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DESIGN AND IMPLEMENTATION OF WIRELESS SYSTEM FOR HEALTH MONITORING BY USING MC ARDUINO

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Northern Technical University (Mosul, Iraq)

The project will measure the temperatures of four patients by using temperature sensors (LM35) and the results are displayed on the screen, especially for that purpose, as is sending these measurements to another device by using radio waves (RF 433MHZ). And a distance not more than 150 meters. In the case of one patient temperature exceeded the allowable limit, the device of the recipient temperatures Horn issued a warning to the controller in charge of the case of patients, that all steps wirelessly sending by using MC Arduino.

Key words: health status monitoring, MC Arduino, kinetic energy, thermodynamics, thermal radiation, medicine.

Introduction

As molecules of all materials are moving so they have kinetic energy. The average kinetic energy of an ideal gas can be shown to be directly proportional with temperature. The same thing is for liquids and solids. The movement of gas molecules are more free than liquid and liquid molecules are more free than solid, an increase of temperature if any material means an increase in the energy of molecules of that material.

In order to increase the temp. of a gas it is necessary to increase the average kinetic energy of its molecules by putting the gas in contact with a flame , the energy transferred from the flame to the gas causing temp. rise is called heat . If enough heat added to a solid, it melts, forming a liquid. The liquid may be changed to a gas by adding more heat. Adding still more heat converts gas to ions.

While adding heat to substance increase its molecular kinetic energy, which increase its temp., the reverse is also true, heat can be removed from a substance to lower the temp.

Heat: in physics, heating is transfer of energy from a hotter body to a colder one, other than by work or transfer of matter. Heat, like work, is always associated with the exchange of internal energy between two systems, and is never a state variable. Heating is a dissipative process that occurs spontaneously whenever a suitable physical pathway exists between the bodies. The pathway can be direct, as in conduction and radiation, or indirect, as in convective circulation [1].

Temperature: A temperature is a numerical measure of hot and cold in a body that is in its own state of internal thermal equilibrium. Its measurement is by detection of heat radiation or particle velocity or kinetic energy, or by the bulk behavior of a thermometric material. It may be calibrated in any of various temperature scales, Celsius, Fahrenheit, Kelvin, etc. The fundamental physical definition of temperature is provided by thermodynamics.

Measurements with a small thermometer, or by detection of heat radiation, can show that the temperature of a body of material can vary from time to time and from place to place within it.

If changes happen too fast, or with too small a spacing, within a body, it may be impossible to define its temperature. With in a body that exchanges no energy or matter with its surroundings, temperature tends to become spatially uniform as time passes. When a path permeable only to heat is open between two bodies, energy always transfers spontaneously as heat from a hotter body to a colder one. The transfer rate depends on the thermal conductivity of the path or boundary between them. Between two bodies with the same temperature, no heat flows. These bodies are said to be in thermal equilibrium.

Relation between heat, hotness, and temperature:

A system's hotness is its tendency to transfer energy as heat. All physical systems are capable of heating or cooling others. This does not require that they have thermodynamic temperatures. With reference to hotness, the comparative terms hotter and colder are defined by the rule that heat flows from the hotter body to the colder. If a physical system is very rapidly or irregularly changing, for example by turbulence, it may be impossible to characterize it by

Amer Farhan Sheet – Northern Technical University (Mosul, Iraq), Ph. D. in Radiotechnics.

a temperature, but still there can be transfer of energy as heat between it and another system.

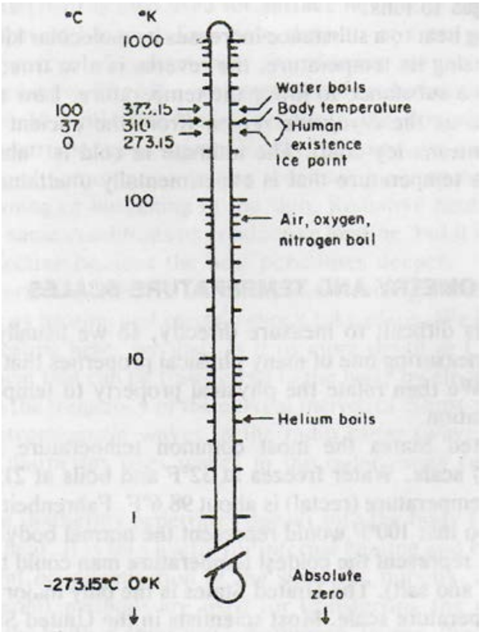

Figure 1. Logarithmic scale of temperatures

Thermometer:

Thermometer is a device that measures the temperature of things. The name is made up of two smaller words: «Thermo» means heat and «meter» means to measure. You can use a thermometer to tell the temperature outside or inside your house, inside your oven, even the temperature of body if you're sick [1].

Medical thermometer:

A medical thermometer, also known as a clinical thermometer, is used for measuring human body temperature the tip of the thermometer is inserted into the mouth under the tongue, under the armpit or into the rectum via the anus [2].

Hermometry and temperature scales:

Temperature is difficult to measure directly, so we usually measure it indirectly by measuring one of many physical properties that change with temperature. We then relate the physical property to temperature by a suitable calibration.

In the united state the most common temperature scale is the Fahrenheit (0F) scale. Water freezes at 32F and boil at 212F, and the normal body temperature is about 98.6 F. Fahrenheit devised this scale in 1724 so that 100F would represent the normal body temperature and 0F would represent the coldest temperature man could then produce (by mixing ice and salt). The United State is the only major country still using this temperature scale. Most scientists in the United State use the Celsius (C) scale (formerly called the centigrade scale), which is in common use throughout most of the world. Water freezes at 0C and boils at 100C, and the normal body temperature (rectal) is about 37°C [1].

Another important temperature scale used for scientific work is the Kelvin (K),or absolute scale which has the same degree intervals as the Celsius scale; 0K (absolute zero) is -273.15 C. on the absolute scale water freezes at 273.15 K and the normal body temperature is about 310K (figure 1). This temperature scale is not used in medicine.

Fahrenheit: is named after the German physicist Gabriel D. Fahrenheit who developed his scale in 1724.

The Celsius scale: is named after Anders Celsius. The Celsius scale used to be called the "centigrade" scale. Anders Celsius developed his scale in 1742.

Kelvin: is named after Lord Kelvin, whose full name is Sir William Thomson, Baron Kelvin of Larges, Lord Kelvin of Scotland.

Lord Kelvin took the idea of temperature one step further with his invention of the Kelvin Scale in 1848 [1].

One of the earliest inventors of a thermometer was probably Galileo. We know him more for his studies about the solar system and his "revolutionary" theory (back then) that the earth and planets rotated around the sun. Galileo is said to have used a device called a “thermoscope" around 1600 – that's 400 years ago. Galileo's thermometer was based on the principle that air expands and contracts with changes in temperature.His early thermometer was called a thermoscope as it identified changes in sensible temperature; it was more of a balancing scale than a device to record precise temperature. In 1638 Robert Fludd invented a thermometer with a scale. His device consisted of a vertical tube with a bulb placed on top of it while the other end was immersed in water. Water in the tube was controlled using the expansion or contraction of air. Today we call this kind of thermometer an air thermometer. The problem of these thermometers was that they were susceptible to air pressure as well, thus making them act as barometers [1]. The thermometer measures temperatures in Fahrenheit, Celsius and another scale called Kelvin [4].

The thermometers we use today are different than the ones Galileo may have used. There is usually a bulb at the base of the thermometer with a long glass tube stretching out the top. Early thermometers used Water, but because water freezes there was no way to measure temperatures less than the freezing point of water. So, alcohol, which freezes at temperature below the point where water freezes, was used. There is usually a bulb at the base of the thermometer with a long glass tube stretching out the top. Early thermometers used Water, but because water freezes there was no way to measure temperatures less than the freezing point of water. So, alcohol, which freezes at temperature below the point where water freezes, was used.

Instrument Description:

The project will measure the temperatures to four patients using temperature sensors (LM35). And those results are displayed on the screen, especially for that purpose, as is sending these four readings to another device using radio waves (RF 433MHZ). And a distance of not more than 150 meters. In the case of one patient temperature exceeded the allowable limit, the device of the recipient temperatures Horn issued a warning to the person in charge of the case of the case patients.

Been relying on a special type of processer (Arduino Nano) as a therapist in the design of this system in terms of reading temperatures and display the results on the screen LCD.

Where they appear to have four readings of heat received from four sensors and thus we presented four temperatures for four people at same time, where a distinction is made between the grades through the sensor number.

Circuit description:

The system consists of two parts:

1. Transmitter circuit:

Which placed in patients room.

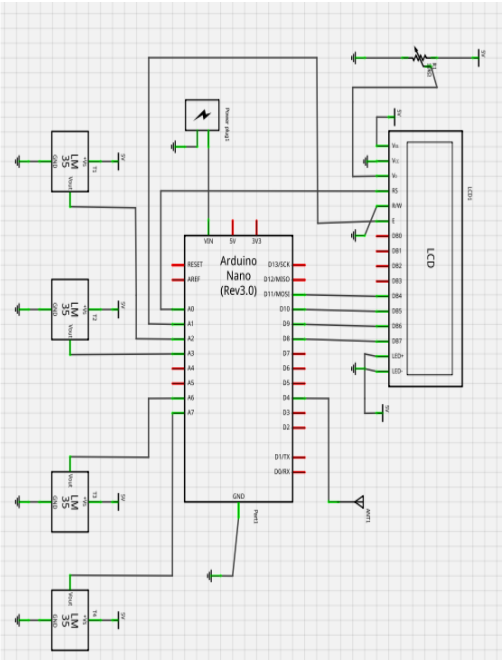

Figure 2. Block diagram of Transmitter circuit

The transmitter circuit consists of six components:

1. Four medical temperature sensors from type (LM 35).
2. The microcontroller Arduino Nano (Rev3.0).
3. Power supply.
4. RF Module (Transmitter).
5. Liquid crystal display (LCD) 2*16.
6. Variable resistance 1KΩ.

The definition and the properties for each part:

1. The temperature sensor (LM 35):

The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in ^{o}C) [6].

The characteristics of this sensor:

1-we can measure temperature more accurately than a using a thermositor.

2-The sensor circuitry is sealed and not subject to oxidation, etc.

3-The LM35 generates a higher output voltage than thermocouples and may not require that the output voltage be amplified.

4-It has an output voltage that is proportional to the Celsius temperature.

5-The LM35 does not require any external calibration or trimming and maintains an accuracy of +/-0.4 ^{o}C at room temperature and +/-0.8 ^{o}C over a range of 0 ^{o}C to +100 ^{o}C.

6-Another important characteristic of the LM35DZ is that it draws only 60 micro amps from its supply and possesses a low self-heating capability. The sensor self-heating causes less than 0.1 ^{o}C temperature rise in still air [5].

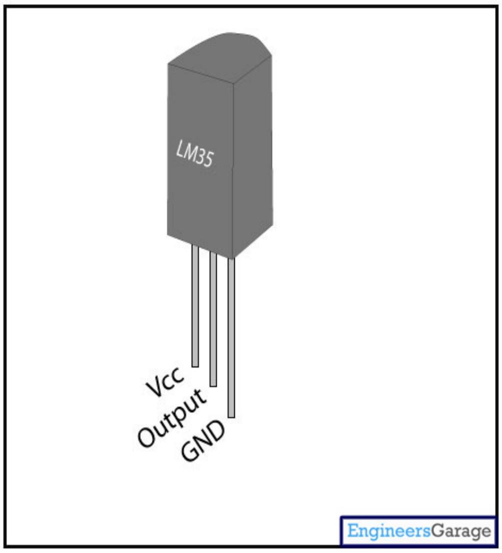

Figure 3. LM35 sensor

The electrical connection of the LM35 sensor:

Each LM35 sensor consist of three pins:

1.VCC : which connected to 5volt.

2.Output: which connected to the Arduino Nano (Rev3.0) and as shown below:

Table 1

Pins of sensors

Sensors	Arduino
1st LM35	To pin (A2)
2nd LM35	To pin (A3)
3rd LM35	To pin (A6)
4th LM35	To pin (A7)

3. GND: ground.

2. The microcontroller Arduino Nano (Rev3.0):

Arduino is a single – board microcontroller, intended to make the application of interactive objects or environments more accessible.

The hardware consists of an open-source hardware board designed around an 8-bit Atmel AVR microcontroller, or a 32-bit Atmel ARM. Pre-programmed into the on-board microcontroller chip is a boot loader that allows uploading programs into the microcontroller memory without needing a chip (device) programmer.

Figure 4. Arduino Nano (Rev3.0)

3-Arduino Nano technology parameters:

1. 14 digital input / output port TX, RX, D2 ~~ D13

2. 8 analog input ports A0 ~ A7

3. 1 pairs TTL level serial transceiver port RX / TX

4. 6 PWM port, D3, D5, D6, D9, D10, D11

5. Atmel Atmega328P-AU microcontroller

6. USB download and power

7. Support for external 5V ~ 12V DC power supply

8. To support 9V battery powered

9. Input voltage (limit) from 6-20 V.

10. Three power supply: USB, VIN, external 5V input.

11. Digital input pins 8.

12. Clock speed 16 MHz. 13. Dimensions 0.73* 1.70.

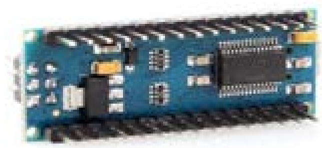

Figure 5. Arduino Nano (Rev3.0)

Table 2

Specifications of MC

Microcontroller	**Atmel ATmega168 or ATmega328**
Operating Voltage (logic level)	5 V
Input Voltage (recommended)	7-12 V
Input Voltage (limits)	6-20 V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	8
DC Current per I/O Pin	40 mA
Flash Memory	16 KB (ATmega168) or 32 KB (ATmega328) of which 2 KB used by bootloader
SRAM	1 KB (ATmega168) or 2 KB (ATmega328)
EEPROM	512 bytes (ATmega168) or 1 KB (ATmega328)
Clock Speed	16 MHz
Dimensions	0.73" x 1.70"

The electrical connections of the arduino's pins in the transmitter circuit is shown below:

- A2, A3, A6, A7 → 1 LM35, 2 LM35, 3 LM35, 4 LM35 respectively.
- VIN → power supply.
- GND → ground.

Figure(5) Arduino Nano (Rev3.0)

- D4 → Antenna.
- A0, A1, D8, D9, D10, D11 → LCD display.

The programming of Arduino Nano(Rev3.0) in the transmitter circuit is:

```
#include <LiquidCrystal.h>
#include <VirtualWire.h>

char sd[20];  // for RF
int i;     // for RF
int t1=11,t2=22,t3=33,t4=44;
LiquidCrystal lcd(A0,A1,11,10,9,8);
void setup(){
 Serial.begin(9600);
  // VirtualWire setup
vw_setup(2000); // Bits per sec
vw_set_tx_pin(4);// Set the Tx pin. Default is 12
  lcd.begin(16, 2);
 lcd.setCursor(0,0);lcd.print("T1= C && T2= C");
 lcd.setCursor(0,1);lcd.print("T3= C && T4= C");
    }
void loop(){
t1=analogRead(A2);
t1=(500*t1)/1024;
delay(40);
t2=analogRead(A3);
t2=(500*t2)/1024;
 delay(40);
t3=analogRead(A6);
t3=(500*t3)/1024;
 delay(40);
t4=analogRead(A7);
t4=(500*t4)/1024;
 delay(40);
lcd.setCursor(0,0);lcd.print("T1= C && T2= C");
```

3. Power supply:

Used for providing the power to the circuit from the main.

4. RF Module (Transmitter & Receiver):

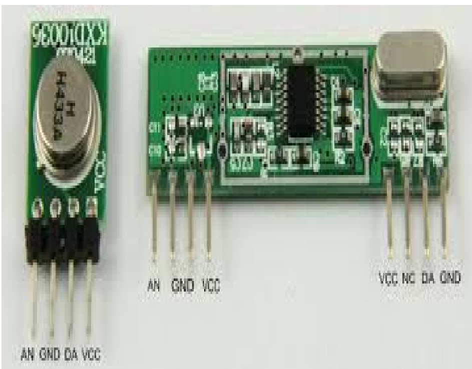

Figure 6. The Transmitter & Receiver

The RF module, as name suggests, operates at Radio Frequency. The corresponding frequency range varies between 30KHZ & 300KHZ , In RF system , the digital data is represented as variations in the amplitude of carrier wave.

This RF module comprises of an RF Transmitter and an RF Receiver. The transmitter/receiver (Tx/Rx) pair operates at a frequency 433 MHZ, An RF transmitter receives serial data and transmits it wirelessly through its antenna [6].

The transmitted data is received by an RF receiver operating at the same frequency as that of the transmitter.

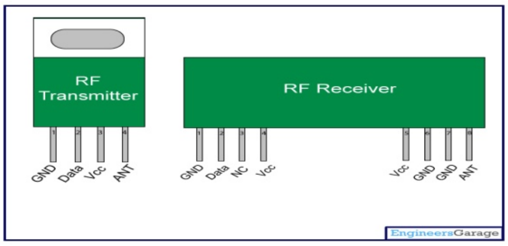

Figure 7. The block diagram of Transmitter & Receiver

Table 3

Pins of RF Transmitter

Pin No	Function	Name
1	Ground (0V)	Ground
2	Serial data input pin	Data
3	Supply voltage; 5V	Vcc
4	Antenna output pin	ANT

Table 4

Pins of RF Receiver

Pin No	Function	Name
1	Ground (0V)	Ground
2	Serial data output pin	Data
3	Linear output pin; not connected	NC
4	Supply voltage; 5V	Vcc
5	Supply voltage; 5V	Vcc
6	Ground (0V)	Ground
7	Ground (0V)	Ground
8	Antenna input pin	ANT

5. Liquid crystal display (LCD) 2*16:

The connection method of LCD in the transmitter circuit of the digital thermometer is shown below:

Table 5
Pins of LCD in the the transmitter circuit

LCD pins	Name of LCD pins	Function of LCD pins	Connect with Arduino Nano pins
1	Vss	Display power ground	Vss (GND)
2	VDD	Display power +5V	V_{DD} (5 V)
3	VD	Contrast Adjust. Altered by adjusting the voltage to this pin, grounding it sets it to maximum contrast	VD Variable resistance)
4	RS	lets the microcontroller tell the LCD whether it wants to display that data (as in, an ASCII character) or whether it is a command byte	A0
5	R/W	Data read/write selector	GND
6	E	Enable stroe	A1
7	D0	Data pin	NO Connect
8	D1	Data pin	NO Connect
9	D2	Data pin	NO Connect
10	D3	Data pin	NO Connect
11	D4	Data pin	A2
12	D5	Data pin	A3
13	D6	Data pin	A4
14	D7	Data pin	A5
15	+ LED	LED backlight power +5V	5 V
16	– LED	LED backlight power ground	GND

6. Variable resistance:

A variable resistor is a device that is used to change the resistance according to our needs in an electronic circuit. It can be used as a three terminal as well as a two terminal device. Mostly they are used as a three terminal device.

Figure 8. Some types of Variable resistances

2-Receiver circuit:

This is the second part of the system which placed in doctor’s room.

The figure below show receiver circuit:

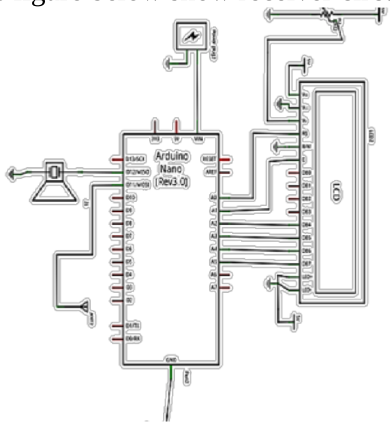

Figure 9. Block diagram of Receiver circuit

The receiver circuit consist of six parts:

1. The microcontroller Arduino Nano (Rev 3.0).
2. The power supply.
3. Liquid crystal display (LCD).
4. Variable resistance (1KΩ).
5. Sound alarm .
6. RF Module (Receiver).

The electrical connection of the arduino in the receiver circuit is:

- A0,A1,A2,A3,A4,A5→LCD
- D11→Antenna
- D12→Sound alarm
- Vin→power supply
- GND→ground

The programming of the arduino nano in the receiver circuit:

```
#include <LiquidCrystal.h>
#include <VirtualWire.h>

char StringReceived[21];
int I;
```

```
int t1,t2,t3,t4;
const int transmit_pin = 12;
const int receive_pin = 11;
const int transmit_en_pin = 3;

LiquidCrystal lcd(A0,A1,A2,A3,A4,A5);
void setup()
{ lcd.begin(16, 2);
 lcd.setCursor(0,0);lcd.print("T1= C && T2= C");
 lcd.setCursor(0,1);lcd.print("T3= C && T4= C");
 pinMode(12,OUTPUT);

 // Initialise the IO and ISR
 vw_set_rx_pin(receive_pin);
 vw_set_ptt_pin(transmit_en_pin);
 vw_set_ptt_inverted(true); // Required for DR3100
 vw_setup(2000); // Bits per sec
 vw_rx_start(); // Start the receiver PLL running
}

void loop()
{
 uint8_t buf[VW_MAX_MESSAGE_LEN];
 uint8_t buflen = VW_MAX_MESSAGE_LEN;

 if (vw_get_message(buf, &buflen)) // Non-blocking
 for (I = 0; I < buflen; i++)
  {
  StringReceived[i] = char(buf[i]);
  }
  delay(50);
  sscanf(StringReceived, "%d,%d,%d,%d",&t1, &t2,&t3,&t4); // Converts a string to an array
  lcd.setCursor(0,0);lcd.print("T1= C && T2= C");
  lcd.setCursor(0,1);lcd.print("T3= C && T4= C");
  lcd.setCursor(3,0);lcd.print(t1);
  lcd.setCursor(13,0);lcd.print(t2);
  lcd.setCursor(3,1);lcd.print(t3);
  lcd.setCursor(13,1);lcd.print(t4);

  if(t1>38 || t2>38 || t3>38 || t4>38 )
  digitalWrite(12,HIGH);
  else digitalWrite(12,LOW);

  delay(1000);

}
```

2. The connection method of LCD in the Receiver circuit of the digital thermometer is shown below:

Table 6

Pins of LCD in the the Receiver circuit

LCD pins	Name of LCD pins	Function of LCD pins	Connect with Arduino Nano pins
1	Vss	Display power ground	Vss (GND)
2	VDD	Display power +5V	V_{DD} (5 V)
3	VD	Contrast Adjust. Altered by adjusting the voltage to this pin, grounding it sets it to maximum contrast	VD (Variable resistance)
4	RS	lets the microcontroller tell the LCD whether it wants to display that data (as in, an ASCII character) or whether it is a command byte	A0
5	R/W	Data read/write selector	GND
6	E	Enable stroe	A1
7	D0	Data pin	NO Connect
8	D1	Data pin	NO Connect
9	D2	Data pin	NO Connect
10	D3	Data pin	NO Connect
11	D4	Data pin	A2
12	D5	Data pin	A3
13	D6	Data pin	A4
14	D7	Data pin	A5
15	+ LED	LED backlight power +5V	5 V
16	– LED	LED backlight power ground	GND

Conclusion

When the first patient touch the first sensor (L1) the measuring temperature will appear on display as (T1 = 37.5 C), in the same time the second patient touch the second sensor (L2) and the measuring temperature will appear on display as (T2 = 38.1 C) and the same case for the other two patients. In this case we can measure the temperature for four patients at the same time and if any of them temperatures increasing over than the certain range an alarm will be horn in the doctor's room.

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РАЗРАБОТКА И ВНЕДРЕНИЕ БЕСПРОВОДНОЙ СИСТЕМЫ МОНИТОРИНГА СОСТОЯНИЯ ЗДОРОВЬЯ С ИСПОЛЬЗОВАНИЕМ МС ARDUINO

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Северный технический университет (г. Мосул, Ирак)

Проект включает в себя измерение температуры четырех пациентов с помощью датчиков температуры (LM35). Новизна проекта заключается в том, что результаты измерений будут отображаться на экране, а не отправляться на другое устройство с использованием радиоволн (RF 433MHZ). Это особенно важно, потому что расстояние не более 150 метров. В случае, если температура одного пациента превысила допустимый предел, устройство получателя температуры Хорн (труба) выдает предупреждение диспетчеру, отвечающему за пациентов на всех этапах беспроводной передачи с использованием МС Arduino.

Ключевые слова: мониторинг состояния здоровья, МС Arduino, кинетическая энергия, термодинамика, тепловое излучение, медицина.