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ДАТЧИК ВЛАЖНОСТИ ГРАФИТ 33 ДЛЯ КОНТРОЛЯ ЛОКАЛЬНОЙ ВЛАЖНОСТИ ДЛЯ ЛЮДЕЙ С ХРОНИЧЕСКИМИ ЗАБОЛЕВАНИЯМИ

Аннотация: *В этом исследовании изготовлен 33 графитовый датчик влажности для постоянного контроля влажности пациентов (Потеют, писают) и недоношенных детей в инкубаторах, мы назвали его датчик графит-33 . Этот датчик прошел испытания в различных погодных условиях. Результаты сравнивались с измерениями датчика влажности SHT75 для калибровки. Мы обнаружили, что изготовленный датчик из графита-33 обладает быстрым откликом, восстановлением и долговременной стабильностью.*

В электронной измерительной цепи использовался микроконтроллер ATmega 88V. обладает высокой производительностью и низкое потребление энергии для обработки электрических сигналов, генерируемых изготовленным датчиком графит-33 чтобы превратить их в настоящую влагу.

Ключевые слова: *датчиком графит-33, Датчик влажности SHT75, микроконтроллер ATmega 88V.*

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GRAPHITE 33 MOISTURE SENSOR FOR LOCALIZED MOISTURE MONITORING OF PEOPLE WITH CHRONIC DISEASES

Annotation: *In this paper, a 33 graphite moisture sensor was manufactured to permanently monitor patients' humidity (perspiration, urination) and premature infants in incubators, we called it the graphite-33 sensor. This sensor has been tested under various weather conditions. The results were compared with measurements given by the SHT75 humidity sensor for calibration. We found that the manufactured graphite-33 sensor has rapid response, recovery and long-term stability.*
In the electronic measuring circuit, an ATmega88v microcontroller, with high performance and low power consumption, was used to process the electrical signals produced by the manufactured graphite-33 sensor in order to convert them into real moisture.

Key words: *33 graphite sensor, SHT75 moisture sensor, ATmega88v microcontroller.*

1. Introduction

Monitoring elderly patients and those with chronic diseases requires constant follow-up and periodic analyzes and measurements for them, and some cases require a long stay in hospitals due to the need for permanent monitoring devices.

This limits the movement of patients, and requires a large number of medical workers, and a high cost of follow-up because the old traditional measuring and analysis devices require a specialized medical staff and cannot be transported and used outside the designated areas with in the medical centers.

With the development of electronic industries in the field of semiconductors and chips, electronic sensors have appeared, which are small devices that convert physical quantities such as temperature, pressure, humidity, and others into electrical quantities such as voltage and current.

Electronic sensors made of semiconductors and various other compounds have replaced the old measuring devices used to monitor patients in general. Because these sensors provided good solutions to many of the problems that existed in the old measurement techniques, such as the need for large samples (blood sample for analysis), and the slow arrival of the measurement result (analysis) due to their reliance on chemical analysis methods that require a relatively long time, and a high cost due to Damage to materials used in the measurement (blood collection equipment and chemicals needed for analysis). As for electronic sensors, they are distinguished by that they do not need any sample for measurement, and their results are almost immediately within less than a minute for the longest measurement process, and they do not consume any materials or equipment in the measurement process.

The human body has a number of physical quantities that can be measured using electronic sensors, the most important of which are: temperature, humidity, pressure, sugar, hemoglobin, and vital cardiac signals [1].

Humidity sensors with high sensitivity, wide detection range, relatively low cost, fast response and short recover time are greatly demanded [2]. Recently surface acoustic wave (SAW) humidity sensors have received significant attention as they have advantages of small size, low power consumption, fast response and high stability [3]. Different kinds of sensing materials like nanomaterials [4] and polymers [5] cover the surface of the SAW sensor to improve the humidity sensitivity of the sensor. Graphene Oxide (GO) as a new type of nanomaterial has large surface to volume ratio and high hydrophobicity [6], which makes it very suitable for humidity sensing. Moreover, the GO film can be directly deposited on the interdigitated electrodes owing to its chemical groups caused insulation characteristic [7]. Humidity sensors with GO sensing layers have been proved to have excellent performance in terms of sensitivity and stability [8]. The performance of the SAW humidity sensor is susceptible to temperature change, which affects the accuracy and stability of the test results of the sensor. So far, only few studies have focused on improving the thermal stability of the SAW humidity sensor. Compared to bulk piezoelectric substrates based SAW sensor, the sensors fabricated on layered structures (the materials of piezoelectric layer and structural layer have opposite temperature coefficients) have low temperature coefficient of frequency (TCF) [9].

Through our study of the known features of graphite 33 and through some preliminary tests, we became certain that it is possible to manufacture a moisture sensor from graphite 33. This sensor has better features than other available moisture sensors.

2. The aim

The aim of this research is to manufacture a humidity sensor with a suitable electronic circuit design in order to measure humidity for patients with chronic diseases and children in incubators, so that it meets the following requirements: 1. Easy to use and connect on the human body so that it does not need specialists, 2. It does not pose any danger to the patient during long use, 3. The patient's data can be transferred to local communication devices such as computers and mobile phones. 4. It has high response, long-term stability and low power consumption requiring short charging time.

This device is part of an integrated electronic system, which we prepare, to measure most of the vital physical signs of people with permanent diseases residing in their homes, send the measurement data to the nearest follow-up medical center, and give a warning signal to the specialized immediate ambulance staff when any change in the data indicates an expected deterioration In the patient's condition. We have created a temperature sensor and published it in a paper entitled [Use of the LM35 temperature sensor with an ATmega88v microcontroller to measure and monitor the temperature of the human body]

3. Electronic devices and elements used

1. ATmega88v microcontroller, 2. NX3224K024 (LCD) display, 3. SHT75 moisture sensor, as standard, 4. Lithium batteries, 5. Capacitors, resistors, circuit breaker, ON/OFF switch,

3.1. ATmega88v microcontroller

The ATmega88v [10] microcontroller has good specifications and features suitable for the work we have accomplished, the most important of which are: High Performance, Low Power Microcontroller**,** Advanced RISC Architectur, 32×8 General Purpose Working Registers, 4/8/16KBytes of In-System Self-Programmable Flash program memory, 256/512/512 Bytes EEPROM, 512/1/1KBytes Internal SRAM, Two 8-bit Timer/Counters with Separate Prescaler and Compare Mode, One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode. 8channel 10-bit ADC in TQFP and QFN/MLF package. 6channel 10-bit ADC in PDIP Package. Operating Voltage: $1.8 - 5.5V$ for ATmega48PV/88PV/168PV, $2.7 - 5.5V$ for ATmega48P/88P/168P. Figure 1 shows the electrodes of the ATmega88v microcontroller.

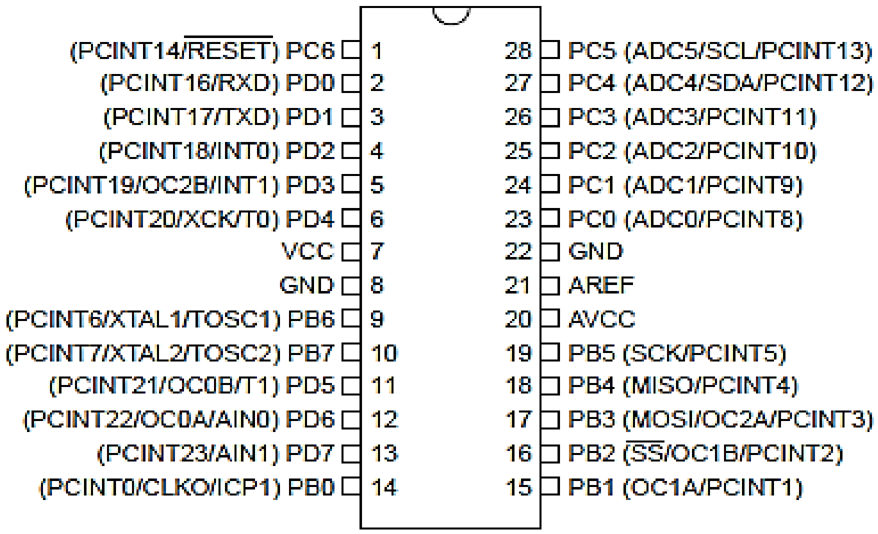

Figure 1: The electrodes of the ATmega88v microcontroller [10].

3.2. Nextion Enhanced 2.4 inch Display NX3224K024

Nextion is a Seamless Human Machine Interface (HMI) solution that provides a control and visualisation interface between a human and a process, machine, application or appliance. Nextion is mainly applied to IoT or consumer electronics field**.** The Nextion TFT board uses only one serial port to communicate. Itlets you avoid the hassle of wiring. We notice that most engineers spend much time inapplication development but get unsatisfactory results. In this situation, Nextion editor hasmass components such as button, text, progress bar, slider, instrument panel etc. to enrich yourinterface design. And the drag-and-drop function ensures that you spend less time inprogramming, which will reduce 99% of your development workloads. With the help of this WYSIWYG editor, designing a GUI is a piece of cake. The screen is distinguished from the rest of the screens as it has 65,536 colors and has memory storage RAM and EEPROM, and the shape shows the screen diagram Fig. 2. Fig. 3 shows a picture of the screen (NX3224K024). Fig. 4 shows the screen design program [11].

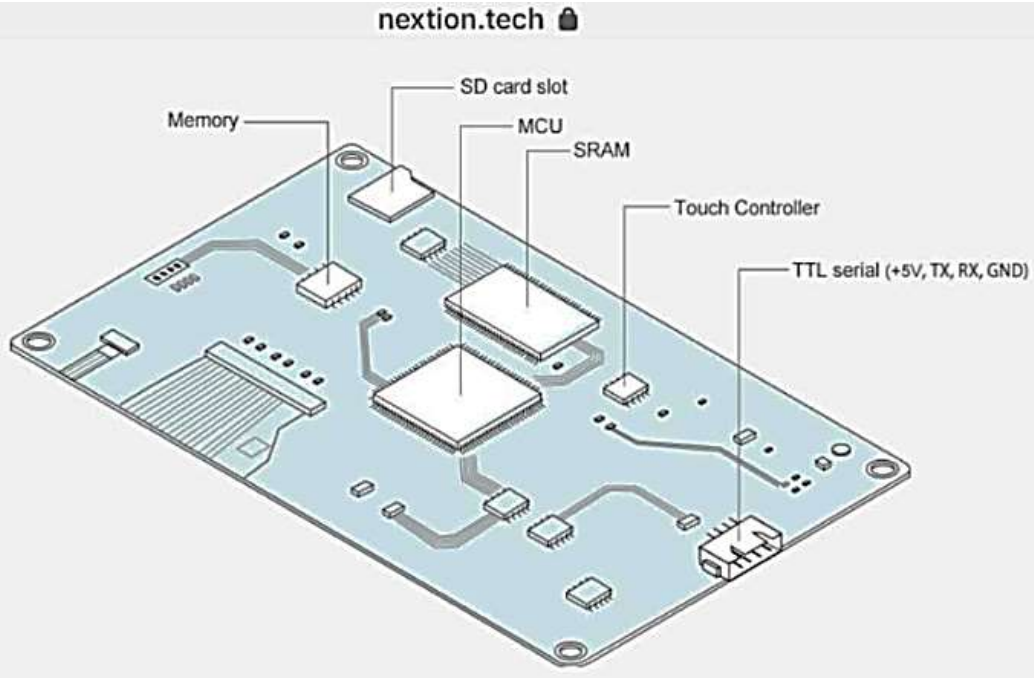

Figure 2: Screen Diagram (NX3224K024).

Figure 3: picture of the screen (NX3224K024)

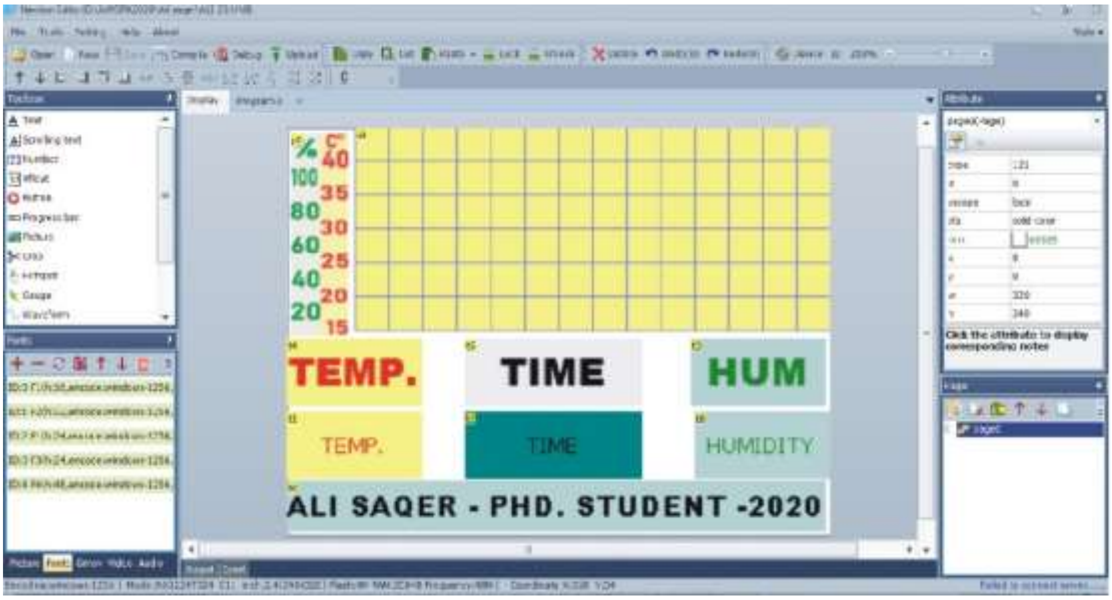

Figure 4. screen design program for LCD (NX3224K024).

3.3. SHT75 Sensor

Humidity and Temperature Sensor IC: Fully calibrated, Digital output, Low power consumption, Excellent long term stability and Pin type package – easy integration. SHT7x (including SHT71 and SHT75) is Sensation's family of relative humidity and temperature sensors with pins Fig. 5.

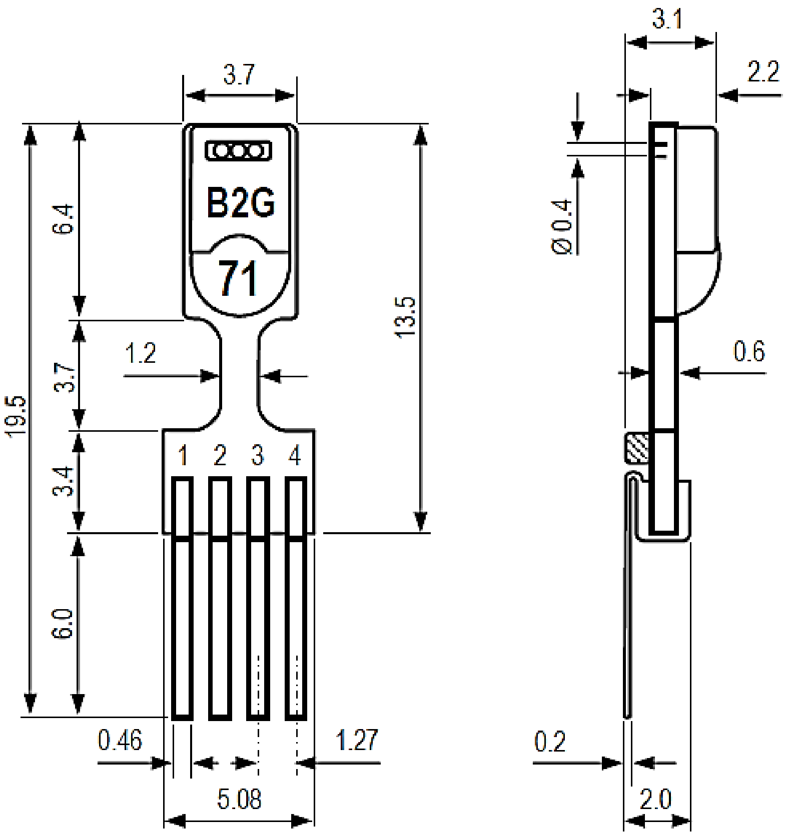

Figure 3. Drawing of SHT7x (applies to SHT71 and SHT75) sensor packaging, dimensions in mm (1mm = 0.039inch). Contact assignment: 1: SCK, 2: VDD, 3: GND, 4: DATA. Hatched item on backside of PCB is a 100nF capacitor [12].

3.4. GRAPHIT 33

GENERAL DESCRIPTION: Graphite lacquer for conductive coatings. Thermoplastic binder with electrically conductive graphite powder.

FEATURES: GRAPHIT 33 contains a high level of pure and fine graphite powder, This results in a good electrical conductivity. The coating exhibits good adhesion on metal, many plastics, glass and wood,

APPLICATIONS: As a **conductive coating** for permanent and safe diverting of electrostatic discharges (ESD)**;** Backs of cathode ray tubes, Electroplating of non-conductive materials**,** ESD safe packages**,** Repair of graphite-coated pcb's in keyboard switches (e.g. remote controls)**,** To firm the ESD protection of packaging and conveyor tube equipment.As **sliding coating** for permanent, temperature resistant, dry sliding coating. As **high-temperature release agent**: conductive protective release coating for high-voltage contacts, high-temperature release agent, e.g. for moulds used for the sintering of abrasive agents in abrasive discs. **Optical applications**: the dark black colour makes GRAPHIT 33 suitable as an absorbent coating in for example laser applications.

DIRECTIONS: When relative small amounts are involved, the easiest way to apply GRAPHIT 33 is to spray from an aerosol can. Shake can thoroughly before use. Spray, from a distance of 20-30 cm onto the dry and degreased surface. After use, always clean button by spraying upside-down until only gas escapes. When larger amounts are needed, GRAPHIT 33 can be applied by spraying using commercial spray guns. Before use, stir vigorously (best for 10 minutes with propeller agitator). During use, shake or stir at regular intervals.The surface resistivity can be further reduced by heating at 90°C (1 hour) or by polishing with a cloth or swab. Polishing makes also the weak graphite layer more firm. At temperatures above 100°C the binding agent will decompose. Never the less a good adhering graphite film remains that can be used as e.g. release coating [13].

Note: Note that the use of Graphite 33 as a moisture sensor is a new application that we are the first to do.

4. The box diagram for the medical monitoring system

Due to the lack of integrated physical models for medical sensors; And the suffering of some human bodies from problems and difficulties when using the sensors of traditional medical measuring devices in terms of their familiarity with the human body, or the patient’s body’s acceptance of these devices, or of their type, weight and energy source needed to operate them. We implemented an electronic circuit that measures the humidity of incubators using a moisture sensor designed from graphite 33. Comparison of his results with an electronic circuit containing the SHT75 moisture sensor. Figure (4) shows a box diagram of the medical monitoring system using a 33 graphite-moisture sensor with the SHT75 sensor for calibration.

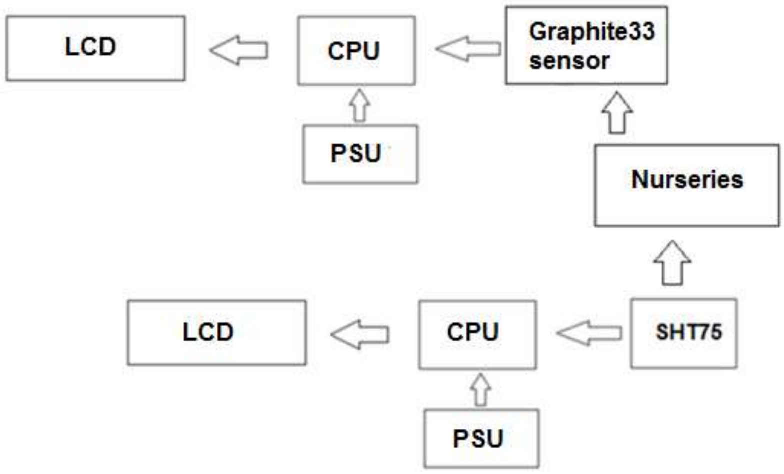

Figure 6. The box diagram for the medical monitoring system.

4.1. Manufacture of graphite moisture sensor 33

We have manufactured several test humidity sensors from a material commercially known as graphite-33. The Figure 7 shows one of the test samples that contains a set of moisture-graphite-33 sensors that appear on the board as black spots. Any graphite-33 sensor consists of two electrodes separated by graphite-33. graphite-33 Sensors differ from each other only by the distance between the electrodes and the following figures illustrate that

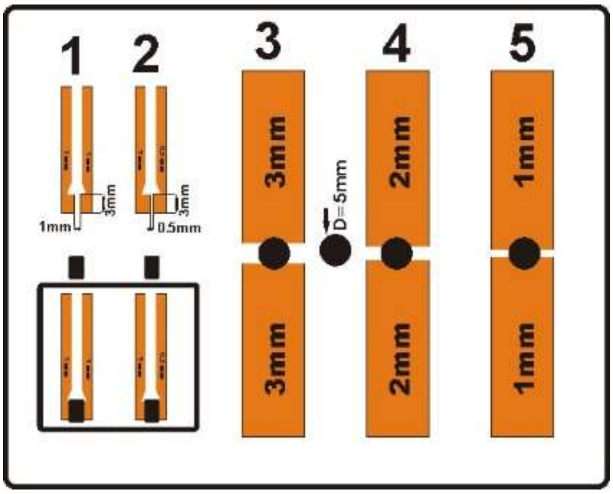

Figure 5: A test set of 33 moisture-graphite sensors deposited on a single fiber board.

4.2. Electronic circuit design

Figure 8 shows the complete designed circuit, consisting of an ATmega88v microcontroller, an LCD, graphite-33-humidity sensor, lithium batteries, capacitors, resistors, a circuit breaker, and an ON / OFF switch.

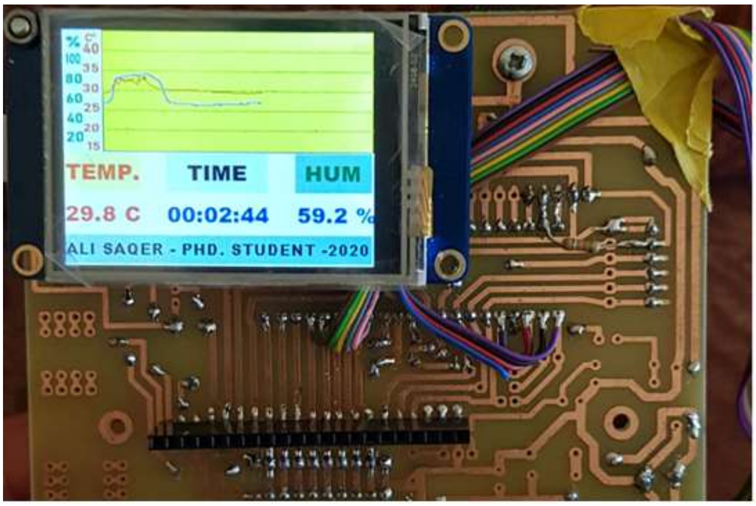

Figure 8: The electronic circuit designed with the SHT75 moisture calibration sensor and the graphite-33 sensor.

5. Results and discussion

As an example of the experimental measurements we present Table (1), which gives the resistance measurement of five graphite-33 sensors with humidity measured by the calibration sensor SHT75. As the humidity is proportional to the resistance of the graphite-33 sensor, and the resistance of the graphite sensor is inversely proportional to its length d and proportional to its width h. The dimensions of the graphite sensors $(d \times h)$ mm presented as a model are: (1×3) mm and we denoted it with R1, (0.5×3) mm and we denoted it with R2, (1×5) mm and we denoted it with R3, and (2×5) mm, we denoted it with R4, and (3×5) mm, and we denoted it with R5. We made the thickness of all the sensors the same.

Table (1): The results of measuring the resistance of the graphite-33 sensor used as an indicator of humidity and comparing it with measurements of moisture taken by the calibration sensor SHT75.

Calibration Sensor	Measurement of resistance of graphite-33 sensors as an indicator of moisture				
SHT75 $(H\%)$	$R1$ $(1 \times 3)mm$	$R2$ $(0.5 \times 3)mm$	$R3$ $(1 \times 5)mm$	$R4$ $(2 \times 5)mm$	$R5$ $(3 \times 5)mm$
43.0	2730	1260	1561	925	681
44.0	2740	1265	1568	930	687
46.5	2760	1277	1577	936	692
47.5	2780	1280	1585	942	697
50.3	2850	1290	1610	953	698
53.0	2920	1310	1635	964	698
56.0	2990	1330	1660	975	699
58.8	3060	1340	1700	985	700
61.8	3080	1350	1720	980	702
71.5	3090	1375	1770	997	708
75.8	3120	1385	1786	1005	713
78.8	3130	1391	1797	1010	717
80.5	3140	1400	1806	1014	721
82.5	3150	1409	1818	1021	727
83.5	3170	1417	1829	1026	730
85.5	3180	1424	1841	1037	740
86.5	3220	1448	1875	1050	750
87.5	3280	1485	1909	1064	760
89.0	3310	1500	1940	1080	770

In order to obtain calibration curves for all graphite-33 sensors, we plot R1, R2, R3, R4 and R5 as a function of the humidity taken by the H% calibration sensor, so that we obtain figures from (9) to (13).

By fitting the experimental data points with a polynomial function, calibration relationships between the humidity measured by the SHT75 and the resistance of the graphite-33 sensors are obtained; That is, the relationships from (1) to (5).

For the sensor R1≡ (1 × 3) mm, we find:

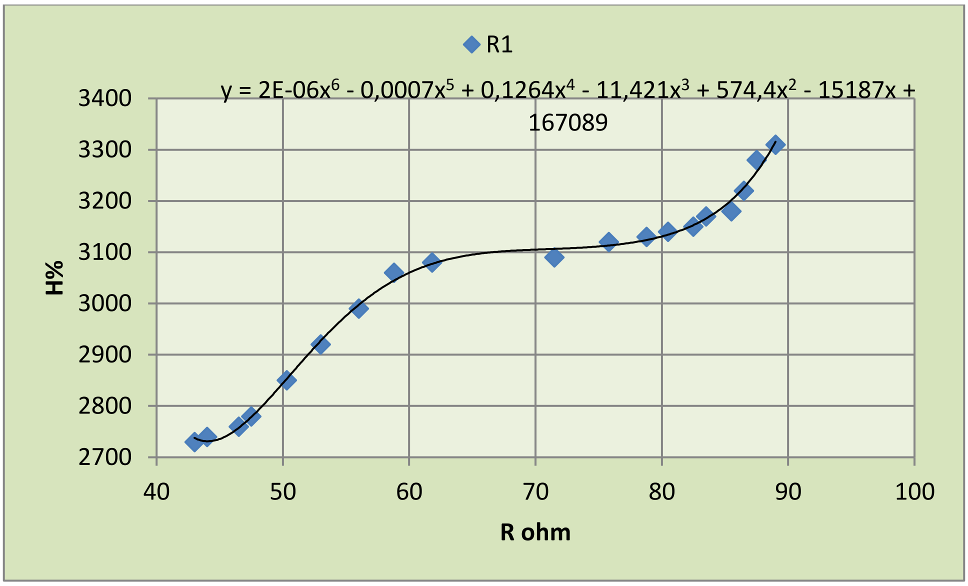

Figure 9. Calibration curve for the graphite-33 sensor, R1≡ (1 × 3) mm.

And we find that the calibration equation:

$$H = 2 \times 10^{-6} R^6 - 0.0007 R^5 + 0.1264 R^4 - 11.421 R^3 + 574.4 R^2 - 15187 R + 167089 \quad (1)$$

For the sensor R2≡ (0.5 × 3) mm, we find that:

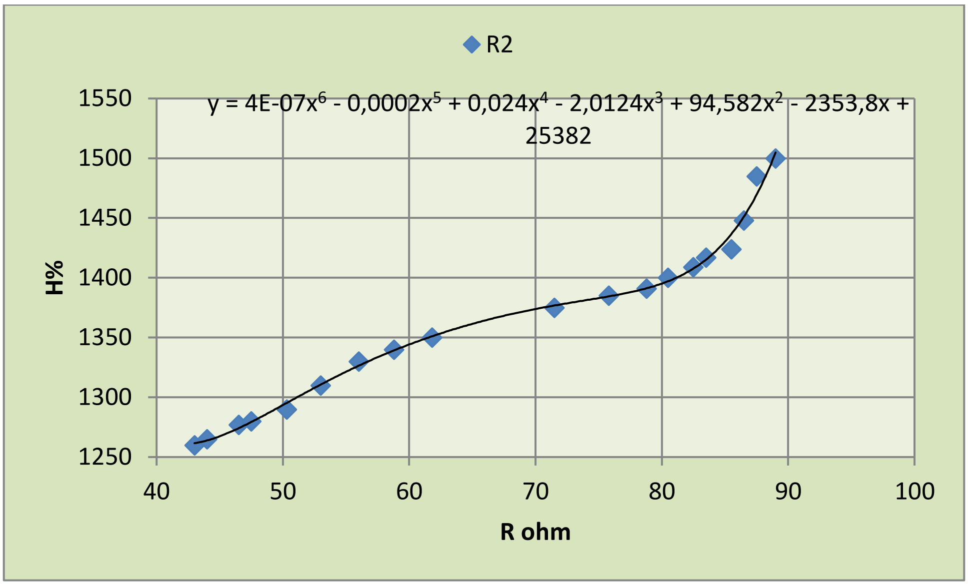

Figure 10. Calibration curve for the graphite-33 sensor, R2≡ (0.5 × 3) mm.

And we find that the calibration equation:

$$H = 4 \times 10^{-7} R^6 - 0.0002 R^5 + 0.024 R^4 - 2.0124 R^3 + 94.582 R^2 - 2353.8 R + 25382 \qquad (2)$$

For the R3≡ (1 × 5) mm sensor, we find:

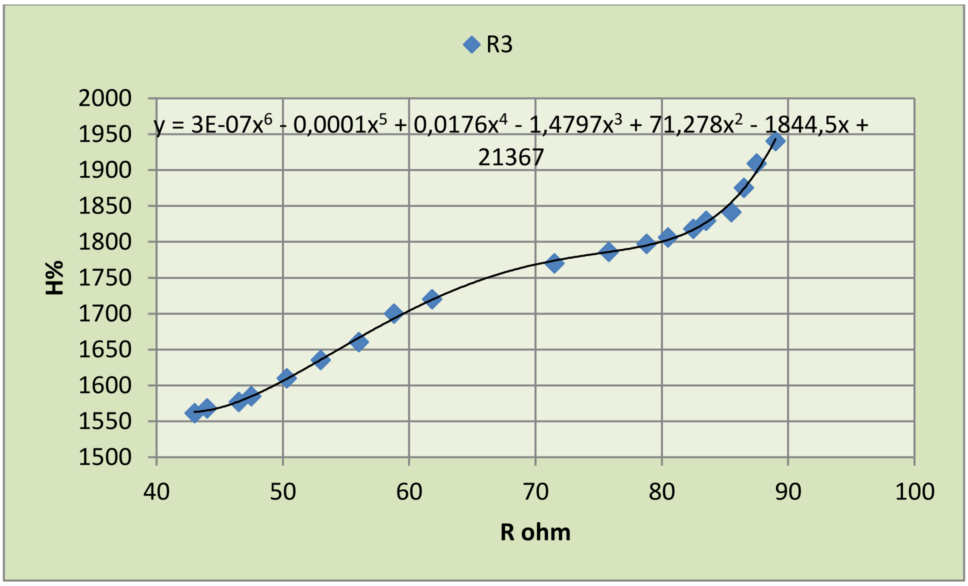

Figure 11. Calibration curve for the graphite-33 sensor, R3≡ (1 × 5) mm.

And we find that the calibration equation:

$$H = 3 \times 10^{-7} R^6 - 0.0001 R^5 + 0.0176 R^4 - 1.4797 R^3 + 71.278 R^2 - 1844.5 R + 21367 \qquad (3)$$

For the R4≡ (2 × 5) mm sensor, we find:

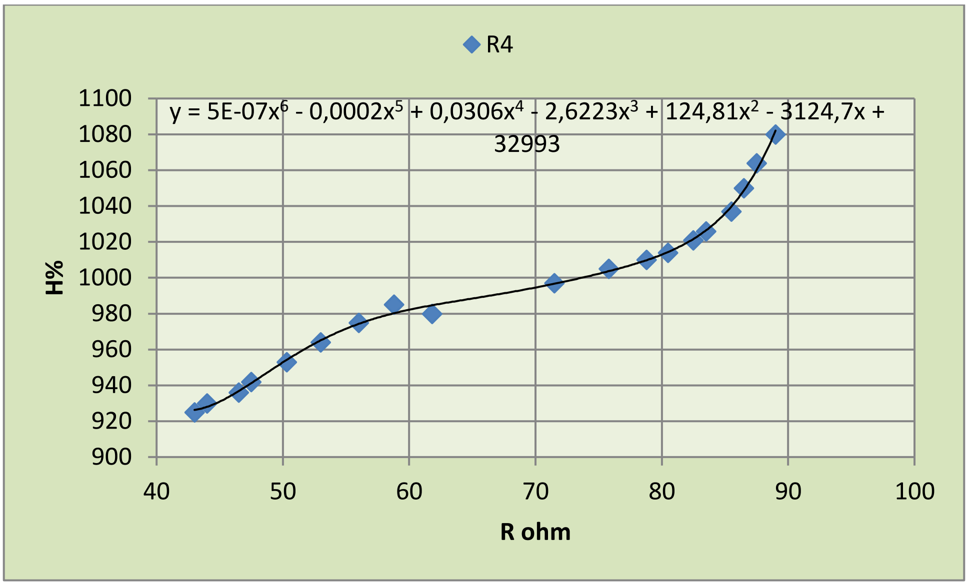

Figure 12. Calibration curve for the graphite-33 sensor, R4≡ (2 × 5) mm.

And we find that the calibration equation:

$$H = 5 \times 10^{-7}R^6 - 0.0002R^5 + 0.0306R^4 - 2.6223R^3 + 124.81\,R^2 - 3124.7R + 32993 \qquad (4)$$

For the R5≡ (3 × 5) mm sensor, we find:

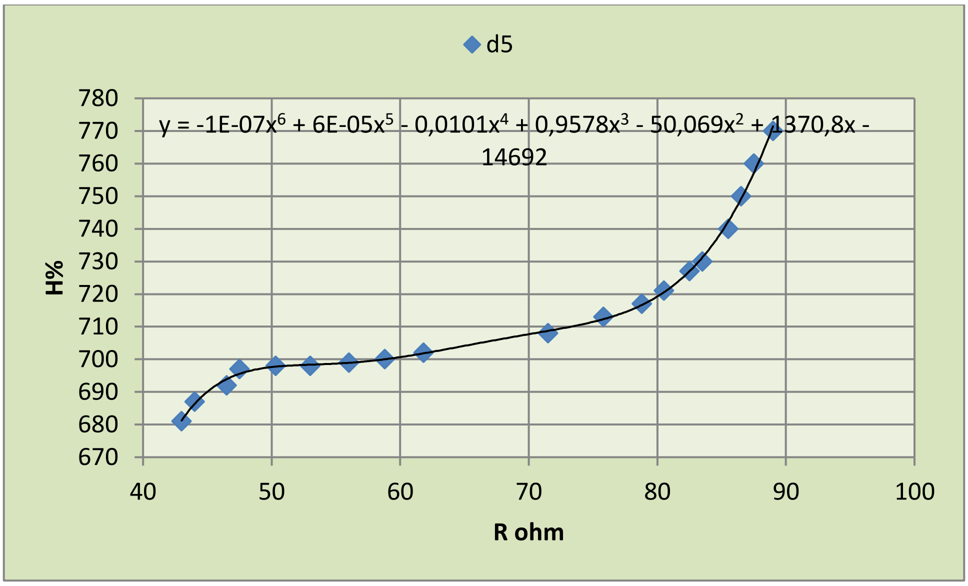

Figure 13. Calibration curve for the graphite-33 sensor, R5≡ (3 × 5) mm.

And we find that the calibration equation:

$$H = -1 \times 10^{-7}R^6 + 6 \times 10^{-5}R^5 - 0.0101R^4 + 0.9578R^3 - 50.096\,R^2 + 1370.8R - 14692 \qquad (5)$$

By programming the calibration relationships from (1) to (5) in the designed device, for any sensor used, we can measure its resistance to determine the humidity, store it, and show it on the screen. By doing so, we have obtained humidity meters. The calibration range used in Table 1 covers the entire human humidity range.

6. Conclusions and proposals

In this research we have reached the following:

1. The possibility of achieving an appropriate standard of humidity in various health conditions and places (incubators) and living to maintain a healthy environment by using an electronic circuit to measure humidity using sensors and a microcontroller and display the results on the advanced LCD screen.
2. By using the programmable ATmega88V microcontroller, fewer electronic components are used in the circuit, thus saving power consumption.
3. More accurate humidity measurements can be obtained. Because the conversion from analogue to digital (A/D) signal of the controller is of 10-bit length, the transformer will give values of 0-1023 for the transformer's input voltage range $0 - 5$ V.
4. Accurate measurements, fast response time and highly reliable results were obtained using the graphite-33 sensor.
5. The designed circuit can preserve the information and data for a sufficient period and display or send it to the concerned health centers.
6. The graphite sensors 33 were designed and manufactured in the laboratories of the Department of Physics and compared with the standard sensor SHT75.
7. A sophisticated 2×4 LCD display was used, and it is distinguished from the rest of the screens by having 65,536 colors and has memory storage RAM, EEPROM and flash.

7. Proposals and future prospects

1. Sensors can be manufactured in very small dimensions and used to measure vital signals in the human body.

2. A single processor can be used to connect all the sensors and perform all the required measurements (temperature, pressure, hemoglobin, ...).
3. The problem of feeding wires can be eliminated. Processors and sensors can be used that operate at very low power. So that a portable battery can last for several continuous days; It can be charged or exchanged with a charged one.
4. Modern processors can save a good amount of data in their internal memory, and they can also be provided with additional memory that is small in size and with a high storage capacity.
5. The data can be stored and presented later to the specialist doctor to study it and take the required measures to suit the patient's health. Processors can also be equipped with wireless circuits to send data simultaneously through different wireless networks, (depending on the local communication system in the region), to the follow-up center or the specialized medical team, to follow up on the patient's condition, without his permanent presence at the health follow-up center.

8. Suggestions

We suggest circulating this method and using this electronic board that we designed and implemented in health centers, hospitals, commercial halls, institutions, companies and pharmacies to maintain a specific humidity, and add some sensors such as temperature and pressure sensors until the system becomes complete for use in hospitals and health centers.

Beneficiaries of the research: Ministry of Health, Universities, schools and health centers, and Pharmacies, institutions and companies that deal with medicine and food.

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