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MICRO-CONTROLLER BASED BIOMETRIC AUTHENTICATION SYSTEM IN SMART WATER TAP RUNNING MACHINE

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Abstract: Smart water tap running machine or system is water supplied to a tap (valve) with incorporation of processor, memory and other computing components. This machine was designed using R3035 fingerprint sensor as authentication device, for enrollment and verification. The ATMEGA328 serves as micro-controller and send the corresponding signal to both the LCD and the tap pumping device so as to grant access to enrolled user and denied non recognized user. The control unit was powered by a constant 5v voltage from voltage regulator 7805 IC while components were powered with 12v from 7805 IC and XFMR step down transformer respectively. The result from this machine shows that by powering it on, the users were asked to place their finger, if he or she is non register user, an enrolment button is pressed, where the LCD display enrollment location and user fingerprint template was stored. The enrolled users were asked to place their finger print on the fingerprint sensor and LCD displayed "ACCESS GRANTED" and the pumping of water start automatically. There is stop button to deactivate the running process or the tap running stops after a preset volume. This proposed system only allowed enrolled or authenticated users to have access to the tap running system, this however will enhance effective management of water resources and improve home appliances security.

Keywords: Biometric, Authentication, Sensor, Verification, Machine, Microcontroller

1. Introduction

Water is actually a natural resources available on planet earth, which is meant to be consumed, used or exploited resourcefully. Likewise, without wastage water has to be made available to avoid problem of scarceness with proper quality and quantity [1], [4], [14]. Water has great influence or impact on so many application areas like industrial usage, agriculture field, domestic purpose etc. 70% of earth surface is been covered with Water bodies out of which only 3% of is drinkable and portable [4], [12]. Earth is made up of 3% fresh water and 97% salt water, therefore without wasting it and also ensuring quality, water has to be provided suitably at appropriate time [3]. The upgrade in the design of flow sensor, flow switch, distribution techniques been made available by the advanced development of science and technology is to achieve appropriate dispersal of water supply across water pipes and tanks [2], [3], [9]. Based on physical activities, age, health issue and environmental conditions, the required quantity of drinking water may vary for each and every person. Water is responsible for 55% and 60% of weight in women and men respectively [5]. Intake of water plays a significant part in human metabolism and also assist in building healthy and refreshed skin [11]. It likewise prepares us to stay alert of numerous diseases. To turn over water from source point to usage point in an efficient way and avoids human error, the automated water distribution and authentication system is used. Through embedded system, automated water supply can be done in cost effective way [6], [13].

2. Review of related works

Nivetha and Sundaresan developed an unmanned drinking water dispersal using Arduino, this system employs water flow switch and water flow sensor which is instructed by arduino mega board [7]. Water is being utilize by the user through flow sensor which generates series of electric pulses and allow the calculation of the amount of water supplied. Also, with this arrangement a relay and valve is incorporated to control the water supply from the main tank. This system only allows the distribution of the required amount of water needed thus ensuring effective flow and reduce wastage of water resources. However, this system doesn't ensure that the rightful user have the access to the water supply as there is authentication unit in the aforementioned water system.

Pahalson and Dayer worked on an automated sensor water tap for hand washing [8]. This system turns ON and OFF a water tap spontaneously with no human manual intervention. It makes use of a passive Infrared (PIR)

Sensor that has a sensitivity range of about 3 meters. This sensor detects the presence of human being and yield a high output. This automated water tap system employs PIC16F628A microcontroller which was programmed in C language. Based on the signal received from the sensor, this microcontroller turn ON the water tap in case there is presence of the hand of a user and turn OFF the tap automatically when the hand is withdrawn. This system provides an easy and convenient way of using tap water. Nevertheless, it doesn't ensure that the water resources are channeled towards only the rightful owner as there is no provision for authentication unit.

Saritha and Abinaya carried out a research work on automated water tap control system [10]. This system makes use of IR Sensor which detect the presence of the user and instruct the Solenoid Valve to open or close through the help of IR recipient circuit. The IR aerial circuit put an infra-red rays on the air, if there is any obstruction in the pathway, then infra-red rays reflect. This particular infra-red rays which are inward bound through handset path is refer to as IR receiver, which form the signal used to control the system by the designed control circuit. This system though allow easy use of water tap system may lead to wastage of water resources as the user may be perceived from a distant and the water may start running even when the user doesn't intend to use the water system.

Hence this research work was done to ensure effective and efficiency management of water resources as the only intending and rightful owner can have access to the water system.

3. Design Methodology

3.1 Components Used

The components used in the constructional research work discussed listed below;

i. Reservoir
ii. Pump
iii. Flow rate meter
iv. Solenoid valve
v. R3035 fingerprint
vi. Atmega328 microcontroller
vii. 16 x 2 LCD
viii. Switch and Push buttons

3.1.1 Reservoir

Water tanks are employed to arrange storage of water for use in many applications agricultural farming, drinking water, irrigation agriculture, fire suppression, both for plants and livestock, food preparation, chemical manufacturing, as well as many other uses.

3.1.1.1 Choice of materials

A bucket is used for the reservoir water tank to create a prototype of the tap running system.

3.1.2 Pump

Pump provide a means to moves something slurries or fluids (liquids or gases), by mechanical action, usually transformed from electrical energy into hydraulic energy. Pumps which consume energy to perform mechanical work moving the fluid, normally operate by some mechanism (typically reciprocating or rotary). In this research work, the SL-4000 pump is used because of it water dispensing pressure is faster compare to others. The pump requires a 12V at normal level but the power supply ranges from 9-14.4V while its current should be 3.5A and its flow rate is 4 litres per minutes which is actually quite faster.

Figure 1: SL-4000 Pump

3.1.3 Flow meter

A water flow meter is a device that actually device a means to size the quantity of water journey through a pipe. Numerous water flow meter technologies are available for selection depending on the keeping conditions, water volume usage, and economic terms. However, the flow rate used in the project requires a 5V DC input power supply and has a flow rate of 1.30 litres per minutes an d also it has a pressure of 1.75MPa.

Figure 2: Back view of a flow meter

3.1.4 Solenoid Valve

Solenoid valve is an electromechanically-operated valve, which vary in the characteristics of electric current used, the strength of the magnetic field been generated by them, the mechanism they employed in regulating fluid and the type and features of fluid they control. In this research work a solenoid valve used requires a power supply of 12V DC and it has a pressure of 0.02 – 0.8MPa has shown in figure 3 below.

Figure 3: Showing a solenoid valve

3.1.5 R305 Fingerprint Sensor

Table 1: The fingerprint Sensor pins and functions

Pin number	Name	Type	Function description
1	Vin	In	Power input
2	GND	-	Signal ground
3	TD/TX	In	Data output
4	RD/RX	out	Data input

This fingerprint sensor is employed for fingerprint enrollment and matching, the matching can be 1:1 or 1:N. When enrolling, the user will place his or her finger on the sensor two times. The system will then process the two-time finger imageries, form a prototype of the finger and store the template. When matching, user enters the finger through optical sensor and system will generate a template of the finger and compare it with templates of the finger library. For 1:1 matching, system will compare the live finger with specific template designated in the Module; for 1:N matching, or searching, system will search the whole finger library for the matching finger. In both circumstances, system will return the matching result, success or failure.

3.1.6 7805 Voltage Regulator

This provide a constant 5v output voltage to the entire components of the system. In the course of this project 7805 IC was used for some purposes. The name 7805 signifies two meaning, "78" means that it is a positive voltage regulator and "05" means that it provides 5V as output.

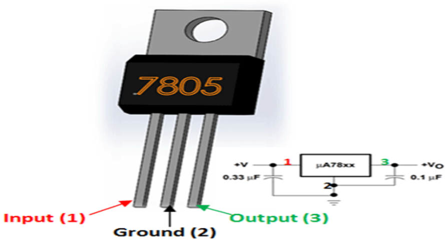


Figure 4: 7805 voltage regulator

3.1.7 Atmega 328

The ATmega328 is a CMOS 8-bit microcontroller with stumpy-power, based on the AVR enhanced RISC architecture. The ATmega328P achieves throughputs approaching 1 MIPS per MHz by executing powerful instructions in a single clock cycle, which allows the system designer to optimize power consumption versus processing speed. This microcontroller supports an actual Read-While-Write Self-Programming mechanism. The SPM instruction can only execute from a separate Boot Loader Section. Atmega328 is selected for its an interrupt vector size of 2 instruction word or vector, fairly big flash memory of 32KB and an EEPROM of size 1KB also a RAM of 2KB.

Table 2: The ATmega328 packages

Speed (MHz)	Power Supply	Ordering Code	Package	Operational Range
20	1.8 – 5.5	ATmega328P- AU ATmega328P- MU ATmega328P- PU	32A 32M1-A 28P3	Industrial (-40°C to 85°C)

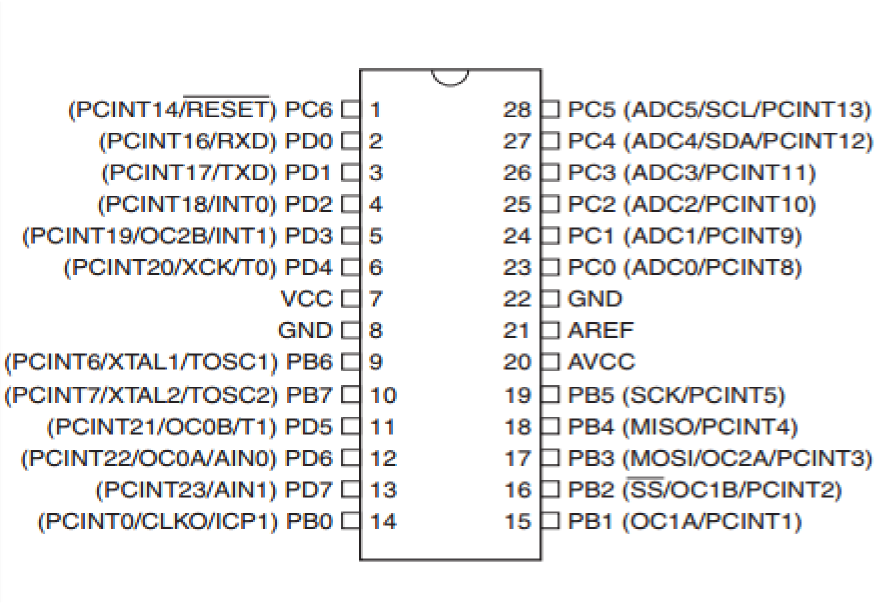


Figure 5: The pin illustration of the ATmega328

3.1.8 16*2 Liquid Crystal Display (LCD)

A liquid-crystal display (LCD) is a flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals combined with polarizer. Liquid crystals do not emit light directly, instead using a backlight or reflector to produce images in color or monochrome. LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images with low information content, which can be displayed or hidden.

Figure 6: Front and back view of the LCD

3.1.9 Selector Switch

This is device employed in interrupting the flow of electrons inside a circuit. Switches are fundamentally dual devices, it is either they are wholly closed or wholly opened.

Selector Switches

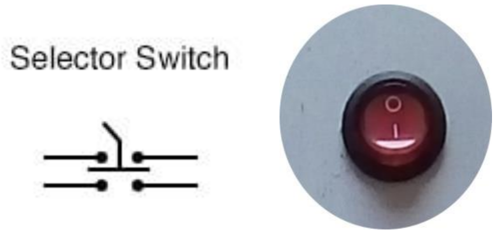


Figure 7: The circuit diagram and the diagram of a selector switch

3.2 Design Subsections

There are several units or sections that made up the entire system design which are as follows:

i. The Power Section
ii. The Enrollment Section
iii. The Deletion Section
iv. The Verification, Authentication, And Control Section

3.2.1 The Power Section

In the power section, the AC voltage from power supply is been stepped down by the step-down transformer, then the voltage is regulated through bridge rectifier, and eventually force to 5volt by LM7805 IC. The voltage is then applied to the system by switching on the system using the switch button on the surface of the system. Afterwards, and initialization stage is attained where the power-on module is being searched by the microcontroller and if found, the system is ready for use to perform other functions by displaying “place your finger” on the screen of LCD. The flowchart for its operation is described in the figure 8 below.

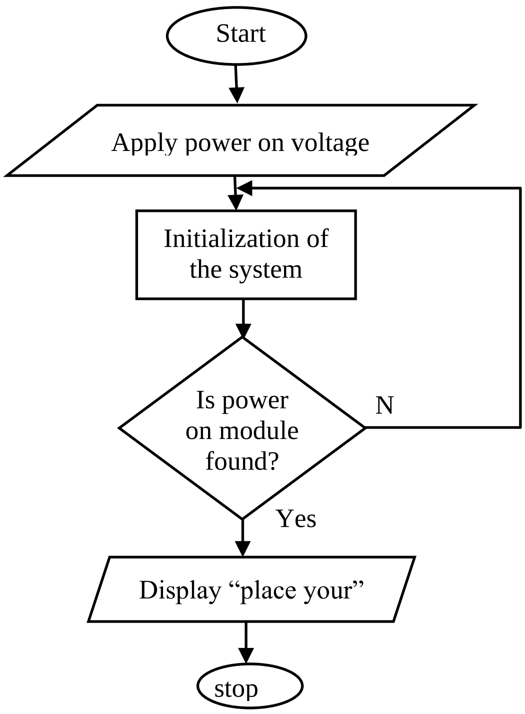
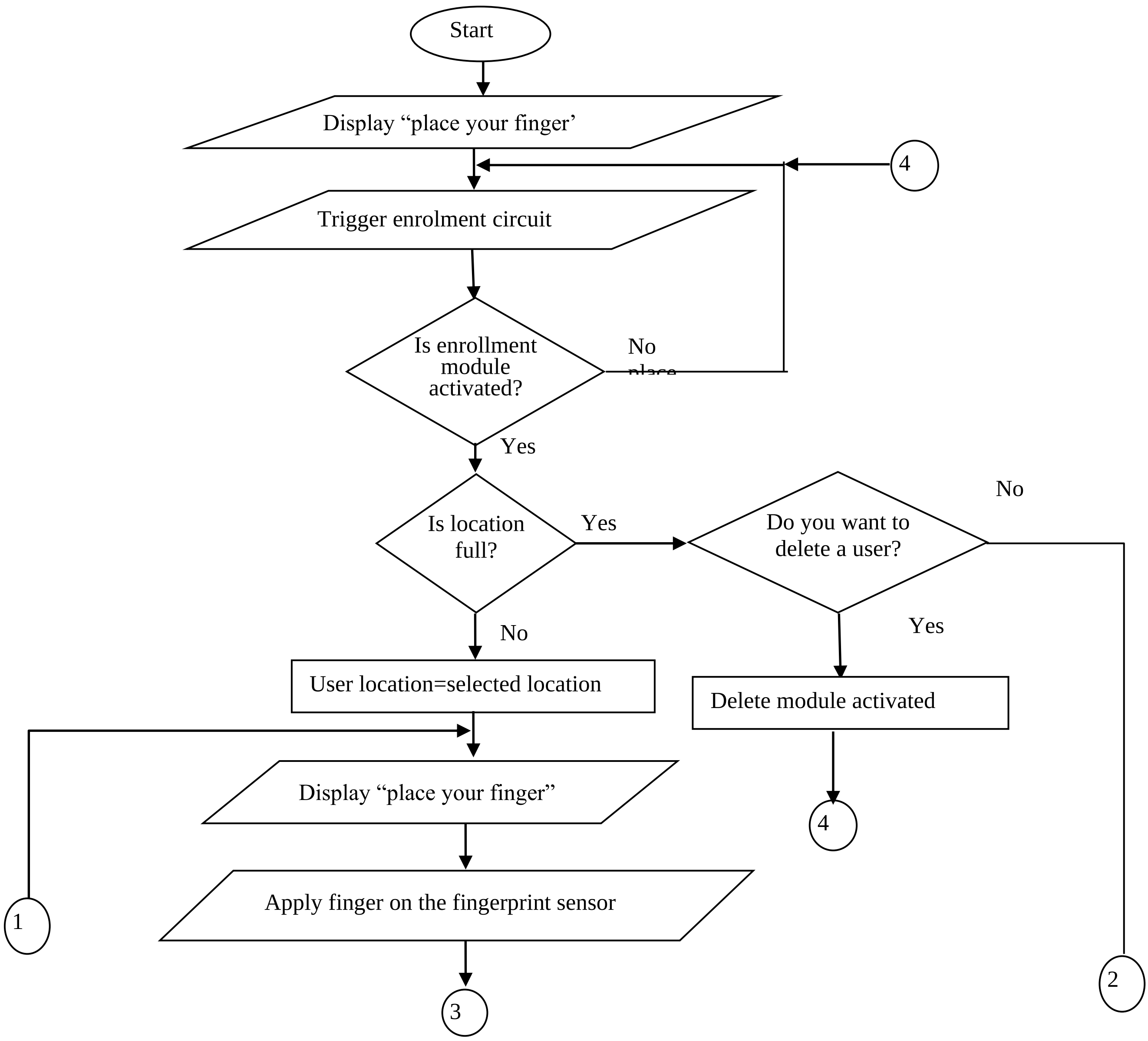


Figure 8: showing the flowchart of the power section

3.2.2 The Enrollment Section

The enrollment section of the system performs the operation of registering new user fingerprint in order to have access to the machine. After the power section has initialized the system, a notation by default stating “place your finger” is displayed by the system. Then the technician or the person in charge of the system will activate the enrollment module by long pressing the enrolling push button at the back of the machine until it gives an instruction to choose a storage location to enroll a new user. But what if the whole memory of the fingerprint is full, then the system will display or go back to the home by default displaying the notation “place your finger”, and then the technician will perform the delete operation in the deletion section. But if there are available spaces on the memory, then the enrolling operation can continue. A location is selected to be the user location. A display will come up stating “place your finger”, the finger to be registered will be placed on the fingerprint sensor. The fingerprint will capture the image of the fingerprint and store it in its RAM and display a notation stating “image taken”. Afterwards a notation will come up again stating to place the finger again on the sensor. Here, the fingerprint wants to compare the previous fingerprint taken at the second request. If they tally, then system will display a notation stating that it is stored but if it doesn’t the person has to start all over. The flow chart showing this working principle is shown in figure 9 below.



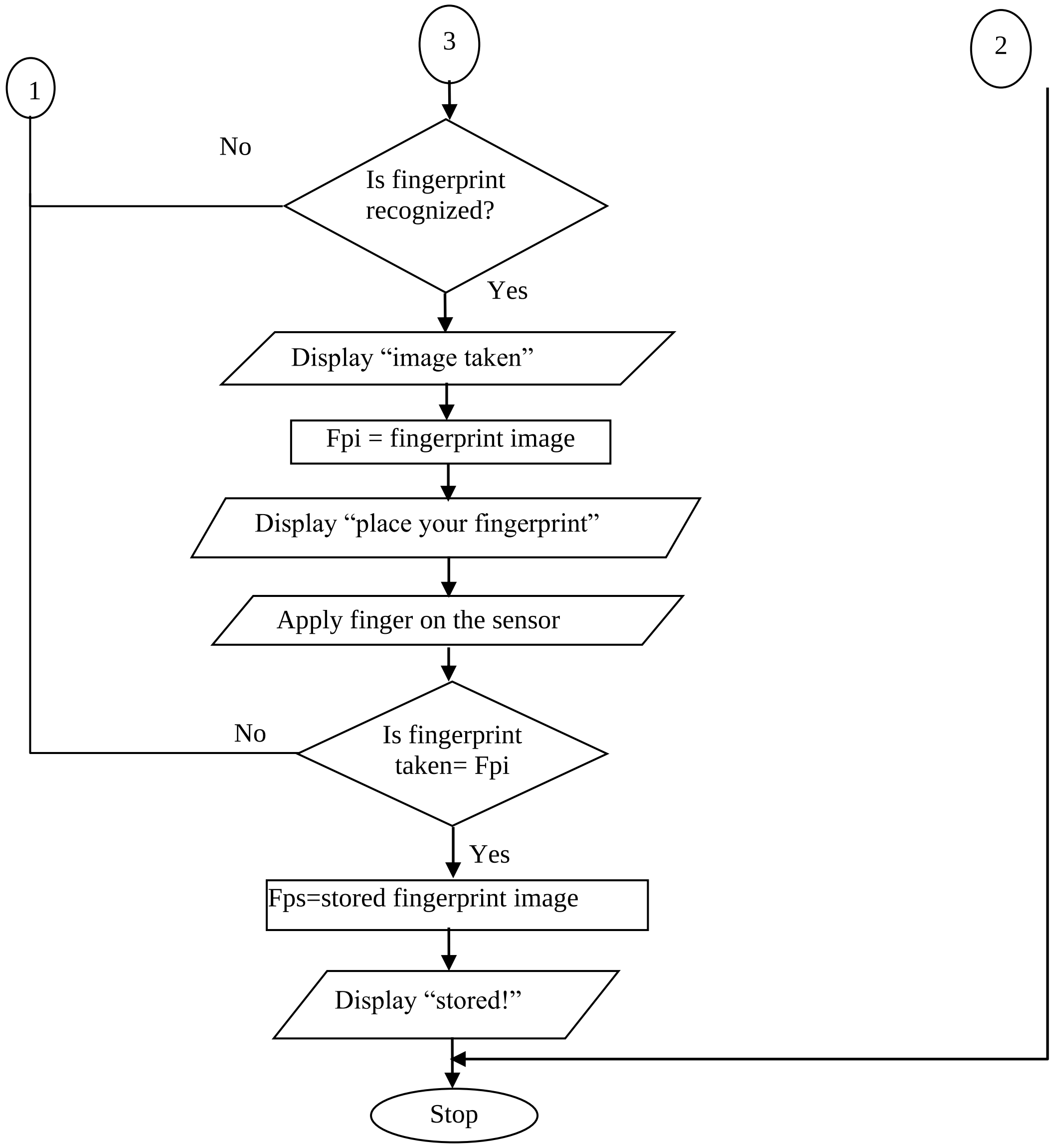


Figure 9: Flowchart of the enrollment section

3.2.3 The Deletion Section

In the deletion section, the admin can delete users' fingerprint who he thinks shouldn't have access to the system anymore or because he wants to enroll a new user. After the initialization stage, the technician or the admin will activate the deletion operation by long pressing the delete push button at the back of the system until an instruction is displayed. Then the technician will choose or select the storage location to be deleted using the up and down push button between the enroll and delete button, and then delete it with the delete button which serves as an OK and DEL button simultaneously. The flowchart describing this operation is shown in figure 10 below.

The deleting equation for the process is descibed below;

$y^{o} = \sum_{i=1}^{n} xi$……………………………..*(memory equation)* (1)

$y1 = \sum_{i=1}^{n} (xi - xj)$……………………….*(available space equation)* (2)

$y\infty = \sum_{i=1}^{n}(xi - xj) - z$…………………*(deleting equation)* (3)

Where,
z= space to be deleted
x= space available
i= space index
n= total space index
j= unavailable space index
$y\infty$= space remaining
y^{o}= entire space
y1=available space

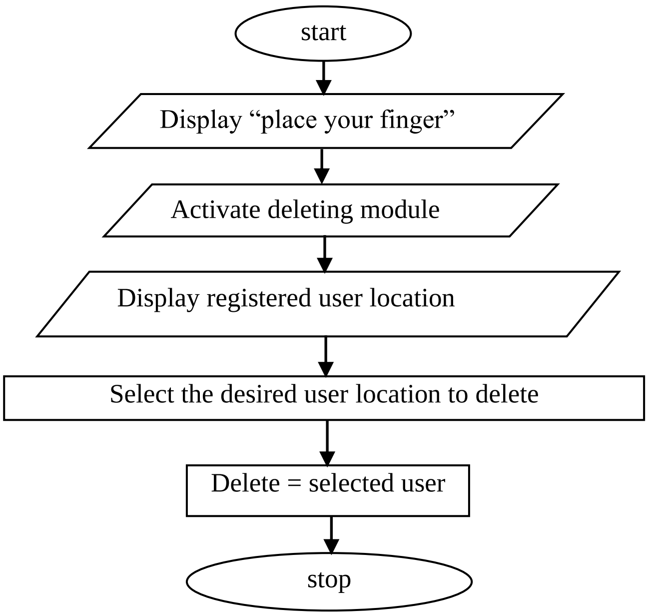


Figure 10: showing the flowchart of the deletion section

3.2.4 Verification, Authentication, and Control Section

This section also has three subsections which are verification, authentication and the control in which each performs a different function but its output serves as an input for the other section. This section is generally responsible for the matching of fingerprint, controlling of solenoid valve, and regulation of volume rate. The working principle can be seen in the flowchart in figure 11.

3.2.4.1 Verification unit

This unit is responsible for the verification of fingerprint placed on the fingerprint sensor. It checks whether the fingerprint placed on the sensor is real or that of an animal.

3.2.4.2 Authentication unit

This unit is quite responsible for checking or authenticating a fingerprint, that is, check whether the fingerprint placed on the sensor matches anyone found on the memory. If it matches any stored one, then the system will open for the next operation.

3.2.4.3 Control unit

In this unit, we have major part of the operation. After the verification and authentication processes, the control unit is responsible for the running of the tap system. After the authenticated tap running system has been activated, it is expected to run for some time. The system will stop either manually or automatically. Manually, it will stop if the stop push button is activated when the volume dispensed it less than 30 litres and automatically when the volume is equals to 30 liters because the program written in the microcontroller says there should be no passage of water when the volume dispensed is equals to 30 liters.

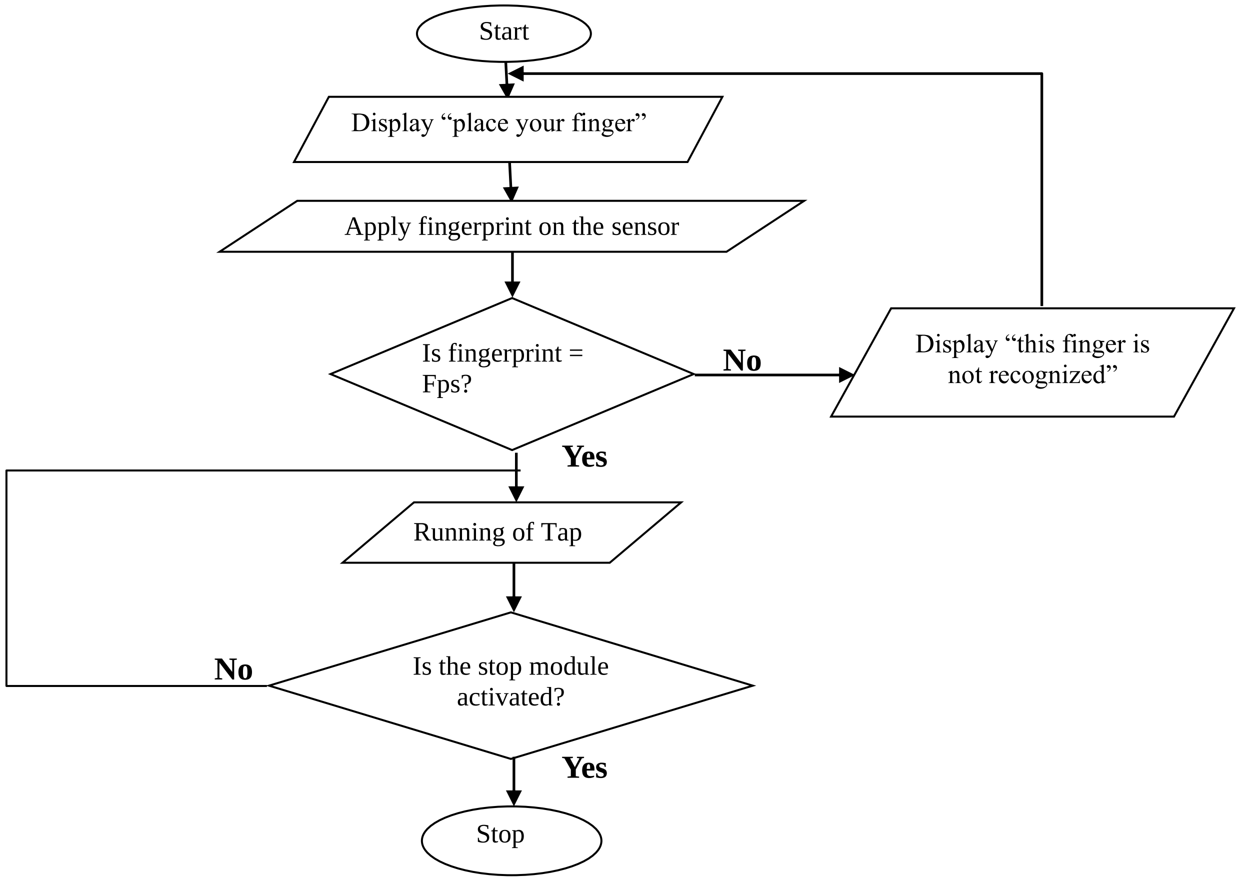


Figure 11: Flowchart of the verification, authentication, and control section

3.3 Final Stage System Design

At the final stage, all the aforementioned modules or units are connected to form the entire tap running system. The fingerprint sensor, the solenoid valve, flow rate meter, are all connected to the PCB where all control components are assembled. In the figure 12 below, the system initializes using the power as discussed earlier, then the technician will decide either to delete a user, or to enroll a new user or to use the authenticated tap running system as discussed earlier. The flow chart and circuit diagram are as shown in figure 12 and 13 below.

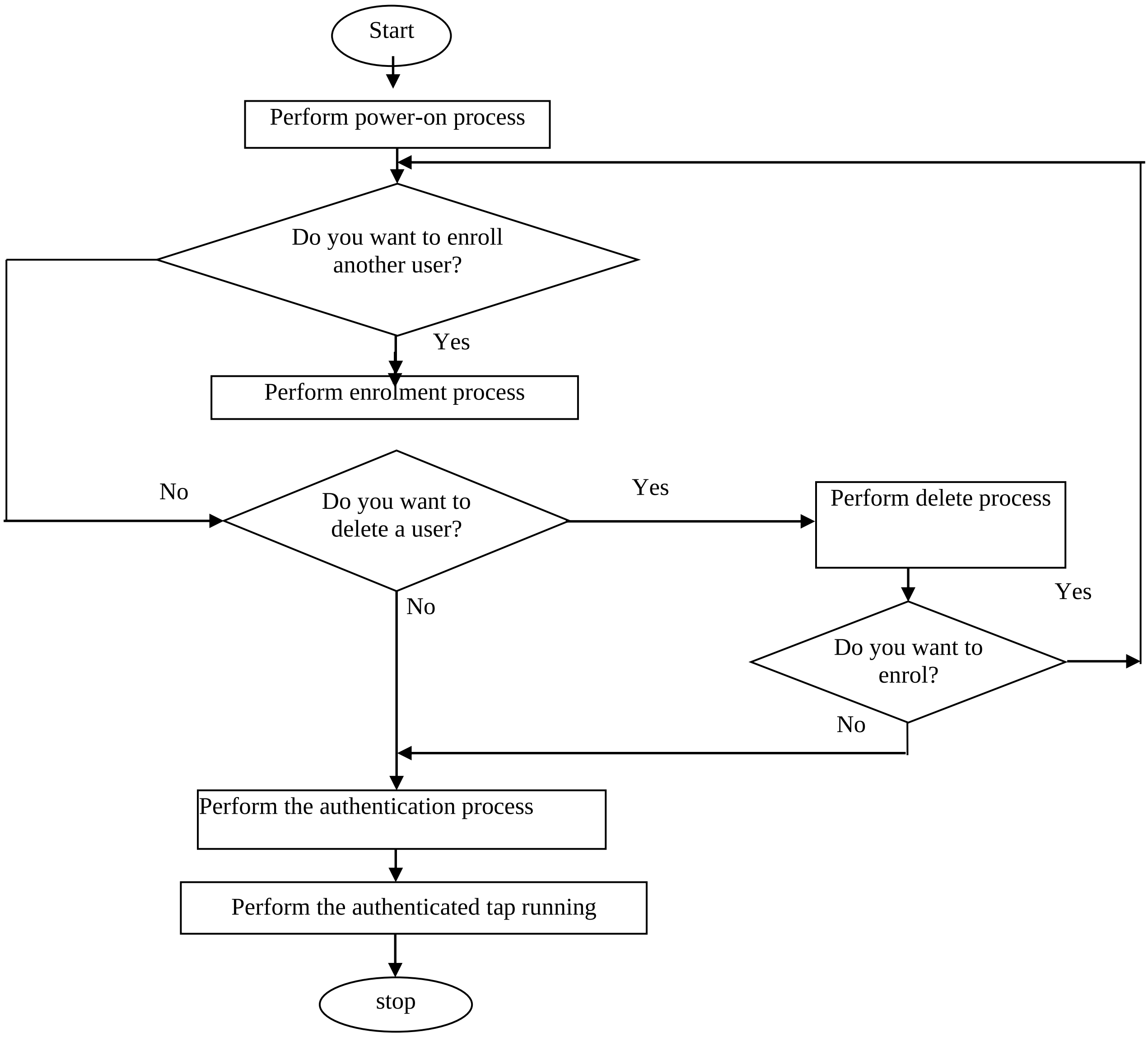


Figure 12: showing the flowchart of the entire system

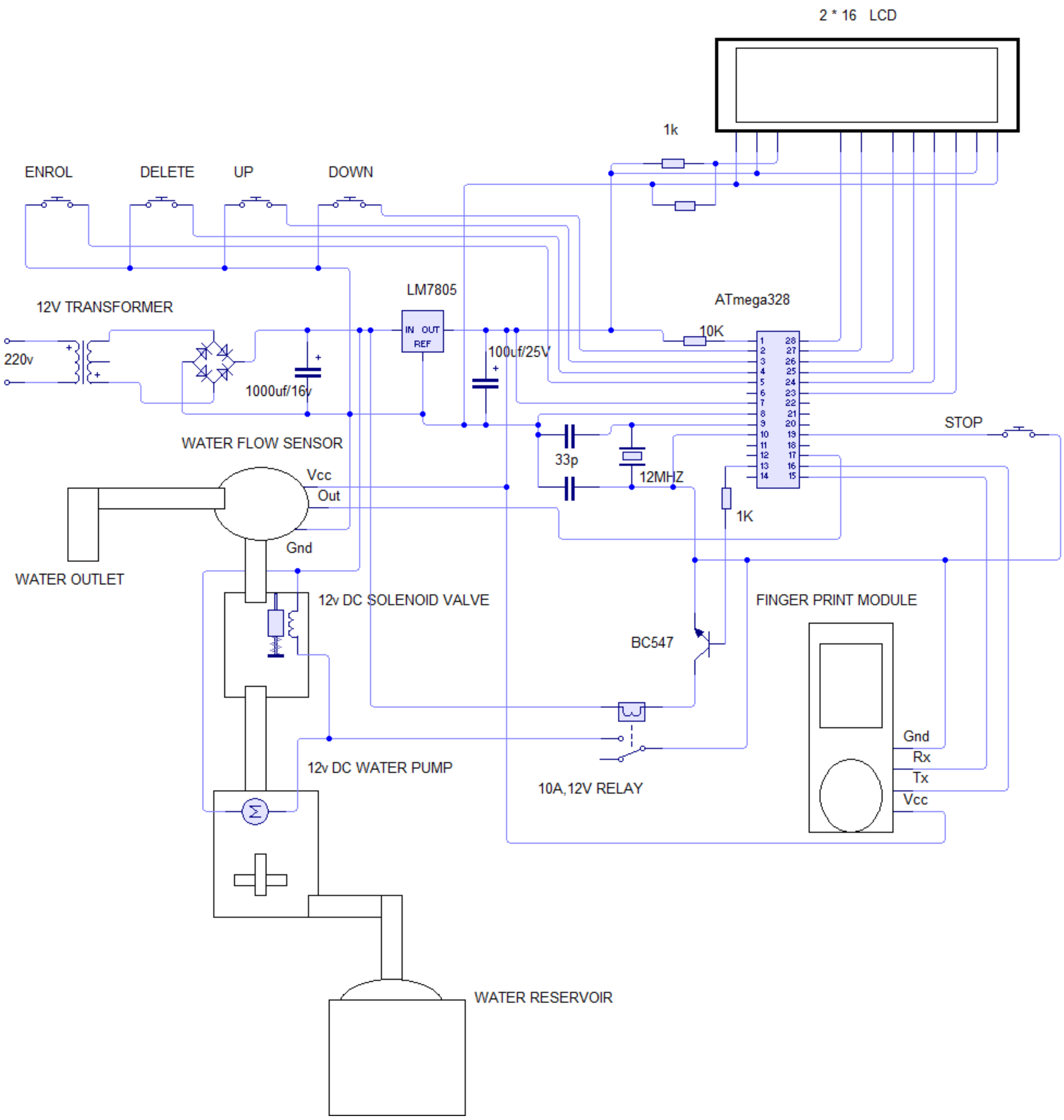


Figure 13: showing the circuit diagram of the complete system

The voltage coming from the power unit is being regulated to 5V by the IC LM7805 voltage regulator, which serves as source of power to other components in the system. The R3035 fingerprint sensor has 4 pins which are Vcc, GND, TX and RX. The fingerprint sensor receives power supply through the pin Vcc connected to the LM7805 regulator while the Gnd pin is connected to the ground. Its pin RX receives data or serves as data input connected to the ATmega pin PB1 while its TX serves as data output and send the image information to the ATmega pin PB2.

The ATmega328 microcontroller has 28 pins. PinPC6 is connected to the 2 x 16 LCD. While the pins PD0 to PD4 are connected to the push buttons for down, up, delete and enroll respectively. Pin 7 serve as the power input pin where it is connector to the LM7805 regulator to which it passes to the power source while pin 8(GND) is connected to the ground. The pin 13 is connected to the 547 transistor to control current passing through the circuit. The pin 19 is connected to the stop push button which makes the process stop and it is also connected to the transistor. The pin 17 is connected to the water outlet which allows the passage of water to occur.

The 16MHz crystal which has two 22μf capacitors installed on it and was connected to the microcontroller through its two pins. The 16MHz crystal is used to aid a very accurate and consistent frequency output to and

from the microcontroller. Pin 9(PB6) and Pin10 (PB7) of microcontroller were connected to the crystal.
2 x 16 LCD has three power pin VSS, VEE and VCC. The Vss was grounded while the VDD was connected to LM7805 also VEE was connected to variable resistor 10k in order to control the brightness of screen then to the ATmega pin 1(PC6) The RW, RS and E pin acts as control pin to the LCD while the pins D2 to D7 act as data pin which accept input from the ATmega328 at pin 23 (PC) to 28(PC5).

The four push buttons for enrol, delete, up and down are connected to the power source. The 12v DC water pump is connected to the 12v DC solenoid valve which is connected to the power source.

4. **Results and Discussion**

The biometric authenticated and automated tap running machine constructed was subjected to rigorous testing, using appropriate equipment, tools and method. The project testing section is divided into four sub-sections discussed below:

i. Power section analysis
ii. Enrollment section analysis
iii. Deletion section analysis
iv. The Main System Testing

4.1 Power Section Analysis

4.1.1 Testing of the Stepdown Transformer

The transformer was tested using multimeter, the input and output voltage was tested by turning the multimeter to the ac volt meter section and also the input and output current was tested by turning the multimeter to the ammeter section. The result in the table 3 below shows that this transformer is ok for use in this project work.

Table 3: Transformer parameter measurement values

v. Input Voltage (Vp)	vi. 220v
vii. Input Current (Ip)	viii. 6.5A
ix. Output Voltage (Vs)	x. 12V
xi. Output Current (Is)	xii. 2A
xiii. Transformer Power	xiv. 24 watt

4.1.2 Testing of The LM7805IC Voltage Regulator

The voltage regulators of used in this research work were put into several testing. The output voltage of the IC was tested in respect to their input voltage and the heat generated by the 7805 as discussed below.

4.1.2.1 Measuring the Input Voltage and Output Voltage of the Voltage Regulator

A DC power supply panel equipped with a voltmeter, a multimeter, regulator IC 7805and the black and red wires was used in the testing. The multimeter was place in the DC voltage setting while the Red and black wires were used as a link between positive polarity (+) and negative (-) of the voltage source to the input pin (1) and ground (2) of the regulator ICs. Output pin (3) and ground (2) of the 7805 IC was also connected to the positive polarity (+) and negative (-) on the voltmeter.
Several input voltage was applied to the voltage regulators and the output voltage was also measured on the pin3 (output pin). It was confirmed from the output of the multimeter that the output voltage of 7805 IC was nearly a constant value of 5v with little variation of ±0.2v which shown that the IC is working efficiently.
The heat generated by the voltage regulators was also tested by subjecting the IC to various input voltages. The result from table 4 below shows the heat dissipated when various input voltages were applied. Also the heat generated increases as the input voltage increases which indicates that the efficient of the 7805 IC also decreases as shown in figure 14 below, therefore the greater the difference between the input and output voltage, the more heat generated.

Table 4: Heat dissipated by 7805

Voltage in (Vin)		**Current (Io)**		**Heat Dissipated (w) 7805**	
xviii.	5	xix.	2.0	xx.	0.00
xxi.	6	xxii.	2.0	xxiii.	2.00
xxiv.	7	xxv.	2.0	xxvi.	4.00
xxvii.	8	xxviii.	2.0	xxix.	6.00
xxx.	9	xxxi.	2.0	xxxii.	8.00
xxxiii.	10	xxxiv.	2.0	xxxv.	10.00
xxxvi.	11	xxxvii.	2.0	xxxviii.	12.00
xxxix.	12	xl.	2.0	xli.	14.00
xlii.	13	xliii.	2.0	xliv.	16.00
xlv.	14	xlvi.	2.0	xlvii.	18.00
xlviii.	15	xlix.	2.0	l.	20.00
li.	16	lii.	2.0	liii.	22.00
liv.	17	lv.	2.0	lvi.	24.00
lvii.	18	lviii.	2.0	lix.	26.00
lx.	19	lxi.	2.0	lxii.	28.00
lxiii.	20	lxiv.	2.0	lxv.	30.00

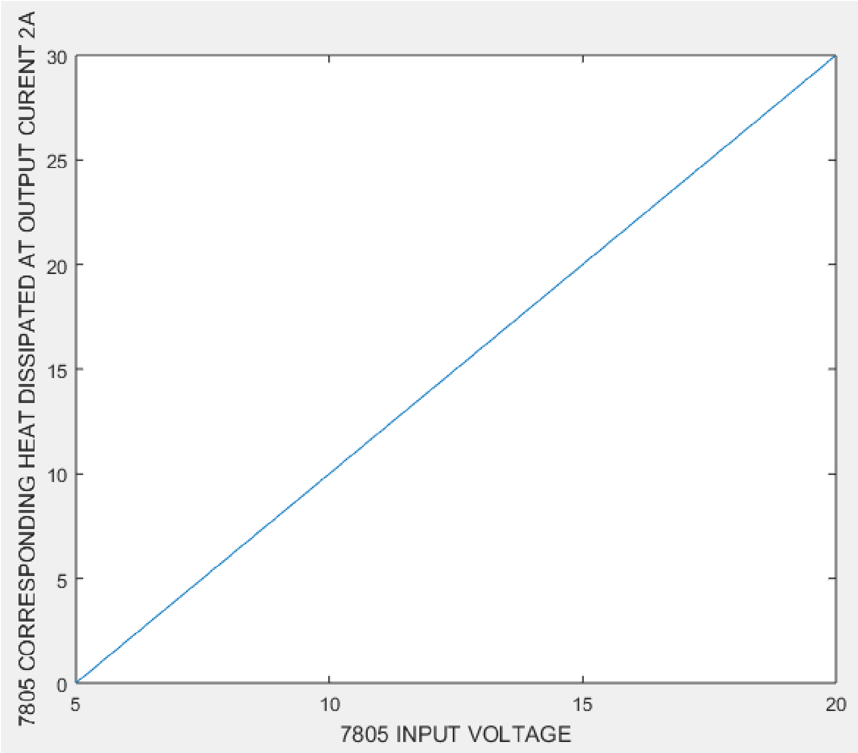


Figure 14: Showing the voltage- heat graph of the 7805 regulator

4.2 Enrollment Section Analysis

To enroll a new finger to become a user of the system, the enrollment push button was long pressed until the display unit gave a response “PLEASE WAIT”. The system actually gave a response as well a delay of about 3 seconds for choosing a fingerprint location as shown in figure 15(a) where a location was selected. After the selecting a location ID 25 as shown in figure 15(b), the system then gave a response of placing a finger. A finger was placed on the sensor to register it. The LCD gave a response stating “IMAGE TAKEN”, then “REMOVE FINGER”. Another response or directive is given by the system stating “PLACE FINGER AGAIN”. After the finger taken is placed again, then the system give a response stating “STORED!”.

(a) (b)

Figure 15: Enrollment process

4.3 Deletion Section Testing

To delete a registered and stored fingerprint on the system, the deletion process was performed. Push button was pressed to trigger the deletion circuit to enable the deletion process. Just like the enrollment process, the LCD gave a response stating "PLEASE WAIT". Then a fingerprint location ID 25 was selected and it was deleted after pressing the OK button which coupled as DEL on the push button. The fingerprint is deleted successfully as stated by the LCD in Figure 16 (b) and that fingerprint cannot have access to the system anymore.

(a) (b)

Figure 16: The deletion process

4.4 The Main System Testing

The Smart Water Tap Running Machine is subjected to test as a whole system. The system LCD displays a directive stating "place your finger". A stored finger was placed and the display unit displayed a word stating "ACCESS GRANTED". Then the process starts by allowing the free passage of water which was displayed on LCD that "TAP IS OPENED" it also display the amount of volume dispensed during the process. It can also be switched off by pressing the off push button in front of the system structure. This process is shown in figure 17 below.

(a) (b)

(c)

Figure 17: showing the main process of the running water

4.4.1 Flow Rate Measurement

In this section, the project was subjected to testing in order to determine the flow rate of the system which is measurement is in litres per seconds. To test the flow rate, the system was powered and undergo the process of initializing all the system modules, after which the time it takes the system to dispense a given volume of water was recorded. The experiment is carried out at some regular amount of volume and the corresponding time values was recorded, as shown in table 5 and figure 18 below. Also the test shows a constant flow rate at normal conditions of 0.0006m^3/s.

Table 5: showing various volumes and their corresponding time taken to finish the process.

i.	Volume (v) in litres	lxvii.	Volume (V) in m^3	lxviii.	Time taken(t) in secs
x.	2	lxx.	0.02	lxxi.	33
i.	4	lxxiii.	0.04	lxxiv.	66
v.	6	lxxvi.	0.06	lxxvii.	100
i.	8	lxxix.	0.08	lxxx.	133
i.	10	lxxxii.	0.10	lxxxiii.	167
v.	12	lxxxv.	0.12	lxxxvi.	200

i.	14	lxxxviii.	0.14	lxxxix.	233
c.	16	xci.	0.16	xcii.	267
i.	18	xciv.	0.18	xcv.	300
i.	20	xcvii.	0.20	xcviii.	333
x.	22	c.	0.22	ci.	367

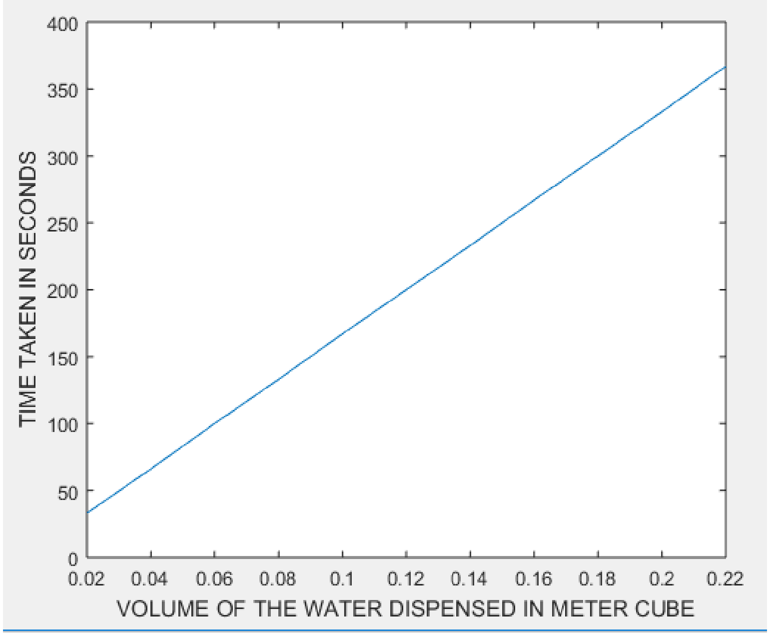


Figure 18: Showing the volume-time graph

The result of the testing procedure carried out on this project shows that the system actually satisfy the requirement as stated in chapter one.

5. Conclusion

The automated smart tap running system has been an emerging area in the field of science and technology, and few works has been done in this area. This constructional research work employs a R3035 fingerprint sensor as its sensing device, ATMega328 as the microcontroller and LCD as the screen to display the operations of the system. The result gotten from its testing and operation has given more hope in the area of biometric and water management as there's a high level of precision of the finger print sensor, and accuracy with efficient management of power and other resources. It also exposed me to the knowledge apply equations and formulas in investigating and fabricating electronic devices as well as some processes like etching, printing, heat transfer, and boring of the PCB. Although trending the world of tap running system fabrication was very tasking, to me it was very interesting and encouraging.

6. Recommendation

Though the result gotten from this study, has actually shows that the machine works to specifications and can be used to better the life of a common man and world at large. There are some improvements that are worthy of incorporation in the future work on the machine. These include:

i. Incorporation of highly selective sensor that will be able to sense a fetching bucket and stop when the tank is full automatically.

ii. Incorporation of voice-controlled sensor to control the machine verbally.

iii. Incorporation of a internet of things (IOT) device to allow the user to control the system from a relatively long distance.

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