Adaptive dryer based on LDR and water brick sensor: Case study at household industrial application

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***Abstract*—Various modern technology for industrial purposes has been encountered in recent times. However, the technology is rarely used by the household or home industrial sector. In this study, a product designed to help food productivity in this sector corresponding with drying process. Adaptive dryer which uses two sensor, LDR and water brick sensor, is controlled by microcontroller ARM NUC 120. When it is rain or cloudy it will automatically close the roof and activate the heater. Temperature measured by LM35 sensor will be displayed on the LCD.**

Keywords—Adaptive dryer;LDR, water brick sensor, LM35, ARM Microcontroller

1. Introduction

The development of electronic technology is rapidly and quickly revolutionized through the means or medium. Various types of equipment have been made by humans to meet the desires and needs in carrying out any activities. Advances in science and technology encourages people to strive to overcome the problems that arise in the vicinity and alleviate human tasks and can simplify daily activities [1]. For example in the world of industry , production equipment and some of the supporting factors largely determine yield. This study takes a case study on home industries related to food dryers. Many industrial players are still using traditional manner in drying process. Moreover, the dependence on weather resulted in the drying process become to be longer. It is to be overcome by making a dryer that can adapt to environmental conditions. Thus, drying still run even though the weather is cloudy or is going to rain.

2. System Component

DT-ARM NUC120 Board is a 32-bit microcontroller module based on ARM Cortex-M0 [3]. DT-ARM NUC120 Board shown in Figure 1 is equipped with a bootloader program that does not require a separate program devices. Its CPU can operate at speeds up to 48 MHz. It has been equipped with USB 2.0 Full Speed Device Controller with flexibilities to be configured for a variety of USB-based applications. Some specifications contained in this tool are [6]:

- Based on NUC120RD2BN 64 KB APROM, 8 KB SRAM, 4 KB Data Flash, CPU ARM Cortex-M0;
- Integrated with 12 MHz external crystal as main clock;
- Integrated with 32.768 kHz as RTC clock;
- 1x USB port and 1x RS-485 port;
- 8x 10-bit ADC channels;
- 3x UART channels with TTL level voltage (3.3 VDC/5 VDC);
- USB port can be used for serial interface as well as programing interface;
- Comes with Serial Wire Debug for debugging and programming, 45 I/O pins;
- Integrated with internal temperature sensor;
- 3.3 VDC/ 5VDC (800 mA) working voltage;
- Input supply voltage: 6,5VDC - 12VDC/ 3,3VDC - 5VDC.

Fig. 1. DT-ARM NUC120 Board

Three components of the sensor used in the circuit are light sensor, water sensor and temperature sensor. These sensor are described below :

***Light Dependent Resistor* (LDR)**

An LDR is a component that has a (variable) resistance that changes with the light intensity that falls upon it. This allows them to be used in light sensing circuits. The most common type of LDR as depicted in Figure 2a [8] has a resistance that falls with an increase in the light intensity falling upon the device (as shown in the image above). The resistance of an LDR may typically have the following resistances [1]: Daylight = 5000Ω and Dark = 20000000 Ω.

(a) (b) (c)

Fig. 2. Three type of sensors a) LDR b) Water Brick Sensor c) LM35

Water Brick Sensor

Figure 2b [7] shows water brick sensor that is designed for water detection. It can be widely used in sensing the rainfall, water level, even the liquate leakage. The brick is mainly comprised of three parts: An Electronic brick connector, an one MΩ resistor, and several lines of bare conducting wires.

LM35

The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in ^{o}C). Some benefits of using this sensor shown in Figure 2c are [2][4]:

1. It can measure temperature more accurately than a using a thermistor.
2. The sensor circuitry is sealed and not subject to oxidation, etc.
3. The LM35 generates a higher output voltage than thermocouples and may not require that the output voltage be amplified.

The other main components is heater. It is used during the weather conditions in cloudiness or rain occurs. There are two main types of electric heating elements are: Electrical Heating Element Basic form that the heating which only covered by an electrical insulator. Examples of heating elements that are included in this parts are ceramic, silica, bank channel and quartz heater. Another form of electrical heating elements are the basic form coated with pipe or sheet metal plate as shown in Figure 3 [5]. This purpose is used for setting heat level.

Fig. 3. Tubular Heater

3. SCHEMATICS

Circuit schemes discussed in this parts are the general block diagram, flowchart and element wiring.

A. General Block Diagram

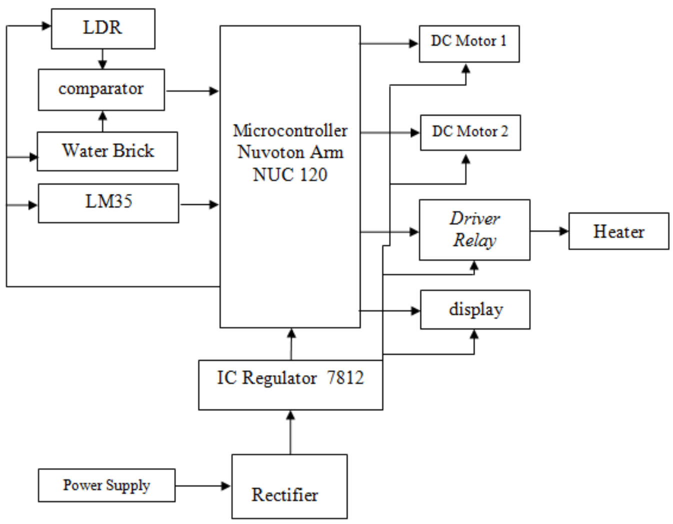

Fig. 4. Block diagram adaptive dryer

Block diagram depicted in Figure 4 consists of three main parts namely :

1. Input components: LDR, Water Brick, LM35, Power Supply with bridge -type rectifier;
2. Processing units : Microcontroller NUC 120, dc motor driver;
3. Output components: DC Motor and Heater element.

B. Flowcharts

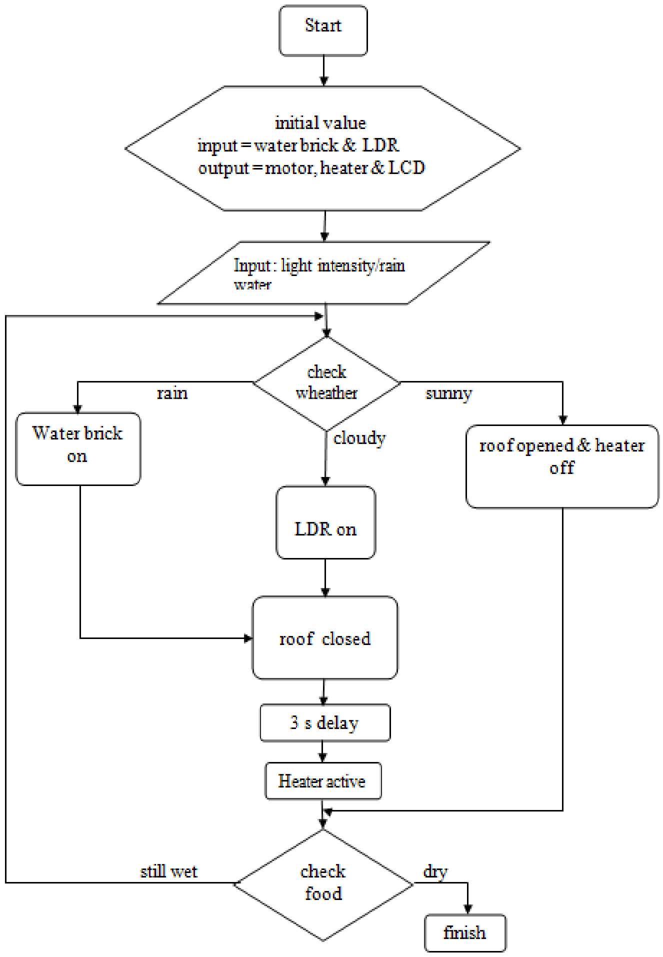

Fig. 5. System flowcharts

Figure 5 shows how the system works. LDR will detect whether the sun has enough intensity to make the process of drying. If intensity is not sufficient or there will be cloudy then microcontroller drives the motor to close the roof. In certain circumstances it rains despite the sunny weather at the time. It is the role of water brick sensors to do the same thing as the LDR. Once fully closed, approximately three seconds or less then the heating process is performed by the heater installed in the drying chamber. The temperature sensor, LM35, installed is to measure adequate heat in the drying process. In the final stage, checking the food is manually done to ensure that the object, in this case the food, has dried completely.

C. Wiring

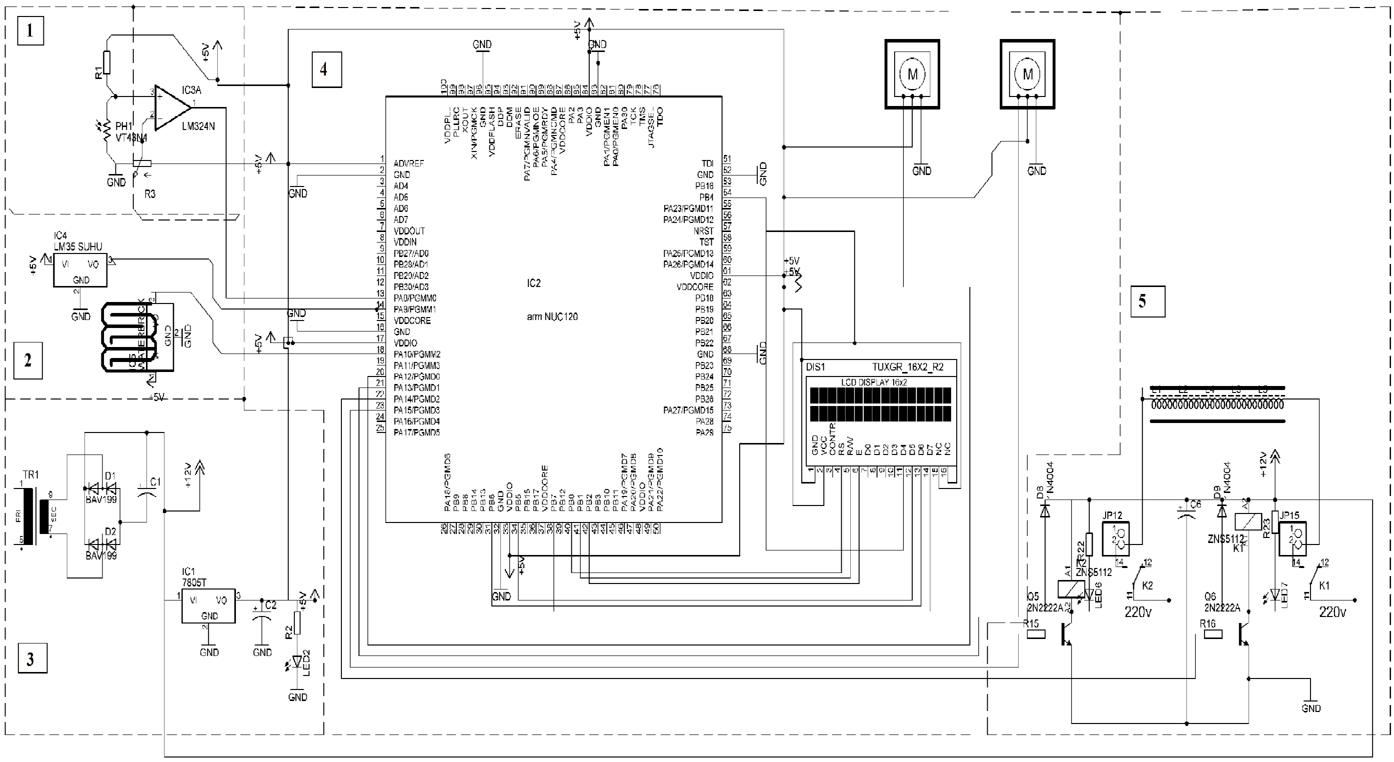

Fig. 6. System wiring

4. INSTALLATION AND ANALYSIS

The next process is components instalation. This corresponds to the exact place where the component is placed such as sensors, motor, heater and microcontroller.

A. *Installation of the main circuit blocks*

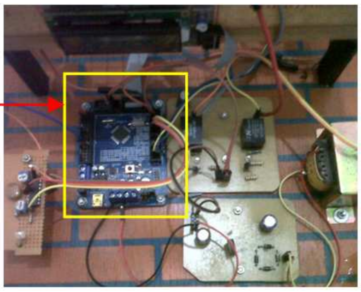

Fig. 7. Main circuit

Figure 7 shows the position NUC120 as controller of all the input and output components of the system. It is put in place that is always dry and protected from water that needs to be installed mica or acrylic cover. Another part in the same Figure are DC motor driver, bridge type rectifier and sensor circuit.

B. *Sensors installation*

Details about the installation of water brick sensor and LDR are depicted in Figure 8a and 8b respectively. Both are installed in the different place. The first sensor is placed on the side roof and the second is placed above the floor.

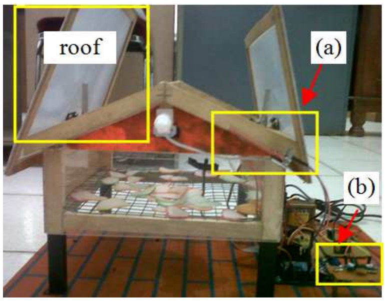

Fig. 8. Sensor installation a) Water brick sensor b) LDR

C. *DC motor, temperature sensor and heater installation*

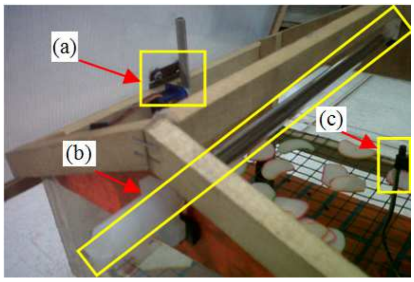

Fig. 9. a) DC motor b) Heater c) Temperature sensor

Figure 9a shows DC motor that used for opening or closing the roof with predetermined conditions. The heater shown in Figure 9b is placed along the main truss roof about as long as 30 cm. Testing is done by placing a sample food in the device. Heat level is measured by a temperature sensor LM35 as depicted in Figure 9c to ensure heat is equitably distributed in it.

D. Measurements result

In this step, determining the measurement points are done with the aim whether the device is designed to work well. There are six points (TP1 to TP6) which have specific function and purpose.

1. TP 1 is on the output transformer before the rectifier circuit. TP 2 is the point after passing through the power supply voltage regulator IC 7812;
2. TP 3 is the output point of LDR;
3. TP 4 is the output point of Water brick sensor;
4. TP 5 is the line input of Motor DC;
5. TP 6 is the line input of Heater;

Measurement results from TP1 to TP6 are summarized in Table 1.

TABLE I. MEASUREMENT RESULTS

Measurement points		**Value**					**Average**
		P1	***P2***	***P3***	***P4***	***P5***	
TP1 (V)		11.9	12	11.9	11.9	12	11.94
TP2 (V)		12	12	12	12	12	12
TP3 (V)	Sunny	4.6	4.8	4.6	4.6	4.6	4.64
	Cloudy	4.9	4.9	5	4.9	4.9	4.92
TP4 (V)	Rain	4.8	4.9	4.9	5	4.9	4.9
	Sunny	5	4.9	4.9	4.9	4.9	4.92
TP5 (V)	Motor 1	4.8	5	5	5	5	4.96
	Motor 2	5	5	4.8	5	5	4.96
TP6 (V)		215	215	215	215	215	215
Idc (mA)		1.3	1.3	1.3	1.3	1.3	1.3

Each point of measurement is made five times. The voltage measured in transformer secondary voltage is 11.94 volts at TP1. The voltage has to be stabilized for supplying a microcontroller and the other components in the system. IC legulator 7812 is installed to perform that task. It can be verified at the measurement point TP2 with the average value of 12 volt. TP3 and TP4 are used for supply indicators of LDR and water brick sensor respectively. Two conditions are observed for LDR at sunny and cloudy weather measured as 4,64 and 4,92 volt. The similar values are shown at TP4 as 4,9 and 4,92 volt. The movement of two DC motors using a voltage of 5 volts measured at TP5. When opening or closing the roof, the movement of the motor are not performed simultaneously. This is done to avoid the voltage drop at the time of the mechanisms done. The voltage used by the heater is 215 volts measured at TP6.

The voltage at TP1 can be obtained from calculations based on (1)

$$V_{AC} = \frac{V_{\max}}{\sqrt{2}} \quad (1)$$

where

$V_{\max}$ = Maximum voltage (volt)

V_{AC} = Secondary voltage transformer (volt)

so

$$\begin{aligned} V_{\max} &= V_{AC}\sqrt{2} \\ &= (11{,}94)\sqrt{2} \\ &= (11{,}94)\sqrt{2} \\ &= 16{,}886 \text{ V} \end{aligned}$$

Ripple contained in DC voltage is then reduced by the capacitor according to (2)

$$V_{DC} = V_{\max} - \frac{4{,}17.(I_{DC})}{C} \quad (2)$$

with C = $1000\mu F$ and $I_{DC} = 1{,}3\,mA$, it can be calculated

$$V_{DC} = 16{,}886 - \frac{4{,}17.(0{,}0013)}{0{,}001} = 11{,}465 \text{ volt}$$

There is a percentage of error with the measurements results given in (3)

$$\%error = \left|\frac{measurement - calculation}{measurement}\right| x100\% \quad (3)$$

with the measurements and calculation equal with 12 volt and 11,465 volt respectively, the percentage of error is 4,45 %. It is still under 10 % tolerance limit specified.

At the measurement point TP3 is known where LDR sensor has a voltage of 4.64 V and 4.92 V during sunny and cloudy weather.

$$\%error = \left|\frac{datasheet - measurement}{datasheet}\right| x100\% \quad (4)$$

Compared with voltage on datasheet, the percentage of error based on (4) are 7,2 % when observed in sunny weather. A smaller percentage if observed on cloudy condition that is 1,6 %. Both are under the tolerance limit. With the same manner, the percentage measured in TP4 are 1,6 % and 2 %.The percentage measured in TP5 is 0,8 %. The result of the error percentage calculation that is still within the limits of tolerance showed that the system be made to work properly and in accordance with its function.

5. CONCLUTION

Adaptive dryer system that has been created is intended to help the household or home industrial sector to increase productivities. Three sensors, two DC motors and a heater are used as main components in this system. It can work properly as indicated by the percentage of error between the measurement results with the value on datasheet is still within tolerance limit.

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