AJSIHD GLOBAL RESEARCH NETWORK

AMERICAN Journal of Science on Integration and Human Development
Volume 2, Issue 11, 2024 ISSN (E): 2993-2750

Saline Solution Generator (S.S.G.)

Ammar Abd Al-Raheem Ibrahim, Malak Moayed Ahmed, Nabaa Hasanin Ali Akabr, Ali Walied Ahmed, Haider Mohammed Sabih, Mustafa Abod Majeed
Al-Farahidi University, College of Medical Techniques, Department of Medical Instrumentation Engineering

Abstract: Saline solution generator is a device that depends on the moisture present in the atmospheric air in order to generate water by utilization of the condensation method, then by mixing the water with a certain calculated amount of salt (0.9 gram of sodium chloride NaCl per liter), this process will produce SALINE SOLUTION which has various applications in medicine. saline is widely used in the health sector (hospitals and clinics). The device was made to vastly reduce the import cost, the solutions large daily use accumulates the cost as it takes space from the general economy. In addition, due to the large unnecessary amount of plastic waste that comes with the packaging and importing of saline solution, producing the solution locally in areas of interest will greatly reduce the waste of packaging, importing and using it. The (S.S.G.) depends mainly on microcomputer called (Raspberry Pi) as a general controller of the device and is linked to many of the electronic parts that will be mentioned later and that receives the orders through a touchscreen located at the top of the device.

CHAPTER I

GENERAL INTRODUCTION

1.1. BACKGROUND OF STUDY

Fluid therapy is a critical component of the clinical management of patients. It consists of colloid therapy as well as crystalloid therapy. The most commonly used crystalloid worldwide is saline which is used in the management and treatment of dehydration (e.g., hypovolemia, shock), metabolic alkalosis in the presence of fluid loss, and mild sodium depletion. This activity describes the indications, action, and contraindications for saline as a valuable agent in the use of fluid and electrolyte resuscitation. This activity also highlights the mechanism of action, adverse event profile, and other key factors (e.g., administration, monitoring, relevant interactions) pertinent for members of the inter professional team in the management of critically ill patients [1]. normal saline is a crystalloid fluid. By definition, it is an aqueous solution of electrolytes and other hydrophilic molecules. The main indication for the use of crystalloid fluids in humans is due to their isotonic nature when compared to serum plasma. In comparison to other types of fluids (e.g., hypertonic, hypotonic), there is less of an osmotic effect. Normal saline contains electrolytes (sodium and chloride ions) which dissociate in solution. sodium ions are the main electrolytes of extracellular fluid, integral in the distribution of fluids and other electrolytes. Another important ion is chloride, which serves as a buffering agent within the lungs and tissues [2]. Here chloride helps to facilitate the binding between oxygen and carbon dioxide to hemoglobin. These ions are primarily under the regulation of the kidneys, which control homeostasis by absorption or excretion within the tubules. additionally, water plays an equally important role. Water is a necessary ingredient of the body and comprises more than two-thirds of total body weight. Similarly, the balance of water is primarily under the control of the lungs and kidneys. The distribution of water depends mainly on the concentration of these electrolytes within various compartments. Within these compartments, sodium plays a significant role in sustaining homeostatic concentrations and the distribution of water. Normal saline functions to expand intravascular volume without disturbing ion concentration or causing large fluid shifts between intracellular, intravascular, and interstitial spaces. Normal saline solution can be administered only via intravenous access. When deciding dosage, the provider must take into account various patient factors (e.g., weight, age, clinical presentation, laboratory findings). Therefore, monitoring should focus on laboratory results and clinical evaluation (see 'Monitoring' section).

Naturally, there are two methods of administration for normal saline:

1. Fluid bolus: This route is normally used in the acute care setting when a rapid infusion of fluids is necessary (e.g., hypovolemia). Delivery of fluid should be administered through large-bore peripheral lines or via central-line access.
2. Maintenance: The calculation of daily fluid requirements is achievable in various ways. Common practices utilize the formulas created by Drs. Holliday and Segar which indicate that one can use the "100-50-25" or "4-2-1" rules [3].

Examples:

For a 50 kg patient

A. First 10 kg weight = 1000 mL (100 mL/kg x 10)

Second 10 kg weight = 500 mL (50 mL/kg x 10)

Remaining 30 kg weight = 750 mL (25 mL/kg x 30)

Total = 2250 mL/day or 94 mL/hr.

B. First 10 kg weight = 4 mL/kg/hr. x 10 = 40 mL/hr.

Second 10 kg weight = 2 mL/kg/hr. x 10 = 20 mL/hr.

Remaining 30 kg weight = 1 mL/kg/hr. x 30 = 30 mL/hr.

Total = 90 mL/hr. [4]

1.2. OBJECTIVE

The main objective of this project is to propose a new mechanism to generate saline solution in environmentally friendly way, through the use of condensation processes, it became possible to convert atmospheric moisture into potable water (where the Compressor was used as the heart of the device, through which this process takes place). After the water is provided, it can be mixed with salt in precise amounts to form a saline solution that can be used for all health needs such as where it can be used topically to clean wounds, help remove contact lenses, and dry cornea and conjunctivitis). Saline solution is also used by Intravenous injection to treat dehydration due to conditions such as gastroenteritis and diabetic ketoacidosis (it is also used to dilute other medications given by injection). Through this device, it became possible to reduce the economic impacts of the health field (by reducing imports and producing it locally) and also reducing the impact on the environment due to plastic waste B by packaging.

1.3. ORGANISATION

To describe the fundamentals and activities of this research to follow the research objectives mentioned previously, this thesis has been organized carefully as follows:

Chapter I: General introduction

Illustrate the background of the study, objective and thesis organization.

Chapter II: Methodology

Presents The Design of SSG and the SSG structure that include:

- ✓ Components (Hardware).
- ✓ Block diagram and explanation of stages.
- ✓ Circuit diagram.

Chapter III: Principle of SSG

Showcase of mechanism and the principle of processing

Chapter IV: Result and future work

Presents the uses of SSG, SSG development, Future vision and the Result of the device.

CHAPTER II

METHODOLOGY

2.1. THE DESIGN OF SSG

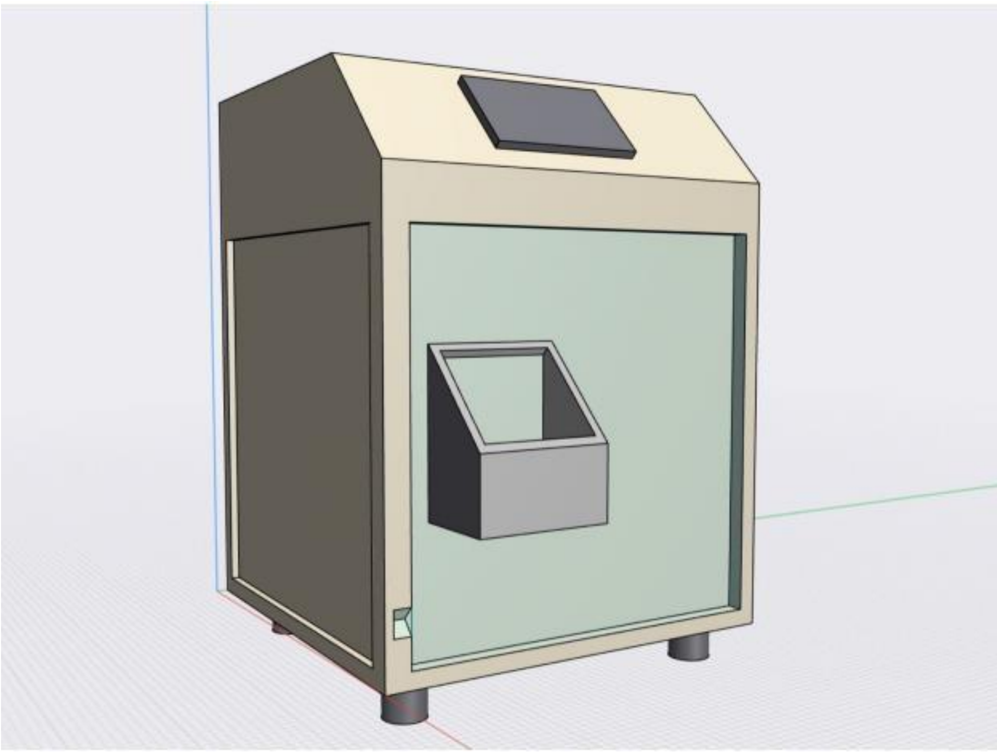


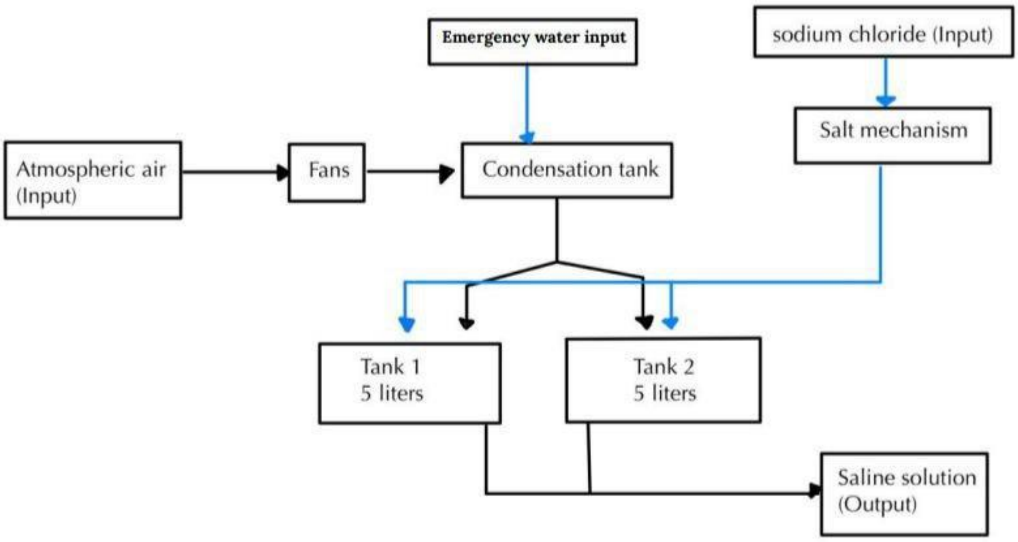
Figure 2.1 the design of S.S.G

From figure 2.1, We can note the shape of the device, the body of the device is made of aluminum to reduce weight, rust resistant and ease of movement. The length and width of the device is 58 cm, while the height of the device is 81 cm (10 + 58 + 13 cm).

10 cm for the prop-ups, 58 cm for the body, while the 13 cm for the header of the device which has a deflection angle of 45 degrees. The header contains touch screen that control the device and show the parameters of water and saline solution, it also contains the electrical circuit of the device. The back of the device contains vents and the radiator of the compressor, while the front contains the saline solution output.

2.2. SSG STRUCTURE

2.2.1. BLOCK DIAGRAM



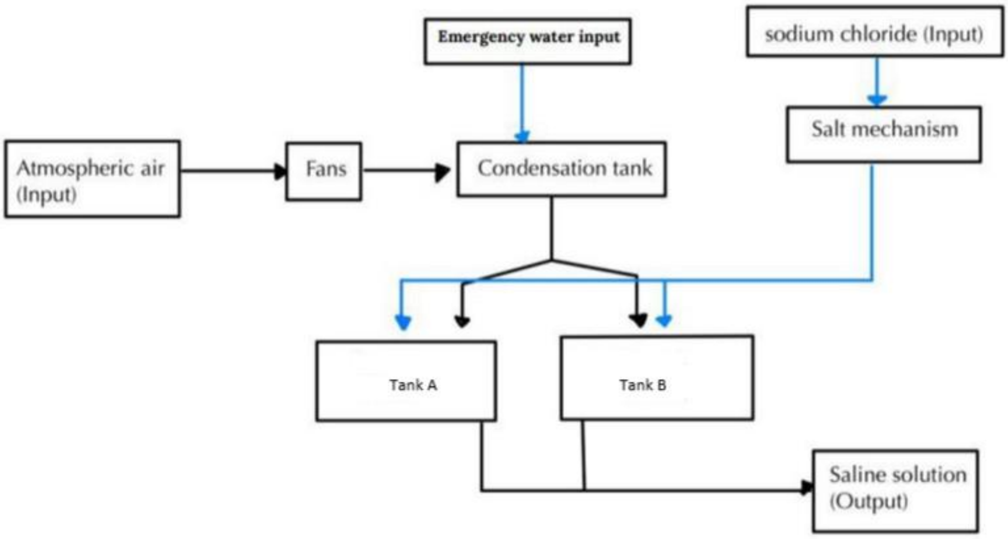


Figure 2.2 Block Diagram of SSG

From figure 2.2, we can see how atmospheric air entering the device through an air filter pulled by the fans, where the filter is used to purify the air, after that air flows into the condensation tank where the condensation process is taking place. A water dispenser compressor has been used to cool the evaporator, thus, the relatively warm air entering the tank would start condensing and turning into pure water. The water that is produced in the condensation tank will be transferred to tank "A" and "B" to be mixed with NaCl provided by the Salt-mechanism to make the saline solution.

In salt-mechanism there is an opening which is used to add the NaCl to be mixed with water, the NaCl will be contained in the salt-mechanism, then a spiral screw controlled by a stepper motor will drop NaCl slowly to be measured by the load cell to determine the required amount needed (0.9g per liter), then the cell load is revolved around X axis by a stepper motor which will drop the NaCl in either tank "A" or "B".

Now the sodium chloride will be mixed with the pure water in the tanks "A" and "B" using DC motors creating the saline solution. after that the saline solution is ready to be used, it will be delivered to the output using delivery tubes and pumps to be used whenever needed.

2.2.2. COMPONENTS

1. **12VDC Power Supply**: is intended for the feeding of the system component by converting the 220VAC to 12VDC, for the components that require said voltage [5]. Figure 2.3

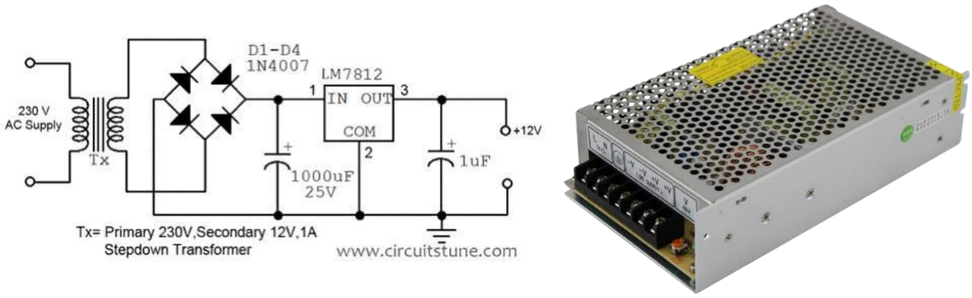


Figure 2.3. 12VDC Power Supply

2. **The Compressor system:** the compressor is the primary component that begins the condensation process by compressing the freon gas in a closed loop in order to cool the evaporator (where air is condensed inside condensation tank) to produce the water for saline solution, then the freon gas loops inside the condenser which is located on the rear end of the device to cool down, it runs on 220VAC and requires around 0.8A as it starts then rests at around 0.5A [8]. Figure 2.4

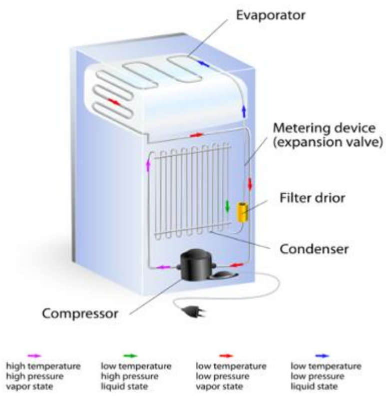


Figure 2.4. the compressor

3. **Raspberry pi 4**: It is a computer that uses a microprocessor as its central processing unit. It is utilized to control the electronic and mechanical parts using relays, furthermore it operates the Touch screen attached to it, making the device future proof. The raspberry pi 4 has a lot of ports to connect several devices, it has several USB ports, micro-HDMI and an audio jack port, also a USB-C port for power [6]. Figure 2.5

Figure 2.5. Raspberry pi4

4. **5V power supply**: is a device that provides a constant voltage output of 5 volts. It converts higher-voltage AC power from the mains or DC power from a battery into low-voltage DC suitable for powering electronic circuits and devices that require 5V DC power. 5V power

supplies are commonly used to power USB devices, microcontrollers, and other electronic components that require a low voltage input. [7] Figure 2.6

Figure 2.6. (5V power supply)

5. **Dual channel relay:** It is an electrical switch that is operated by an electromagnet. The electromagnet is activated by a separate low-power signal from the raspberry pi. When activated, the electromagnet pulls to either open or close an electrical circuit. Figure 2.7

Figure 2.7. Dual channel relay

6. **DC controlled solenoid valve:** A 12V solenoid valve is a most prominent and commonly used valve in electro-mechanical systems, to control the flow of liquids or gases. It's main purpose in the device is to control the water flow between tanks or to the output, it utilizes the properties of electromagnetic field to move a metal gate which controls the flow. Figure 2.8

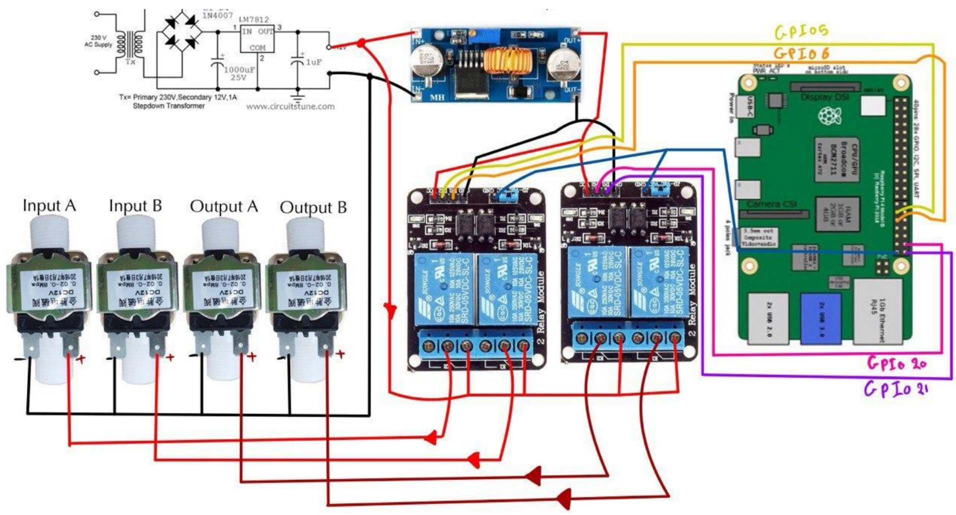


Figure 2.8. DC controlled solenoid valve

7. **Digital load cell & HX711:** is an electro mechanical sensor used to measure force or weight using flex resistor, due to the weak signal it produces, it's paired with the HX711 amplifier which will amplify the signal measured by the load cell, and together they become a

weighing system. It’s used in the salt mechanism to measure the amount of salt needed to make the saline solution [9]. Figure 2.9

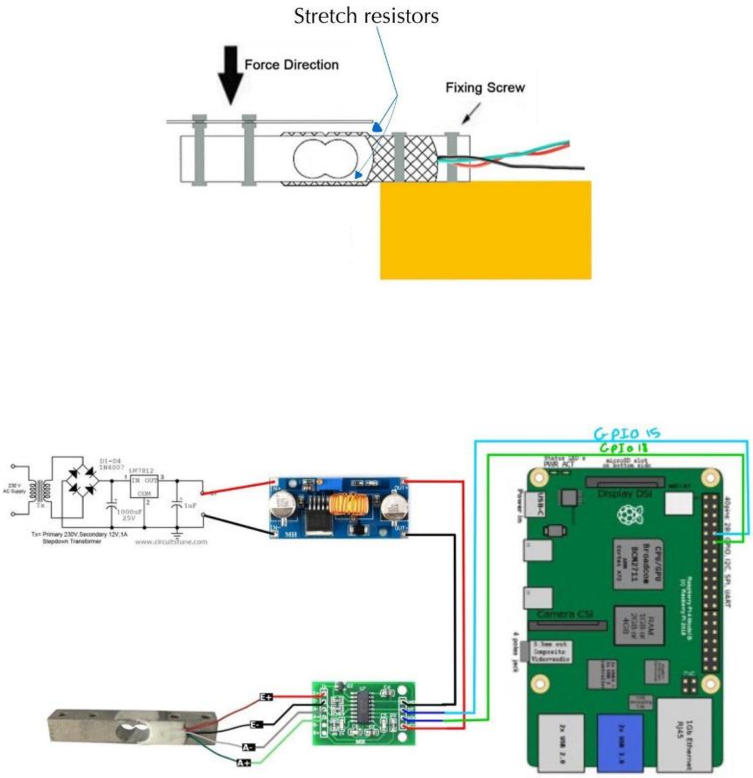


Figure 2.9. Digital load cell & HX711

8. **DHT11:** The DHT11 is a temperature and humidity sensor. It consists of a capacitive humidity sensor and a thermistor to measure temperature. It’s used it in the device to measure the room’s temperature and humidity to provide information about the surrounding environment in order to get the best results [9]. Figure 2.10

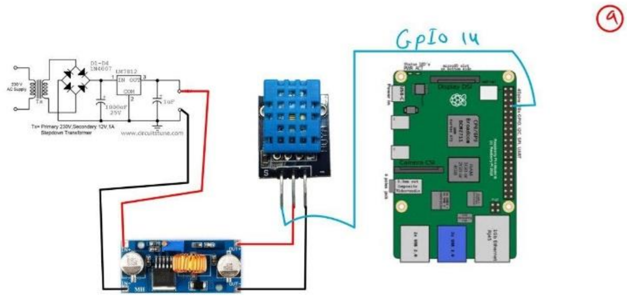


Figure 2.10. DHT11

9. **Ultrasonic sensor:** it’s used to check the water level in the tanks, it is a sensor that measures distance by using ultrasonic waves. It works by emitting short bursts of high frequency sound

waves and then receive to the echoes that bounce back from the water surface then determine water level. [9]. Figure 2.11

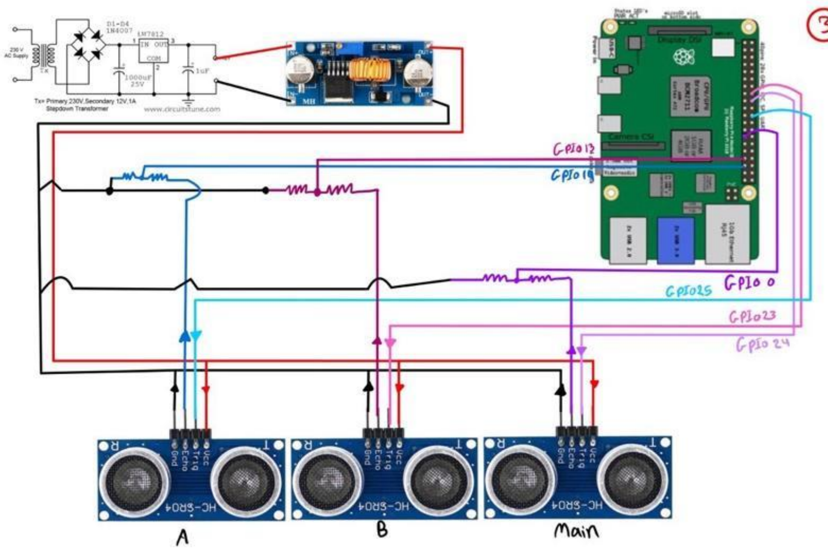


Figure 2.11. Ultrasonic sensor

10. **12VDC fans & 5VDC fans:** Four fans are used in the device, two of them (12VDC) are used to cool the electronic parts, and the others (5VDC) are used to draw atmospheric air into the condensation tank. Figure 2.12

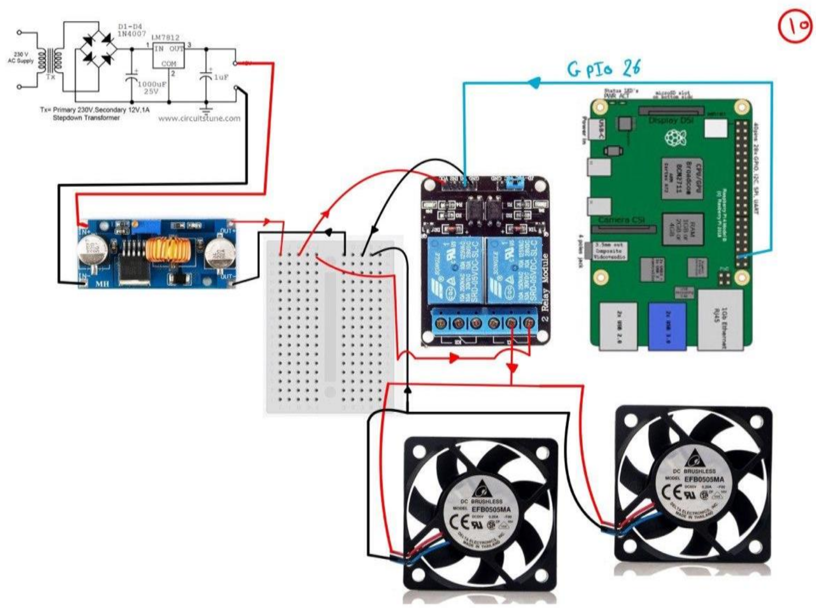


Figure 2.12. (12VDC) fans & 5VDC fans

11. **DS18B20 temperature sensor:** To measure the temperature of the evaporator (inside the condensation tank) in order to turn the compressor on and off [9]**.** Figure 2.13

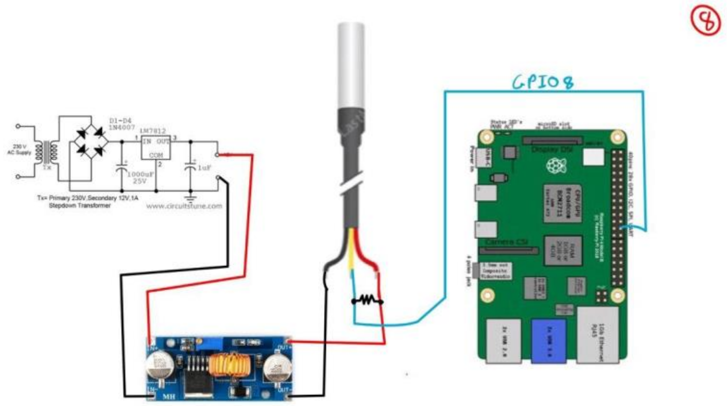


Figure 2.13. DS18B20 temperature sensor

12. **Mini breadboard:** A mini breadboard is a small, portable version of a breadboard used for prototyping electronic circuits. It provides a platform for quickly and easily connecting electronic components and creating temporary circuits without the need for soldering. Figure 2.14

Figure 2.14. Mini breadboard

13. **Stepper motor:** Stepper Motor Basics A stepper motor is an electric motor whose main feature is that its shaft rotates by performing steps, that is, by moving by a fixed number of degrees. This feature is obtained thanks to the internal structure of the motor, and allows to know the exact angular position of the shaft by simply counting how may steps have been performed, with no need for a sensor. This feature also makes it fit for a wide range of applications. Figure 2.15

Figure 2.15. Stepper motor

14. **Active Buzzer Module:** for Arduino is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric. Figure 2.16

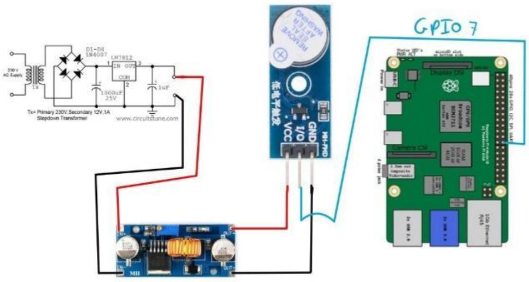


Figure 2.16. Active Buzzer Module

15. **(7-inch) touch screen:** 7inch IPS screen, 1024x600 hardware resolution with Capacitive touch control Supports popular mini-PCs such as Raspberry Pi, and also supports Raspbian OS. Figure 2.17

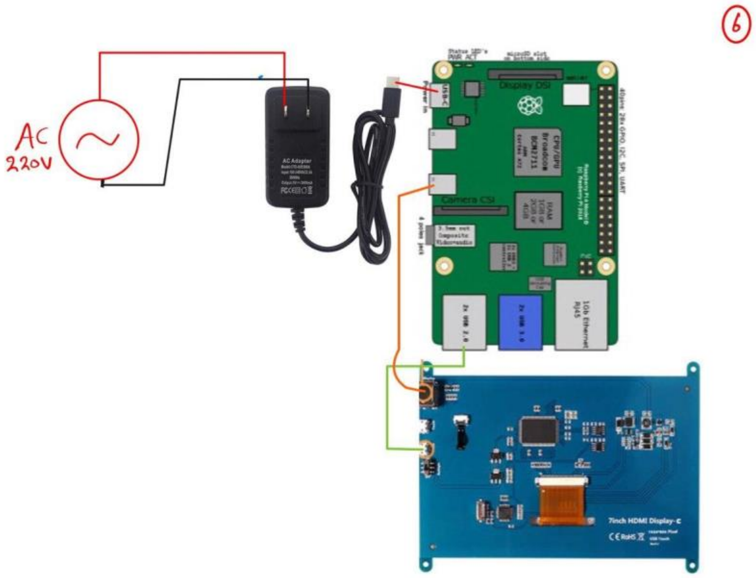


Figure 2.17. (7-inch) touch screen

16. **UV LED:** a light emitting diode that emits ultraviolet (UV) light. These LEDs produce a narrow spectrum of high-energy light in the UV spectrum, which may be used in a variety of applications, including sterilization, water purification, counterfeit detection, and curing adhesives and coatings. Figure 2.18

Figure 2.18. (UV LED)

17. Mixer: it's a DC motor connected to a shaft, which holds blades at the end of it, which play a pivotal role in the mixing process. These blades are carefully designed to maximize efficiency and optimize the blending action. Typically constructed from durable materials such as stainless steel, the blades are shaped and positioned to create fluid dynamics conducive to effective mixing, it is used to mix the water with the NaCl to create saline solution. Figure 2.19

Figure 2.19 Mixer

18- IR Sensor: an infrared sensor, is a device that detects and measures infrared radiation in its surrounding environment. Infrared radiation is a type of electromagnetic radiation with longer wavelengths than visible light, and it is typically invisible to the human eye. IR sensors can detect the presence or absence of an object within a specific range without physical contact. it is used in the output of the device. Figure 2.20

Figure 2.20 IR sensor

2.2.3. CIRCUIT DIAGRA

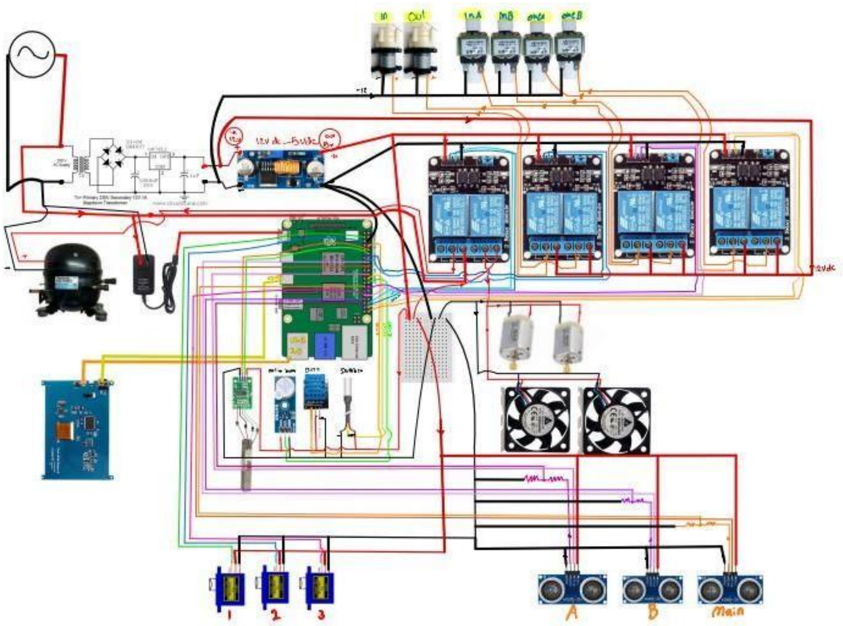


Figure 2.21. circuit diagram

CHAPTER III

PRINCIPLE OF WORK

3.1. MECHANISM

The device depends entirely on the moisture present in the atmospheric air. Therefore, through two intake fans, the moisture-laden air enters the water formation chamber that contains a network of tubes branching from the compressor. Because the down pressure in these tubes, it is become cold, reaching -20 C, and thus the moisture of the atmospheric air in contact with the tubes will turn into ice sticking to the tubes, and after a few minutes the compressor will turn off and the temperature will begin to rise, then the ice on the tubes will melt and turn into water that is stored inside the condensation tank, and thus the stage of water formation has ended. In case of emergency, when time is of the essence and saline solution is required with the upmost speed, the device contains a fail-safe feature that is essentially a manual water supply to directly pour water into the tank and have the device ready to produce saline solution within seconds, note that the water added must be sterilized and pure so as to get the best results. Figure 3.1

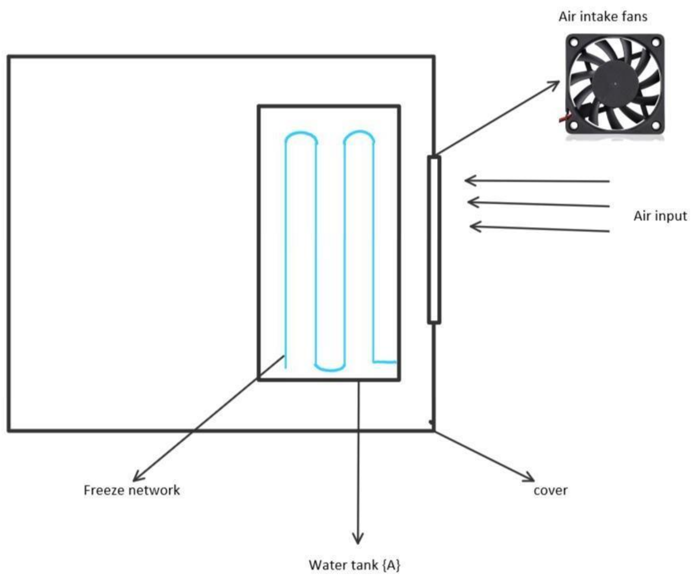


Figure 3.1. principle of work

After water formation process, the process of distributing water to the saline solution storage tanks (A) and (B) begins, through a pump the water is withdrawn from the condensation tank and then two Solenoid valves that are parallel to each other allowing the water to fill the tanks (A) and (B).

The Solenoid valve (A) allows the water to pass into the tank (A) and when its full, the Solenoid valve (A) will close and the Solenoid valve (B) opens, which will pass the water to the saline solution tank (B) and thus the water distribution process is completed. Figure 3.2

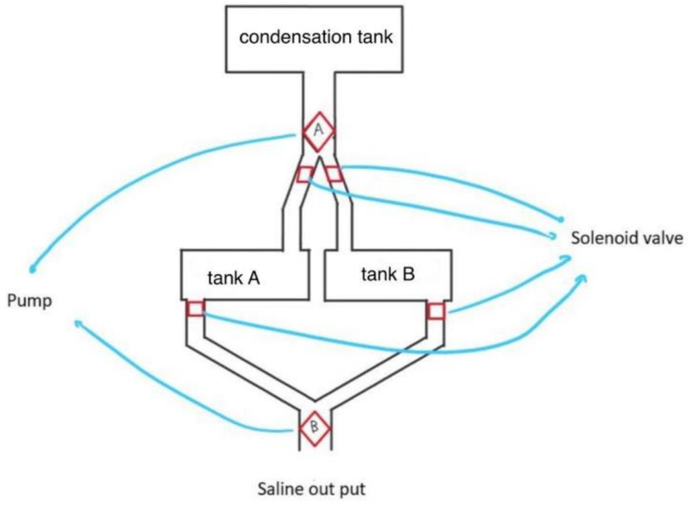


Figure 3.2. water distribution process

Now begins the process of adding and mixing salt with watervin the saline solution tanks through the salt mechanism. The percentage of salt entering the water is controlled with a high accuracy. a spiral screw prompted by the load cell allows the supplement of salt at a ratio of (0.9g per liter of water), where when the load cell reading reaches 4.5g of salt, the load cell implemented with a holder will revolve around the X-AXIS by a stepper motor allowing the salt to fall into the saline solution tank (A) and the mixing process begins and then 5L of saline solution is formed. Then the load cell contraption will revolve to the opposite side allowing another 4.5g of salt into tank (B), and mixing is also done. Thus, we have a total of 10L of saline solution that is used alternately. Figure 3.3

Figure 3.3. salt mechanism and its parts

3.2. PROCESSING

python used to program the device because python is a high-level, general-purpose programming language, and with its various libraries it is the most commonly used programming language.

Firstly, the touch screen and GUI was programmed so user can interact with the device. Then, the relays have been programmed to control the dc devices (pumps, valves, … etc.), also, the compressor was connected to a relay and controlled via the raspberry pi.

After that the sensors and stepper motors calibrated and interfaced with the controller to get their readings and make the slat mechanism work, in order create conditions (algorithms) so the S.S.G can run automatically.

CHAPTER IV

USES AND FUTURE VISION

4.1. RESULTS

4.2. USES AND BENEFITS OF SSG

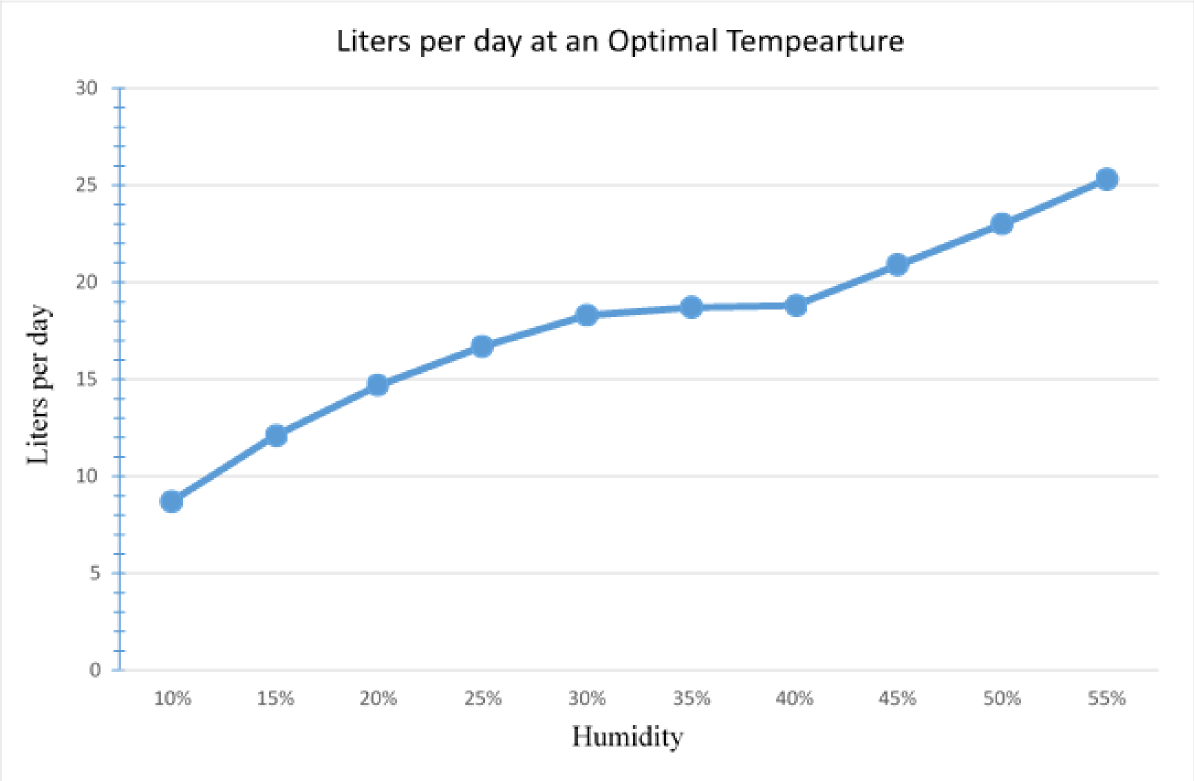


Figure 4.1 Results

SSG is capable to making saline solution quickly and accurately, saline solution is a solution of NaCl in water, and it has many industrial and medical uses. The ability to produce saline solution efficiently can be particularly valuable for businesses that rely on it as a key ingredient in their products or processes. The SSG is able to provide saline solutions on a permanent basis in healthcare sectors which is our main purpose for the current version of the device. This feature can be particularly useful in areas where medical resources are limited or in situations where a reliable and independent source of saline is required.

By producing saline solutions on-site, healthcare facilities can become more self-reliant and reduce their dependence on external suppliers. Finally, SSG has the potential to significantly reduce the costs associated with importing, transporting, and storing essential liquids such as water and saline. By producing these solutions on-site, businesses and communities can avoid the expenses and logistical challenges that come with procuring them from external sources. This can result in substantial cost savings and greater efficiency in various industries**.**

4.3. SSG DEVELOPMENT AND FUTURE WORK

The device is a prototype, where it can be exposed many updates and developments that will contribute to increasing its efficiency. Among these developments, the size of the device as a whole can be increased and thus the size of the water storage tanks will increase, as a result more saline solution will be generated.

The moist air inside the device can also be increased by enlarging the intake fans and connecting them with a hose to more humid place to benefit as much as possible from the atmospheric air. the device can also be developed to be more automatic Thus, human intervention is only when turning it on and off. There is an idea to make the device work through solar energy, but the increase in its cost and the increase in the space it occupies prevented this idea. When the necessary space is available, this can be done. the device can be a complete, self-functioning system that supplies the health department with the largest amount of saline solution (making it a central unit) if several conditions are met, then there is no objection to the system's work. Also, it can be manufactured into smaller more portable size to make it easier to transport, run on car battery or solar energy, less solution will be produced but the device will be easier to move around and occupy smaller area. The SSG has a variety of applications that make it a valuable asset in various industries. Firstly, it can be tweaked to produce sterile potable water that is free of any impurities. This function is particularly useful in situations where the water supply is compromised, such as in disaster-stricken areas or in regions with poor water quality. By creating clean drinking water, it can contribute to the health and wellbeing of affected communities. In the future, when developing the device, it will make more saline solutions, especially when it relies on solar energy, and thus it will literally be environmentally friendly, and then it will be effective on three factors, which are (Reducing electricity consumption - reducing water consumption - reducing economic expenses).

4.4. FISCAL PERKS

SSG is able to make a qualitative leap in the field of health and the environment due to the self-manufacturing of the saline solution. After several contacts with pharmacies in two of the largest hospitals in Iraq, namely Al-Kadhimiya Hospital and Al-Yarmouk Hospital, it was found that the average daily use of saline solution is 650 units (500ml bottles). Thus, the average monthly use is 19500, and since the price of one unit delivered to the hospital is 525 IQD, the total price is monthly. It is 10,237,500 IQD, and this is the price for one hospital. According to Ministry of Health the number of government hospitals in Iraq (excluding Kurdistan territory) is 192, and with a very simple mathematical equation we will be able to calculate the general costs of saline per month in Iraq which is 1,965,600,000 IQD. Through SSG, the price of the saline solution will roughly be 150 dinars, and thus the final total price will be 561,600,000. We can notice the big difference between the two prices, as it decreased by 71.4%

REFERENCES

1. Chang R, Holcomb JB. Choice of Fluid Therapy in the Initial Management of Sepsis, Severe Sepsis, and Septic Shock. Shock. 2016 Jul;46(1):17-26. [PMC free article] [PubMed]
2. Epstein EM, Waseem M. StatPearls [Internet]. StatPearls Publishing; Treasure Island (FL): Aug 7, 2022. Crystalloid Fluids. [PubMed]
3. Boyd JH, Forbes J, Nakada TA, Walley KR, Russell JA. Fluid resuscitation in septic shock: a positive fluid balance and elevated central venous pressure are associated with increased mortality. Crit Care Med. 2011 Feb;39(2):259-65. [PubMed]
4. Holliday MA, Ray PE, Friedman AL. Fluid therapy for children: facts, fashions and questions. Arch Dis Child. 2007 Jun;92(6):546-50. [PMC free article] [PubMed]

5. Pressman's textbook updated by Billings is a classic for switching power supply design. A very detailed analysis of circuits, magnetics and feedback control loop for main converter topologies (including PFC boost). Best for learning power supply design for the beginners
6. Raspberry Pi Cookbook: Software and Hardware Problems and Solutions
7. Digital Linear and Non-linear Controllers for Buck Converters: Fuzzy controlled Buck Converter Paperback – May 31, 2012 by Shyama M. (Author)
8. Air Conditioning and Refrigeration REX MILLER Professor Emeritus State University College at Buffalo Buffalo, New York MARK R. MILLER Professor, Industrial Technology The University of Texas at Tyler Tyler, Texas
9. Measuring Electronics and Sensors: Basics of Measurement Technology, Sensors, Analog and Digital Signal Processing BY Herbert Bernstian
10. Handbook of Small Electric Motors (McGraw-Hill Handbooks) by William Yeadon (Author), Alan Yeadon (Author)