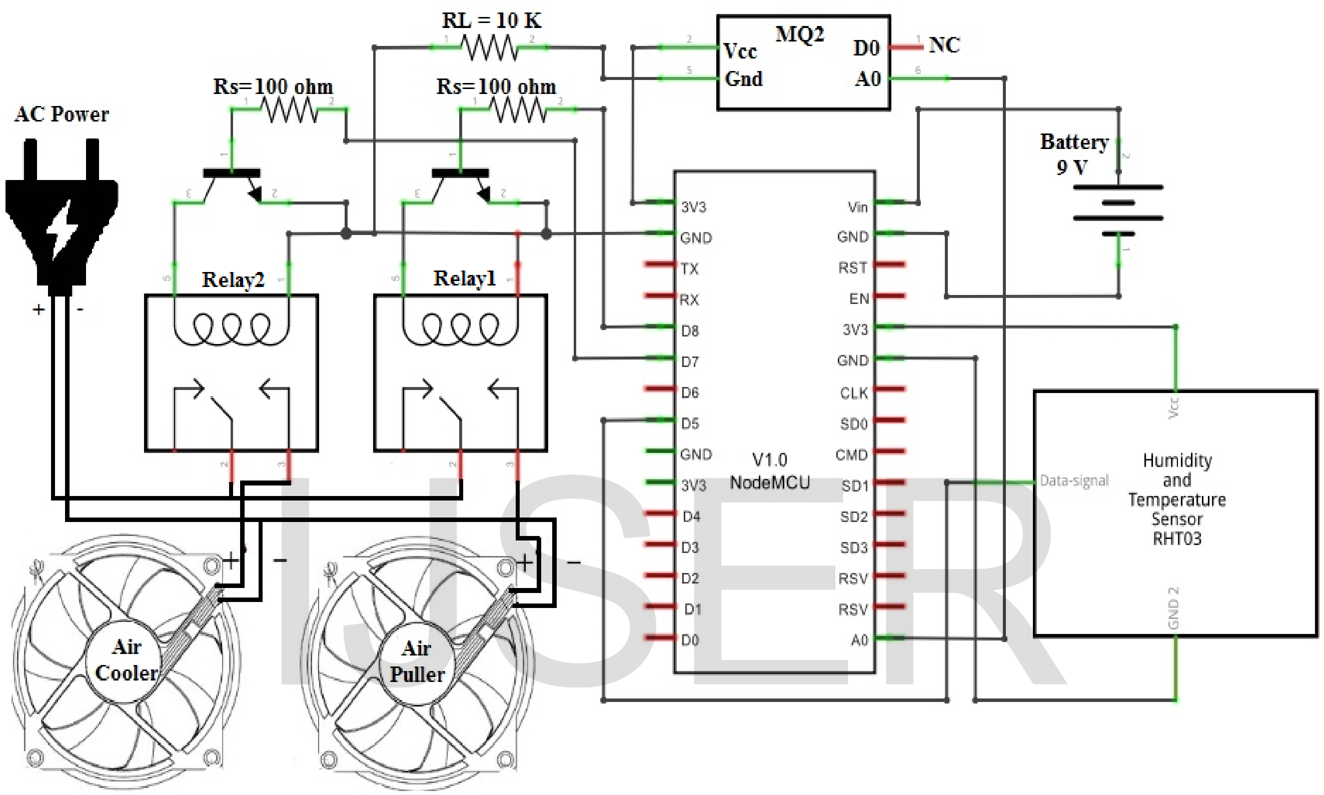

Fig.9. The Schematic Connection of the Whole Module

The webpage based control monitoring system is demonstrated as shown in Fig. 10, which exposes the webpage with the realized results. As mentioned before the system can apply control action even automatically or manually through the observer person (admin) that put into charge to supervise the whole process.

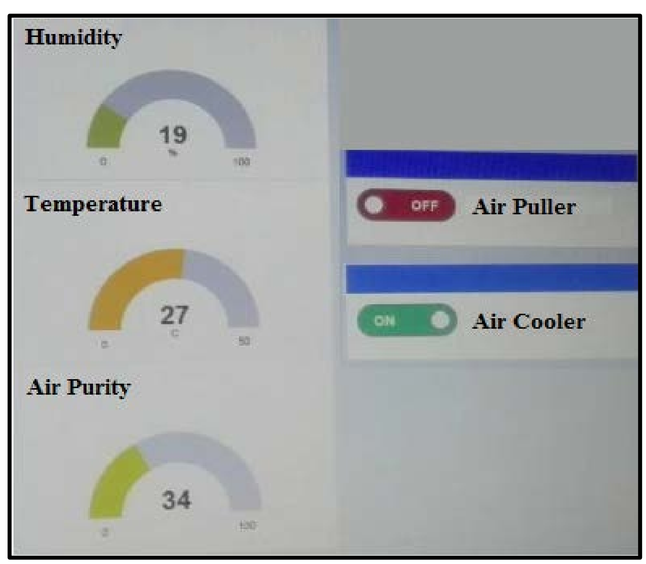

Fig.10. Net Pie Page based Control Monitoring System

5. Programming Methodology

Due to the complexity of the programing code, it is proposed to show the whole code as a simple flow chart shown in Fig. 11. First of all, it has to be reminded that the analog read range for a sensor connected to one of the analog pins in the Arduino is specified by (0 - 1023). The chart shows that the whole procedure starts by reminding the status of the main power key (ON/ OFF), then starts reading the LPG sensor, Temperature and Humidity sensor in order to decide and discover the situation of the environment. Once reading operation is completed, a conditional decision making operation takes place to apply control action according to a given result. In this work, it is proposed to assign two precautions based on decision results. The first precaution takes place by considering that MQ – 2 Sensor stated that gas concentration as an analog value is elevated. The purity of the air is obtained programmatically by subtracting the value of gas concentration from the max analog read as exposed in the equations (2) and (3). Furthermore, whenever DHT1 sensor stated that the temperature is greater than 25oC and the air quality is less than 70%, the automatic control precautions will be activated such that the air cooler and the air puller are turned ON to cool environment situation in the store down and to pull the contaminated air out in order to reserve the foodstuff. It is worth mentioning that key 1 and key 2 are used to fulfill the control action approach manually by the administrative person through the webpage. Finally, the chart checks whether the system is still working to stay in the loop for a while, or to terminate the program if the power button was set to OFF status.

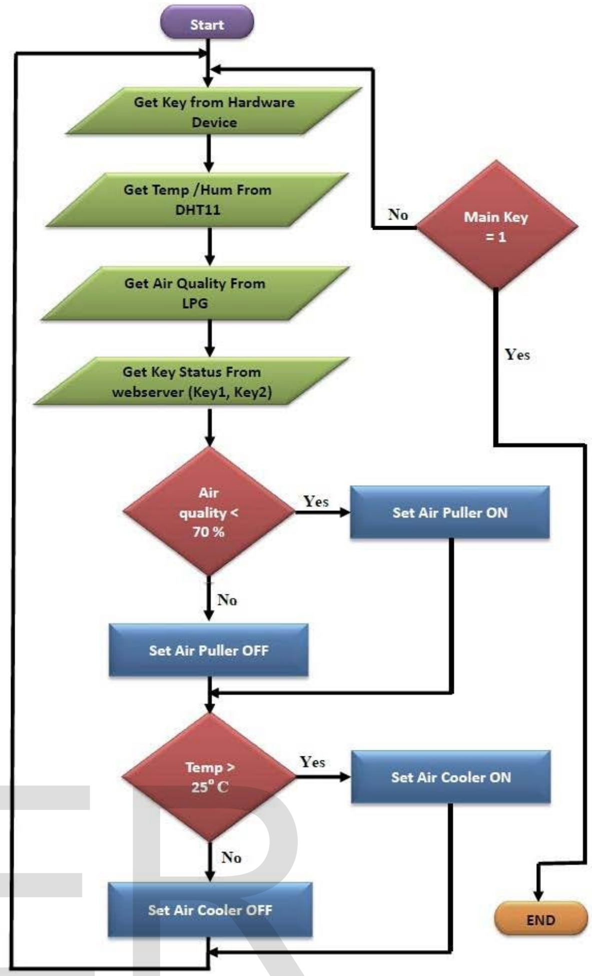

Fig 11: Programming code as flow chart

This next part aims to fulfill the idea of this work and confirm that the created system works properly with respect to the realized results. First, it is intended to demonstrate the realized Temperature, Humidity, and Air quality results with respect to the time for 24 hours starting from 07:00 as shown in Fig.12.

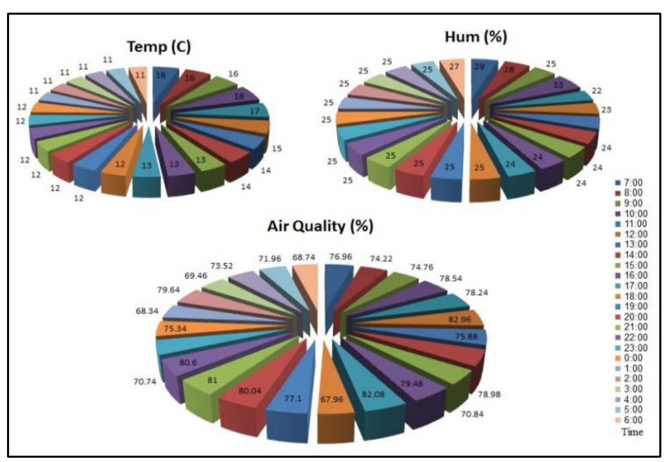

Fig.12. The Output Results of the Sensors

Finally, the results of the Temperature, Humidity, and

Air quality are gathered in an overall information bar as shown in Fig.13.

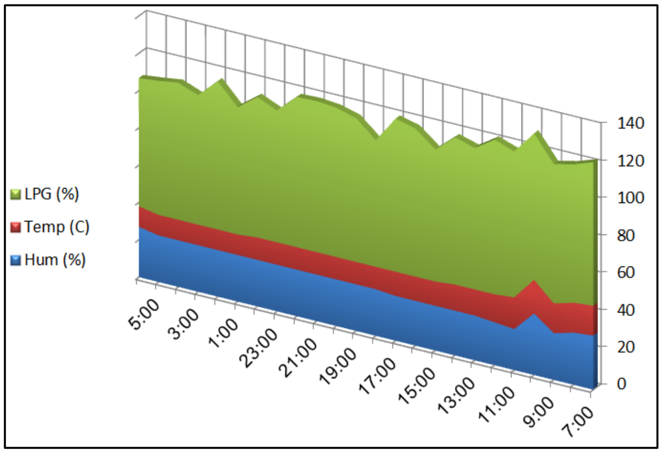

Fig.13. The Overall Results (Temp, Hum, LPG)

6. CONCLUSIONS

This paper exhibits a robust friendly and organized control system design with low cost limitations. The project charms the (IoT) features due to the implementation in various fields particularly as weather monitoring system in order to align the navigations, choosing transportation way such as sailing, riding or flying, and to plant the seeds in the farms in specific conditions, etc. This work proved that implanting the system in the agricultural fields was a wise decision due to the following results:

1. The system is designed in low cost limitations.
2. The employed ESP8266 module is considered more efficient and applicable than Arduino microcontroller because it can be used as a Wi-Fi station and accesses point AP at the same time.
3. In this paper, three foodstuff stores at three different remote locations are communicated together based on ESP module.
4. The realized data at three locations are shared and demonstrated in different aspects based on the Net Pie webserver.
5. The environments of the proposed locations in the worst cases are kept in the desired situation due to implementing double impact automatic and manual control point actions.
6. The automatic control action keeps the temperature in the desired level by cooling the store by the air cooler, and keeps the quality of the air uncontaminated by pulling the impure air out through the air puller.
7. The control action can even be done manually by the administrative person of the webpage server.
8. Finally, the design and application cost based on ESP8266 Node MCU module is considered inexpensive comparing to GSM that activates triggers the data and the control actions by SMS messages.

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