DESIGN AND IMPLEMENTATION OF AN INCUBATOR'S TEMPERATURE CONTROL SYSTEM FOR MULTI TYPES OF EGGS [+]

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Abstract :

The work presented in this paper deals with the design of a new egg incubator temperature control system, which is used for controlling the on/off cooling/heating devices (fan and heater) by using a temperature sensor and a microcontroller. The system consists of a voltage divider circuit that includes a temperature sensor or thermistor which senses any change that may happen in the incubator temperature and translates this change to a voltage value this voltage is suitable for the next stage which is the microcontroller, pic16f88 is used in order to control the on/off of the cooling devices if the temperature is changed by programming it to accept the voltage value that come from the sensor and give an order to switch on or off the relays connected to the cooling devices. The system was implemented for different values of temperature and it could be considered have a good accuracy.

تصميم وتنفيذ نظام السيطرة على حرارة الحاضنة لعدة انواع من البيوض

ريم جمال عباس

المستخلص :

العمل المقدم في هذا البحث يهتم بتصميم نظام جديد للسيطرة على حرارة حاضنة البيض, حيث يستعمل هذا التصميم للسيطرة على تشغيل واطفاء انظمة التبريد (المروحة او المسخن) وذلك باستعمال المتحسس الحراري والمسيطر الدقيق. يتكون النظام من دائرة مقسم الفولتية المحتوية على المتحسس الكهربائي الذي يتحسس اي تغيير يحدث في حرارة الحاضنة ويحول هذا التغيير الى قيم فولتية ليكون مناسب للمرحلة التالية والتي هي المسيطر الدقيق. PIC 16f88 استعمل للسيطرة على تشغيل واطفاء اجهزة التبريد عند تغير الحرارة وذلك ببرمجته لقبول قيم الفولتية القادمة من المتحسس واعطاء امر التشغيل او الاطفاء لاجهزة الابدال المربوطة باجهزة التبريد.النظام نفذ لقيم مختلفة من الحرارة ويمكن اعتباره ذو دقة جيد

1. Introduction :

Automatic control has played an important role in the advances of engineering and science. In addition to its extreme importance in robotic systems, and at time automatic control has become an important and integral part of modern manufacturing and industrial

[+] **Received on 5/5/2013 , Accepted on 8/9/2014**

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processes. Automatic control is essential in such industrial operations as controlling pressure, temperature, humidity, viscosity, and flow in the process industries [1].
Industrial rising of farm animals indoors under conditions of extremely restricted mobility, is commonly known as factory farming. It is done as part of industrial agriculture, which is a set of methods that change as laws and technology change (known as industrial agriculture) which is designed to produce the highest output at the lowest cost. So for incubator the components that must be controlled are temperature, humidity, and ventilation [2].
In order to hatch a good percentage of fertile eggs, the incubator must be able to maintain a constant temperature. Where the temperature is dependent on the types of eggs, different sorts of eggs require different heat levels [3].
The system designed will control the temperature for various types of eggs. The function of egg incubator is to take over the animal job to incubate an egg until hatching.
The aim of this study was to apply a new technology for controlling temperature of incubator with easy design, good temperature sensitivity and good accuracy or tolerance at a relatively low cost.

2. Temperature sensor (negative temperature coefficient thermistor) :

A thermistor is a type of resistor whose resistance varies significantly with temperature. Thermistors are widely used as inrush current limits, temperature sensors, self reseting over current protectors, and self regulating heating elements [4].
NTC thermistors offer many desirable features for temperature measurement and control within their operating temperature range, it exhibits a decrease in electrical resistance with increasing temperature. Depending on the materials and methods of fabrication, they are generally used in the temperature range of -50 ºc to 150ºc. And its resistance value is typically referenced at 25ºc [4].
This device is nonlinear and is highly depending upon process parameters.
NTC thermistor offer a degree of accuracy or tolerance at a relatively low cost, and the small size make a very rapid response to temperature changes [6].

3. PIC 16F88 Description :

This powerful (200 nanosecond instruction execution) yet easy-to-program (only 35 single instructions) CMOS Flash-based 8-bit microcontroller PIC16f88 packs Microchip's powerful PIC architecture into an 18-pin package and is upwards compatible with the PIC16c7x, pic16c62xA, pic16c5x and pic12cxxx devices. The PIC16f88 features 8MHz internal oscillator, 256 bytes of EEPROM data memory, a capture/compare/PWM, an addressable USART, a synchronous serial port that can be configured as either a 3-wire serial Peripheral interface or the 2-wire inter-integrated circuit bus, 7 channels of 10-bit analog-to-digital convertor and 2 comparators. All of these features make the pic16f88 ideal for advantage analog/integrated level applications in automotive, industrial, appliances and consumer applications [7].

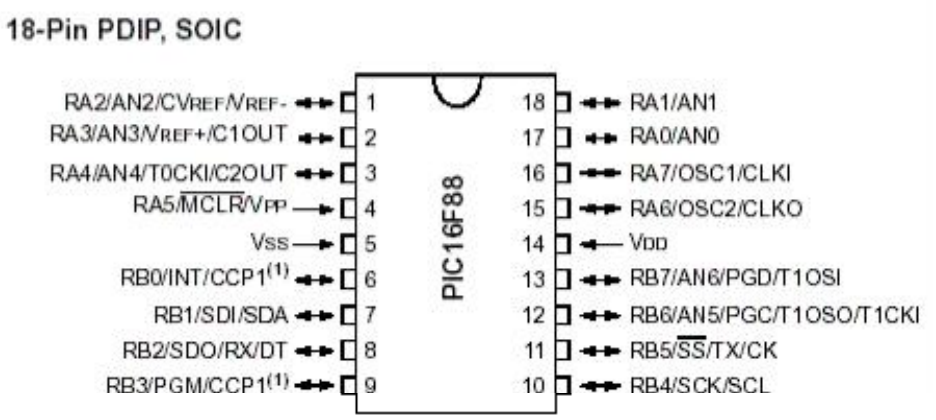

Figure (1): PIC 16f88 pin configuration [7].

4. Practical part of the proposed design :

The idea of this research is to control the temperature of the incubator for multi types of eggs used. When the temperature is increased or decreased the controller gives an order to run a fan or a heater to keep the temperature fixed at its suitable value, the whole design block diagram is shown below.

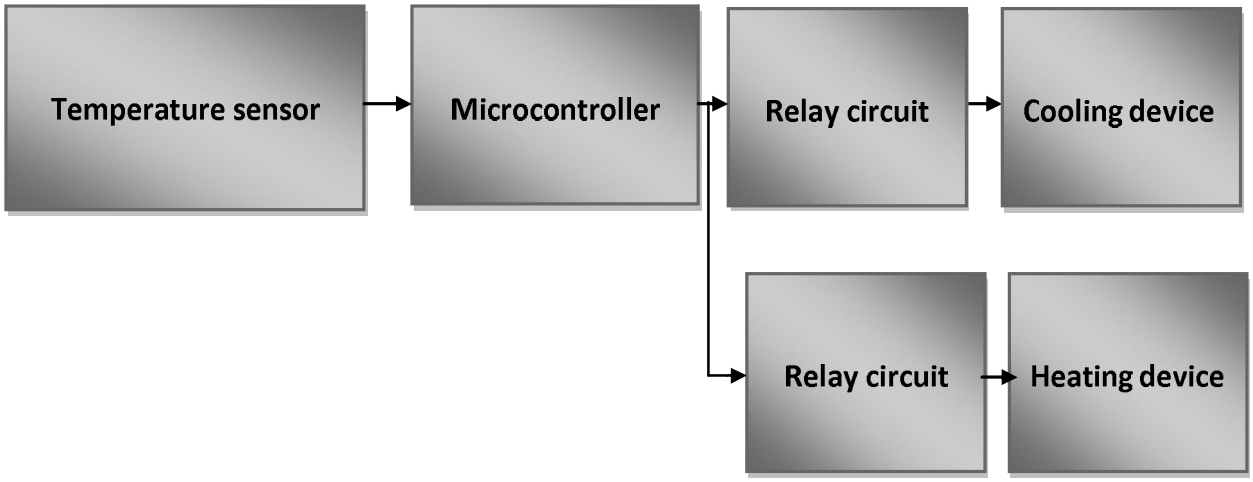

Figure (2): The incubator temperature control system

The overall design circuit diagram is shown in figure (3). In this diagram three NTC are used and the controller is connected with three fans and three heaters in order to control the temperature for three kinds of eggs.
The implementation of this design is shown in figure (9) and figure (10).
The system was tested for chicken's eggs, where in figure (9) the temperature was below 37º so the heater switched on and the fan off, in figure (10) the temperature was above 38º so the fan switched on and the heater off.

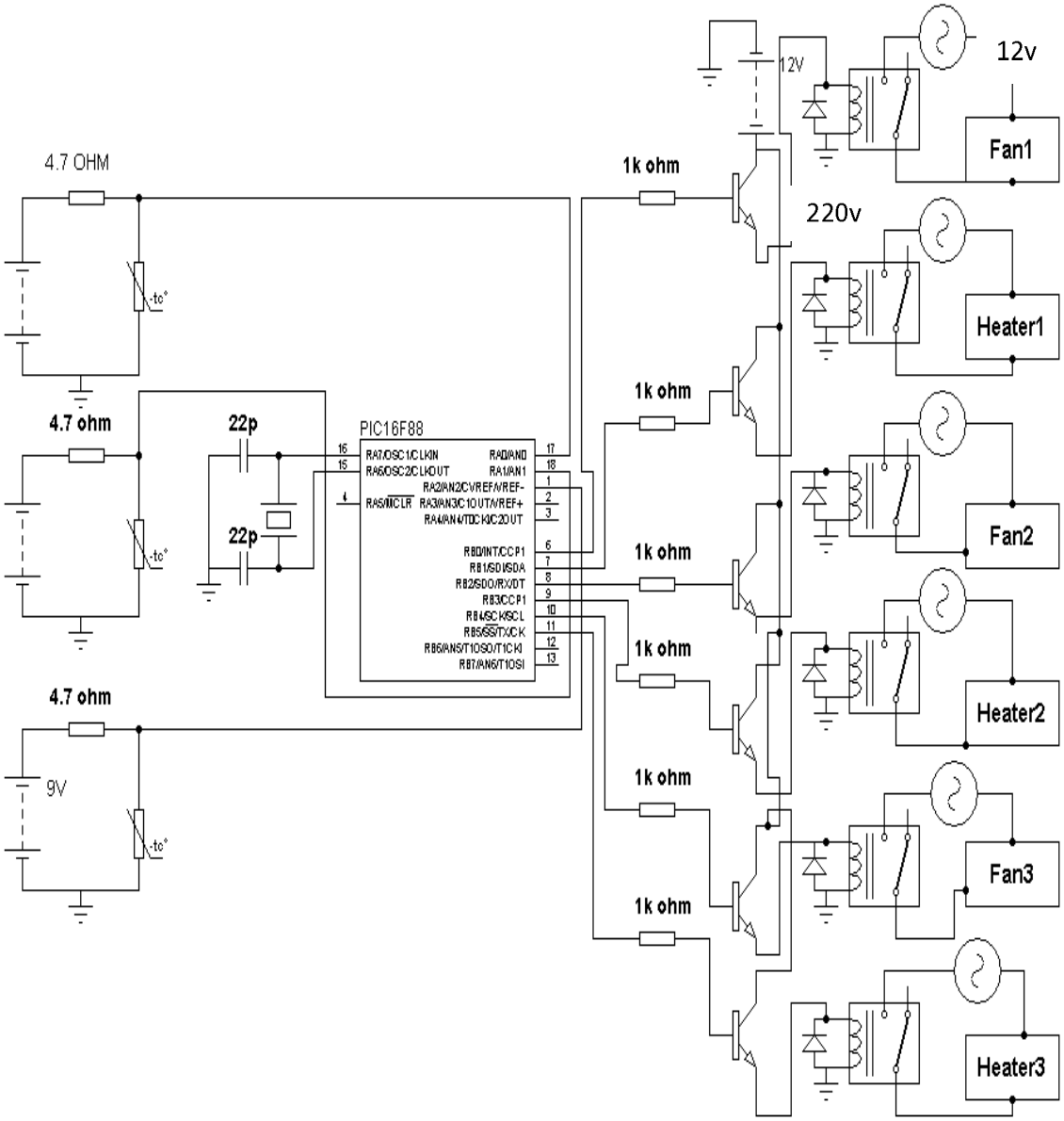

Figure (3): The incubator's temperature control system diagram (the overall design).

4.1 Temperature sensor (NTC Thermistor) :

The thermistor or temperature sensor senses any change in temperature around which leads to change the resistance of the sensor and to convert this change to a suitable voltage that is accepted by the controller, a voltage divider circuit was used. This circuit consists of a dc voltage source of "9v", a "4.7Ω" resistor, and the sensor as shown in figure (4). Any change in temperature lead to change the voltage of the sensor and by using a voltmeter the values of the temperature against voltage were measured as shown in table (1).

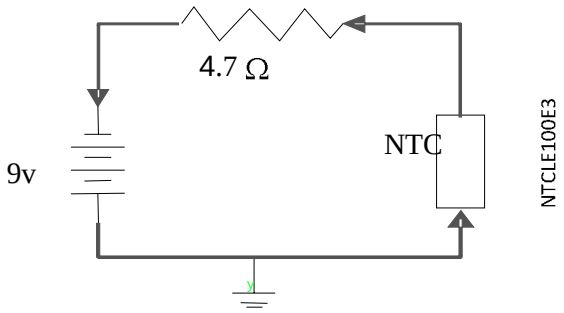

Figure (4): voltage divider circuit.

Table (1): Measured Temperature Vs Voltage values.

Temperature	Voltage
26	6.4
28	6.18
30	6.01
32	5.91
33	5.8
36	5.71
36.5	5.63
37	5.59
37.5	5.41
38	5.39
42	5.35
45	5.29

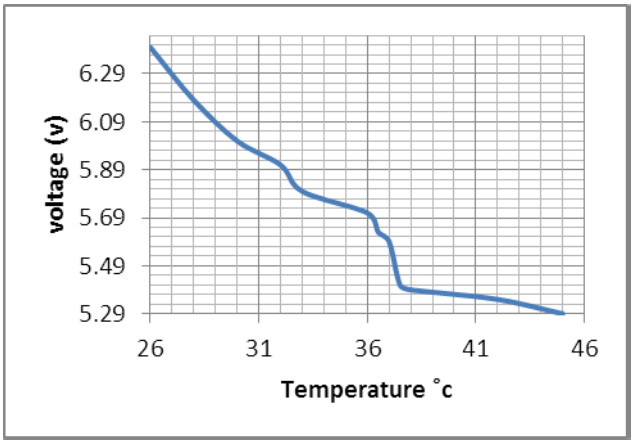

Figure (5): Temperature versus voltage curve.

4.2 The microcontroller (pic16f88) :

This controller programmed using an assembly language program to accept voltage values from the sensors and give an order to run on or off the cooling devices according to the temperature value that is needed for the type of egg used. The temperature values used in this research were for three types of bird's egg, which are chicken, turkey, and ostrich .And their temperature ranges were (37º-38º for chicken, 37.5º for turkey, and 36º-36.5º for ostrich). The flowchart of the microcontroller program is shown in Figure (6).

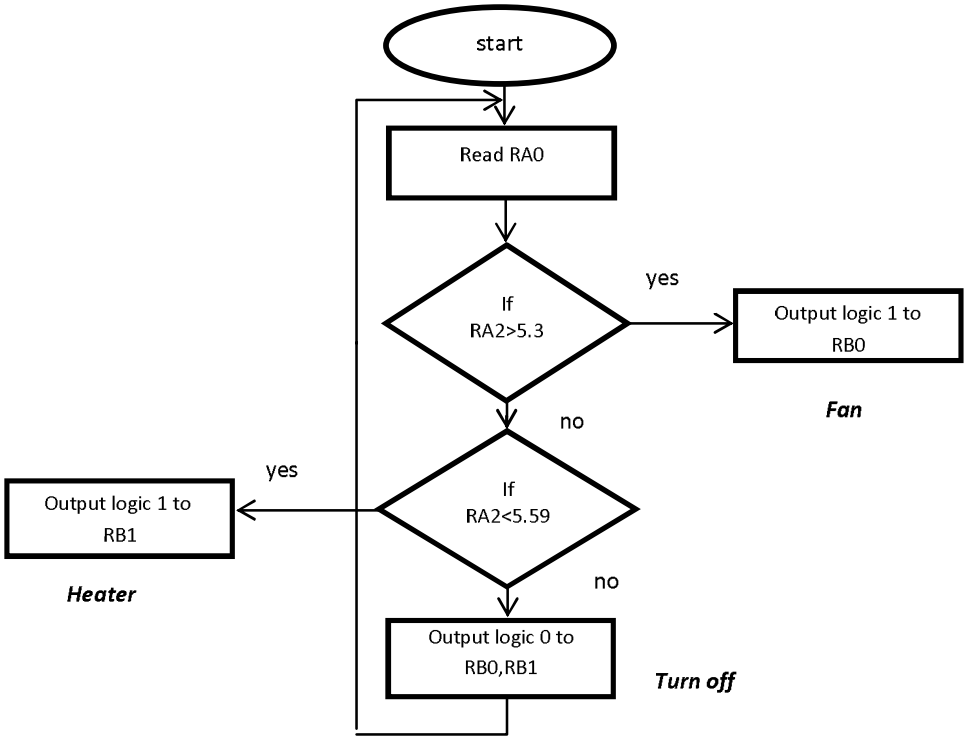

Figure (6-a): Chicken eggs incubator microcontroller p

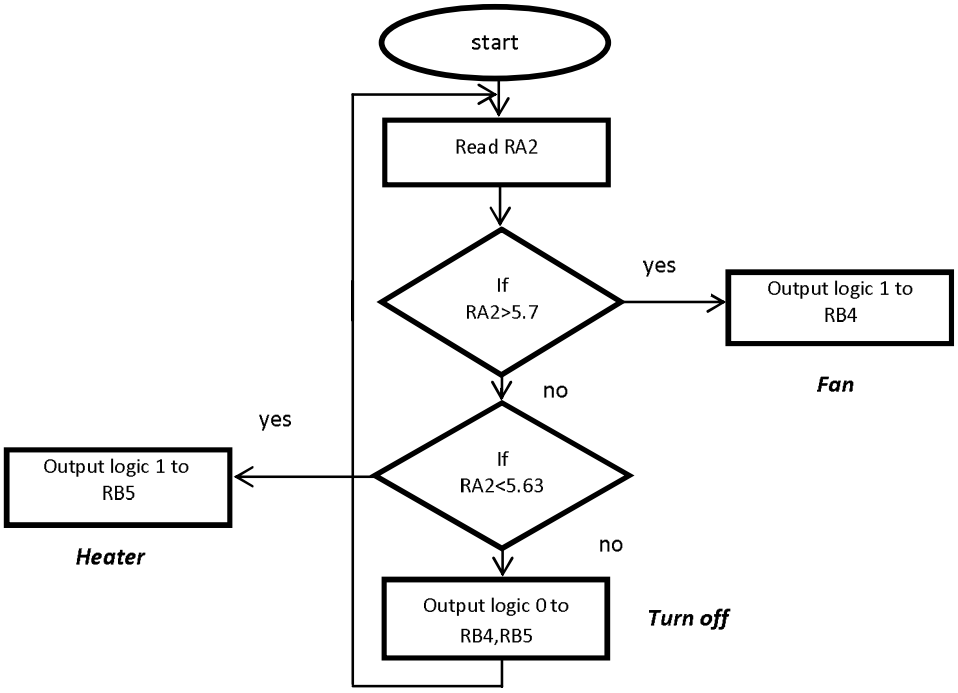

Figure (6-b): Flowchart of turkey eggs incubator microcontroller program

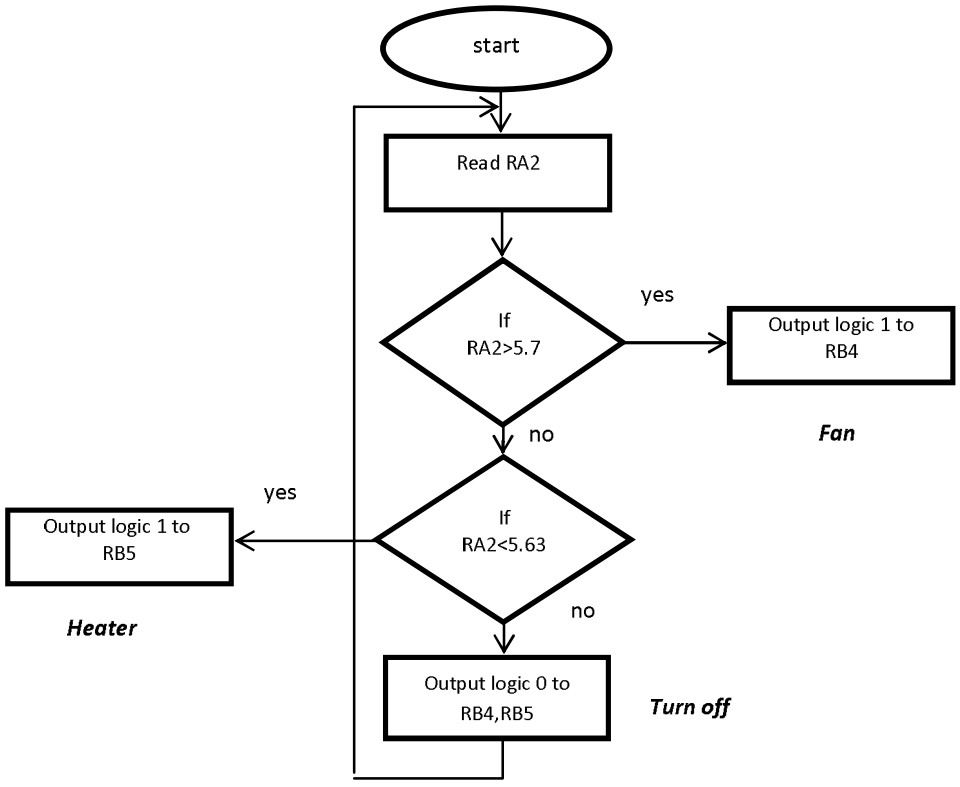

Figure (6-c):Flowchart of ostrich eggs incubator microcontroller program.

4.3 A/D convertor of pic16f88 :

Analogue to digital conversion seems to be a difficult task, yet it's really simple and easy when working with PIC microcontrollers. Figure (7) shows an overall plan of ADC. The 8 channels are multiplexed into ADC module one by one. The selection and configuration of channels is determined by ADC0N0 and ADC0N1 register whereas the output of ADC module, which is 10 bit number is given in two 8 bit registers ADRESH and ADRESL.

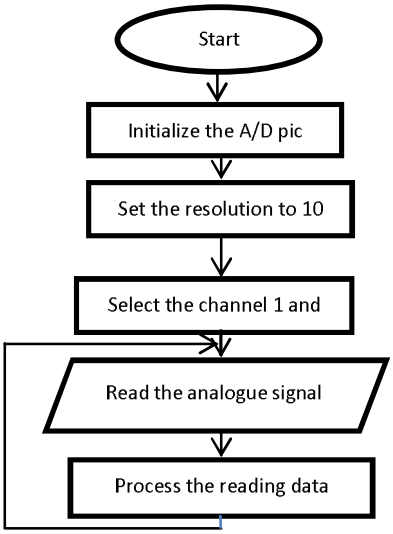

Figure (7): Sequence of A/D operation

4.4 Driver circuit :

Cooling devices (heater and fan) operate at 220V AC and the operating signal voltage from the controller is about 5V DC so it needs to use a driver circuit to operate the heater and the fan. Driver circuit consists of switching circuit (resistor 1k, transistor 2N222) in addition to relays are used in this design as shown in figure (8). The transistor used is connected as an emitter follower.Where the transistor sensing the signal from the pic and switching the relay to turn on or off.

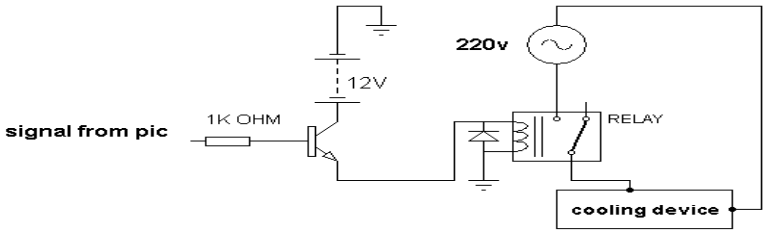

Figure (8): Driver circuit of cooling devices

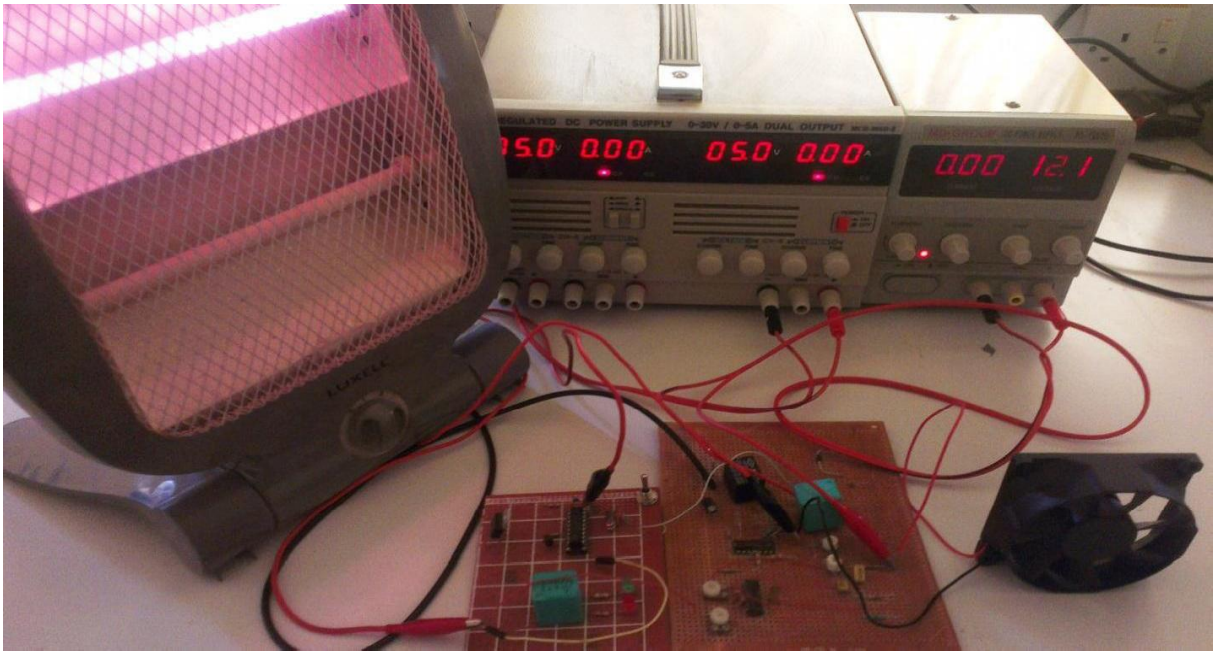

Figure (9): System practical implementation for chicken's eggs when temperature below 37° (Fan off, Heater on)

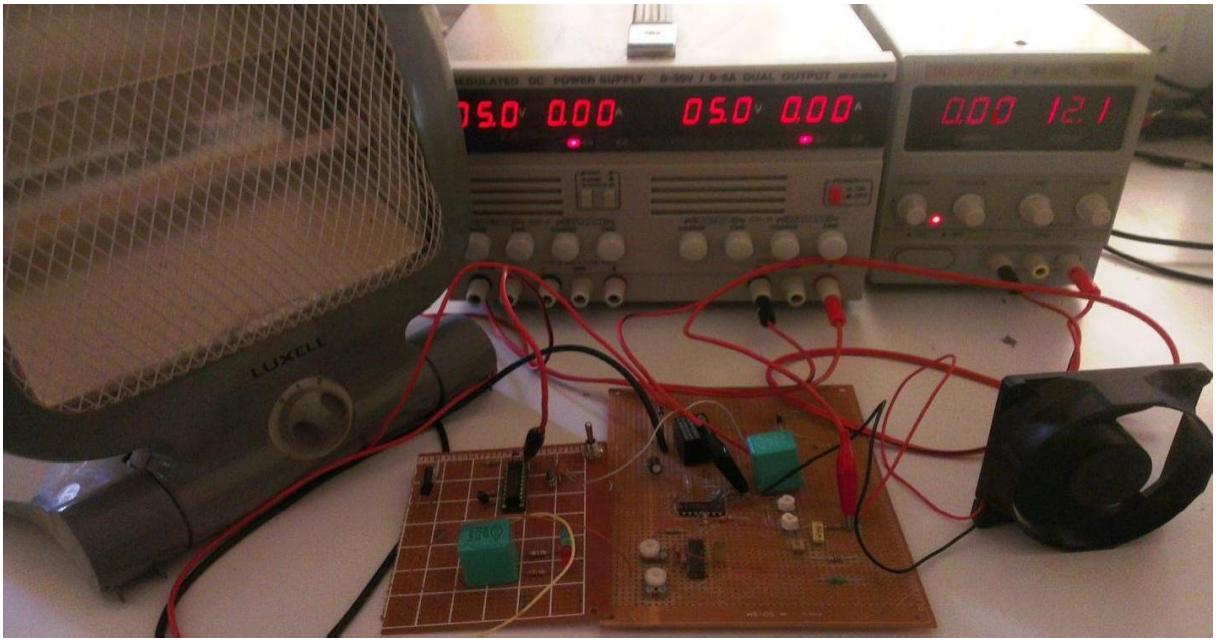

Figure (10): System practical implementation for chicken's eggs when temperature above 38°. (Fan on, Heater off).

Conclusion :

1. The voltage values of the sensor were measured for different values of room temperature and it was found that these values decrease with increasing temperature and the relationship between them is nonlinear.
2. Three NTC thermistors are used in this design to control the incubator temperature of three types of bird's egg by using the same system but separated incubators, each incubator has one fan and one heater device.
3. The values of temperature used in this design are for three kinds of birds which are chicken (37-38), turkey (37.5), and ostrich (36-36.5) and the voltage values for these kinds were measured to be (5.59-5.39) for chicken,(5.41) for turkey, and (5.71-5.63) for ostrich.
4. NTC thermistor has a high temperature sensitivity and good accuracy or tolerance so it has been used in this system implementation.

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