Ho Chi Minh City University of Technology

Faculty of Computer Science and Engineering

Microprocessors - Microcontrollers (Semester 182)

A SMART LOW-TEMPERATURE FOOD DEHYDRATION SYSTEM

Instructor: Dr. Nguyễn Trần Hữu Nguyên

Name: Nguyễn Hữu Trung Nhân **Student ID:** 1752392

Content

Acknowledgements

First and foremost, I would like to express my deep and sincere gratitude to Dr. Nguyễn Trần Hữu Nguyên, the professor of Microprocessors-Microcontrollers course in semester 192, for providing every students in this course including me invaluable knowledge about how the Programmable Intelligent Computer (PIC) operates as well as how to program the PIC to solve practical issues in the industry and in daily life. He has taught all of his students the methodology to carry out this project as well as to present the research works as clearly as possible. It was a great privilege to study under his guidance.

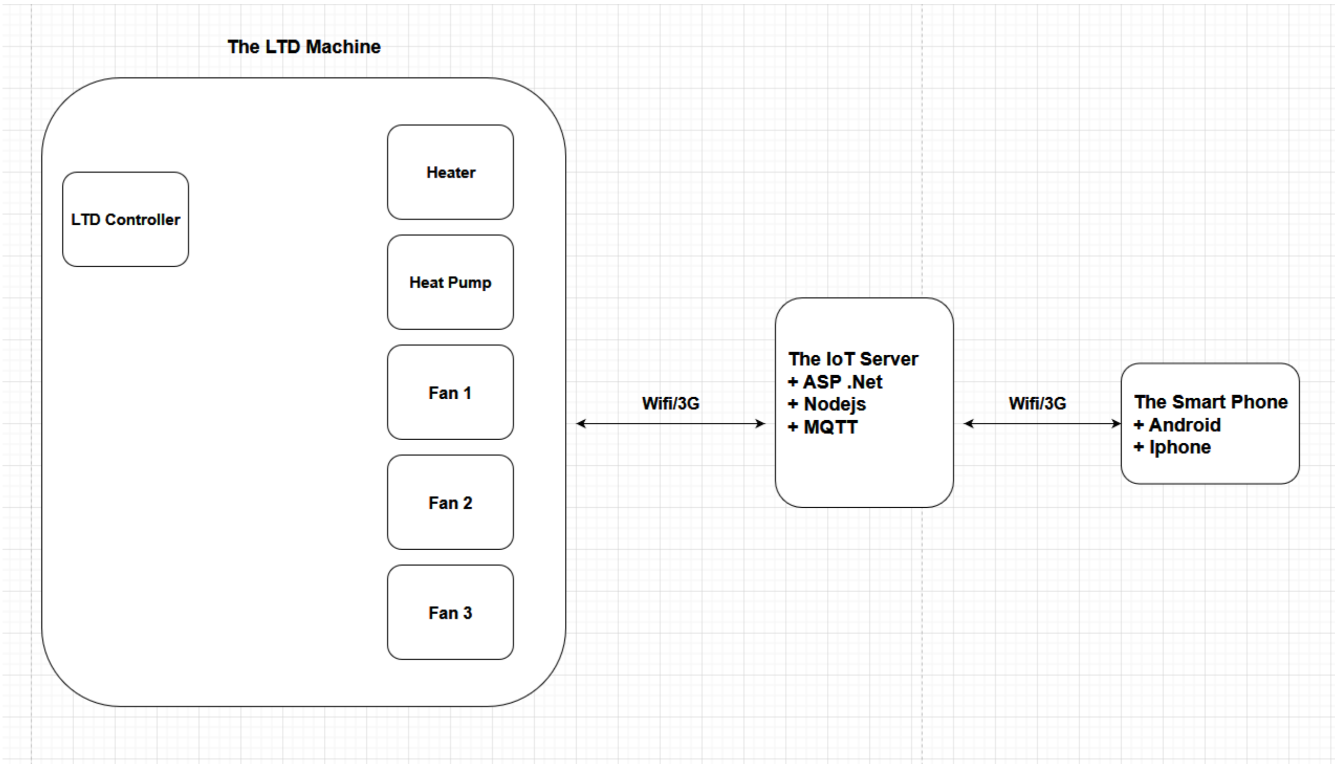
1. Introduction

1.1. Overview

The dry food can be stored for a longer period of time and is less vulnerable to spoilage due to bacteria, molds, and insect growth. One of the most common techniques for the dry food is the use of Low Temperature Dehydration (LTD). In the industry, many machines that embed the LTD technique for food preservation. However, most of these machines are imported, independent, controlled locally and expensive. Such machines work mostly under constant or intermittent conditions or under fixed conditions. This causes resources to be lost, computer life expectancy decreased, and labor costs increased.

In this research, we aim to develop a SMART LTD system that supports centralized and real-time monitoring of multiple LTD machines, high reliability, high availability and scalability, and affordability for Vietnamese users. The SMART LTD consists of LTD controllers, a centralized web server and a cell-phone app. The LTD controller controls the LTD machine based on the temperature and humidity inside and outside of the dry room. It sends temperature and humidity information to the IoT server in real time via Wifi/3G connectivity. The IoT server saves the data to the database for the future use and send them to the user app. The user app that can run on an Android or iOS cellphone, is used to check the status of the current operation of the LTD machines and to send new commands for any LTD controller.

1.2. Block Diagram



1.3. Aims

To build a Low-Temperature Dehydration (LTD) controller that can sense the temperature and humidity inside and outside the dry room as well as can control fans, the heater and heat-pump adaptively.

The LTD controller operation:

1. At the beginning, the heater will be turned on to warm the dry room. When the temperature inside the dry room reaches a user-defined maximum temperature value, the heater will be stopped.

2. When the heater is on, the fan2 will be on as well to make the temperature of the air be evenly distributed in the dry room.

3. If the humidity inside the dry room is greater than a user-defined maximum humidity, the fan1 will be turned on to transfer the humidity air from the dry room to the outside. We can control the speed of the fan1. For example, when the humidity is about 90% or more, the fan1 will run in full speed. When 80%, the fan will run at 80% of the full speed and so on.

4. When the heat pump is on, the fan 3 is also on to help the heat pump work better.

5. Please note that when the heater is on, the heat pump is off and vice versa.

6. The user can set the timer so that the heater and heat pump can be turned on periodically.

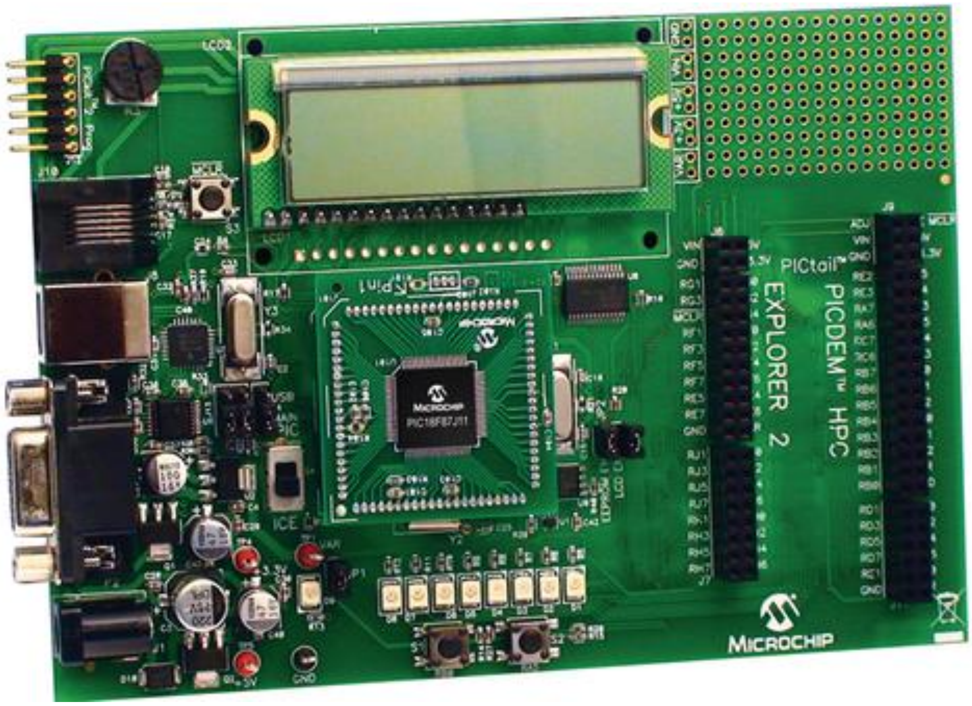
7. The controller should add time out for each operation.

8. The controller should have at least three humidity sensors and three temperature sensors for reliability operations.

1.4. Platforms

To build the code for this LTD controller, “MPLAB X IDE” is used.

As well as the PICDEM PIC18 Explorer Demonstration Board which uses the chip PIC18F8722 (Because MPLAB X IDE and board PIC18 are main objects that were taught in this course):



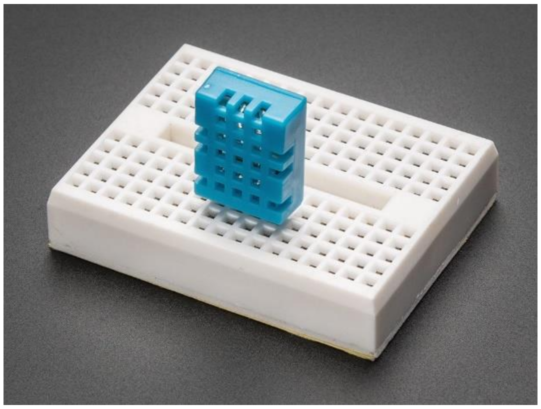
2. Design

2.1. Hardware Components

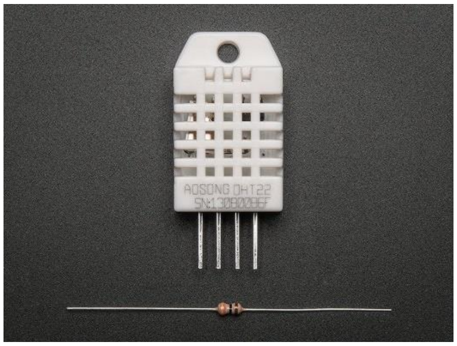
	Name	Quantity
1	Heater	1
2	Heat Pump	1
3	Fan	3
4	Temperature and Humidity Sensors	At least 3
5	LTD controller	1
6	Current Sensors	At least 3
7	Transmitting/ Receiving modules	At least 3

Temperature and Humidity Sensors: In order to increase the reliability of the LTD system, a triple redundancy technique is applied. At least three Temperature and Humidity Sensors are three sensors are connected to three pins of a processor. When one sensor fails, this device will still run. The failed sensor is informed to the system administrator to repair it without interrupting the function of the LTD computer as soon as possible.

Temperature and Humidity Sensors			
Device	DHT11	DHT22	Si7021
Output	Digital	Digital	Digital
Temperature Range	0~50°C ± 2°C	-40~80°C ± 0.5°C	-10~85°C ± 0.4°C
Humidity Range	20~80% ± 5%	0~100% ± 2%	0~80% ± 3%
Price	1.29 USD	3.43 USD	8.95 USD

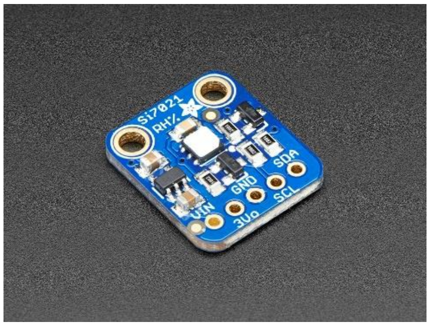


The DHT11 is a digital temperature and humidity sensor that is simple, ultra low-cost. To measure the surrounding air, it uses a capacitive humidity sensor and a thermistor and spits a digital signal on the data pin (no analog input pins required). This sensor works in a small range of temperature/humidity, less expensive as well as less accurate.



The DHT22 is a digital temperature and humidity sensor that is basic and low-cost. To measure the surrounding air, it uses a capacitive humidity sensor and a thermistor and spits a digital signal on the data pin (no analog input pins required). Compared to the DHT11, this sensor is more precise, more accurate and works in a bigger range of temperature/humidity.

In this project, temperature and humidity sensor DHT22 is recommended to use because it is popular in Vietnamese markets that makes DHT22 easy to buy, its precision is acceptable as well as the price is reasonable.



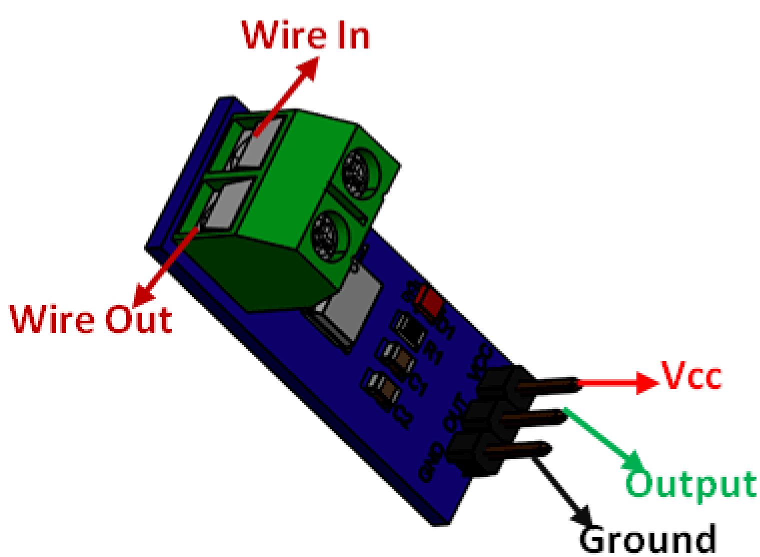
The temperature and humidity sensor Si7021 has the relative humidity measurement of 3% with a range from 0~80% RH, and ± 0.4°C temperature accuracy at a range of -10 to 85°C. It uses I2C to transfer data so it fits with a wide variety of microcontrollers. There's a PTFE filter on the surface of the sensor in order to keep the sensor clean. However, Si7021 sensor in not so common in Vietnamese market. It is quite hard to find a store that sells this sensor. Besides, the price of this sensor is too expensive. Compare this Si7021 sensor to DHT22 sensor, the quality is quite similar. Therefore, this Si7021 sensor is not recommended to use in this project.

LTD controller: The microchip PIC18F8722 is chosen to be the LTD controller for this LTD system because this chip can be programmed to carry out a huge range of tasks. This chip's architecture consists of registers and stack where registers function as Random Access Memory (RAM) and stack saves the return address. Therefore, specifically in this LTD system project, this property will help to save the data sensor that can be used to improve the system for the next operation.

The Microchip PIC18F8722 Datasheet link:

https://www.alldatasheet.com/view.jsp?Searchword=PIC18F8722

Current Sensors: In order to know exactly any component in the system work, current sensors help to determine if there is any current running inside the device. A triple redundancy technique is applied, which means at least three current sensors are used. When one sensor fails, this device will still run. The failed sensor is informed to the system administrator to repair it without interrupting the function of the LTD computer as soon as possible. One recommended current sensor module for this LTD controller project is the ACS712 module:



The ACS712 module operates based on Hall Effect principle. It can measure current AC or DC current ranging from +5A to -5A, +20A to -20A and +30A to -30A. The module requires supply voltage approximately from 4.5V ~ 5.5V. The ACS712 module's price is quite reasonable as well as it is common within Vietnamese market. Therefore, this module is recommended to use to check if the current exists within devices in this microcontroller project.

<u>Transmitting/ Receiving modules:</u> Data transmission between the LTD controller and the IoT server is established using data transmitting modules. There are two common and familiar modules in transmitting data to sever: Module SIM800L and Wifi ESP8266 NodeMCU. If the wifi signal is strong enough, ESP8266 NodeMCU is one option. However, in case that there is no wifi available in the area, module SIM800L is an alternative option.

2.2. Features

- Ability to process the temperature and humidity data collected from sensors and control devices (heater, heat pump, fans) to reduce moisture of food to the user's desire level.
- Transmitting the collected data to the IoT server in real time via Wifi/3G connectivity in order to save these data to the database for future use.
- User App that runs on Android or iOS mobile phone is able to display the current status of the LTD machine as well as modify the maximum temperature level, maximum humidity level for the Dehydration process.

3. Implementation

3.1. Finite State Machine (FSM)

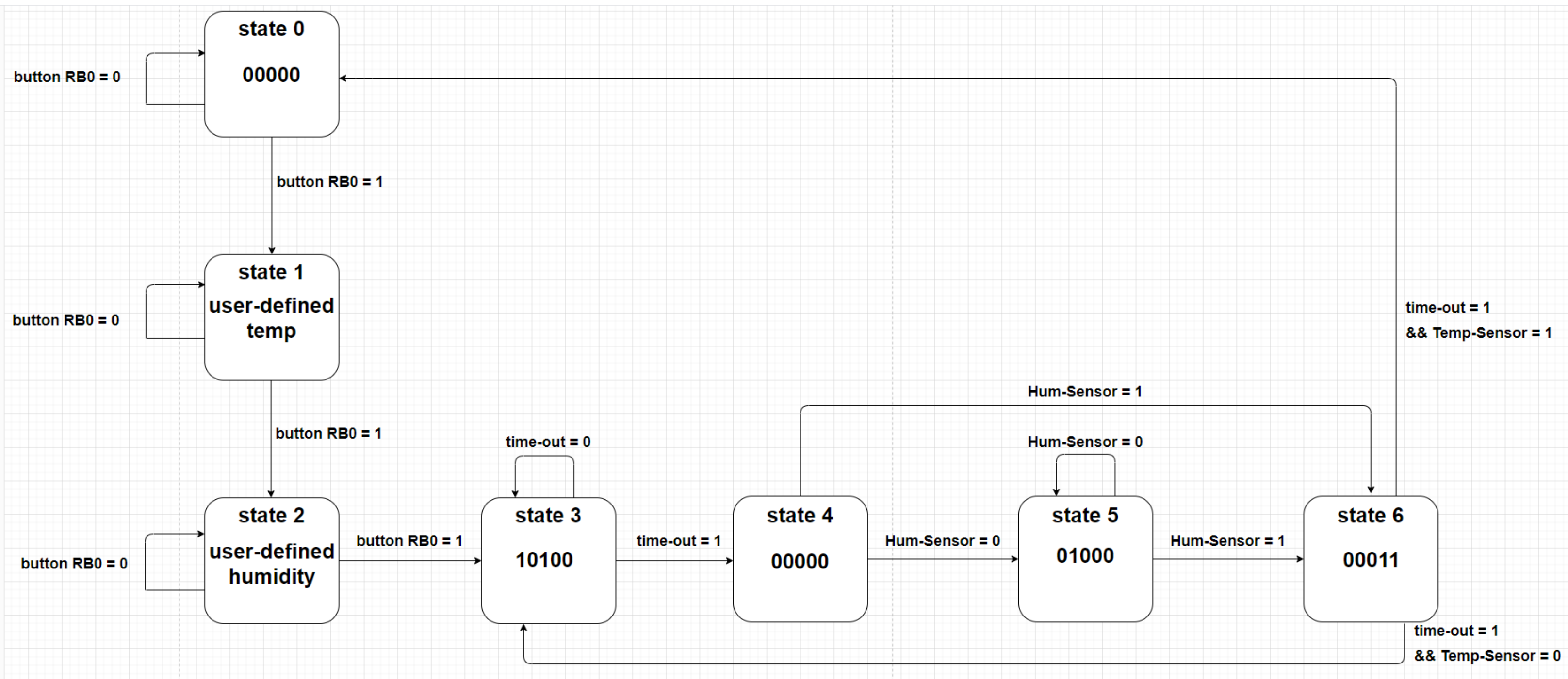
Inputs:

Temperature Sensors:	1 (temperature inside reaches the user-defined value)
	0 (temperature inside is lower than the user-defined value)
Humidity Sensors:	1 (humidity inside satisfies the user-defined value)
	0 (humidity inside is greater than the user-defined value)
Time-out:	1 (time for the state is over)
	0 (time for the state is not over)
Button RB0:	1 (button is pressed)
	0 (button is not pressed)

Outputs:

Heater	1	0
Fan_01	1	0
Fan_02	1	0
Fan_03	1	0
Heat Pump	1	0

Output Format: Heater | Fan_01 | Fan_02 | Fan_03| Heat Pump



3.2. The Operation

At the very beginning, the LTD controller is in idling state – state 0, there is no device functioning in this state. Then, when the button RB0 is pressed, the current state changes to state 1. In state 1, a function that allows the user to modify the desired temperature is called. This function continues to run in state 1 until button RB0 is pressed. In state 2, “user-defined humidity” function is called, which allows the user to determine the desired humidity in the food. When button RB0 is pressed, the current state switches to state 3. In state 3, heater and fan 2 run, when the time is over, current state switches to state 4. From state 4, if the humidity is satisfied, current state will switch to state 6. Otherwise the current state will switch to state 5. In state 5, fan 1 runs in order to lower the humidity to match the user-defined humidity level. When the humidity level satisfies, from state 5, the current state switches to state 6 where the heat pump and fan 3 run. In the final state, if time for this state runs out and the temperature satisfies, current state will return to state 0. Otherwise, current state will change to state 3 and the process begins again.

4. Conclusion

So far, the simulation of the LTD controller on the PICDEM PIC18 Explorer Demonstration Board which uses the chip PIC18F8722 runs as expected. The simulation satisfied every state in the Finite State Machine (FSM). This project has helped student to understand deeply about how Microcontroller-Microprocessor is applied in the industry. Moreover, this project has introduced a new knowledge a about a process of reducing moisture of food so that food can be preserved within longer period of time, which helps higher the quality of daily life. In near future, I will try to figure out the way to send and store the data in IoT sever as well as learn how to program on mobile phone in order to make an app to upgrade what I have completed in this project to a new level.