University of Jordan

Mechatronics Engineering Department

"Mechatronic System Design Lab Project"

Automatic liquid level control with indicator

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Abstract

This study presents the design and implementation of an automatic liquid level control system integrated with a real-time indicator for monitoring and maintaining liquid levels in a container. The system utilizes sensors to detect the liquid level, employing a microcontroller-based control mechanism to regulate the inflow and outflow of liquid to maintain a preset level. Additionally, a visual indicator provides real-time feedback to users, enhancing monitoring and control efficiency.

Whole system

Figure below show the whole specification of an automatic liquid level control with indicator:

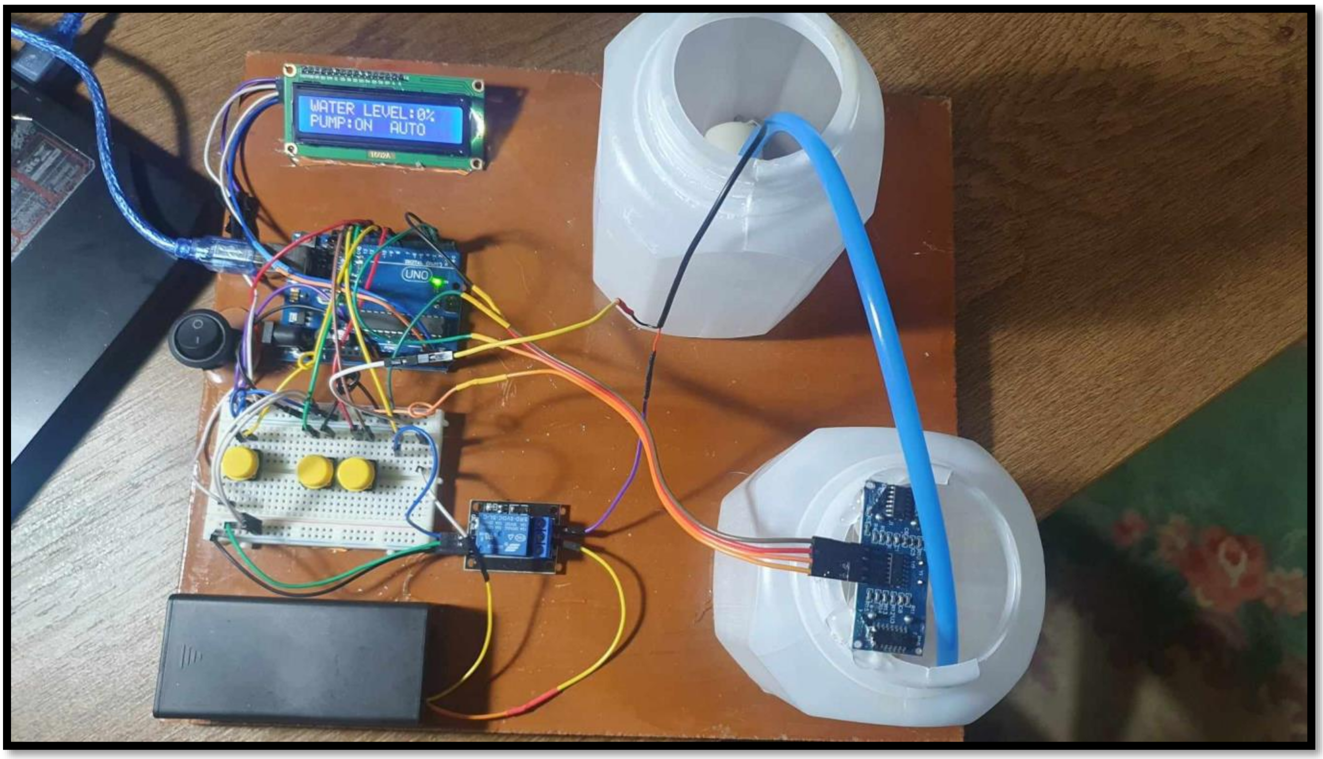


Figure1: whole specification of the system

The figure below shows the schematic of the system:

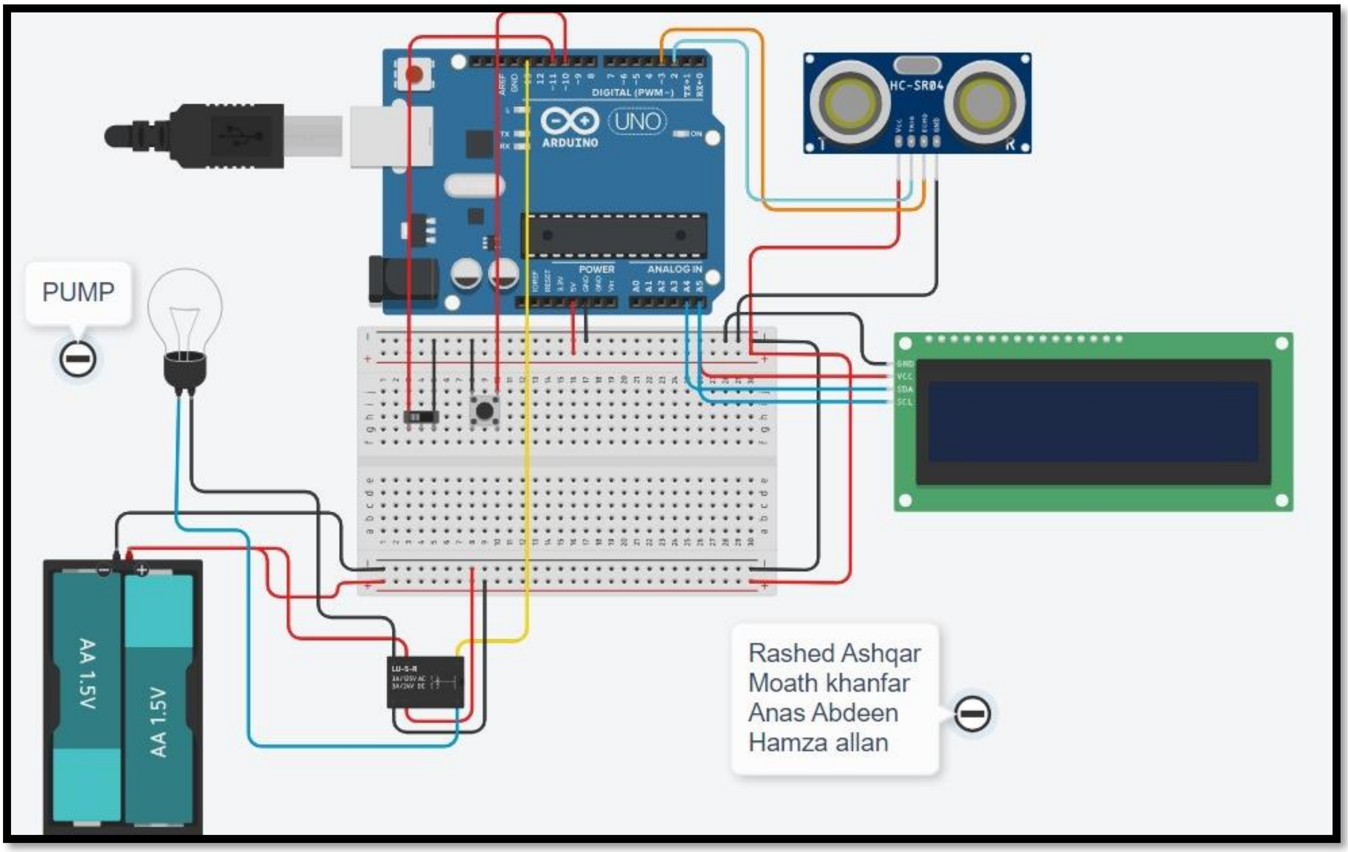


Figure 2: schematic of the system

Problem Statement

Design and implement an automatic liquid level control system for a 800ml water tank using an Arduino Uno as a microcontroller. The system will allow the user to set desired water levels (such as 25%, 50%, etc.) The water level will be continuously monitored using an ultrasonic sensor, and the current level will be displayed on a 16x2 LCD connected via an I2C module. The system will control a water pump through a relay, switching it on or off to maintain the water at thes elected level plus that the pump will refill the tank when it gets a signal that the water level gets lower than the desired level.

System components properties

Potentiometer: 10Kohms

2 Series lithium batteries: 3.7 + 3.7 = 7.4volts

LCD module: 1602A 16X2

Relay: SRD – 5VDC – SL – C

Arduino Uno: R3, AT mega

Ultrasonic sensor: HC – SRO4

5v DC Pump

Serial I2C: 5V Power supply

Contrast control via potentiometer

Size 41.6mm x 19.2mm

Switch: 16 mm diameter small round Boat

6A / 125V Rocker switch seesaw power switch

Water tank: 800ml

Required Calculation

Ultrasonic

To measure the maximum height of the water surface level for calibration purposes we are going to consider the speed of air since the ultrasonic measuring ability depends on the speed of the sound waves and the time it takes to come back after hitting an object we are going to use the following formula for this formula:

$$\boldsymbol{Distance = \frac{Time}{2} \times Speed\ of\ sound}$$

We used a stopwatch to measure the time required to get a full tank and we got 30 seconds to reach the max readings of the ultrasonic so the max distance we will get is and the speed of light is measured as 343 m/s

$$\boldsymbol{Distance = \frac{30}{2 * 60} \times 343 = 85.75\ mm}$$

Actual Liquid Level

After obtaining the ultrasonic distance from maximum water level we can calculate the actual liquid level in the tank Real-time by subtracting distance we get from the max distance level

And after that we can calculate the percentage of the water level and can be expressed as follows:

$$\boldsymbol{Water\ level\ percentage = \frac{Current\ water\ level}{Max\ water\ level} \times 100\%}$$

So, the percentage at any level will be expressed as:

$$\boldsymbol{Water\ level\ percentage = \frac{Current\ water\ level}{85.75} \times 100\%}$$

Pump Control

Here we will calculate the required flow rate of the pump for the system using the Formula:

$$\boldsymbol{Pump\ flow\ rate \left(\frac{ml}{min}\right) = \frac{Tank\ Volume(ml)}{Time\ to\ fill\ tank(min)}}$$

And so, we get the following flow rate needed for the system to operate on an 800ml tankas intended:

$$\boldsymbol{Pump\ flow\ rate = \frac{800 \times 60}{30} = 1600\ (\frac{ml}{min})}$$

System modelling with Flow chart

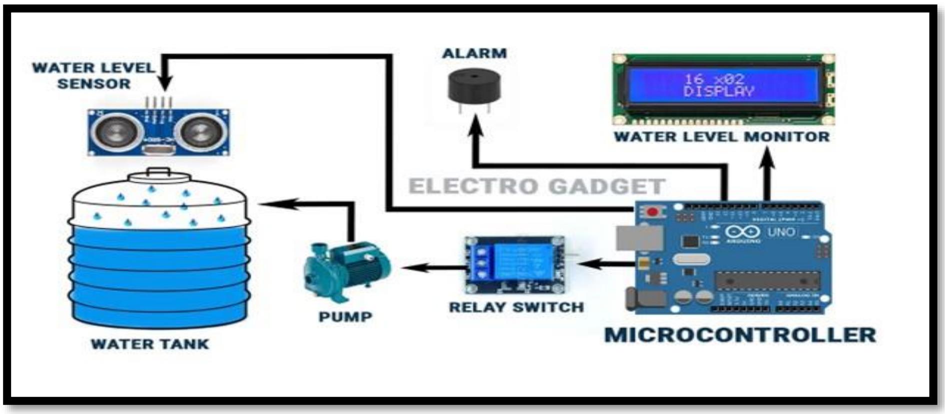


Figure 3: system modelling

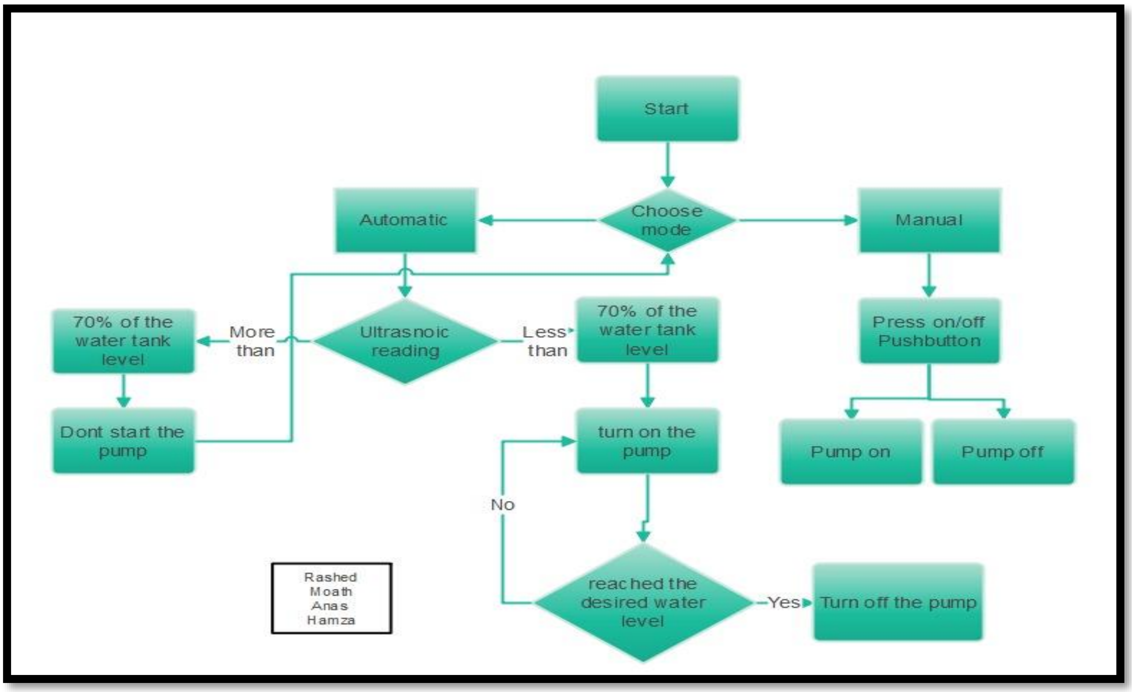


Figure 4: flow chart

Actuator selection

We used DC pump to provide precise control flow rates, allowing for accurate adjustments to maintain the desired liquid level within a container. Their compact size and low power consumption make them ideal for automated systems, ensuring seamless integration without consuming excessive energy [1]. And now will review the specification of the pump:

DC voltage: 2.5v – 6v

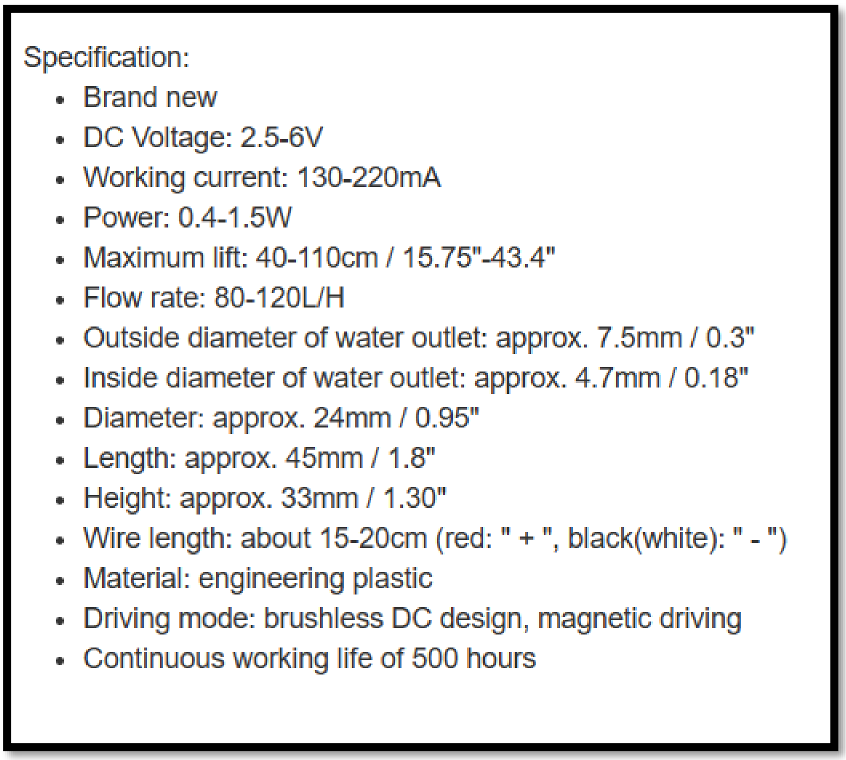
Working current: 130 – 220mA

Power: 0.4 – 1.5W

Flow rate: 80 – 120 L/H

Diameter: 24mm / 0.95

Figure 5 bellow show the data specification of the water pump:



Specification:

- Brand new
- DC Voltage: 2.5-6V
- Working current: 130-220mA
- Power: 0.4-1.5W
- Maximum lift: 40-110cm / 15.75"-43.4"
- Flow rate: 80-120L/H
- Outside diameter of water outlet: approx. 7.5mm / 0.3"
- Inside diameter of water outlet: approx. 4.7mm / 0.18"
- Diameter: approx. 24mm / 0.95"
- Length: approx. 45mm / 1.8"
- Height: approx. 33mm / 1.30"
- Wire length: about 15-20cm (red: " + ", black(white): " - ")
- Material: engineering plastic
- Driving mode: brushless DC design, magnetic driving
- Continuous working life of 500 hours

Figure 5: snapshot of specifications for water pump

Figure 6 bellow show the dc pump used in the project:

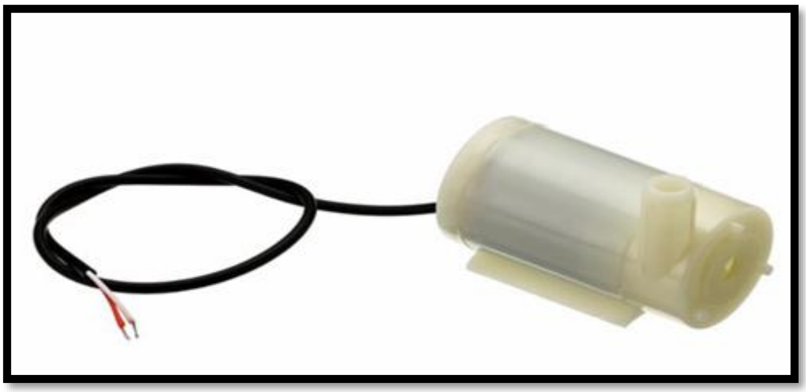


Figure 6: DC Pump

Specification of component:

DC-Relay:

Relays are integral to our automatic liquid level control with indicator project as they are pivotal in managing the functionality of diverse components like pumps or valves according to the liquid level sensed by sensors. Once the liquid level hits a specific point, the relay initiates or halts the operation of these components, guaranteeing precise maintenance of the liquid level within the preferred parameters [2].

This figure bellow shows the relays used in the project:

Figur7: relays

Figure 8, 9 below shows the specification of SRD - 5VDC - SL – C:

Coil Sensitivity	Coil Voltage Code	Nominal Voltage (VDC)	Nominal Current (mA)	Coil Resistance (Ω) ±10%	Power Consumption (W)	Pull-In Voltage (VDC)	Drop-Out Voltage (VDC)	Max-Allowable Voltage (VDC)
SRD (High Sensitivity)	03	03	120	25	abt. 0.36W	75%Max.	10% Min.	120%
	05	05	71.4	70				
	06	06	60	100				
	09	09	40	225				
	12	12	30	400				
	24	24	15	1600				
	48	48	7.5	6400				
SRD (Standard)	03	03	150	20	abt. 0.45W	75% Max.	10% Min.	110%
	05	05	89.3	55				
	06	06	75	80				
	09	09	50	180				
	12	12	37.5	320				
	24	24	18.7	1280				
	48	48	10	4500	abt. 0.51W			

Figure 8: specification of SRD - 5VDC - SL – C

Item \ Type	SRD FORM C	SRD FORM A
Contact Capacity Resistive Load (cosΦ=1)	7A 28VDC 10A 125VAC 7A 240VAC	10A 28VDC 10A 240VAC
Inductive Load (cosΦ=0.4 L/R=7msec)	3A 120VAC 3A 28VDC	5A 120VAC 5A 28VDC
Max. Allowable Voltage	250VAC/110VDC	250VAC/110VDC
Max. Allowable Power Force	800VAC/240W	1200VA/300W
Contact Material	AgCdO	AgCdO

8. PERFORMANCE (at initial value)

Item \ Type	SRD
Contact Resistance	100mΩ Max.
Operation Time	10msec Max.
Release Time	5msec Max.
Dielectric Strength Between coil & contact Between contacts	 1500VAC 50/60HZ (1 minute) 1000VAC 50/60HZ (1 minute)
Insulation Resistance	100 MΩ Min. (500VDC)
Max. ON/OFF Switching Mechanically Electrically	 300 operation/min 30 operation/min
Ambient Temperature	-25°C to +70°C
Operating Humidity	45 to 85% RH
Vibration Endurance Error Operation	 10 to 55Hz Double Amplitude 1.5mm 10 to 55Hz Double Amplitude 1.5mm
Shock Endurance Error Operation	 100G Min. 10G Min.
Life Expectancy Mechanically Electrically	 10^7 operations. Min. (no load) 10^5 operations. Min. (at rated coil voltage)
Weight	abt. 10grs.

Figure9: SRD - 5VDC - SL - C datasheet snapshot

16x02 LCD:

The inclusion of an LCD (Liquid Crystal Display) in our automatic liquid level control system provides a clear visual interface for users, presenting real-time information about the liquid level within the container in a comprehensible manner. Beyond merely indicating the current liquid level, the LCD also offers the capability to showcase system status updates, error messages, and other pertinent information. This multifunctional display enhances user engagement, ensuring seamless and efficient operation of the liquid level control system [3].

This figure below shows the LCD used in the project:

Figure 10: LCD

Figure 11 below shows the specification of 1602A:

Item	Symbol	Condition	Min	Typ	Max	Unit
Supply Voltage For Logic	V_{DD}-V_{SS}	—	4.5	—	5.5	V
Supply Voltage For LCD	V_{DD}-V_0	Ta=0℃	—	—	4.2	V
		Ta=25℃	—	3.8	—	V
		Ta=50℃	3.6	—	—	V
Input High Volt.	V_{IH}	—	2.2	—	V_{DD}	V
Input Low Volt.	V_{IL}	—	—	—	0.6	V
Output High Volt.	V_{OH}	—	2.4	—	—	V
Output Low Volt.	V_{OL}	—	—	—	0.4	V
Supply Current	I_{DD}	V_{DD}=5V	—	1.2	—	mA

Figure11: 1602A Datasheet snapshot

Selection of Feedback devices

We chose ultrasonic sensor because it's a kind of accurate liquid level monitor. By emitting ultrasonic waves and measuring the time taken for the waves to bounce back from the liquid surface, the sensor determines the exact level of the liquid in the water tank. This data is then processed by the system's control mechanism to regulate the inflow and outflow of liquid, ensuring that the desired level is maintained.

Figure 12 bellows show the specification of HCSR04 [4]:

Working Voltage	DC 5 V
Working Current	15mA
Working Frequency	40Hz
Max Range	4m
Min Range	2cm
MeasuringAngle	15 degree
Trigger Input Signal	10uS TTL pulse
Echo Output Signal	Input TTL lever signal and the range in proportion
Dimension	45*20*15mm

Figure 12:HCSR04 Snapshot

Figure 13: ultrasonic sensor

Selection of Controller: -

Arduino Uno

The Arduino Uno serves as the central control unit in our automatic liquid level control system with an indicator, orchestrating the operation of various components for precise liquid level management. Leveraging its digital and analog input/output pins, the Arduino Uno communicates with sensors such as ultrasonic or float switches to accurately measure the liquid level within the container.

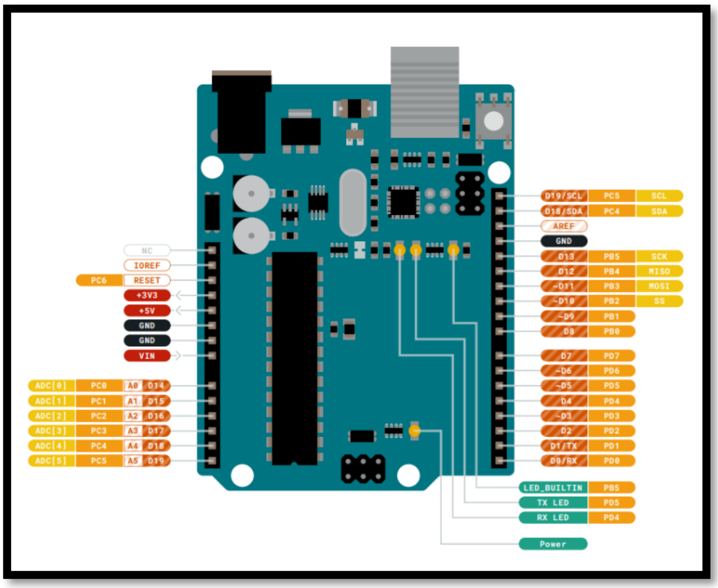


Figure14: Arduino Uno

Figure 15 bellow show the electrical characteristic of Arduino Uno [5]:

ELECTRICAL CHARACTERISTICS V_{DD}=4.7V to 5.3V, T_A=25°C

ITEM		SYMBOL	CONDITION	STANDARD VALUE			UNIT
				MIN.	TYP.	MAX.	
SUPPLY VOLTAGE FOR LOGIC		$V_{DD}-V_{SS}$	–	–	5.0	–	V
SUPPLY CURRENT FOR LOGIC		I_{DD}	V_{DD}=5V	–	2.0	3.0	mA
INPUT VOLTAGE	HIGH	V_{IH}	–	2.2	–	V_{DD}	V
	LOW	V_{IL}	–	0	–	0.6	V
OUTPUT VOLTAGE	HIGH	V_{OH}	–	2.4	–	–	V
	LOW	V_{OL}	–	–	–	0.4	V

Figure15: electrical characteristic of Arduino Uno

Results & discussions

Our project showcases the system's precision in maintaining liquid levels within the desired range, exhibiting minimal deviation from the set point. We delve into the influence of factors like sensor precision and control algorithm effectiveness on system performance. Ultimately, our project emphasizes the efficacy and promise of the automatic liquid level control system with an indicator in tackling crucial liquid management hurdles.

Conclusions

In conclusion, our examination of the automatic liquid level control system with an indicator underscores its exceptional precision and dependability in managing liquid levels. Extensive experimentation and analysis confirm the system's proficiency in maintaining liquid levels within specified parameters, demonstrating negligible deviation from the target level. Moreover, our investigation elucidates critical factors impacting system performance, including the accuracy of sensors and the efficiency of control algorithms. These insights highlight the system's practical effectiveness and potential for diverse applications, reaffirming its significance in addressing liquid management challenges across industries.

References

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