

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	Robert Watts	Student ID number:	1810524
Programme:			
Module:	Embedded Systems		
Module code:	PCEE4004	Contribution to Overall Module Assessment (%):	100%
Lecturer:	Sarah Williams	Internal Verifier:	
Assignment Title:	Office Environment Monitor	Word count (or equivalent):	2000
Submission deadline:	10th May 2019	Return date of provisional marks & written feedback:	24th May 2019
Submission method:	All written assessments, where practical and possible, must be submitted via Turnitin unless otherwise instructed by the Lecturer. (Please DO NOT put this assessment specification into Turnitin or it will match many similarities with other students' submissions.) Alternative submission method (if applicable): Late submission of the assessment will result in a late penalty mark. Penalties for late submission: Up to one week late, maximum mark of 40%. Over one week late, 0%. Only the Extenuating Circumstances Panel may approve a change to submission dates.		
Academic honesty / referencing:	Academic honesty is required. In the main body of your submission you must give credit to authors on whose research and ideas your work is based. Append to your submission a reference list that indicates the books, articles, etc. that you have used, cited or quoted in order to complete this assessment.		

STUDENT FEEDBACK FORM

This section details the *extent* to which the assessment criteria are demonstrated by you, which in turn determines your mark. The marks available for each category of skill are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Generic Assessment Criteria	Marks available	Marks awarded
1. Engagement with Literature Skills		
Evidence of extensive research provided.	10	7
2. Knowledge and Understanding Skills		
Evidence of planning and consideration of components to use, justification of decisions made included. Hardware and software design provided, using standard conventions and demonstrate very good understanding of the topic area.	20	14
3. Cognitive and Intellectual Skills		
Evidence is provided to show that the system has been tested effectively and demonstrated as working as required in class. Also further discussion provides valid and justified ways in which the system might be further improved.	25	19
4. Practical Application Skills		
Basic circuit however it effectively allows for the user to identify when the temperature is within acceptable ranges, and when outside. Code should be commented, although an extensive description of the functions of the code is included in the report. Unused code that is commented out should normally be deleted, unless it is there for testing purposes. Code is simple, but reflects flowchart provided at design stage. Overall the project demonstrates a very good deployment of both practical programming and electrical circuit design and construction.	35	22

5. Transferable Skills for Life and Professional Practice		
Work is coherent, very fluent and is presented professionally. Throughout you have demonstrated that you can work effectively independently.	10	8

Assessment Mark (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)	Late Submission Penalties (tick if appropriate)		70%
	Up to 1 week late (40% Max)		
	Over 1 week late (0%)		

GENERIC ASSESSMENT CRITERIA

Level 4

In accordance with the Framework for Higher Education Qualifications, at the end of Level 4 students will be expected to have demonstrated knowledge of the basic underlying concepts and principles of a subject, and an ability to evaluate and interpret these within the context of that area of study. They should be able to present, evaluate and interpret qualitative and quantitative data in order to develop lines of argument and make sound judgements in accordance with basic theories and concepts of their subject(s) of study. They will have learned how to evaluate different approaches to solving problems, and will be able to communicate the results of their study/work accurately and reliably, and with structured and coherent arguments. They will be able to undertake further training and develop new skills within a structured and managed environment and will have the qualities and transferable skills necessary for employment requiring the exercise of some personal responsibility.

Level 4	FAIL	MARGINAL FAIL	SATISFACTORY (3 rd / Pass)	GOOD (2.2 / Pass)	VERY GOOD (2.1 / Merit)	EXCELLENT (1 st / Distinction)	EXCEPTIONAL (1 st / Distinction)
Category	0-29%	30-39%	40-49%	50-59%	60-69%	70-84%	85-100%
Engagement with literature (including reading, referencing, academic conventions and academic honesty)	Little or no evidence of reading and/or reliance on inappropriate sources. Views and findings mostly unsupported and non-authoritative. Referencing conventions used incoherently or largely absent.	Poor engagement with essential reading. No evidence of wider reading. Reliance on inappropriate sources, and/or indiscriminate use of sources. Heavily reliant on information gained through class contact. Inconsistent and weak use of referencing.	Engagement with a limited range of mostly relevant and credible sources but with some reliance on information gained through class contact. Some omissions and minor errors. Referencing conventions evident though not always applied accurately or consistently.	Engagement with an appropriate range of literature, including sources retrieved independently. Some over-reliance on texts rather than other sources. Referencing may show minor inaccuracies or inconsistencies.	Engagement with a wide range of literature, including sources retrieved independently. Selection of relevant and credible sources. Generally sound referencing, with no/very few inaccuracies or inconsistencies.	Engagement with an extensive range of relevant and credible literature. Consistently accurate application of referencing.	Exceptional engagement with an extensive range of relevant and credible literature. High-level referencing skills consistently applied.
Knowledge and understanding (Knowledge of the basic underlying concepts and principles of a subject.)	Major gaps in knowledge and understanding of the basic underlying concepts and principles of the subject matter. Inclusion of irrelevant material. Substantial inaccuracies.	Gaps in knowledge of the basic underlying concepts and principles, with flawed or superficial understanding. Some significant inaccuracies and/or irrelevant material.	Limited knowledge and understanding of the basic underlying concepts and principles within the subject area. Some elements may be missing.	Knowledge of the basic underlying concepts and principles is accurate with a good understanding of the field of study but lacks depth and/or breadth.	Competent knowledge of the basic underlying concepts and principles. Exhibits very good understanding.	Excellent knowledge and understanding of the basic underlying concepts and principles of the subject.	Exceptional, detailed knowledge and understanding of the basic underlying concepts and principles

Level 4	FAIL	MARGINAL FAIL	SATISFACTORY (3 rd / Pass)	GOOD (2.2 / Pass)	VERY GOOD (2.1 / Merit)	EXCELLENT (1 st / Distinction)	EXCEPTIONAL (1 st / Distinction)
Category	0-29%	30-39%	40-49%	50-59%	60-69%	70-84%	85-100%
Cognitive and intellectual skills (Evaluate underlying concepts and principles of a subject and interpret qualitative and quantitative data in order to develop lines of argument and make sound judgements.)	Wholly or almost wholly descriptive work. Little or no evaluation of the underlying concepts and principles. Failure to develop arguments, leading to illogical or invalid judgements. Minimal or no use of evidence to back up views.	Largely descriptive work, with superficial evaluation of the underlying concepts and principles. Weak interpretation of data, flawed development of arguments and judgements. Information accepted uncritically, uses generalised statements made with scant evidence and unsubstantiated opinions. Ideas sometimes illogical and contradictory.	Limited attempt at evaluation of the underlying concepts and principles, tending towards description. Can interpret qualitative and quantitative data but with some errors. Some evidence to support emerging arguments and judgements but these may be underdeveloped or with a little inconsistency / mis-interpretation.	Good evaluation of the underlying concepts and principles. Can interpret qualitative and quantitative data, with minor errors. An emerging ability to use evidence to support the argument. Mostly valid arguments and logical judgements.	Sound evaluation of the underlying concepts and principles. Can interpret qualitative and quantitative data accurately. Ability to devise arguments using evidence to make mostly appropriate and valid judgements.	Excellent evaluation of the underlying concepts and principles. Can interpret qualitative and quantitative data accurately and with some insight. Excellent ability to devise arguments using evidence and make appropriate and valid judgements.	Exceptional evaluation of the underlying concepts and principles based evidence. Outstanding interpretation of qualitative and quantitative data. Exceptional ability to devise arguments using evidence and make wholly appropriate and valid judgements.
Practical skills (Different approaches to solving problems in particular contexts.)	Limited or no use of taught, basic methods, materials, tools and/or techniques. Little or no appreciation of the context of the application. Very weak evidence of different approaches to problem-solving in particular contexts.	Rudimentary application of taught, basic methods, materials, tools and/or techniques but without consideration and competence. Flawed appreciation of the context of the application. Weak evidence of different approaches to problem-solving in particular contexts.	An adequate awareness and mostly appropriate application of basic methods, materials, tools and/or techniques. Basic appreciation of the context of the application. Can identify problems in particular contexts and propose basic alternative approaches or solutions though there may be errors.	A good and appropriate application of basic methods, materials, tools and/or techniques. Clear appreciation of the context of the application. Good evidence of different approaches to problem-solving in particular contexts and proposes mostly appropriate solutions.	A very good application of a range of basic methods, materials, tools and/or techniques. Very good consideration of the context of the application. Very good evidence of different approaches to problem-solving in particular contexts and proposes appropriate solutions.	An advanced application of a range of taught, basic methods, materials, tools and/or techniques. The context of the application is well considered, and insightful. Excellent evidence of different approaches to problem-solving in particular contexts and proposes appropriate solutions.	Exceptional levels of application and deployment skills in particular practical contexts. Outstanding identification of problems in particular contexts and formulation of wholly appropriate, thoughtful solutions / different approaches.

Transferable skills for life and professional practice (Communicate the results of their study/work accurately and reliably, and with structured and coherent arguments; the qualities needed for employment requiring the exercise of some personal responsibility within a structured and managed environment.)	Work is poorly structured, disorganised, inaccurate and/or confusingly expressed. Very weak use of language and/or very inappropriate style. Failure to work effectively individual or as part of a group. Little or no evidence of the skills for employment requiring the exercise of some personal responsibility.	Work is poorly presented in a disjointed manner. It is loosely, and at times incoherently, structured, with information and ideas often poorly expressed. Weak use of language and/or inappropriate style. Flawed approach to individual or group work, meeting only partial obligations to others. Limited evidence of the skills for employment requiring the exercise of some personal responsibility.	Mostly ordered presentation and structure in which relevant ideas / concepts are reasonably expressed. Work may lack coherence and/or accuracy in places. Can work as part of a group, meeting most obligations to others but perhaps with limited involvement in group activities. Demonstrates the basic skills for employment requiring the exercise of some personal responsibility, with some areas of minor weakness.	Mostly coherent, organised and accurate work, in a suitable structure and is for the most part clearly expressed. Can work effectively independently and/or as part of a team, with clear contribution to group activities. Demonstrates the skills for employment requiring the exercise of some personal responsibility, with some areas of strength and some of minor weakness.	Work is accurate, coherent, fluent, well-structured and organised. Can work effectively independently and/or as part of a team, with very good contribution to group activities. Demonstrates very good skills for employment requiring the exercise of some personal responsibility, with just occasional minor weakness.	Work is coherent, very fluent and is presented professionally. Can work effectively independently and/or as part of a team, with an excellent contribution to group activities. Demonstrates excellent skills for employment requiring the exercise of some personal responsibility with an appetite for further development.	Work is accurate, exceptionally coherent, very fluent and presented well. Can work effectively independently and/or as part of a team, with an exceptional contribution to group activities. Demonstrates exceptional skills for employment requiring the exercise of some personal responsibility with an appetite for further development.
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EMBEDDED SYSTEMS

Temperature Indication System

James Watts

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Introduction

The following report is based on the effectiveness of heating systems in my workplace as there has been numerous questions raised regarding its efficiency in keeping the area at a comfortable working temperature. To resolve this issue I am going to design and construct a device capable of indicating whether the working conditions are acceptable or not. The device will indicate to my colleagues if it is too cold, too warm or if the temperature is within the acceptable range. The temperature indication will need to attract attention so that any of my colleagues or myself will notice it. Therefore, allowing an appropriate control measure can be used utilised to deal with the situation.

The report will include a detailed view the construction of the circuit, including the components required and the programming algorithm and final code used to carry out the monitoring of temperature as well as the testing of the final system.

Hardware Design

The microcontroller that I have decided to use for temperature indication system is the Orangepi Arduino board. A microcontroller is a computer which contains a memory and is able to have inputs and outputs to and from external devices. They are used within equipment to carry out a specific task. This is supported by Brain (No date, How Stuff Works) who states 'Microcontrollers are "embedded" inside some other device (often a consumer product) so that they can control the features or actions of the product.' This device will be used to interact between a temperature-sensing input and provide the appropriate output. Appendix A shows the features of the Orangepi Arduino microcontroller.

	7 Segment Display	Buzzer	LED
Indication	-1	0	+1
Commissioning	0	0	0
Preference	-1	0	+1
	-2	0	2

Table 1 - Decision Matrix of Potential Indicators

The temperature indication device that I have chosen to produce will use a light-emitting diode (LED) output so that my colleagues will be provided with visual indication. The system will need to be able to visibly show whether the temperature is too warm, too cold or within the acceptable temperature range. This will mean that three different coloured LED's will need to be used. Therefore, I have chosen to use a tricolour LED which has red, green and blue colours incorporated into one device (see Appendix C). This will save space on the breadboard and also make the circuit wiring easier to accomplish.

The LED will require a resistor in series with the power supply to it as the microcontroller provides a 5V supply which is too great for the LED. Therefore, resistors will be used to lower the voltage supply to the LED to protect it from overheating. Equation 1 shows the formula used to calculate the theoretical resistor size that should be used in the circuit board, which is 110Ω . However, to prolong life expectancy and to reduce the heat generated from the LED; I have chosen to use a 220Ω resistor.

Equation 1 - LED Resistor Formula

$$LED \text{ Resistor Calculation} = \frac{Voltage \text{ Supply} - LED \text{ Voltage}}{LED \text{ Current}}$$

$$Mean \text{ LED Voltage} = \frac{1.9 + 3.2 + 3.3}{3} = 2.8V$$

$$LED \text{ Resistor Size} = \frac{5 - 2.8}{20 \times 10^{-3}} = 110\Omega$$

The temperature detector that I have chosen to use is the DHT11 temperature sensor. This is because it has a wide temperature measuring span of 50°C, accommodating the temperatures that will be measured in the workplace. It is able to be powered from a 5V (see Appendix B) supply in which the chosen microcontroller is able to provide.

Table 2 includes all of the components required to create the temperature indicator. Figures 1 and 2 show the physical layout of the circuit that I will use within the workplace.

Temperature Indication Circuit Components	
Component	Quantity
Orange-pip Arduino Microcontroller	1
Kingbright RGB LED	1
DHT11 Temperature Sensor	1
220Ω Resistor (±5%)	3
Breadboard	1
Male to Male Jumper Cable	7

Table 2 - Components Table

Software Design

The temperature indication system must be able to notify the people in the workplace of the current temperature conditions, showing whether the temperature is too warm, too cold or in an acceptable range. Therefore, I must decide on appropriate temperature band limits. As there are many employees at my place of work, it is difficult to determine a comfortable working temperature range. Therefore, I have chosen to use 16°C as the lower band temperature limit as it is recommended by Health and Safety Executive (HSE). This is shown by Unknown, (No date, Health and Safety Executive) explaining that the 'minimum temperature in a workplace should normally be at least 16 degrees Celsius.' However, there is no maximum working temperature provided by the HSE. Therefore, I have asked my colleagues to carry out a survey for the upper temperature band limit and the results are shown in figure 3 below. The results show that 22°C is the most voted for temperature, which I will use for the temperature indication system.

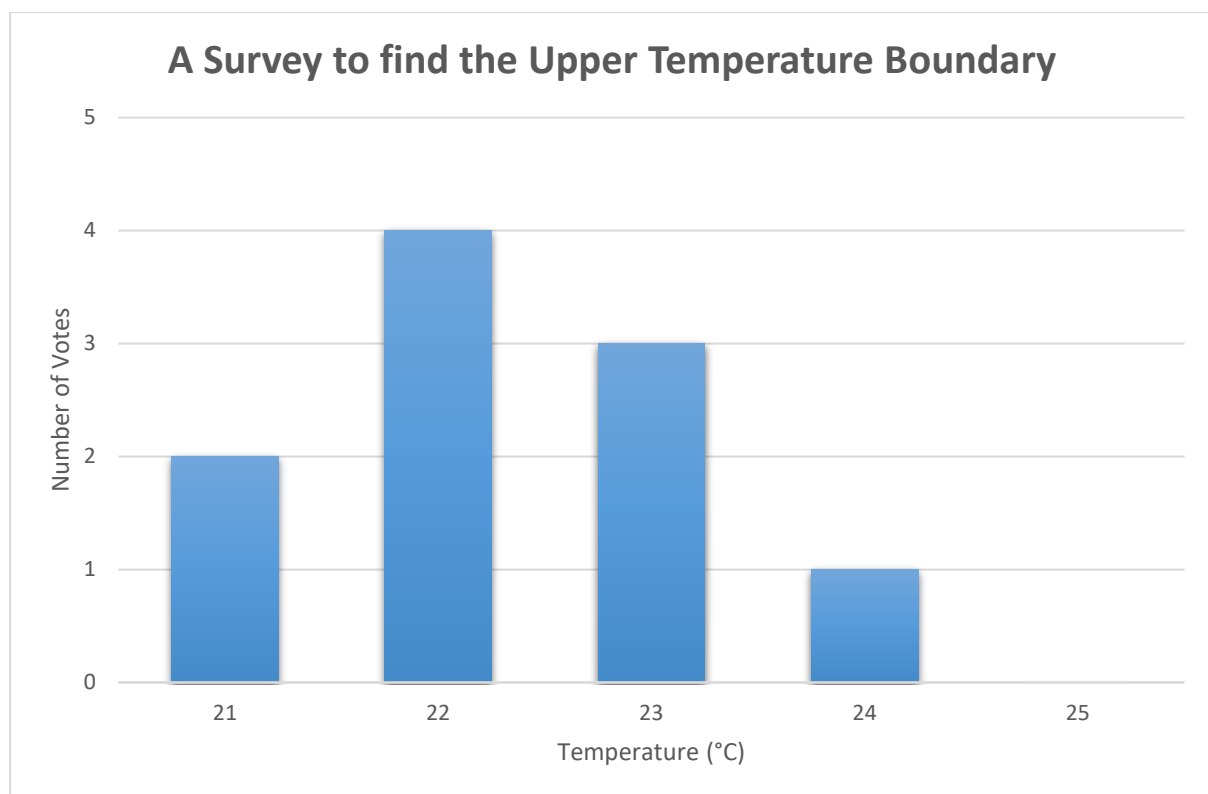


Figure 3 - Upper Temperature Limit Survey Results

Following establishing the temperature band limits for the indication system, the next step is to design the operation of the system. The temperature indication system will need to continuously monitor the workplace temperature and feedback information to personnel via the LED. Figure 4 is a flow chart of the temperature indication system operation which is used to show the sequence of events used to provide feedback.

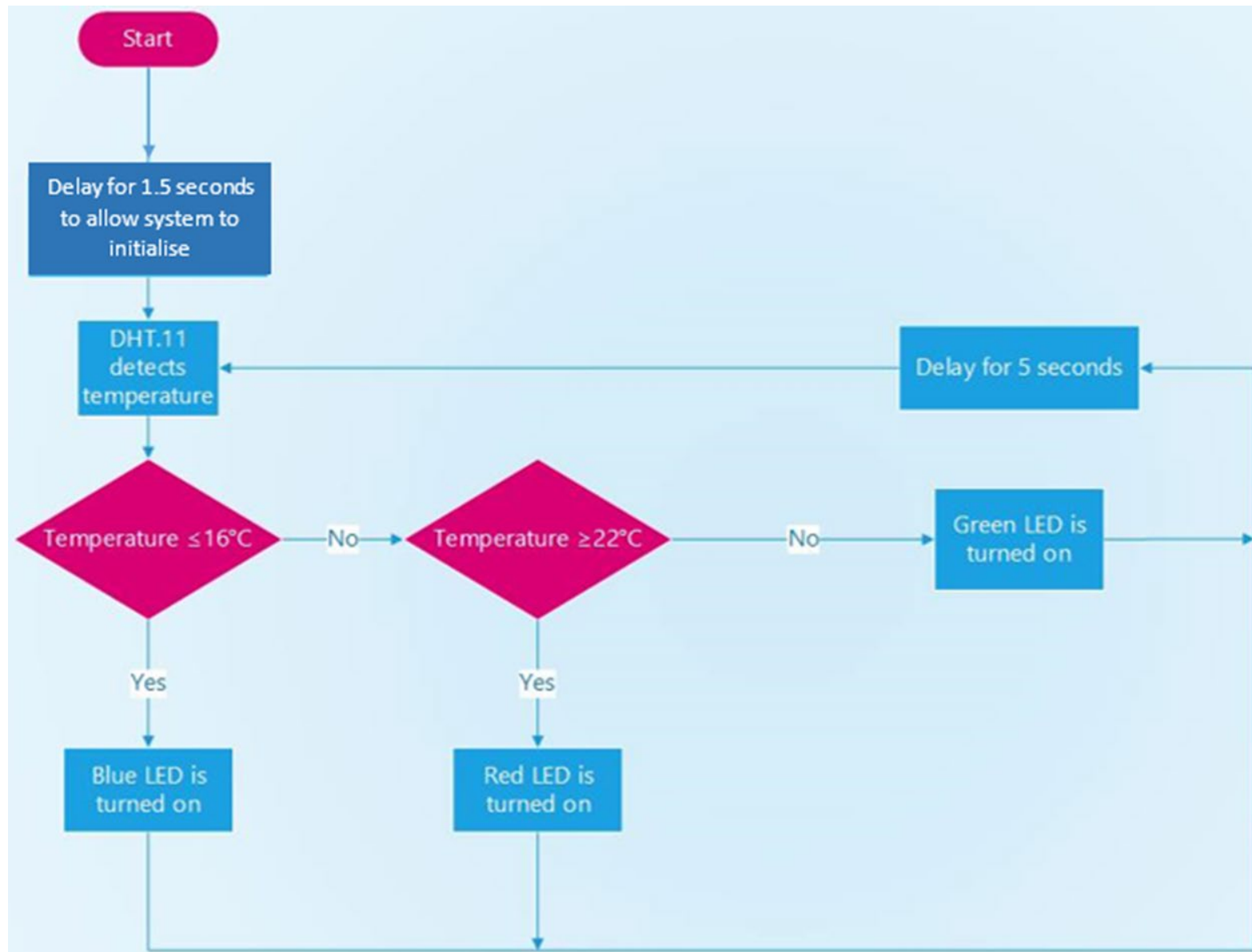


Figure 4 – Operational Flow Chart

Circuit Test Report

Temperature Indication System Circuit Test Plan

Component Check						
Component: Orangepip Arduino Microcontroller						
Is the microcontroller the correct type?	Yes	✓	No		Initial	JW
Component passed?	Yes	✓	No		Initial	JW
Component: DHT11 Temperature Sensor						
Is the temperature sensor the correct type?	Yes	✓	No		Initial	JW
Component passed?	Yes	✓	No		Initial	JW
Component: Tricolour LED						
Is the LED the correct type?	Yes	✓	No		Initial	JW
Component passed?	Yes	✓	No		Initial	JW
Component: 220Ω Resistors						
Are the resistors the correct type?	Yes	✓	No		Initial	JW
Component passed?	Yes	✓	No		Initial	JW
Component: Male to Male Jumper Leads						
Are the jumper leads the correct type?	Yes	✓	No		Initial	JW
Component passed?	Yes	✓	No		Initial	JW
Circuit Visual Inspection						
All components installed?	Yes	✓	No		Initial	JW
Component polarity correct?	Yes	✓	No		Initial	JW
All connections tight?	Yes	✓	No		Initial	JW
Any short circuits?	Yes		No	✓	Initial	JW
Any open circuits?	Yes		No	✓	Initial	JW
Final Circuit Inspection						
Circuit Passed	Yes	✓	No		Initial	JW

Table 3 – Testing of Circuit

Testing of Temperature Indication System

The following tests were carried out by subjecting the temperature sensor to conditions in each of the temperature zones. The serial monitor was used to measure the temperature whilst checking that the correct LED colour was present.

Below Normal Temperature Conditions		
Temperature	LED Colour	Passed
16	Blue	✓
15	Blue	✓
14	Blue	✓
Normal Temperature Conditions		
Temperature	LED Colour	Passed
17	Green	✓
19	Green	✓
21	Green	✓
Above Normal Temperature Conditions		
Temperature	LED Colour	Passed
22	Red	✓
30	Red	✓
41	Red	✓

Table 4 – Functional Testing

The results obtained in table 4 shows that the temperature indication system has proven to be a success. This is because the correct LED colour is illuminated according the temperature that the DHT11 temperature sensor is exposed to. Evidence is provided from figures 5-10 showing the temperature measurements by using the serial monitor display. This is used to print the temperature and humidity measured by the DHT11 temperature sensor. The figures also show the LED colour compared to the temperature reading to verify that the temperature indication system is functioning correctly.

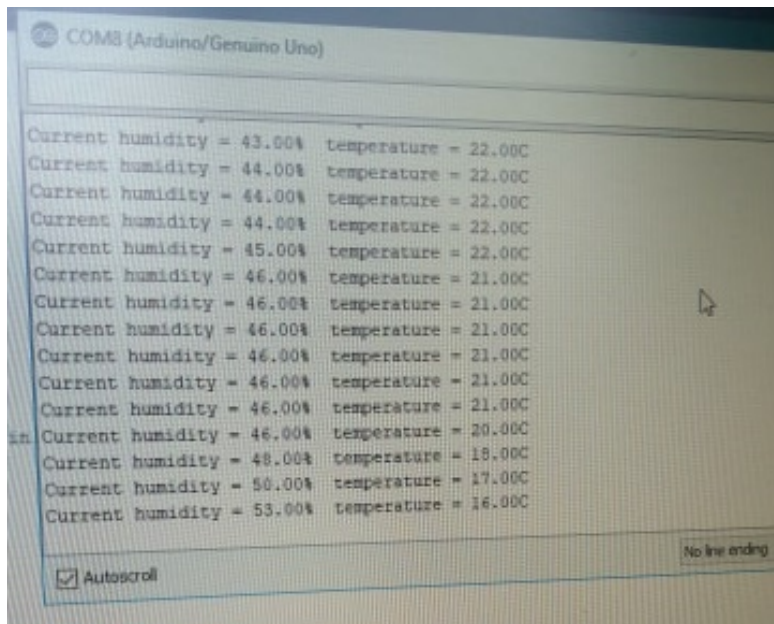


Figure 5 - Serial Monitor Results for Lower Temperature Band

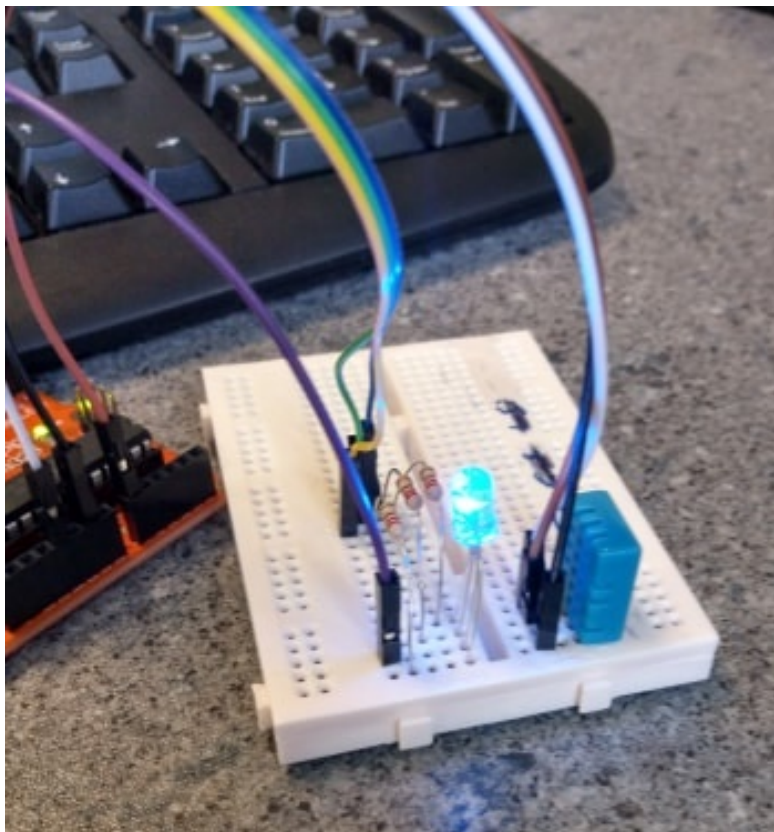


Figure 6 – Blue LED displayed for Lower Temperature Band

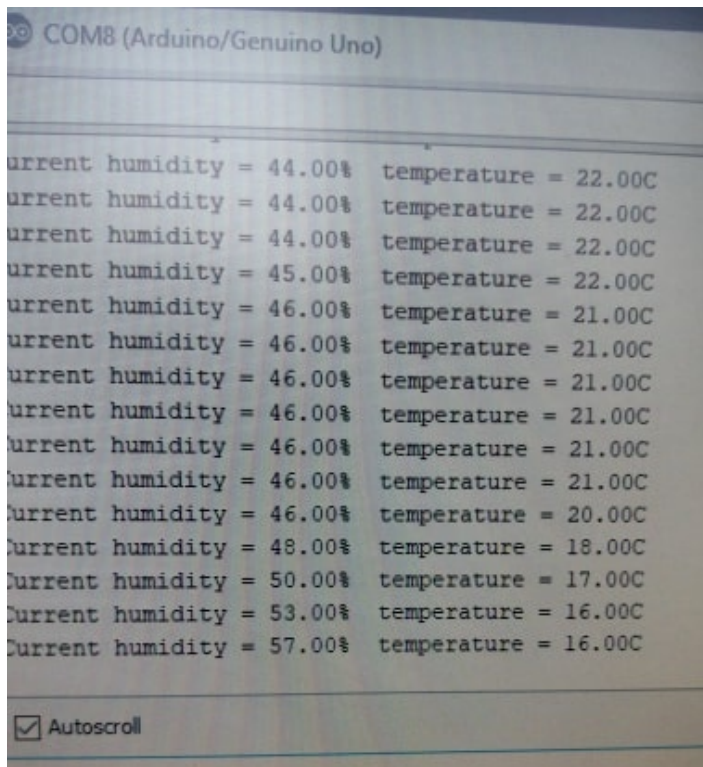


Figure 7 - Serial Monitor Results for Normal Temperature Conditions

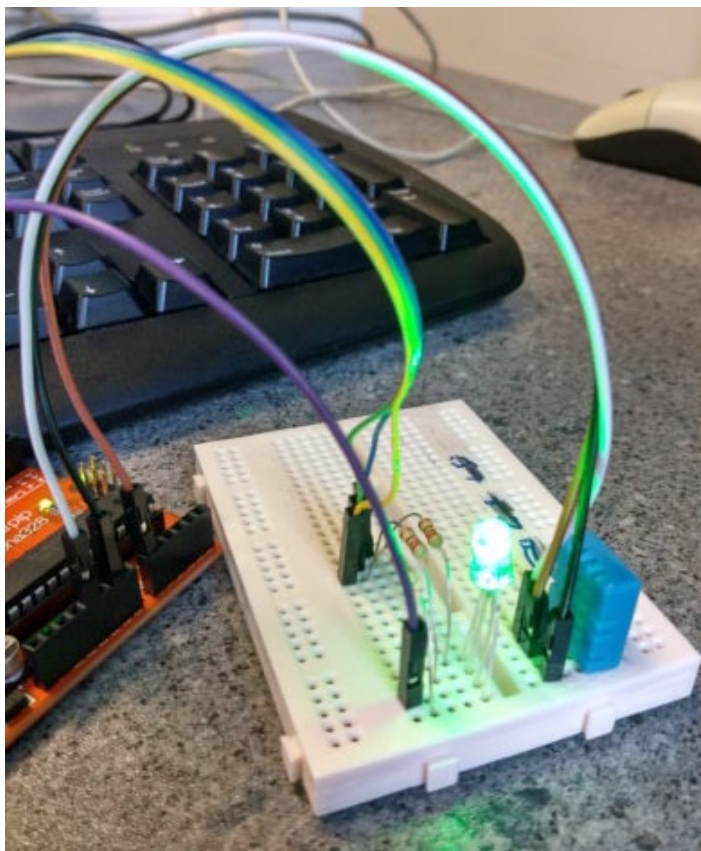


Figure 8 – Green LED Displayed for Normal Temperature Conditions

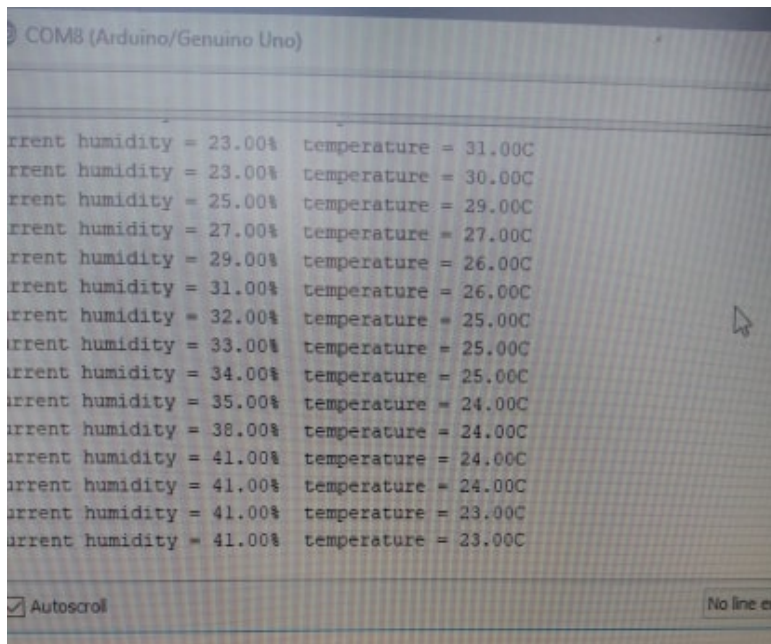


Figure 9 - Serial Monitor Results for Lower Temperature Band

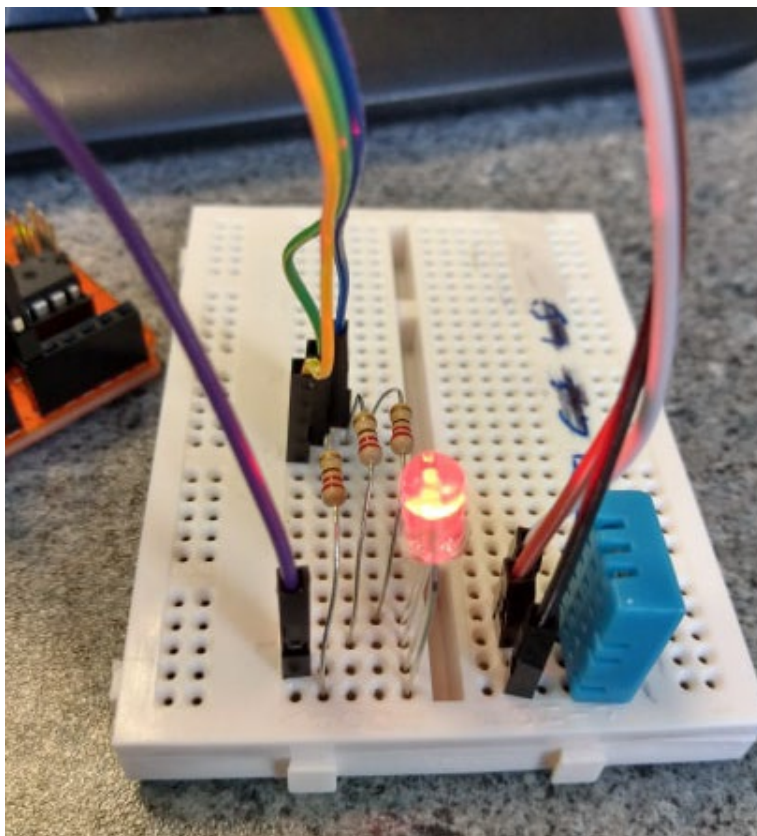


Figure 10 - Red LED Displayed for Upper Temperature Band

Documentation

```
const int Rled = 11;
const int Gled = 10;
const int Bled = 9;
const int LIGHT = 0;
const int MIN_TEMP = 16;
const int MAX_TEMP = 22;
int val = 0;

#include "dht.h"
#define dht_pin A0
dht DHT;

void setup() {

    Serial.begin(9600);
    delay(500); //Delay to let system boot
    Serial.println("DHT11 Humidity & temperature Sensor\n\n");
    delay(1000); //Wait before accessing Sensor

    pinMode(Rled, OUTPUT);
    pinMode(Gled, OUTPUT);
    pinMode(Bled, OUTPUT);

}

void loop() {

    DHT.read11(dht_pin);

    Serial.print("Current humidity = ");
    Serial.print(DHT.humidity);
    Serial.print("% ");
    Serial.print("temperature = ");
    Serial.print(DHT.temperature);
    Serial.println("C ");
    val=DHT.temperature;
    delay(5000); //Wait 5 seconds before accessing sensor again.

    if (val >= MAX_TEMP)
    {
        analogWrite(Rled, 255);
        analogWrite(Gled, 0);
        analogWrite(Bled, 0);
        //digitalWrite(Rled, HIGH);
        //digitalWrite(Gled, LOW);
        //digitalWrite(Bled, LOW);
    }
    else if (val <= MIN_TEMP)
    {
        analogWrite(Rled, 0);
        analogWrite(Gled, 0);
        analogWrite(Bled, 255);
        //digitalWrite(Rled, LOW);
        //digitalWrite(Gled, LOW);
        //digitalWrite(Bled, HIGH);
    }
    else //if (val >16 || val<22)
    {
        analogWrite(Rled,0);
        analogWrite(Gled, 255);
        analogWrite(Bled, 0);
        //digitalWrite(Rled, LOW);
        //digitalWrite(Gled, HIGH);
        //digitalWrite(Bled, LOW);
    }

}
```

Figure 11 - Temperature Indication System Code

Figure 11 above shows the coding of the system. The first part of the code is the variable declaration section where the variables are assigned to the microcontroller. This includes the external hardware connected into the microcontroller such as the DHT11 temperature indicator as shown by saying `#include "dht.h"`. This allows the extension header file to be used within the program so that the sensor is able to function. The `#define dht_pin A0` is used to change the name in the program to the value measured by the component which is an input via the A0 pin. Therefore when the name is used within the code, the pre-processor will change the name to the temperature being measured by the DHT11. The output pins are assigned to the LED's using `const int Rled = 11;` which is used to assign an LED with a read-only pin. The temperature band boundaries are also assigned during this section so that if the limits need to be changed, it can be achieved here as it is clearly shown.

The void setup section is where the actions only take place a single time so it is used for the initiation of the microcontroller and the temperature sensor. The temperature sensor requires a specific signal transmission rate (baud) so that it is able to communicate with the microcontroller. For this reason, `Serial.begin(9600);` is used to establish the transmission rate between the DHT11 and microcontroller. As the serial monitor is used to compare the measured temperature against the LED colour, a title is used to show what is being measured. This is achieved by using `Serial.println("DHT11 Humidity & temperature Sensor\n\n");`. The pins are also assigned as an output in this section as they go to the LED's which are used for indication purposes only.

The void loop section is where its contents run continuously until the system is turned off. This allows the temperature sensor to repeatedly scan for temperature and humidity, whilst displaying the results on the serial monitor by using the print function. The measured temperature has been assigned with a variable name `val=DHT.temperature;`. This is then able to be incorporated within the indication system by stating the maximum and minimum temperature values at the variable declaration section. This can then be used to illuminate the appropriate LED by using multiple if statements and setting temperature boundaries and setting the appropriate LED to be turned on. However, the LED indication is only registering temperature and not humidity. This is achieved using the `analogWrite` which outputs a voltage to a selected pin. The voltage can be changed by altering the scale reading but 255 is the maximum output level for the LED.

System Explanation

The software uses the processed values from the temperature sensor to carry out a designated output which is dependent on the written code. The written code is compiled and transformed into a format that the microcontroller can perform. This is supported by Burgess (1999, p.6) stating 'a compiler which takes the typed source program and converts it into an object file that the computer can execute.' The compiler is used to search for any errors within the code that will cause the programme not to run. Once the code has been compiled and error free, it can then be exported to the microcontroller which uses a variety of logic gates to achieve the correct output which is specific to the code. For example, the green LED is illuminated when the temperature is greater than 16 and less than 22, 'else //if (val >16 || val<22)'. This is an example of an AND gate because the value needs to be greater than 16 but less than 22 for the green LED to be illuminated.

The microcontroller is able to receive discrete and analogue signals from external devices such as the DHT11 temperature sensor. However, the microcontroller is unable to register a temperature reading with respect to change in voltage. Therefore, it converts the analogue signal into a binary signal, enabling the microcontroller to understand the information, allowing it to be utilised. This is supported by Unknown, (No date, Arduino) explaining that 'Arduino boards contain a multichannel, 10-bit analogue to digital converter. This means that it will map input voltages between 0 and the operating voltage ... into integer values'.

Evaluation

Now that I have completed the project which was to design and create a simple, yet effective system that monitors the room temperature and informs personnel of the working conditions. I am now able to evaluate the whole process from designing up until the testing of the finished system.

On completion of coding, circuit testing was performed and the results are shown in table 3. This was carried out to verify that if there were any faults with the program, it would be within the code as the circuit had already been tested, saving time when fault finding. The functional testing of the system shown in table 4, demonstrates that the system worked accordingly. This is because the associated LED with the temperature zone was illuminated.

On the whole, I feel that even though the project was a success as the specification contents were achieved, the system could still be improved. This is because in a busy workplace the LED may become unnoticed so a cluster of LED's would be more effective when indicating personnel. It would be beneficial if the cluster of LED's were housed in a suitable enclosure to protect the components from being damaged. It would also be advantageous if the system was portable by using a DC battery supply, enabling the system to move around the workplace without the need of a fixed power supply. With regards to the coding, I feel that the delay of five seconds is too short between in scan of the temperature and think that a scanning interval of one minute would be more suitable for the system. The system could be improved by adding a keypad allowing individuals to change the upper and lower band temperatures without the need of myself to change the code to carry out this change. I think that a sounder/buzzer would improve the system if it were to be used alongside the LED indication so that the system would still be detected if visual indication was to be accidentally covered by an object. However, if the workplace was to become noisy, restricting the ability for someone to hear the sounder/buzzer the LED indicator would be seen.

References

Appendix A – Orangepip Microcontroller Datasheet. Available from:

https://static.rapidonline.com/pdf/75-0550_v1.pdf

Appendix B – DHT11 Temperature Sensor Datasheet. Available from:

<https://image.dfrobot.com/image/data/KIT0003/DHT11%20datasheet.pdf>

Appendix B – Kingbright Tricolour LED Datasheet. Available from: <https://docs-emea.rs-online.com/webdocs/139d/0900766b8139d70c.pdf>

Brain, M (No date). How Stuff Works. (Online). (1 May 2019). Available from:

<https://electronics.howstuffworks.com/microcontroller1.htm>

Burgess, M (1999). *C Programming Tutorial*. 4th Edition. (s.n)

Unknown, (No date). Arduino. (Online). (6 May 2019). Available from:

<https://www.arduino.cc/reference/en/language/functions/analog-io/analogread/>

Unknown, (No date). Health and Safety Executive. (Online). (5 May 2019). Available from: <http://www.hse.gov.uk/temperature/law.htm>

Bibliography

Bird, J (2007). *Electrical and Electronic Principles and Technology*. 3rd Edition.

Oxford: Elsevier Ltd

Brain, M (No date). How Stuff Works. (Online). (1 May 2019). Available from:

<https://electronics.howstuffworks.com/microcontroller1.htm>

Burgess, M (1999). *C Programming Tutorial*. 4th Edition. (s.n)

Miller, R and Miller, M.R. (2014). *Industrial Electricity and Motor Controls*. 2nd Edition.

London: McGraw-Hill Education

Unknown (No date). Resistor Guide. (Online). (1 May 2019). Available from:

<http://www.resistorguide.com/resistor-for-led/>

Unknown, (No date). All About Circuits. (Online). (6 May 2019). Available from:

<https://www.allaboutcircuits.com/worksheets/microcontroller-principles/>

Unknown, (No date). Arduino. (Online). (6 May 2019). Available from:

<https://www.arduino.cc/reference/en/language/functions/analog-io/analogread/>

Unknown, (No date). Health and Safety Executive. (Online). (5 May 2019). Available from:

<http://www.hse.gov.uk/temperature/law.htm>



Kona328 Arduino UNO Compatible Development Board

Order code: 75-0550

Overview

The Kona328 is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

The Kona328 differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the ATmega8U2 programmed as a USB-to-serial converter. Revision 2 of the Kona328 board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode.

Summary

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

Power

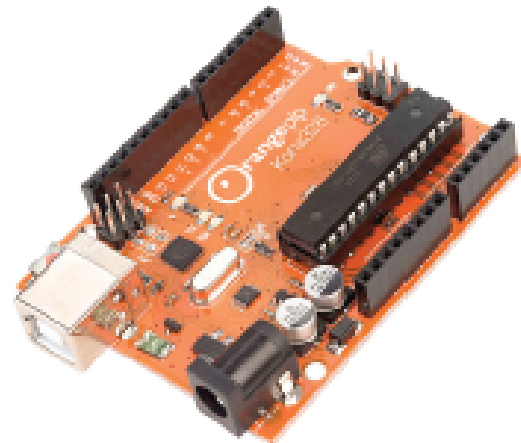
The Kona328 can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

VIN The input voltage to the Kona328 board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.



5V The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.

3V3 A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.

GND Ground pins.

Memory

The ATmega328 has 32 KB (with 0.5 KB used for the bootloader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

Input and Output

Each of the 14 digital pins on the Kona328 can be used as an input or output, using `pinMode()`, `digitalWrite()`, and `digitalRead()` functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

Serial: 0 (RX) and 1 (TX) Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

External Interrupts: 2 and 3 These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the `attachInterrupt()` function for details.

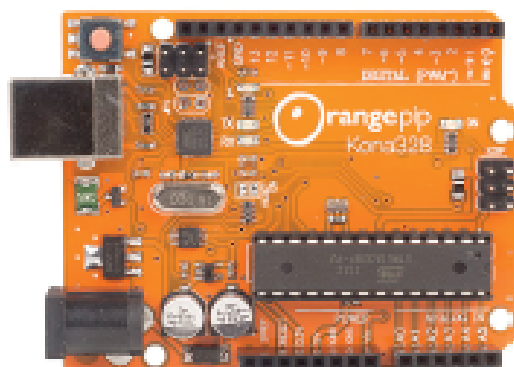
PWM: 3, 6, 9, 10, and 11 Provide 8-bit PWM output with the `analogWrite()` function.

SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK) These pins support SPI communication using the SPI library.



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LED: 13 There is a builtin LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Kona328 has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though it is possible to change the upper end of their range using the AREF pin and the `analogReference()` function. Additionally, some pins have specialized functionality:

I2C: A4 (SDA) and A5 (SCL) Support I2C communication using the Wire library. There are a couple of other pins on the board:

AREF Reference voltage for the analog inputs. Used with `analogReference()`.

Reset Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

See also the mapping between OrangePi pins and ATmega328 ports?

Communication

The Kona328 has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega8U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '8U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, a .inf file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

A SoftwareSerial library allows for serial communication on any of the Kona328's digital pins.

The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation for details. For SPI communication, use the SPI library. Programming

The Kona328 can be programmed with the Arduino software. Select "Arduino Uno" from the Tools > Board menu (according to the microcontroller on your board). For details, see the reference and tutorials.

The ATmega328 on the Kona328 comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).

You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header; see these instructions for details.

The ATmega8U2 firmware source code is available. The ATmega8U2 is loaded with a DFU bootloader, which can be activated by connecting the solder jumper on the back of the board and then resetting the 8U2. You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer.

Automatic (Software) Reset

Rather than requiring a physical press of the reset button before an upload, the Kona328 is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2 is connected to the reset line of the ATmega328 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the bootloader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.

This setup has other implications. When the Kona328 is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the bootloader is running on the Kona328. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data.

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The Kona328 contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line.

USB Overcurrent Protection

The Kona328 has a resettable polyfuse that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

Physical Characteristics

The maximum length and width of the Kona328 PCB are 2.7 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Four screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins.

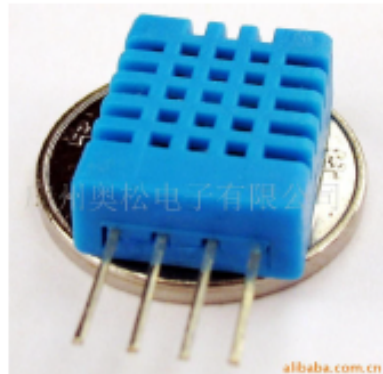


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Appendix B – DHT11 Datasheet

Digital-output relative humidity & temperature sensor/module – DHT11



Resistive-type humidity and temperature module/sensor

1. Feature & Application:

* Full range temperature compensated * Relative humidity and temperature measurement
* Calibrated digital signal * Outstanding long-term stability * Extra components not needed
* Long transmission distance * Low power consumption * 4 pins packaged and fully interchangeable

2. Description:

DHT11 output calibrated digital signal. It utilizes exclusive digital-signal-collecting-technique and humidity sensing technology, assuring its reliability and stability. Its sensing elements is connected with 8-bit single-chip computer.

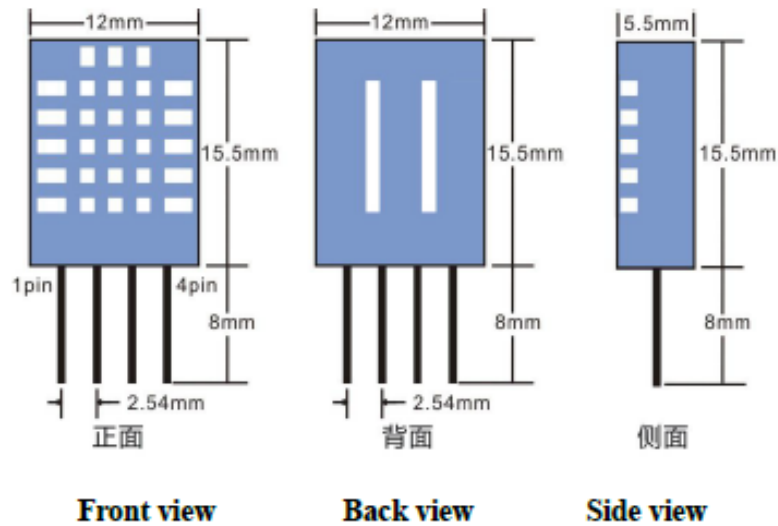
Every sensor of this model is temperature compensated and calibrated in accurate calibration chamber and the calibration-coefficient is saved in OTP memory.

Small size & low consumption & long transmission distance(20m) enable DHT11 to be suited in all kinds of harsh application occasions. Single-row packaged with four pins, making the connection very convenient.

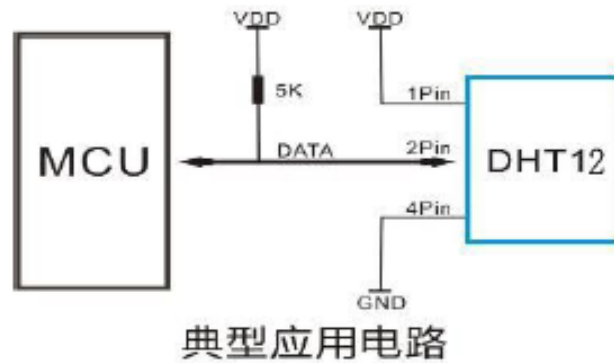
3. Technical Specification:

Model	DHT11		
Power supply	3-5.5V DC		
Output signal	digital signal via single-bus		
Sensing element	Polymer resistor		
Measuring range	humidity 20-90%RH; temperature 0-50 Celsius		
Accuracy	humidity $\pm 4\%$ RH (Max $\pm 5\%$ RH); temperature ± 2.0 Celsius		
Resolution or sensitivity	humidity 1%RH;	temperature 0.1 Celsius	
Repeatability	humidity $\pm 1\%$ RH;	temperature ± 1 Celsius	
Humidity hysteresis	$\pm 1\%$ RH		
Long-term Stability	$\pm 0.5\%$ RH/year		
Sensing period	Average: 2s		
Interchangeability	fully interchangeable		
Dimensions	size 12*15.5*5.5mm		

4. Dimensions: (unit—mm)



5. Typical application



3Pin=NULL, MCU=Microcomputer or single-chip computer

6. Operating specifications:

(1) Power and Pins

Power's voltage should be 3-5.5V DC. When power is supplied to sensor, don't send any instruction to the sensor within one second to pass unstable status. One capacitor valued 100nF can be added between VDD and GND for power filtering.

(2) Communication and signal

Single-bus data is used for communication between MCU and DHT11.

7. Electrical Characteristics:

Item	Condition	Min	Typical	Max	Unit
Power supply	DC	3	5	5.5	V
Current supply	Measuring	0.5		2.5	mA
	Stand-by	100	Null	150	uA
	Average	0.2	Null	1	mA

Selection Guide

Part No.	Dice	Lens Type	Iv (mcd) [2]@ 20mA		Viewing Angle [1]
			Min.	Typ.	
L-154A4SUREQBF2GEW	Hyper Red (AlGaInP)	White Diffused	400	1000	60°
			*120	*250	
	Blue (InGaIn)		300	500	
			*300	*500	
	Green (InGaIn)		900	1700	
			*900	*1700	

Notes:

1. 60° is the angle from optical centerline where the luminous intensity is 1/2 of the optical peak value.

2. Luminous Intensity/ luminous Flux: $\pm 15\%$.

* Luminous intensity value is traceable to the CIE 127-2007 compliant national standards.

Electrical / Optical Characteristics at TA=25°C

Symbol	Parameter	Device	Typ.	Max.	Units	Test Conditions
λ_{peak}	Peak Wavelength	Hyper Red Blue Green	645 480 520		nm	I=20mA
λ_D [1]	Dominant Wavelength	Hyper Red Blue Green	630 485 525		nm	I=20mA
$\Delta\lambda_{1/2}$	Spectral Line Half-width	Hyper Red Blue Green	25 25 35		nm	I=20mA
C	Capacitance	Hyper Red Blue Green	45 100 100		pF	V=0V, f=1MHz
V _f [2]	Forward Voltage	Hyper Red Blue Green	1.9 3.3 3.2	2.5 4 4	V	I=20mA
I _r	Reverse Current	Hyper Red Blue Green		10 50 50	uA	V _r =5V

Notes:

1. Wavelength: $\pm 1nm$.

2. Forward Voltage: $\pm 0.1V$.

3. Wavelength value is traceable to the CIE 127-2007 compliant national standards.

Absolute Maximum Ratings at TA=25°C

Parameter	Hyper Red	Blue	Green	Units
Power dissipation	75	120	120	mW
DC Forward Current	30	30	30	mA
Peak Forward Current [1]	200	150	100	mA
Reverse Voltage	5			V
Operating/Storage Temperature	-40°C To +85°C			
Lead Solder Temperature [2]	260°C For 3 Seconds			
Lead Solder Temperature [3]	260°C For 5 Seconds			

Notes:

1. 1/10 Duty Cycle, 0.1ms Pulse Width.

2. 2mm below package base.

3. 5mm below package base.

SPEC NO: DSAJ9604

REV NO: V.6A

DATE: MAR/22/2013

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