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DESIGN AND DEVELOPMENT OF MICROCONTROLLER BASED LOCALISED AIR HEATER

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***Abstract*— Although Malaysia is an equatorial country that has a tropical climate, it still has several places that have relative low ambient temperature due to the high altitude. For Cameron Highlands, the air temperature is ranged from 14.6°C to 23.3°C along the year. Humans may feel uncomfortable or unwell since the thermal comfort zone of human body ranges from 20°C to 27°C. Hence, an air heating system needs to be developed in order to solve this problem. This paper discussed the development of an air heating system that can heat up the room automatically when the temperature drops to certain value. This system is designed for a low cost but high performance. The microcontroller is used to provide control mechanism when the sensors detected a temperature drop. Fans and heating elements provide the air flow and heat.**

***Keywords*—Microcontroller; Thermistor; Air heating.**

I. INTRODUCTION

Malaysia is a country located on the equator that has a tropical rainforest climate that is relatively hot throughout the year. However, there are several places in Malaysia that have low temperature climate due to their high altitude. Genting Highlands and Cameron Highlands are the examples of these places. Daily temperature for Cameron Highlands is recorded to be ranged between 14.6°C to 23.3°C.

In Cameron Highlands, the average temperature during daytime is around 21°C to 23°C, which is within the thermal comfort zone of human body in a range of 20°C to 27°C. However, the surrounding temperature can go as low as 14.6°C at night or rainy day. This may causes the people to be sick or uncomfortable due to the cold temperature. Hence, an air heating system is developed for the purpose to heat up the room temperature during cold climate. This air heating system is used to heat up the room when the temperature drops to certain values. The microcontroller in the system is installed with working code to control other peripherals such as fans and heating elements. Once the sensors in this system determined the room temperature is lower than targeted temperature, the microcontroller controls the heating elements to heat up the air, hence provides a comfort environment to the user.

Microcontroller has been widely used in various applications because it provides multiple functions at very low cost. Various control mechanisms can be achieved easily by using microcontroller in the system. Al Emon et. al. [1] developed a temperature controller for the application of industrial temperature control. In this controller, the microcontroller was implemented to produce an inexpensive and flexible temperature controller. The temperature sensors, LM35 and the ATMEGA8 microcontroller were used to detect and control the temperature.

Microcontroller can be used in portable devices too since a microcontroller consumes very low power. This provides extraordinary performance to the device that is powered by battery. Qin and Cui [2] designed a portable granary thermometer to overcome the shortcomings of typical granary thermometer that is lack of flexibility, consists of complex structures and has high performance price ratio.

II. MATERIALS AND METHODS

A. System decomposition

The system of the air heater is divided into six subsystems in order to reduce the complexity of the system development. The subsystems have smaller size than the complete air heating system and each subsystem can work independently. Hence, any problem or bug in the subsystems can be detected easily and this minimize the time for debugging.

The six subsystems is later combined together to produce the complete air heating system, as shown in Fig. 1. These six subsystems are:

1. LCD Display Subsystem
2. Temperature Measurement Subsystem
3. User Interface Subsystem
4. Heating Control Subsystem
5. Air Flow Control Subsystem
6. Power Supply Subsystem

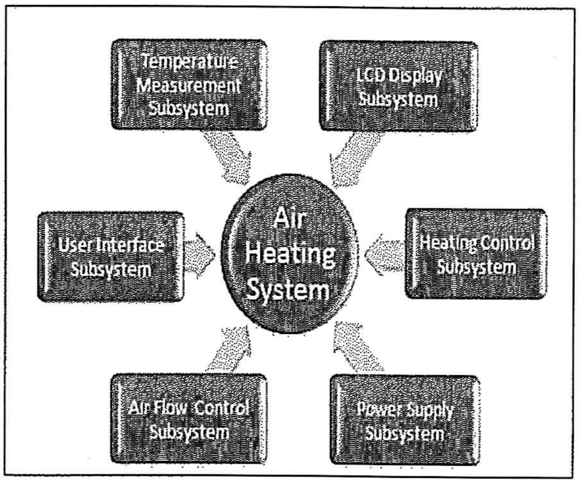

Figure 1. System decomposition.

B. Microcontroller

In this study, the MSP430 microcontroller is chosen as the core of the overall air heating system. The MSP430 microcontrollers are based on the Von Neumann architecture as shown in Fig. 2, so the volatile and non-volatile data will be stored in a single set of addresses.

This microcontroller provides the control mechanism for the whole air heater. The integrated Analog-Digital Converter (ADC) is used to measure the voltage signal from the thermistor. The flash memory is used to store the code of the control system. The static ram included is used for temporarily storage. The advantages for using microcontroller are ease of use, low cost, multi-function, and small size. This reduces the complexity and lead time of the manufacturing for the air heater.

Inside the microcontroller, the Digitally Controlled Oscillator (DCO) provides the clock for the system and it can be configured in various frequencies. Besides the DCO, MSP430 can use external oscillator to provide the more precise working frequency in the critical control system. However, the internal DCO is used in this air heating system because it has lower power consumption and better flexibility on the frequency as shown in Fig. 3.

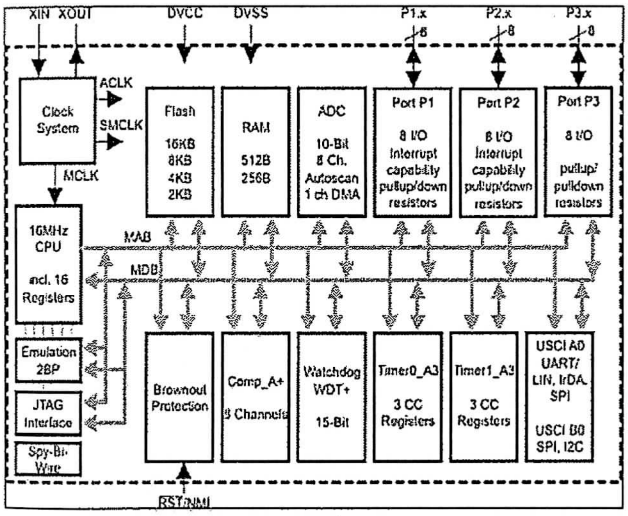

Figure 2. Internal structure of a MSP430 microcontroller

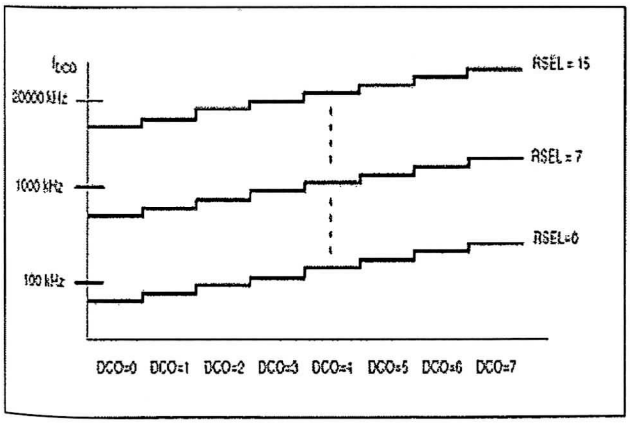

Figure 3. Frequency selection graph for the DCO.

C. LCD display subsystem

Referring to Fig. 4, the Alphanumeric type of LCD is used because it is easier to be configured. The 2 lines and 16 columns characters space are suitable and enough for display of the information such as the temperature values. It can be used to display the setting for the air heater.

The alphanumeric LCD has a memory that can store 160 ASCII characters code, which can be used for the display information by microcontroller. Fig. 5 shows the process flow for LCD display and in order to enable the LCD module to be controlled by the MSP430 microcontroller, it is required to initialize the LCD module. The function set determines the control interface between the microcontroller and LCD module. The cursor or display shift is setting for the operation of cursor shifting. The display on/off setting represented the operation of display and cursor. The entry mode set is the setting for the moving direction of cursor and display. As the microcontroller needs to output a character, it will set the required bits into the cursor or display shift. The cursor will move to the correct location and the character is selected according to font map included in the module memory.

Figure 4. LCD display module.

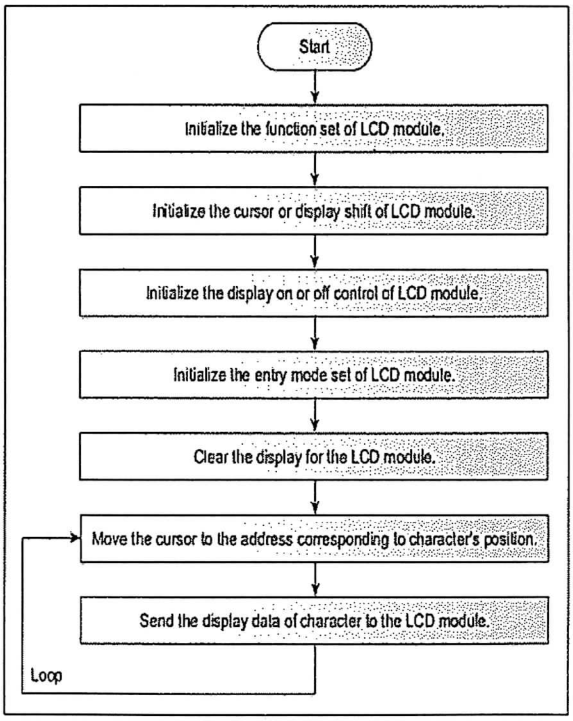

Figure 5. Process flow for LCD display subsystem.

D. *Temperature measurement subsystem*

For the temperature measurement of the air heating system, a NTC thermistor is used. The NTC thermistor has the lowest price compared to RTD and thermocouple. The high sensitivity of the NTC thermistor leads to high output voltage signal and this reduces the complexity of the system. The thermistor can response quickly to the temperature change since it has a very simple structure. It can be interfaced to electronic instrumentation easier compared to the thermocouple that needs a temperature reference.

Thermistor also has good electrical noise immunity and this allows the remote measurement through thermistor. However, the characteristic of a typical NTC thermistor is the resistance decreases nonlinearly as the temperature increases as shown in Fig. 6. This changing curve of resistance can be approximated through the equation of Steinhart and Hart with the constant value in the datasheet provided by manufacturer.

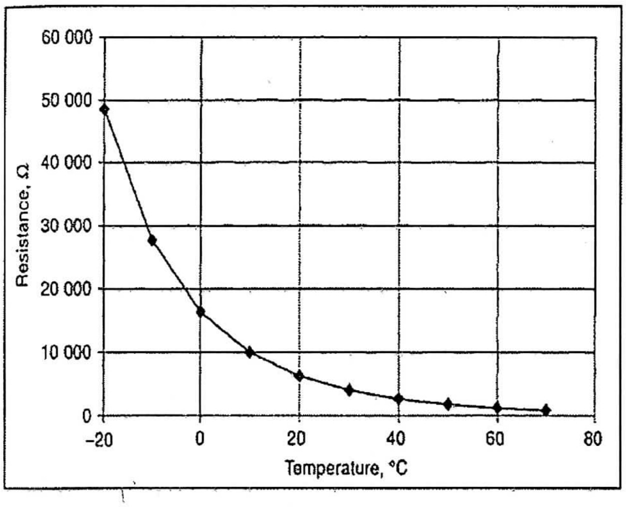

Figure 6. Typical characteristic of a NTC thermistor.

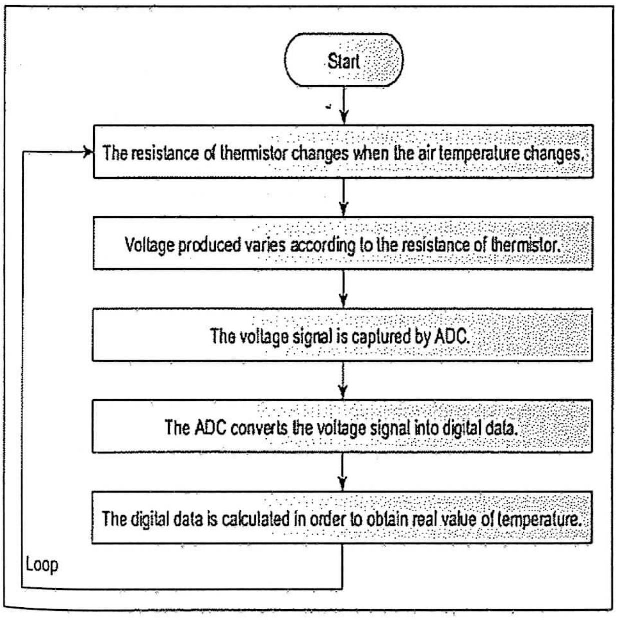

Figure 7. Process flow for temperature measurement subsystem.

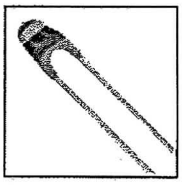

Figure 8. The NTC thermistor.

E. *User interface subsystem*

In order to provide the options for the user to set the target temperature of air heating system, a four-key keyboard and rotary encoders are used. The keyboard allows the user to access various options provided by the system. The user is able to set the target temperature that the heater needed to achieved through the rotary encoder.

A typical rotary encoder consists of three pins, which two pins connected to the supply voltage with resistors and one pin connected to the ground. When the rotary encoder is rotated, it works likes the switch that connects and disconnects with ground repeatedly. As the user turns the rotary encoder, this voltage signal will be sent to the microcontroller for the counting purpose. This will cause the target temperature to be increased. As the opposite, the targeted temperature decreases as the rotary encoder turning left. The rotary encoder in Fig. 9 provides advantage of less complexity when interfacing with the microcontroller. It is working in digital mode, which is different from typical potentiometer that required analog digital conversion.

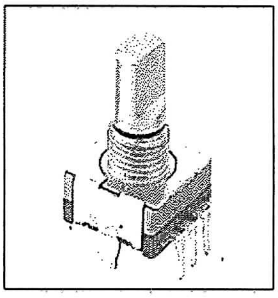

Figure 9. The rotary encoder.

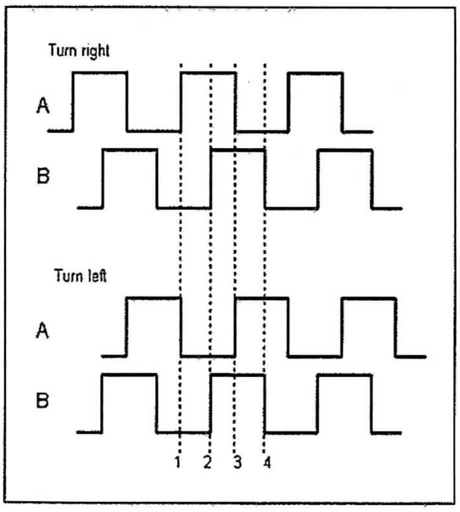

Figure 10. Output of the rotary encoder.

F. Heating control subsystem

For the heating section of the system, the resistance wire in Fig. 11 is used to heat up the air. A resistance wire is the cheapest solution compared to various methods for heating. It provides excellent durability too.

The material of the resistance wire is the Nichrome, which is a non-magnetic alloy of nickel and chromium. Nichrome is a type of material that has very high electrical resistance. As a current flow through the resistance wire, the high resistance in the wire causes a high power loss. This electrical power loss is released as heat. By applying the resistance wire in the air heating system, the heat can be generated using electricity. The microcontroller is able to control the amount of the current flow into the resistance wire, hence produces suitable amount of heat to increase the air temperature.

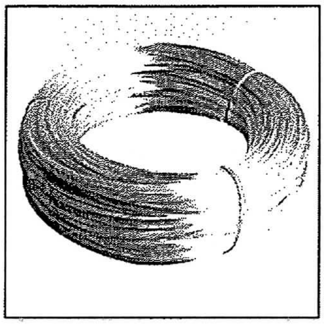

Figure 11. The resistance wire.

G. Air flow control subsystem

The PWM controlled fans are used to control the air flow of the heating system. There are 4 pins used in a PWM controlled fans which are sense, control, Vcc and ground. The speed of the fans is detected through the sense pin and is controlled though control pin using PWM waveform, as shown in Fig. 12.

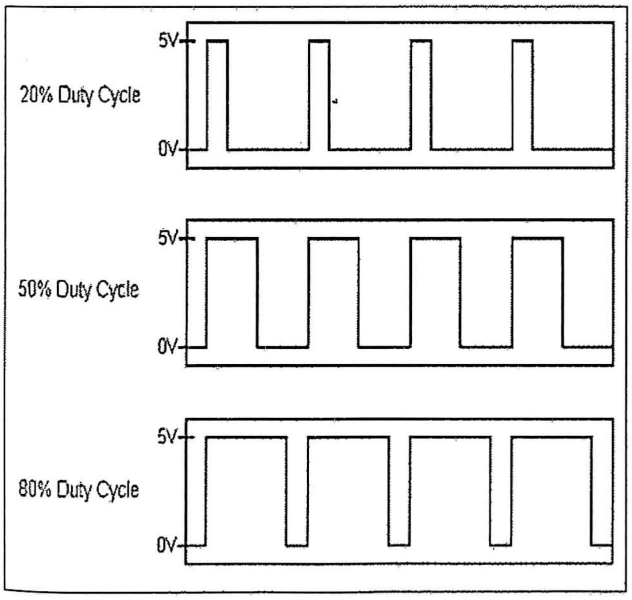

Figure 12. The PWM waveforms.

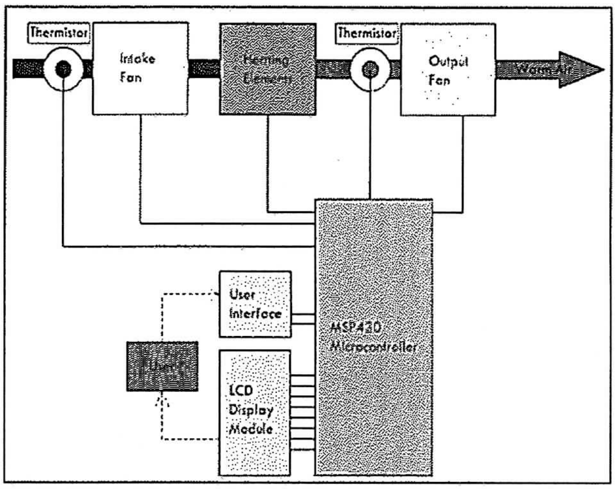

Figure 13. The simplified structure of the air heater.

III. Conclusions

In conclusion, the air heating system is developed for the purpose to heat up the room temperature during cold climate. The subsystems are developed independently before combined into a complete air heating system. Various component selections and constructions are done to produce a low cost air heating system. The program code for the microcontroller is composed in order to provide control mechanism for other components. The thermistor is able to detect the air temperature and produce voltage signal. This signal is compared to the targeted temperature by the microcontroller. Lastly, the working of heating elements is controlled by microcontroller and hence the air is heated up.

References

[1] A.R. Al Emon, A. Zamee, T. Alam, E.G. Ovy, & S. Seeraji, Development of a Microcontroller Based Inexpensive and Flexible Controller for Industrial Temperature Control. *International Journal of Robotics and Automation*, (IJRA), 2(4), 2011, pp. 1-10.

[2] G. Qin, & D.Q. Cui, The Design of Portable Granary Thermometer. American Journal of Engineering and Technology Research, 11(9), 2011, pp. 571-577.

[3] J.H. Davies, *MSP430 Microcontroller Basics*. Newnes, United State, 2008.

[4] D. Ibrahim, Microcontroller-based Temperature Monitoring and Control. Newnes, Oxford, 2002.

[5] J. Luecke, *Analog and Digital Circuits for Electronic Control System Applications: using the TI MSP430 microcontroller.* Elsevier Newnes, United State, 2005.

[6] S. Saini, & C.R. Suri, Design and Development of Microcontroller Based Auto-Flow Assembly for Biosensor. *International Journal of Computer Applications,* 6(1), 2010, pp. 21-27.