Available online at www.elixirpublishers.com (Elixir International Journal)

Electrical Engineering

Elixir Elec. Engg. 120 (2018) 51361-51365

ISSN: 2229-712X

Development of a Microcontroller-Based Irrigation Control System

Oke Alice Oluwafunke, Alo Oluwaseun Olubisi and Ogirima Sanni Abubakar Omuya
Ph.D, Department of Computer Science and Engineering, Ladoke Akintola University of Technology, Ogbomoso , Oyo State, Nigeria.

ARTICLE INFO
Article history:
Received: 04 June 2018;
Received in revised form:
10 July 2018;
Accepted: 20 July 2018;

Keywords
Irrigation,
YL-69 soil moisture sensor,
Arduino microcontroller,
LM393 comparator,
DHT11 Temperature,
Humidity sensor.

ABSTRACT

Irrigation is the artificial application of water to land or soil. It is used to assist in growing of agricultural crops, protection of plant against frost, preventing soil consolidation, maintenance of landscapes, and re-vegetation of distributed soils in dry areas and during periods of inadequate rainfall. Many of the irrigation systems operated worldwide are used on farms or lands that are located on the outskirts of towns and difficult to monitor. The manual operation of these systems over time has resulted in either under watering or over supply of water. The consequence of which are reduced crop yield and withering of crops respectively. Over irrigation further results in leaching of soil nutrients. The manual approach to practicing irrigation is both cost and resource inefficient. To address these challenges an efficient and cost effective microcontroller based irrigation control system designation is proposed for enhancing food security.

© 2018 Elixir All rights reserved.

1. INTRODUCTION

Agriculture is considered as the background of any country's economy. Many techniques have been put in place to increase the yield of agricultural produce [8]. Water is the most important factor in determining the yield [3]. The life of the plant greatly depends on the amount of moisture present in the soil [2]; [7]. It also regulates the temperature through process of transportation [15]. When the water provided by the farmer is not enough, it leads to the decease of the plant.

The control of greenhouse plants simply by ventilation and regulation of heat has been an old practice, unknowingly; this practice has hindered other factors affecting the growth and health of the plants [12]. However, the use of microcontroller couple with some sensors has now made it easier and efficient to regulate some of the basic factors affecting the growth of plants in the greenhouse. The government has helped to operate, maintain these schemes and provided agro-support services such as land preparation, seeds, fertilizers and chemicals to farmers. Farmers virtually have no roles to play except to divert water from the channels and operate their respective farm plots. Very few farmers' groups were actively concerned with irrigation management and system maintenance. The interaction between the farmers and government could be classified as benevolent patron-client relationship. However, since 1988 when the governments (especially, federal) have partially withdrawn from providing funds and services, these have contributed to the serious deterioration of most systems' structures and have resulted in the low-level performance of many schemes. [13]. Microcontroller-based crop irrigation system will assist farmers during dry season, as a result of this, Crops grown under controlled conditions results in reduction of the use of fertilizer, tends to be healthier and therefore give more yields.

Irrigation is the application of controlled amount of water to plants at needed intervals. Irrigation systems are also used for cooling livestock, dust suppression, disposal of sewage, and in mining. Irrigation is often studied together with drainage, which is the removal of surface and sub-surface water from a given area. Irrigation has been a central feature of agriculture for over 5,000 years and is the product of many cultures. Historically, it was the basis for economies and societies across the globe, from Asia to the South western United States. Several attempt and research has been conducted in the area of irrigation some of which are: a completely autonomous and cost-effective system for watering indoor potted plants placed on an even surface [12]; [11], presented a plant watering autonomous robot encompasses of the Arduino Duemilanove microcontroller which has a pre-loaded boot loader so that codes can be downloaded to it using the USB cable. "[6]" developed a wireless system consisting of five wireless sensor modules which are distributed over a farm with each sensor module monitoring an area of about 1.8km radius. The module continuously collect parameters such as relative humidity, soil moisture content, sunlight etc which are sent to a base station using the ZigBee radio and the results are uploaded to the internet with the help of Raspberry pie. "[5]", used HPAA (heat pump android application) software for properly growing plants in a well-controlled and desired manner. "[9]" decided to enable plants move in their flowerpot to imitate the autonomous behavior of pets" by building a system which automatically search for sunlight by moving to a sunny spot and also interact with people in times of need of water and also express happiness after being watered .

2. OVERVIEW OF THE DESIGN

The design of this system has three major sections; inputs section through couple of sensors, the control section through the Arduino Uno microcontroller and the output section using a LCD display. In accomplishing this, two stages were undertaken: the software stage and the hardware stage whose block diagram is as shown in Figure 1. The hardware stage comprises of all the units in the block diagram which are explained in the following sections.

Tele:
E-mail address: aooke@lautech.edu.ng.

© 2018 Elixir All rights reserved

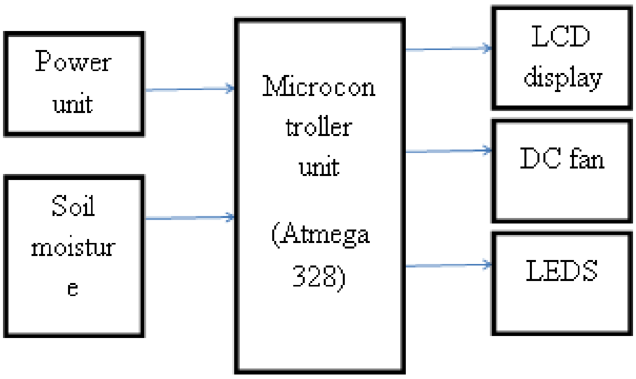

Figure 1. Block diagram of the design.

2.1 Power Unit

The microcontroller runs on a DC voltage of about 7V - 12V [1]. To achieve this, an AC to DC converter circuits was designed which comprises of Transformer, Diodes, Capacitors, Resistors, and Voltage Regulator. To power the circuit, 18V transformer couple with four diodes D1 – D4 as shown in Figure 2, a 2200µF capacitor was connected to the point where D2 and D4 meets. Also the output was connected to VI (3) pin of the voltage regulator, pin 1 to ground and V0 (2) pin was connected to another 100µF capacitor which was now connected to the power jack of the microprocessor. For efficient connectivity, a 1K ohm resistor and a LED were used as the power indicator.

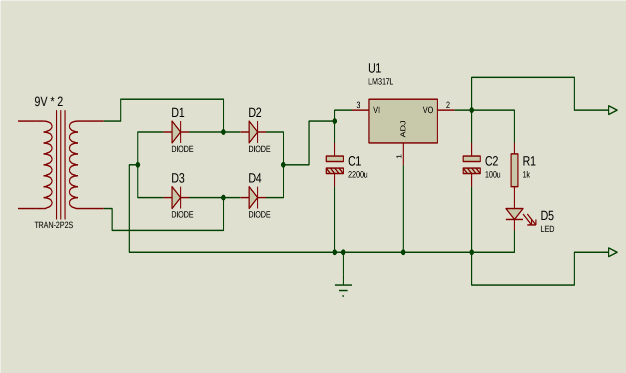

Figure 2. Power Circuit.

2.2 Sensing Unit

The YL-69 soil moisture sensor was interfaced with the Arduino microcontroller through a digital PCB which comprises of a digital potentiometer and a LM393 comparator. The digital potentiometer was used to alter the sensitivity of the soil moisture sensor when connected in digital mode while the LM393 comparator compares the value of the voltages across the sensor probe with the VCC voltage. This configuration was used for more accurate result. Figure 3 shows the connection of the sensor to the microcontroller.

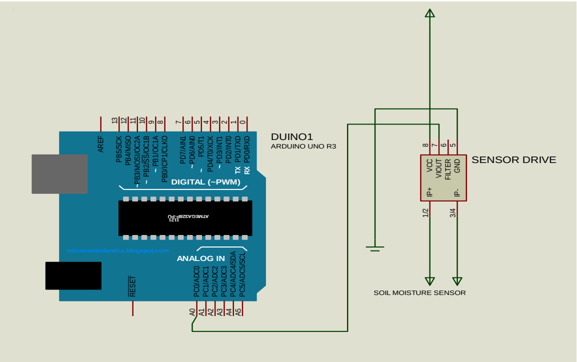

Figure 3. YL-69 connection with Arduino.

2.2.1 DHT11 Sensor

The DHT11 Temperature and Humidity sensor features a temperature and humidity sensor complex with a calibrated digital signal output. By using the exclusive-digital-signal acquisition technique and temperature and humidity sensing technology, it ensures high reliability and excellent long-term stability. This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to a high-performance 8-bit microcontroller, offering excellent Quality, fast response, anti-interference ability and cost-effectiveness. Figure 4 shows the connection of the sensor to the microcontroller

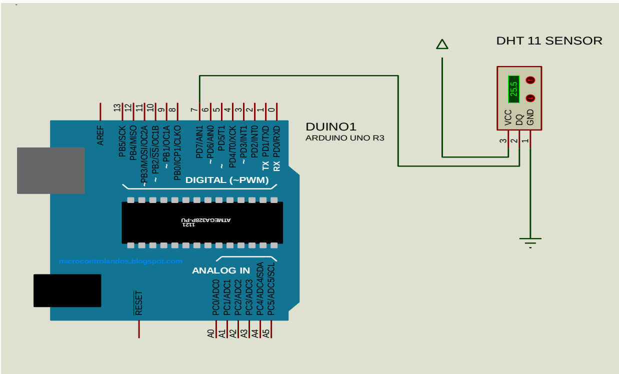

Figure 4. DHT11 connection with Arduino.

2.3 Control Unit

ATmega328 microcontroller on the Arduino platform was selected as the microcontroller for the design as shown in Figure 5. It has a total input pins of 20 of which 14 are used as digital input while the remaining 6 are analogue input pins. 6 of the digital pins can be used as PMW. The board is rated as 5V, 16MHz and has a USB connector and a power jack. Table 1 shows the pin configuration.

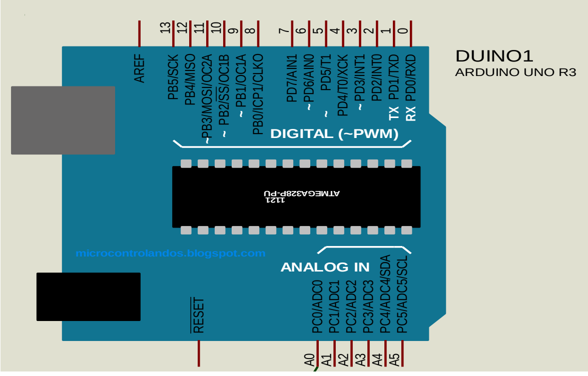

Figure 5. ATmega328 Arduino.

Table 1.Arduino pin configuration.

Pin	Function
5V	Regulated power to the board
Vin	Input voltage (from external power source)
3.3V	3.3V generated by the onboard FTDI chip
GND	Ground
A0	YL-69 SOIL MOISTURE SENSOR
A1	PHOTORESISTOR
D7	Led
D6	Led
D5	Led
D4	BUZZER
D8	DHT 11 Temperature Sensor
D10	Water PUMP

2.4 Output Unit

This unit shows the result of the processed data prior to the sensor's application on the soil through the use of Liquid

Crystal Display (LCD), light emitting diodes (LEDs) and DC fan. Liquid Crystal Display (LCD) of the configuration of 16x2 i.e. 16 rows and 2 columns was used. Pins D4, D5, D6, and D7 were used as the data lines and were connected to pins 5, 4, 3, 2 on the Arduino respectively. Pins 15 and 16 are for the GRND and VCC. The Enable pin (E) is connected to pin 11 on the controller, while the Register Select (RS) pin is connected to pin 12 and Read/Write (R/W) to the ground. Figure 6 shows the LCD interface with the Arduino. In other to indicate the conditions of the soil, three LEDs were used: for moist, soggy and dry, connected to pins 13, 12, and 11 respectively as shown in Figure 7. Each pin lights for the corresponding conditions.

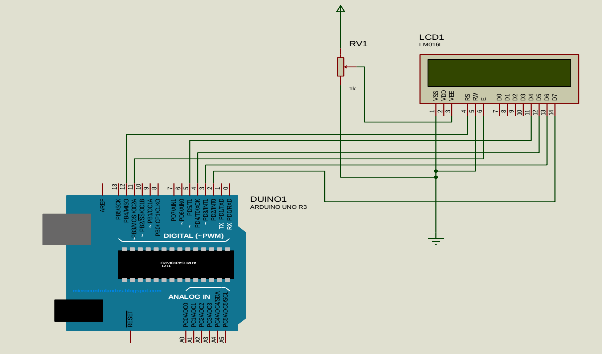

Figure 6. LCD interface with Arduino R3.

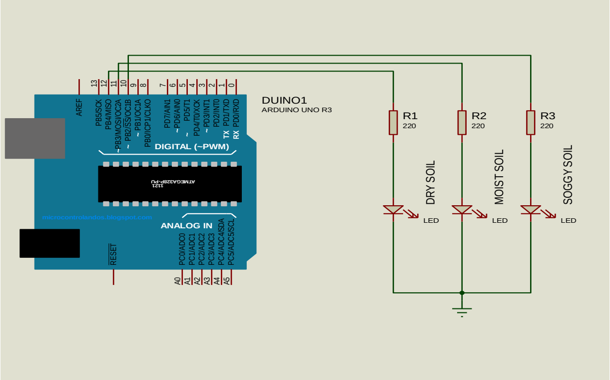

Figure 7. LEDs connection to Arduino.

The values of the resistors used with the LEDs, was determined using Ohms law.

$V = IR$ equation 1

where V = Voltage, I = Current, R = Resistance

V = VCC (5V) – Voltage drop across the LEDs

(2V) = 3V

$I_{LED} = 20mA$

R = V / I = 3 / 0.02 = 150ohms

Here a value greater than the minimum value of the resistance was selected so as to achieve the current limitation. Therefore, a resistor of 220 ohms was used. The DC Fan consists of an electric motor (12V DC) fan. The sensing and control unit were powered by a 5V DC. It was interfaced with the Arduino as shown in Figure 8 while the circuit diagram for the complete design is as shown in Figure 9.

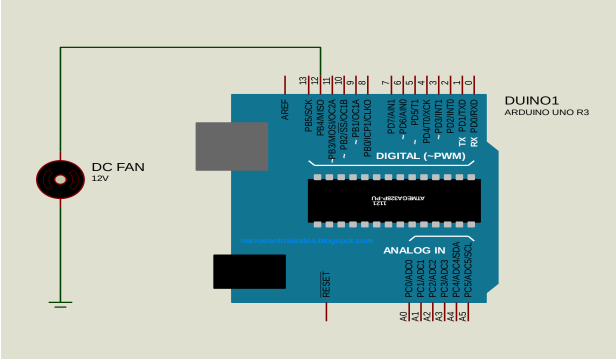

Figure 8.Dc fan configuration with Arduino.

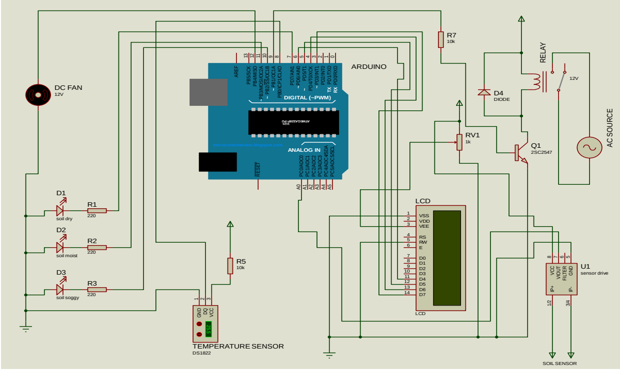

Figure 9. Circuit Diagram.

2.5 Software Stage

The Arduino integrated development environment (IDE) was used to automate the various hardware components, with C programming language. The codes were compiled and uploaded to the microcontroller through the USB cable. An extract of the code is as shown

2.5.1 Program pseudo-code

```
READ sensorvalue
COMPARE sensorvalue with set threshold
IF sensorvalue > maximum set value
TURN-ON pump
DISPLAY soil condition on LCD
DISPLAY temperature and relative Humidity on LCD
LIGHT dry soil LED
ELSE IF sensorvalue < maximum set value > minimum set value
TURN-OFF pump
DISPLAY soil condition on LCD
DISPLAY temperature and relative Humidity on LCD
LIGHT moist soil LED
ELSE IF sensorvalue < minimum set value
TURN-OFF pump
DISPLAY soil condition on LCD
DISPLAY temperature and relative Humidity on LCD
LIGHT soggy soil LED
```

3. RESULT

In other to calibrate the sensor for efficient result, the Volumetric Water Content (VWC) of the three types of soil (Sandy, Clay and Loamy) was calculated with respect to the environmental temperature and humidity. Equal quantity of each soil was measured with 2.5cl water at interval. Table 2 shows the summary of the VWC of the soil with respect to volume of water at room temperature. The table shows decrease in temperature with increase in water level and increase in humidity with increase in water level (Temperature is inversely proportional to the Humidity) until a certain stage where increase in water produces and insignificant change in temperature and humidity.

Table 2. Volumetric Water Content.

Soil Water Content (cl)	**SENSOR READINGS (%)**					
	SANDY SOIL		**CLAY SOIL**		**LOAMY SOIL**	
	Temp	**Humidity**	**Temp**	**Humidity**	**Temp**	**Humidity**
0	33	39	33	38	33	37
2.5	32	39	32	38	32	37
5.0	31	40	31	38	31	38
7.5	30	40	30	39	31	39
10.0	30	41	29	39	30	40
12.5	29	42	29	40	29	41
15.0	28	43	28	41	28	42
17.5	27	43	27	42	27	42

3.1 System Operation

Figure 10 shows the system unit with the input as the sensor probe and the output as the DC fan which may be implemented on a larger scale by connecting to a water pump or solenoid valve. The three LEDs represent the output condition of the soil: RED for dry, BLUE for moist and YELLOW for soggy. The system is powered and dry soil sample is tested to validate the system. The sensor probe tip was inserted into the soil (real life application of which will be closer to the root of the plant) and its condition was displayed on the LCD as shown in Figure 11, which is “DRY SOIL, NEEDS WATER”. This indicated that the water content was low, it will turn the RED led on and the controller then triggers the fan to roll and consequently irrigate the soil automatically. When enough water is supplied the LCD displays the temperature and humidity percentage of the soil and that the water level of the soil is enough with the display “THANKS FOR THE WATER”. This turn the BLUE led on and the DC fan stops automatically as shown in Figure 12.

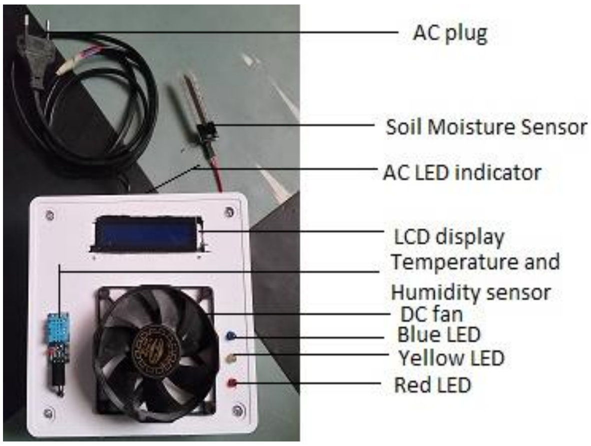

Figure 10. The enclosed design.

Figure 11. System testing on dry soil.

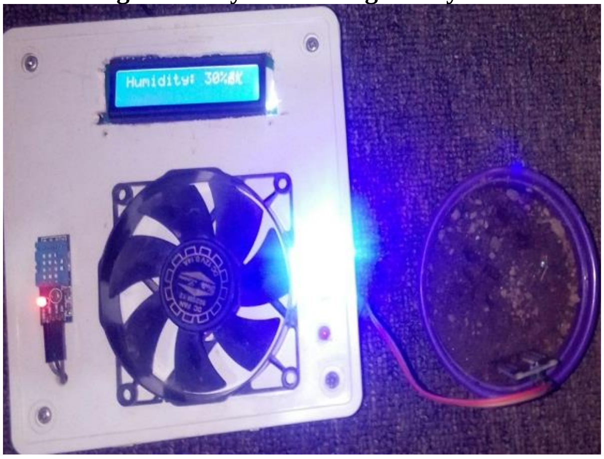

Figure 12. humidity percentage of wet soil.

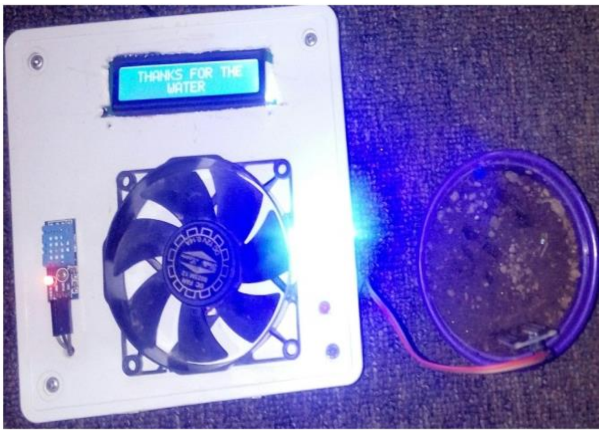

Figure13.Sufficient water on the soil.

4. CONCLUSION

In this paper, a viable solution to the problem of unsustainable irrigation was proposed. An automatic crop irrigation system was developed with a YL-69 soil moisture sensor, an Arduino Uno R3 microcontroller, LEDs, Buzzer, 16 * 2 LCD, a 12V DC inbuilt power pack and 5V DC relay for switching a water pump. The device was built with inexpensive materials which will optimize cost on a large scale; it is also easy-to-use with no complex training required on the part of the user. The benefit to the environment will be lesser consumption of water, no labour force and enabling the immediate user (farmers) concentrate on making other improvements and maximizing yield for the crops due to optimized irrigation.

REFERENCES

[1]Aborisade,D.O.,Adeyemo,Z.K.,Ajenikoko,G.A.,Adepoju, G.A.,Ojo,J.A.,Okelola,M.O.,Adebayo,V.X.(2009).BasicElectrical Engineering.18.

[2]Blaine,Hanson,Schwankl, Larry, and Futon., A. (1999). Scheduling Irrigations: When and How Much Water to Apply. *UC ANR*.

[3]Clemmens,A. J.(1990).Feedback Control for Surface Irrigation Management. *ASAE publication*, 04-90.

[4]Dunn,W.C.(2005).Introduction to Instrumentation Sensors, and Process Control. *British Library Cataloguing*.

[5]Dursun,M.,Aksoz,A.,and Saygin, A.(2005).A HPA Application for Greenhouse Temperature Control System: Advances in Environmental and Agricultural Science (ICESEEI),Dubai.

[6]Gaddam,A.,Al-Hrooby, Me.,and Esmael,W.(2002). *Designing a Wireless Sensors Network for Monitoring and Predicting Droughts.* Paper presented at the Proceedings of the 8th International Conference on Sensing Technology, Liverpool, UK.

[7]Hanson,B.R.,and Orloff,S.A.(2007).MonitoringSoil Moisture for Irrigation WaterManagement. *UC ANR*(21635).

[8]Hanson, B. R., and Peters, D. W. (2000). Soil types affects accuracy of dielectric moisture sensors. *California Agriculture, 54(3)*, 43-47.

[9]Kawakami, A., Tsukada, K., Kambara, K., and Siio, I. (2011). *PotPet: pet-like flowerpot robot.* Paper presented at the Proceedings of the fifth international conference on Tangible, embedded, and embodied interaction.

[10]Manas, K. P., Banasree, D., and Gautam, D. (2013). An Overview of Microcontroller Unit: From Proper Selection to Specific Application. *International Journal of Soft Computing and Engineering (IJSCE)*, *2*(6), 228-231.

[11]Nagaraja,H.,Aswani, R.,and Malik, M. (2012). Plant Watering Autonomous Mobile Robot. *IAES International Journal of Robotics and Automation (IJRA)*, *1*(3), 152-162.

[12]Nugroho,A.P.,Okayasu,T.,Fushihara,H.,Hirano,O.,Mitsuoka, M., and Inoue, E. (2012). *Development of intelligent control system for greenhouse.* Paper presented at the AFITA/WCCA.

[13]Ogunwale, S.A.,MauryaP.R.,Owonubi,J.J.(2005).Farmers View on the Management of Irrigation Schemes inNigeria.

[14]Rana,B.,Romit,B.,Ankita,B.,Shamik,C.,andRaghavT.(2015). Solar-Powered Automated Plant/Crop Watering System. *International Journal of Advanced Engineering and Global Technology*, *03*(01), 261.

[15]Rawls, W. J., Ahuja, L.R., Brakensiek, D.L., and Shirmohammadi, A. (1993). Infiltration and soil water movement. *Handbook of hydrology*, 5.1–5.51.