HOCHSCHULE RHEIN-WAAL
Rhine-Waal University of Applied Sciences

Milestone 3

Group 27

Faculty of Technology and Bionics

Automated Cocktail Mixer PerBa

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Submission Date

16 Jan 2024

Statement of Originality

We certify that, to the best of our knowledge, that all text passages and other content of this report are our own work unless referenced differently. The report was produced solely by the listed members of our student group.

Kleve, 02.11.2023
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1. Executive Summary

PerBa emerges as a transformative addition to the cocktail-making landscape, seamlessly integrating into the household environment. This machine has been crafted with simplicity, elegance, and cleanliness in mind, eliminating the need for prior mixology expertise. Its self-operating nature means it not only prepares cocktails but also self-cleans, offering a combination of efficiency, hygiene, and convenience at the touch of a button.

Requiring eight different spirits and mixers that can be easily attached, PerBa invites users to simply pour their chosen drinks into the machine. Selection of a cocktail is made effortless through its user-friendly interface, leaving the intricate process of cocktail preparation to the machine's intelligent systems. PerBa stands out with its intelligent mixing technology, ensuring a consistently high standard in every cocktail it creates. Additionally, its dual-tier cleaning system is meticulously designed to prevent any form of contamination, guaranteeing purity and safety.

Our strategy for introducing PerBa into the market revolves around leveraging state-of-the-art technology while adhering to a competitive pricing model that ensures affordability. The initial launch is strategically focused on the German market, particularly targeting households with a penchant for cocktails. Plans are in place to make PerBa available across various official appliance retail outlets and through online platforms, ensuring easy accessibility for potential customers. To further our reach, we will employ a blend of social media marketing and traditional promotional methods, ensuring that PerBa becomes a household name in the realm of cocktail preparation.

Keywords: Intuitive, smart, versatile, Automated,Aesthetic, PerBa.

2. Contents

3. Introduction/ Background

In response to the evolving landscape of cocktail preparation, we have undertaken the development of the Automated Cocktail Mixer **PerBa**. This innovative solution addresses the challenges associated with traditional methods, streamlining the process through a singular, user-friendly touch interface or the convenience of a mobile App. The prevailing market conditions, marked by an increasing demand for convenient and sophisticated home entertainment options, served as a crucial impetus for this endeavour.

Prior to arriving at our chosen solution, extensive research and consideration were dedicated to exploring various approaches. These ranged from systems with pumps to measure flow rate to using load sensors to measure weight of the liquid, each presenting distinct advantages and drawbacks. However, it became evident that a fully automated, one-button operation and gravity/valve based system stood as the most efficacious and accessible option, aligning seamlessly with our objective of simplifying the cocktail-making process.

Moreover, PerBa is crafted from a selection of robust and enduring materials, ensuring both durability and aesthetic appeal. Stringent quality control measures have been implemented throughout the production cycle to uphold our unwavering commitment to excellence.

The prevailing market conditions, characterised by an increasing preference for premium home entertainment solutions, coupled with the key technological parameters driving this innovation, have converged to propel the Automated Cocktail Mixer to the forefront of the industry. With its intuitive interface, diverse recipe selection, and elegant design, it promises to redefine the at-home cocktail experience for households in Germany and beyond.

4. Marketing Decisions

4.1 Product:

Conventional cocktail crafting often demands significant time and effort. In contrast, our automated cocktail mixer simplifies this process, requiring just a single button press to prepare a variety of beverages. This inventive system provides households in Germany with an easy and effective means to savour a diverse selection of cocktails. Crafted for convenience, the sleek and compact design of our automatic mixer fits seamlessly into any kitchen or bar setup. Its intuitive interface makes it user-friendly for both beginners and cocktail enthusiasts alike. With a wide array of pre-programmed recipes and customizable options, you have the freedom to explore an endless world of cocktail creations.

4.2 Market overview:

The German cocktail mixer market is on the brink of substantial growth, the market is valued 50 million Euros [1] in 2023 according to the report by Research and Markets and projected to achieve a 10% Compound Annual Growth Rate (CAGR) over the next five years reaching 80 million Euros by 2028. This growth is underpinned by several key factors, including heightened consumer interest in cocktails, an escalating demand for convenient and efficient products, an upswing in disposable income among consumers, and an increased trend in home entertainment. The market is dominated by the household segment, which accounts for 60% of the market. The restaurant and bar segment accounts for 30% of the market, and the retail store segment accounts for the remaining 10% of the market.

The key players in the market include Bartesian, Keurig, and Fizzics. These companies offer a wide range of cocktail mixer machines and capsules, which gives consumers a lot of choice.

Insightful pie charts depicting market demand also have an impact on our strategic choice. Given its strong economic position, Germany is an important primary market for our goods with significant room to grow into other European areas.

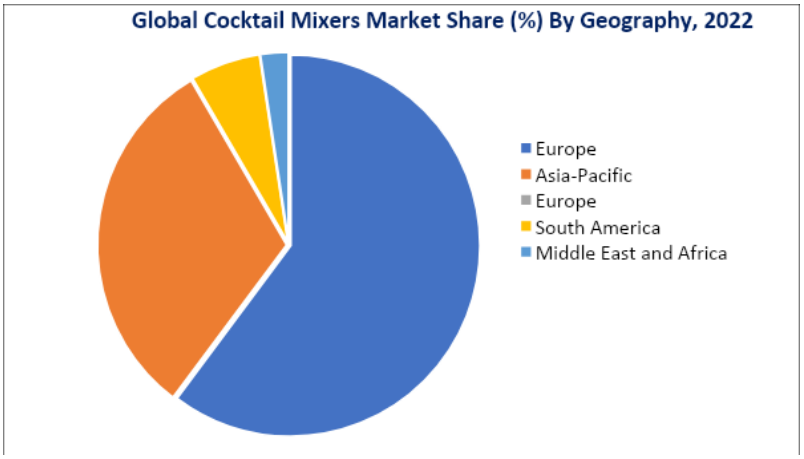


Figure 4.1.1: Global Cocktail Mixer Market Source: DataM Intelligence

4.3 Target market:

German households are our target customers for the cocktail mixer, leveraging our proximity and past experience within Germany. Expansion into broader European markets is part of our future strategy. Germany offers a promising landscape, with a substantial 37 million households, among which roughly 42% monthly incomes exceed 5,000 Euros [2]. Additionally, a 2022 survey conducted by the German Federal Statistical Office indicates that 77% of German adults aged 18 and above partake in alcohol consumption, with preferences shaped by variables like age, gender, and regional influences[3]. Priced at €699, our cocktail mixer aligns seamlessly with our target customers. According to the German Federal Statistical Office [4], 73% of German adults who earn over 5,000 euros drink alcohol, which makes our target market of around **11 million people.**

4.4 Pricing

Our cocktail mixer has a suggested retail price of 699 euros. This pricing strategy considers a number of variables, such as the cost of acquiring external components, internal manufacturing expenses, labour costs, marketing and advertising expenses, research and development costs, profit margins, overheads, and packaging costs. With 595 euros as the entire cost of manufacturing, there is a 15% profit margin. Our short-term objective is to reach a 15% profit margin; as we grow our sales over the next few years, we hope to leverage the economies of scale and lower our production cost to reach a 20% profit margin. Our main focus in the first phase is to improve our brand's recognition through keeping a lower profit margin.

4.5 Expected Sales Volume

We are targeting to sell 1400 units annually with the increment of 200 units every year. Considering our large target market of 11 million households, there should be plenty of room to expand into in the upcoming years. We want to progressively expand into additional European markets, which will result in a significant increase in sales.

4.6 Promotions

We aim to conduct an aggressive grassroot marketing campaign. Through a variety of marketing platforms, we will reach our targeted customers. Among them will be specifically targeted social media ads on Facebook, Instagram, and Pinterest. A key component of our strategy will be interacting with mixology lovers via blogs and online material with a cocktail theme. For reviews and social media advertising, working with local bartenders and influencers will be crucial. To increase the visibility of our product, we also want to employ email marketing, take part in online marketplaces, and exhibit it at trade exhibitions. Additionally, forming alliances with pubs and eateries to promote our product and get media attention will be essential. We also plan to acquire distribution partners like MediaMarkt and Saturn who already have a huge access to customers.Our goal is to develop a complete marketing plan that is specific to our target market by combining these approaches.

5. Overall product concept

5.1 Requirements list

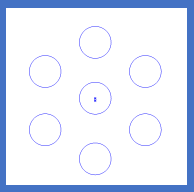
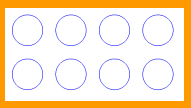
1. Ability to hold 8 different liquids (alcohol/juices/soda) in custom glass containers with good support.
2. Effective usage of space through non linear arrangement of bottles.
3. Flow of liquid from each bottle must be controlled and measured independently to ensure precise mixing.
4. Different operating modes for mixed and layered drinks.
5. Construction from sustainable materials.
6. Touchscreen display
7. WiFi enabled controller.
8. Mobile app to interact with the machine
9. Durable construction able to withstand mild misuse from the user.
10. List of premade recipes (more than 6) for popular cocktails on the app
11. RGB lighting of the bottles to look good in a dark setting.
12. Ice dispenser setup
13. Size limitation: 700x500x500mm
14. Cocktail glass size: 90mm diameter, 200mm height (upper limits, not both at same time)Typically 250ml.
15. 20s time per cocktail
16. 230V AC power input
17. Target price of 699 EUR
18. Built in cleaning system
19. Easy to use and operate, with parts assembled in a manner to support “Right to Repair” of the users.

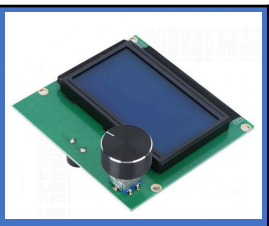
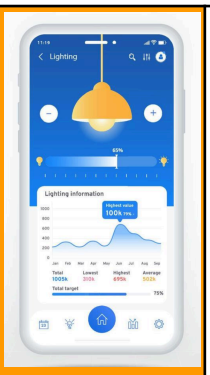
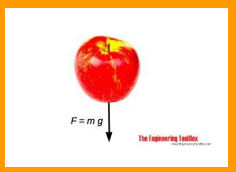
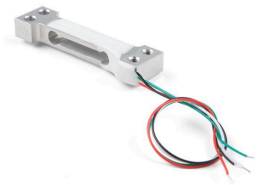
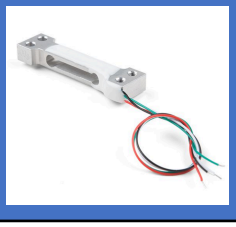
5.2 Morphological box:

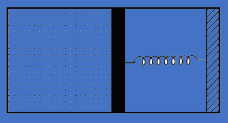
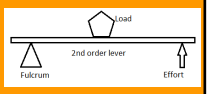
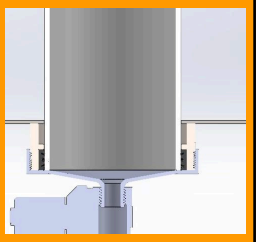
Legend for the morphological box:

Colour	Option
	A(selected one)
	B

Table 5.2.1 - Legend for the morphological box

Parameter	Option 1	Option 2	Option 3	Option 4
Construction	Monocoque design - stressed skins	Body on frame design		
Bottle arrangement	Hexagonal 	 Linear	 2-row linear	
Liquid containment	Custom bottle [1] 	Original bottle of the liquid [2] 		
Control system	Single board computer [3] 	Microcontroller [4] 		
User interface	Knobs + LCD Screen [5]	Touchscreen [6]	Mobile app [7]	

				
Cleaning system	Pressurised water [12] 	Heated water [13] 	Water with soap solution [14] 	
Flow method	Pumps [12] 	Gravity fed [28] 		
Volume sensing method for layered drinks	Load cell on cup [15] 	Ultrasonic measurement of liquid level [17] 	Flow gauge in pipes [16] 	Controllable pump [12] 
Volume sensing method for mixed drinks	Load cell on mixing chamber [15] 	Ultrasonic measurement of liquid level [17] 	Electric liquid level sensor [18] 	Pressure gauge [19] 

Mixing system	Mechanical stirrer in mixing chamber [20] 	Recirculation pump [12] 	None	
Ice dispensing system	Electrically actuated [21] 	Horizontal chamber with spring [22] 	Vertical chamber opened by a mechanical lever [23] 	
Joining method for construction	Bolts [24] 	Welding [25] 	Rivets [26] 	
Bottle holding system	Clamps [27] 	Held only at neck with a screw [29] 	Held only at neck with a rubber seal [30] 	Bottle supported on both sides 
Liquid drain	Drain outlet with a valve [31] 	Removable tray emptied by user [33] 		

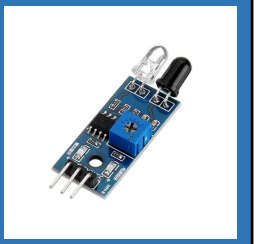
Drain overflow sensor	Electric conductivity based sensor [18] 	Infrared transceiver [32] 	Ultrasonic sensor [17] 	

Table 5.2.2 - Morphological box

5.3 List of Main Components

Item No.	Part Name	Description	#	Exp. Price
1	Single Board Computer	Will be used to interface with the user through the App, touchscreen and give commands to the pumps, relays and LEDs.	1	55€
2	Touchscreen	Screen on the machine for the user to interact with the machine	1	25€
3	Valves(24V)	Will be used to open/close flow of drinks from the tanks	9	90€
4	Water pump(24V)	Will be used to pump water from the tank to clean the system	1	20€
5	Relays	Used to control the pumps and the valves with a signal from the Single Board Computer	9	9€
6	Ultrasonic transceivers	Will be used to calculate total volume in the mixing tank	1	2€
7	Water Level Sensor	Will be used to detect liquid in the overflow container	1	2€
8	Power Supply	Will be used to convert 230V city power to power components	1	20€

9	Controllable LED Strips	Will be used to Light the Drink tanks and can be controlled by the user via the touchscreen or the App	8	3€
10	Drink Tanks	A storage container, where the user can put their choice of drinks. These can be removed by the user to clean	8	20€
11	Mixing Chamber	A small acrylic chamber, where all the drinks from the User's order stored before going to the glass. This is where we will measure the volume of each drink.	1	4€
12	Water tank	A removable chamber, where the user can add water to clean the system	1	6€
13	Ice Tank	A isolated chamber to store Ice	1	4€
14	Lever arm	A mechanical link to the Ice tank, the user can use it to add ice to their drink	1	5€
15	Silicone Pipes	They enable liquid flow between main functional components.	1.5 m	10€
16	Pipe Fittings	Enable water-proof assembly and connection for many crucial components.	18	27€
17	Drain Tray	Will store the water used for cleaning.	1	3€
19	Frame	Necessary component to support the overall structure. Aluminium square tubes 20*20*2 *mm*	6m	24€
20	Frame Walls	They will cover the frame and will improve the overall look.	$1.5m^2$	30€

Table 5.3.1 - List of components

5.4 Functional structure

5.4.1 Functional Structure - Main Chassis

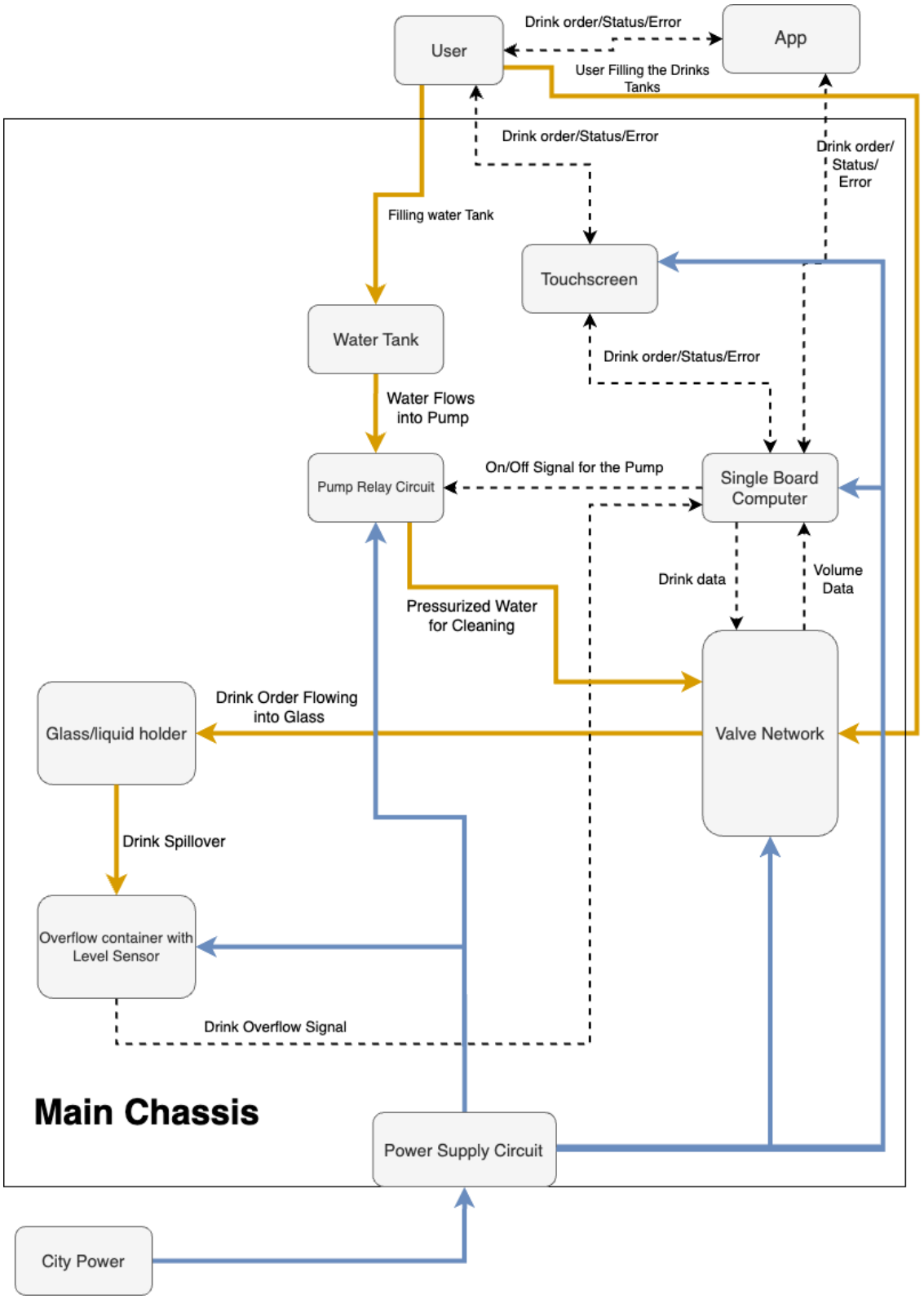


Fig. 5.4.1.1 - Functional structure of the main chassis

5.4.2 Functional Structure - Valve Network

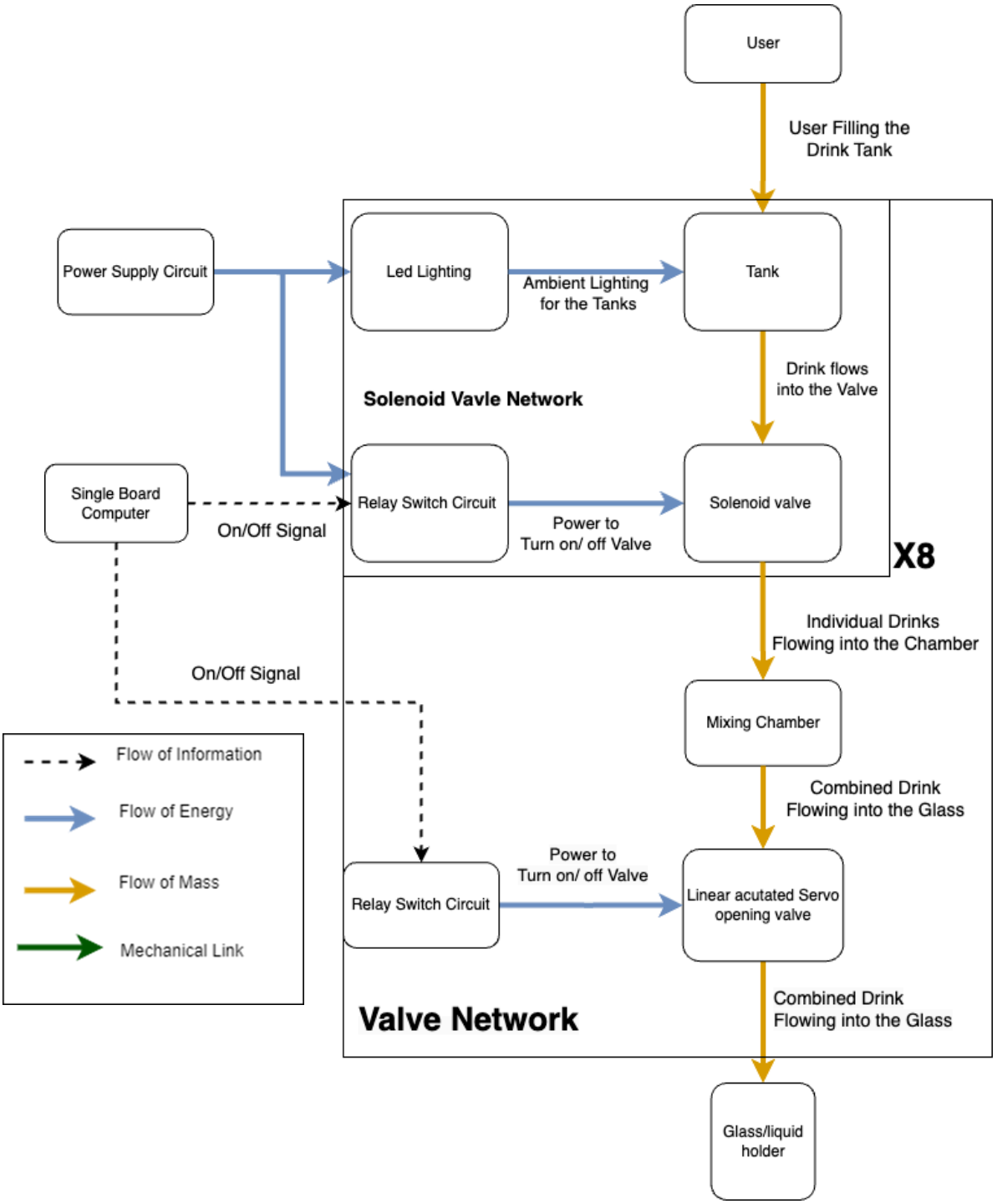
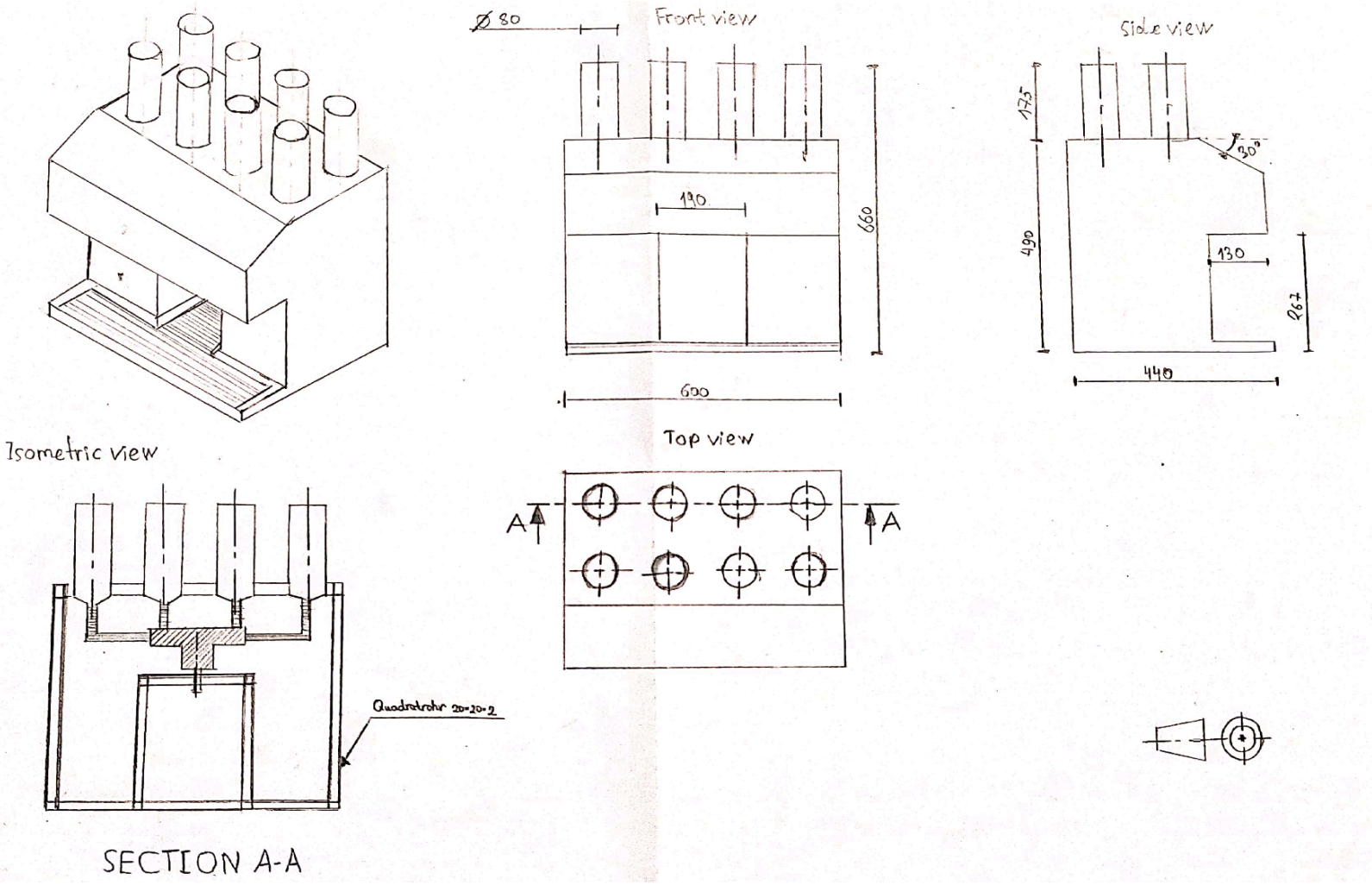


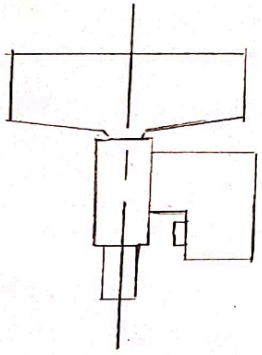
Fig. 5.4.2.1 Functional structure of the valve networ

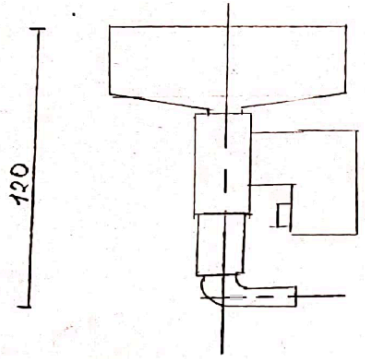
5.5 Freehand sketches

To see in full resolution click: Freehand sketches. PDF



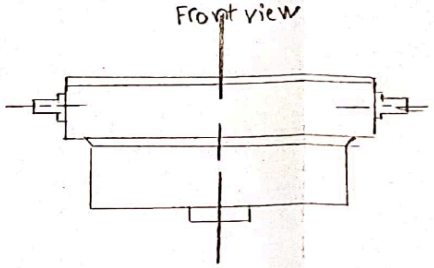
Liquid Holder Type 1



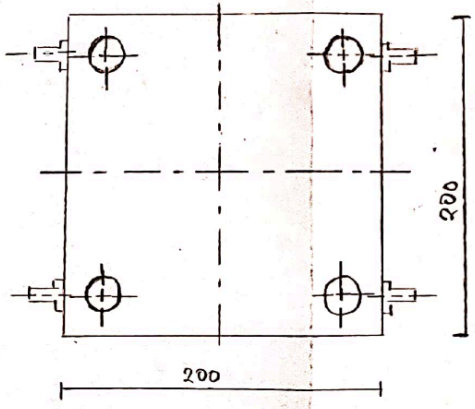


Liquid Holder Type 2

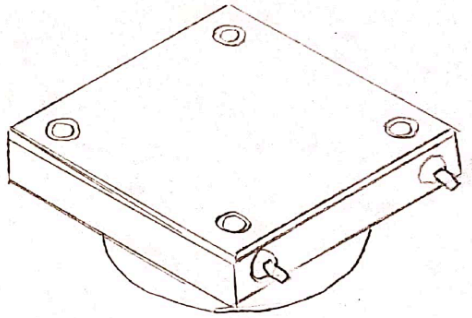
Mixing Chamber
Front view

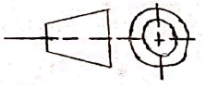


Mixing Chamber
Top view



Mixing Chamber
isometric view





6. D-FMEA (Design-Failure Methods Effects Analysis)

6.1 Assessment criterion[1]

1. Severity, probability and detection are each scored on a scale of 1 to 10.
2. RPN-Risk Priority Number is the product of the scoring for severity, probability and detection. Therefore it is on a scale from 1 to 1000. However, if the severity is very high, the risk is considered as high.
3. Detection of the problem is scored on an inverse scale i.e. harder to detect gets a higher score due to the higher risk.
4. Detection method-Visual inspection by the user

Severity
The severity was graded as per the following[2]
The Severity of each effect is selected based on the impact or danger to the end user / customer. The severity ranking is typically between 1 through 10 where:

- 1: Negligible impact, small visual defects
- 2-4: Annoyance or squeak and rattle; visual defects which do not affect function
- 5-6: Degradation or loss of a secondary function of the item studied
- 7-8: Degradation or loss of the primary function of the item studied
- 9-10: Regulatory and / or Safety implications

Key for the table:

S - Severity

P - Probability of occurrence

D - Detection

Level	Criticality	RPN	Priority
1	0-5	0-25	None
2	6-10	26-35	Minor
3	11-15	36-48	Very Low
4	16-25	49-90	Low
5	26-39	91-140	Moderate
6	40-59	141-200	High
7	60-70	201-250	Very high

RPN - Risk Priority Number - Product of S, P and D scores.

Criticality - Product of S and D scores

Table 6.2.2 - Legend for Design FMEA table

6.2 D-FMEA (Design-Failure Methods Effects Analysis)

Sl.No.	Item	Function	Failure Mode	Effect of failure	S	Causes	P	D	RPN	Crit.	Action
1	Glass bottles	Holds the liquid	Cracking of glass	Leakage of liquid	3	Improper handling of glass during cleaning, damage during transports, wrong heat treatment during manufacturing	3	2	18	6	Improved QC and better packaging
			Breakage of glass	Sudden spill of liquid, injury to people standing nearby	7	Pouring of cold liquid into hot glass and vice versa, rough handling of machine/impacts	3	8	168	56	User must express caution and prevent thermal shock during operation. Usage of borosilicate glass to withstand thermal shock.
2	Holding seal for bottle	Provides a proper leakproof connection between the bottle and the valve.	Not holding bottle tightly	Loose connection, allowing bottle to move around. Leakage of liquid and spillage on LEDs	5	Wear and tear over time. Improper installation of bottle by user.	5	3	75	15	User must replace the sealing material regularly as specified in the manual
3	Bottle holder sleeve	Supports the bottle in place	Scratches the bottle while inserting	Appearance of bottle degrades over time due to scratches	3	Rough edges and high surface roughness	4	3	36	9	Surface to be polished to decrease roughness and edges to be filleted.
			Does not allow bottle to be placed due to deformation	Loss of function due to inability to use 1 slot of the machine	7	Physical damage due to machine mishandling, improper installation of bottle holder.	1	9	63	63	Sufficient safety factor to be used to ensure strength

4	Valves	Open or close the connection between the input pipe and output pipe.	Not starting fluid flow-Jammed closed	No flow of liquid from bottle	8	Inadequate cleaning, resulting in sticky particles accumulating in valve; Breakage of link between solenoid and valve	5	1	40	8	User must run the cleaning program as per the frequency specified in the manual.
			Not stopping fluid flow-Jammed open	Uncontrollable flow from bottle	7	Breakage of link between solenoid and valve	5	1	35	7	Usage of high quality components.
			Short circuiting	Burning of valve, tripping of internal breaker.	8	Incorrect amount of power supplied due to wrong assembly of the circuit components, faulty valve.	2	3	48	24	Better QC of the PCB
			Leakage-partial flow	Incorrect mixing of drink	8	Wear and tear over time, Failure of valve before specified number of cycles	5	1	40	8	Usage of high quality components, frequent cleaning.
			Solenoid stuck due to improper circuit operation	Jamming	7	Faulty programming of single board computer	1	6	42	42	Proper testing of the program during the development process.
5	Water tank	Holds water for cleaning	Leakage	Spill of water onto powersupply	8	Improper assembly, faulty connections	4	6	192	48	Usage of leakproof connections with sealing elements
			Cracking of tank	Leakage of water, possible short circuiting/damage to exposed electronics	8	Rough handling by the user, long exposure to sunlight	2	9	144	72	Proper QC of supplied water tank to ensure sufficient lifetime,
6	Frame	Creates a structure for the machine and	Bending	Loss of correct shape, possible leakage in liquid connections	4	Impacts from dropping the machine; Improper assembly such as bolts fastened in a crooked fashion.	2	4	32	16	Bolts to be inserted straight during the assembly process. The User must handle the machine with care.

		protects internal components	Breakage	Loss of structure and damage to internal components	8	Impacts from dropping the machine.	1	1	8	8	Use must not throw or drop the machine.
7	Tubes	Carries the liquid from the input to the output	Leakage	Leakage of drink into spaces within the machine resulting in corrosion; exposure of electronics to liquids	7	Improper transport of pipes; Contact with sharp objects	3	6	126	42	Care taken during assembly to ensure no sharp objects are used near the tubes
			Blockage	Reduction or stoppage of fluid flow	8	Insufficient cleaning; Usage of liquids with large particulates such as boba tea	4	1	32	8	Liquids used should not contain large particles.
			Breakage	Spillage of significant quantity of liquid into internal volume of the machine; Exposure of electronics to liquids	8	Tube of insufficient length used, resulting in high stresses and eventual failure; Prolonged exposure to sunlight.	2	8	128	64	Tube of sufficient length to be used; Machine must not be kept in sunlight without all housing walls intact.
8	Mixing chamber	Holding various liquids and providing sufficient space for the mixer operate	Leakage	Leakage of drink into spaces within the machine resulting in corrosion; exposure of electronics to liquids	7	Loose connections; Porosity in chamber due to improper manufacturing	3	3	63	21	Usage of connectors with sufficiently tight tolerances; Better designed process to decrease porosity.
			Breakage	Spillage of significant quantity of liquid into internal volume of the machine; Exposure of electronics to liquids	8	Large impact loads by user during operation.	1	1	8	8	User must not throw the machine or subject machine to impacts.

			Accumulation of dirt	Loss of hygiene; growth of microorganisms	9	Infrequent cleaning by user; Insufficient water pressure and flow rate during cleaning	4	5	180	45	Water pump of sufficient power should be used; User must annually dismantle the mixing chamber and clean it by hand.
9	Single board computer	Acts as the interface between the display, mobile app and devices of the machine. Gets input from various sensors and controls the various actuators installed.	Failure of WiFi module	Loss of ability to control machine from mobile app	7	Out of date drivers; Improper programming	2	1	14	7	Usage of programs that do not interfere with the driver; Deploying over the air updates only when the program is updated along with the driver
			Failure to boot due to corrupted boot drive	Complete loss of function	8	Loose contact in SD card slot; Usage of low quality SD card	2	1	16	8	Usage of high quality SD card
			Slow and unresponsive operation	Failure to meet target time for one cocktail; User annoyance	4	Program too complex for the given single board computer	1	1	4	4	Optimisation of the program to ensure low latency.
10	Program on the single board computer	List of commands which instructs the single board computer what to do when.	Security problems	Loss of data security	9	Hacking; Insecure program	1	5	45	45	Usage of obfuscation techniques and encryption
			Errors	Loss of function until rebooted	4	Poorly made code	4	1	16	4	Usage of industry standard practices to make high quality code
11	Mobile app	Collects inputs from the user and tells the Raspberry Pi what drink is needed as well as giving the user notifications	Security problems	Data theft, espionage	9	Hacking; Insecure program	3	5	135	45	Certification of mobile app with third party cybersecurity consultants.
			Lack of features	Below par user experience	3	Poorly designed app	4	1	12	3	Good graphic design to make a good looking and a feature rich app

			Inability to connect to the machine	Loss of ability to control machine from mobile app	7	Improperly configured WiFi settings; Poorly made code	6	1	42	7	Usage of touch screen panel to provide a hassle free connection process.
12	Relay	Controls the flow of power to the valves as per the signals from the microcontroller	Failure to respond to control inputs	Loss of control over valves	8	Loose contact/Improperly soldered joint	3	2	48	16	Training of staff to make good quality connections
			Overheating	Reduced lifetime of component	7	Lack of ventilation; Cocktail machine kept in close proximity to heat source or in a confined space	3	7	147	49	Placing of holes for ventilation in the walls of the housing as well as usage of heatsinks on the relays.
13	PCB	Provides the circuit to hold all solid state components in one place and distribute power.	Wrong circuit connections	Potential for cascading damage and total failure	8	Poorly manufactured PCB	1	5	40	40	Usage of sufficient gaps between traces and suppliers with good reputation
			Loose contact	Loss of signal or power flow in the affected region	7	Loose contact/Improperly soldered joint	2	5	70	35	Training of staff to make good quality connections
14	Breaker	Protects against short circuits and over currents.	Prematurely trips before the rated current is reached	Inability to use the machine due to repeated tripping of breaker	8	Exposure to heat/magnetic fields; Incorrectly rated breaker	1	1	8	8	Usage of good quality circuit breaker
			Failure to trip at the rated current	Failure to protect power supply against overload-Permanent damage	8	Exposure to heat/magnetic fields; Incorrectly rated breaker	1	5	40	40	Usage of good quality circuit breaker
15	Power supply	Converts the 230V AC input to 12V DC for the electronic components	Failure to provide sufficient power	Slow operation of valves; Insufficient flow rate of cleaning water	7	Usage of components of inadequate continuous power rating	1	6	42	42	Usage of components with sufficient safety factor

			Overheating	Reduction in lifetime of components.	8	Lack of ventilation; Cocktail machine kept in close proximity to heat source or in a confined space	3	6	144	48	Placing of holes for ventilation in the walls of the housing as well as usage of heatsinks and a cooling fan.
16	Touchscreen display	Displays the drinks on order as well as the status of the machine	Display of wrong colours/stripes	Poor user experience; Loss of functionality	7	Exposure to liquids, sunlight or heat	4	1	28	7	User must not expose the screen to sunlight for prolonged periods of time; Usage of a waterproof screen
			Failure to respond to touch	Loss of ability to control machine directly	7	Loose connector; Degradation due to wear and tear; Presence of liquids on the screen	4	1	28	7	Usage of firm connections between the cable and the PCB
17	Ice dispenser lever	Opens or closes the ice tank to allow ice to be dropped into the drink	Jamming of shutter	Inability to add ice to the cocktail	6	Change in geometry due to thermal contraction; Inadequate cleaning	1	1	6	6	Design with gaps to allow for thermal contraction
			Ice not falling out in sufficient time	User having to wait too long for ice	5	Shutter too small	2	1	10	5	Shutter to be made large enough to allow ice cubes to fall out freely
18	Cleaning liquid pump	Pumps water from the cleaning tank into the pipe system to clean it	Jamming	Loss of cleaning function	7	Usage of dirty water for cleaning; Backflow of dirty water from cleaning	3	2	42	14	User must fill only drinking water in the cleaning tank
			Short circuiting	Burning of motor, trips internal breaker	7	Improper circuit operation;Wrong assembly	1	5	35	35	Circuit to be tested thoroughly
			Inadequate flow/pressure	Ineffective cleaning	6	Usage of motor of insufficient continuous power	2	5	60	30	Usage of a sufficiently powerful motor

19	RGB leds	Provides lighting for the glass bottles for cosmetics	Overheating	Reduction in lifetime of components.	5	Lack of ventilation; Cocktail machine kept in close proximity to heat source or in a confined space	3	6	90	30	Designing with gaps to allow air flow
			Inadequate brightness	Looks are affected	2	LED's of insufficient power used	2	1	4	2	LED's of sufficient power are used.
			Short circuiting	Damage to circuitry and tripping of internal circuit breaker	7	Improper circuit operation;Wrong assembly	1	5	35	35	RGB leds to be connected in the right polarity
20	Bottle cap	Covers the top of the bottle	Complete sealing preventing air from entering	Interruption/Stoppage of drink flow from bottles	8	Cap installed wrongly; Air input valve covered with external object	3	1	24	8	Cap must not be covered with an external object
			Gaps allowing dust in	Contamination of drinks	8	Cap too loose due to inadequate sealing	3	3	72	24	Seal of sufficient thickness to be used
21	Drain liquid tray	Collects spilled drinks, meltwater from the ice as well as dirty water from the cleaning cycle	Leakage	Spilling of drain liquid over the platform on which the machine is placed	4	Porosity due to improper manufacturing; Formation of cracks due to rough handling	3	1	12	4	Tray to be manufactured with low porosity; User must handle tray with care
22	Housing walls	Covers the sides, bottom and top of the machine.	Formation of holes	Exposure of internal components to dust and liquid spills	6	Strong impact with sharp object; Improper assembly	1	1	6	6	Designed in such a manner that form fits prevent the formation of large gaps during assembly
23	Drain tray overflow sensor	Detects whether drain tray is full	Short circuiting	Damage to controller, complete loss of function	8	Exposure to liquids	4	1	32	8	Usage of optocouplers to isolate the controller. Waterproofing of the sensor

			Wrong readings	Drain tray overflows, spilling drain water outside the machine	4	Presence of debris in front of the sensor; Presence of other infrared sources	4	1	16	4	Sensor view of tray must not be obstructed by debris. User must clean the sensor face. Sensor shielded from external light
24	Ultrasonic liquid level sensor	Detects the amount of liquid in the mixing chamber	Short circuiting	Damage to controller, complete loss of function	8	Exposure to liquids	2	1	16	8	Usage of optocouplers to isolate the controller. Waterproofing of the sensor
			Wrong readings	Drinks are not mixed correctly	7	Presence of debris; Ripples/Splashes of liquid detected	4	5	140	35	Sensor shielded from debris through a net; Program is modified to exclude data from splashing liquid

Table 6.2.1: Design FMEA

7. Project Plan

7.1 Work Breakdown structure

In this project we are a group of four students from different study courses in the faculty of Technology and Bionics at Rhine-Waal University of Applied Sciences.

Team Member	Study Course
Roman Pistun	Mechanical Engineering (ME)
Ali Hussain	Industrial Engineering (IE)
Karthick Ashwath Onnu Ananth Deeparani	Mechanical Engineering (ME)
Anirudh Madhusudhan	Mechatronics System Engineering (SE)

Table 7.1.1: Team members and study courses

The task for each milestone is distributed among the team members in accordance with their respective study courses are shown in table below

Task	Assigned to
Milestone 1: Concept Design	
Marketing decision	Ali Hussain
Overall product concept	All of us
Requirement list	All of us
Free hand sketch	Roman Pistun
Functional structure	Anirudh Madhusudhan
Morphological box	Karthick Ashwath Onnu Ananth Deeparani
D-FMEA	Karthick Ashwath Onnu Ananth Deeparani
Project plan	Ali Hussain
Milestone 2: Product Design	
Complete 3D model	Roman Pistun
Electric drives	Anirudh Madhusudhan
Circuit diagram	Anirudh Madhusudhan
MoB decision	All of us
Technology selection for ‘make’ parts	Anirudh Madhusudhan and Roman Pistun
Requirements manual for ‘buy’ parts	All of us
Milestone 3: Complete Project Documentation	
Technical drawings	Roman Pistun
Program flow chart	Anirudh Madhusudhan
Bill of material	Roman Pistun and Anirudh Madhusudhan
Production planning	All of us
Cost calculation	All of us

Table 7.1.2: Project tasks distribution

7.2 Gantt-Chart

The tasks in this project are distributed to three milestones:

- Concept Design
- Product Design
- Project Documentation

Project planning and completion estimation are made easier with the help of the Gantt chart below.

Figure 7.2.1: Gantt-chart for the work packages

7.3 Work packages

Figure 7.3.1: Work packages for each of the milestone

8. Make or Buy decisions

For the various parts selected in our design, choices have to be made as to whether they will be made or bought. As we are a small company with a somewhat small production run, efforts have been used to go for standard off the shelf parts which can directly be bought from various suppliers and minimal custom made parts. For the custom parts as well, choices have been made to decrease the capital cost of setting up the production.

Item #	Part	Qty.	Description	Material	Make or buy decision
1	Square tubes 20mmx20mmx2mm	8m	Square tubes are used to provide the basic structure to build the frame. It is a standard part made by multiple suppliers	Plain carbon steel	Buy
2	Bolts M3x30mm	58	Bolts are used to assemble the frame together. It is a standard part made by a large number of suppliers.	Steel	Buy
3	Nuts M3	58	Nuts are used to tension and hold the bolt in place. It is a standard part made by a large number of suppliers.	Steel	Buy
4	Hose fitting adapter male Thread 3/8"to 8mm	5	This adaptor is used to connect the hose to the threaded insert in the mixing chamber.	Stainless-Steel	BUY

5	Frame	1	The basic structure which holds up the weight of the bottle and provides mounting points for all the components. It will be made of aluminium pipes, brackets, bolts and nuts.	Steel	Pipes are cut to length and assembled in house(MAKE)
6	Frame cover plates	1 set	The cover plates provide a housing for all the components	Stainless steel	Laser cutting of custom geometries(MAKE) Assembly in house
7	Mixing chamber	1	Container in which the various liquids get mixed before being output to the user. Has a custom geometry	Food safe acrylic	Custom geometry, therefore make
8	Bottles	8	Containers that are used to hold the input drink for mixing	Glass	Custom geometry, therefore make
9	Mixing chamber cap	1	Acts as a cover for the mixing chamber with openings for all the hose fittings.	HDPE Plastic	Make
10	Bottle caps	8	Removable cover for the bottles which allows air to enter and keeps dust out	HDPE Plastic	Make

11	Bottle holders	8	Support the weight of the bottle and the weight of valves.	PA (Nylon)	Make
13	Front panel	1	Acts as a transparent window into the inside of the machine, showing the mixing chamber. Improves aesthetics and allows for visual inspection.	Glass	Make
14	Silicone Seal 80*10mm	8	Prevent leakage from the interface of the bottle and bottle holder	Silicone	Buy
15	Silicone hoses	0.53 m	Food grade silicone hoses are used to connect the outlet of the valve to the mixing chamber.	Silicone	Buy
16	Servo motor subassembly	1	Actuates the output valve of the mixing chamber	NA	Buy
17	Single board computer	1	The main controlling unit	NA	BUY
18	Water Solenoid Valve ⅜	8	Controls the flow of liquid from the bottles to the mixing chamber Standard component	NA	Buy
19	Water pump	1	Pumps water from the water tank during the cleaning cycle Standard component made by multiple manufacturers	NA	Buy
20	Water Tank	1	Holds the water required for the cleaning cycle	HDPE	Make

21	Drip cover	1	Acts as a base to place the drink, while allowing spilled drinks to pass through	Stainless steel	Make
22	Tray	1	Acts as a collector for spilt drinks and for dirty water from the cleaning cycle	Aluminium	MAKE Deep drawing
23	Mixing chamber outlet valve	1	Controls the flow of liquid from the mixing chamber into the glass placed by the user	NA	Make (custom geometry)
24	24V to 5V Buck Converter		Converts 24V DC from the power supply and converts it to 5V at 50W	NA	MAKE Etching and Automatic Pick and place Assembly
25	24VDC Power Supply	1	The main power supply of the machine, which converts city power into 24V	NA	BUY
26	Power Socket with Fuse and Switch	1	Interface between the city power and the power supply. With inbuilt switch and fuse	NA	BUY
27	Valve Network Circuit	1	Circuit to select and control opening/closing of valves	NA	MAKE Etching and Automatic Pick and place Assembly
28	Led Network Circuit	1	Circuit to control the color and brightness of LEDs surrounding the Tanks	NA	MAKE Etching and Automatic Pick and place Assembly

29	Water Level Sensor	1	To detect overflow and to inform the user to empty the spillage container	NA	BUY
30	24V Water pump	1	Used for cleaning the Mixing chamber	NA	BUY
31	7 inch Touch screen	1	One of the interfaces for the user to order drinks	NA	BUY
32	Ultrasonic Transceiver	1	To detect volume of the drink in the mixing chamber	NA	BUY
33	5V to 3.3V converting Circuit	2	To convert the output of the sensors from 5V to 3.V	NA	MAKE Etching and Automatic Pick and place Assembly
34	Pump controlling Circuit	1	To control the water pump	NA	MAKE Etching and Automatic Pick and place Assembly
35	Screw Terminal 2-pin 10A	2	For the input/output of the buck converter	NA	BUY
36	Screw Terminal 2-pin 5A	16	For the input/output of the valves and power for the controlling circuits	NA	BUY
37	Screw Terminal 4-pin	2	For the Signal and Multiplexer Channel select terminals	NA	BUY

38	Screw Terminal 1-pin	18	Output terminals for the controlling circuits to the valves and the LEDs	NA	BUY
39	8:1 Multiplexer	2	To control Valves/LEDs without running a dedicated I/O from the single board computer	NA	BUY
40	Optocouplers	8	To separate the 24VDC power rail and 5VDC power rail in the Valve controlling circuit	NA	BUY
41	Darlington Array IC	2	To amplify input current from the Optocoupler to activate the relays	NA	BUY
42	Relays	9	To turn on High power devices like the valves and the water pump	NA	BUY
43	10kΩ Resistors	9	To avoid a high impedance state for the valves	NA	BUY
44	Buck converter IC	1	IC to use passive components to make a buck converter	NA	BUY
45	Diode	10	To not allow reverse current to flow back in the buck converter IC	NA	BUY
46	220µF Polarised Capacitor	1	To smoothen the 24V input voltage	NA	BUY
47	470µF Polarized Capacitor	1	To smoothen the 5V output voltage	NA	BUY

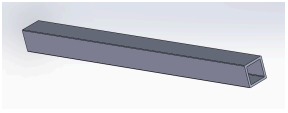
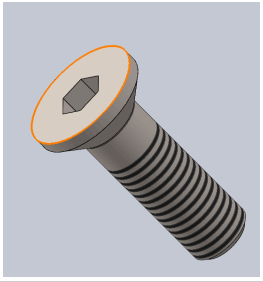
48	2.2μF Capacitor	3	To smoothen the 24V input voltage	NA	BUY
49	100μF Capacitor	1	To smoothen the 5V output voltage	NA	BUY
50	4.7μF Capacitor	1	Decoupling capacitor	NA	BUY
51	100nF capacitor	2	Decoupling capacitor	NA	BUY
52	40kΩ Resistors	2	To set the switching frequency of the Buck converter IC	NA	BUY
53	1.5kΩ Resistors	1	Current limit resistor	NA	BUY
54	N-Channel Mosfets	2	Switching Transistors	NA	BUY
55	33nH Inductor	1	To smoothen output 5VDC	NA	BUY
56	1.91kΩ Resistors	1	Feedback resistor for the Buck convertor IC	NA	BUY
57	16 Gauge Wire	1m	To carry 10A currents from the Power Supply	NA	BUY
58	22 Gauge Wire	2m	To carry 3A currents to the valves and pumps	NA	BUY

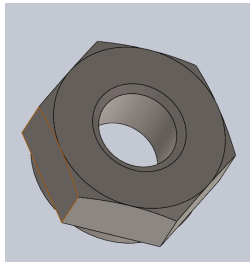
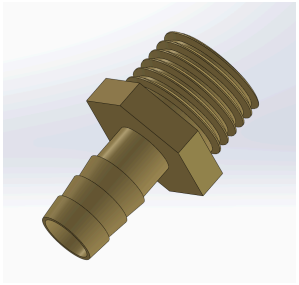
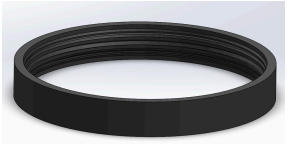
59	28 Gauge Wire	3m	To carry 0.7A currents to Sensors	NA	BUY
60	Lever nuts(Wagos)	6	To connect multiple wires together	NA	BUY
61	M3 screws	20	To connect Circuits and sensors to the frame of the machine	NA	BUY
62	M3 silicone washers	20	To electrically isolate the circuit from the metal chassis	NA	BUY
63	Coupling 35mm - 3/8”	4	Acts as an adaptor between the outlet of the valve and the silicone hose fitting. This part is required because of the differing diameters.	Stainless-Steel	BUY
64	Hose Barb 3/8" Male Thread 90 degree Elbow Pipe Fitting	4	This pipe fitting is necessary to create the 90 degree elbow joint from the outlet of the valve to the inlet of the mixing chamber.	Stainless-Steel	BUY
65	Threaded insert 3/8"	6	Threaded inserts are used in the mixing chamber to create a strong thread for threaded connections. This is necessary because the mixing chamber is made of plastic.	Stainless-Steel	BUY
66	38mm Double-Nipple male 3/8" Thread	4	This is the fitting used to create a direct connection between the 4 bottles in the middle and the mixing chamber which is directly below.	Stainless-Steel	BUY

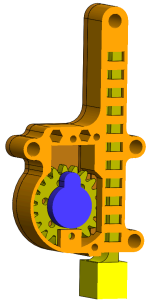
67	AC Power Leads	1	Power cable for the power supply	NA	BUY

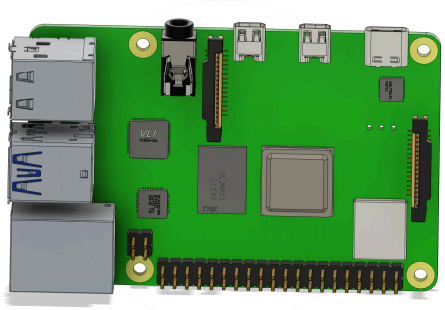
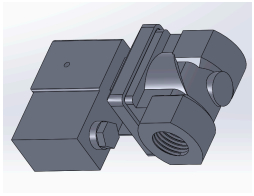
Table 8.1.1: Make or Buy decisions

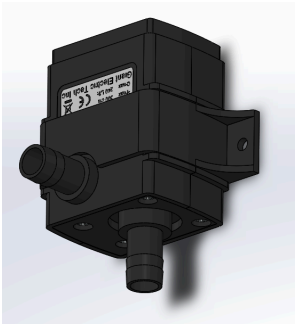
8.1 Requirements manual for “buy” parts

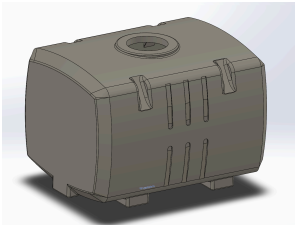
Nr.	Component	Specification
1	Square pipes 	Dimensions: 20mmx20mmx2mm Material: Low carbon mild steel Length: 8m
2	Bolts 	Countersunk. Material: Steal Dimensions: M3x30mm. Quantity: 65 Dimensions: M3x10mm. Quantity: 32 Dimensions: M3x8mm. Quantity: 2

3	Nuts 	Quantity: 99 Dimensions: M3 Material: Steel
4	Hose fitting adapter male Thread 3/8"to 8mm 	Quantity: 5 Dimensions: ⅜ “ to 8mm Material: Stainless-steel
5	Silicone seal 	Quantity:8 Dimensions: 80mmx10mm Material: Silicone

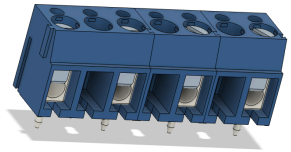
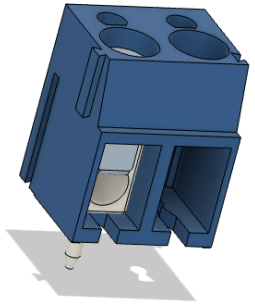
6	Silicone hoses 	Length: 0,53m Dimensions: 8mm inner and 12mm outer Material: Silicone
7	Servo motor 	Quantity: 1 Voltage: 5V Degree of operation: 180°

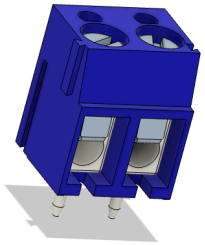
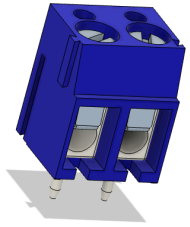
8	Single board computer 	Quantity: 1 GPIO pins: At Least 30 Power consumption< 15W Operational voltage: 5V USB ports: At least one USB-A and one HDMI Network: Wifi 5 support RAM >2GB
9	Liquid solenoid valve 	Quantity: 8 Operational voltage: 24V Power consumption: < 20W Normally closed Valve Dimensions: Bore diameter: ⅜” or greater

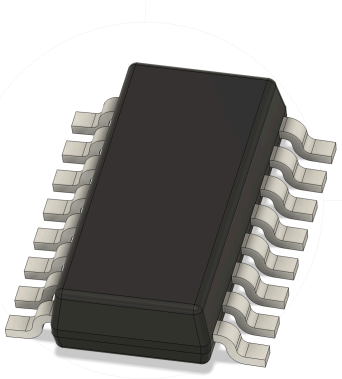
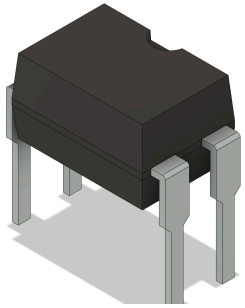
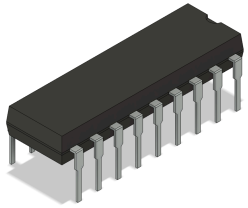
10	Water pump 	Quantity: 1 Voltage: 24V Flow rate: 6.5 L/m Material: Plastic Type: Centrifugal Target dimensions: 100mmx80mx80mm

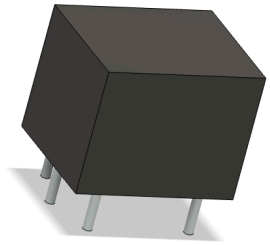
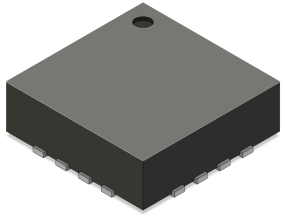
11	Water tank 	Quantity: 1 Dimensions: 200mmx200mmx250mm Volume: Approx 1.5l Material: HDPE
12	Power supply 	Quantity: 1 Input voltage: 220V-230V @50 Hz Output voltage: 24V DC Power output: 100W Efficiency: > 80%
13	Power socket with fuse and switch 	Quantity: 1 Replaceable fuse Voltage rating: 230V AC Current rating: 10A Switch: YES

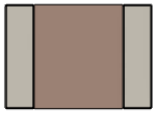
14	Water level sensor[20] 	Quantity: 1 Operation voltage: 5V Output voltage: 5V
16	Touch screen 	Quantity: 1 Dimensions: 7 inch Operational voltage: 5V Type of Touch screen: Capacitive Screen Input: HDMI Touch output: USB
17	Ultrasonic Transceiver[21] 	Quantity: 1 Operational voltage: 5V Output voltage: 5V Closest distance: 10cm

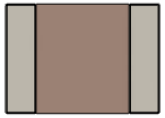
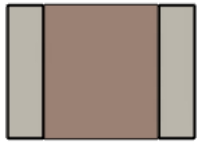
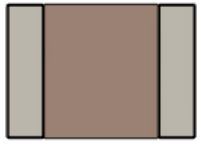
18	Screw terminal 	Quantity: 2 Number of pins: 4-Pin Current rating: 1A
19	Screw terminal 	Quantity: 16 Number of pins: 1-Pin Current rating: 1A

20	Screw terminal 	Quantity: 2 Number of pins: 2-Pin Current rating: 10A
21	Screw terminal 	Quantity: 14 Number of pins: 2-Pin Current rating: 5A

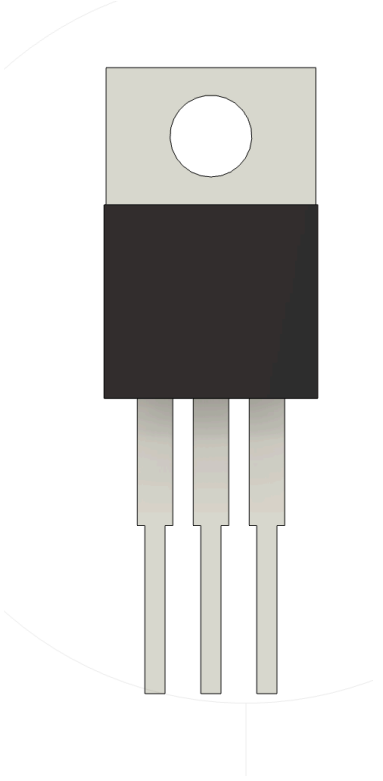
22	Multiplexer 	Quantity: 2 Output: 8 channels Channel selection: 3-bits Signal: 1
23	Optocouplers 	Quantity: 8 Current rating: 300mA Operational voltage: 5V
24	Darlington array IC 	Quantity: 2 Number of darling transistors: 8 Operational voltage: 5V-48V Fly-back diodes included

25	 Relays	Quantity:8+1 Activational voltage: 8x5V + 1x3.3V
26	Resistors 	Quantity: 9 Resistance: 10kΩ Mount type: SMD Power rating: 5W
27	Buck converter IC 	Quantity: 1 Input voltage: 3V-48V Output voltage: 5V Output current: 11A Switching frequency: > 300kHz Efficiency: > 80%

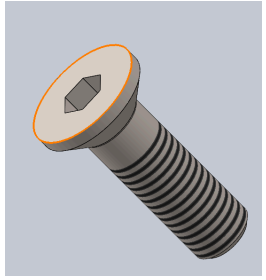
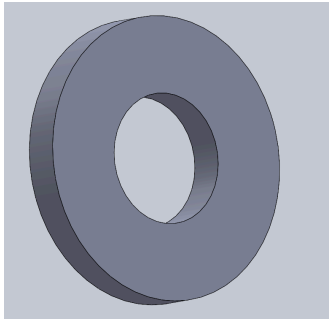
28	 Diode	Quantity: 10 Reverse voltage: 30V Operational voltage:upto 240V Diode drop: < 1V Maximum reverse recovery time: < 100ns
30	Polarised capacitor 	Quantity: 1 Capacitance: 470µF Voltage rating: 24V Mount type: SMD
31	Polarised capacitor 	Quantity: 2 Capacitance: 220 µF Voltage rating: 24V Mount type: SMD
32	Capacitor 	Quantity: 3 Capacitance: 2.2µF Voltage rating: 24V Mount type: SMD
33	Capacitor	Quantity: 1 Capacitance: 100µF Voltage rating: 5V Mount type: SMD

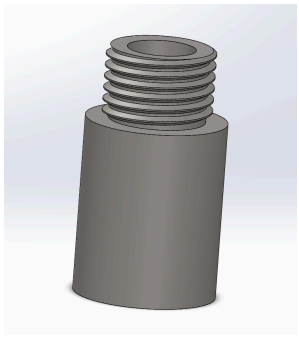
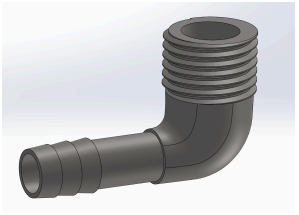
		
34	Capacitor 	Quantity: 1 Capacitance: 4.7µF Voltage rating: 5V Mount type: SMD
35	Capacitor 	Quantity: 1 Capacitance: 100nF Voltage rating: 5V Mount type: SMD

36	 Resistors	Quantity: 2 Resistance: 40kΩ Voltage rating: 5V Mount type: SMD
37	Resistors 	Quantity: 1 Resistance: 1.5kΩ Voltage rating: 5V Mount type: SMD

38	N-Channel Mosfets 	Quantity: 2 V_{GS}: 5V $R_{DS(on)}$:9.5mΩ

39	Inductor 	Quantity: 1 Induction: 33nH Power rating: < 1W Current rating: > 11A Coil resistance: < 20mΩ
40	Resistors 	Quantity: 1 Resistance: 1.5kΩ Voltage rating: 5V Mount type: SMD
41	Gauge wire	Gauge: 16 Length: 1m
42	Gauge wire	Gauge: 22 Length: 2m

43	Gauge wire	Gauge: 28 Length: 3m
44	Lever nuts (Wagos)	Quantity: 6 Dimensions: NA Material: NA
45	Screws 	Quantity: 20 Dimensions: M3 Material: NA
46	Silicone washers 	Quantity: 20 Dimensions: M3 Material: NA

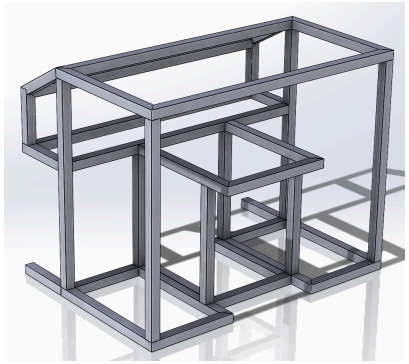
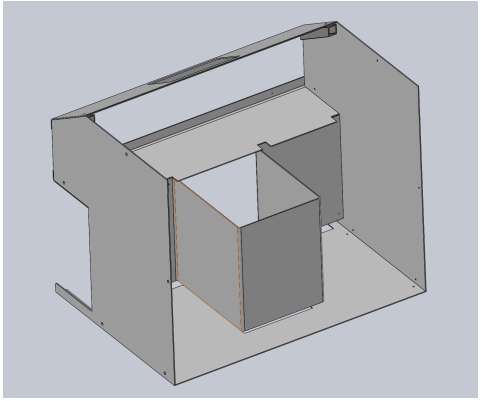
47	Coupling 	Quantity: 4 Length: 35mm Material: Stainless-steel Diameter: ⅜”
48	Hose Barb 3/8" Male Thread 90 degree Elbow Pipe Fitting 	Quantity: 4 Dimensions: ⅜ “ Material: Stainless-steel
49	Threaded insert 	Quantity: 6 Diameter: ⅜ “ Material: Stainless-steel Length:9mm
50	Double-Nipple male 3/8" Thread	Quantity: 4 Dimensions: ⅜ “

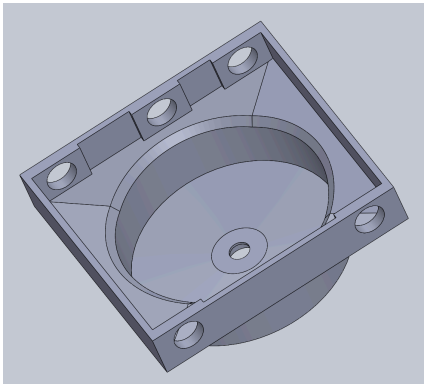
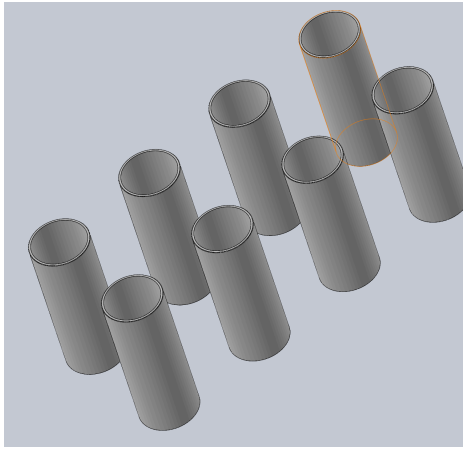
		Length: 38mm Material: Stainless-steel
51	AC power lead[22] 	Quantity:1 Length:2m Current limit:10A

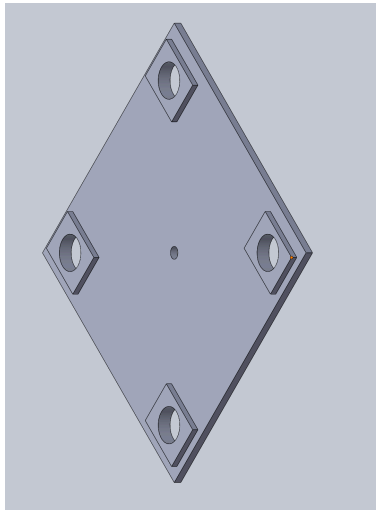
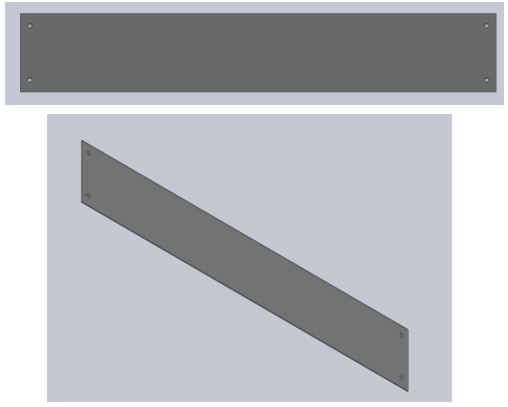
Table 8.1.2: Requirements Manual for Buy parts

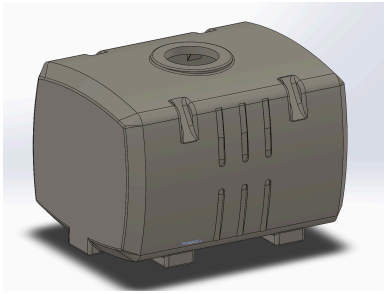
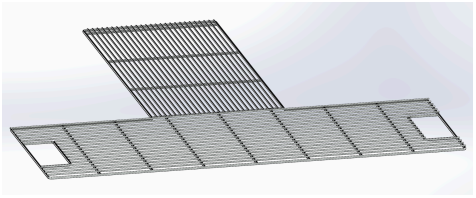
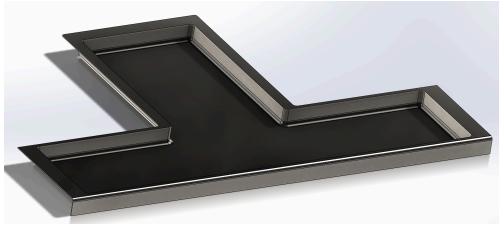
8.3 Technology selection for make parts:

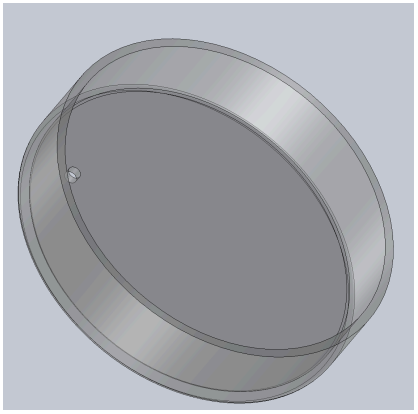
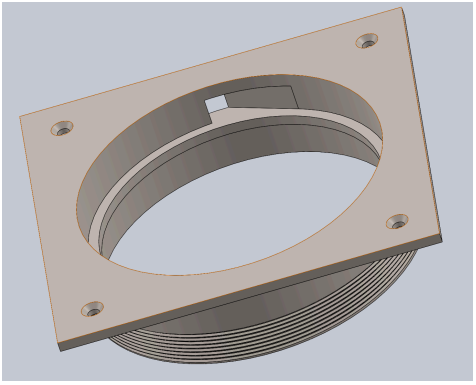
Mechanical components:

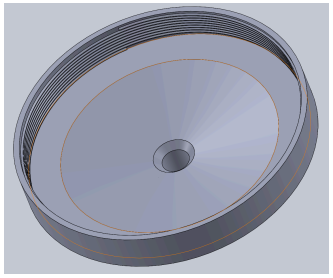
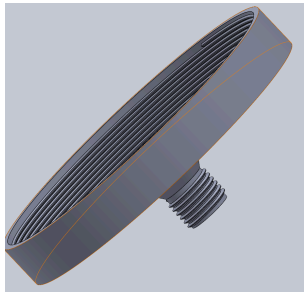
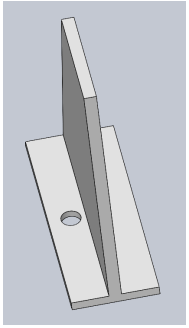
Item #	Part	Material	Manufacturing technology	Assembly method
1	 **Frame**	1.0301(AISI 1010/DIN Ck10) Low carbon mild steel (for better weldability [13])	Sawing and painting Pipes are cut to length by sawing on a mitre saw as the wall thickness of the pipe is only 20mm [3] To provide corrosion resistance, it will be painted. There are no special requirements regarding heat treatment, hardness or surface finish.	**Welding** The welds are simple and short, which helps to decrease the cost of manufacturing.
2	 **Frame cover**	SAE 304 stainless steel (X5CrNi18-9) (for good appearance and corrosion resistance)	CNC Laser cutting (as the sheet is only 2mm thick) Hydraulic press forming to create bends wherever necessary. Semi-automatic operation due to the relatively low volume of the production run.	**Bolted connections** The finished plate is fastened to the steel frame by means of countersunk bolts.

3	 **Mixing chamber**	Clear food grade acrylic (PMMA) Allows user quick visual inspection	Injection moulding Wall thickness 5mm The parting line is perpendicular to the cylindrical section i.e. it passes through the hole on the middle of the left side. This removes the need for inserts. Draft angles are added as needed.	**Bolted connections** As it is quite light, even with a full load of the cocktail, it is simply held in place through 4 pipe fittings connecting the chamber to the inlet valves.
4	 **Bottles**	Clear soda lime glass As it doesn't need thermal shock resistance [4]	Blow forming Blow and blow type is used due to the wide neck[5] Extrusion is not selected as it is not commonly used for glass	**Slide in** The bottles are slid into the holder by the user when in use.

5	 **Mixing chamber cap**	HDPE (High Density Poly Ethylene) plastic Rated as food safe by FDA[6]	Injection moulding The parting line is along the perimeter of the large rectangular surface. No draft angles are needed due to the small wall thickness.	**Adhesion** The cap is glued to the mixing chamber with non toxic 2 component epoxy
6	 **Front panel**	Borosilicate glass For better scratch resistance	Float glass process to make the rectangular piece. Glass drilling to make the holes.	**Bolted connections** Countersunk bolts attach it to the frame.

7	 **Water Tank**	HDPE (High Density Poly Ethylene) No special surface finish necessary	Injection moulding is used to make a cylindrical pre-form, Blow forming is then used to expand the workpiece and create the hollow interior.	**Bolted connections** The water tank is screwed in place and the outlet hose is connected.
8	 **Drip cover**	SAE 304 stainless steel (X5CrNi18-9) Stainless steel is used as the part is under constant exposure to liquids.	Semi automatic spot welding The feedstock is rods of stainless steel that are welded at all the overlap points. A worker is required to remove the finished piece after welding.	**Slide in** It is slid into place. No special fasteners are used.
9	 **Tray**	SAE 304 stainless steel (X5CrNi18-9) Stainless steel is used as the part is under constant exposure to liquids.	Cold deep drawing as the degree of deformation is relatively small. The fold at the end of the part is also made in the same step, but is just a simple bend.	**Slide in** It is slid into place. No special fasteners are used.

10	 **Bottle cap**	HDPE (High Density Poly Ethylene) Satin finish is used to give a good user experience	Injection moulding The parting line is midway in the cylinder, along the circular edge. Due to the relatively small size, parting lines are unnecessary. Wall thickness: 2mm VDI Grade 18 surface finish is used to get a satin finish.[15]	**Slide in** The bottle cap is simply slid onto the top of the bottle by the user after filling the drink.
11	 **Bottle holder**	Nylon/PA (PolyAmide) Nylon is chosen due to its higher tensile strength[16]. It is also rated as food safe.[6]	Injection moulding A sliding insert is used for the hole tangential to the cylindrical surface. The parting line is the bisecting line of the square face, passing through the midpoint of 2 opposite sides. No inserts are needed to make the thread.[17,18] Draft angle of 0.5 degree is used due to the size of the part.	**Bolted connection** The bottle holder is screwed in place by means of 4 countersunk bolts which support the weight of the bottle as well as other components attached below it (valves, LED strips etc.)

12	  **Bottle adaptor**	Nylon/PA (PolyAmide) Nylon is chosen due to its higher tensile strength[16]. It is also rated as food safe.[6]	Injection moulding Parting line is perpendicular to the axis of the cylinder. While the external thread can be directly made in the mould, the internal thread is made by using a rotating thread insert[18].	**Screwing** The bottle adaptor is screwed onto the bottle holder. The valve is then screwed into this bottle adaptor. As the threads are made of plastic, a slight interference of the threads is sufficient to create a seal.
13	 **Mixing chamber outlet valve sub assembly- Mounting plate**	HDPE (High Density Poly Ethylene)	Injection moulding The parting line is along the perimeter of the large trapezium to decrease the depth of the mould.	**Bolted connection** The backplate is bolted to the mixing chamber cap while the other servo components are mounted to the backplate.

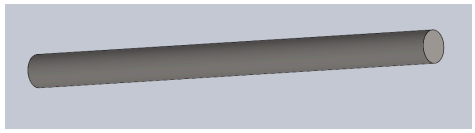
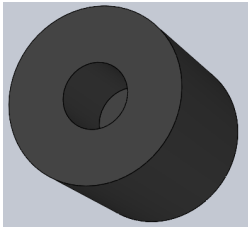
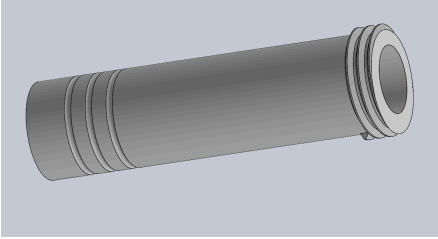
14	 **Mixing chamber outlet valve sub assembly- Plunger rod**	Nylon/PA (PolyAmide) Nylon is selected for its higher rigidity to avoid chances of buckling.	Extrusion The part is a simple cylinder and well suited for extrusion through a hollow cylindrical nozzle	**Adhesion** The plunger is glued to the rack of the servo mechanism with non toxic 2 component epoxy adhesive.
15	 **Mixing chamber outlet valve sub assembly- Sealing element**	Silicone rubber Rubber is selected as it is an elastomer, which allows it to seal gaps well.	Transfer moulding Transfer moulding is more suitable for making rubber components.[23] The parting line is perpendicular to the axis of the cylinder.	**Adhesion** The sealing element is glued to the plunger rod with non toxic 2 component epoxy adhesive. Epoxy adhesives have the added benefit of being leak proof, which increases the lifetime of the bond.
16	 **Outlet nozzle/tap**	HDPE (High Density Poly Ethylene)	Injection moulding - The external thread can be made directly without any inserts. Parting line is perpendicular to the axis of the cylinder. Extrusion is not selected due to the short length(50mm) of the part	**Screwing** The outlet nozzle/tap is screwed into the outlet of the mixing chamber

Table 8.2.1: Technology selection for make parts

Electronic components:

1. 24V to 5V Buck Converter

Component selection:
The selection of passive components were made by the equations given in the datasheet of the Buck controller IC(MIC2101YML-TR)[12] or were directly recommended by the datasheet of the IC. The selection of the IC MIC2101YML-TR IC was done because of the requirement of high output current of 10A.

Calculations for the Buck convertor using MIC2101YML-TR IC

Prerequisites

1. $V_{in} = 24V$
2. $V_{out} = 5V$
3. $I_{out} = 10A$
4. $\Delta I_{L(pp)} = 0.4A$
5. $R_{DS(on)} = 9.5m\Omega$

Calculations

Please refer to the datasheet of the MIC2101YML-TC IC[12] for the formulas Microchip Technology, 27/11/2023.

Calculations for the Feedback Circuit

$$V_{out} = V_{FB} * (1 + R1/R2),\ V_{FB} = 0.8V$$

EQUATION 5-22 Datasheet

The datasheet recommends R1 to be from 3kW to 10kW, we have chosen 10 kW, which offers high efficiency at light loads.

$$R2 = (V_{FB} * R1)/(V_{out} - V_{FB})$$

EQUATION 5-22 Datasheet

$$R2 = 1.91k\Omega$$

The feedback circuit's overall stability has been improved with the addition of a 100nF feedforward capacitor.

Selecting a switching frequency

$$f_{sw-adj} = f_o(R20/(R19 + R20))$$

From the Figure 5-2 in the datasheet, (from the datasheet) R20 = $40k\Omega$ choosing 300kHz switching frequency and $f_o = 600kHz$

$$R19 = (f_0/f_{sw-adj} - 1) * R20$$
$$R19 = 40k\Omega$$

Selecting a circuit current limit

$$R_{cl} = ((I_{CLIM} + \Delta I_{L(pp)} * 0.5)R_{DS(on)} + V_{cl})/I_{CL}$$

EQUATION 4-3 Datasheet

$$I_{CLIM} = 11A, \Delta I_{L(pp)} = 0.4A, I_{cl} = 80\mu A\ (Typical\ from\ datasheet)$$
$$, V_{cl} = 14mV(Typical\ from\ datasheet),\ R_{DS(on)} = 9.5m\Omega(Typical\ from\ datasheet)$$

$$R_{cl} = 1505\Omega \cong 1.5k\Omega$$

I_{cl} has been chosen as 11A to handle spikes in current when operating at 10A maximum load conditions.

Inductor selection

$$\Delta I_{L(pp)} = (V_{out}(V_{in(max)} - V_{out}))/(V_{in(max)} * f_{sw} * L)$$

$$L = (V_{out}(V_{in(max)} - V_{out}))/(V_{in(max)} * f_{sw} * \Delta I_{L(pp)})$$

$$L \cong 33nF$$

EQUATION 5-10 Datasheet

$$I_{L(pk)} = I_{out(max)} + \Delta I_{L(pp)}$$

$I_{L(pk)}$ = 11.2A **Peak current**

All the other Resistors and Capacitors used are directly recommended by the datasheet.

Manufacturing technology:

In order to create complex circuitry, PCB (Printed Circuit Board) etching is a critical stage in the electronic manufacturing process. The main technique is chemical etching, in which the circuit layout on the board is defined by a photoresist substance. Precise circuit traces are left behind after undesired copper is selectively removed by immersion in an acid etchant. This method, which is renowned for its accuracy, makes it possible to create complex and small circuit designs that are essential for contemporary electronic gadgets. For even more accuracy, sophisticated methods like laser or plasma etching may be used. To sum up, PCB etching is an essential procedure that effectively creates electronic circuits and greatly advances technological innovation.

Assembly technology:
Automated pick-and-place machines, which use robotics and computer vision to precisely and quickly place electrical components on printed circuit boards, are essential to PCB manufacturing. Because these machines can handle multiple component kinds at once, they improve productivity in high-volume manufacturing. Because they are automated, there is less chance of human error, which guarantees accurate assembly and increases the dependability of electronic equipment. The speed, accuracy, and adaptability of these devices are further enhanced by ongoing technical developments, confirming their crucial position in the production of contemporary electronics.

2. Valve Network Circuit

Component selection:

We chose the relays based on the coil activation voltage of 5V, the multiplexer was chosen to save some I/O pins on the single board computer and the Darlington Array IC was chosen to amplify current and voltage from the multiplexer.

Manufacturing technology:

In order to create complex circuitry, PCB (Printed Circuit Board) etching is a critical stage in the electronic manufacturing process. The main technique is chemical etching, in which the circuit layout on the board is defined by a photoresist substance. Precise circuit traces are left behind after undesired copper is selectively removed by immersion in an acid etchant. This method, which is renowned for its accuracy, makes it possible to create complex and small circuit designs that are essential for contemporary electronic gadgets. For even more accuracy, sophisticated methods like laser or plasma etching

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3. LED Network Circuit

Component selection:
The multiplexer was chosen to save some I/O pins on the single board computer and the Darlington Array IC was chosen to amplify current and voltage from the multiplexer to an acceptable “High” voltage for the ICs in the LED strip.

Manufacturing technology:

In order to create complex circuitry, PCB (Printed Circuit Board) etching is a critical stage in the electronic manufacturing process. The main technique is chemical etching, in which the circuit layout on the board is defined by a photoresist substance. Precise circuit traces are left behind after undesired copper is selectively removed by immersion in an acid etchant. This method, which is renowned for its accuracy, makes it possible to create complex and small circuit designs that are essential for contemporary electronic gadgets. For even more accuracy, sophisticated methods like laser or plasma etching may be used. To sum up, PCB etching is an essential procedure that effectively creates electronic circuits and greatly advances technological innovation.

Assembly technology:

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4. 5V to 3.3V converting Circuit

Component selection:
We chose 2 resistors who have a ratio of 3:2 and placed it in series, with the larger resistor after the smaller. There is a terminal connected to the smaller and 2 screw terminals connected to the larger one to enable two ground connections. The output of this circuit is the terminal connected in the middle of the resistor network.

Manufacturing technology:

In order to create complex circuitry, PCB (Printed Circuit Board) etching is a critical stage in the electronic manufacturing process. The main technique is chemical etching, in which the circuit layout on the board is defined by a photoresist substance. Precise circuit traces are left behind after undesired copper is selectively removed by immersion in an acid etchant. This method, which is renowned for its accuracy, makes it possible to create complex and small circuit designs that are essential for contemporary electronic gadgets. For even more accuracy, sophisticated methods like laser or plasma etching may be used. To sum up, PCB etching is an essential procedure that effectively creates electronic circuits and greatly advances technological innovation.

Assembly technology:
Automated pick-and-place machines, which use robotics and computer vision to precisely and quickly place electrical components on printed circuit boards, are essential to PCB manufacturing. Because these machines can handle multiple component kinds at once, they improve productivity in high-volume manufacturing. Because they are automated, there is less

chance of human error, which guarantees accurate assembly and increases the dependability of electronic equipment. The speed, accuracy, and adaptability of these devices are further enhanced by ongoing technical developments, confirming their crucial position in the production of contemporary electronics.

5. Pump controlling Circuit

Component selection:
We chose the relay based on the coil activation voltage of 3.3V as it will be directly powered by the single board computer.

Manufacturing technology:

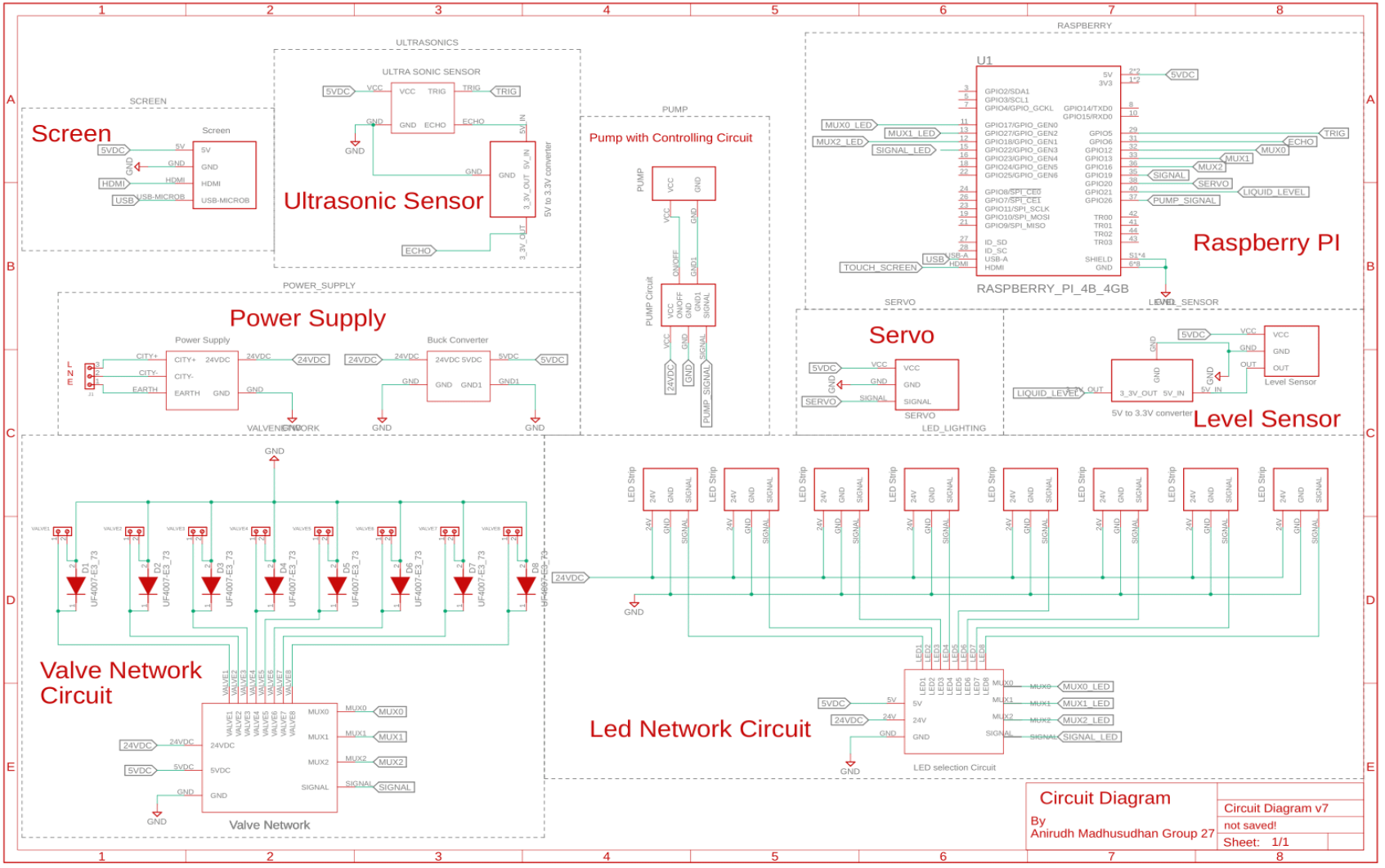
In order to create complex circuitry, PCB (Printed Circuit Board) etching is a critical stage in the electronic manufacturing process. The main technique is chemical etching, in which the circuit layout on the board is defined by a photoresist substance. Precise circuit traces are left behind after undesired copper is selectively removed by immersion in an acid etchant. This method, which is renowned for its accuracy, makes it possible to create complex and small circuit designs that are essential for contemporary electronic gadgets. For even more accuracy, sophisticated methods like laser or plasma etching may be used. To sum up, PCB etching is an essential procedure that effectively creates electronic circuits and greatly advances technological innovation.

Assembly technology:
Automated pick-and-place machines, which use robotics and computer vision to precisely and quickly place electrical components on printed circuit boards, are essential to PCB manufacturing. Because these machines can handle multiple component kinds at once, they improve productivity in high-volume manufacturing. Because they are automated, there is less chance of human error, which guarantees accurate assembly and increases the dependability of electronic equipment. The speed, accuracy, and adaptability of these devices are further enhanced by ongoing technical developments, confirming their crucial position in the production of contemporary electronics.

9. Circuit Diagram

9.1 Electrical Wiring Diagram

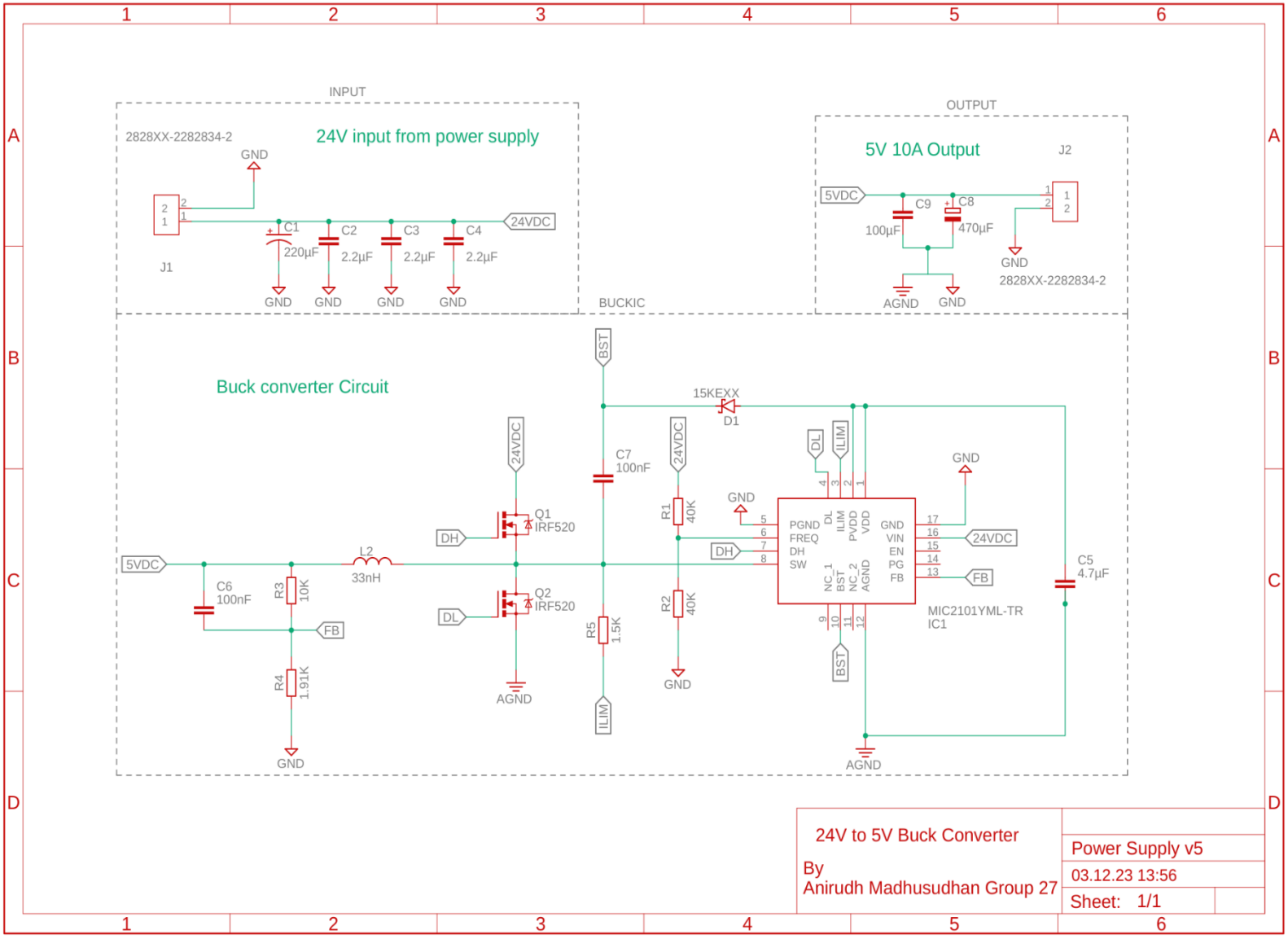
To see in full resolution click: [Circuit Diagram PDF]



05.12.23 22:19 f=0.51 /Users/anirudhmadhusudhan/Downloads/Group project/Circuit_diagram.pdf (Sheet: 1/1)

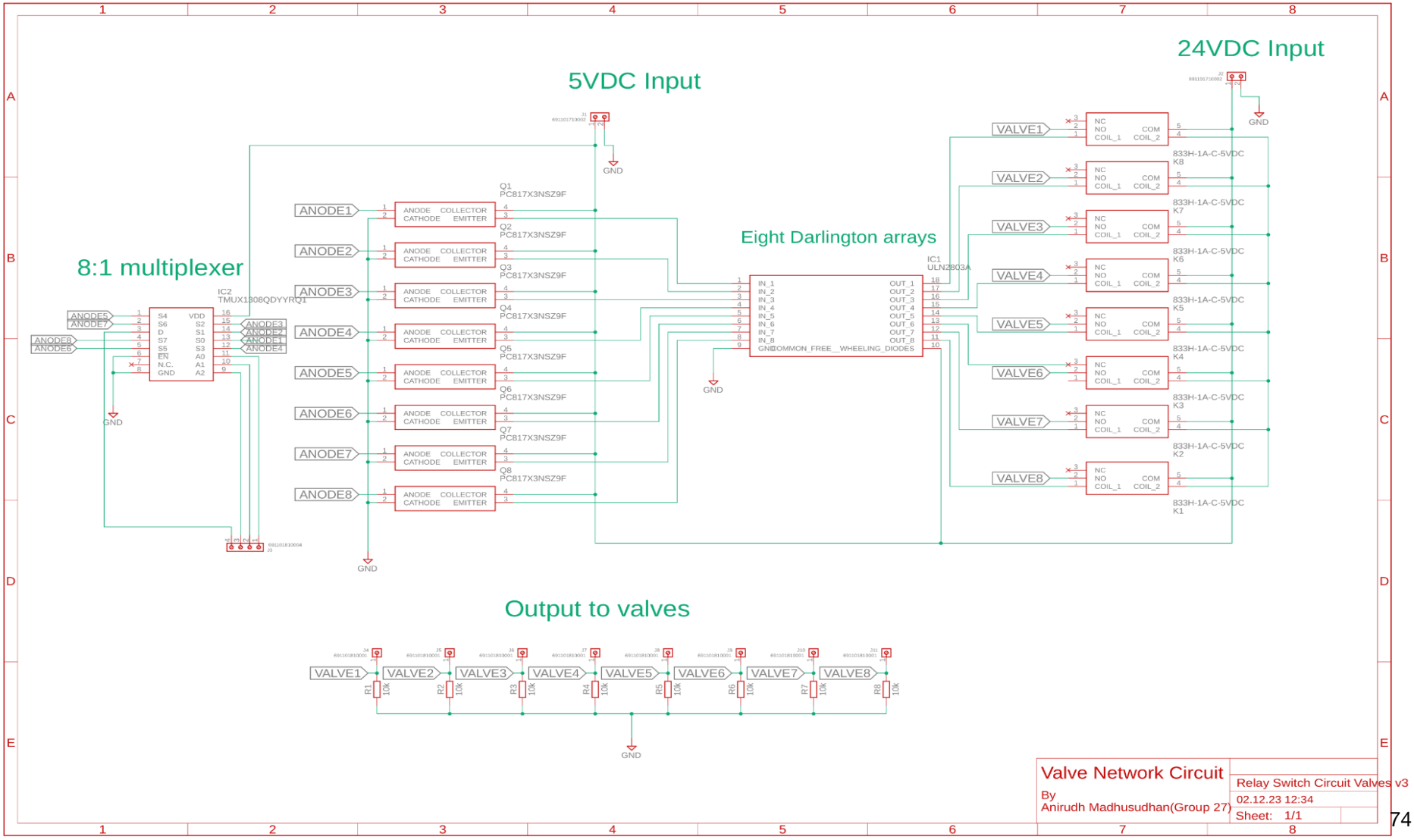
9.2 24V to 5V Buck Converter Schematic

To see in full resolution click: **Buck converter PDF**



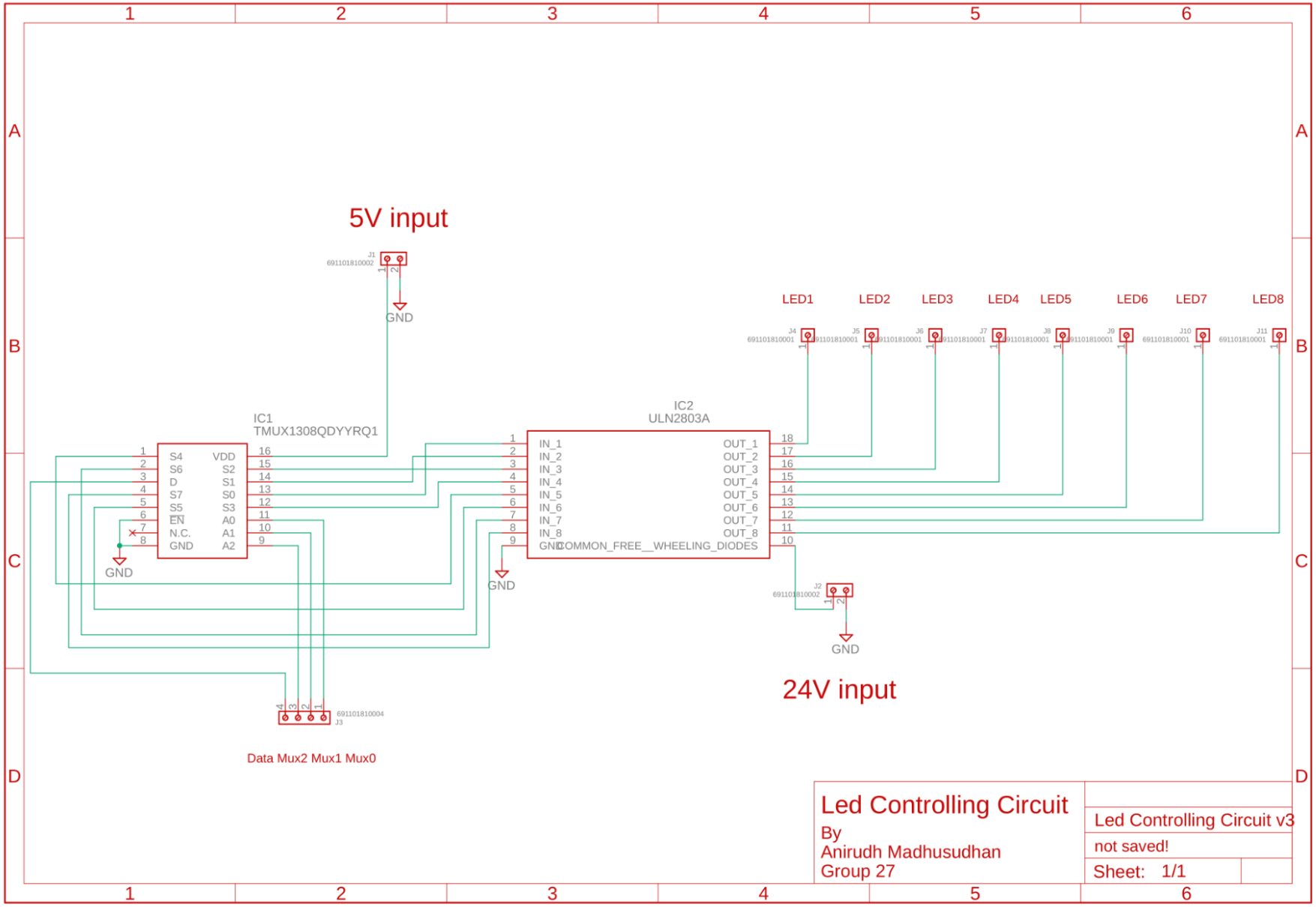
9.3 Valve Network Circuit

To see in full resolution click: **Valve Network Circuit**



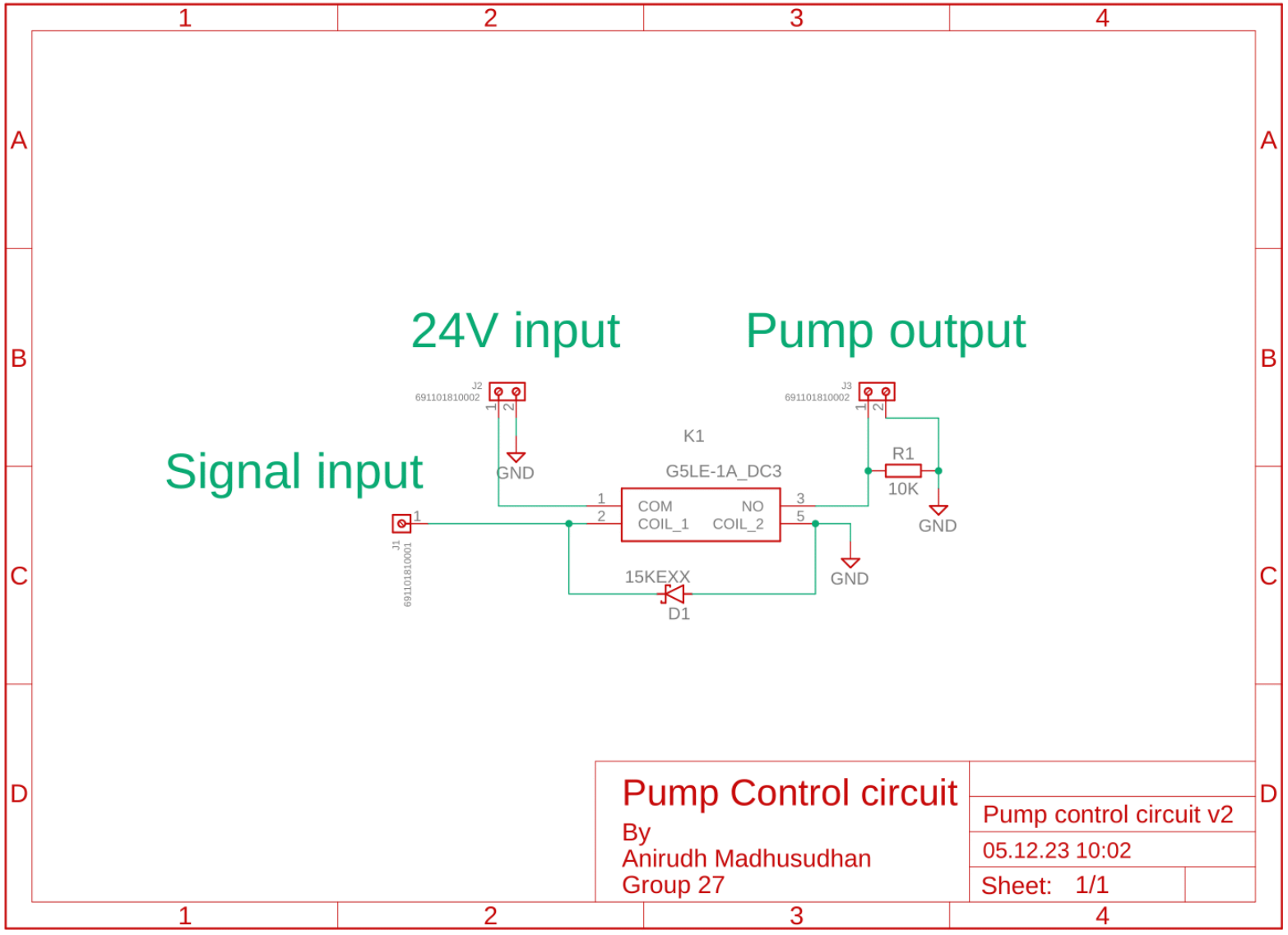
9.4 LED network Circuit

To see in full resolution click: **LED network Circuit**



9.5 Pump Control circuit

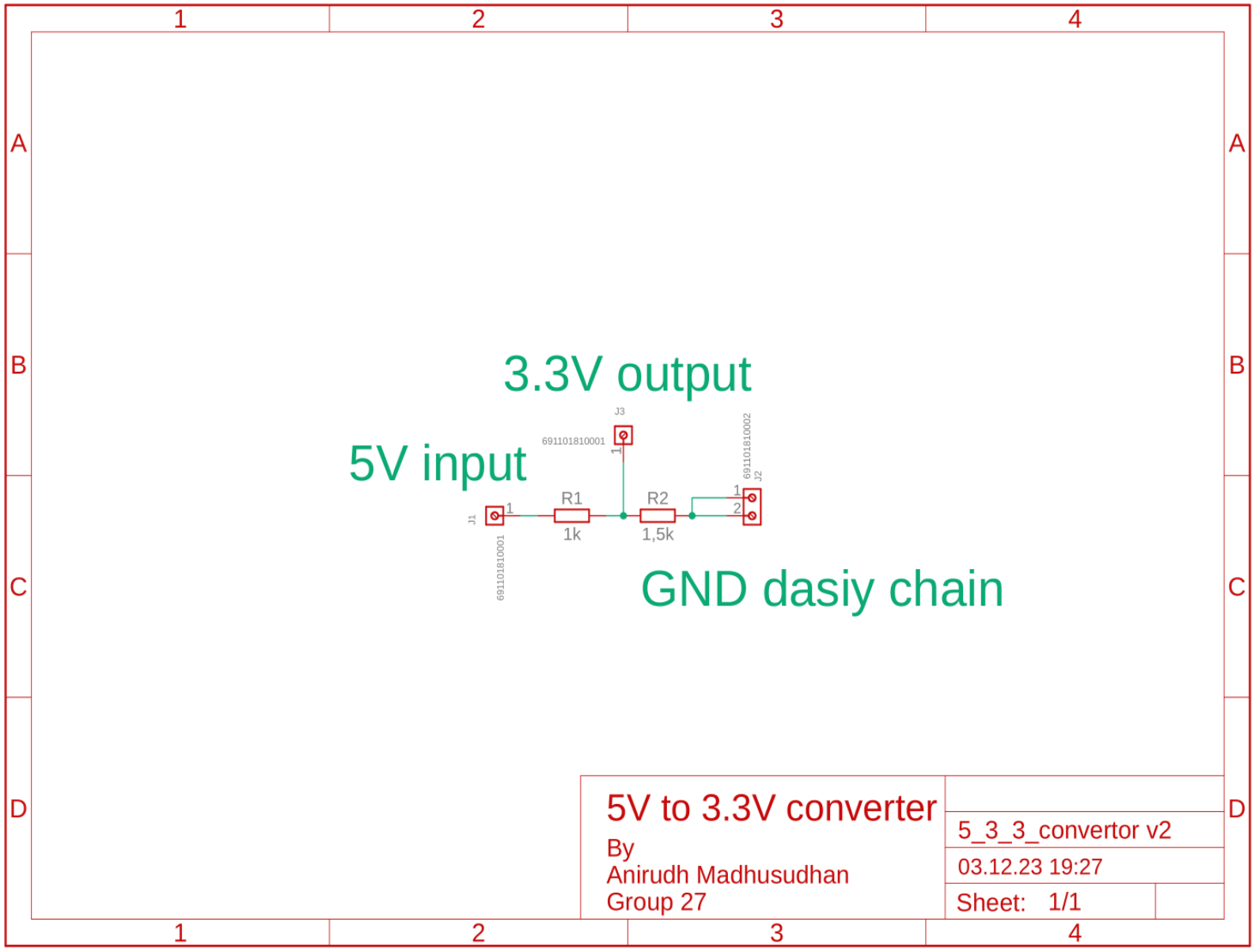
To see in full resolution click: **Pump Control circuit**



05.12.23 10:02 f=0.99 /Users/anirudhmadhusudhan/Downloads/Group project/Pump control circuit v1.pdf (Sheet: 1/1)

9.6 5V to 3.3V Logic converter

To see in full resolution click: **5V to 3.3V Logic converter**



10. Energy and Power Calculations

10.1 Major Power consumptions

Component	Power
Water Pump	5.3W[7]
Solenoid Valve	17W[8] (only one will be active at a time)
Touchscreen	3.1W
Single Board Computer	15W[10]
Led Strips	28.8W[11]
Loss from the buck converter	4.4W[12]
Loss from the power supply	9.6W[19]
Total Sum	**83.2W**

Table 10.1.1:Power Consumption of major components

10.2 Energy consumption for one Cocktail

This energy consumption is calculated assuming each cocktail consists of four drinks of 125ml each and the height of the drinks in their respective tanks are in the lowest possible configuration. This energy calculation also takes into account a cleaning cycle.

The volume flow rate is calculated as follows:

$Q = \frac{\Delta P \pi r^4}{8\eta l}$ (as per Poisseulle's law)

The pressure difference is calculated as follows:

$\Delta P = \rho g h$, where the height difference as per our construction is 15cm.

Making adjustments as per real world data, we get a volume flow rate of **0.59l/min**.[14]

Thus each valve should be open for **12.7s** for a total of **50.8 seconds** for all the four drinks.

As for the cleaning cycle, the pump has a flow rate of **6.5l/min** and the mixing chamber has a volume of **0.77L**. The time needed to fill the mixing chamber is **7.1s.**

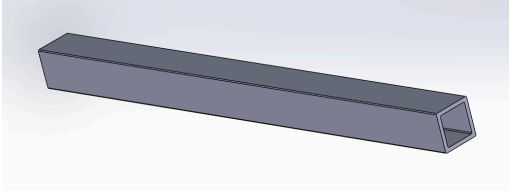
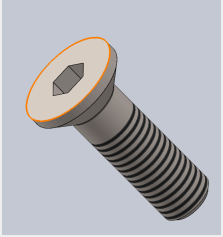
Component	Power	Running Time	Energy
Water Pump	5.3W	7.1s	37.6J
Solenoid Valve(single)	17W	50.8s	863.6J
Touchscreen	3.1W	57.9s	179.5J
Single Board Computer	15W	57.9s	868.6J
Led Strips	28.8W	57.9s	1.67KJ
Miscellaneous	5W	57.9s	289.5J
Loss from the buck converter	4.4W	57.9s	254.8J
Loss from the power supply	9.6W	57.9s	555.8J
Total sum	**83.2W**		4.7KJ

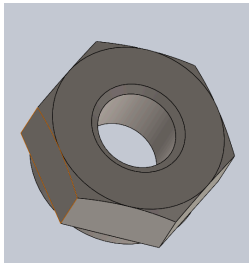
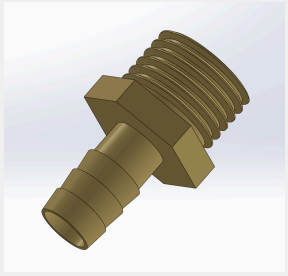
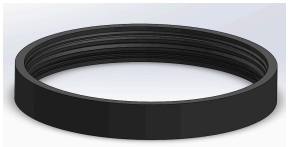
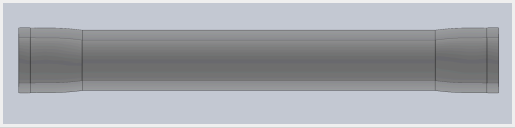
Table 10.2.1:Energy consumption for one cocktail

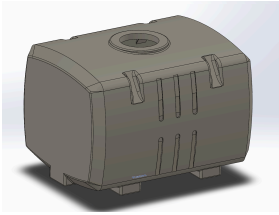
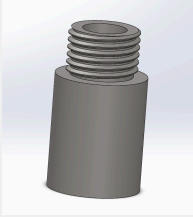
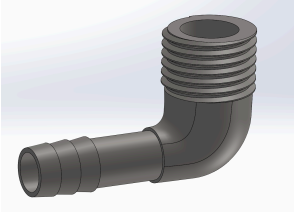
Miscellaneous includes power consumption from sensors, controlling circuits losses and small power consuming components.

11. Bill of Materials

11.1 Mechanical

Item #	Part	Qty.	Price / unit €	Total price €	Manufacturer	Purchase Link
1	Square pipes: 20mmx20mmx2mm 	8m (10 kg)	1.35	13.5	Wuxi XHD Metal Products Co	Link
2	Screws:  1) ISO 10642 - M3 x 10 - 10C 2) ISO 10642 - M3 x 30 - 18C 3) ISO 10642 - M3 x 8 - 8C 4) ISO 10642 - M3 x 16 - 16C	39 51 2 4	0.05 0.07 0.05 0.06	1.95 3.57 0.10 0.24	JIAXING XIUCHENG	Link

3	Nut: M3 DIN934 	97	0.07	6.68	JIAXING XIUCHENG	Link
4	Hose fitting adapter male Thread 3/8"to 8mm 	5	1.8	8.99	QUARKZMAN	Link
5	Silicone seal 80mmx10mm 	8	1.08	8.64	TYGERIX	Link
6	Silicone hose 8mm*12mm - 25m 	0.53m	168.69	3.57	Fisher Scientific	Link

11	Water tank: 200mmx200mmx250mm 	1	14.80	14.80	Yasa Environmental	Link
12	Coupling ⅜” -25mm 	4	4.61	18.44	Kingdom Flow	Link
13	Hose Barb 3/8" Male Thread 90 degree Elbow Pipe Fitting 	4	3.445	13.78	Garosa	Link

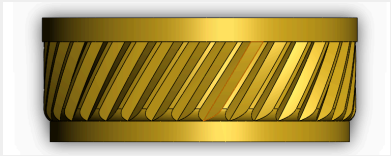
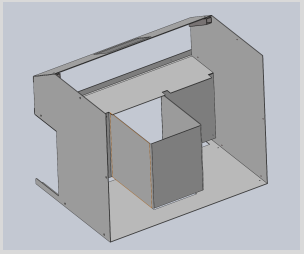
14	Threaded insert ⅜ - 15 pcs pack. 	6	9.99	4.00	Ruthex	Link
15	Double-Nipple male 3/8" Thread K-07A 	4	1.98	7.92	KI Kingdom	Link
16	Stainless steel sheets: 	3.5 m^2	11.35	39.75	Jiang Su Xin Xiang Sheng	Link
Total:				**134.36 Euro**		

Table 11.1.1 - Mechanical components

11.2 Electrical

No.	Qty.	Component	Package	Manufacturer	Vendor	Ordering code (manufacturer)	Ordering code (vendor)	Price per unit€*	Total Price €*	Link
1	1	Raspberry Pi 4 2GB	N.A	Raspberry Pi	Mouser	SC0193(9)	358-SC01939	35,17 €	35,17 €	Raspberry PI 4 2GB
2	8	Stainless Steel Water Solenoid Valve 24VDC, 17W	N.A	COVNA	Alibaba	S91B	N.A	8,60 €	68,80 €	Stainless Steel Water Solenoid Valve
3	1	Water pump 24VDC	N.A	TOPSFLO	Alibaba	TL-B03-A12-06 02	N.A	12,66 €	12,66 €	Water pump 24VDC
4	1	100W Power Supply	N.A	XP Power	Mouser	LCS100US24	209-LCS100US 24	12,50 €	12,50 €	100W power Supply
5	1	IEC connector plug with fuse	N.A	N.A	Conrad	501638	501638 - VQ	3,68 €	3,68 €	IEC connector plug with fuse
6	1	Water Level Sensor	N.A	IDUINO	Reichelt	N.A	ARD SEN WET2	0,68 €	0,68 €	Water Level Sensor
7	1	7 inch Touch display	N.A	Shenzhen Loten	Alibaba	MP7002	N.A	16,61 €	16,61 €	7 inch Touch display

8	1	HC-SR04 Ultrasonic sensor	N.A	acme systems	Roboter-bausatz	N.A	RBS10001	0,97 €	0,97 €	HC-SR04 Ultrasonic Sensor
9	2	4-pin screw Terminal	THT	CAMDENBOSS	Reichelt	CTB0502/4	CTB0502-4	0,50 €	1,00 €	4-pin screw Terminal
10	16	1-pin screw Terminal (but we are using 2-pin variants)	THT	PHOENIX-CONTACT	Reichelt	1729128	LAKL 1,5 2 5,08	0,55 €	8,80 €	1-pin screw Terminal
11	16	2-pin screw Terminal	THT	PHOENIX-CONTACT	Reichelt	1729128	LAKL 1,5 2 5,08	0,55 €	8,80 €	2-pin screw Terminal
12	2	8:1 Multiplexer IC	SMD	Texas Instruments	Mouser	TMUX1308QDYYRQ1	595-TMUX1308QDYYRQ1	0,12 €	0,24 €	8:1 Multiplexer IC
13	8	Optocoupler	THT	Sharp Microelectronics	Mouser	PC817X3NSZ9F	852-PC817X3NSZ9F	0,07 €	0,52 €	Optocoupler
14	2	Darlington array IC	THT	STMicroelectronics	Mouser	ULN2803A	511-ULN2803A	0,96 €	1,92 €	Darlington array IC
15	8	5V Relays	THT	HONGFA	Reichelt	HF3FA/005-ZTF	HF3FA-005-Z	0,63 €	5,04 €	5V Relays
16	1	3V Relay	THT	OMRON	Reichelt	G5V-1 3DC BY OMZ	G5V-1 3DC	0,97 €	0,97 €	3V Relay
17	9	10 kΩ Resistor	SMD	TE Connectivity / Holsworthy	Mouser	352210KJT	279-352210KJT	0,18 €	1,62 €	10 kΩ Resistor

18	1	Buck converter IC	SMD	Microchip Technology	Mouser	MIC2101YML-TR	998-MIC2101YMLTR	0,98 €	0,98 €	Buck converter IC
19	10	Diode	THT	onsemi / Fairchild	Mouser	UF4007	512-UF4007	0,08 €	0,84 €	Diode
20	1	Polarised capacitor 470µF	THT	Lelon	Mouser	RGA471M1EBK-1012G	140-RGA471M1EBK1012G	0,13 €	0,13 €	Polarised capacitor 470µF
21	2	Polarised capacitor 220µF	THT	Lelon	Mouser	RGA221M1EBK-0811G	140-RGA221M1EBK0811G	0,04 €	0,07 €	Polarised capacitor 220µF
22	2	Polarised capacitor 100µF	THT	Panasonic	Mouser	ECA-1EM101B	667-ECA-1EM101B	0,06 €	0,12 €	Polarised capacitor 100µF
23	3	Capacitor 2.2 µF	SMD	TAIYO YUDEN	Mouser	TMK316BJ225KLHT	963-TMK316BJ225KLHT	0,05 €	0,15 €	Capacitor 2.2 µF
24	1	Capacitor 4.7 µF	SMD	Samsung Electro-Mechanics	Mouser	CL21A475KAQNNNF	87-CL21A475KAQNNNF	0,02 €	0,02 €	Capacitor 4.7 µF
25	1	Capacitor 100nf	SMD	Samsung Electro-Mechanics	Mouser	CL05B104KA54PNC	187-CL05B104KA54PNC	0,01 €	0,01 €	Capacitor 100nf
26	2	Resistor 40kΩ	SMD	Vishay / Dale	Mouser	CRCW080540K0FKEA	71-CRCW080540K0FKEA	0,01 €	0,02 €	Resistor 40kΩ
27	2	Resistor 1.5kΩ	SMD	Vishay / Dale	Mouser	CRCW06031K50JNEAC	71-CRCW06031K50JNEAC	0,01 €	0,01 €	Resistor 1.5kΩ

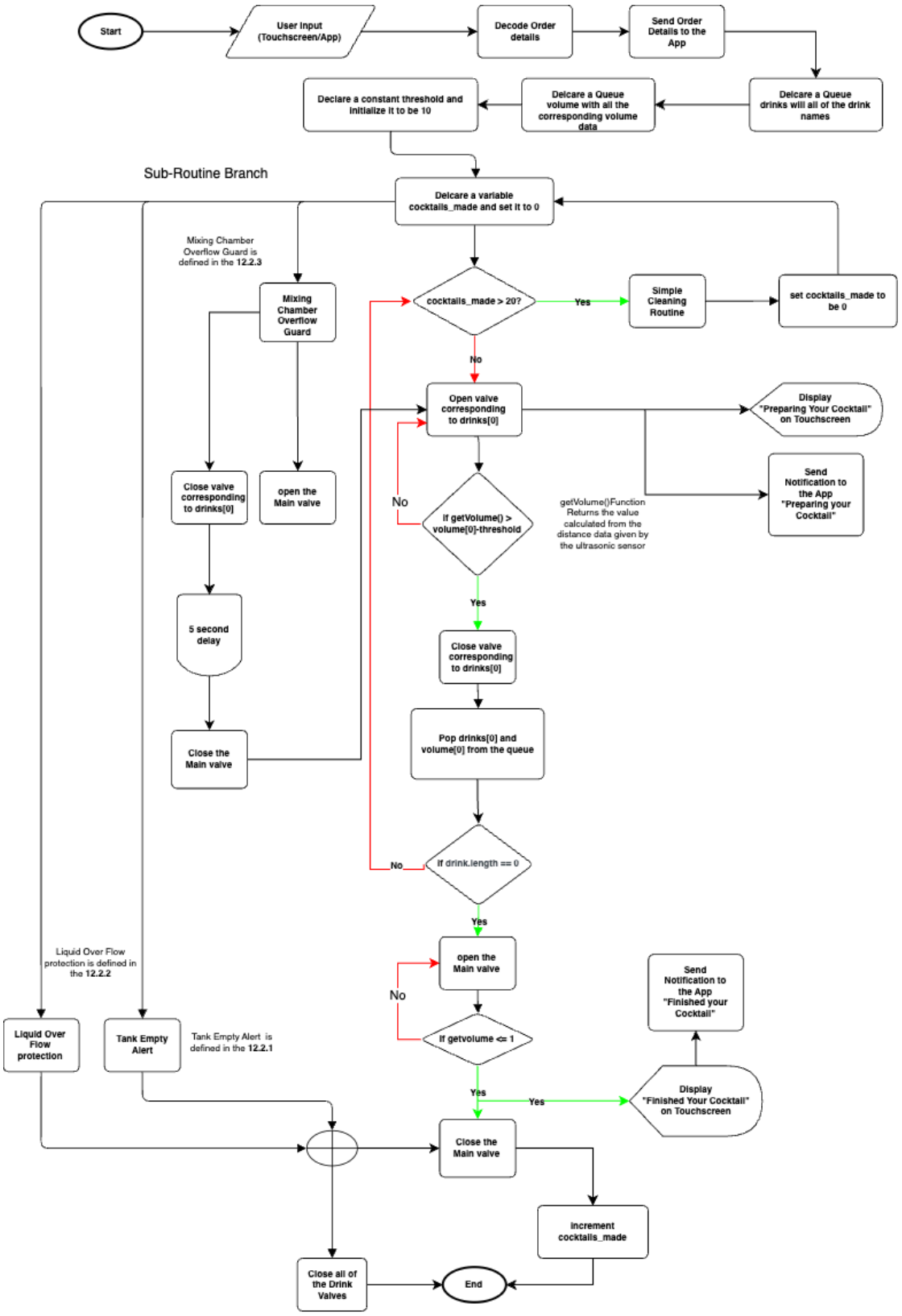
28	2	N-Channel Mosfets	SMD	Infineon Technologies	Mouser	IRFR3707ZTRPBF	942-IRFR3707ZTRPBF	0,29 €	0,58 €	N-Channel Mosfets
29	1	Inductor 33nH	SMD	Vishay / Dale	Mouser	IHSR1616ABER33NM01	70-IHSR1616ABR33NM01	0,60 €	0,60 €	Inductor 33nH
30	20	M3 Screw	N.A	APM HEXSEAL	Mouser	RM3X8MM-2701	608-RM3X8MM	0,21 €	4,20 €	M3 Screw
31	20	M3 Silicon washers	N.A	N.A	orbitalfasteners	N.A	N.A	0,03 €	0,50 €	M3 Silicon washers
32	1	Ac Power Cable	N.A	GOOBAY	Reichelt	68605	GOOBAY 68605	2,60 €	2,60 €	Ac Power Cable
33	1	Fuse 250V 600mA	N.A	bel Fuse	Mouser	5TT 600-R	530-5TT600-R	0,21 €	0,21 €	Fuse 250V 600mA
34	0,5	JUMPER MALE TO FEMALE	N.A	DEBO	Reichelt	AC046	DEBO KABELSET13	1,67 €	0,84 €	JUMPER MALE TO FEMALE
35	0,02	50M 16 gauge hook-up wire	N.A	Alpha Wire	Mouser	67150 RD321	602-67150RD321	92,54 €	1,85 €	50M 16 gauge hoop-up wire
36	0,00656168	1000ft 22 Gauge hook-up wire	N.A	Alpha Wire	Mouser	3051/1 RD001	602-3051/1-1000-03	101,55 €	0,67 €	1000ft 22 Gauge hook-up wire
37	0,00973	1000ft 28 Gauge hook-up wire	N.A	Alpha Wire	Mouser	2628 BK001	602-2628-1000-02	494,48 €	4,81 €	1000ft 28 Gauge hook-up wire
38	6	Lever Nuts	N.A	WAGO	Reichelt	221-413	WAGO 221-413	0,31 €	1,85 €	Lever Nuts

39	1	Servo	N.A	Robo	Roboter-bausatz	SG90	N.A	1,58 €	1,58 €	Servo
40	0,4	LED Lights	N.A	LEDoDM	LEDoDM	SL-5050-60UCS1902	SL-5050-60UCS1903	4,00 €	1,60 €	LED Lights
41	1	Valve Controlling PCB	N.A	JLC PCB	JLC PCB	N.A	N.A	2 €	2 €	Valve Controlling PCB
42	1	Buck Converter PCB	N.A	JLC PCB	JLC PCB	N.A	N.A	2€	2€	Buck Converter PCB
43	1	LED Controlling PCB	N.A	JLC PCB	JLC PCB	N.A	N.A	2 €	2 €	LED Controlling PCB
44	1	Pump Controlling PCB	N.A	JLC PCB	JLC PCB	N.A	N.A	2€	2€	Pump Controlling PCB
45	2	3.3V to 5V converter	N.A	JLC PCB	JLC PCB	N.A	N.A	1 €	2 €	3.3V to 5V converter
46	1	Hdmi to mini hdmi cable	N.A	GOOBAY	Reichelt	69122	GOOBAY 69122	1,64€	1,64€	Hdmi to mini hdmi cable
47	1	USB A to micro-b cable	N.A	GOOBAY	Reichelt	96190	GOOBAY 96190	0,92€	0,92€	USB A to micro-b cable
Total:									**216,28 €**	

Table 11.2.1 - Electrical components

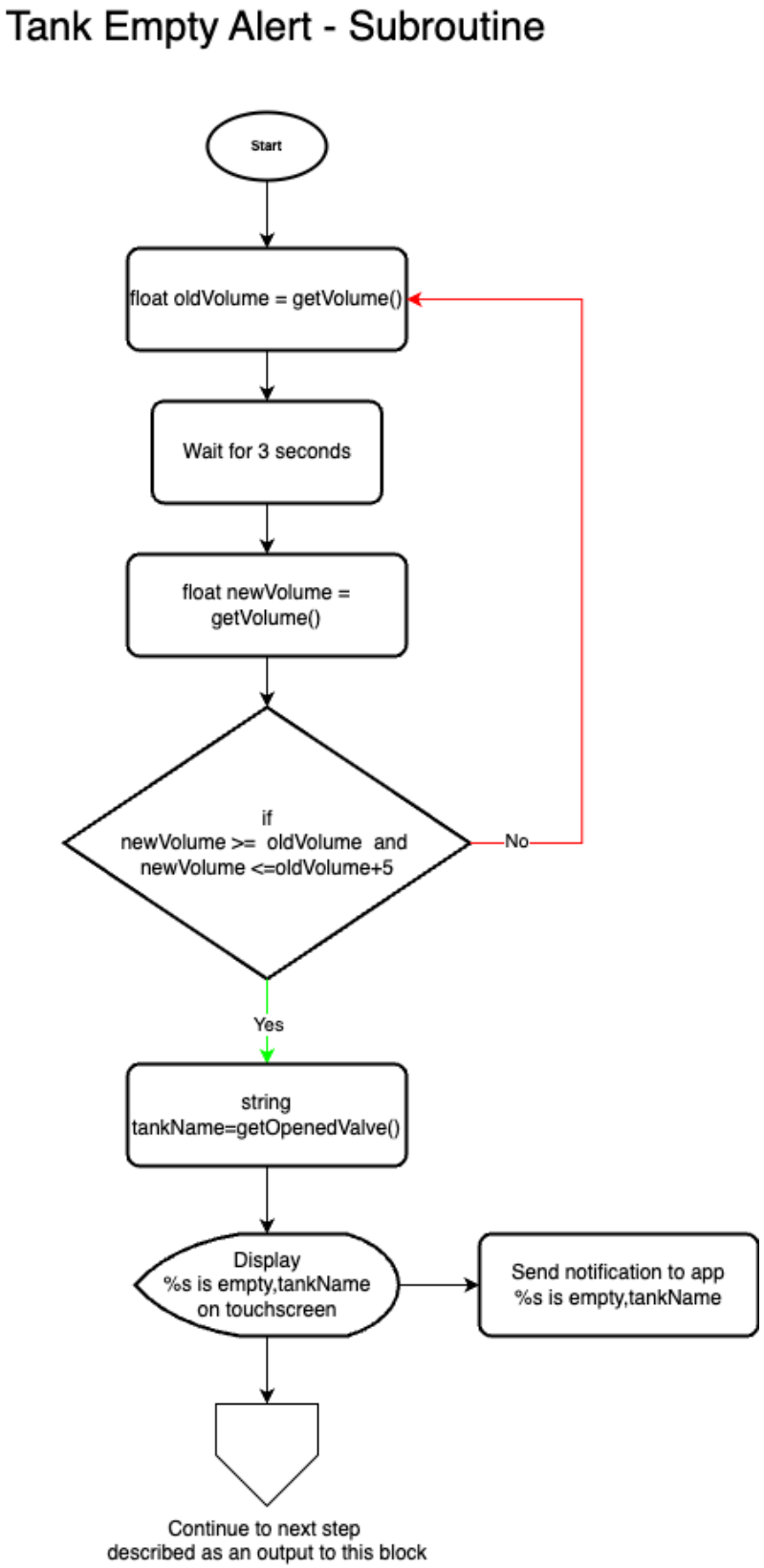
12. Program Flowchart

12.1 Program flow chart to make a drink

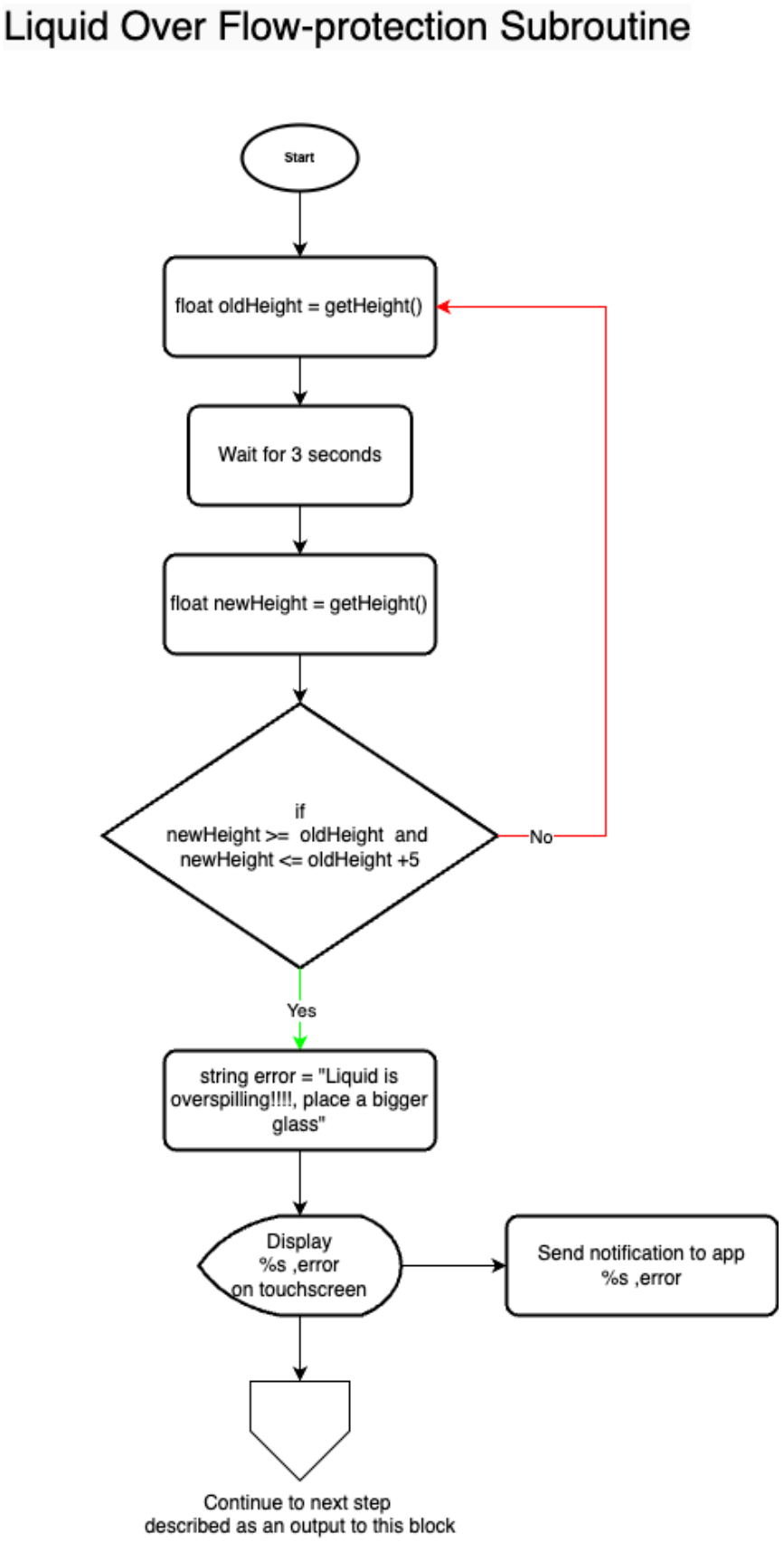


12.2 Sub-Routines

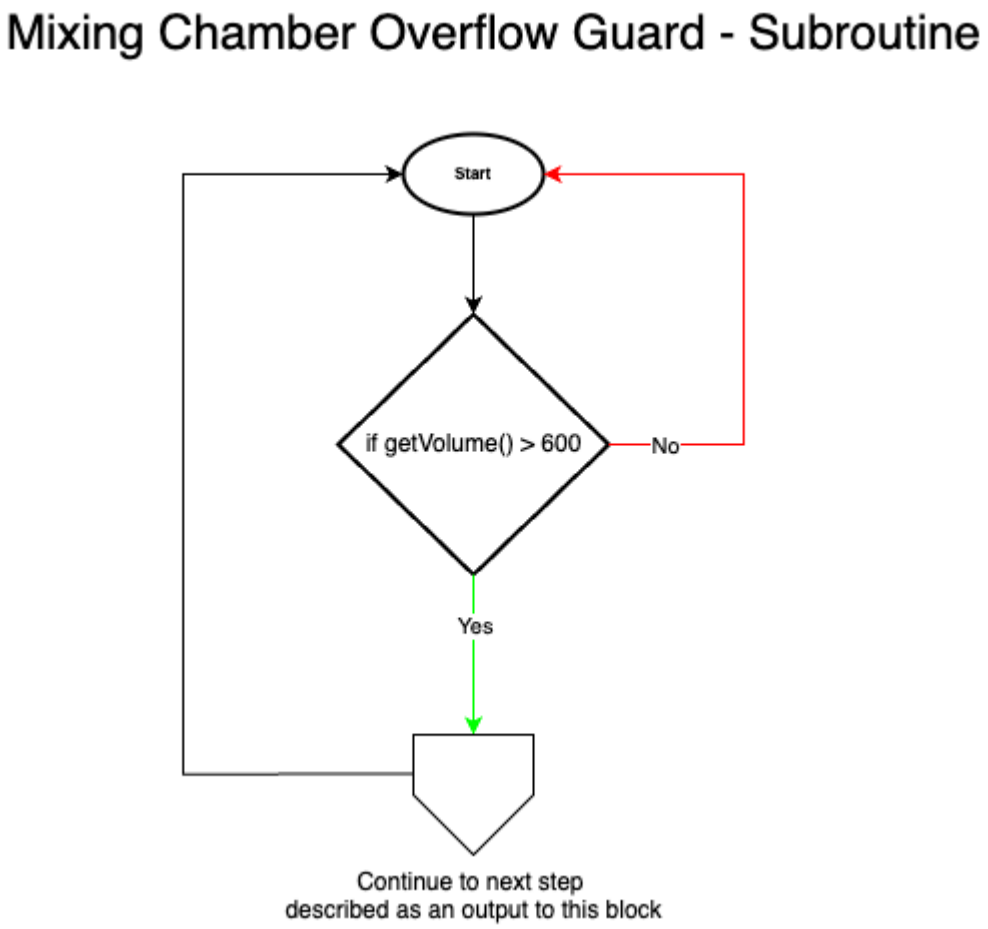
12.2.1 Tank Empty Alert



12.2.2 Liquid Over Flow-protection

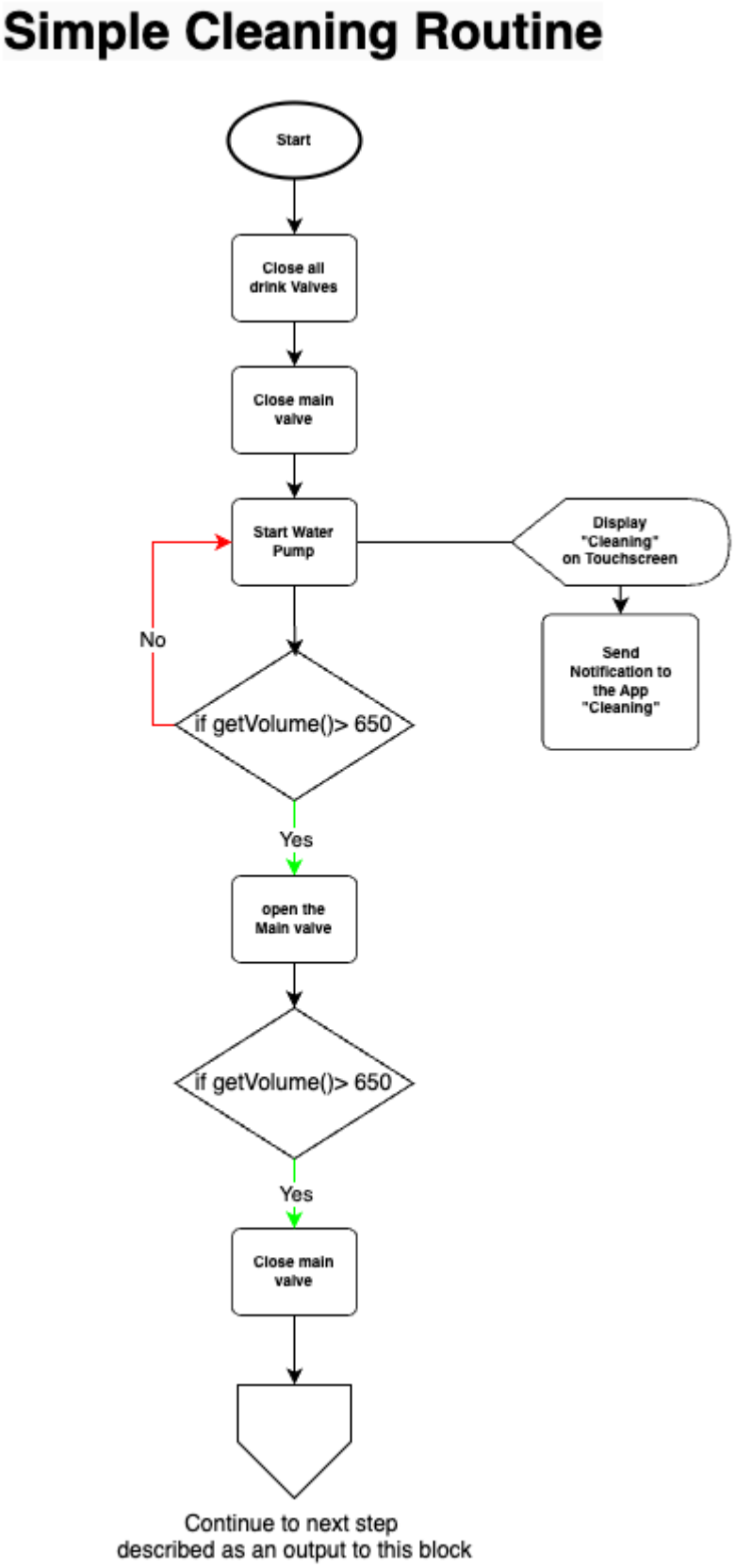


12.2.3 Mixing Chamber Overflow Guard

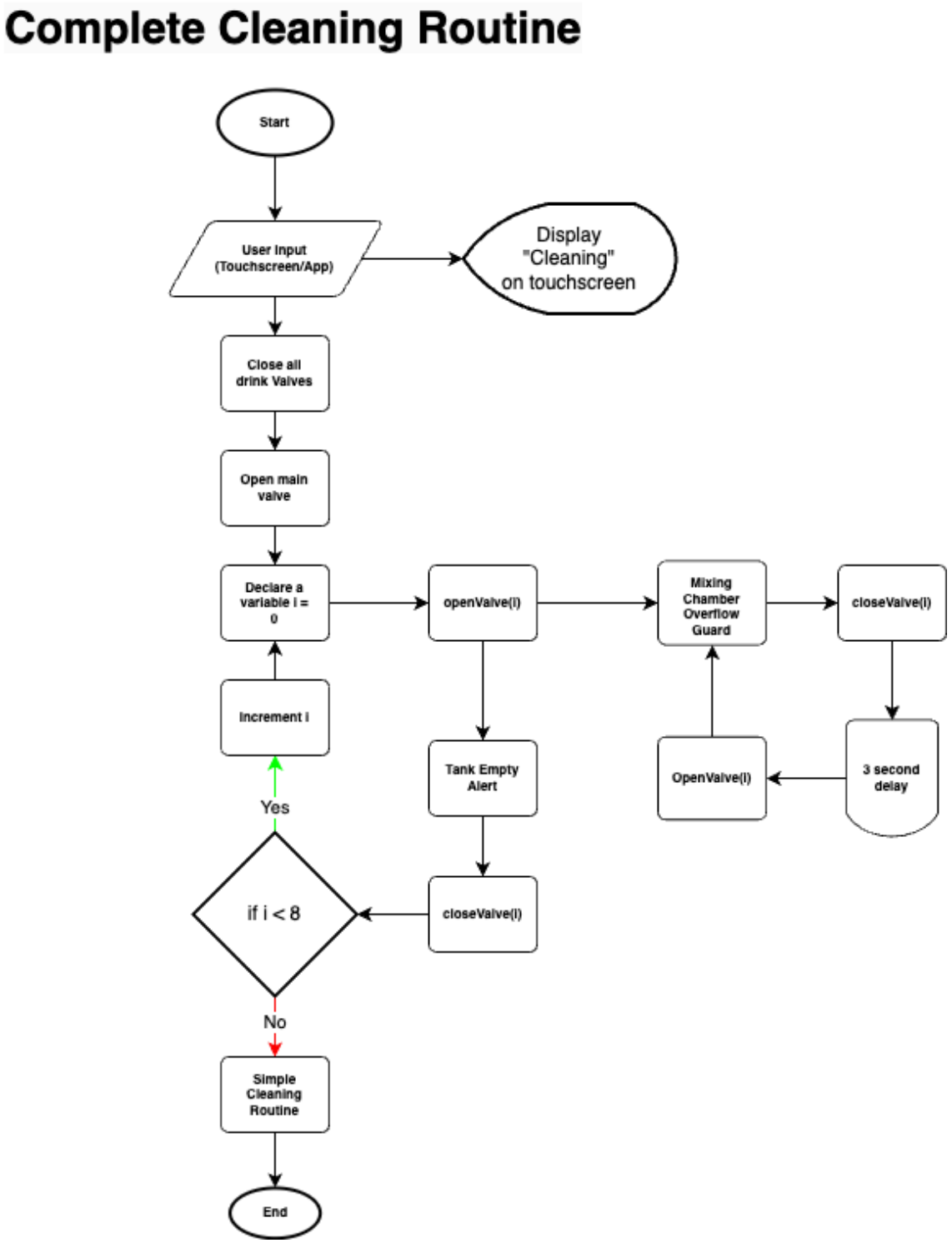


12.3 Cleaning Routines

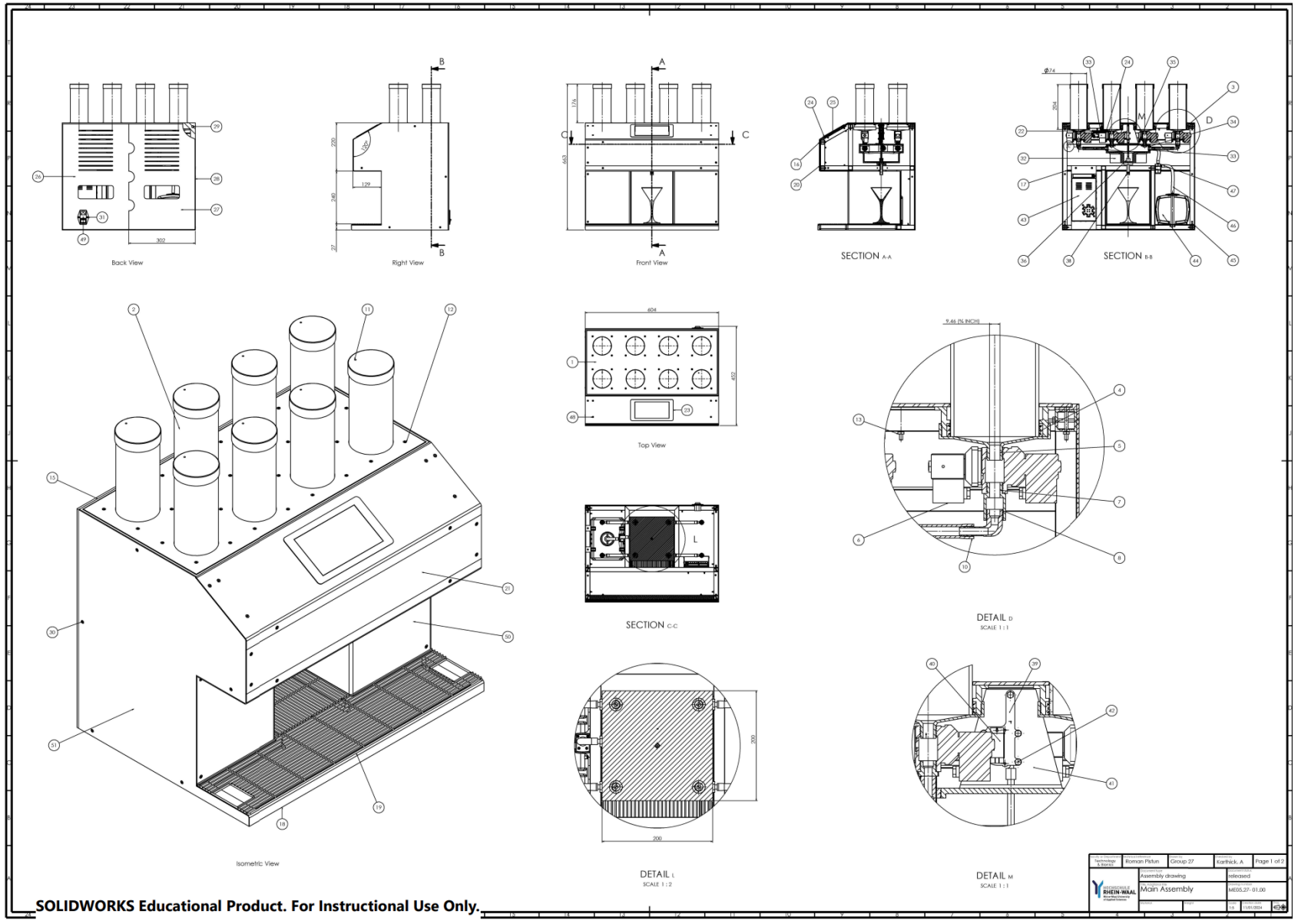
12.3.1 Simple Cleaning



12.3.2 Complete Cleaning



13. CAD


Back View
Right View
Front View
SECTION A-A
SECTION B-B
Top View
SECTION C-C
DETAIL D
SCALE 1 : 1
DETAIL L
SCALE 1 : 2
DETAIL M
SCALE 1 : 1
Isometric View
Roman Pistun
Group 27
Karthick, A
Page 1 of 2
Assembly drawing
released
Main Assembly
ME05_27- 01.00
SOLIDWORKS Educational Product. For Instructional Use Only.

ITEM NO.	Description	Specification	Material	QTY.
1	Top plate		SAE 304 stainless steel	1
2	Drink's Reservoir		Clear soda lime glass	1
3	Drink's_LED&Seal_holder		Nylon/PA (PolyAmide)	8
4	Silicone Seal		Sillicone (FDA)	8
5	197_to_16_adapter_1		Nylon/PA (PolyAmide)	8
6	Valve_0.75 in		Stainless Steel	8
7	Coupling_F2M		Stainless Steel	4
8	Hose Elbow 3_8 Inch_r		Stainless Steel	4
9	Double_Nipple		Stainless Steel	4
10	Pipe		Sillicone (FDA)	4
11	Cap		Clear soda lime glass	8
12	Countersink head screw	ISO 10642 - M3 x 10 - 10C	Stainless Steel	39
13	Nut	ISO - 4032 - M3 - W - N	Stainless Steel	97
14	Frame		Low carbon mild steel	1
15	Holder_support		Mild Steel	1
16	SM_support		Mild Steel	3
17	SM_support_exclusive		Mild Steel	1
18	Tray		SAE 304 stainless steel	1
19	Tray_drip		SAE 304 stainless steel	1
20	SM_support_v		Mild Steel	2
21	Glass_panel		Borosilicate glass	1
22	PCB, RPi4ModelB.STEP		Composite	1
23	Touchscreen		Borosilicate glass	1
24	Chassis		Mild Steel	1
25	Front plate		Mild Steel	1
26	Backplate_1		Stainless Steel	1
27	Backplate_2		Stainless Steel	1
28	Backplate_base		Stainless Steel	1
29	Neodymium_Magnet		Neodymium, Boron	8
30	Socket countersink head screw	ISO 10642 - M3 x 30 - 18C	Stainless Steel	51
31	Socket countersink head screw	ISO 10642 - M3 x 8 - 8C	Stainless Steel	2
32	Mixing_Chamber		FDA Acrylic	1
34	Tapered Heat-Set Inserts for Plastic	93365A142	Stainless Steel	10
33	Hose Fitting 3_8 Inch_real		Stainless Steel	5
35	Mixing_Chamber_Cap		FDA Acrylic	1

ITEM NO.	Description	Specification	Material	QTY.
36	Rubber_Cap		FDA Rubber	1
37	Rod		Stainless Steel	1
38	Tap		Stainless Steel	1
39	Cover servo		HDPE	1
40	Servo motor		Composite	1
41	Servo_backplate		FDA Acrylic	1
42	ISO 4014 - M3 x 25 x 12-S		Stainless Steel	3
43	Power Supply		Composite	1
44	Water Tank		HDPE	1
45	Water_Tank_support		Mild Steel	2
46	Hose_cleaning_1		Sillicone (FDA)	1
47	Pump		Composite	1
48	Socket countersink head screw	ISO 10642 - M3 x 16 - 16C	Stainless Steel	4
49	Plug IEC with switch fuse		Composite	1
50	Center Plate		Stainless Steel	1
51	Side Plate		Stainless Steel	2

Faculty or department: Technology & Bionics | Technical reference: Roman Pistun | Drawn by (last name) typ: Group 27 | Drawing date: 1/3/2024 | released by:

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projection method | scale: 1:8

Drawing no. prefix: ME.5.20151.27

Drawing no.: 200124-01

Type of document: bill of material

rev.: 00 | date of issue: 1/16/2024 | sheet: 2 /2

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14. Production planning

14.1 Capacity Calculation

In our pursuit of efficiently manufacturing the PerBa cocktail mixer, it is essential to develop a comprehensive production plan. This plan encompasses various factors such as operational hours, takt time, machinery capacity, lot size, and lead time. Our primary goal is to produce 1400 units annually in the year 2024.

Operational Time and Takt Time Calculation:

Working days in a year= 50 working weeks x 5 working days/week = 250 days

For the year 2024, we have 250 working days(50 working weeks, 5 working days per week), with each day consisting of a 7,5-hour shift, summing up to 1875 operational hours.

Yearly Operational Hours=250 days×7,5 hours=1875 hours

Takt time, representing the time required to manufacture one unit, is calculated as follows:

Takt time = Yearly Operation hours / Planned annual lot size = 1875 hours / 1400 units = 1,34 hours / units.

To achieve our goal of producing 1400 units in 2024, we must manufacture approximately 1 unit every 1,34 hours during the 250 working days.

Operational Metrics:

1. Time per Piece:
    - The duration required to manufacture one part of a specific unit.
2. Setup Time:
    - The time necessary to prepare and set up machinery.
3. Operational Time:
    - The overall time during which a machine or manufacturing process is actively working.

Operational Time = Total available time - Break

Operational Time=8 hours−0.5 hours=7.5 hours

Lot Size Calculation:

Considering our total production target of 1400 units, with 250 working days and a lead time of 2 weeks (accounting for 4 days of weekend holidays), the lot size is determined as follows:

Lot size= (Total units / Working days) x Lead Time
Lot size= (1400 / 250) x 10 days = **56 units**

This implies that we need to produce 56 units within two weeks to meet our annual target of 1400 units.

Time per Order:

The total time required to fulfil an order, inclusive of setup time and production time, is expressed as:

Time per Order=Setup Time+(Lot Size×Time per Piece)

The table below provides details on various parts along with their corresponding manufacturing processes. Additionally, valuable insights into Lot Size, Time per Order, and Overall Equipment Efficiency (OEE) for each part are also available. The marked yellow part is our bottleneck:

Part	Manufacturing Process	Time per piece (min.)	Setup time (min.)	Operational time (hrs.)	Lot size	Time per order (hrs.)	OEE %
Frame (6m)	Sawing (including marking and measuring)	30,0	5,0	7,5	56,0	28,0833333	70
Frame	Arc welding	60,0	3,0	7,5	56,0	56,05	75
Frame cover	CNC Laser cutting	2,0	5,0	7,5	56,0	1,95	80
Frame cover	Hydraulic press forming	1,0	0,0	7,5	56,0	0,93333333	85
Mixing chamber	Injection moulding	2,0	10,0	7,5	56,0	2,03333333	80

Bottles	Extrusion	0,2	8,0	7,5	448,0	1,62666667	85
Mixing chamber cap	Injection moulding	0,3	10,0	7,5	56,0	0,44666667	80
Front panel	Glass drilling	1,0	5,0	7,5	56,0	1,01666667	70
Water tank	Stretch blow moulding	0,2	10,0	7,5	56,0	0,35333333	75
Drip cover	Semi automated spot welding	12,0	8,0	7,5	56,0	11,33333333	80
Tray	Cold deep drawing	2,0	5,0	7,5	56,0	1,95	85
Bottle cap	Injection moulding	0,8	8,0	7,5	448,0	6,10666667	80
Bottle holder	Injection moulding	0,9	8,0	7,5	448,0	6,85333333	80
Bottle adaptor	Injection moulding	1,0	10,0	7,5	448,0	7,63333333	80
Mixing chamber outlet valve sub assembly-Mounting plate	Injection moulding	0,5	8,0	7,5	56,0	0,6	80
Mixing chamber outlet valve sub assembly-Plunger rod	Extrusion	0,5	5,0	7,5	56,0	0,55	75
Mixing chamber outlet valve sub assembly-Sealing element	Transfer moulding	0,5	2,0	7,5	56,0	0,5	70

Outlet nozzle/tap	Injection moulding	0,3	10,0	7,5	56,0	0,44666667	80

Table 14.1.1 - Capacity calculation

14.2 Calculations for machinery:

Arc Welding as a Bottleneck:

Arc welding stands out as a bottleneck in our production process. A single machine has the capacity to meet the demand in approximately 8 days, calculated as the Time per Order divided by Operational Time (56,1 / 7,5 = 7,48). Considering our lead time of 10 days, it becomes evident that a single Arc welding machine can effectively fulfil our demand within the specified timeframe.

Injection Moulding:

The injection moulding process has been meticulously analysed for efficient production planning. The total time per order is calculated at 24 hours, taking into account various components. Remarkably, a single Injection moulding machine is sufficient to produce the required parts within 3,2 days, calculated as the total time per order divided by the operational time (24 hrs / 7,5 hrs). Considering a lead time of 2 weeks (75 hrs), the decision is made to install **one machine**, ensuring the order fulfilment on the 4th day. This strategic approach optimises the production timeline and resource utilisation.

Price given for machinery in the table below takes into account approximate cost of shipping and customs.

Machinery sequence:

No.	Machine / equipment	Specifications needed	Quantity	No. of worker(s) per equipment	Machine Cost (Euros)
1	Mitre saw machine	Compatible of cutting 20mm wall thickness pipes for making the frame	1		1.050[28]

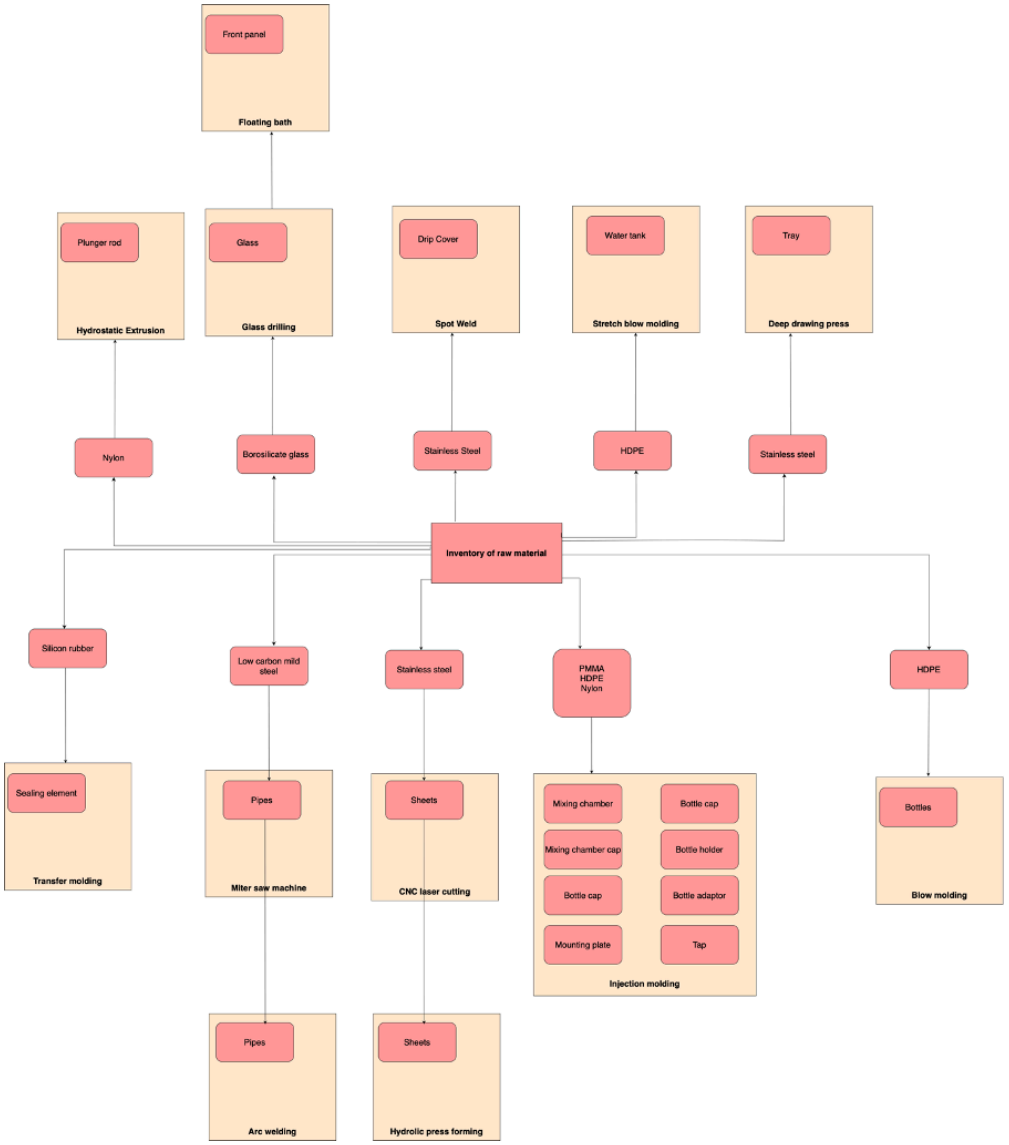
2	Arc Welding machine	Any welding apparatus capable of welding 20mm pipes made of low carbon mild steel that have been cut.	1	1	5.000[29]
3	CNC laser cutting	Programmable capable of cutting 2mm thick stainless steel sheets for frame covers.	1		100.000[30]
4	Hydraulic press forming	Compatible of creating bends of stainless steel where necessary for making frame cover.	1		30.000[31]
5	Injection moulding	Compatible with PMMA/HDPE, capable of producing multiple parts simultaneously, and equipped with automatic part ejection.	1	1	39.000[32]
6	Glass drilling machine	Able to make holes in Borosilicate glass for making front panels	1	1	30.000[26]
7	Spot welding machine	Capable of working with stainless steel rods and proficient in welding all overlapping points to create a drip tray.	1		13.000[33]
8	Stretch blow moulding machine	Compatible of blow forming HDPE material	1		28.000[34]

		and create holes.			
9	Deep drawing press	Able to press SAE 304 stainless steel and create the shape of the tray	1		35.000[35]
10	Hydrostatic Extrusion	Compatible with Nylon/PA (PolyAmide) which can extrude cylinder to a plunger rod	1		49.000[36]
11	Transfer moulding machine	Suitable with Silicone rubber to make sealing element	1		12.500[37]
12	Stencil Printer	Suitable for PCB of size less than 100mm x 100mm	1		1.620[38]
13	Pick and Place machine	Maximum placement area of 300 mm x 300 mm	1		74.400[39]
14	Inline Reflow oven	Belt width of atleast 300mm	1		43.300[40]
15	Wave soldering Machine	Maximum placement area of 300 mm x 300 mm	1		50.970[41]
				Total machinery cost	**512.840**

Table 14.2.1 - Machinery Needed

The table above shows the machinery and equipment needed to manufacture PerBa cocktail mixers, along with the corresponding number of operators required. Our intention is to adhere to this plan throughout 2024. Any adjustments or enhancements will be considered as we aim to scale up production targets in the coming years.

The Following flowchart shows the machinery which will be used for production and its sequence:



Flow chart 14.2.2 - Machinery sequence

14.3 Assembly layout

The cocktail machine has been split up into 8 subassemblies wherever necessary to simplify the assembly process due to the relatively high total component count (47 electronic components and 49 mechanical components). The grouping has been done either based on component proximity or function.

Actuator subassembly:

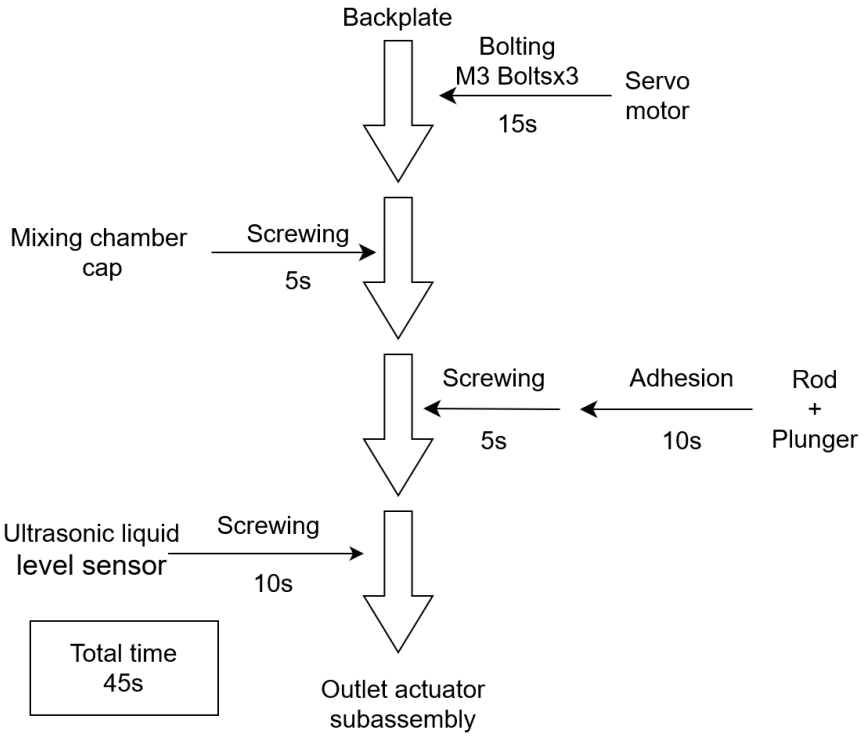


Fig. 14.3.1: Assembly layout of Actuator subassembly

Front plate subassembly:

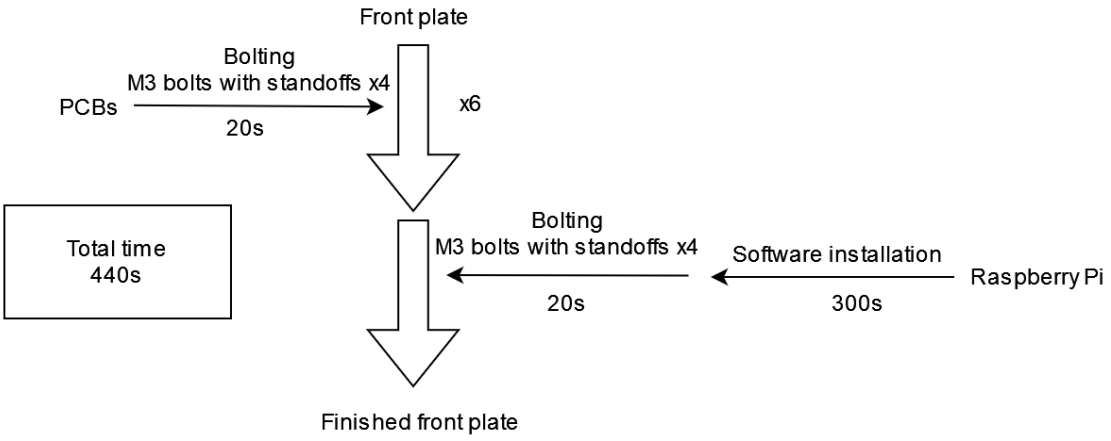


Fig. 14.3.2 Assembly layout of front plate subassembly

Bottle holder subassembly:

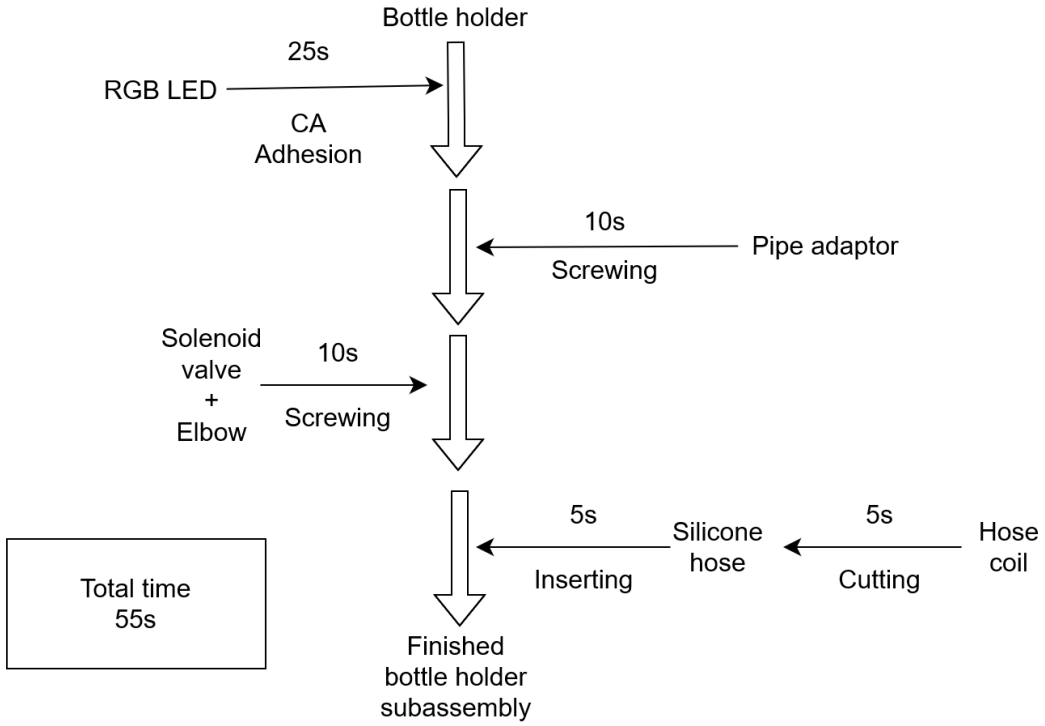


Fig. 14.3.3 Assembly layout of bottle holder subassembly

Top plate subassembly:

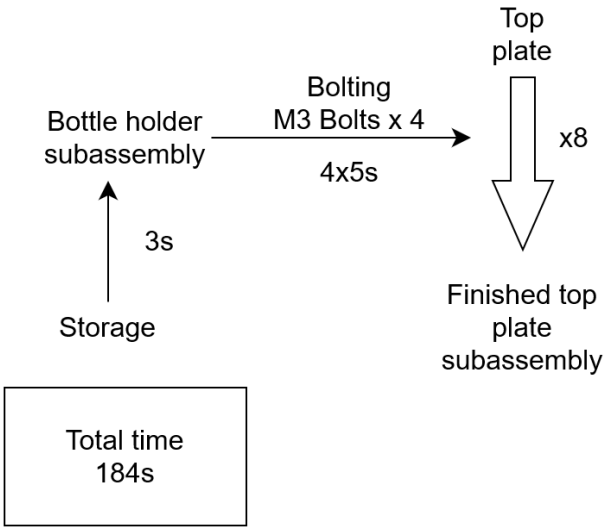


Fig. 14.3.4 Assembly layout of top plate subassembly

Centre plate subassembly:

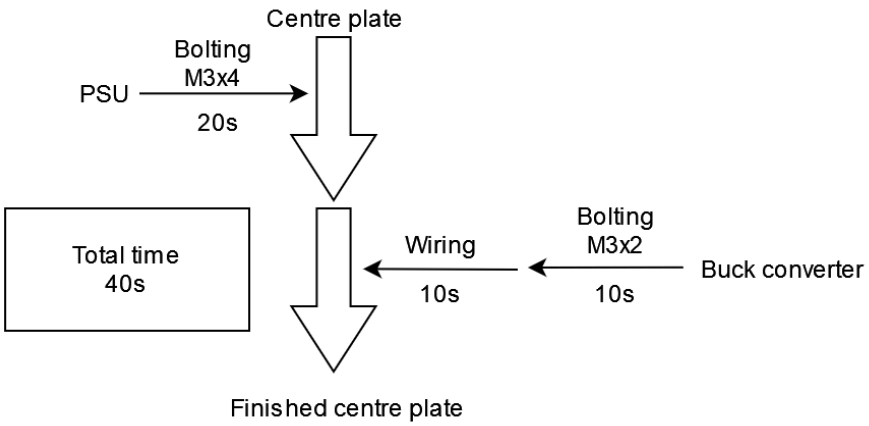


Fig. 14.3.5 Assembly layout of centre plate subassembly

Cleaning system subassembly:

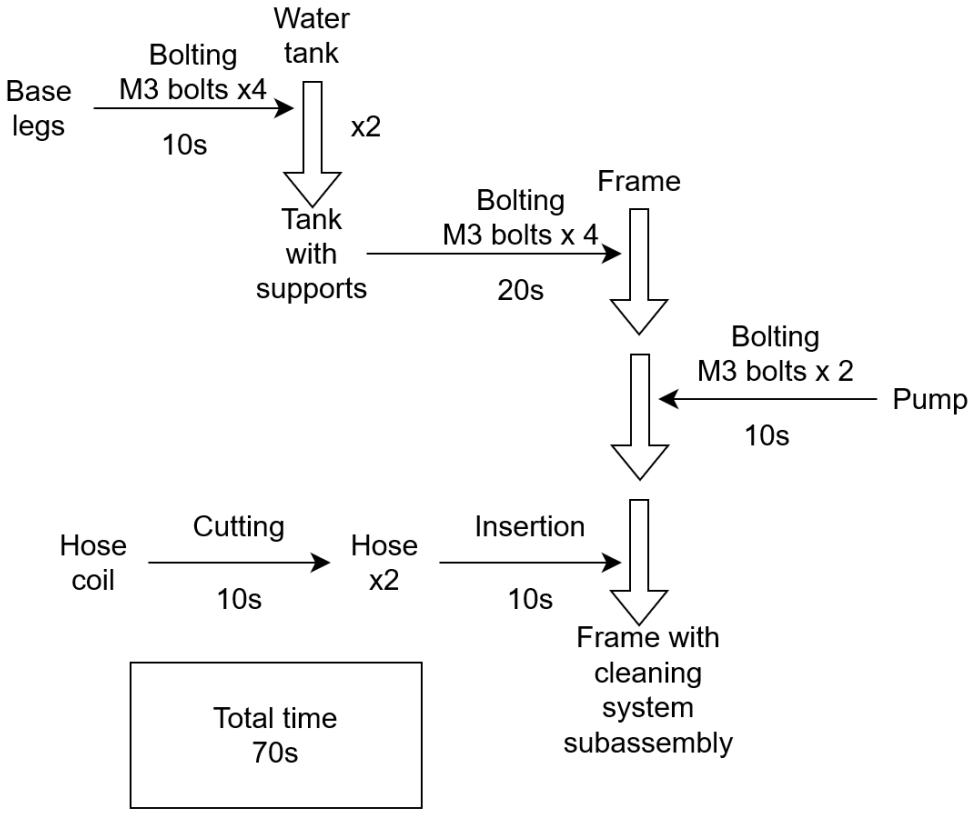


Fig. 14.3.6 Assembly layout of cleaning system subassembly

Mixing chamber subassembly:

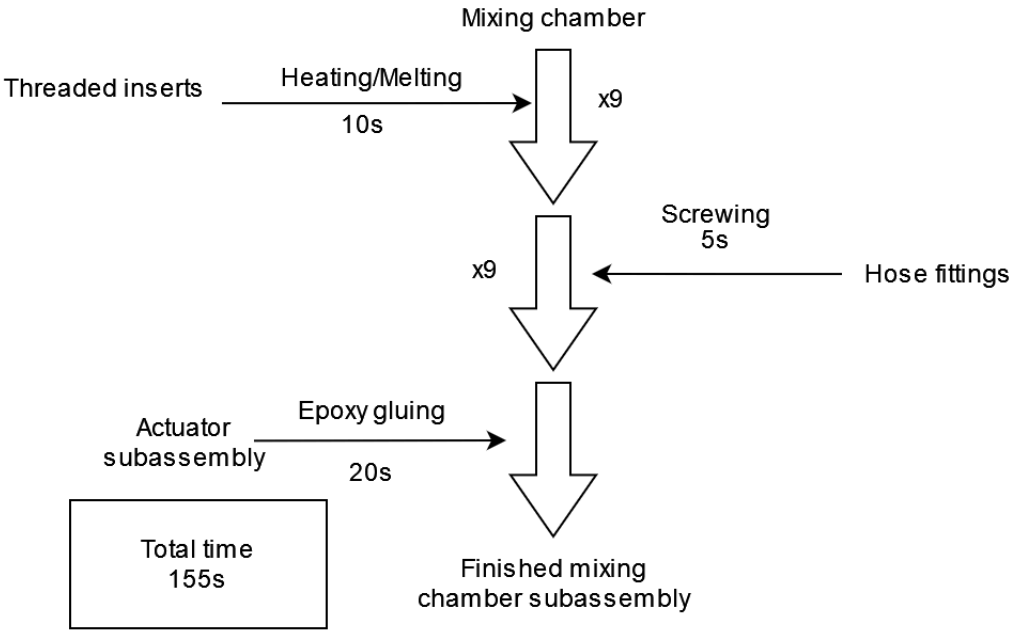


Fig. 14.3.7 Assembly layout of mixing chamber subassembly

PCB subassembly:

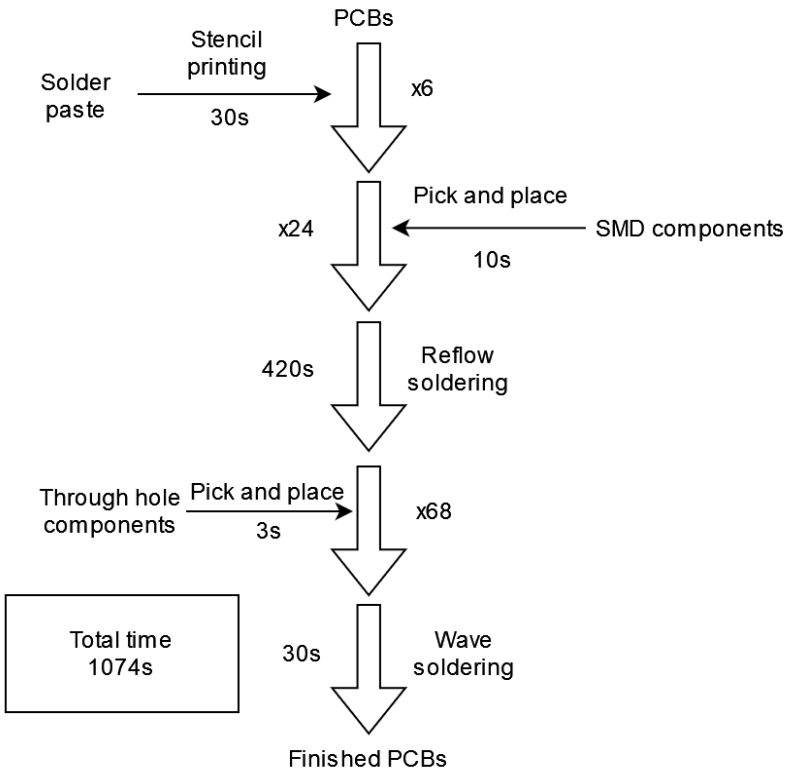


Fig. 14.3.8 Assembly layout

Final assembly:

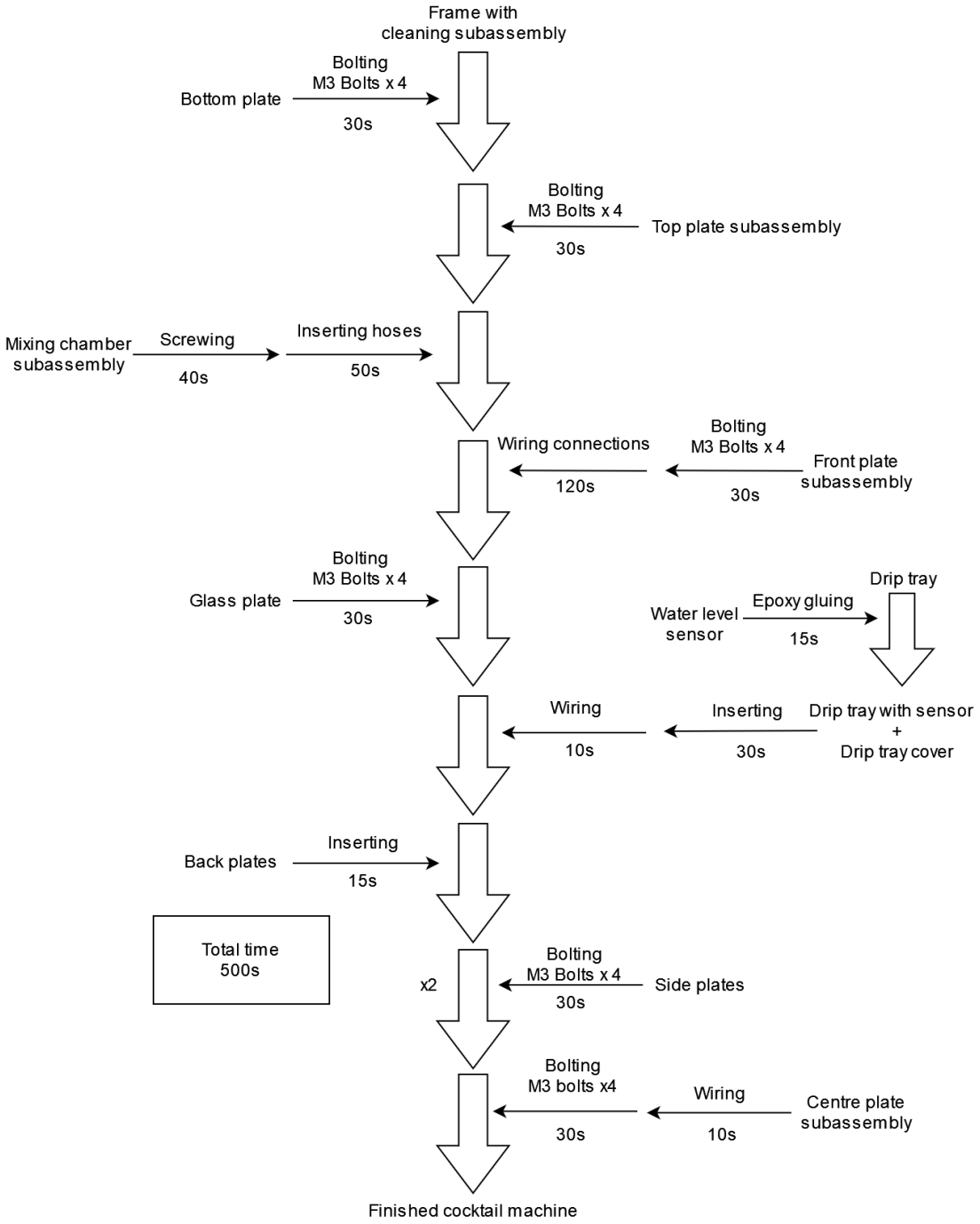


Fig. 14.3.9 Assembly layout of the final assembly

Summary of takt time:

The targeted production rate is 1 batch of 56 products in 2 weeks. This gives a takt time as follows:

$$Takt\ time\ = \frac{Time\ in\ minutes}{Number\ of\ units}$$

$$Takt\ time\ = \frac{10 \times 7.5 \times 60}{56}$$

$$Takt\ time\ = 80.3\ min$$

Total time taken for assembly:

Sl. No.	Assembly step	Takt time in s
1	Bottle holder subassembly	440
2	Top plate subassembly	184
3	Cleaning subassembly	70
4	Actuator subassembly	45
5	Mixing chamber subassembly	155
6	PCB subassembly	1074
7	Centre plate subassembly	40
8	Front plate subassembly	440
9	Final assembly	500
10	Quality check	600
11	Packaging	300
	Total	3848

Table 14.3.1: Takt times of different steps in the assembly process

The total time is found to be 3848s or 64.13min, for start to finish assembly of 1 unit. The production times are not considered as they are in stock.

Therefore, it is sufficient to have 1 employee for the assembly and quality check process.

Utilisation rate(UR):
The utilisation for the employee is calculated as follows:
OEE (Overall Equipment Effectiveness) of 85% is considered.

$$Available\ time\ per\ unit\ =\ OEE\ \times\ Scheduled\ time\ per\ unit$$
$$Available\ time\ per\ unit\ =\ 85\%\ \times\ 80min$$
$$Available\ time\ per\ unit\ =\ 68min$$

$$UR\ =\ \frac{Effective\ working\ time\ per\ unit}{Available\ working\ time\ per\ unit}\times\ 100$$
$$UR\ =\ \frac{64.13min}{68min}\times\ 100$$
$$UR\ =\ 94.3\%$$

The relatively high utilisation rate of 94% is acceptable as the OEE has taken into account deficiencies in the employee and availabilities.

Assembly equipment:

1. Handheld power screwdriver
2. Epoxy applicator[43]
3. Hose pipe cutting jig - Spool holder, measuring scale and movable blade
4. Suction cup glass holder
5. Drain pipes
6. Water tank for quality check

Food safe adhesives (epoxy[42]) is used for joints exposed to the cocktail. For other joints, cyanoacrylate adhesives[44] are used.

15 Cost Calculation

15.1 Electricity Cost calculation

Machine	Power Requirement	Time per unit	Energy Usage
Miter saw machine	2kW	0.5hrs	1kWh
Arc Welding machine	1kW	1hr	1kWh
CNC laser cutting	1,5kW	0,03hrs	0,045kWh
Hydraulic press forming	3kW	0,01hrs	0,03kWh
Injection moulding	45kW	0,09hrs	4kWh
Glass drilling machine	0,08kW	0,01hrs	≈ 0kWh
Spot welding machine	3kW	0,2hrs	0,6kWh
Stretch blow moulding machine	11,2kW	0,003hrs	≈ 0kWh
Deep drawing press	7,5kW	0,03hrs	0,2kWh
Hydrostatic Extrusion	120kW	0,003hrs	0,36kWh
Transfer moulding machine	5,5kW	0,003hrs	≈ 0kWh
Pick and Place machine	1kW	0,06hrs	0,06kWh

Inline Reflow oven	15kW	0,1hrs	1,5kWh
Wave soldering Machine	11kW	0,003hrs	0,03kWh
Total Energy for each Unit			8,825kWh

Table 15.1.1 - Energy calculation

Using this final energy value and with the price of one kWh in Q4 of 2023 being **26.5cents**[25], with this we can approximate our energy cost for each unit to be **2,4€.** We can add **2,6€** to the previous price to handle any miscellaneous energy costs, bringing the total up to **5€**

15.2 Material Cost

The cost breakdown is as follows:

Both numbers are taken from table 11.1.1 and 11.2.1

- Mechanical parts: **134.36 Euros**
- Electrical parts: **216.28 Euros**

The total material cost for one piece is calculated as the sum of these two amounts: 134.36 + 216.28 = **350.64 Euros**.

15.3 Labour wages

We are planning to allocate a total of 4 workers for our production, including assembly. Specifically, we have decided to assign 3 workers to production since the majority of our machines are automated and do not require an operator, except in cases of malfunction. The following table shows the specific information of labor cost.Total labor cost per unit can be calculated by using following formula:

Total labour cost per unit = Total cost per year/ Production volume per year.

Worker Position	Salary in year per person	No. of workers	Total cost	Total cost per unit
Assembly station worker	33750€	1	33750€	24,1€
Machine operators	33750€	3	101250€	72,3€

Table 15.3.1 - Labour cost

15.4 Assembly for Electronics Cost

Assuming a cost of **5 cents/component** for SMD components and **3 cents/component** for a Through hole component, We can estimate the cost for 24 SMD components to be **1.2€** and for 68 through hole components to be **2.04€,** for a combined total cost of **3.24€**

15.5 Final Cost

Referring to Table 14.2.1, the total machinery cost is recorded as **512.840 Euros**. To determine the cost per single unit, the calculation is performed as follows: **512.840/1400** = **366,3 Euros per**.

The capital cost of the machinery is depreciated over 10 years, which makes depreciation cost 36,6 Euros for one unit.

No.	Description	Cost contribution (in %)	Cost per unit (€)
1	Material cost (Mechanical parts + Electrical parts)	50,2	350,64
2	Electronics assembly cost	0,5	3,24
3	Depreciation machinery cost	5,2	36,6
4	Electricity cost	1,4	10
5	Heating/Ventilation cost	2,2	15
6	Labour wages	13,8	96,4
7	Overheads Cost (20%)	14,6	102,4
8	Profit	12,1	84,7
		Total	**699**

Table 15.4.1 - Machinery Cost

15.6 Final Price Discussion

After completing our final cost calculations, we have confirmed that the selling price of our PerBa cocktail mixer will be maintained at **699€** , in line with our initial quote. The set price we believe reflects a balanced consideration of production expenses, market trends, and consumer expectations.

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