Mobile Solar Drier

Developing solar drier for maturing and drying of dates in the Arabian Peninsula

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Project: Developing sustainable production systems for date palm in the Gulf Cooperation Council countries

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Background

Date farming is of great economic and social importance in the Arabian Peninsula. It is an important family based agricultural activity. The moisture content of the fruit varies from 60% at the mature to about 25% at the dried stage. High content of moisture can lead to undesired fermentation process during the different marketing stages including handling, transportation and storage. The safe moisture content of date particularly for storage leis between 24% and 25%. For special purposes the water content could be reached down to 12%.

Therefore, producers are drying their fresh date yield for maturing and to enhance the quality and extend the shelf life. Drying of dates under sun protected area is providing a solution to obtain the desired date color needed for marketing. Also, it helps in protecting the yield form dust and seasonal rain.

ICARDA successfully developed and tested the polycarbonate chambers and houses in different countries in the region.

To reduce costs and make the technology mobile, ICARDA is developing a solar mobile dryer that work of grid and can be stored in a small area.

Solar mobile date dryer

Yet green innovation is well developed to be involved in different sectors including agriculture, particularly solar energy. Solar radiation is utilized in heat and electricity generation. Both energies are key factors in food processing. the electricity is used in driving mechanical power and controlling processes, whereas, heat is utilized in maturing, concentration, drying, sterilization different other processes. The Arabian Peninsula is a solar rich region where solar radiation could be successfully utilized in agricultural and food processing. ICARDA developed and tested innovations where solar power is utilized such as enhancing milk quality through innovative solar cooling.

Industrially, dates could be dried in drying chambers at a maximum temperature of 70°C. drying above this temperature could lead to textural changes and fruit hardness and color changes. In relation to the previous ICARDA work on polycarbonate chambers and houses, different synergies could be developed to upgrade the houses to enhance the processing procedure. In this regard, a mobile solar off grid solution was discussed and developed.

The mobile solar dryer consists of tables with covers that form a tunnel. The walls and the cover consists of polycarbonate sheets that are fixes in a metal frame. Each table is 3 m long and 1 m in width. The walls are 15-30 cm in hight. The tables are raised 40 cm from the earth by metal legs (shown in the illustration in diagram section). The dates will be placed on a mesh so that the air will flow also below the product for enhanced drying.

Innovation

So far two version of the tables were made. The first version was produced in Jordan (Picture 1) using a iron frame and the dryer consists of 4 tables that could be put together to form a 12 m tunnel. The solar drier is equipped with a DC fan 12V 40 W, that is installed on a separated part with the control unit. The system is designed to have an autonomy of 6 hours working period during day and 2 hours during night. The dryer is controlled by temperature sensor. The solar system consists of one panel and a control unit.


Picture 1. Solar dryer, Jordan version

The second version was produced in UAE using aluminum frame that is lighter in weight (Picture 2 and 3). The dryer is equipped with 12V 80 W fan. Which is fixed on one table. The dryer is controlled by temperature and humidity sensor. The solar system consists of 2 solar panels and 20 A changing controller.

Picture 2. Solar dryer, UAE version. Left, frame at the manufacturing shop; Right, electronic board


Picture 3. Solar drier. UAE version

Material

Item	Specification	Quantity
Polycarbonate board	8-10 mm	2
Fiber board	Dark color 6mm	2
metal bars	3×3 cm thickness 2mm	20
metal bars	2×2	10
metal hinges	Small size max 10mm	8
Fan	12 V 40-80 W	1
Battery	12 V 55A	1
Solar panel	170W 12V	1-2
Charger control 1	Off grid 12 V 20 A	1
Fuse	10A	2
Switch	10A	2
DC Relay	16A	1
Sensor	Temperature – Humidity	2
Arduino micro processor		1
LCD screen	4x20	1
DC Relay	4 relay module	1
Voltage regulator	1-40 V	1
Plastic terminal box	30x40 cm	1
Clock module	5 V	1
SD card Module	5 V	1
BCP board		2
Wires	Different sizes and colors	
Connectors	1.5 mm	10

Diagrams

The diagram of the first prototype produced in Jordan are presented in diagram 1 and 2. Diagram 3 presents the electrical connections for the UAE version dryer.

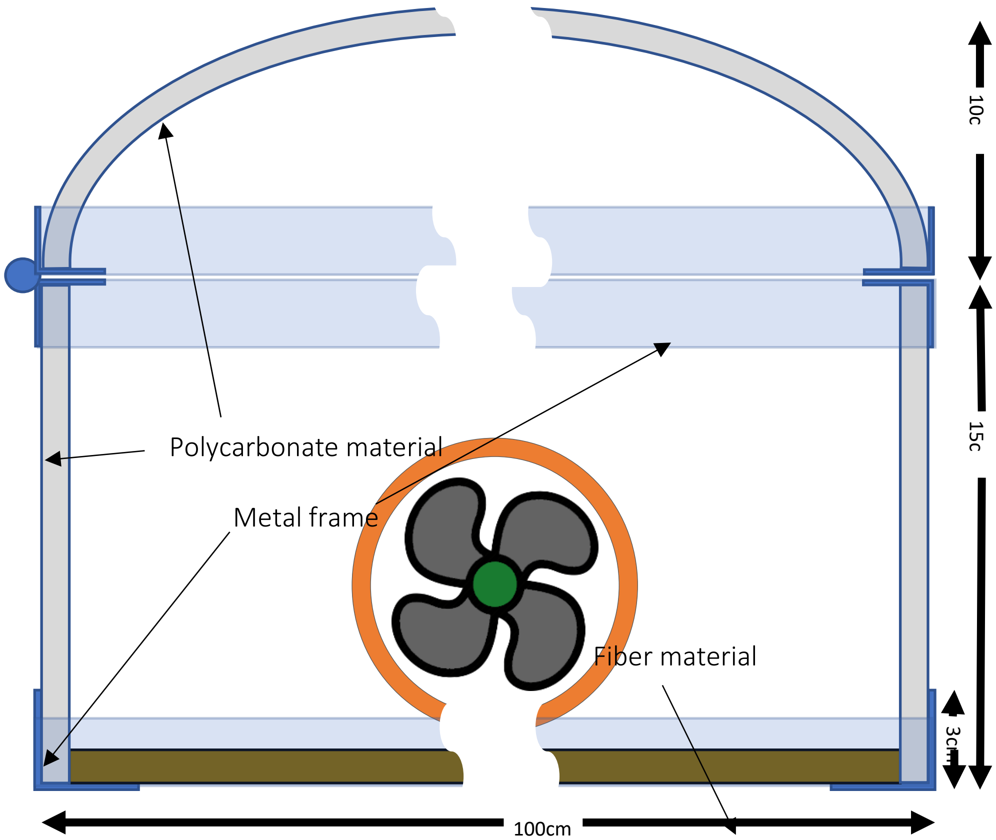


Diagram 1. Side view, the width view

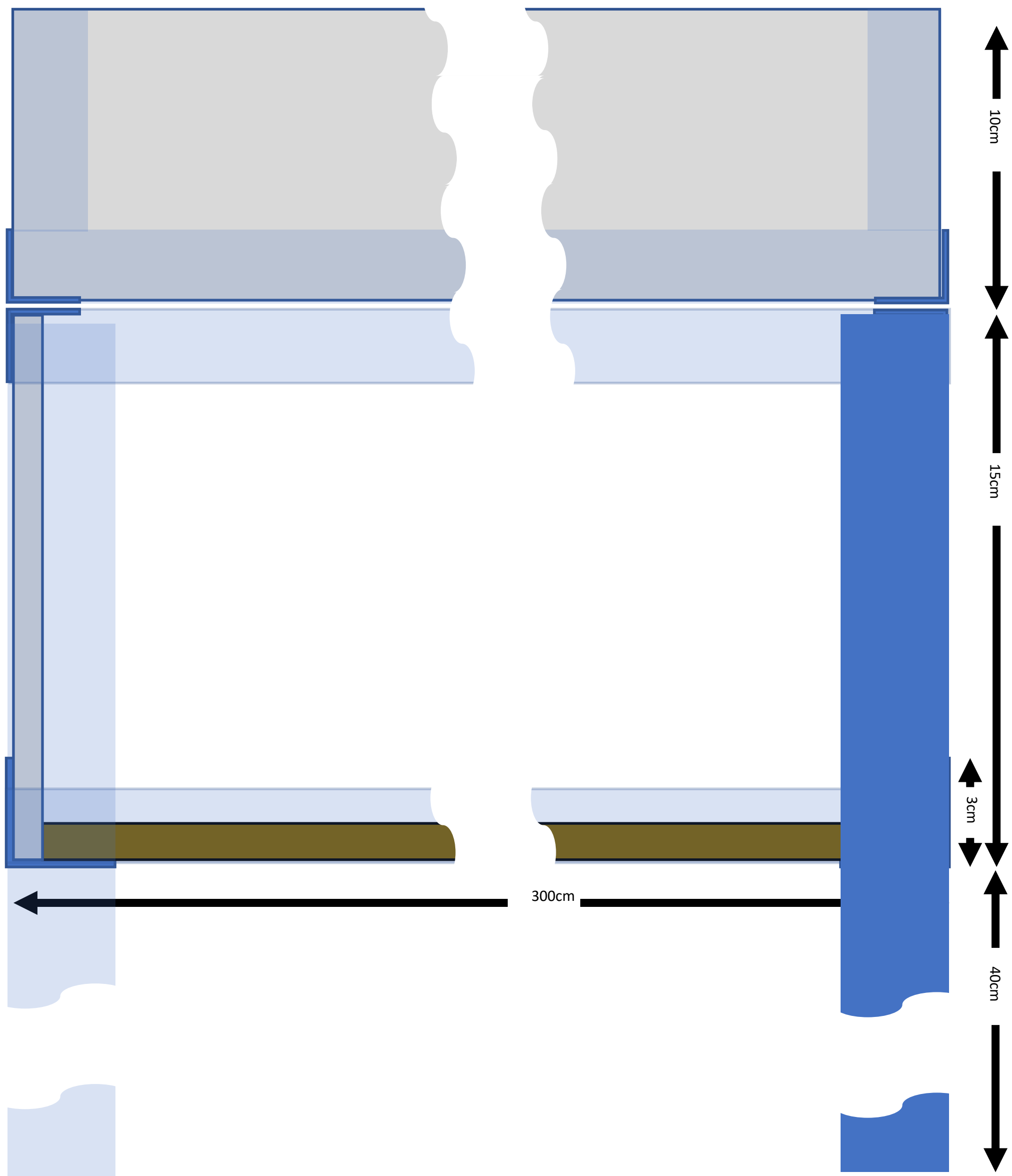
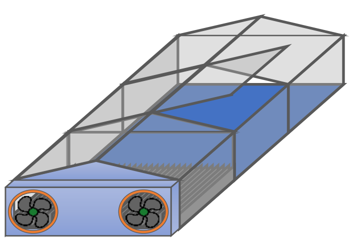


Diagram 2. Length view



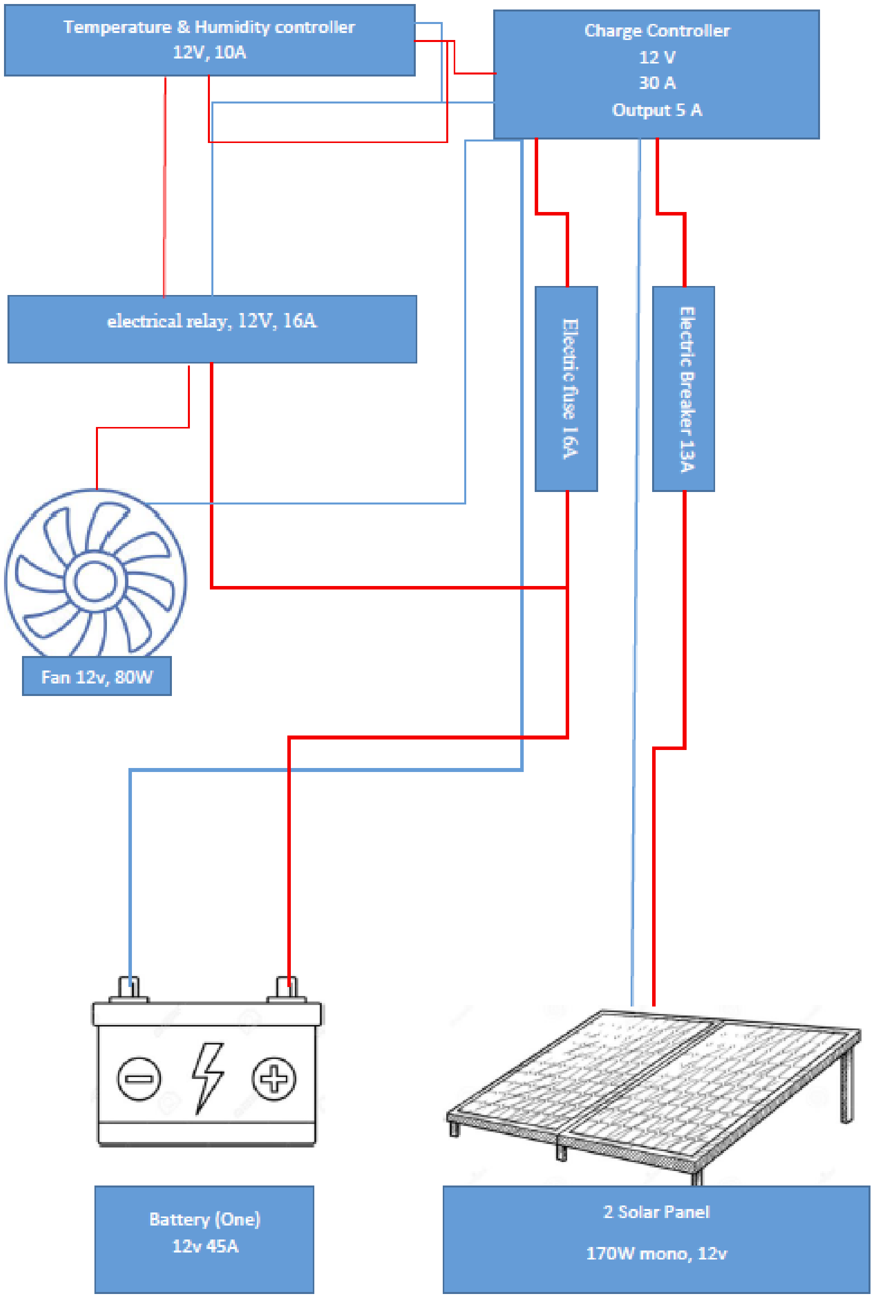
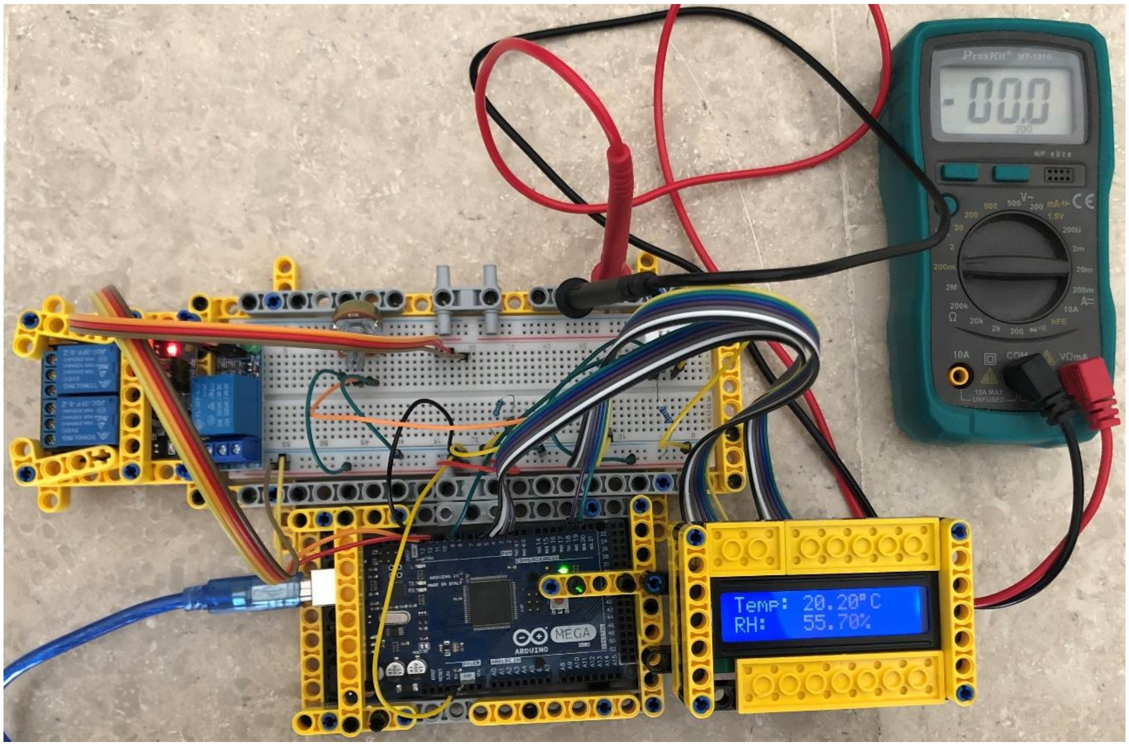


Diagram 3. Electronic control unit of the UAE dryer

Updates

Based on discussions with UAE ICARDA team and considering environmental challenges during the drying process in the Arabian peninsula region, A new electronic control unit was developed that can be fully programmed based on data received from temperature and humidity sensors placed inside and outside the dryer. This enables the working of the system based on humidity difference and temperature ranges that can be programmed for different environments. The system is still under development. Till this end, the system (Picture 4).



Picture 4. First electronic system drafted for the solar dryer

The electronic system was developed on open source microprocessor chip that will control electrical gates and relays up to 240 V and 10 A. the Ver. 1.0 of the system consists of Microprocessor that can be programed using PC. The microprocessor will process data collected from two combined thermal and humidity sensors (picture 5) that are placed inside outside the drier and present actual values on an LCD screen (Picture 5). Based on set up values programed the microprocessor will control a fan that is fixed on the dryer. the detailed parts of the electrical and electronics are summarized in diagram 4.

Picture 5. Input and output devices of the electronic control unit. Left picture sensor; Right picture LCD screen

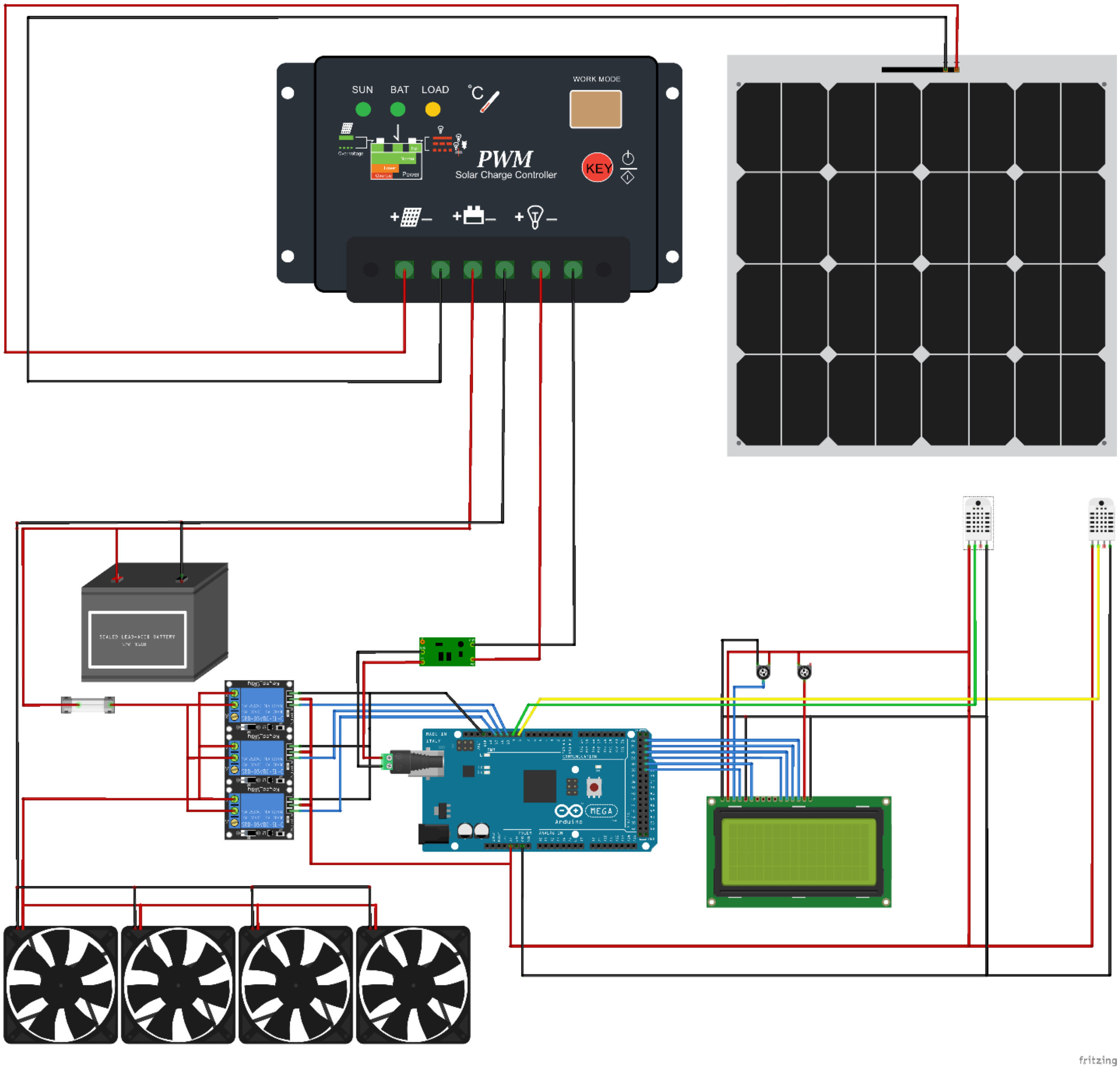
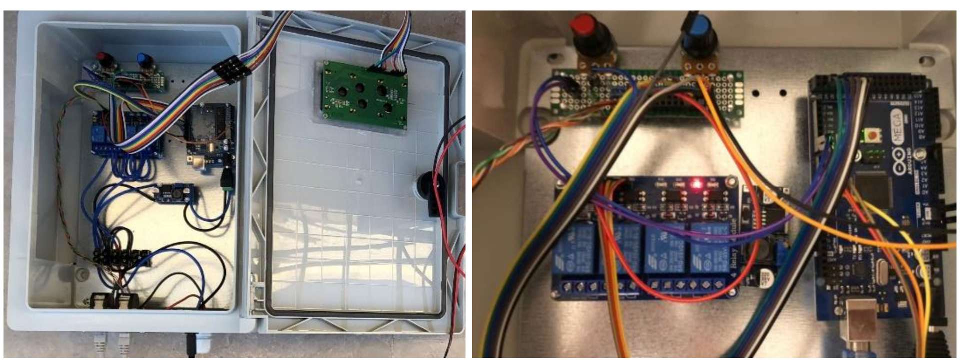


Diagram 4. Electronic parts and connections. Drown using Fritzing software, www.fritzing .org



Picture 6. Electronic parts in control box

Software

Ver1.1

The first code used is:

```
/*
International Center for Agricultural Research in the Dry Areas
Solar drier developed under AFESD, ICARDA RALS, Jordan and Date Palm Project, ICARDA APRP, UAE
Written by: Djamal El-Dine Hilali and Muhi El-Dine Hilali
*/
#include <Wire.h>
#include <LCD.h>
#include <LiquidCrystal.h>
#include <DHT.h>
#include <Adafruit_Sensor.h>
#include <DHT_U.h>

// Creates an LCD object. Parameters: (rs, enable, d4, d5, d6, d7);
LiquidCrystal lcd(7, 6, 5, 4, 3, 2);
DHT dht1(15, DHT22);
DHT dht2(14, DHT22);

int RelayTemp = 2;
int RelayHumd = 3;
int RelayTime = 4;
int LedTemp = 13;
int LedHumd = 8;
//unsigned long Time;

long day = 86400000;
long hour = 3600000;
long minute = 60000;
long second =  1000;

void setup()
{
  Serial.begin(9600);
  lcd.begin(20,4);
  dht1.begin();
  dht2.begin();

  pinMode(RelayTime, OUTPUT);
  pinMode(RelayHumd, OUTPUT);
  pinMode(RelayTemp, OUTPUT);
  pinMode(LedTemp, OUTPUT);
  pinMode(LedHumd, OUTPUT);

  lcd.setCursor(7,0);
```

```
  lcd.print("ICARDA");
  lcd.setCursor(6,1);
  lcd.print ("RALS  APRP");
  lcd.setCursor(8,2);
  lcd.print("MuHi");
  lcd.setCursor(2,3);
  lcd.print("Software Ver 1.1");
  delay (5000);
  lcd.clear();
}

void loop()
{
  time();

  float h1 = dht1.readHumidity();
  float t1 = dht1.readTemperature();
  float h2 = dht2.readHumidity();
  float t2 = dht2.readTemperature();
  float m1;
  Serial.print("Temperature = ");
  Serial.print(t1);
  Serial.print("°C - ");
  Serial.print(t2);
  Serial.print("°C ");
  Serial.println(" ");
  Serial.print("Humidity = ");
  Serial.print(h1);
  Serial.print(" % - ");
  Serial.print(h2);
  Serial.println(" % ");
  Serial.println("");
  //Time = millis();
  //set low temperature
  if(t1>=60)
    {digitalWrite(RelayTemp,LOW);digitalWrite(LedTemp,HIGH);}
  //set high temperature
  if(t1<=45)
    {digitalWrite(RelayTemp,HIGH);digitalWrite(LedTemp,LOW);}
  //set high humidity difference

  if(h1-h2>=20)
    {digitalWrite(RelayHumd,LOW);digitalWrite(LedHumd,HIGH);}
  //set low humidity difference
  if(h1-h2<=5)
    {digitalWrite(RelayHumd,HIGH);digitalWrite(LedHumd,LOW);}

  // Check if any reads failed and exit early (to try again).
```

```
  /*if (isnan(h1) || isnan(t1))
     {
       lcd.clear();
       lcd.print("Check the sensor In");
       return;
     }
  if (isnan(h2) || isnan(t2))
     {
       lcd.clear();
       lcd.print("Check the sensor Out");
       return;}
  */
   //lcd.setCursor(0,0);
   //lcd.print(Time/1000);
  // lcd.clear();
   lcd.setCursor(0,1);
   lcd.print("        In      Out  ");//shows degrees character
   lcd.setCursor(0,2);
   lcd.print("T, ");
   lcd.print((char)223);//shows degrees character
   lcd.print("C: ");
   lcd.print(t1);
   lcd.print("   ");
   lcd.setCursor(15,2);
   lcd.print(t2);
   lcd.print("  ");
   lcd.setCursor(0,3);
   lcd.print("RH, %: ");
   lcd.print(h1);
   lcd.print("   ");
   lcd.setCursor(15,3);
   lcd.print(h2);
   lcd.print("  ");
   delay(5000);
}

void time(){
  long timeNow = millis();
  int days = timeNow / day ;
  int hours = (timeNow % day) / hour;
  int minutes = ((timeNow % day) % hour) / minute ;
  //int seconds = (((timeNow % day) % hour) % minute) / second;

   lcd.setCursor (0,0);
   lcd.print(days, DEC);
   lcd.print(" Days ");
   if (hours <10) {lcd.print('0');}
   lcd.print(hours);
```

```
   //printDigits(hours);
   printDigits(minutes);
}

void printDigits(byte digits)
{
 lcd.print(":");
 if(digits < 10)
   lcd.print('0');
 lcd.print(digits,DEC);
}
```