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CONTENT

About the Journal

Journal of Millimeterwave Communication, Optimization and Modelling (JOMCOM) is an international on-line and refereed journal published 2 times a year in English. Journal of Millimeterwave Communication, Optimization and Modelling (JOMCOM) published its first issue in 2021 and has been publishing since 2021. Manuscripts in JOMCOM Journal reviewed of at least 2 referees among the referees who have at least doctorate level in their field.

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Editor in Chief:

Assoc. Prof. Dr. Muhammet Tahir GÜNEŞER

Istanbul Technical University

Faculty of Engineering

Department of Electronics and Communications Engineering

Istanbul, TURKEY

jomcomeditor@gmail.com

PUBLISHER

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Aims & Scope

Communication Technologies: Journal of Millimeter-wave Communication, Optimization and Modelling (JOMCOM) publishes original research and review articles in Communication Technologies, Innovative Technologies, and Systems in the broad field of Information-Communication Technology. Purpose of JOMCOM; To create value in the field by publishing original studies that will contribute to the literature in wireless communication sciences and be a resource for academia and industrial application whole over the world. Besides, JOMCOM aims to bring the valuable work of researchers working in Communication studies to a broader audience at home and abroad. Readership of JOMCOM; valuable representatives of the wireless communication area, especially those who do academic studies in it, and those who do academic studies about modelling and system design and other interested parties. Since JOMCOM will appeal to a broader audience in article submissions, it prioritizes studies prepared in English.

Optimization and Modelling: Journal of Millimeter-wave Communication, Optimization and Modelling (JOMCOM), within the scope of Wireless Communication Sciences, publishes articles on communication theory and techniques, systems and networks, applications, development and regulatory policies, standards, and management techniques. It also reports experiences and experiments, best practices and solutions, lessons learned, and case studies. Additional studies on System Design, Modelling and Optimization. Subject areas of interest covered in the journal include the following but are not limited to:

5G-6G Technologies

Circuits for Optical Communication Systems

Antenna Design

Communication Design Materials

Fiber Optic Communication

Innovative Designs for Communications

Integrated Circuits for Communications

Optimization Methods on Engineering

Realization of Antenna Systems

Realization of Microwave, Radar, and Sonar Systems

RF Circuits

System Design

Visible Light Communication

Wireless Communication

Solar Energy as a Solution for Iraq's Power Outages

Received: 28 February 2025; Accepted: 5 July 2025 *Research Article*

Othman Hassan
Department of Electrical -Electronics Engineering
Karabuk University
Karabuk, Turkiye
232813108@ogrenci.karabuk.edu.tr

***Abstract*—Iraq is facing a shortage in electricity supply during the summer months. The current work analyses this energy crisis and its significant impact on citizens, which has started in more last three decades. The study focuses on getting the benefit of solar energy to provide a sustainable energy source to the country. It addresses the fundamentals of solar energy, its suitability in the Iraqi context, and how it could drive transformative change in the energy industry. In addition, the environmental and economic impacts of the use of solar energy are assessed and a comprehensive perspective is provided on its impact on Iraq. In this study, we discuss the solar system as a whole and the challenges we may face due to natural effects**

Keywords— solar energy, photovoltaic (PV), Iraq

I. INTRODUCTION

After the American invasion of Iraq, Iraqis suffered from constant power outages, especially in the summer. Iraqi governments have spent billions of dollars to solve the electricity problem, but due to corruption in the administration, successive governments have been unable to solve this problem. The Iraqi government expressed hopes in May 2014 regarding its plan to increase electricity generation by 8,000 MW, reaching a capacity of 20,000 MW by December 31, 2015, to ensure 24-hour power supply. Importantly, the Ministry of Electricity admitted a grid loss of over 8,000 MW. Although Iraqi nationals typically have a maximum of five to eight hours of daily power supply under the best conditions, as noted, they are concerned about the ministry's recent commitment to increase production to 12,000 MW by summer 2015 [1].The shortage in electricity supply in Iraq is a long-standing problem where the electricity struggled for many years. The persistent imbalance between energy demand and supply in Iraq, in turn, led to an estimated annual loss in the Iraqi economy of $40 billion. In addition, the growing need for electricity associated with a daily cut of energy for up to five hours, is a widespread problem [2]. Accordingly, with the current world's transformation towards renewable energy, by the use of natural phenomena including sunshine, wind, rain, ocean waves, and tides, renewable energy such as solar photovoltaic technology is an important solution to the Iraqi energy crisis. This includes the use of both small, off-grid solar systems and large, grid-connected solar infrastructures. It can be used as a power source of variety systems such as vehicles, heating water pumps, lights, solar-powered cars, trains, and many other systems [3]. In Iraq, the use of photovoltaics remains low despite the country's great solar energy prospects. The absence of strong government policy and financial incentives hinders homeowners from installing solar panels on their homes and motivate the development of large-scale projects by investors[2]. The Ministry of Electricity has outlined a forward-looking strategy to meet over 25% of the country's future electricity needs from renewable sources. The goal is to expand the power grid by 500 to 1,000 megawatts annually. Achieving this goal requires increased legislative and regulatory efforts.

II. THE LOCATION AND THE CLAIMT OF IRAQ

A. Iraqi location

Iraq is located in the Northern and Eastern Hemispheres of the Earth at coordinates of 29°5' N - 37°22' N latitude and 38°45' E - 48°45' E longitude in the south-western part of Asia.. Baghdad, which is 34 m above sea level, is the capital of Iraq and is located at coordinates 33.3406° north latitude and 44.4009° east longitude[5].

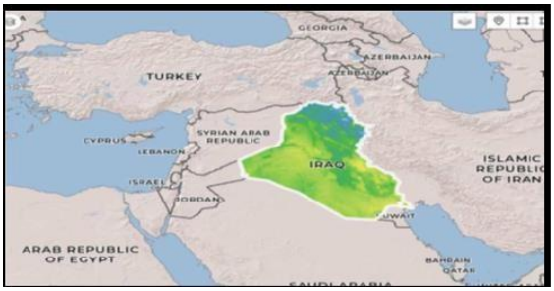

Fig. 1. The location of Iraq republic

B. The weather of Iraq

Iraq has weather conditions that are due to the subtropical climate and are characterized by long, dry summers and a wet winter season. There are two main weather conditions in Iraq: an unbearably long summer with high temperatures and a very short winter with moderate to bitter temperatures. Precipitation is negligible over a four-month period and does not exceed 15 millimeters in the remaining warm months of the cycle.There is a wide range in temperature difference between winter and summer in Iraq. For example, in January, the temperatures are between 7°C and 12°C with moderate snowfall observed in the mountainous areas. While in July, the temperature sometimes reaches over 50 °C [6].

C. The population growth in Iraq

Iraq's growth rate is one of the fastest in the world. Population numbers show that Iraq's population has grown from about 3 million people in 1927 to 39.5 million people in 2020. Because of this, Iraq needs to make more energy to meet its growing energy needs.

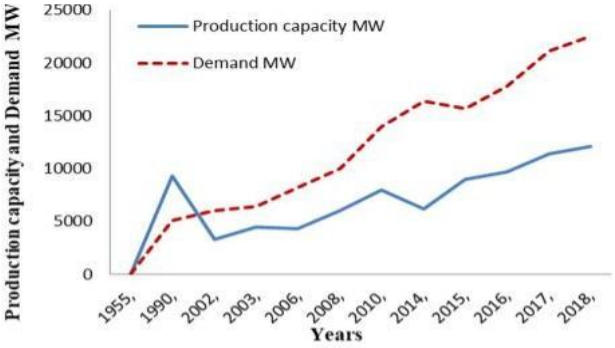

Fig. 2. Electricity production and demand in Iraq [8]

TABLE I. POPULATION GROWTH RATE ESTIMATION [3]

Year	Population (million)	Growth rate (%)
2003	26	5.4%
2005	27.1	2.6%
2006	28.1	3.2%
2007	29	3.3%
2008	29.8	3.1%
2009	30.7	2.4%
2010	31.7	2.3%
2011	32.67	2.3%
2012	33.45	2.3%
2013	34.22	2.0%
2014	35	2.0%
2015	35.81	2.0%
2016	36.81	2.0%
2017	36.52	2.0%
2018	37.25	2.1%
2019	38.76	2.0%
2020	39.53	2.0%
average		2.7%

III. THE ELECITRICITY IN IRAQ

Many countries, such as Iraq, have established electricity generation systems as part of their economic framework. The disruption to Iraq's energy system was influenced by military activity in the country that has been ongoing for two decades. Likewise, the conflict has negatively influenced the structure of the system over the past three decades. Accordingly, cumulative production in 1990 averaged 9,300 MW. However, global economic sanctions were imposed following Iraq's invasion of Kuwait in August 1990, and subsequent military actions in Kuwait invasion damaged most of the power grid. This reduced The overall capacity of available power connection to just 340 Mega W. Some efforts to rebuild the electric power system were made between 1992 and 2002, but were destroyed in 2003. Therefore, the current status is that the country only supplies electricity for 12 hours[7]. Solar systems could therefore be a solution to the current electricity problem in Iraq.

IV. PV SYSTEM

A. Angles of the sun

Various definitions of angles can be employed to ascertain the relationships between direct solar radiation and the orientation of a plane on Earth. The computation of solar energy for an inclined plane in the Northern Hemisphere involves the use of angle measurements, namely beta and gamma. Figure 3 demonstrates that the solar azimuth angle and solar elevation angle together fully describe the position of the sun. Sun angles are formed by the position of the sun and the Earth's surfaces, creating connections between these angles.. [9-10].

B. Radiation from the sun

Nuclear fusion, which takes place in the sun's core and turns hydrogen gas into helium, is the source of solar energy. A measurement of 1370 Watt/m² was made of the solar irradiance that is measured above Earth's atmosphere. But because of atmospheric effects, the amount of solar energy received might vary from zero to one hundred hundred W/m² when it reaches Earth's surface.. Thus, even a minuscule fraction of this energy source At its 150 million kilometer distance from the Sun, Earth receives energy at a rate twenty thousand times higher than our yearly energy requirement. Atmospheric reflection accounts for roughly 30% of solar radiation, whereas absorption accounts for around 50%. As a result of this absorption, the surface of the Earth warms, making it an ideal environment for life. Patterns of wind, precipitation, and ocean currents are all directly influenced by solar energy. The number ten.

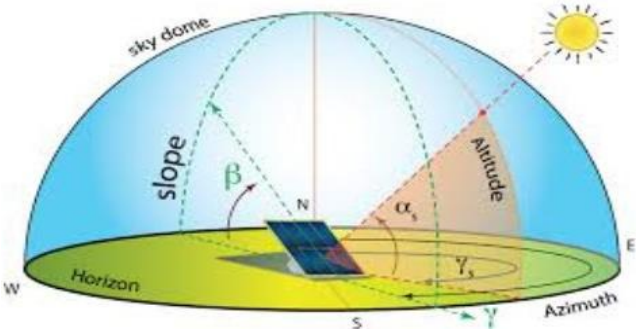

Fig. 3. The sun's rays at various inclinations [9]

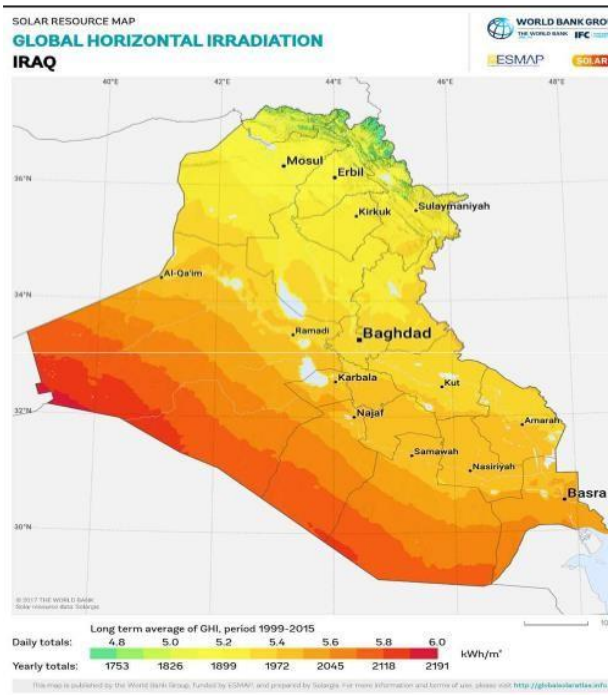

Fig. 4. Horizontal radiation across Iraq on a worldwide basis.

In a nutshell, below are the Republic of Iraq's radiation requirements:

- Nearly 200% in the southern region. Summer months see 27 MJ/m² of solar radiation, while winter months see 13 MJ/m²..
- 300% in the north. In June the values are 23 MJ/m² and in December equal to 7 MJ/m².
- Midway point: 50%. The following are the variations in the months in question: June sees 24 MJ/m² and January sees 8 MJ/m². Out of all the indications, the north–south solar radiation intensity differential stands out more than the others. Wintertime sees it rise even higher, while summertime sees it fall.

- Annual average daily energy demand of the Iraqi zone (2000 to 2500 kWh/m2) from global solar radiation as as depicted in Figure. 4[11,2].

C. Solar panel system

A solar panel system comprises an interconnected structure, known as an array, composed of photovoltaic (PV) solar cells. Solar power cells employ photovoltaic technology to turn solar energy into electrical energy by directly converting the sun's photons. The power production, measured in V or W, fluctuates according on the specific system and kind of solar cell employed. The whole system is composed of solar modules or panels, each including a metal frame housing a cluster of solar cells. A typical solar panel is composed of either sixty, seventy-two or ninety-six photovoltaic cells. Light travels via several wavelengths with varying energy levels across the electromagnetic spectrum, and the solar panel does not capture all of these wavelengths. [2]. The energy of sunlight that may be Utilized by photovoltaic panels and converted The conversion of energy towards electricity can be measured in eV. approximately comparable to 1.1 V [12-13]. When photons of greater energy levels collide with the plate, there is energy depletion. In order to enhance the absorption of photons, other materials can be employed in compact solar panels, but at the expense of reducing the panel's voltage. As solar panel technology progresses, there is a delicate equilibrium between material selection and electric field strength, as the energy produced by these panels is determined by the multiplication of current and voltage. It is worth noting that these panels only possess a p junction [2].

D. Grid-connected photovoltaic electricity generation system

Grid-connected PV systems supplement the existing power grid. They differ from standalone solar systems in that they allow the user to consume electricity generated by solar energy and, when there is insufficient sunlight, check power from the grid. This involves an alternating current flow and a constant power supply. The components of a grid-connected system include:

- Solar panels: are devices that capture sunlight and transform it to direct current.
- Solar inverter: It converts the electricity generated into alternating current for use in households.
- Net meter: Also known as a bidirectional meter, it records the flow of energy. Since a lot of heat and electricity is generated during the day, some of it is fed into the grid, and when the sun goes down, the vehicle is powered to run the systems.
- Grids: The power grid is an e-power backup whenever you generate more power your energy is transmitted to the grid, and whenever you fail to produce enough power, you withdraw energy from the grid.
- Mounting structures: Ensure that the panels are securely attached with a shelter[10,14-15].

V. How To Chose a Suitable Solar Panel

Currently, companies such as SunPower, LG, Panasonic and JinkoSolar are well-known manufacturers of monocrystalline solar modules. A specific group of companies compete for recognition for producing the most effective rooftop solar panels. These special modules, currently available on the market, can convert just over 20% of solar energy into electricity. When selecting an appropriate solar system, several variables must be taken into consideration:

The wattage (W) of a solar panel represents its standard energy production under certain test circumstances conditions consist of an irradiation of 1000 W/m2 and an environmental temperature of 25°C.. For instance, if a 300W solar panel is used under standard test conditions (STC) for five hours, it may generate 1,500Wh, which is equal to 5 times the power output of 300W or 1.5 kilowatt-hours (kWh). The cost of a solar module is mostly determined by its rated power capacity. The range of numbers is from 2 to 4, inclusive. [2-4].

Efficiency indicates what percentage of the sunlight absorbed by a solar module is converted into usable electricity. The efficiency of residential solar models is usually expressed as a percentage and is usually in the range of 16-22%[2,16] Solar modules are predominantly made from polycrystalline silicon or monocrystalline silicon cells. While polycrystalline modules are more economical, monocrystalline modules offer higher efficiency and a more elegant appearance

The warranty period for solar panels is typically 10 to 25 years, ensuring longevity and performance reliability. A solar module's \"performance guarantee\", also called a \"linear performance guarantee\", The module is ensured to maintain a specific proportion of its initial production after a predetermined amount of years, often ranging from 80% to 90% after 25 to 30 years. [2].

The term "temperature coefficient" denotes the proportional decline in performance for every incremental increase in degrees Celsius over 25°C. As a result, solar panels have a minor decrease in efficiency in hotter weather conditions, often with a temperature coefficient of approximately [17]. The size of solar modules is of utmost importance when choosing them, particularly in cases where there is limited roof space. The normal size of a solar panel is approximately

2 square meters. However, manufacturers have created smaller variants to accommodate various spatial constraints. Weight is a factor to consider for fragile roofs, as heavier panels may not be appropriate. Lightweight panels are a necessary choice for individuals who are looking for alternatives owing to their concerns about the structural integrity and weight-bearing capacity of roofs. [18].

VI. The Pv Nature Challenging In Iraq

As already mentioned, the weather in Iraq is harsh. Weather and natural factors affect the operation of the solar energy system. These impacts include:

A. The temperature Effect

Iraq meets all the mentioned requirements: its proximity to major population centers, flat terrain, and abundance of sunshine. Every year, this country is exposed to scorching temperatures for about six months: June to August are its hottest months. What is more, research indicates that only a little temperature increase significantly degrades the efficiency of solar power systems if they use photovoltaic cells, especially crystalline silicon ones. The electricity is produced through the absorption of light, but for it to function best, the light that it absorbs should increase, too. Instead, the

cells produce heat, which is why the actual performance he here below rather than above theoretical values. That additional heat not only decreases the power output – it also degrades the physical properties of the PV modules [19] which in turn lowers their performance. Some areas of Iraq experience particularly high temperatures, which reduce the efficiency and power output of solar panels. To address this issue, potential strategies involve implementing cooling systems such as water or air conditioning, or integrating hybrids solar PvT technologies.

B. *The effect of Humidity*

Efficiency of Photovoltaic systems can be heavily influenced by the hydrolysis of polymer components, glass, metal networks, and connecting lines. Air humidity may infiltrate photovoltaic cells (PV cells) through their pores. The infiltration of water into the solar cell body leads to the activation of weak adhesive connections at interfaces, resulting in a series of detrimental effects. PV panel delamination, increased openings, and deteriorating welded seams. Corrosion is mostly caused by water, and it spreads rapidly, particularly in hot and humid environments.

Temperatures above 40 °C and humidity levels below 60% induce long-term degradation. Relative humidities between 75% and 95% can also cause surfaces to become sticky, which is ideal for fungal development.

C. *Wind Effect*

The efficiency of PV systems is directly affected by the speed of the wind, as these systems are always exposed to it. The sun has an indirect impact on wind energy, whereas the average wind speed is mostly influenced by the Earth's resilience.Furthermore, wind could contribute to the improvement in PV-modules' efficiency through the reduction of the relative humidity, as well as via the development of the natural and forced convection. Moreover, the cooling effect of the wind under the sun's radiation equal to 1000 W/m 2 and the wind speed of 10 m/s allows reducing temperatures by 15-20°C. However, there are some disadvantages that have to be taken into account. For example, specialists understand that wind's power can damage to cell's structure, and they are also aware that using the special technology, such a flying sand and dust can reduce the amount of energetics received by the surface of cells; in its turn, it can cause the decrease in the photovoltaic efficiency.. [20].

D. *The effect of Dust*

Pollen, bacteria, and fungus are all examples of the small, solid particles that make up dust. Their diameter is usually less than 500 micrometers. Environmental elements (such as location and weather), human actions, surface characteristics (such as roughness, slope angle, humidity, and wind speed), and the dust's chemical and physical qualities are all factors that affect its deposition. Dust on photovoltaic (PV) panels reduces their efficiency because it prevents light from reaching the cells, which in turn reduces the amount of electricity generated. Dust collection is common in dry, hot places like North Africa and the Middle East, making this problem much more severe. Notwithstanding these obstacles, the abundance of solar radiation and the availability of land resources in these places make them ideal for PV installation. [21].

VII. CONCLUSION

The findings of the research show that solar energy can indeed assist Iraq to solve its energy crisis. In particular, the research emphasizes that Iraq can become energy self-sufficient and end power outages by efficiently integrating solar technologies. Thus, it is possible if policymakers enact the necessary regulatory reforms and make the required infrastructure investments to ease the integration of solar power into the grid. The conclusion calls for immediate action, suggesting that solar energy systems shall exponentially enhance the lives of Iraqis while promoting advancements in all socio-economic aspects. Importantly, this means that both the government and the private sector must collaborate to tap the solar power and solve Iraq's long-lasting struggle with energy.

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Antenna Design for 6G

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Research Article

Nabaa Algburi
Department of Electrical-Electronics Engineering.
Karabuk University
Karabuk, Turkey
nabaa.imad44@gmail.com

***Abstract*—The primary objectives of next-generation technology for communication and 6G Antennas functioning in the terahertz (THz) frequency technologies are to attain elevated data rates, minimize energy consumption, and facilitate extended connectivity. These goals are driven by the substantial proliferation of devices belonging to the Internet of Things and 6G antenna technology. These electronic devices are expected to be used for a variety of services including cellular communication, environmental monitoring, telemedicine, biological applications, and intelligent traffic management, among others. Hence, the present communication devices have difficulties in accommodating a large variety of services. This article provides a concise overview of the underlying factors driving the development of the 6G communication system, as well as an examination of its inherent capabilities and distinguishing characteristics. Subsequently, a concise overview is provided regarding the present cutting-edge 5G antenna technology, including the utilization of prevailing 6G Antennas functioning in the terahertz (THz) frequency ranges. The research also delineated the efficacious methodologies and strategies used in current antenna design endeavors, which have the potential to alleviate the obstacles and apprehensions associated with the nascent 5G & 6G applications. The research article concludes by presenting the main characteristics and prerequisites of 6G Antennas that operate in the terahertz frequency range, catering to the demands of future-generation technology.**

Keywords—antenna, 6G, characteristics, design

I. INTRODUCTION

Worldwide mobile data traffic has experienced a significant surge over the last few years due to the growing need for secure, high-speed, and efficient transmission of large volumes of data. In this regard, the existing 3G/4G/WiFi wireless communication networks are under significant demand to enhance their capacity and performance. Every successive iteration of mobile and wireless communication systems has been developed to fulfill these requirements. However, the proliferation of data-intensive devices used in the applications above has significantly grown, necessitating substantial data transmission speeds [1,2].

Among the potential approaches for improving capacity and data rates in both present and next mobile as well as wireless generations is by expanding the available bandwidth [3,4]. The relationship between data rates and bandwidth is one of direct proportionality. According to sources [5,6], increased bandwidth results in greater data rates.

The existing frequency bands, including the 1.7 GHz GSM band, 1.8 GHz 4G/LTE band, 2.0 GHz 4G/LTE band, 2.1 LTE band, and 2.6 GHz band, provide a restricted amount of bandwidth. Lately, there has been a growing interest in using high-frequency ranges for 5G usage.

In millimeter-wave communication, it has been shown that the route loss is considerably elevated. Therefore, it is essential that the selected antenna has radiation patterns with high directional gain in the direction of wave propagation to effectively reduce path loss. A significant obstacle encountered in several applications, such as mobile communication in microwave and mm-wave bands, is the lack of continuous communication direction [7].

The precise geographical position and alignment of the mobile phone in relation to the base station remain undetermined. Therefore, there is a need for innovative and unparalleled methods that may provide comprehensive antenna beam coverage, consistent radiation patterns, and increased directional gain. Furthermore, throughout the migration towards millimeter-wave (mm-wave) 5G communication, it is important to note that existing technologies such as 3G, 4G, WiFi, and sub-6 GHz 5G will continue to coexist. Therefore, the use of shared-aperture antenna architectures is essential for the development of fully integrated antenna modules.

In addition, the extent of coverage is a significant factor to consider in the context of both present and future communication systems. The current 5G systems, which are mostly terrestrial, have limitations in achieving comprehensive coverage and delivering consistent data rates for outdoor communications in various settings, such as aerial, maritime, rural, and isolated places.

Therefore, it is anticipated that space communication systems, which serve as a supplement to terrestrial communication systems, will merge with 5G systems to establish a comprehensive and integrated 6G communication system [8]. Fig. 1, presents a schematic representation of the envisioned integrated 6G communication infrastructure.

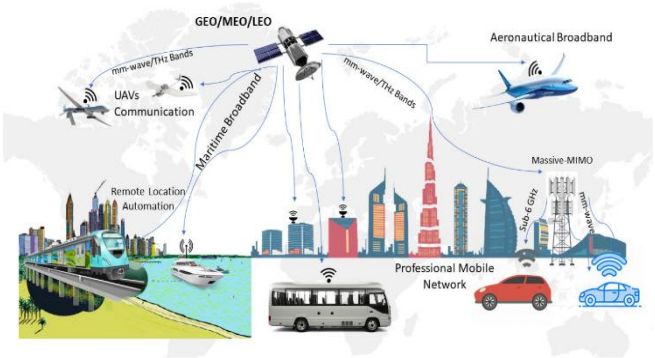

Fig. 1. A schematic representation of the envisioned integrated 6G-communication infrastructure.

Based on historical patterns of mobile technology evolution, characterized by generational shifts occurring about every decade (e.g., 1G in the 1980s, 2G in the early 1990s, 3G in the latter part of the century, 4G in the 2010s, and 5G in the 2020s), it is anticipated that the deployment of 6G will likely occur by 2030 or maybe earlier, driven by advancements in transition technologies. The following section provides an overview of the components and specifications of an interconnected 6G communication system [9].

According to [10], the rationale for using bandwidth in excess of 100 GHz is their capacity to deliver a broad bandwidth, making them very suitable for the goal of short-range communications. The first development of the antenna used a transmitter frequency of 300 GHz, and its efficiency was assessed by comparing three different patch substances: copper, graphene, and gold. The analysis of the antenna properties was thereafter conducted. The results suggest that the graphene patch has a coefficient of return of -27.70 dB, a peak bandwidth of 10.4 GHz, and a maximum radiation efficiency of 98.38%. The study is on the assessment of the budget allocated to the mobile network Unity, with a specific emphasis on achieving a data rate objective of 100 GB/s. This evaluation pertains to the operation of the connection within a bandwidth of 30 GHz and across a distance of 10 meters. The validation of link budget estimations is achieved by considering many criteria, including coding rate, target signal-to-noise ratio (SNR), path loss, and the required number of antenna components. The proposed connection budget is eventually verified for several modulation techniques using the MATLAB software. Consequently, it has the capacity to facilitate the development of efficient and extensively interconnected wireless communication networks, with data speeds that approach 100 Gb/s. This article provides a comprehensive examination of hardware integration in the context of a thorough analysis of the current research. It discusses the many obstacles and potential solutions pertaining to the implementation of real 6G wireless systems in the D-band [11].

In [12], the visualization of the anticipated output or result via simulation of the proposed patch antenna is of utmost importance in the design of antennas, as it plays a critical role in attaining the desired outcomes for future research endeavors. The simulation enables us to assess many characteristics, such as bandwidth and antenna isolation, in order to determine the higher performance criteria of the built device. The Duroid 5880 substrate is often used in designs because of its low-loss and cost-effective properties. In the context of 6G frequencies, it is essential to have a bandwidth above 20 GHz, since this characteristic has significant value for both research and practical applications.

According to [13], the antenna under consideration was simulated in order to evaluate the power transfer at the antenna terminal through the transmission line. This evaluation was conducted to determine the impedance bandwidth ($S11 < -10$ dB) at frequencies of 326.67 GHz, which corresponds to a power level of −50.524 dB. It is worth noting that this frequency range has been designated by the Federal Communications Commission for the allocation of 6G applications.

II. Towards The Growth Of 6G Communication Systems

The design development and formation of 6G communication is now underway [14]. The increasing need for high data rates has led to the adoption and enhancement of existing 5G technology into 6G communication systems, prioritizing attributes such as ultra-low latency, exceptional capacity, heightened security, and expanded coverage for both broadcast and mobile applications in academic and industrial domains.

The scope of this technology encompasses a wide range of communication situations. The scope of coverage encompasses expansive geographical regions, including urban, rural, distant, oceanic, and aerial domains. These categories, together with their corresponding scenarios for implementation, are shown in Fig. 2.

A. The key characteristics of 6G communication

Each generation of wireless communication technology has brought revolutionary capabilities. As we move beyond 5G, expectations for 6G are growing [15,16]. The 6G communication method is intended to revolutionize wireless networks. This latest generation is expected to have several characteristics that surpass 5G. From ultra-high data speeds and ultra-low latency to artificial intelligence and worldwide connectivity, 6G promises to change how people connect, communicate, and engage with the digital world.

1) Connectivity

Connectivity stands out as a prominent attribute in the shift from the 5G to the 6G of wireless communication technology. It is anticipated that a substantial quantity of IoT devices will be interconnected in various circumstances, including both line-of-sight and non-line-of-sight connections. The attainment of uninterrupted connection may be realized via the use of reconfigurable meta-surfaces that are helped by artificial intelligence. The attainment of connectivity across expansive regions is anticipated via the use of combined satellite and 5G networks.

2) Mobility

The anticipated advancements in intelligent transport systems are predicted to result in increased mobility characterized by much higher speeds. The use of ultra-low latency in data transmission has the potential to enhance the efficiency and effectiveness of the transportation system. The maximum velocity taken into account for airplane communication situations in 6G is 1000 Km/h, a much greater value compared to 5G.

Fig. 2. The essential characteristics of the 6G-communication technology.

3) Security

The preservation of data privacy and security has significant importance within communication systems, particularly within areas such as the military and finance. The use of deep learning and artificial intelligence methodologies inside the physical and network layers of 6G networks has the potential to enhance security measures for devices, infrastructures, and assets.

4) Broadcasting

The next 6G technology promises novel multimedia applications and facilities that prioritize ultra-high video streaming, live broadcasting, and pleasure. The attainment of a high standard of service is expected to be accomplished by the integration of satellite communication, television, and cell phone technologies.

5) Ubiquity

The anticipated coverage area of ubiquity is projected to surpass that of 5G technologies. The next 6G systems are anticipated to include space and marine communication in addition to ground-based communication in order to attain extensive coverage and enhanced data speeds. The availability of the service will be facilitated via the use of a hybrid network consisting of both GEO/LEO satellite and terrestrial components. This aspect has significant importance, particularly in the context of communication inside aircraft, maritime vessels, and individuals living or operating in isolated regions.

6) Data Rates

According to Shannon's equation, the enhancement of bandwidth and the increase in the number of antennas have a direct proportional relationship with the improvement of data rates. The millimeter-wave/terahertz (mm-wave/THz) frequency bands provide a substantial increase in bandwidth ranging from 1 to 10 GHz. Therefore, the use of a large number of antennas and the utilization of the Mm-wave/THz band are two direct approaches to meet the increasing need for faster data speeds.

The anticipated performance target is to attain a data transmission rate of 1 Tbps, surpassing the capabilities of 5G technology in both the uplink and downlink directions. The increased data rates have considerable importance across several industries, including activities such as ultra-high-definition video streaming and the handling of enormous data files in office environments.

B. The Frequency Spectrums of 6G

During the process of transitioning to the 5G communication network, it is important to note that the 3G, 4G, and WiFi systems of communication continue to coexist. Hence, the use of sub-6 GHz communication continues and will be integrated within the framework of 6G communication. The implementation of 5G communication, particularly in the realm of mobile communication, has commenced and is now functioning within the sub-6 GHz frequency range. The allocation of sub-6 GHz bands for 5G networks varies across various nations. In the United States, these bands are designated as 3100–3550 MHz and 3700–4200 MHz. In Europe, the allocated range is 3400–3800 MHz. China has designated the bands as 3300–3600 MHz and 4800–5000 MHz, while South Korea has allocated the 3500 MHz band [17]. The chart is further illustrated in Fig. 3, illustrating the anticipated frequency spectrums for 6G communication together with their corresponding bandwidth.

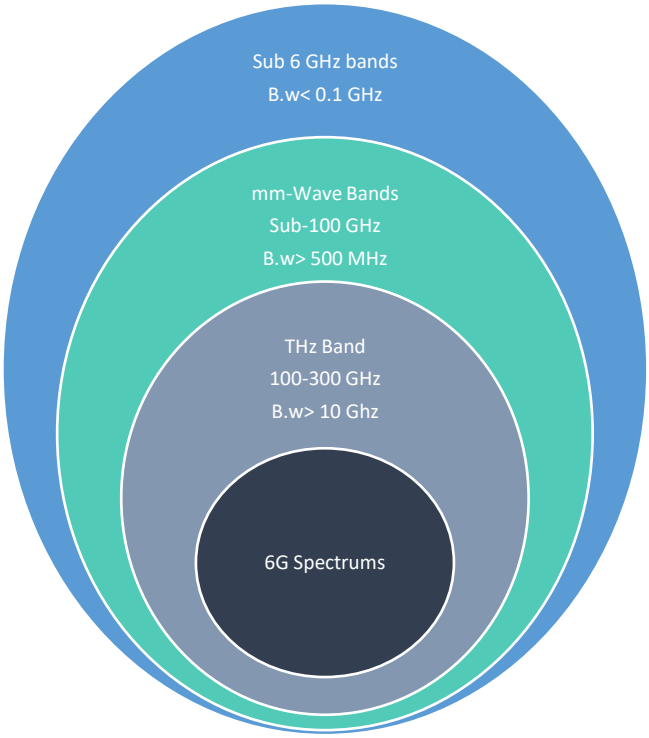

Fig. 3. The frequency spectrum used in 6G transmission.

III. 6G ANTENNAS OPERATING WITHIN THE TERAHERTZ (THZ) FREQUENCY BANDS

As previously mentioned, the frequency bands ranging from 100 to 300 GHz in the terahertz (THz) range are being explored for use in 6G communication systems. The complexity of antenna design escalates with higher frequencies, leading to increased difficulties in material selection, design procedures, manufacturing methods, and experimental verifications. Therefore, this section provides a comprehensive summary of newly published designs for 6G antennas [18]. Several kinds of antennas have been examined in recent literature for their suitability in the 6G terahertz (THz) frequency bands. The paper [19] introduces a conical horn antenna operating inside the 300 GHz frequency range. The horn antenna exhibits highly directed radiation patterns with significant gain at a frequency of 300 GHz. Additionally, it has a wide bandwidth ranging from 270 to 330 GHz, making it a suitable choice for applications in this frequency range. The performance shown is exceptional and meets the criteria set out by the 6G specifications.

An additional antenna design is introduced in reference to operation inside the 60 GHz frequency range. The development of an antenna in a package was facilitated via the use of printed circuit board technology [20]. The use of an antenna in a package technology is both cost-effective and highly advantageous for applications operating at high frequencies. Fig. 4 illustrates the comprehensive design of the antenna, together with the several stages of its evolutionary development. It is important to mention that, the antenna has a frequency range of 292 to 297 GHz, resulting in a bandwidth of 5 GHz. The procedure of fabricating the antenna is achieved by the use of laser technology. In contrast, a dielectric waveguide is used in several methodologies to get antennas with high gain, directional properties, and compact dimensions.

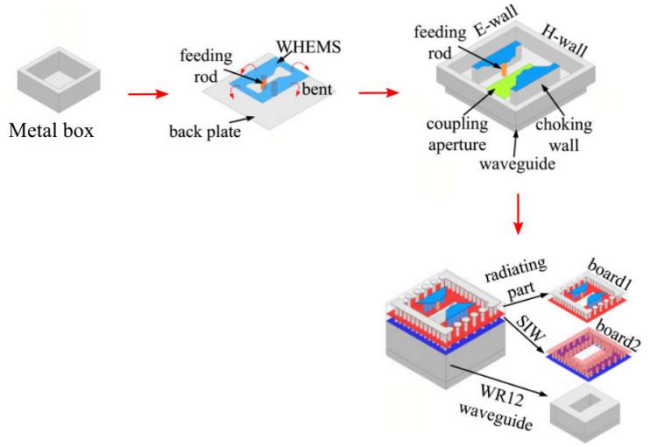

Fig. 4. The progressive development of a packaged antenna operating at a frequency of 60 GHz.

IV. CONCLUSION

This article provides a summary of the prospective 6G communication technology and its essential characteristics. The next iterations of communication systems and 6G antennas operating within the terahertz (THz) frequency band technologies, often referred to as 5G, B5G, and 6G, have been proposed with the objective of attaining many key advancements. These advancements include fast data rates, enhanced security measures, reduced energy consumption, ubiquitous access to broadband internet, and the ability to support a vast number of Internet of Things (IoT) connections. Due to the inclusion of many services operating across various frequency spectrums (Sub-6 GHz, mm-wave, and THz), the task of integrating a larger quantity of antennas into a single device poses a significant challenge. Therefore, this paper provides a comprehensive overview of the latest advancements in 5G antennas and arrays, highlighting their potential for future communication systems. The essay concludes by presenting the essential characteristics and prerequisites of 6G antennas that operate in the terahertz (THz) frequency range, catering to the demands of future technology. In future works, the gain, bandwidth and efficiency performances of the antenna can be improved by conducting multi-objective optimization studies for the design parameters.

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Design and Simulation for Washing Machine by Arduino with Proteus Software

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Research Article

Milad Ashour
Department of electrical and electronics engineering
Karabuk University
Karabuk, Turkey
milad.elhadia@gmail.com

Saleh Abufana
Department of computer
Bani Waleed University
Bani Waleed, Libya
s.g.abufana@gmail.com

Ahmed Mousay
Department of electrical and electronics engineering
Karabuk University
Karabuk, Turkey
ahmedmohammedmousay@karabuk.edu.tr

***Abstract*— Embedded systems have become a cornerstone of modern electronic design, offering efficient and cost-effective solutions for a wide range of applications. However, the advent of microcontrollers, particularly platforms like Arduino, has revolutionized embedded system development. This paper focused on the use of embedded systems based on Arduino controllers designed specifically for the automatic cleaning of parts within a juice filling machine. This machine is part of a factory presented at the Center of Research and development in the mechanical technical branch depending on orange juice. The designed system is simulated by the Proteus simulator and the results show the designed system works with high efficiency, improved reliability, and low costs, and the designer can supervise all system operations and identify any faults that may occur during the operational phases.**

Key Words- Filling Juice Machine, ARDUINO Board, Servo Motor, Proteus Simulator.

I. INTRODUCTION

An embedded system represents a practical computerized system designed to manage diverse functions. The definition of embedded systems is constantly changing due to the swift evolution of technology, resulting in a widely fluctuating interpretation of its scope and capabilities. Progressing technology leads to reduced manufacturing costs and facilitates the integration of diverse hardware and software components into embedded systems [1]. Typically, systems comprise inputs, outputs, and a compact processing unit. In the beverage filling and packaging industry, an array of controllers is utilized to execute the beverage filling and packaging procedures [2]. This paper focuses on employing an Arduino to effectively control and manage the washing unit as an integral part of the juice machine system. Furthermore, the system's control operations are executed through relays. Employing the Arduino Due microcontroller and its development environment, the system was meticulously designed. The programming of the Arduino system was carried out using the C programming language. Arduino efficiently processes sensor data, forwarding it to other system components. The primary considerations in designing the system were its user-friendly nature and cost-effectiveness in manufacturing[3]. The entire design process was divided into four distinct sections: design model, architecture model, implementation, and testing. The practical application of system design theory was pivotal in shaping the project's practical aspect. This theory extensively elucidates the utilization of the Arduino microcontroller in embedded systems. The practical segment of the project delineates into two facets: Hardware and Software. It elaborates on the manufacturing intricacies of the washing machine system. To facilitate easy replication for individuals without practical experience, a Proteus simulation was employed to create a comprehensive wiring diagram. Embedded system architecture serves as a broad conceptualization of the system. It does not delve into granular implementation details like software source code or hardware circuit design. Instead, it presents the hardware and software components as integral parts of interacting elements. These elements represent both hardware and software, focusing primarily on behavioral aspects and inter-relationships. A structure, within this context, serves as a specific representation of the architecture of embedded system as shown in “Fig. 1”

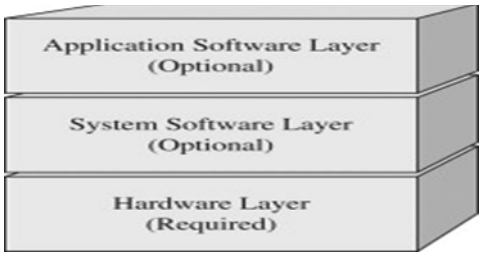

Fig. 1. Overview of Embedded Systes Architecture [4].

II. STRUCTURE OF WASHING PART IN FILLING JUICE MACHINE

The washing part is constructed from many parts, like sensors, relays, servo motor, bottle conveyor, turntable and star wheel. In this paper we will explain the benefits of each part in washing part and how it works, the “Fig. 2” shows how to connect all parts with an Arduino board.

A. Sensors

It is a device that detects and responds to some type of input from the physical environment. The specific input could be light, heat, motion, moisture, pressure, or any one of a great number of other environmental phenomena. These sensors make the system more efficient and reliable. The output is generally a signal that is converted to a human-readable display at the sensor location or transmitted electronically over a network for reading or further processing. In our project we will use many types of sensors, like:

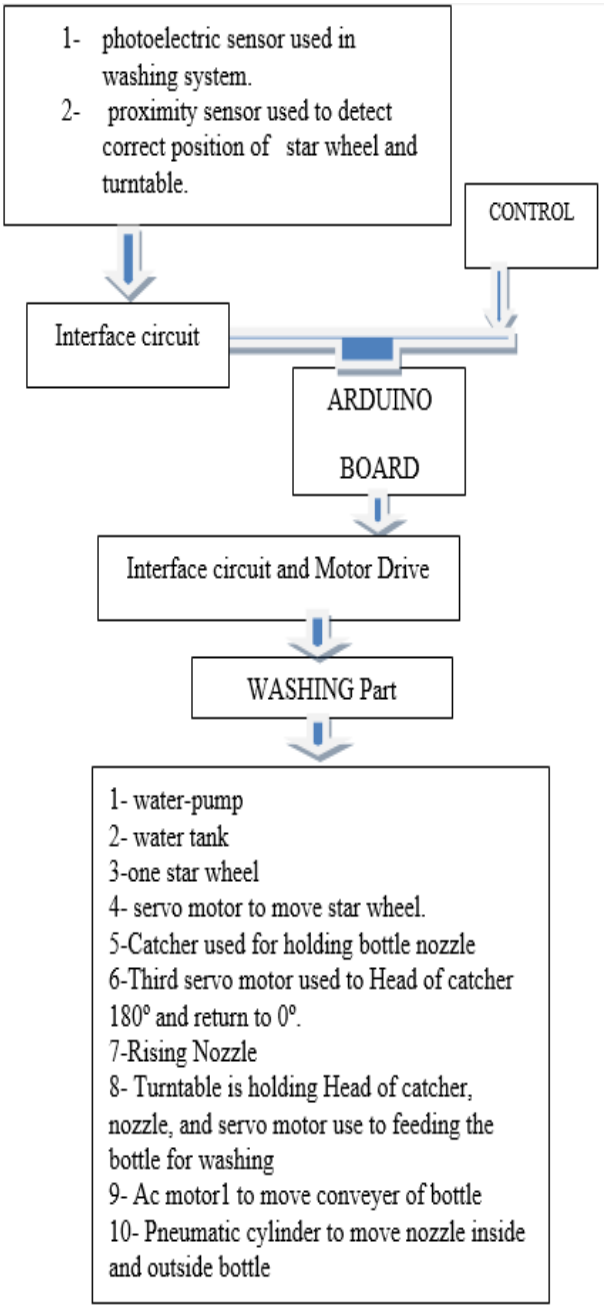

Fig. 2. shows process steps of washing unit.

a) Inductive proximity sensor:

Inductive proximity sensors are electronic devices that can detect metal objects without physical contact. The sensor generates an electro-magnetic field that is disturbed by when a metal target enters within its range. The sensor detects the presence of the metal object and electronically switches its output circuit [4]. Inductive proximity sensors are very useful in industrial control applications where contaminants such as dirt, oil, and water would cause problems for other sensing technologies, as shown in "Fig. 3".

b) Optical Sensors:

A photoelectric sensor is a device used to detect the absence or presence of an object using an infrared transmitter and photoelectric receiver. They are largely used in industrial manufacturing [7].

c) Through-beam Sensor:

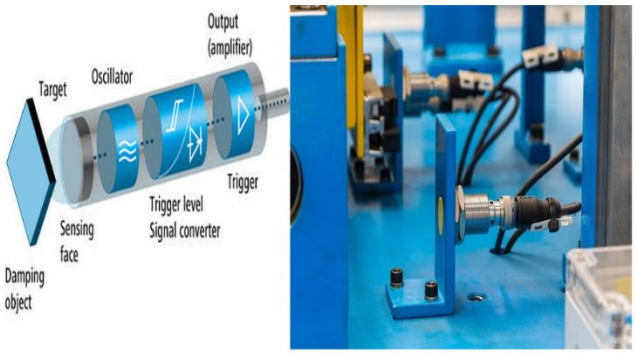

Fig. 3. Component and position of Inductive proximity sensor [5, 6]

The Emitter and Receiver are installed opposite each other to enable the light from the Emitter to enter the Receiver. When a sensing object passing between the Emitter and Receiver interrupts the emitted light, it reduces the amount of light that enters the Receiver [8]. This reduction in light intensity is used to detect an object as shown in "Fig. 4".

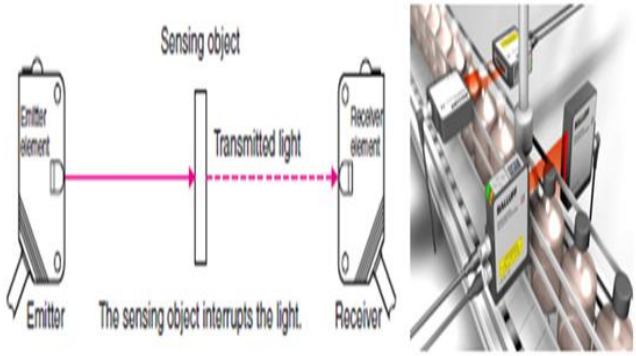

Fig. 4. explain basic work of Through-beam Sensor [9].

d) Relay:

Relay is an electromechanical switch which uses electromagnetism from small current or voltage to switch higher current or voltage for different appliances [10]. When a relay is in Normally Open (NO) contact, there is an open circuit until the relay is energized. If a relay is in Normally Close (NC) contact, there is a closed circuit until the relay is energized. As shown in "fig 5".

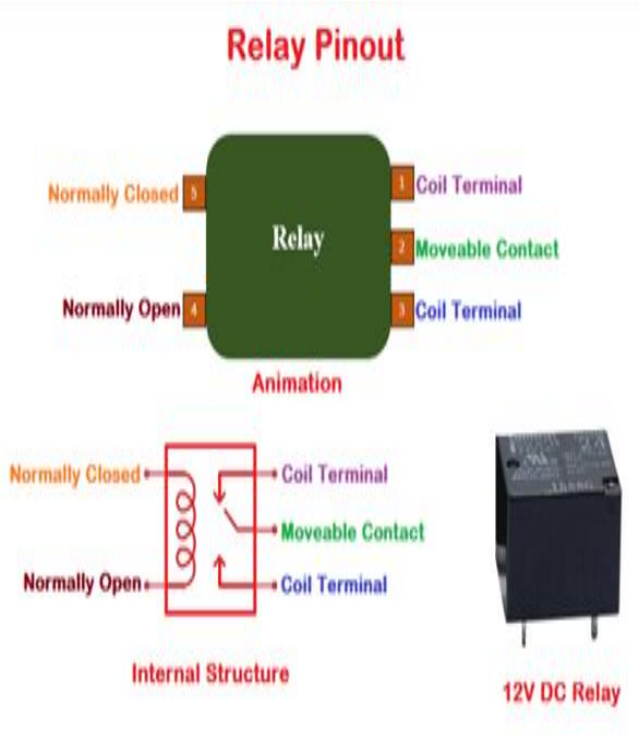

Fig. 5. Explain the Relay diagram [11].

e) Liquid level switch:

Liquid level sensor determines the amount of liquid in the water tank.

B. Pneumatic system:

A pneumatic cylinder uses air as its power source and converts it to a possible movement such as linear and rotary movement [12]. The pneumatic system is used in the washing system to move the nozzle inside or outside the bottle during washing, and it is used in the filler system to pull juice from the tank into a piston, then pump juice into the bottle and used to motion the nozzle into the bottle for filling bottles with juice, finally it is used in capper system to motion steeper down on hole of the bottle for close bottle with cap.

C. Electro valve:

A valve is a device that controls the flow of liquid. It can be opened and closed to control the flow of fluid. Valves can be hydraulic or electrical. In a hydraulic valve, the valve opens or closes depending on the liquid or air pressure [13]. In electrical valves, an electric signal is used to open or close the valve. In this paper we will use an electro valve, where it opens when the nozzle inside the bottle and closes when the nozzle is outside the bottle.

D. Turntable:

It is a disc consisting of bottle clips (head) and it's rotated on the shaft by a servo motor. The function of the bottle clip is to lock the bottleneck, where each bottle clip is equipped with a servo motor, photo sensor and pneumatic cylinder which holds spray on the nozzle as shown in “fig 6”.

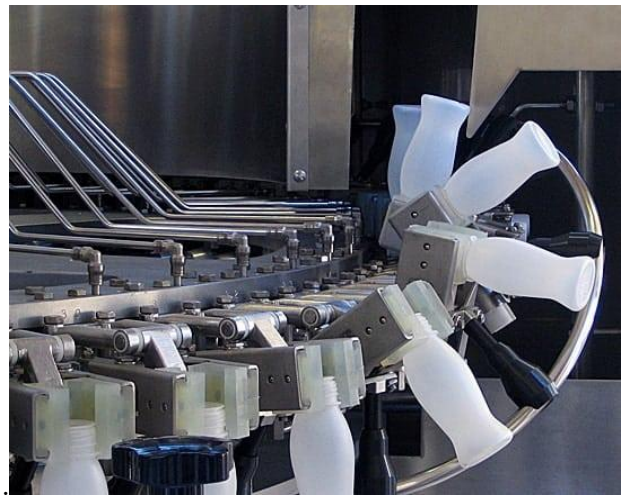

Fig. 6. head of Turntable [14].

E. Star wheel

It is a disc with specific spaces. Each space must be wide enough to fit the diameter of the bottle. When the star wheel rotates, the bottle enters a specific space in the star wheel. Then it is transmitted by using position control for the star wheel. The star wheel needs a device to rotate it at the suitable speed and angle, so that the bottle will be in its right position. The star wheel is fixed on a shaft and rotated by a servo motor, the bottle which entered it will be replaced by another one repeatedly throughout the production run by the star wheel as shows in “fig 7”.

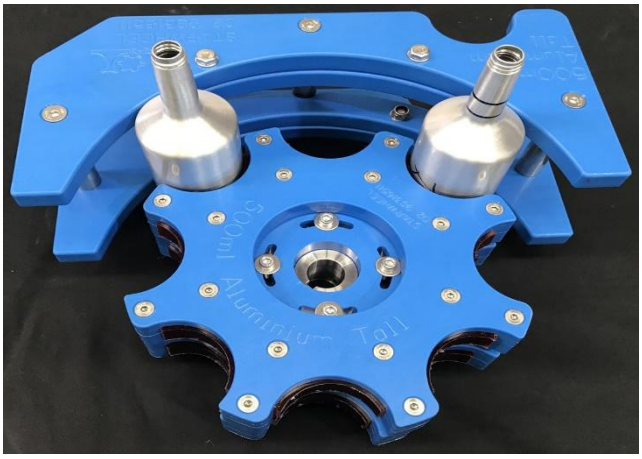

Fig. 7. holes of star wheel [15].

F. Conveyor:

The conveyer system contains two conveyors, the first for bottles and the second for caps. Each conveyor consists of AC Motor which is used to move the belt by rollers. The speed of the conveyor is controlled through a control board. After the start time and adjustment of the star wheel and turntable, the control board gives a control signal to the conveyor to carry the bottle along the production line, starting from the washing system, filling system until the capping system.

G. G. Servo Motor:

A servo motor is one of the widely used variable speed drives in industrial production and process automation and building technology worldwide [16]. While servo motors

don't belong to a distinct motor classification, they are purposefully crafted for motion control applications demanding precise positioning, rapid reversals, and outstanding performance. Their utilization spans various domains, including robotics, radar systems, automated manufacturing, machine tools, computers, CNC machines, and tracking systems. A servo motor is a linear or rotary actuator that provides fast precision position control for closed-loop position control applications as shown in "fig 8.a and fig 8.b". Unlike large industrial motors, servo motors are not used for continuous energy conversion. Servo motors have a high-speed response due to low inertia and are designed with a small diameter and long rotor length. Servo motors work on a servo mechanism that uses position feedback to control the speed and final position of the motor. Internally, a servo motor combines a motor, feedback circuit, controller, and other electronic circuit [17].

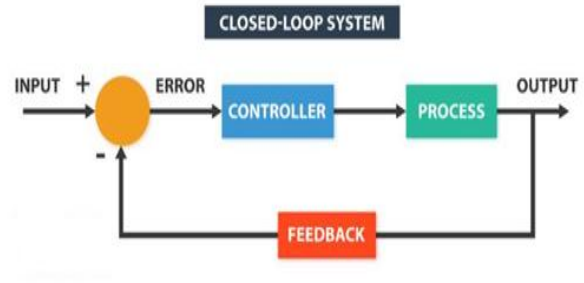

Fig. 8. a: explain close loop system [18].

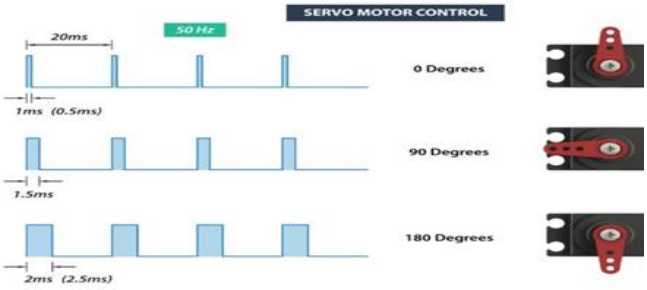

Fig. 8. b:explain Input pulse of servo motor [18].

a) Types of Servo Motors:

Basically, servo motors are classified into AC and DC servo motors depending upon the nature of supply used for its operation. Brushed permanent magnet DC servo motors are used for simple applications owing to their cost, efficiency, and simplicity [19].

b) Rotary encoder:

A rotary encoder, also called a shaft encoder, is an electro-mechanical device that converts the angular position or motion of a shaft or axle to analog or digital output signals [20]. There are two main types of rotary encoder are absolute and incremental. The output of an absolute encoder indicates the current shaft position, making it an angle transducer [21]. The output of an incremental encoder provides information about the motion of the shaft, which typically is processed elsewhere into information such as position, speed, and distance. Rotary encoders are used in a wide range of applications that require monitoring or control, or both, of mechanical systems, including industrial controls, robotics, photographic lenses, computer input devices [22].

III. ARDUINO

Arduino stands as an open-source platform used to create computers capable of sensing and controlling aspects of the physical world beyond the capabilities of standard desktop computers. The Arduino development board embodies the principles of wiring, a corresponding physical computing platform rooted in the processing multimedia programming environment [23]. "Fig 9". illustrates the fundamental model of an Arduino system.

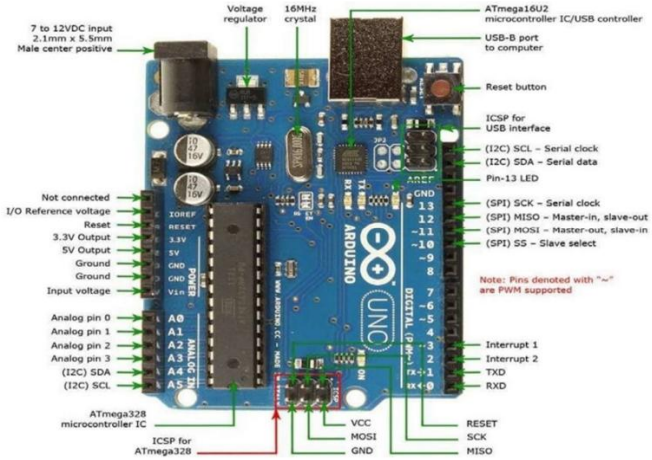

Fig. 9. Arduino Uno microcontroller [24].

A. Arduino IDE:

The Arduino IDE serves as a programming environment enabling users to create various programs and upload them into the Arduino microcontroller [25]. This IDE incorporates a built-in code parser to scrutinize user-written code before transmitting it to the Arduino. Upon program testing, it can be uploaded to the Arduino via a USB cable, the specifications of which may vary across different models [26].

IV. FLOW CHART OF WASHING SYSTEM.

The Flow Chart shown in "Fig 10" illustrates the actions to be taken by the system. The flow chart below shows the steps done in detail during the washing machine where explained all the steps from the start of work of the washing until completed the all steps of the washing part.

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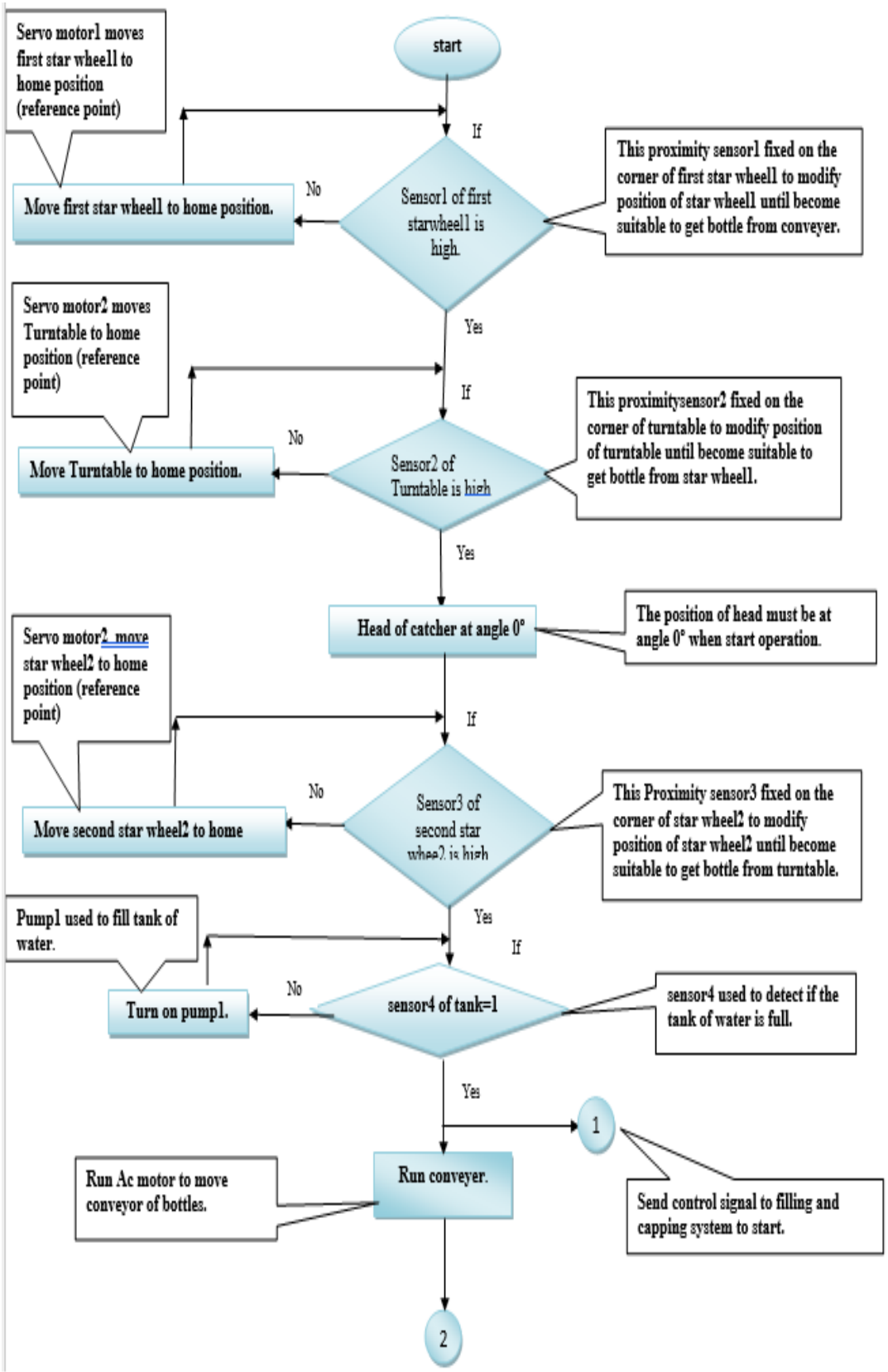
Servo motor1 moves first star wheell to home position (reference point)
start
If
Move first star wheell to home position.
No
Sensor1 of first starwheel1 is high.
This proximity sensor1 fixed on the corner of first star wheell to modify position of star wheell until become suitable to get bottle from conveyer.
Servo motor2 moves Turntable to home position (reference point)
Yes
If
Move Turntable to home position.
No
Sensor2 of Turntable is high
This proximitysensor2 fixed on the corner of turntable to modify position of turntable until become suitable to get bottle from star wheell.
Yes
Head of catcher at angle 0°
The position of head must be at angle 0° when start operation.
Servo motor2 move star wheel2 to home position (reference point)
If
Move second star wheel2 to home
No
Sensor3 of second star wheel2 is high
This Proximity sensor3 fixed on the corner of star wheel2 to modify position of star wheel2 until become suitable to get bottle from turntable.
Yes
Pump1 used to fill tank of water.
If
Turn on pump1.
No
sensor4 of tank=1
sensor4 used to detect if the tank of water is full.
Yes
1
Run Ac motor to move conveyor of bottles.
Run conveyer.
Send control signal to filling and capping system to start.
2

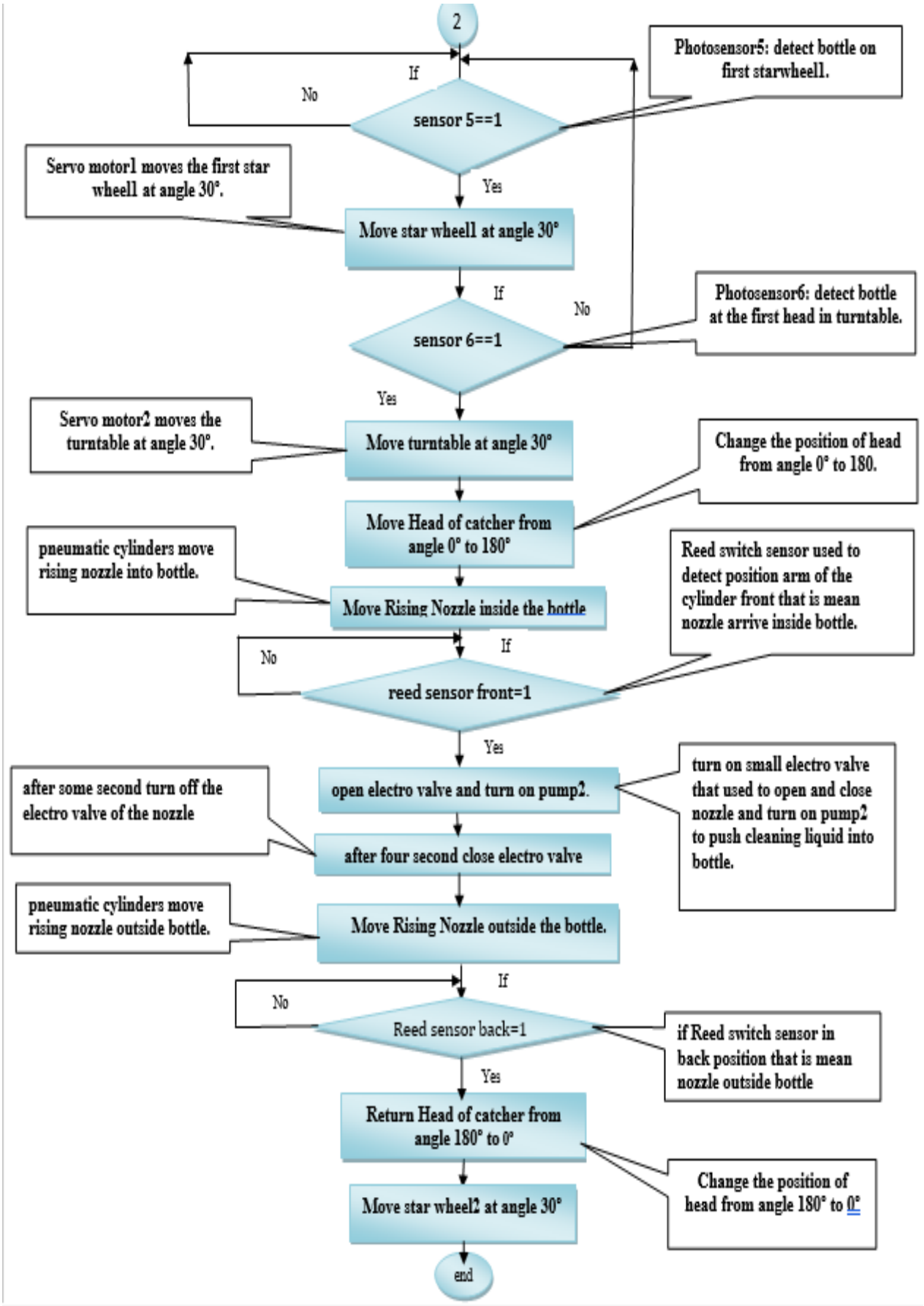

Fig. 10. shows flow chart of washing machine.

V. HARDWARE IMPLEMENTATION

There are several testing tools that uses to analyze and emulate the system behavior before design and implementation, the hardware emulation is done via emulator tool proteus as shown in figure (12).

a) Proteus software: Proteus (Processes and Transactions Editable by Users) is simulation software designed for various microcontrollers-based designs, enabling the simulation of the entire design before its implementation. The Proteus package consists of two main components, Isis and Ares. In this simulation, Proteus ISIS Circuit Simulation will be used as software which utilizes drawing schematics and simulating circuits in real-time [27].

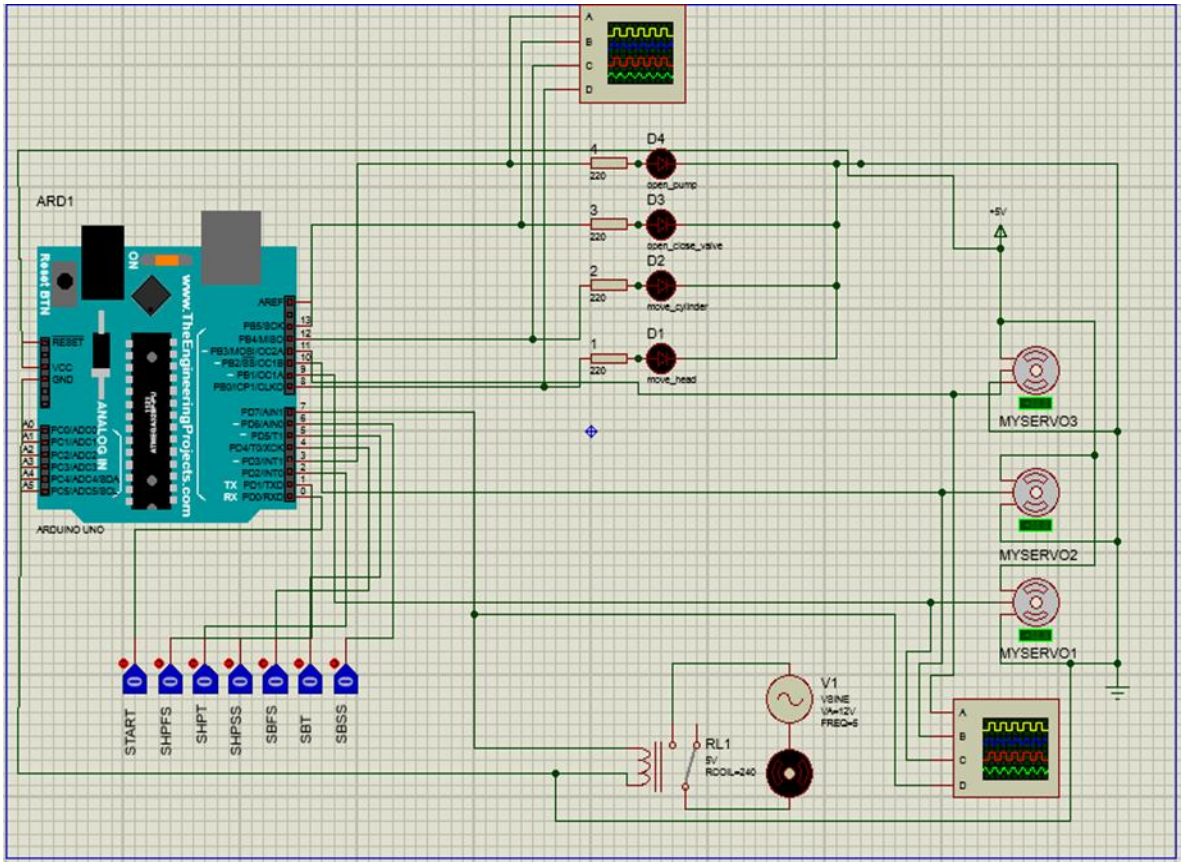

Fig. 11. Explain interface of different components with Arduino Board.

VI. RESULT

This section displays the simulation results derived from the Proteus ISIS environment, which confirm the functionality and timing of the proposed control system for the automated bottle washing unit. The simulation was created to evaluate the coordinated functionality of the sensors, actuators, and the Arduino Due controller according to the flowchart logic illustrated in Fig. 10. The primary performance metrics assessed were the accurate sequential functioning of the actuators and the suitable response of the controller to sensor inputs and outputs as shown in table 1.1. Figure 12 illustrates the logic analyzer virtual instrument in Proteus, displaying a specific sequence of HIGH signals on the designated digital output pins (D2, D3, D4).

This verifies that the code effectively executes the homing routine, positioning all-star wheels and the turntable to a defined reference point (0°). This is an essential initial step to guarantee the synchronization of all mechanical components prior to the commencement of the conveyor. A definitive screenshot illustrating the concurrent activation of the three digital pins to HIGH (5V).

Figure 13 illustrates the transition of the Arduino output pin connected to the AC motor relay (Pin D5) from a LOW (0V) to a HIGH (5V) state. The HIGH signal would activate the relay, completing the circuit to power the AC motor and initiate the conveyor belt. The simulation verifies that the control logic accurately commences the material handling process solely after the machine is appropriately initialised, thereby averting possible collisions or jams. A screenshot highlighting the status of Pin D5 and the virtual relay component indicating activation.

Figure 14 demonstrates how the photosensor activates, causing its output pin linked to an Arduino analogue input to alter its state. The Arduino code accurately reacts to this sensor input. The servo motor governing the initial star wheel receives a new pulse width, instructing it to rotate to a -60° position to engage the bottle. This illustrates the essential closed-loop feedback for automation: a sensor input directly activates a specific actuator response.

TABLE I. SUMMARIZING THE SIMULATION OUTCOMES.

Simulation Phase	Trigger	Arduino Output	Result	Validation Outcome
Initialization	Power On	Home Servos (D2, D3, D4 → HIGH)	All servos moved to 0°	PASS - System synchronized.
Conveyor Start	Homing Complete	Start AC Motor (D5 → HIGH)	Conveyor belt moved	PASS - Process started correctly.
Bottle Handling	Photosensor triggered	Rotate Star Wheel	Star wheel moved	PASS - Sensor feedback loop works.
Washing Cycle	Bottle in position	Activate Cylinder, Valve, Pump (D6,D7,D8 → HIGH)	Nozzle moved in, fluid dispensed, nozzle retracted	PASS - Core washing sequence is correct and safe.

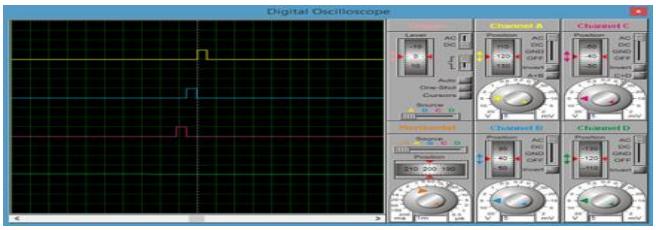

Fig. 12. Syatem Initialization and Homing Sequence

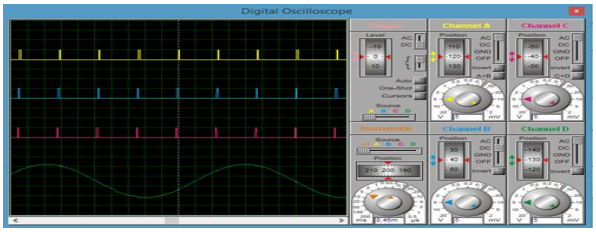

Fig. 13. Conveyor System Activation

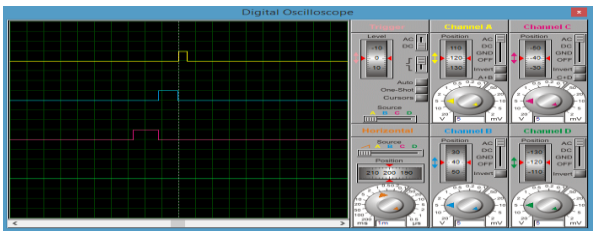

Fig. 14. Bottle Detection and Servo Positioning

In figures 15 and 16, as the bottle advances into the washing station, a series of outputs is activated. This encompasses: the extension of a pneumatic cylinder (Pin D6 → HIGH), the activation of an electro-valve (Pin D7 → HIGH), and the initiation of a pump (Pin D8 → HIGH). Subsequent to a predetermined delay, these outputs become inactive (LOW). The timing diagram of these signals represents the paramount outcome. The control system effectively performs the core washing function as demonstrated in Figure 15. The nozzle enters the bottle prior to the valve's activation.The valve activates and the pump operates for a specific duration to release cleaning fluid. The valve closes, and the pump ceases operation prior to the retraction of the nozzle. This sequence is essential to avert spills and guarantees effective washing. The simulation confirms that the timing delays programmed in the Arduino sketch are functionally accurate. A clear screenshot of the Proteus logic analyser displays the timed sequence of these four control signals returning to a low state, as illustrated in Figure 16.

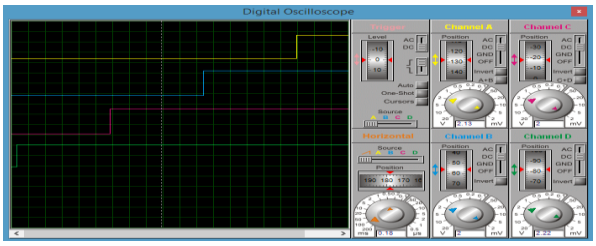

Fig. 15. Washing Cycle Execution

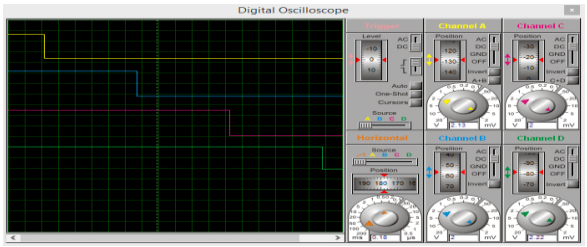

Fig. 16. Return control signal to low.

VII. CONCLUSION

The control system designed based on Arduino to control of steps of washing unit in juice factory. Arduino microcontrollers are constantly evolving development platform.Troubleshooting and maintenance of the control system are very easy because it can changed, added, removed any component via the software in the design time and uploading that software again into it, Arduino has ability to control on multiple motor controller on one chip. The designed system is low power consumption, more reliability while reducing cost and works very easy with Protes software. The designer can supervise the whole operations of the system and detect any faults that occurs during the operation steps. The Proteus simulation effectively confirmed the design and control logic of the Arduino-based washing unit. The findings indicate that the software accurately interprets sensor data and produces the requisite output signals to control the actuators in the correct sequence and timing. All essential operational phases from initialisation and bottle handling to the exact washing cycle were performed as intended. The simulation validates the system's functional accuracy before physical implementation, thus mitigating development risk, expense, and duration. This demonstrates the effectiveness of utilising the Arduino platform in conjunction with Proteus simulation for the design and validation of cost-effective industrial automation solutions.

CONTRUBITION OF THE AUTHORS

The contributions of the authors to the article are equal stated in this section.

CONFLICT OF INTEREST

There is no conflict of interest between the authors.

STATEMENT OF RESEARCH AND PUBLICATION ETHICS

Rresearch and publication ethics were observed in the study.

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