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.

Smart Irrigation Pump Design Building Range Using Arduino Atmega 328

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Abstract– *The integration of technology into agriculture has become increasingly prevalent, with smart irrigation systems emerging as a crucial tool for sustainable crop management. This research focuses on the design and implementation of a smart irrigation pump system using Arduino ATMEGA328 microcontroller, aiming to optimize water usage and enhance crop yields. The system utilizes a combination of sensors, actuators, and control logic to automate irrigation processes and adapt to changing environmental conditions. The device can also be used on surface irrigation systems because it can monitor the surface of the container in the water pad, so that the water is not wasted in vain because there is no control system, because the prototype device is running well. With an average accuracy rate of 98.3%.*

Keywords: Arduino ATMEGA 328; Smart Irrigation; Pump Design

1. INTRODUCTION

In recent years, the convergence of technology and agriculture has ushered in a new era of precision and efficiency in farming practices. One such innovation is the development of smart irrigation systems, which leverage the power of microcontrollers like the arduino atmega328 to optimize water usage and improve crop yields[1][2]. In this research, we delve into the realm of smart agriculture by designing and building a sophisticated irrigation pump system using the arduino atmega328 microcontroller[3][4]. by integrating various sensors, actuators, and communication modules, we aim to create a comprehensive solution that not only automates the irrigation process but also adapts to environmental conditions in real-time.

The core objective of our research is twofold to enhance water management practices and to minimize resource wastage with the increasing scarcity of water resources globally, efficient irrigation systems play a pivotal role in sustainable agriculture[5][6][7]. By deploying smart technology, we can precisely monitor soil moisture levels, ambient temperature, and other critical parameters, allowing us to tailor irrigation schedules to the specific needs of crops while conserving water. Our system will be equipped with a range of sensors, including soil moisture sensors, temperature and humidity sensors, and rain sensors, enabling it to gather accurate data about the surrounding environment[8]. This data will be processed by the arduino atmega328 microcontroller, which will execute intelligent algorithms to determine optimal watering times and durations. Sensor such as water pumps and solenoid valves will be employed to control the flow of water to different irrigation zones, ensuring precise and efficient distribution [9][10][11][12]. furthermore, communication modules such as wi-fi or gsm will enable remote monitoring and control of the system, empowering farmers to manage their irrigation infrastructure from anywhere with internet access[13][14].

Throughout the research, we will emphasize not only functionality but also usability and scalability. A user-friendly interface will be developed to provide intuitive control and real-time feedback, while robust data logging and analysis capabilities will facilitate continuous optimization and improvement of the system over time[15][16]. By embarking on this endeavor, we aim to contribute to the advancement of sustainable agriculture practices while demonstrating the transformative potential of technology in addressing global challenges. Through innovation and collaboration, we endeavor to create a smarter, more resilient future for farming communities around the world.

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2. RESEARCH METHOD

2.1 Research Flow Diagram

Research flow diagrams outline the sequential steps involved in conducting research for a particular topic. In the context of designing smart irrigation pumps using the Arduino ATMEGA328, the research flow diagram serves as a guide to systematically explore various aspects of the research, as seen in Figure 1.

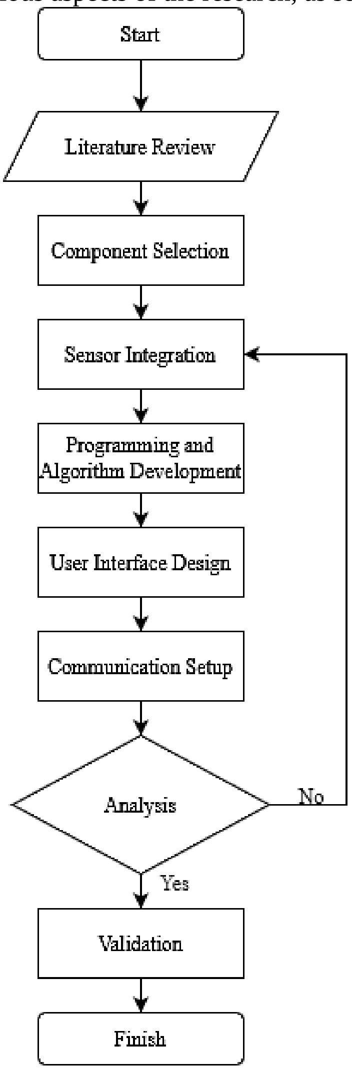

Figure 1. Research Flow Diagram

2.2 Tools and Materials

The tools and materials used in this research are:

1. Soldering Iron and Solder.
2. Wire Cutters and Strippers.
3. Breadboard.
4. Multimeter.
5. Computer with Arduino IDE.
6. USB Cable.
7. Arduino Uno.
8. Jumper Cable.
9. Adaptor 12V.

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10. Relay 1 Channel.
11. Ultrasonic Sensor.
12. Water pump.
13. 1-phase contactor.
14. MCB 2 poles.
15. MCB 1 phase.
16. Board thickness 12mm (30x40 cm).
17. Indicator light 220V.
18. MCB rail.

2.3 Irrigation

Irrigation is generally understood to be the use of water to deliver the liquids required for plant growth. On the other hand, a broader definition of irrigation includes the following eight uses of water in the soil:
a. Adding water to the soil to provide the fluid required for plant growth.
c. Offering a harvest guarantee throughout the brief monsoon season.
c. To chill the atmosphere and soils, thereby fostering a favourable condition for plant growth.
d. To lessen the chance of freezing; e. To remove or lessen the amount of salt in the soil.
f. in order lessen the risk of soil erosion.
g. to get rid of dirt clamping and piracy.
h. to slow the formation of shoots by cooling due to evaporation.

2.3.1 Types of Irrigation

1. Surface Irrigation

Surface Irrigation is an irrigation system that transmits water directly into the river through the bending building or through the free-intake building, then the irrigated water is gravitative discharged through the channel to 5 farmlands. Here are known primary, secondary, and tertiary channels. The water arrangement is done with the water gate. The process is gravity, high soil will get water first.

b. Irrigation A water pump

Water is taken from an inward well and supplied through a water pump, then distributed in various ways, for example by pipes or channels. During the rainy season, this irrigation can continue to flow through the pit.

c. Gravitational irrigation

Gravitational irrigation is irrigations that utilize gravitational traction to flow water from local sources in need, generally this irrigation is widely used in Indonesia. This irrigation is divided into:
1. Wild irrigations.
2. Irrigation of seals from the canal.
3. Irrigations of streams and waves.

d. Sprinkler Irrigation

If water is given by spraying or by simulating rain (sprinkler), the water sprayed will be like fog, so that the plant gets water from above, the leaves will be wet first, then drop to the roots. In practice this spraying is done by flowing water through the pipe at a certain pressure (4-6 Atm) so that it can wet a large area. Water supply in this way can save in terms of soil treatment because with irrigation in this manner there is no need for a flat soil surface and irrigations can reduce water loss in the canal as the water is sent through a closed canal. There are two different ways of water supply in this way, with the oscillating system, which is by placing the main pipes underground and the distribution pipes are mounted vertically above it and on this pillar are connected so that the pipe can be rotated. Whereas the next way is by the rotating sprinkler system, this system is cheaper than the oscillation system, because the system consists of one carrier pipe and its pipe children installed on the surface of the ground at a distance of 10-30 m, made of a galvanized pipe with a length of 6m. e. The amount of irrigation water to be given is determined based on the needs of plants, nor the soil holding water, as well as the irrigating means available. This irrigation is similar in principle to flow irrigations only the tertiary pipe is made through the tree lines and the pressure is smaller because it is just to drop. The advantages of this system are:
1. There is almost no water loss, as water drops directly on the tree.
2. Water can be mixed with fertilizer.
3. Peptides are not washed.
4. No surface flow.
5. Water distribution is even and controlled.

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2.4 Arduino Atmega

The Arduino Uno microcontroller board is based on the ATMega328. It features 16 MHz crystal oscillators, USB connections, power jacks, ICSP headers, reset buttons, and 14 pins of input from a digital output, of which 6 pins are used as PWM outputs and 6 equivalent input inputs. Simply use a USB cable, an AC-to-DC adapter, or a battery to power the Arduino Uno board in order to enable the microcontroller for use. Using the pinMode(), digitalWrite(), and digitalRead functions(), any of the Arduino Uno's 14 digital pins can be used as an input or output. Five volts is the operating voltage for each function. Each pin contains a 20–50 kOhm pull-up resistor and a maximum current capacity of 40 mA. Several communication features allow Arduino Uno to interact with various microcontrollers, computers, and other Arduino devices. Digital pins 0 (RX) and 1 (TX) of the ATMega328P support UART TTL (5V) serial communication.

The Arduino Uno can be powered via a power supply or USB connection. You can use a battery or a DC adapter as a power supply. The input supply port connection's adapter jack is where the adapter can be connected. Arduino features a 32 KB flash memory for storing code and a 2 KB bootloader. Data transmission one piece at a time is known as serial communications. In serial communications, data is transmitted bit by bit. The ATMega328P microcontroller, also known as Alf and Vegaard's Risc Processor, is an 8-bit Complementary Metal Oxide Semiconductors (CMOS) series manufactured by Atmel on the foundation of RISC architecture. Computer with a Reduced Instruction Set. Nearly every instruction in the programme is carried out in a single clock cycle. The 8 Kbyte in-system programmable flash of the ATMega328P enables read/write access to programme memory over a serial connection known as the Serial Peripheral Interface (SPI).

Compared to other microcontrollers, AVR has the benefit of executing programmes more quickly because the majority of its instructions are completed in a single clock cycle. (Mesmerizingly faster than MCS 51's keluarga microcontrollers with an architecture of Complex Input/Output Set Compute). With a throughput of roughly 1 million instructions per second (MIPS) per MHz, the ATMega328P lowers power consumption to match the speed at which commands are executed. This microcontroller is a type of AVR microcontroller that can be easily programmed and reprogrammed on multiple platforms. One of them is through the Arduino Prototype and the arduino IDE application.

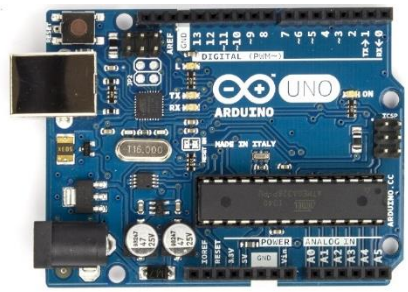

Figure 2. Arduino Uno Atmega

2.4.1 Arduino Atmega Features

The ATMega328P is an output microcontroller from Atmel that has a RISC (Reduced Instruction Set Computer) architecture where every data execution process is faster than the CISC architecture. (Completed Instruction Set Computer). Here are some of the features of the ATMega328P microcontroller:

1. It has 130 types of instructions that are almost all executed in one clock cycle.
2. It has an execution speed of 16 MIPS with a clock 16 MHz
3. It has 32 Kb Flash Memory.
4. It has EEPROM (Electrically Erasable Programmable Read Only Memory) of 1 Kb.

2.4.2 Atmega Pin Configuration

The ATMega328P has a standard foot of 28 pins that has different functions either as a port or as other functions. The 28-pin configuration includes:

1. VCC is a pin that serves as an input power supply.
2. GND is a Ground pin.
3. Port B (PB0 – PB7) is a two-way input/output pin (full duplex) and each port has its own special functions.
4. Port C (PC0 – PC6) is a full duplex inputs/outputs and each of the ports has a special function.

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5. Port D (PD0 – PD7) is an input/ outputs double-directional pin and each gate has a specific function.
6. RESET is a PIN that is used to set up or restart the original program that has already been inserted into the microcontroller.
7. XTAL1 and XTal2, are an external clock input pin.
8. AVCC is an ADC (Analog-Digital Converter) voltage input pin.
9. AREF is the ADC voltage reference pin.

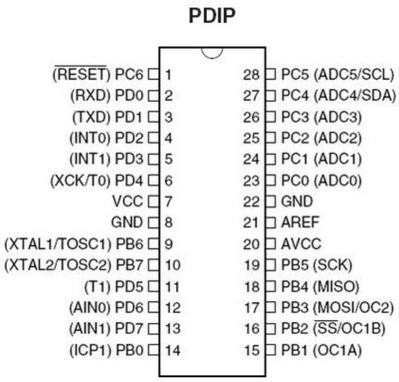

Figure 3. Atmega Pin Configuration

2.5 Ultrasonic Sensor

The HC-SR04 sensor is an ultrasonic wave-based distance measurement sensor. The principle of this kind of operation is to emit a wave and then calculate the reflective time of the wave. The frequency at which ultrasonic waves operate range from 20 kHz to 2 MHz. The operating frequency of ultrasonic waves is dependent on the type of media they are passing through, ranging from liquid to high densities.

The ultrasonic sensor is made up of an ultrasound microphone, an ultrasonic speaker, and a 40 kHz signal generating chip. The 40 kHz signal is transformed into sound by the ultrasonic speaker, and its voice reflection is detected by the ultrasonic microphone. For 200 µs, ultrasonic sound at a frequency of 40 KHz will be released. Figure 4 illustrates how this sound will intermittently travel through the air at a speed of 340 m/s, or 29.412 µs per 1 cm, touch an item, and then reflect back into the ultrasonic sensor.

Figure 4. Ultrasonic Sensor

2.6 LCD

The LCD is a component that functions to display characters or numbers. The LCD used is the type M1632 which is a 2x16 character LCD (see picture 5). The LCD is divided into two sides, the Backlight, and the Liquid Crystal. A white LCD backlight will illuminate the liquid or liquid crystals. The liquid crystal will filter the backlight it receives and reflect it at the desired angle to produce the color it needs.

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Figure 5. LCD

2.7 Relay

Electric-mechanical switches that are powered by electricity, relays are made up of two primary parts: mechanical contacts and electromagnetic coils. In order to produce higher voltage electricity with a little current (low power), the relay moves the switch contacts using the electromagnetic principle. For instance, the relay can move the Armature Relay, which acts as the switch, to deliver 220V and 2A by employing 5V and 50 mA electromagnets. Figure 6 below is a relay module picture.

Figure 6. Relay Module

2.8 Arduino IDE

The Arduino IDE software is published as Open Source, available to experienced programmers for further development. The language can be further developed through C++-based libraries for AVR. Figure 7 below shows an Arduino IDE application.

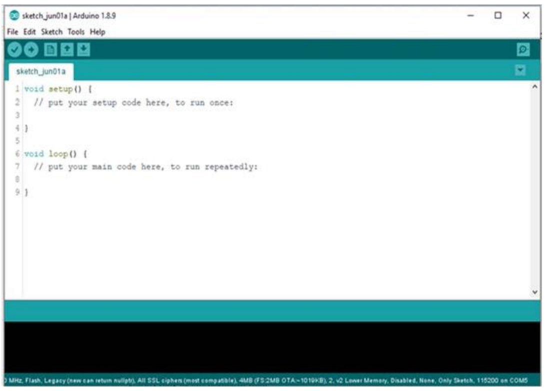

Figure 7. Arduino IDE Application

The programming language used by the Arduino IDE in developing microcontroller applications is C/C++. Of course, there is a special style that distinguishes it:

1. Void main(void) as the main function of the program is replaced by void loop (). The difference in c usually does not occur loop, so there must be a looping added for example while (1) {......}. In Arduino, the loop () function automatically returns from the beginning if the bottom of the instruction has been executed. The loop part is the core part of an Arduino program. Commands written in the form of program lines will be repeated continuously. The primary commands to be commanded to the system can be loaded in this area.
2. Added function void setup(void), this function is used to initialize the microcontroller before the main function loop () is executed. The setup part is the part that is the area where the code initializes the system before entering the loop part. (body). In principle, a setup is a part that is executed only once at the start of a program, so this part is an important part of Arduino programming because it covers codes that affect the body of the program later.
3. Do not bother with register settings, because Arduino has already put it in its library and automatically adjusts to the Arduino board type according to the type of microcontroller. So set up the hardware is easy.

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2.9 Contactor

Magnetic contactors are electrical devices that operate on the principle of electromagnetic induction. On the contactor there is a circuit where the electrical current will create a magnetic field on the iron core, which will make the contact attracted by the magnetic force that emerged. The Help Contact NO (Normally Open) will close and the Help Contact NC (Normal Close) will open. Contacts on contactors consist of the primary contacts and the Help contacts. The primary contact is used for the power grid while the Help contact is for the control grid. In an electromagnetic contactor there is a primary curve that's in the iron core. The short-circuit curve acts as a vibration suppressant when the two iron cores are attached to each other. When the main curve is drawn by current, a magnetic field will appear on the iron core that will pull the iron cores from the short-core curve coupled with the main contact and the Auxiliary contact of the contactor. This will result in the primary contact and the support contact moving from the normal position where the NO contact will be closed while the NC will be opened. If the main curve of the contactor is still in the current, the contacts will remain in the operating position. If the contactor curve is given too high voltage, it will cause a decrease in age or damage to the contactor curve, but if the voltage given is too low it will reduce the pressure between the contactors of the contactors. This will cause flames on the surface and can damage the contacts. The magnitude of the voltage tolerance for a contactor curve is between 85% - 110% of the working voltage of the contactor.

Figure 8. Contactor

2.10 MCB

The MCB (Miniature Circuit Breaker) is an electromechanical device that protects the electrical system from overcurrent’s. (overload). The MCBs have the same function as the fuse, which is to disconnect the electric current from the circuit when there is an over-current interference. The difference between the two is that when interference occurs, the MCB will trip and when the network is normal, MCB bias in the ON again (reset) manually, while the fuse will be disconnected and unbiased to use again. According to IEC 60974-2, the circuit breakers for low voltage installations must be accompanied by the trip unit.

MCBs are commonly applied or used on housing installations, on lighting installations and on electric motor installations in industry and so on. When a bimetal or an electromagnet works, it breaks the contacts located on the arc extinguisher and opens the switch. Household MCBs such as melt fire extinguisher houses are preferred for short connection protection, so their use is preferred to secure the installation or conductor. While the MCB on the APP is preferred as a carrier as a current carrier with the characteristics of CL (Military Current) besides it is also a short-circuit security exercise that works at a time.

MCBs are used by the PLN or others to restrict current at the same time as security in an electrical installation. The MCB serves as a short-circuit secure and acts as an overload secure. The MCB will automatically immediately break the current when the current passing through it exceeds the nominal current specified on the MCB. The nominal currents of the MCBs are 1A, 2A, 4A, 6A, 10A, 16A, 20A, 25A, 32A, and so on. The nominal MCB is determined by the size of the large current he sends; the unit of the current is ampere. So, if the MCB has a nominal current of 2 ampere then only need to be written with MCB 2A.

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Figure 9. MCB

2.10.1 MCB Working Principles

Under normal conditions, the MCB acts as a manual switch that can connect (ON) and disconnect (OFF) electric current. In the event of overload or short circuit connections, the MCB will operate automatically by interrupting electric current passing through it. Visually, we can see the move of the button or button from the ON condition to the OFF condition. This automatic operation is done in two ways as shown in the picture below, namely by means of Magnetic Tripping and Thermal Tripping. Thermal Tripping (Trip) At overload conditions, the bimetallic current leads to a curved bimetal temperature that breaks the MCB contact. Magnetic Tripping when there is a sudden short circuit connection or a very high overload. (Heavy Overload). Magnetic Tripping or disconnection of electrical current magnetically will be implemented. In the case of short contact or heavy overload, the magnetic field on the MCB Solenoid will pull the Latch (pole) and disconnect MCBs (Trip). Most of the MCBs (Miniature Circuit Breakers) used today use these two mechanisms of electrical current disconnection (Thermal Tripping dan Magnetic Tripping).

3. RESULTS AND DISCUSSION

3.1 Smart Pump Block Diagram

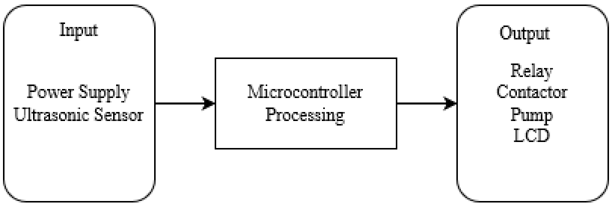

Figure 10. Smart Pump Block Diagram

Figure 10 above explains that the power supply and ultrasonic sensors are input sources to the microcontroller, the output data generated by the ultrasonic sensor will be input to the microcontroller, for which the microcontrollers will process through some of the algorithms that have been programmed on the micro controller, at the stage of output the microcontroller will give a command signal to the relay input source, the pump and the LCD as the character display.

3.2 Smart Pump Control Network

The controls used on the smart pump device can be seen in Figure 11.

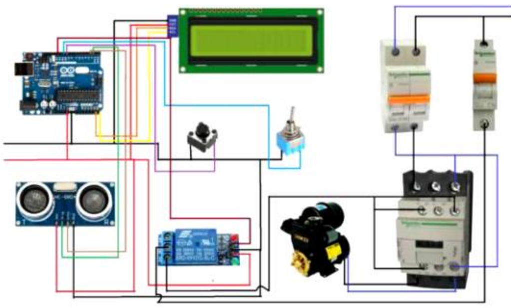

Figure 11. Smart Pump Control Network

From figure 11 above that generally a device requires a useful control system to regulate all input and command, here is a flow diagram of the device control system found in figure 12.

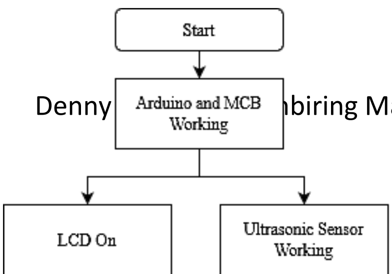

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Figure 12. Control System Flow Diagram

3.3 Discussion

The test of the device was carried out to see how smooth and functional the device is, for a picture of the entire device can be seen in figure 13.

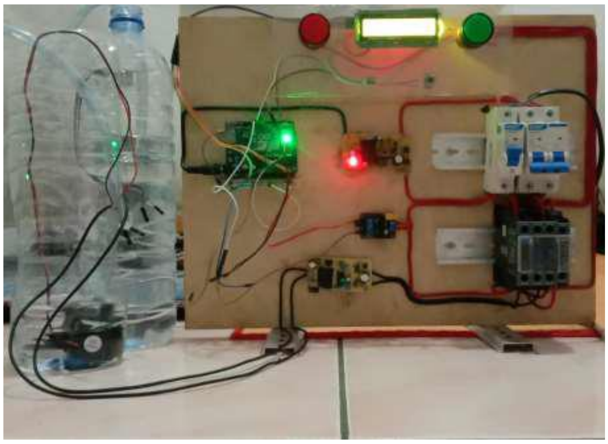

Figure 13. Smart Pump Prototype

From figure 13 above that the Arduino operates commands to the ultrasonic sensor to be able to control the contactor where the relay will be connected to the A1 coil and the A2 coil is connected directly to the neutrals of the MCB and where the coil A1 and the Coil A2 on the contactors are used to move or change the contact condition NO to NC connected with a voltage of 220 Volt controlled through the ultra-sonic sensor. And where the main contact NO upper foot is used as the input of the MCB 2 pole with code 1L1,3L2,5L3. whereas the bottom is used for the output or input toward the load with code 2T1,4T2,6T3. And for as the auxiliary contact and as the lock on the contact NO is code 13 and 14 and the contact NC with code 21 and 22 can be connected to the indicator light. The water pump can be controlled through a contactor where the contactor is at NO position then the water pump will not be alive and when the contactor is at NC position then a water pump is alive where the water pumps are connected to the NC contactors with codes 2T1,4T2 and 6T3, for the type of water pump used in this study is a mini water pump 12 V to be used at a voltage 220 V, aka a DC adapter 12 V is required as a voltage supplier to the pump. As for the prototype test results of the smart pump, you can see in table 1.

.

Table 1. Smart Pump Prototype Test Result Data

Testing to	Test Distance (cm)	Distance to Grid (cm)
1	2	1.8
2	4	3.8
3	6	5.9
4	8	7.8
5	10	9.8
6	12	11.8
7	14	13.8
8	16	15.9
9	18	17.8
10	20	19.8
11	22	21.8
12	24	23.8
13	26	25.9
14	28	27.8
15	30	29.8
16	32	31.8
17	34	33.8
18	36	35.9
19	38	37.8
20	40	39.8

In table 1 we can see some test results obtained, to determine the accuracy of the test data using the equation:

$$\text{Accuracy} = \frac{\text{Distance to Grid}}{\text{Test Distance}} \text{ x } 100\% \quad (1)$$

By using the equation above the flat, the accuracy level of the tool can be calculated and presented in table 2.

Table 2. Accuracy Level of The Tool Results

Testing to	Accuracy (%)
1	90
2	95
3	98.3
4	97.5
5	98
6	98.3
7	98.5
8	99.3
9	98.8
10	99
11	99
12	99.1
13	99.6
14	99.2
15	99.3
16	99.4
17	99.4
18	99.7
19	99.5
20	99.5
Average Accuracy (%)	98.3

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From table 2 that the average accuracy rate of testing of a smart pump prototype device was 98.3%, which means that testing of the smart pump prototype device runs in accordance with this research plan.

4. CONCLUSION

The design and implementation of a Smart Irrigation Pump using an Arduino ATmega328 microcontroller present a promising solution for optimizing water usage in agricultural settings. Throughout this research, several key components were integrated to achieve an efficient and reliable irrigation system. Firstly, the Arduino ATmega328 microcontroller served as the central processing unit, facilitating communication between various sensors, actuators, and the user interface. Its versatility and compatibility with a wide range of peripherals made it an ideal choice for this application. Secondly, the sensors utilized in the system, such as soil ultrasonic sensors, play an important role in determining the low altitude of the water in the shelter tank, thus preventing water wastage and promoting efficient water usage. Thirdly, the relay module controlled the irrigation pump, allowing for automated watering based on predefined thresholds and user-defined schedules. By interfacing the relay module with the Arduino, precise control over the irrigation process was achieved. The device has an average accuracy rate of 98.3% after testing.

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