UNIVERSIDAD DE VALLADOLID

ESCUELA DE INGENIERIAS INDUSTRIALES

Grado en Ingeniería Electrónica Industrial y Automática

Automatic Animals´ Feeder

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Marta Herráez Sánchez

Vilnius TECH

Valladolid, Junio 2023.

TFG REALIZADO EN PROGRAMA DE INTERCAMBIO

TÍTULO:	**Automatic Animals´ Feeder**
ALUMNO:	**Álvaro Díez Redondo**
FECHA:	**06/06/2023**
CENTRO:	**Faculty Of Mechanics**
UNIVERSIDAD:	**Vilnius TECH**
TUTOR:	**Ernestas Šutinys**

Resumen en Español:

La tesis final de licenciatura presenta un proceso de diseño de un comedero automático para animales orientado a la alimentación de caballos, pero extensible a otros animales. La parte analítica ofrece una visión general de construcciones análogas. Se comparan los puntos clave del diseño y luego se explica la decisión tomada. Las diferentes partes del diseño consisten en los cálculos del tornillo sin fin, la elección del motor y la elección del reductor. Posteriormente se realiza una descripción del principio de construcción y funcionamiento, compuesto por un esquema cinemático, un esquema del bloque eléctricos, un esquema de control y el algoritmo de control del dispositivo. Se definen las reglas de seguridad y funcionamiento y el tratamiento de la máquina después de su vida útil. La última parte realiza un análisis económico del producto.

Palabras clave:

Comedero automático, animales, mecatrónica, tornillo sin fin, algoritmo de control.

Abstract:

The final bachelor thesis presents a design process of an Automatic animal's feeder oriented to the feeding of horses but extendable to other animals. Analytical part provides an overview of analogical constructions. The key points of the design are compared and then the decision taken is explained. The different parts of the design consist of the calculations of the endless screw, the choice of the motor and the choice of the gearbox. Then a description of the construction an operational principle is done, it is made out of a kinematic scheme, electric block scheme, controlling scheme and the algorithm of management of the device. The safety and operation rules are defined and also the machine disposal after its service life. The last part makes an economic analysis of the product.

Keywords:

Automatic feeder, animals, mechatronics, endless screw, control algorithm

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FACULTY OF MECHANICS

DEPARTMENT OF MECHATRONICS, ROBOTICS AND DIGITAL MANUFACTURING

Álvaro Díez Redondo

AUTOMATIC ANIMALS´ FEEDER

Final Bachelor's Project

Study programme MECHATRONICS AND ROBOTICS,

Code 6121EX048

Vilnius, 2023

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APPROVED BY
Head of Department

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(Date)

Álvaro Díez Redondo

AUTOMATIC ANIMALS´ FEEDER

Final Bachelor's Project

Study programme MECHATRONICS AND ROBOTICS,
Code 6121EX048

Supervisor: Assoc. prof. Ernestas Šutinys   2023-05-17
(Title, Name, Surname)   (Signature)   (Date)

Vilnius, 2023

VILNIUS GEDIMINAS TECHNICAL UNIVERSITY

Álvaro Díez Redondo
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(Student name and surname, Student ID)

FACULTY OF MECHANICS
_____
(Faculty)

MECHATRONICS AND ROBOTICS, Code 6121EX048, MRfcu-19
_____
(Study programme, academic group)

COURSE PROJECT (WORK, INTEGRATED PROJECT)
DECLARATION OF ACADEMIC INTEGRITY

2023   May   17
_____
(Date)

I confirm, that my Final Bachelor's Project, which topic is

AUTOMATIC ANIMALS´ FEEDER
_____

_____

is written independently. The material presented in this project (work, integrated project) is not plagiarized. Quotations from other sources used directly or indirectly are indicated in the literature references.

The Final Bachelor's Project (work, integrated project) was inspected by:

Assoc. Prof. Ernestas Šutinys
_____

There is no contribution of other persons to the course project (work, integrated project). I have not paid any statutory sums of money for this work.

DIEZ REDONDO ALVARO - 45578701S
Firmado digitalmente por DIEZ REDONDO ALVARO - 45578701S
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Signature

Álvaro Díez Redondo
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(Name and Surname)

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APPROVED BY
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Vytautas Bučinskas
(Name, Surname)

_____14-02-2023_____
(Date)

Production and Manufacturing Engineering study field

Mechatronics ir robotics study program, state code 6121EX048

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OBJECTIVE FOR BACHELOR`S DEGREE FINAL WORK (PROJECT)
10-02-2023 No. 01
Vilnius

</div>

For student Alvaro Diez Redondo

Final work (project) title: Automatic Animals Feeder.

The Final work has to be completed by 19 May 2023.

THE OBJECTIVES:

Data: Technical Features: The maximum mass of the designed object: 90 kg; Dimensions of equipment: maximum lengch – 1.5 m, maximum width – 1.2 m, maxmimum height – 1.5 m; Maximum devices power supply voltage – 24 V; Angular velocity of the actuator – 0.3 rad/s.

Explanatory note:
1. Introdaction. Analysis of analogous constructions. Justification of the adopted decisions.
2. Design calculations. Description of design and operation principle.
3. Creation of control system.
4. Requirements for sate work and environmental when using the designed design.
5. Economic analysis with calculations.
6. Final conclusions.
7. References.

Drawings:
1. General view 1 page (A1).
2. Assembly drawing 1 page (A1).
3. Kinematic scheme 0,25 page (A1).
4. Control algorithm of object 0,5 page (A1).
5. Structural-block diagram scheme 0,25 page (A1).
7. Two part`s working drawing`s 0,5 lapo A1.
8. Economic indicators 0,5 page (A1).

Academic Supervisor

(Signature)

Assoc. Prof. Ernestas Šutinys
(Title, Name, Surname)

Objectives accepted as a guidance for my Final work (project)

DIEZ REDONDO ALVARO - 455787015

(Student`s signature)

Alvaro Diez Redondo
(Student`s Name, Surname)

10-02-2023
(Date)

Vilnius Gediminas Technical University	ISBN ISSN
MECHANICS faculty	Copies No. ………
	Date ….-….-….

MECHATRONICS AND ROBOTICS study programme bachelor (master) thesis.

Title: **AUTOMATIC ANIMALS´ FEEDER**

Author **Álvaro Díez Redondo** Academic supervisor **Ernestas Šutinys**

Thesis language

[ ] Lithuanian

[v] Foreign (English)

Annotation

The final bachelor thesis presents a design process of an Automatic animal's feeder oriented to the feeding of horses but extendable to other animals. Analytical part provides an overview of analogical constructions. The key points of the design are compared and then the decision taken is explained. The different parts of the design consist of the calculations of the endless screw, the choice of the motor and the choice of the gearbox. Then a description of the construction an operational principle is done, it is made out of a kinematic scheme, electric block scheme, controlling scheme and the algorithm of management of the device. The safety and operation rules are defined and also the machine disposal after its service life. The last part makes an economic analysis of the product.

This bachelor thesis has the following main chapters: Content, list of pictures, list of tables, introduction, overview of analogic constructions, calculation of the project, description of the construction and operational principle, work safety, economic calculation, conclusions, list of literature and annexes.

Barchelor thesis part consist of 67 p. of text without appendixes, 62 figures, 11 tables, 56 bibliographc sources. Drawings part has a Genal View (A1), Assembly (A1), Kinematic Scheme (A3), Electric Block Scheme (A3), two part´s working drawings (2x A3), Logic Scheme (A2), Economic Calculations (A2).

Keywords: Automatic animal's feeder; mechatronics; screw; control algorithm.

MECHATRONIKA IR ROBOTIKA studijų programa bakalauro (magistro) darbas.

Pavadinimas: **AUTOMATIC ANIMALS´ FEEDER**

Autorius **Álvaro Díez Redondo**   Vadovas **Ernestas Šutinys**

Thesis language

☐ Lithuanian

☑ Foreign (English)

Anotacija

Baigiamajame bakalauro darbe pristatomas automatinės gyvūnų šėryklos projektavimo procesas, orientuotas į arklių šėrimą, bet pritaikomas ir kitiems gyvūnams. Analitinėje dalyje apžvelgiamos analogiškos konstrukcijos. Palyginami pagrindiniai konstrukciniai punktai ir paaiškinamas priimtas sprendimas. Atlikti projektiniai skaičiavimai, kur apskaičiuota sraigto, variklio ir pavarų dėžės pasirinkimas. Pateikiamas konstrukcijos aprašymas ir veikimo principas, sudaryta kinematinė schema, elektrinė-blokinė schema ir įrenginio valdymo algoritmas. Apibrėžiamos saugos ir eksploatavimo taisyklės, įrenginio utilizavimas pasibaigus jo eksploatavimo laikui. Paskutinėje dalyje pateikiama ekonominė produkto analizė.

Šį bakalauro darbą sudaro šie pagrindiniai skyriai: Turinys, paveikslų sąrašas, lentelių sąrašas, įvadas, analogiškų konstrukcijų apžvalga, projektiniai skaičiavimai, konstrukcijos ir veikimo principo aprašymas, darbų sauga, ekonominiai skaičiavimai, išvados, literatūros sąrašas ir priedai.

Bakalauro rašto darbą sudaro: 67 p. teksto be priedų, 62 paveikslai, 11 lentelių, 56 bibliografiniai šaltiniai. Grafinę dalį sudaro: bendro vaizdo brėžinys (A1), mazgo surinkimo brėžinys (A1), įrenginio kinematinė schema (A3), elektrininė-blokinė schema (A3), dviejų dalių darbo brėžiniai (2× A3), valdymo algoritmas (A2), ekonominiai skaičiavimai (A2).

Reikšminiai žodžiai: Automatinė gyvūnų šėrykla; mechatronika; sraigtas; valdymo algoritmas.

CONTENT

LIST OF PICTURES

LIST OF TABLES

INTRODUCTION

Nowadays there are many automatic systems in all fields and sectors. Therefore, they also exist in animal husbandry and in the field of domestic pets. These systems cover numerous processes to facilitate the user's work from cleaning to feeding. In particular this work is oriented towards horse feeding. But the product could be adapted to other types of animals if the format of the feed is similar to the used by horses.

Horses eat mainly two types of feed, straw and granular feed. Hay does not normally need to be fed every day, but granular feed does. The granular feed needs to be fed at least twice a day, which means a great deal of dependence and responsibility on the part of the farmer.

In extensive farming there are numerous procedures and equipment for feeding the livestock as well as several people in charge of the farm, which makes it difficult for the animals to go without being fed. In countries like Spain, horse breeding is mainly for leisure, so often only one or two horses are kept and only one person is in charge of them. In case that the farmer is unable to go due to illness or bad weather, for example, the animals would be left without food.

That is why it has been decided to create a feeder for this kind of needs, for one horse only. This device will have enough capacity to feed the horse for several days, so the farmer will only have to refill it when the food in the hopper runs out. The design of the feeder has been done in order to have the enough height for placing the food in the horses thought, at the same time having the top of the container at a height that is accessible to fill the container without using a ladder.

The feeder will be connected to normal AC power. Meal scheduling will be programmed through a simple menu in which the time of the meals and the time the motor must be running can be set. The time can also be changed at any time.

1. OWERVIEW OF ANALOGIC CONSTRUCTIONS

1.1. Automatic feeder for cats and small dogs

There are many kinds of feeders, first of all I am going to talk about a small animal's feeder for cats and small dogs (Fig. 1.1).
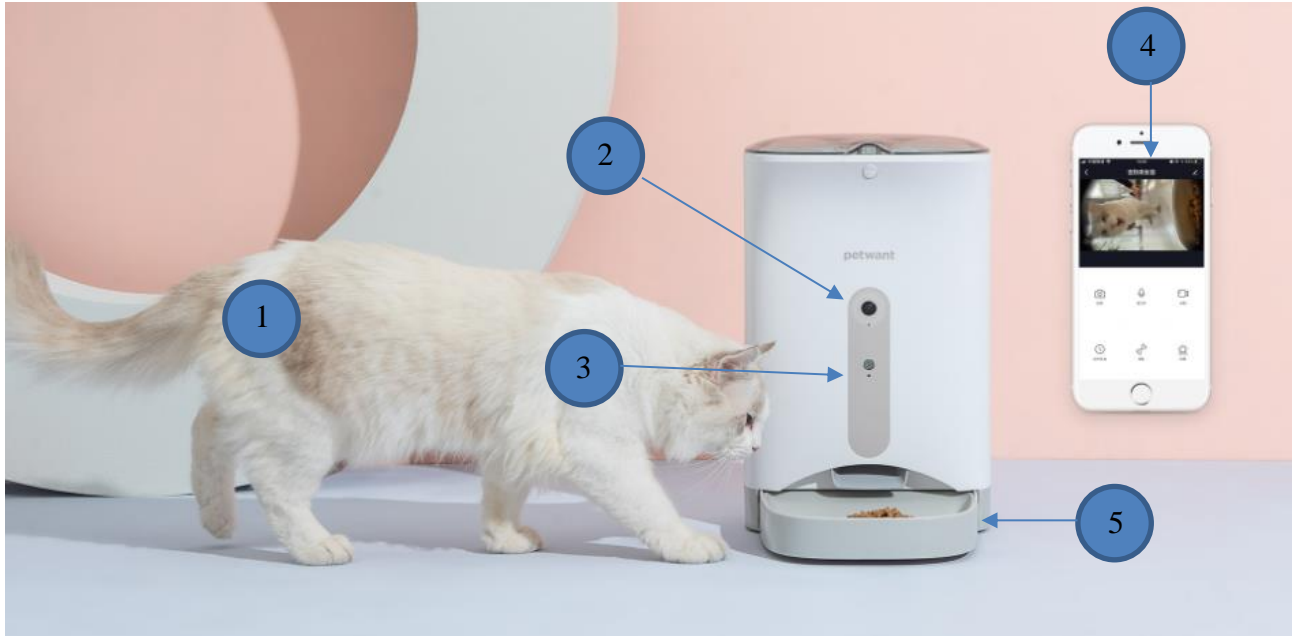
Fig. 1.1: Small animal's feeder: 1 – cat; 2 – camera; 3 – Microphone and speaker; 4 – Phone App; 5 – Food Bowl (https://www.petwant.com/?portfolio=f1-c)

This feeder has been designed by the Chinese brand Pet want, a company which main dedication is making feeders form small animals with different characteristics. Between all the catalogues I have chosen the product F1.

The general characteristics of F1 are this:

- 4'3L capacity.
- Up to 4 meals per day.
- Regulable meals from one to ten 10 grams portions.
- Record voices and reproduce it.
- Record videos and take pictures.
- Phone app.
- Battery and DC power cable supply.
- Dimensions: 24'5×19'5×38 cm
- Weight: 2'13 kg (https://www.petwant.com/?portfolio=f1-c).

The main parts of the device are the following ones which we can see in the different 1.1 figures (https://www.petwant.com/?portfolio=f1-c):

1. <u>Animal:</u> It could be any small animal; it is important to know the needs of the animal because the feeder has a limit of 100 grams per meal.
2. <u>Camera:</u> 1 Mpx Full HD camera with a 180º wide angle. One of the main characteristics of this camera is that it has night vision, so you can see your pet also at night when you are outside.
3. <u>Microphone and speaker:</u> It allow you to record and reproduce your voice to call your pet when is meal time so your pet recognise your voice.
4. <u>Phone App (Fig. 1.2):</u> Up to 6 people can be connected through the app to the same feeder so each member of the family is able see the family pet.

Fig. 1.2: Phone app (https://www.amazon.ae/PETWANT-camera-Automatic-smartphone-enabled/dp/B089FDKHCF)
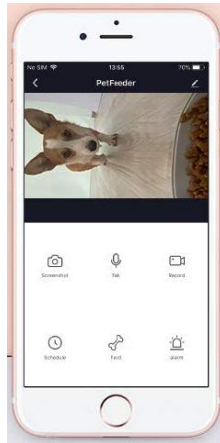
As we can see in the **¡Error! No se encuentra el origen de la referencia.** the mobile app allows you to take pictures, record videos, talk with your pet or put alarms. Also, you can change the schedule of the meals from the app, so you do not need to be at home to change it making much easier to feed the animal.

Another function of the app is that it allows you to share your pet´s activity in your social networks.

5. <u>Food Bowl (Fig. 1.3):</u> One of the main characteristics of the food bowl is his mechanism.

Fig. 1.3 :Removable Bowl (https://www.amazon.ae/PETWANT-camera-Automatic-smartphone-enabled/dp/B089FDKHCF)

As we can see (Fig. 1.3) the bowl has one tab in each side so if you push both of them at the same time and pull at the same time the bowl will separate of the whole feeder. Doing this you are able to wash the bowl apart.

In the Figure 1.4 we can see other components of the feeder.

Fig. 1.4: Small animals' feeder: 6 – Container; 7 – Scheduler; 8 – Food supplier mechanism (https://www.petwant.com/?portfolio=f1-c)

6. <u>Container (Fig. 1.5)</u>: The capacity of the container is 4'3L, made out of plastic materials.

Fig. 1.5 Removable container (https://www.voltio.cz/en/smartpet/1315-petwant-f1-c-smart-feeder-with-camera-6924876100470.html)

Like the bowl, one of the main characteristics of the container is that it is removable (**¡Error! No se encuentra el origen de la referencia.**) so we can clean it better.

7. <u>Scheduler (Fig. 1.4)</u>: It is not explain in any of the catalogues but it may be made from a memory and small microprocessor that is in charge of all the electronic functions and connecting to internet for the online connexion. For scheduling the meals, we have two ways, from the phone app or from the feeder controller.

8. <u>Food supplier mechanism (Fig. 1.4)</u>: As we can see it is made of two propellers. The upper one´s function is to avoid food clog so the fodder can fall inside of the cylinder. The second propeller is inside the named cylinder and it´s function is to propel the food to the bowl. It is not explained, but I suppose that the volume of each division that form the second propeller with the cylinder is

the measurement of one portion of the meal. We also do not have information about the join mechanism from the motor to the two propeller axis. But in my opinion the best way to control the mechanism and avoid mistakes is with a stepper motor (https://www.petwant.com/?portfolio=f1-c).

1.2. Automatic Lamb Feeder ECO

In the breeding of lambs (Fig. 1.6) one of the most important issues to bear in mind is the correct diet of the lambs in the first weeks of life. This is the reason of the creation of the following device that is going to be analysed (https://pdf.agriexpo.online/es/pdf-en/foerster-technik-gmbh/automatic-lamb-feeder-eco/171678-40174-_4.html).
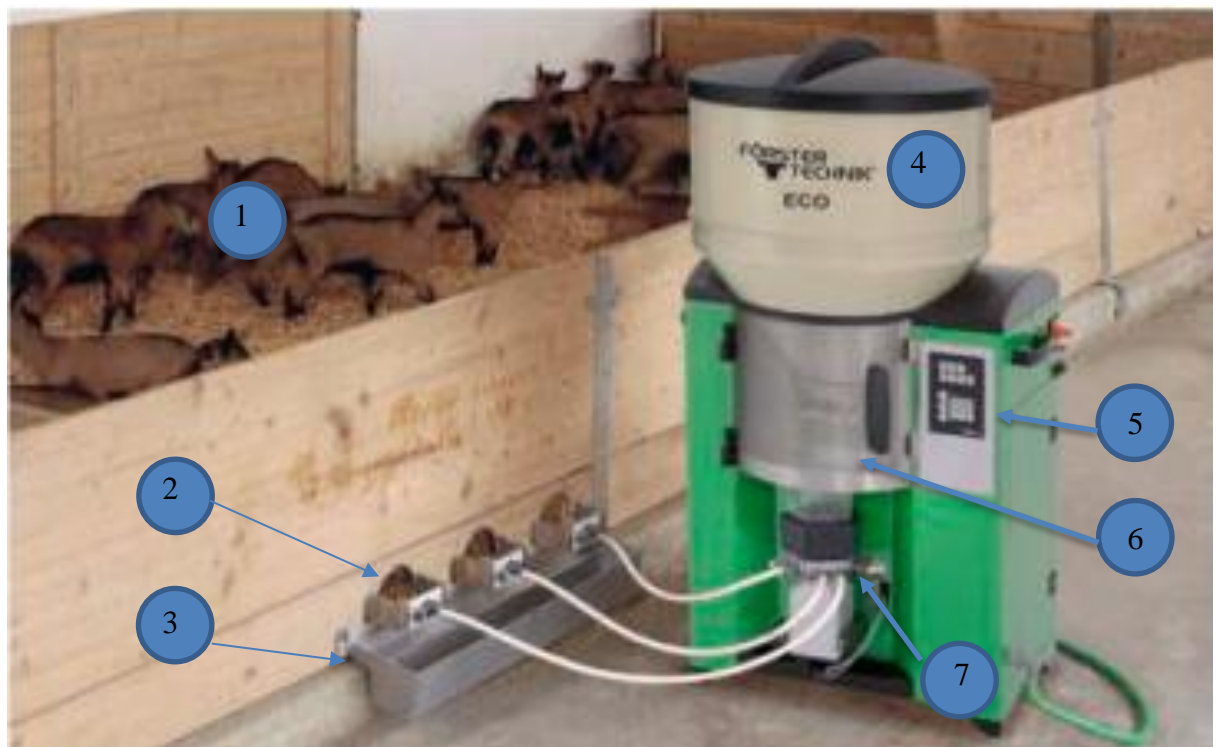
Fig. 1.6: Automatic Lamb Feeder: 1 – Lambs, 2 – Front plate, 3 – Spatter collector, 4 – Milk substitute container, 5 – Control Unit, 6 – Flies protection, 7 – Mixer (https://pdf.agriexpo. online/es/pdf-en/foerster-technik-gmbh/automatic-lamb-feeder-eco/171678-40174-_4.html)

The general characteristics are the following ones:

Capacity of the powder tank:	35Kg
Heat output	2,8 kW (240V); 3,2 kW (230V); 5,0 kW (400V)
Feed preparation	2,5-3 l/min
Feeding stations	6–8
Number of lambs	20–30 per feeding station
Dimensions	52×64×114 cm
Weight	34 kg

Standard equipment:	-Electronic heating regulation with minimum temperature monitoring -Water level indicator
Accessories:	-Fly protection -Mixer heating -Water tank -Height adjustable front plate with teat

Table 1.1: Automatic lamb feeder general characteristics.

This mixer has 3 different models, the main variation between them it is his power and the power supply:

Machine type	TAPS-EZ2-26	TAPS-EZ2-32	TAPS-EZ2-50
Heat output (kW)	2,8	3,2	5,0
Elecrical Connection	240V/L1, L2/Grd/60Hz/15 A	230V/L/N/PE/50Hz/16A	230V/400V/3/N/PE/50Hz
Max. feeding stations	6	6	8

Table 1.2: Models of automatic lamb feeder

As we can see in the specifications one station is able to feed up to 30 lambs, with a production of 2'5-3L per station, but if is needed to feed more lambs. Depending on the model we can install until 8 feeding stations.

One of the things that we can notice from these characteristics is the supply voltage. Depending on the machine type that we choose we need different electricity supply voltage. For the 5 kw power machine is need a three-phase connexion. It is a common voltage for industrial machines, so I suppose that it is the main reason for having this requirement.

After talking about the general characteristics, we are going to talk about the specific parts of the machine. First of all, we are going to talk about the ones that we see in the **¡Error! No se encuentra el origen de la referencia.**.

1. Lambs (**¡Error! No se encuentra el origen de la referencia.**): It could be from a sheep or from a goat or any medium mammal animal. The animals just have to suck the teat to get the food. This machine is designed for been used in farms that have many labs because it reduces the amount of time that you need to take care of the animals, because you just have to check if the machine is working for its feeding.

2. Front Plate (**¡Error! No se encuentra el origen de la referencia.**, **¡Error! No se encuentra el origen de la referencia.**): The front plate is made from metal and a rubber teat.
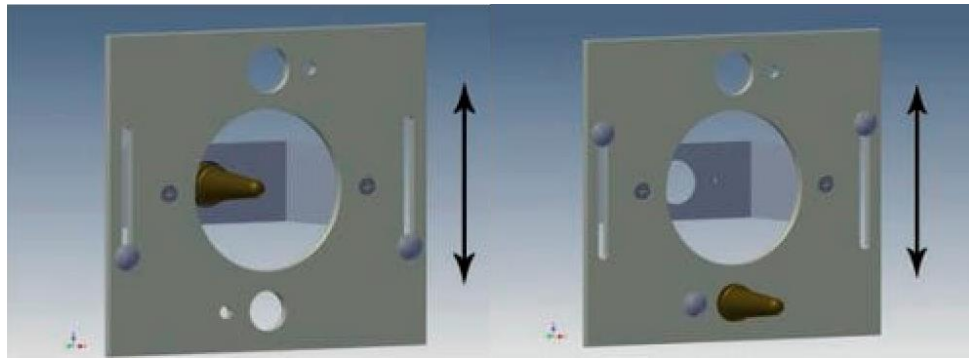
Fig. 1.7: Front plate (https://pdf.agriexpo.online/es/pdf-en/foerster-technik-gmbh/automatic-lamb-feeder-eco/171678-40174-_2.html)

As we can see in the picture, the plate is designed for putting the teat and plate in different positions making possible to fit to every stage of the lamb growth.

3. <u>Spatter Collector</u> (**¡Error! No se encuentra el origen de la referencia.**): As it name says this part is used for preventing the food to go all over the floor so we can keep the place clean.

4. <u>Milk Substitute Container</u> (**¡Error! No se encuentra el origen de la referencia.**; **¡Error! No se encuentra el origen de la referencia.**): The container has a capacity of approximately 35 kg. The milk substitute powder is protected from exterior agents thanks to its top cover.

Fig. 1.8: Milk substitute container (https://www.agriexpo.online/es/prod/foerster-technik-gmbh/product-171678-28045.html)

5. <u>Control Unit</u> (**¡Error! No se encuentra el origen de la referencia.**; **¡Error! No se encuentra el origen de la referencia.**): The control is has 13 buttons and a display. Inside of it may have a microprocessor with a little memory that make all the operations and it is in charge of the correct operation of the machine.

Fig. 1.9: Control Unit (https://www.agriexpo.online/es/prod/foerster-technik-gmbh/product-171678-28045.html)

The adjusting of the main parameters, amount of powder, water and temperature is easy thanks to the low buttons and display. Also, there is an option to prove that the amount of ingredients and temperature is correct by clicking the auto mode. Another functionality of the controller is giving information of the behaviour of the lambs to see if they are eating properly.

6. Flies Protection (**¡Error! No se encuentra el origen de la referencia.**; **¡Error! No se encuentra el origen de la referencia.**): This metal part keeps the flies out of the mixing jar.
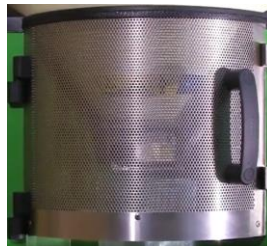
Fig. 1.10: Flies protection cover (https://www.agriexpo.online/es/prod/foerster-technik-gmbh/product-171678-28045.html)

7. Mixer (**¡Error! No se encuentra el origen de la referencia.**; **¡Error! No se encuentra el origen de la referencia.**): The mixer is one of the most complex parts of the machine. It is responsible of making the correct mix of powder and water.

Fig. 1.11: Mixer working (https://www.agriexpo.online/es/prod/foerster-technik-gmbh/product-171678-28045.html)

When it is need the engine on the bottom of the powder container activates, at the same time the water pump activates, and everything gets together in the mixer. During this process the motor of the mixer activates, so the food is ready.

The water is preheated in an electronic controlled boiler (**¡Error! No se encuentra el origen de la referencia.**) that supply the water always at the temperature that is required.

Fig. 1.12: Boiler (https://www.agriexpo.online/es/prod/foerster-technik-gmbh/product-171678-28045.html)
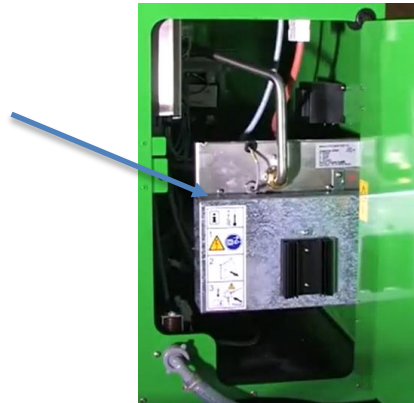
There is an optional accessory that is able to heat the food and maintain it at the right temperature all the time, even if the lambs do not dink during a long time.

1.3. Vertical Mixer with One Endless Screw and Conveyor Belt Model MV-8 10 12 14 18

In the medium and big domestic animal´s farms is usual to use a mix of different foods in it´s diet, they use to have different forms some of them are granular and others hay. The Vertical Mixer (**¡Error! No se encuentra el origen de la referencia.**) machine that is going to be analysed is focused in making this mix, loosen the hay and distribute the food.

Fig. 1.13: Vertical Mixer with one endless screw and conveyor belt MV-8 10 12 14 16 18; 1 – Power take-off; 2 – Hook; 3 – Hydraulic base; 4 – Manual controller; 5 – Leader; 6 –

Conveyor belt; 7 – Food container; 8 – Weel axis

(http://www.grupotatoma.com/producto.php/es/Mezclador-vertical-un-sinfin-con-cinta-descarga-MV-8/87)

Since the creation of the tractor the industry has progressed a lot, nowadays there are many machines principally for agriculture and livestock that can be adjusted to a tractor. This equipment usually takes the power from the tractor so having their own engine is not need, reducing the cost and maintenance. One of this machinery is the Vertical Mixer MV- (**¡Error! No se encuentra el origen de la referencia.**) **(**http://www.grupo tatoma.com/producto.php/es/Mezclador-vertical-un-sinfin-con-cinta-descarga-MV-8/87**)**.

The equipment that is going to be analysed has two principal designs, one with the conveyor belt at the front and other in the back part of the machine. The design that is going to be analysed is the one that has the conveyor part at the front, below in the **¡Error! No se encuentra el origen de la referencia.**. we can see its main characteristics **(**http://www.grupotatoma.com/producto.php/es/Mezclador-vertical-un-sinfin-con-cin ta-descarga-MV-8/87**)**.
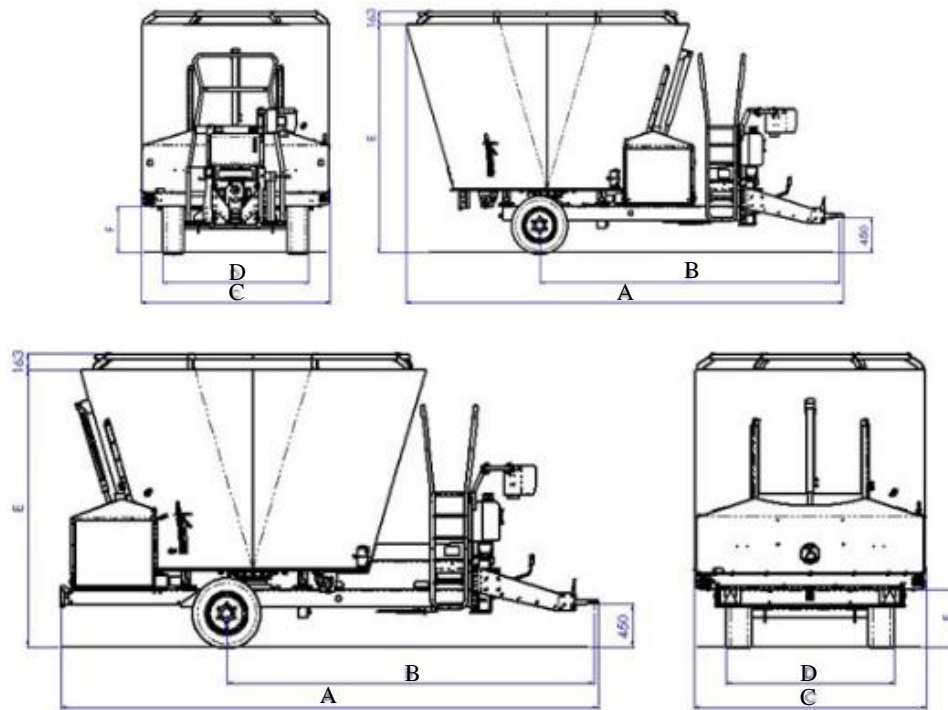
CINTA DELANTERA	MV8	MV10	MV12	MV14	MV16	MV18
CAPACIDAD m³	8	10	12	14	16	18
POTENCIA CV	65	70	75	80	85	90
NEUMATICOS	12,5/60-15	12,5/60-15	12,5/60-15	445/45-19,5	8/15/15 twin	445/45-19,5
A mm	5484	5520	5634	5694	5778	5855
B mm	3859	3859	3859	3859	3859	3859
C mm	2300	2300	2435	2435	2437	2600
D mm	1875	1875	1875	2042	2120	2242
E mm	2556	2676	2833	3143	3293	3403

Fig. 1.14: Vertical mixer MV technical characteristics (http://www.grupotatoma.com/produc to.php/es/Mezclador-vertical-un-sinfin-con-cinta-descarga-MV-8/87)

We can see (**¡Error! No se encuentra el origen de la referencia.**) that depending on the model, the power of the tractor required (CV) changes, also we can see that the volume is proportional to the power.

Next, we are going to explain the different parts of the machine.

1. Power take-off (**¡Error! No se encuentra el origen de la referencia.**): A cardan join (**¡Error! No se encuentra el origen de la referencia.**) is connected to this part and to the tractor to transmit the power to the machine.

Fig. 1.15: Cardan join and power take off (https://www.tractoresymaquinas.com/transmision-de-potencia-en-el-tractor/)

The power take-off is carrying the power to a gearbox that transform the rotational power into hydraulic power. This hydraulic power is transmitted by circuit to all the actuators of the machinery through a hydraulic system.

2. <u>Hook (**¡Error! No se encuentra el origen de la referencia.**)</u>: As we can see in **¡Error! No se encuentra el origen de la referencia.** this part of the equipment is part of the chassis. It is hitch up to the tractor so when the tractor moves, the rest of the machinery moves.

3. <u>Hydraulic base (**¡Error! No se encuentra el origen de la referencia.**)</u>: This base is useful for connect the equipment to the tractor through the hook. Also is used during the load of the food when the tractor is not joined.

4. <u>Manual Controller (**¡Error! No se encuentra el origen de la referencia.**)</u>: This controller (**¡Error! No se encuentra el origen de la referencia.**) is connected to the electric system of the machinery, it allows you through a scale with 4 weighting cells, to measure the amount of food that you add to the mixer. The controller can have up to 15 different weight ingredients indications.

Fig. 1.16: Manual Controller
(https://www.youtube.com/watch?v=WRDfR5v2OO8&list=UU2T _U1o_MWTGGTD2r-M9MhQ)

Also in order to facilitate the control of the equipment it has a remote control that you can use from the tractor cab (**¡Error! No se encuentra el origen de la referencia.**).

Fig. 1.17: Remote control (https://www.youtube.com/watch?v=WRDfR5v2OO8&list= UU2T_U1o_MWTGGTD2r-M9MhQ)

5. Leader (**¡Error! No se encuentra el origen de la referencia.**): It is useful to see inside of the mix container. It is possible to use it from both sides of the machinery.

6. Conveyor belt (**¡Error! No se encuentra el origen de la referencia.**): This part has the function of taking out the food out of the container and sprayed in the animal's trough. We are going to differentiate three different parts and accessories to analyse it correctly. First of all it is going to be treated the entrance of the food to the conveyor belt (**¡Error! No se encuentra el origen de la referencia.**).

Fig. 1.18: Conveyor belt entrance door (https://www.youtube.com/watch?v=WRDfR5v2OO8 &list=UU2T_U1o_MWTGGTD2r-M9MhQ)

As we can see in the entrance, we have a sliding vertical door that is powered up by a hydraulic piston. This door communicates the container with the food with the conveyor belt. The endless screw which we will talk about later will be in charge of pushing the food through the door (https://www. youtube.com/watch?v=WRDfR5v2OO8&list=UU2T_U1o_MWTGGTD2r-M9MhQ).

Secondly, we are going to analyse the conveyor belt mechanism (**¡Error! No se encuentra el origen de la referencia.**):

Fig. 1.19: Conveyor belt mechanism and door
(https://www.youtube.com/watch?v=P6z82QJMzy0)

As we can see in the **¡Error! No se encuentra el origen de la referencia.** it is made out of metal, as all the equipment´s parts. It is composed by a static base and a moving mechanism. This mechanism consists of two lateral chains that are connecter to the power system, between them with metal bars that will drag the food (https://www.youtube.com/watch?v=P6z82QJMzy0).

To finalise it is going to be treated an accessory. It is not included in all the models but it is a very functional part for many installations. It is an additional conveyor belt connected to the other (**¡Error! No se encuentra el origen de la referencia.**).

Fig. 1.20: Additional conveyor belt with adjustable height
(https://www.youtube.com/watch?v= WRDfR5v2OO8&list=UU2T_U1o_MWTGGTD2r-
M9MhQ)

The main thing to address about this part is the capacity of regulate the exit height thanks to another hydraulic piston. This allows to adapt the machine to all kind of different installations, not only the ones with the trough in the floor (https://www.youtube.com/watch?v= WRDfR5v2OO8&list =UU2T_U1o_MWTGGTD2r-M9MhQ).

7. Food container (**¡Error! No se encuentra el origen de la referencia.**): The food container depending on the model of machine that we use is different, but it´s characteristics are very similar.

The containers are opened at the top, so the farmer can fill it with the tractor shovel (**¡Error! No se encuentra el origen de la referencia.**).

Fig. 1.21: Container filling (https://www.youtube.com/watch?v=WRDfR5v2OO8&list=UU2 T_U1o_MWTGGTD2r-M9MhQ)

Inside of the container we have a conic endless screw (**¡Error! No se encuentra el origen de la referencia.**) with serrated blades that oversees the division and mixing of the food.

Fig. 1.22: Conic endless screw (https://www.agriexpo.online/es/prod/tatoma/product-170384-8813.html)
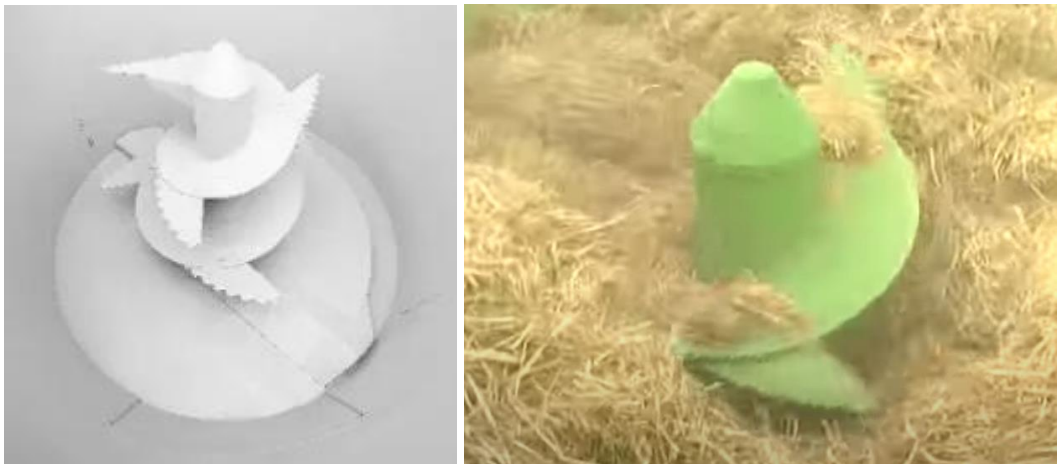
When the food is mixed the screw keep spinning during all the process of feeding. When the process has finish there is another sliding vertical door at the back (**¡Error! No se encuentra el origen de la referencia.**) of the machine, so the cleaning is easier.
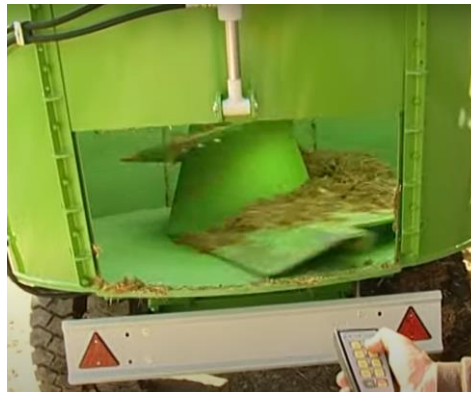
Fig. 1.23: Back door (https://www.youtube.com/watch?v=WRDfR5v2OO8&list=UU2T_U1 o_MWTGGTD2r-M9MhQ)

1.4. Substantiation of the decision

It is well known that taking care of animals is a work that requires of many sacrifices. It is not only the cleaning of the place or taking care of its´ health. Also, there is a need of going to the farm to feed the animals at least twice a day and there is no way of skip it. This sometimes is hard or even impossible, because of the bad weather the farmer illness or other unexpected situations. This is the main reason to create an automatic feeder.

For big farms and intensive livestock farming is usual to have industrial automatic feeders or machines that help the farmers in the process of feeding the big number of animals like the machines in the 1.2 and 1.3 subchapter. The feeder that is going to be designed is not focus on the named industries that may have more than one worker and have more resources. The animal that we are going to focus on is the horse. In Spain is usual to see small horse's farms. The principal use of this farms is the leisure and usually just have one person in charge of the farm, so the situations when the farmer couldn´t go occur more frequently.

The horses usually have two kind of food hay and granular, the feeder is focus on the last. These animals usually live in two forms in these farms one is inside of enclosures and the other, in which we are going to focus is inside a stable. In the stables the horses are not supposed to have access to the principal part of the feeder, they would just see the food coming out of a hole in the wall. Inside the stable the feeding trough should at a height between 1.00 and 1.20 m for horses and 0.55 and 0.90 m for ponies. These heights will have influence in the design of the feeder. Despite of been focused on the stables horses this machine could be used for the others kinds of forms of having horses.

The main mechanism of the feeder is going to be an endless screw powered by an DC engine, that will move the food from the container to the position were the food will fall in the horses´ trough. This endless screw will have a 35º inclination, this inclination is due to the height that has to reach the end of the endless screw. If the endless screw is horizontal, and we want to have the maximum

container volume, we would have the top of the container at a higher height. In order to facilitate the container filling without leader or others tools we want the smaller height as far as possible, so the farmer can fill it just with the use of a bucket.

Figure of the feeder

The choose of an endless screw instead of the conveyor belt (subchapter 1.3) or other mechanism, is because the endless screw do not have much space between the end of the screw and the back plate that separates the screw and the transmission. Also, this mechanism provides a constant flow of food and can go with a cover that avoid the entrance of non-desired particles that could pollute the food.

For the measurement of the food that is provide in each meal the first option was to have a scale in the trough and connect it to the controller. But considering that horses have a lot of strength they could break them too easily. This is why we have opted for not using this system and measure the amount of food in function of the time due to the practically constant flow of the food through the endless screw as in the Lamb automatic feeder (subchapter 1.2.).

The food container is going to have a cubic form but the edges will be rounded so the food do not get stuck in them. The minimum inclination of all the container parts is 45º to avoid the food to get jammed. At the bottom of the container will be a hole that will be connected with the endless screw.

This machine is designed for horses but will be possible to use it for other animals as the operation condition could be the same or similar for other animals.

2. CALCULATION OF PROJECT

To do a good design and choosing the correct calculation of the different elements we need to start from the actuator, in this case the endless screw. After knowing the work conditions, we will be able to choose the engine and transmission.

2.1. Calculation of the endless screw

This calculation is going to be done by following the steps from the following guides: (https://ingemecanica.com/tutorialsemanal/tutorialn143.html; http://opac.pucv.cl/pucv_txt/Txt-4500 /UCC453801.pdf; https://www.udocz.com/apuntes/111773/calculo-tornillo-sin-fin).

First of all, we have to know the class of the materials that are going to be carried out. There are five material classes:

1. Nonabrasive, density between 0.4 and 0.7 t/m³, flow easily, mainly powdery materials
2. Nonabrasive, density between 0.6 and 0.8 t/m³, flow easily, presented in grains or small sizes materials.
3. Semi abrasive, density between 0.6 and 1.2 t/m³, small size materials mixed with powdery.
4. Semi abrasive, density between 0.8 and 1.6 t/m³, small size or granular materials mixed with powdery.
5. Abrasive materials.

As we do not know specifically the kind of material that is going to be used as horse food. We are going to calculate the mechanism as if it is going to be used for materials in the class number 4, the most restrictive one. The chose is due to the kind of material can be powdery or granular, and also the density, some foods are compressed so they can reach a high density. If the calculation of the screw is more restrictive they could still work in less restrictive conditions. The class number 5 materials are not suitable for it use in endless screws.

Now we are going to proceed to the calc of some general parameters:

- Fillling area of the transporter (S):

$$S = \frac{\pi \cdot D^2}{4} \cdot \lambda \tag{2.1}$$

where D – Transporter cylinder diameter; λ – Filling coefficient of the section, this coefficient depends on the type of material that is going to be use.

Type of material	λ
Heavy and abrasive	0,125
Heavy and less abrasive	0,250
Light and less abrasive	0,320
Light and nonabrasive	0,400

28

Table 2.1: λ parameter for the different types of material.

In our feeder we are going to have a diameter of 0.12m. The toughest working conditions will be with heavy and less abrasive materials so the λ will be 0.25. If we insert these parameters in the equation we are going to get the filling area of the transporter.

$$S = \frac{\pi \cdot D^2}{4} \cdot \lambda = \frac{\pi \cdot 0.12^2}{4} \cdot 0.25 = 0.00283 \; m^2 \qquad (2.2)$$

- Transporter travel speed (v):

The transporter travel speed is the velocity of movement of the food inside of the endless screw. We will be able to know it after solving the following equation:

$$v(\frac{m}{s}) = \frac{p \cdot n}{60} \qquad (2.3)$$

where p – Pitch of the screw; n – rotation speed in rpm.

First of all we need to define the rotation speed of the screw, in the general data the velocity given is 0.3 rad/s so we have to pass it to rpm:

$$n(rpm) = \frac{0.3 \; rad}{1 \; s} \cdot \frac{60s}{1 \; min} \cdot \frac{1rev}{2\pi rad} = 2.86 rpm \qquad (2.4)$$

This velocity will be too slow and give one meal will take so long, so we are going to increase this velocity up to 12.2 rpm.

Secondly is going to be defined the pitch of the screw, depending on the use there is a need of using different types of screws. For our endless screw as it is going to be used for solid materials and it has inclination is recommended to use a measurement of the half of the screw diameter. In this case the diameter of the screw is 0.10 m. It is 2 cm less than the transporter cylinder diameter so the screw do not touch the cylinder. The pitch is 0.05 m.

Replacing the data inside of the equation:

$$v(\frac{m}{s}) = \frac{p \cdot n}{60} = \frac{0.05 \cdot 12.2}{60} = 0.01 m/s \qquad (2.5)$$

- Flow of material (Q):

The flow of material is the amount of food in tons that the screw is able to move in one hour:

$$Q = 3600 \cdot S \cdot v \cdot \rho \cdot i \qquad (2.6)$$

where S – Filling area of the transporter; v – Transporter travel speed; ρ – Density of the material; i – Flow reduction coefficient due to the inclination.

The data of the S and the v are known. Now we are going to proceed to calculate and deduct the others.

The density of the materials that are going to be carried depends on each food, some of them has a density of 0.65 t/m^3 for example the ones of the company Royal Horse (https://www.royal-horse.com/es/alimentacion-caballos/h200-alimento-granulado-caballos-competicion/), but its

density can be different if the manufacturer compacts more the elements, so we are going to take a density of 0.9 t/m^3.

The flow reduction coefficient depends on the inclination. Our endless screw will have an inclination of 35º, so the coefficient takes the value of 0.2.

Substituting into the equation:

$$Q = 3600 \cdot S \cdot v \cdot \rho \cdot i = 3600 \cdot 0.00283 \cdot 0.01 \cdot 0.9 \cdot 0.2 = 0.018 t/h = 0.306 \ kg/min \quad (2.7)$$

After getting all these parameters is possible to calculate the power that is need to action the endless screw.

- Drive Power:

The total drive power is composed out of 3 different powers.

$$P = P_H + P_N + P_i \quad (2.8)$$

where P_H – Horizontal material displacement power; P_N – Power needs to move the screw without material inside; P_i – Power need for inclination screws.

Now we calculate the different powers separated:

Horizontal material displacement power:

$$P_H(kW) = C_0 \cdot \frac{Q \cdot L}{367} \quad (2.9)$$

Q is the flux of material, L the longitude of the screw and C_0 is the resistance coefficient of the material. To choose C_0 is given the next table:

Type of material	Value of C_0
Flour, sawdust, granular products	1,2
Peat, soda, coal dust	1,6
Anthracite, coal, rock salt	2,5
Gypsum, dry clay, fine earth, cement, lime, sand	4

Table 2.2: C$_0$ parameter depending on the material.

As we do not know which material is going to be moved, we are going to take the most restrictive material with a coefficient of 4.

$$P_H(kW) = C_0 \cdot \frac{Q \cdot L}{367} = 4 \cdot \frac{0.018 \cdot 0.86}{367} = 0.00017 kW \quad (2.10)$$

Power needed to move the screw without material:

$$P_N(kW) = \frac{D \cdot L}{20} = \frac{0.12 \cdot 0.86}{20} = 0.0052 kW \quad (2.11)$$

where D is the diameter of the cylinder and L its longitude.

Power needed due to the inclination:

$$P_i(kW) = \frac{Q \cdot H}{367} = \frac{0.018 \cdot 0.49}{367} = 0.000024 kW \quad (2.12)$$

Finally, we add all the powers:

$$P = P_H + P_N + P_i = 0.00017 + 0.0052 + 0.000024 = 0.006924 kW = 6.924 W \quad (2.13)$$

To move the screw is need at least 6.924 W. Once we know this data, we will be able to find and design the rest of the elements.

2.2. Choice of the motor

Arter doing research of the motors that could fit in the feeder the chosen one is the DC current motor EMG49 this motor is made out of an encoder, a motor and a 49:1 gearbox (http://www.robot-electronics.co.uk/htm/emg49.htm).

The main characteristics of this motor are the following ones:

Rated voltage	24V
Rated torque	16 kg/cm
Rated speed	122 rpm
Rated current	2100 mA
No load speed	143
No load current	500 mA
Stall Current	13 A
Rated output	34.7 W
Encoder counts per output shaft turn	980

Table 2.3: Motor EMG49 characteristics

The main characteristics accomplish with the specifications of the project. So, this motor is suitable for the feeder. Also one of the main things that drive to the choose of this motor is the encoder. With this encoder we will be able to measure its movement. This will make the control of the controller much easier.

In the Figure 2.1 we can see the graphical motor characteristics so we can see how the characteristics change during the different working conditions:
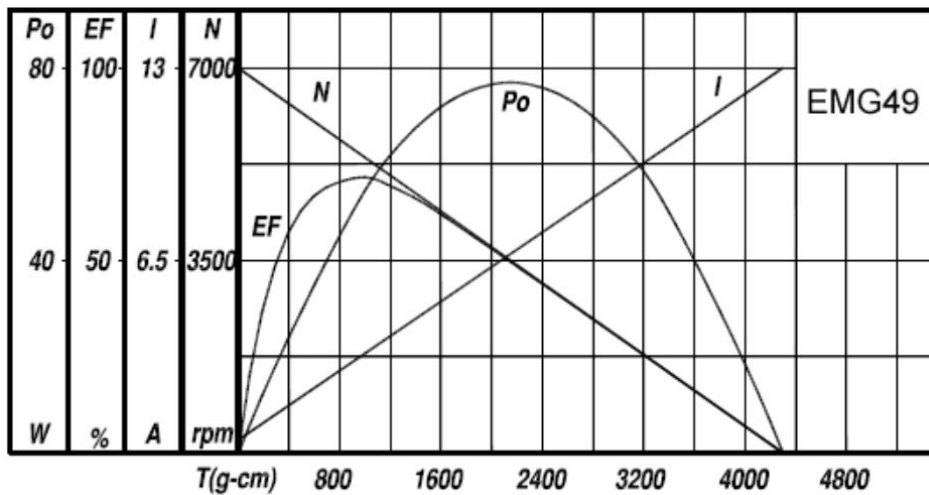
Fig. 2.1: EMG49 motor characteristics (http://www.robot-electronics.co.uk/htm/emg49.htm)

The motor uses two hall sensors that could be powered supplied by the controller. It has 4 connections, one for the control of each hall sensor and other two connexions for the Vcc and the ground. The motor has its own supply wires.

Also one important aspect to consider is the well defined dimensions and draws of the motor (Fig. 2.2), that will make the work much easier.
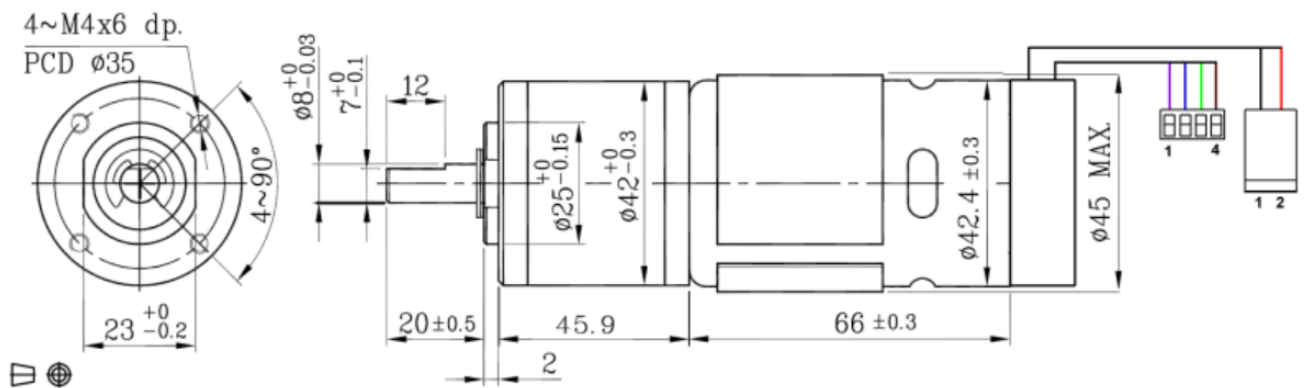
Fig. 2.2: Motor measurements (http://www.robot-electronics.co.uk/htm/emg49.htm)

The rated speed of this motor is not the working speed that we need for out endless screw, so we need another gearbox to adapt it to what we need.

2.3. Choice of the gearbox

We are going to work with the motor rated speed, which is the manufacturer indications, so we need to calculate the relation of sped and find a commercial gearbox.

First o all the relation of speed:

$$R_t = \frac{n_{out}}{n_{in}} = \frac{12.2}{122} = 0.1 \rightarrow 10:1 \qquad (2.14)$$

We need a 10:1 gearbox with an 8 mm axis hole. There wasn´t any specific gearbox for the motor chosen, but there is one that have an inlet diameter of 8 mm and a reduction relation of 10:1.

Also one of the main things to keep in mind is that the screws do not coincide with the motor so the placement of both will be suitable.

Fig. 2.3: Gearbox 10:1 (https://www.omc-stepperonline.com/es/caja-de-cambios-planetaria-de-la-serie-mg-relaci%C3%B3n-de-engranajes-10-1-contragolpe-30-arc-min-para-eje-de-8-mm-nema-23-motor-paso-a-paso-mg23-g10-d8**)**

The principal specifications of this gearbox are the following ones:

Manufacturer Part Number:	MG23-G10-D8
Gearbox type:	Planetary
Transmission ratio:	10:1
Efficiency:	90%
No-load backlash	≤ 30 arcmin
Maximum allowable torque	15 Nm (153 kg-cm)
Noise	≤60 dB
Waterproof rating	IP54
Lifetime:	20000 hours

Table 2.4: Gearbox characteristics

The main characteristic is the maximum torque that can reach. It is much higher than the torque that can produce the motor, so it will be a good gearbox and suitable for our project.

The efficiency is less than 100% so the power need is higher now:

$$6.924W = 0.9 \cdot Real\ Power \rightarrow Real\ power\ need = 7.69W \qquad (2.15)$$

The engine supply more power than is need so it does not have influence in the design of the feeder.

3. DESCRIPTION OF THE CONSTRUCTION AND OPERATIONAL PRINCIPLE

3.1. Kinematics scheme

In this chapter is going to be described the kinematic scheme (Fig. 3.1). It shows how are the different parts of the mechanism and its components. In the next picture it is show the different parts of the mechanism.
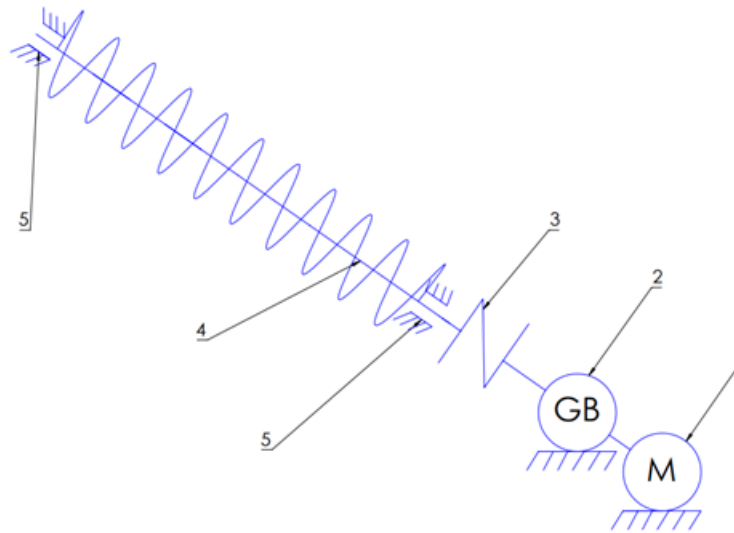
Fig. 3.1: Kinematic scheme

1. Motor EMG49: This motor has an 8 mm axis that rotate at a rated speed of 122 rpm.
2. Gearbox: It has a reduction of 10:1 and an output axis of 14 mm that move at a velocity of 12.2 rpm.
3. Join: Through it is transmitted the movement from the gearbox axis to the endless screw axis. The joining method is through a screw. The gearbox axis gets inside the endless screw axis, there are three screws that are perpendicular to both axes in order to fix one axis to the other. There is a thread in the endless screw axis so the screw can fit into an indentation in the gearbox axis shaft.
4. Endless screw: Its central axis has a diameter of 25 mm. Its outside diameter is 100 mm and the screw pitch is the half of the diameter.
5. Ball bearing: this bearing has the following datasheet (https://medias.schaeffler.es/es/producto/ soportes/soportes-brida-de-agujeros/pccj25/p/402901#Product%20Information). This bearing has a support that allows it to be fixed, an important characteristic in the feeder.

All this mechanism will have a 35º inclination.

3.2. Electric-block scheme

Before explaining the electric-block scheme (Fig. 3.2) we are going to show the picture of all the finished scheme, for doing it is been used the Kikad app, where is possible to create your own drawings and schemes.
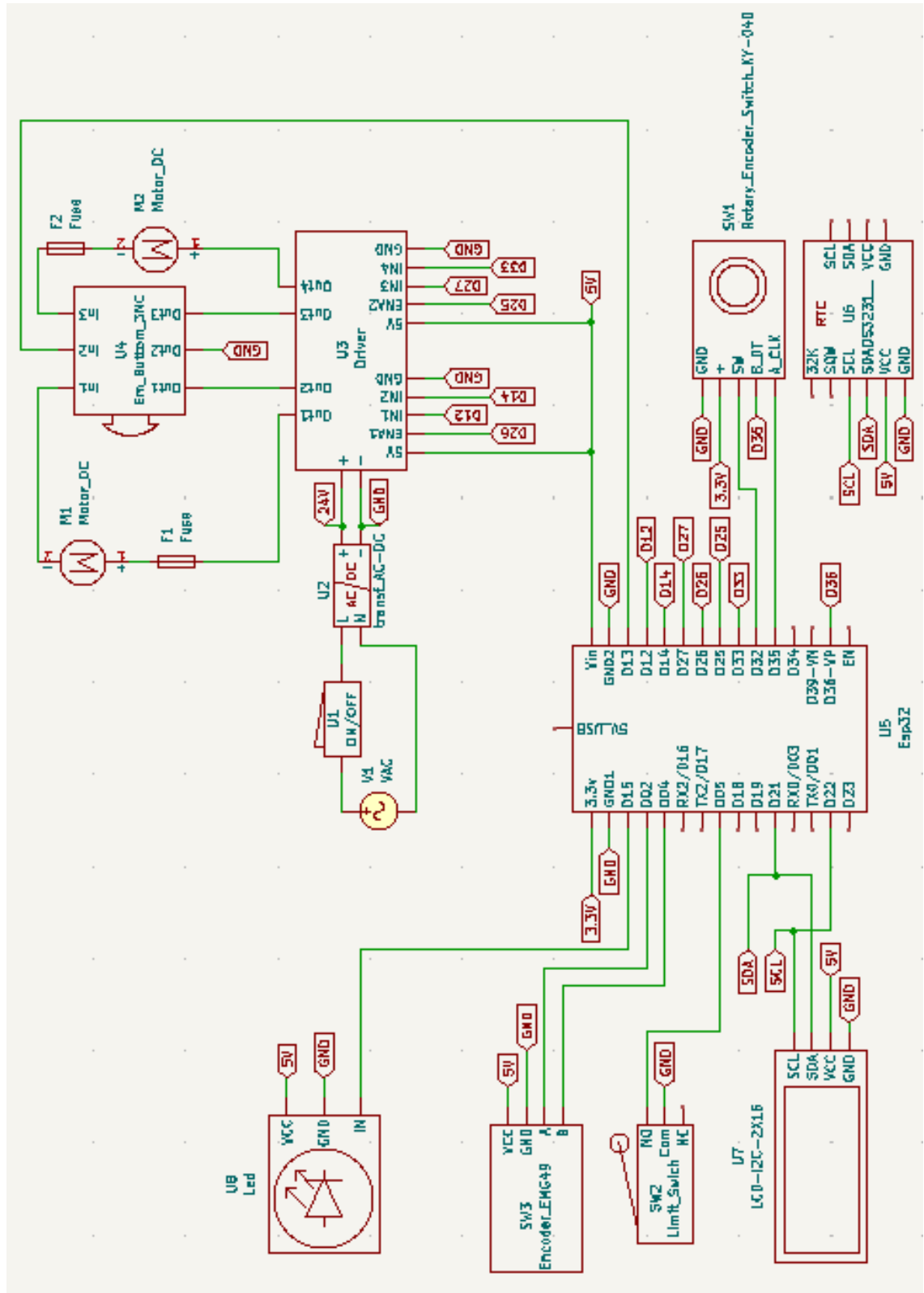

Fig. 3.2: Electric-block Scheme

After showing the complete scheme all the components are going to be analysed and there will be an explanation of every component and why is suitable for the circuit.

First of all is good to know that the principal motor EMG49 is the base of the circuit and all the other elements are focused in making the motor work properly. This motor needs a 24V and 13A continuous current supply.

The feeder is going to be connected to the general alternating current at 220 volts so a transformer is need. Between all the possible options the transformer that better adapts to our circuit is the following one in the figure 3.3. This transformer supply with 24V and up to 16.5A which is enough for our system, also one of the things that have driven to it's choose is it´s price.

Fig. 3.3: Transformer

(https://es.aliexpress.com/item/33015484435.html?pdp_npi=3%40dis%21EUR%21%E2%82%AC%2017%2C50%21%E2%82%AC%2012%2C95%21%21%21%21%21%402101d8b516801974849942695eae9c%2112000032443782461%21sh01%21%21&spm=a2g0o.store_pc_home.productList_2001834557655.subject_4)

In this kind of circuits, a fan is usually need for having a good refrigeration, the one that is been chose works at the same voltage as the EMG49, this is because if it would work in a different voltage another transformer would be necessary. Between all the models has been chose a fan that is not the biggest in order to save space inside of the electronics box.
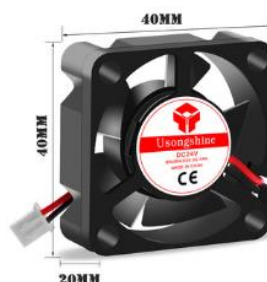
Fig. 3.4: 4020 FAN

(https://es.aliexpress.com/item/32972111881.html?spm=a2g0o.productlist.main.13.20244f34esza1F&algo_pvid=8d5df695-28f9-401d-82c6-a5487a0acaea&algo_exp_id=8d5df695-28f9-401d-82c6-a5487a0acaea-6&pdp_ext_f=%7B%22sku_id%22%3A%2212000023093174823%22%7D&pdp_npi=3%40dis%2

To control these motors is needed a driver (Fig. 3.5). The driver needs to have some requirements, it has to be able to supply 24V and 13A to two motors, also a 5V supply is need for the controller. The most common drivers are the L9110, L298N or the L297D. The chosen one is the L298N H bridge driver. The main characteristics if it is that it has a maximum current of 50A enough for the circuit and a rated current of 7A which can fit with the motors.

Fig. 3.5: Driver

For the controller at the beginning was going to be used an Arduino UNO, that could reach the objectives of this project. But due to its high price the chosen one is an ESP32 (Fig. 3.6) that is a more powerful controller but it´s price is less.

Fig. 3.6: ESP32

The feeder needs to know the time because its actions depend on the time. The Esp32 dev module has an internal RTC, but it would need to settle the hour every time that the feeder is started and if the power is switched off accidentally during its use the time will have a mistake. This is why an auxiliar RTC clock with its own battery is need.

The most common used RTC clocks are DS1307 and DS3231 (Fig. 3.7) they are very similar, but the main difference it´s its precision, the DS3231 have less error than the DS1307. The prices of both are very similar, so the chosen one is the DS3231.
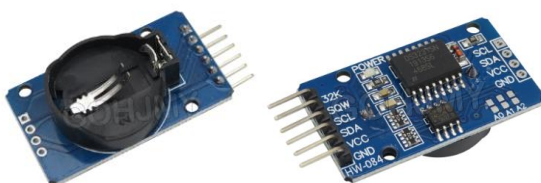
Fig. 3.7: RTC DS3231

The pins that are going to be used are the SDA, SCL, VCC and GND, the other pins are not needed for this project.

Once we have the basic elements for the supply and control of the motors, we need auxiliar elements for showing information, control the Esp32 and ensure that is safe to use the feeder.

Information elements:

For giving information of the state of the feeder we have one light, and a screen, the led (Fig. 3.8) that has been chosen is appropriate for its use in Arduino. It works at 5V and just need one connection pin to the Esp32:

Fig. 3.8: Led

This led will turn on if the system is switched on, also in case of emergency this led will be blinking.

The information screen is an I2C led screen (Fig. 3.9) with 16 columns and 2 rows. This screen will show information about the different operation modes. The farmer will be able to change and made the different adjustments by looking at this screen that will have a menu.
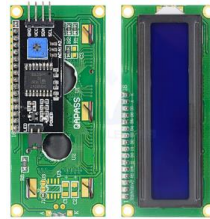
Fig. 3.9: I2C led screen

There will be necessary a power supply of 5V and to GND. Also, for the connexion and control of the screen is needed to connect the SDA and SCL pins to its respective ones in the Esp32.

Control elements:

For the control for browsing in the menu and change the different parameters at first were going to be three push buttons one for going up, another for going down and the last an OK button for selection. But this control may be too slow for changing some parameters, so a change was needed. The new control swich is a rotary encoder that also can be pushed for selection. This rotary encoder is the Keyes KY-040 (Fig. 3.10).

Fig. 3.10: Keyes KY-040

As we can see it has 5 pins, 2 for the supply power (5V), 2 for the control of the encoder CLK and DT, and the last one SW for detect if the encoder is pushed down.

The next three elements are switchers with different functions.

Fig. 3.11: ON/OFF button (https://int.rsdelivers.com/product/rs-pro/rs-pro-illuminated-dpst-on-none-off-rocker-switch/1858229**)**

The ON/OFF button (Fig. 3.11) is need as its name says to switch on the power of the machine. Inside of the circuit this is the first element if you look from the AC supply, it is in charge of isolate the circuit when the feeder is not working.

Fig. 3.12: Limit switch (https://int.rsdelivers.com/product/omron/d4mc-1000/omron-lever-limit-switch-no/nc-ip67-spdt-480v-ac-max-ac-3-a-dc-250ma-max/7529980**)**

The limit switch (Fig. 3.12) is located in the top of the feeder, it detects if the top cover of the feeder is close, so anything can get inside of the container while the endless screw is working. The main characteristic of this element is that as it will be outside of the electric box it has IP67 to ensure the correct working. It will be connected to the Esp32.

Fig. 3.13: Emergency 3NC button (https://int.rsdelivers.com/product/eao/61-64414067/eao-61-compact-series-red-emergency-stop-push-3nc/1702227**)**

The emergency button (Fig. 3.13) as the limit switch will not be inside of the electric box so it has IP67 protection. In case of emergency if it is pushing the motors will be disconnect and the Esp32 will receive a signal.

The last elements to analyse are the fuses for the protection of the motors. The fuses will be two 13A cartridges fuses (Fig. 3.15) with a double fuse holder (Fig. 3.14).

Fig. 3.14: Fuse Holder

(https://es.aliexpress.com/item/4001257581604.html?spm=a2g0o.productlist.main.43.a3831f7cdSb
SUm&algo_pvid=715f7b39-f586-4569-a184-defce03a95a8&algo_exp_id=715f7b39-f586-4569-
a184-defce03a95a8-
21&pdp_npi=3%40dis%21EUR%211.83%211.83%21%21%21%21%21%4021224cdb1681398537
0441846d070a%2110000015492603299%21sea%21ES%212287947606&curPageLogUid=YuptrZ
CYAf84)

Fig. 3.15: Fuse

(https://es.aliexpress.com/item/4000772424401.html?spm=a2g0o.productlist.main.5.37b872d3UC5
atM&algo_pvid=f09b9ad7-0594-40cb-842c-d3166c7b5fd1&algo_exp_id=f09b9ad7-0594-40cb-
842c-d3166c7b5fd1-
2&pdp_npi=3%40dis%21EUR%211.33%210.93%21%21%21%21%21%4021224cdb16813987793
045208d070a%2110000007734887957%21sea%21ES%212287947606&curPageLogUid=wj0FXx
bWP8fL)

All this elements are going to be connected between them using a protoboard that will be very helpful principally in the power supply of the different elements.

3.3. Controlling scheme

In the Figure 3.16 we can see all the elements and interconnexion of them. In this subchapter we are going to focus on the controller (Esp32) and the pin assignment. Because depending on the type of signal the pin needs to have different characteristics. First of all is need to analyse the Esp32 pins and its characteristics. In the next figure (Fig. 3.16) are show all the pins and its functions.

Fig. 3.16: Pin map (https://acortes.co/tutorial-esp32/)
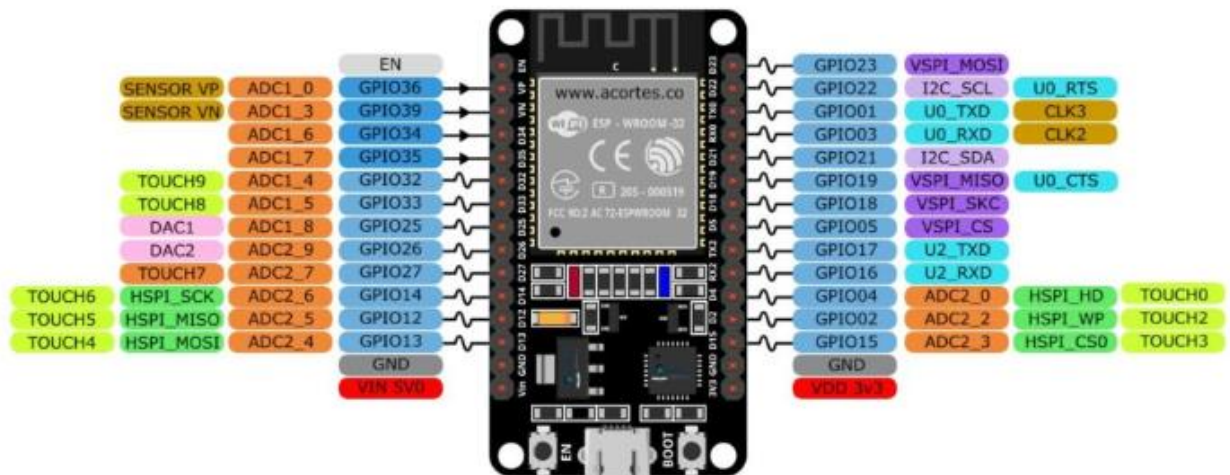
The meaning of all the abbreviations are the next:

- **GPIOX WITH AN ARROW:** These pins just can receive digital signals, they cannot send it.

- **GPIOX:** Through this pins is possible to send and receive digital signals.

- **ADCX_CH:** Analogic to digital converter, this pins can interpret analogical signals and convert them to digital so the processor can understand them.

- **EN:** Enable.

- **SENOIDAL SIGNAL:** This pins have the capacity to transmit digital PWM signals.

- **HSPI:** For SPI (Serial Peripheral Interface) communication. By using this pins is possible to make a synchronism communication between two devices.

- **TOUCH:** This pins have a capacitive sensor that can detect if it´s been touch, without using any auxiliar mechanic elements.

- **VSPI:** For SPI communication. (Same function as HSPI)

- **I2C:** For I2C (Inter-Integrated Circuit) communication. These pins are for communicate the Esp32 with one or more I2C devices with different address at the same time. This communication is also synchronous.

- **UART (light blue):** UART (Universal Asynchronous Receiver Transmitter) communication.

- **DAC_X:** Digital to analogic converter. This pins are able to transmit a complete PWM wave unlike the PWM signal that the digital pins send, that just have 2 labels.

- **GND:** Ground**.**

- **VIN 5V0:** 5V power.

- **VDD 3V3:** 3´3V power

Once all the different functions and pins have been explained we are going to show and explain the election of the different pin connexions (Fig. 3.17). The tags have changed respect the previous figure 3.16 to facilitate the understanding of the wires showing the different parts of the circuit separate:
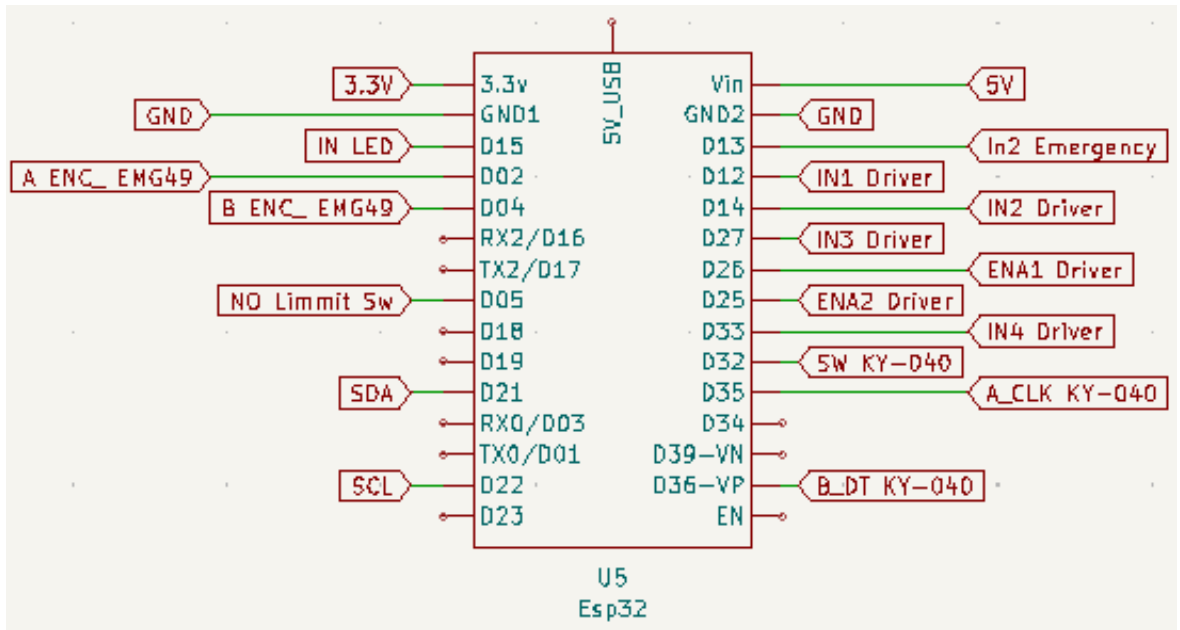
Fig. 3.17: Esp32 connections scheme

Now we are going to explain the different elements that communicate with the Esp32 separating them into small groups.

- Driver and Emergency button:
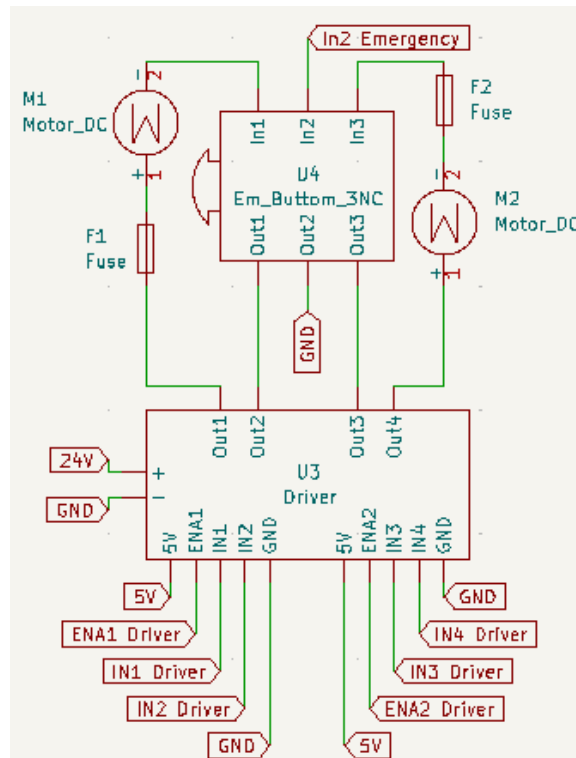
Fig. 3.18: Driver and Emergency Button connection scheme

The driver has 6 connections with the Esp32, we can split it in two groups, for the two motors. ENA1, IN1, IN2 for motor 1 and ENA2, IN3 and IN4 for the second motor. This driver can regulate the rotation speed of the motor through the ENA pins that need a PWM signal. The Esp32 has two different types of PWM signals digital and analogic, the analogic has the full range of values between the up and low voltage, so it is more exact. As these elements are one of the most important of the circuit the pins that are going to be used are the number GPIO25 and GPIO26 with an analogic PWM pulse. The inputs 1, 2, 3 and 4 regulate the direction of rotation by changing the digital value so just need a normal GPIOX pin. In the figure 3.18 we also can see the Emergency button, it has 3NC switcher that are connected to both motors and the Esp32. As through this pin just need to know if the circuit is open or not there is needed a usual GPIOX.

- RTC and I2C Led Screen (Fig. 3.19 and Fig. 3.20):
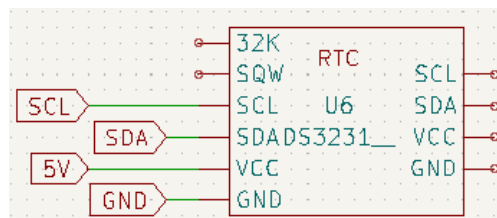
Fig. 3.19: RTC connection scheme
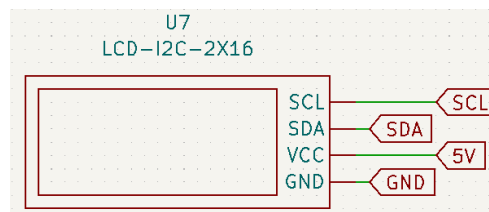
Fig. 3.20: I2C Led Screen connection scheme

These two elements need to be analysed together because they use both I2C communication. The Esp32 just have two I2C pins, GPIO21 (SDA) and GPIO22 (SCL), so both components need to be connected to the same pins. This is possible because the I2C devices have different address, so the Esp32 can identify from which of the elements is receiving or sending information.

- Rotary Encoder Keyes KY-040
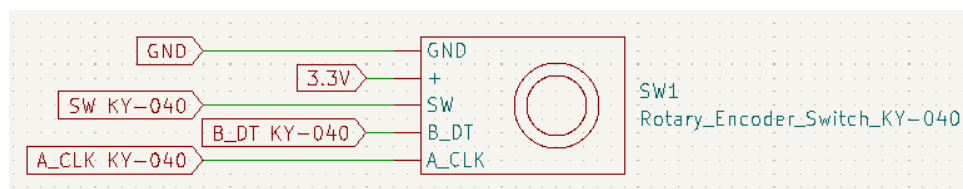
Fig. 3.21: Rotary Encoder KY-040 connection scheme

This rotary encoder (Fig. 3.21) has three outputs that go connected to the Esp32. The A and B outputs give an analogic signal, so need to be connected to an ADCX_CH that can read this signals.

The SW pin is an NO switch, it just need to identify digital signals, so it just need connexion to a usual GPIOX pin.

- Led:
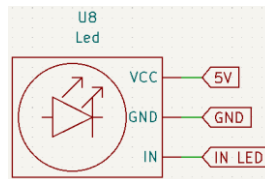
Fig. 3.22: Led connection scheme

This led (Fig. 3.22) just need a GPIOX connection pin in the Esp32 that will be able to send a signal to turn on the light. If this signal is a PWM the led will regulate the intensity of the light, in this project is not going to be use this function, but as we had the option of connect it to a pin that can send PWM signals we have done it.

- Encoder EMG49:
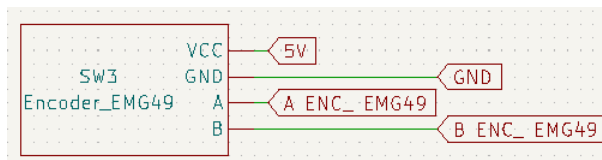
Fig. 3.23: Encoder EMG49 connection scheme

This encoder is part of the motor EMG49 (Fig. 3.23), but it works as an electronic independent part. It is powered by 5V, the motor uses 24V. This encoder through a hall sensor encoder gives information about the position of the motor in each moment. The signal is going to be connected to a GPIOX that also can read analogic signals.

- Limit Switch:
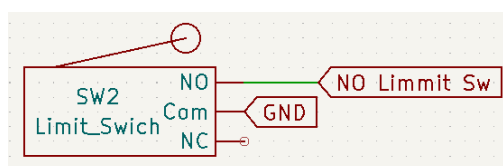
Fig. 3.24: Limit switch connection scheme

This limit switch (Fig. 3.24) has two possible operation modes, NC and NA, we are going to use the NO option as we want to detect a low signal when the switch is not pushed by the top container cover. The limit switch will be connected to a usual GPIOX pin in the Esp32.

With this pin map the Esp32 will be able to have a good performance achieving all the goals and specifications needed for the feeder.

3.4. Algorithm of management of device or node

As the UML algorithm of management is too big to show It in just one picture, It is going to be explained splitting it in different parts. It also will explain additional information, to facilitate the correct understanding of the algorithm.
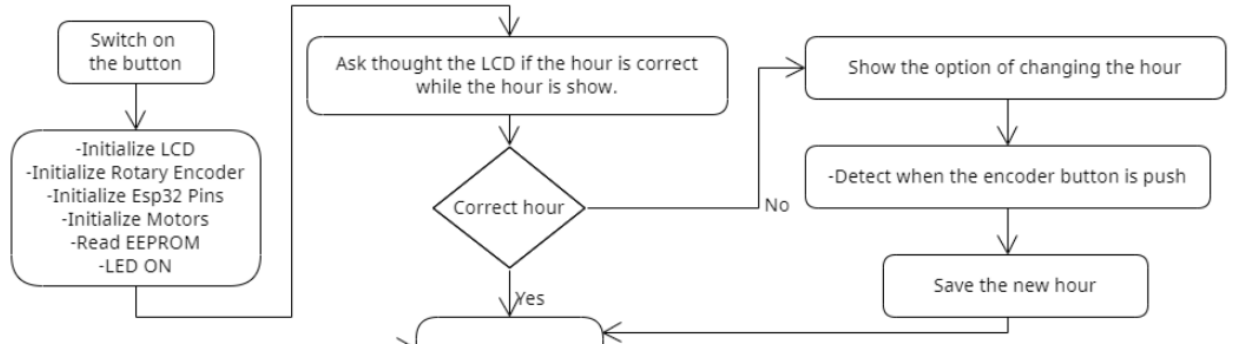
Fig. 3.25: First part of the diagram.

In the picture we can see the first part of the diagram. When the user start the machine all the different electronic elements of the feeder initialize. The EEPROM is the permanent memory of the Esp32. In the memory is saved the previous configuration of the feeder with all the hours and time. Also, the led switch ON to indicate that the machine is ON.

After this, there will be a message in the LCD asking the user if the hour is correct, while the hour is show in the second row of the LCD. Then an option menu will appear, if the user says that it is good with the rotary encoder the program will enter in the main loop. In case of been bad the option of changing the hour appears. The user can modify it with the encoder and when the encoder button is pushed the hour is saved and the programme enters in the principal loop.
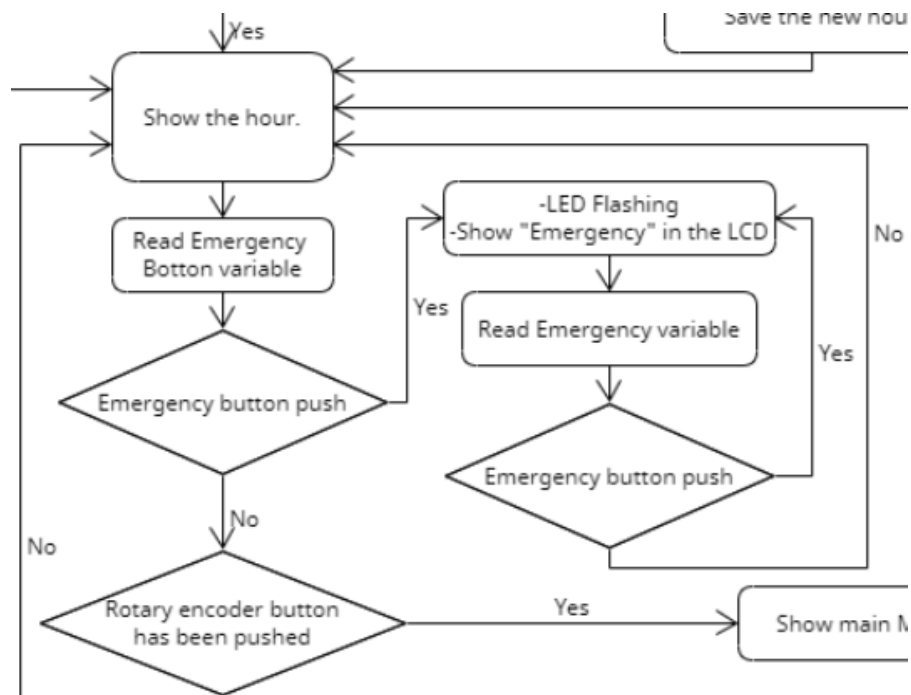
Fig. 3.26: Second Part of the diagram

In second place we can see the first part of the principal loop. This part is focus on the safety as the system check if the emergency button is push. In case of having the button push the LED will begin blinking until the emergency button is released while show at the same time the emergency text in the LCD. Once the button is released, we will go to the principal loop state and show the hour.

If the emergency button is not push the programme go to the next condition that is checking if the encoder button has been push.
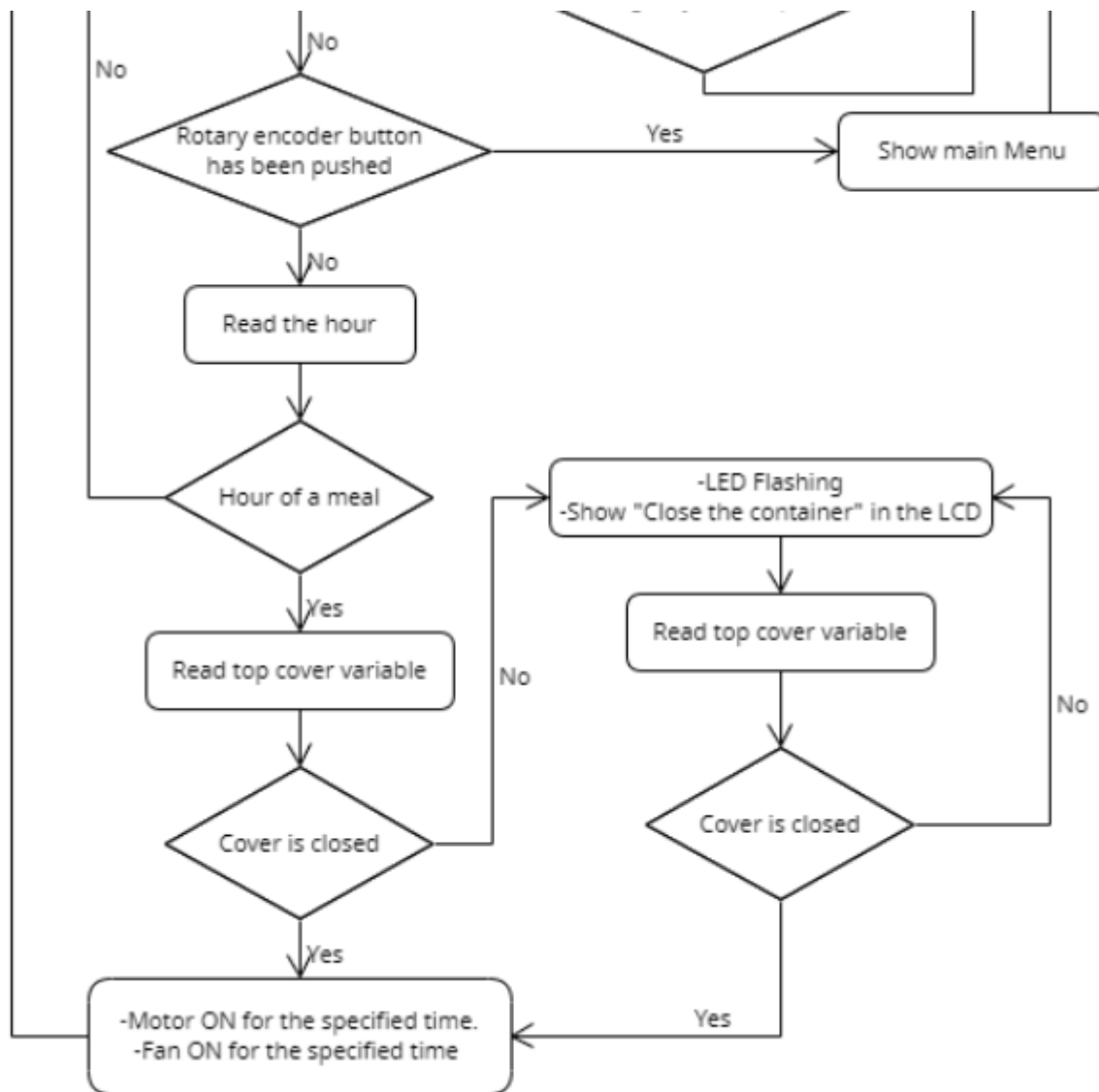
Fig. 3.27: Third Part of the diagram

Depending on whether the user has pressed the encoder button or not, we have two paths. The previous image shows the way to follow in case of not having pressed the button, which will be the one normally performed. The system compare the actual hour with the different meals hours and if none of them matches the flow will go to the first principal loop action.

In case of match the hour, before activating the motors the system check if the container is closed so no one can put his hand next to the endless screw avoiding injuries. In case of not been close the procedure is similar as with the emergency button, but this time when the cover is on the

motors switch on. Through the motor encoder the system ensure that the motor is moving. When the specified time has ended the system goes to the principal loop.
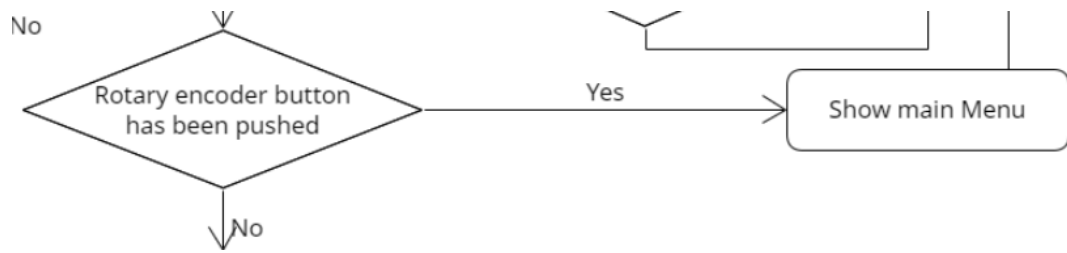
Fig. 3.28: Forth part of the scheme

The second path, the encoder button has been pushed. A multiple option menu will appear in the LCD display with the following options: Change hour, Change meals and END.

Now in the next figure is possible to see the development of the Change hour and END modes.
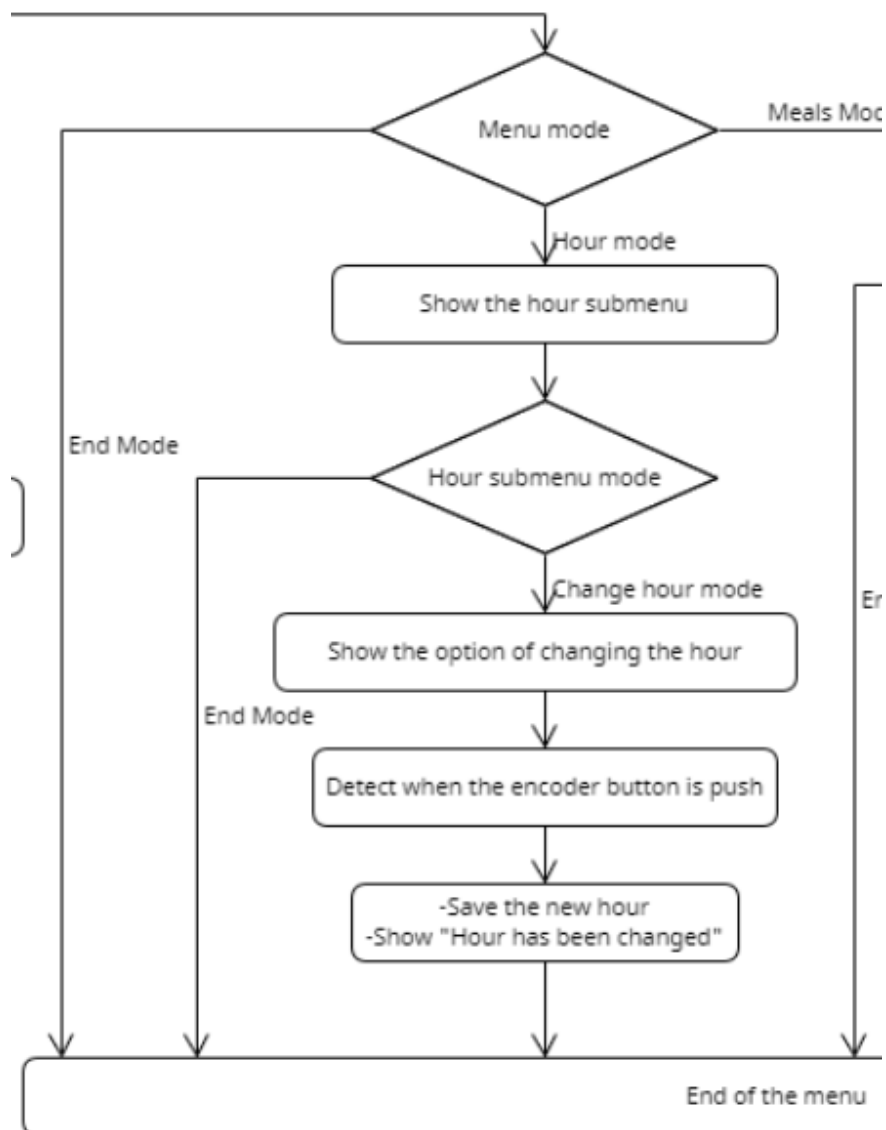
Fig. 3.29: Fifth part of the scheme

The end mode is just an option to exit and go to the principal loop in case of not wanting to do anything.

Change hour mode has another submenu inside of it. In order to not force the user to do any action there is also an End mode in this menu. In case that is wanted to change the hour the user selects the mode and trough the rotary encoder can change it. Once the person pushes the encoder button the hour is saved and a message of it is show in the LCD. Then the last square goes to the first state of the principal loop.
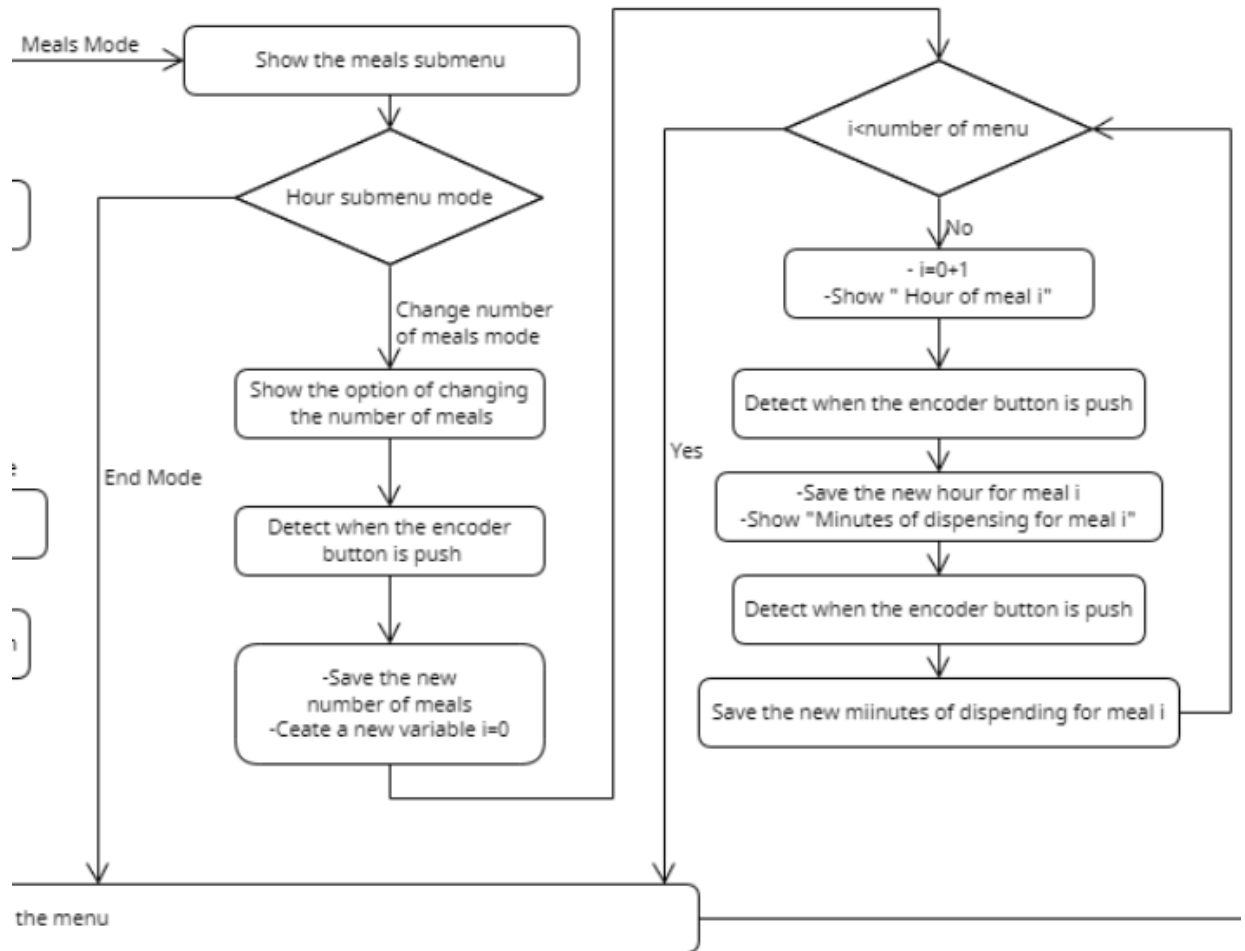
Fig. 3.30: Sixth part of the scheme

In last place we have the Meals mode. As the hour menu this submenu also has an end option. If the user wants to change the number of meals, he just must choose the option and automatically trough the display using the Keyes KY-040 they are able to choose the number of meals and when they push the encoder the number is saved.

The variable i is created for using it in a while loop in case of i< n of meals will appear the option of sett the hour of each meal and the amount of food that is dispensed. When all the meals have been defined the menu finish and the arrow goes to the first principal loop state.

4. WORK SAFETY

4.1. General provisions and requirements for safe working and environmental protection

Before switching on the device is need to ensure that all the parts, screws and different elements fits correctly. When the machine is correctly installed is necessary to follow the next general rules:

- The usage and maintenances should be done by an adult, the adult should not be under the effects of alcohol, drugs, or medicines.
- Before filling the container is necessary to try the correct machine working without food inside.
- Before doing any kind of handling is necessary to swich off the machine, independently of the activity that is going to be done. These actions could be the opening of the top cover for filling the container or the cleaning of the machine.
- Is forbidden introduce the hand through the food dispenser hole. If the hand reach the endless screw it probably will get a cut.
- Before each filling make sure that all the elements are in proper working conditions.
- Do not introduce stones or other materials that could damage the machine.
- Do not get under the machine.
- Do not start the machine before closing the top cover and placing the different parts. To avoid the projection of materials.
- Do not open the electrical circuit panel without disconnecting the power supply.
- Before any manipulation of the motor is necessary to have the food container without materials.
- Do not use any kind of tool if the machine is not completely stopped and disconnected of the power supply.
- If you see any sparks or indications of electrical faults, swich off the feeder as soon as it´s possible to avoid electric damage and fires.

During the machine usage there isn´t any environmental pollution, just the usage of electricity.

Provides general provisions and requirements for the safe operation and protection of working with similar devices and equipment.

4.2. Work safety and environmental requirements of Automatic animal feeder

In addition of that rules there will be some components that will facilitate the correct use of the feeder. Such as stickers and signals.

Basic alerts

There will be the following warning (Fig. 4.1) stickers placed in the specific parts:

Fig. 4.1: Risk of crushing (http://www.aman.pt/ms_imp_produto/15616/1/0/es/**)**

This sticker (Fig. 4.2) will be placed in a place where everyone can see it. To advertise the people to not gen under the machine.

Fig. 4.2: Risk of cutting (https://brero.es/shop/peligro/274-cartel-riesgo-de-corte.html)

This alert will be placed in the entry of the food and the outside (Fig. 4.3) of it too.

Fig. 4.3: Do not repair the machine while is working (https://syssa.com/es/senalizacion-seguridad/riesgo-laboral/prohibicion/disco-prohibido-reparar-la-maquina-en-funcionamiento-referencia-rmf**)**

This sticker (Fig. 4.4) should be placed next to the door of the mechanism.

Fig. 4.4: Electric risk (https://www.epis-services.com/accesorios/687-riesgo-el%C3%A9ctrico-9x9cm.html**)**

This sticker will be in the controller door.

Button of Emergency stop

There will be an emergency stop button. Is this button is pressed, the electricity of the machine will be disconnected. This button must be used just in emergency not as usual form of stopping the feeder.

Safety precautions when power is turned on

When the power is turned on there will be a light turned on.

Security measures upon completion of work

There will be some sensors to ensure that the top door of the container is close to star running the motor.

Fire-security

In case of fire use dry powder fire extinguisher so the electronic components don´t get damage.

4.3. Recycling material process

The feeder is made from different materials. After it usage, in order to protect the environment is necessary to separate all the different parts. There will be necessary to separate them in three different groups; metal, plastic and electronic components. The most important components to recycle are the electronic components because some of the components could have heavy metals that very dangerous to the environment and could contaminate the soil.

5. ECONOMIC CALCULATION

The economic analysis of a product is one of the main factors to be taken into account during the design and manufacturing a product. It is so important because even though a product may be very good it has to produce profits, in the end the objective of private companies is to obtain income through their products.

The analysis that is going to be carried out is theoretical and approximate, as has been done the design, it hasn't been built, the values may change.

5.1. Calculations of fixed assets and production costs

About the infrastructure of the company is going to be supposed that is not a new company so the initial investment of the office and manufacturing premises are amortised, so we don´t have to include them in the list of initial investments. The following table shows the rest of the initial investments.

Type of the long-time fixed cost	Price of the investment
Machinery and tools (workshop crane, toolbox, welding machine, torque spanner)	750€
Software (Solidworks)	9970€
Total	**10720€**

Table 5.1: Initial investments

Once the initial costs are known, the fixed and variable production costs are calculated. To do this, it is necessary to know the approximate cost of all the components, both those that will be produced in-house and those that will be purchased from third parties. The table below shows the elements that will be purchased:

No.	Component Name	Quantity	Price of one piece (€)	Total price (€)
	Mechanical Components			
1	ISO 7046-1 M4×16-Z-16N	4	0,37 €	1,48 €
2	ISO 7046-1 M4×12-Z-12N	4	0,35 €	1,40 €
3	ISO 7046-1 M5×10-Z-10N	3	0,60 €	1,80 €
4	ISO 7045 M3×8-Z-8N	4	0,32 €	1,28 €
5	ISO 7380 M12×16-16N	4	0,80 €	3,20 €
6	ISO 4762 M8×16-16N	16	0,66 €	10,56 €
7	ISO 4762 M8×12-12N	4	0,64 €	2,56 €
8	ISO 4762 M12×35-35N	4	0,85 €	3,40 €
9	Grarbox MG23-G10-D8	1	32,18 €	32,18 €

10	Bearing PCCJ25	2	81,25 €	162,50 €
	Electric/electronic components			
11	Motor EMG49	1	84,90 €	84,90 €
12	Transformer	1	13,54 €	13,54 €
13	420 FAN	1	0,99 €	0,99 €
14	Driver	1	7,74 €	7,74 €
15	Esp32	1	1,01 €	1,01 €
16	RTC DS3231	1	2,23 €	2,23 €
17	LED	1	0,46 €	0,46 €
18	I2C led screen	1	0,79 €	0,79 €
19	Keyes KY-040	1	0,98 €	0,98 €
20	ON/OFF button	1	2,14 €	2,14 €
21	Limit switch	1	2,83 €	2,83 €
22	Emergency 3NC button	1	9,49 €	9,49 €
23	Fuse holder	1	1,73 €	1,73 €
24	Fuse	2	0,09 €	0,18 €
25	Power cable	5	1,49 €	7,45 €
26	DC cable reel	1	11,45 €	11,45 €
27	AC connector	1	0,84 €	0,84 €
Total				**369,11 €**

Table 5.2: Comercial Components

The price in the table above is in the case of buying just one unit, normally companies have agreements in which a lower price is specified for buying in bulk.

The rest of the pieces will have to be ordered and made to measure. The main material to be used is 316 stainless steel, this material is suitable for having contact with food so as not to contaminate the animal feed. Just the electric box cover is made of plastic.

No.	Component Name	Quantity	Total price (€)
1	Endless Screw	1	85,00 €
2	Gearbox Housing	1	29,29 €
3	Endless Screw Housing	1	143,15 €
4	Top Gearbox housing cover	1	4,33 €
5	Endless Screw Housing Cover	1	25,32 €
6	Electric box	1	60,16 €
7	Electric box cover	1	22,00 €

8	Container	1	563,55 €
9	Container top cover	1	170,76 €
10	Supporting structure	1	176,30 €
Total			**1.279,87 €**

Table 5.3: Custom Elements

Once we have all the components prices it´s possible to know the total cost of the materials that should be purchased by add the commercial cost (A_1) and the customized elements (A_2).

$$I_1 = A_1 + A_2 = 369,11 + 1279,87 = 1648,98€ \tag{5.1}$$

After analysing the materials, we need to set the number of workers, There are two different parts in the construction of the feeder, the electric and electronic part, and the mechanical part, so two different workers are need. The working week in Lithuania is 40 hours per week, divided into 5 days per week, so that is a total of 8 hours per day, in a full month people work 20 days. Each feeder is calculated that needs 2.5 working hours of each worker. So in one month is possible to do 64 feeders. Now we need to calculate the salary of the workers the one that is going to be set is the average of Lithuania (1900.03€ https://www.finansistas.net/vidutinis-darbo-uzmokestis.html). All the salaries are added and divided between the units produced in one month:

$$I_2 = \frac{2 \cdot 1900,03}{64} = 59,37€ \tag{5.2}$$

We proceed to analyse the consumption of resources during production, in terms of energy the main one is human labour, as the workshop crane would be manual, the soldering iron for electronic components consumes around 80W depending on the soldering iron chosen. The highest price of electricity in December 2022 in Lithuania was 0,2429€/kwh, so the cost won´t be high:

$$I_3 = \frac{80W \cdot 2,5h \cdot 1kW}{1000W} \cdot 0,2429€/KWh = 0,05€ \tag{5.3}$$

Another cost to add is the packaging of the feeder, as it is made of robust materials, these will not be very high, therefore they will be considered $I_4 =10€$.

Transport costs will not be included in the price of the product, as these can vary greatly depending on the place where it is sent, therefore an external company will manage the costs and shipping.

Lastly, there are the costs of the material consumed, only stain for soldering and some tools that must be repaired or replaced, so the cost is not great, about $I_5=2€$.

Cost	Amount
Components and Materials	1.648,98 €
Employee	59,37 €
Energy	0,05 €
Packaging	10,00 €
Tool material consumption	2,00 €
Total	**1.720,40 €**

Table 5.4: Total Variable Cost per unit

The total variable costs amount to 1720.40€ in each unit.

5.2. Calculation and determination of fixed costs

Fixed costs of a product are those expenses or costs that remain constant regardless of the level of production or sales. These costs do not vary according to the units produced or sold but remain stable within a certain period of time or range of activity. All the cost that are going to be calculated are for one year.

As the production of this feeder is a new department of the company has been need to hire an administration personal and a commercial. This people will earn the average salary 1900.03€ as the workshop workers.

$$I_6 = 1900,03 \cdot 2 \cdot 12 = 45600,72€ \tag{5.4}$$

Also is need to rent a new space for manufacture the product, this space will cost 1500€ each month.

$$I_7 = 1500 \cdot 12 = 18000€ \tag{5.5}$$

Once the software Solidworks Professional first license is bought, each year to maintain and update it, it is necessary to pay $I_8 = 2.375€$.

The money invested initially will be amortised over a number of years. Among these expenses were the solidworks licence and the tools and machinery. The software licence will be amortised in 20 years, while the tools will be amortised in only 5 years.

$$Software \rightarrow I_9 = \frac{9970}{20} = 498,50€ \tag{5.6}$$

$$Tools\ and\ Machinery \rightarrow I_{10} = \frac{750}{5} = 150€ \tag{5.7}$$

Lastly, there are office and service costs. Here the costs for heating, internet, water, etc. are taken into account. Despite of having changes between summer and winter the average will be 600€

$$I_{11} = 600 \cdot 12 = 7200€ \tag{5.8}$$

Fixed Cost	Amount (€)
Salaries	45600,72€
Rent	18000€

Solidworks	2,375€
Software	498,50€
Tools and Machinery	150€
Office and services	7200€
Total	**73824,22€**

Table 5.5: Total Fixed Cost

Now that we have the total amount of fixed cost we can calculate how this cost are distributed, we are going to suppose that all the units are sold each year, in one year is possible to produce 768 units, assuming that we sell all:

$$Fixed\ cost\ per\ unit: \frac{73824,22}{768} = 96,13€ \tag{5.9}$$

After recovering all the cost, Fixed and Variable is possible to do a circular graphic of how each one affects the product.
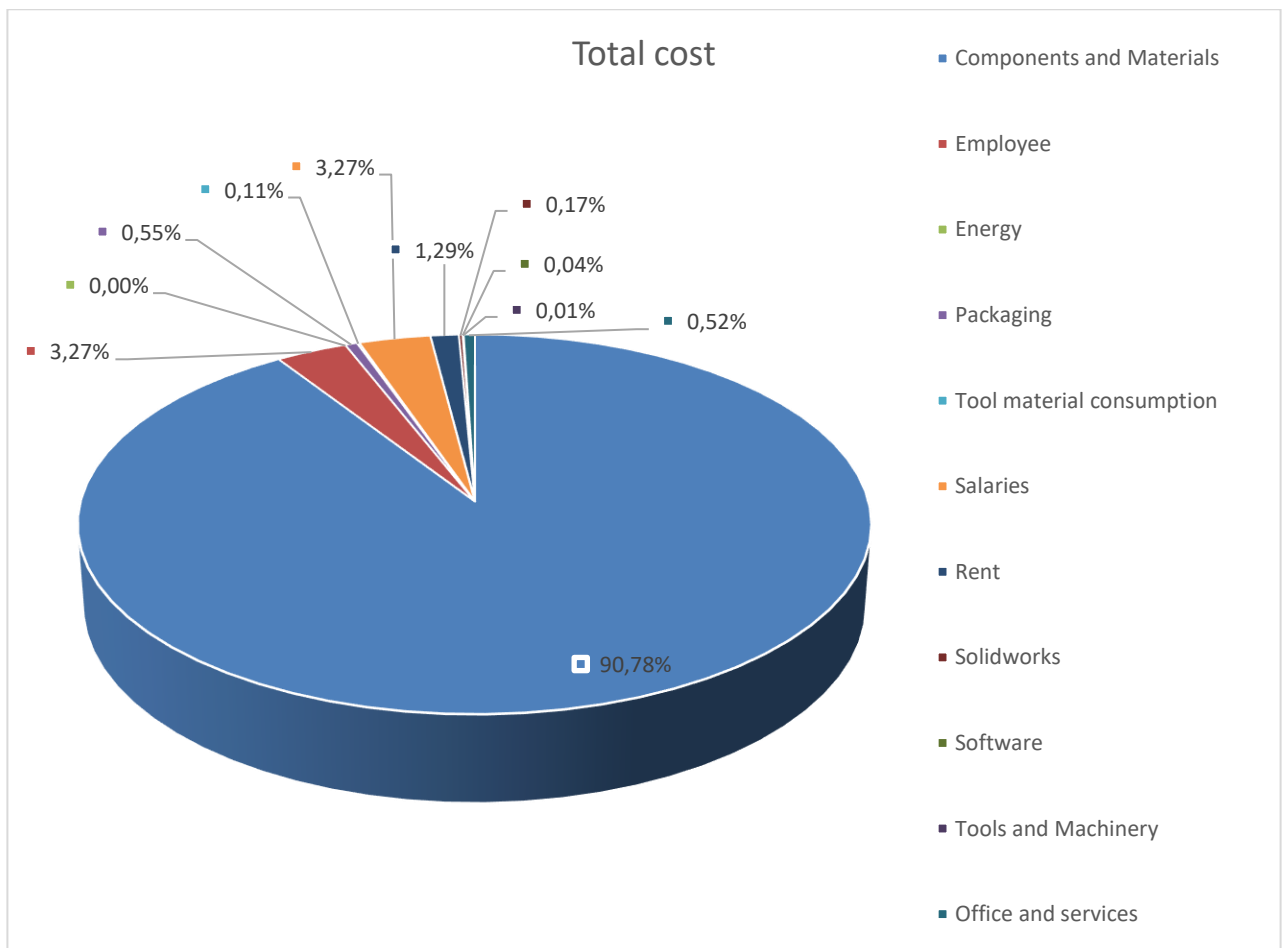
Fig. 5.1: Pie chart of Cost

In the graph we are able to see the % of the cost that each part take part including the different types of cost.

5.3. Charging of product price and break point calculations

For calculating the prime cost of the feeder we are going to suppose that we sell all the feeders that are produced, so the fixed prices will affect the minimum to each product. The overall commercial prime cost of all products (Total cost, TC) will be:

$$TC = Total\ unit\ variable\ cost\ (TuVC) \cdot Units\ Selled\ (US) + Total\ Fixed\ cost(TFC) =$$
$$= 1720,40€ \cdot 768u + 73824,22€ = 1395091,42€ \qquad (5.10)$$

Now we calculate the prime cost of each product (TCu):

$$Overall\ price\ of\ one\ products\ (TCu) = \frac{TC}{US} = \frac{1395091,42}{768} = 1816,52€ \qquad (5.11)$$

Once we have the overall price of one product, we are able to add a profit for it, we are going to calc a margin of 12% of the overall price.

$$M = TCu \cdot 0,12 = 1816,52 \cdot 0,12 = 217,98€ \qquad (5.12)$$

The total price of the product will be:

$$TP = TCu + M = 1816,52 + 217,98 = 2034,50€ \qquad (5.13)$$

Now we calculate the total revenue:

$$TR = TP \cdot US = 2034,50 \cdot 768 = 1562496€ \qquad (5.14)$$

In last place before doing the graph, calculate the total viable cost:

$$TVC = TuVC \cdot US = 1720,40 \cdot 768 = 1321267,20€ \qquad (5.15)$$

Now we proceed to do the brake-point graph:
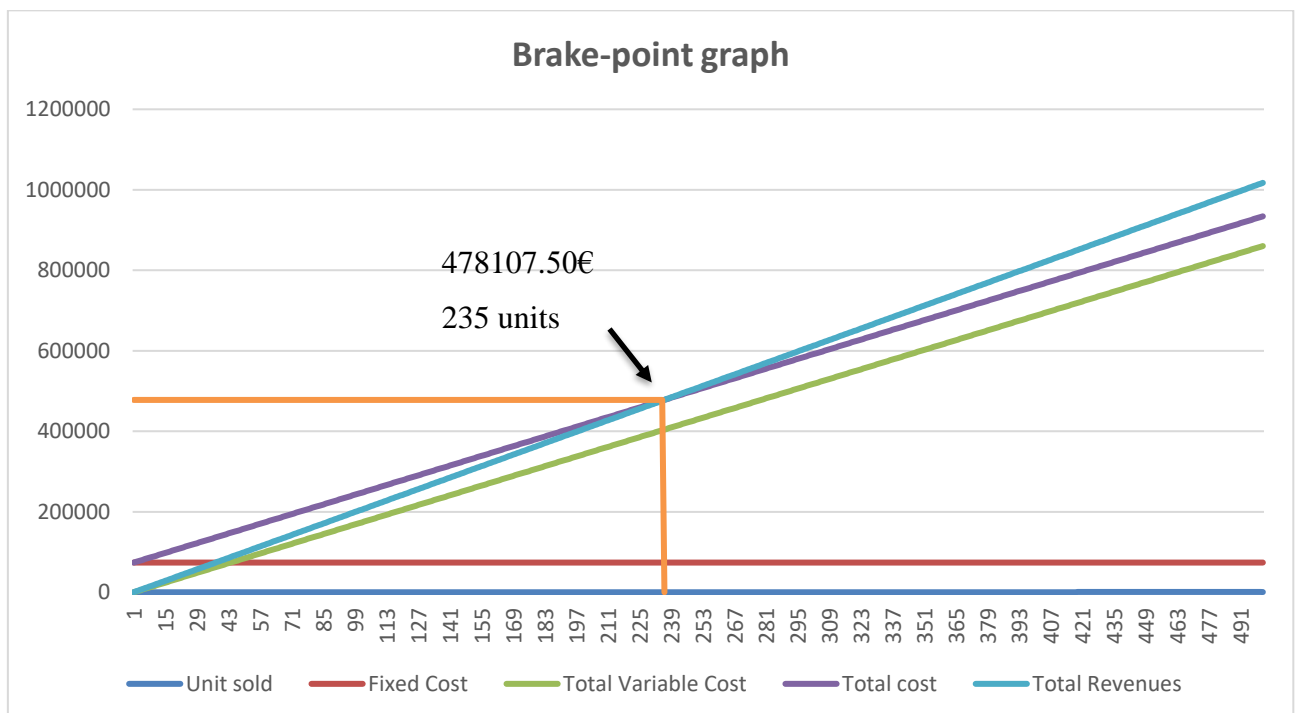
Fig. 5.2: Brake-point graph

As we can see in the picture it is necessary to sell 235 units to be able to recover all expenses and not to produce losses. Once we sell more than these units we will be able to make a profit in the company.

CONCLUSIONS

1. The feeders on the market that have been analysed have been chosen because of their differences. Each feeder is for a different type of animal and has a different feed format. As they are so different machines, we have to analyse them separately, there are several differences with our trough. As for the first trough for domestic use it has the same type of feed and animal units, but the dimensions and materials would not be suitable for use with horses. Secondly and thirdly the scope of use changes, it is focused on intensive livestock farming and large farms, not as ours. The lamb feeder has a different purpose, as it must keep the feed continuously. The last trough needs the action of at least one worker and auxiliary machinery, which is the opposite of what we are looking for, but this has the correct materials.

2. The calculations made for this project focus on the dimensioning and calculation of the endless screw parameters. To obtain these parameters we have used mainly the most restrictive coefficients and variables, in order to ensure that the feeder is robust. Once the main parameters have been obtained, the motor and gearbox have been chosen in relation to them. The main characteristic for the costumer will be the material flow (with a density of 0.9): 0.306 kg/min.

3. In the third chapter is possible to analyse the different parts that compose the kinematic scheme at its position. It is a very simple mechanism because it only have 3 main elements motor, gearbox and actuator. About the electrical block scheme and controlling scheme are quite similar. In the electrical scheme all the electric components are show. The control scheme difference with the electrical scheme is that it is focus on the controller and the assignment of pins. In last place we have the program control scheme that shows and explain how the program will act in different situations and the possibilities that the user will have.

4. The first two parts of work safety share the same objective, which is to prevent accidents. One of them does this by setting rules to be followed and the other one does it by using visual signals, sensors and switches. The main risk ere the endless screw while is working, receiving an electric shock from the control panel, or being crushed by the trough itself as it is a very heavy element. In the last part is explain how should be threated the feeder at the end of its useful life. In order to not pollute or affect the environment.

5. The economic calculations analyse all the costs that starting to manufacture the product would entail. From initial investment to fixed and variable costs. A possible market price of the product is estimated at 2034.50€ and lastly the break point is estimated with 235 units and a total revenue of 477924,4€.

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40mm 80mm 90mm 120mm caja de plástico ventilador Filtro de polvo Protector de parrilla cubierta a prueba de polvo PC ventiladores de la computadora caja de limpieza de filtro- aliexpress.com. (s.f.). AliExpress - Compra online de Electrónica, Moda, Casa y jardín, Deportes y ocio, Motor y seguridad, y más. - AliExpress - AliExpress. [interactive]. (See 12-04-2023). In internet: <https://es.aliexpress.com/item/33021515892.html?spm=a2g0o.productlist.main.25.6e5954091bPN5M&algo_pvid=40f26b4c-1440-434b-8592-39dd4fc6c436&algo_exp_id=40f26b4c-1440-434b-8592-39dd4fc6c436-12&pdp_ext_f=%7B"sku_id":"67187905867"%7D&pdp_npi=3@dis!EUR!2.11!0.01!!!!!@211bf14716801925106468818d0717!67187905867!sea!ES!2287947606&curPageLogUid=fiaTONA26vKQ>

5015/4010/4020 12V y 24V Turbo ventilador de refrigeración sin escobillas piezas de impresora 3D 2 pines para extrusora DC ventilador de refrigeración parte ventiladores de plástico negro|Accesorios y partes de impresoras 3D| - AliExpress. (s.f.). aliexpress.com. [interactive]. (See 12-04-2023). In internet: <https://es.aliexpress.com/item/32972111881.html?spm=a2g0o.productlist.main.13.20244f34esza1F&algo_pvid=8d5df695-28f9-401d-82c6-a5487a0acaea&algo_exp_id=8d5df695-28f9-401d-82c6-a5487a0acaea-6&pdp_ext_f=%7B"sku_id":"12000023093174823"%7D&pdp_npi=3@dis!EUR!2.16!0.01!!!!!@2102160416801899816153126d06f3!12000023093174823!sea!ES!2287947606&curPageLogUid=SHREnNPMQ6Xu>

THE ANNEXES

Format	Area	Item No.	Mark	Title	Quantity	Note
				<u>Documentation</u>		
A1			MERS BM 23 01 01.00.00.00 GV	General view	1	
				<u>Units</u>		
		1	MERS BM 23 01 01.01.00.00	Electrical Block	1	
A1		2	MERS BM 23 01 01.02.00.00 AD	Doser	1	
		3	MERS BM 23 01 01.03.00.00	Bunker	1	
		4	MERS BM 23 01 01.04.00.00	Frame	1	

Responsible agency	Consultant	Document type		Document status	
MERS Department			Specification		Educational
Owner	Compiled	Title		Mark	
Vilnius TECH	Álvaro Díez Redondo			MERS BM 23 01 01.00.00.00 SP	
	Checked		Automatic Feeder	Rev.	Date 10-05-2023 / Lang. en / Sheet 1/1
MDRfuc-19	Ernestas Šutinys			A	

Format	Area	Item No.	Mark	Title	Quantity	Note
				Documentation		
A1			MERS BM 23 01 01.02.00.00 AD	Assembly drawing	1	
				Parts		
		4	MERS BM 23 01 01.02.00.04	Endless Screw	1	
		5	MERS BM 23 01 01.02.00.05	Gearbox Housing	1	
		6	MERS BM 23 01 01.02.00.06	Endless Screw Housing	1	
		7	MERS BM 23 01 01.02.00.07	Top Gearbox Housing Cover	1	
		8	MERS BM 23 01 01.02.00.08	Endless Screw Housing Cover	1	
				Standard components		
		9		ISO 7046-1 M4x16-Z-16N	4	
		10		ISO 7046-1 M4x12-Z-12N	4	
		11		ISO 7046-1 M5x10-Z-10N	3	
		12		ISO 7045 M3x8-Z-8N	4	
		13		ISO 7380 M12x16-16N	4	
		14		ISO 4762 M8x16-16N	8	
		15		ISO 4762 M12x35-35N	4	
		16		ISO 4762 M8x16-16N	8	

Responsible agency	Consultant	Document type		Document status		
MERS Department		Specification		Educational		
Owner	Compiled	Title		Mark		
Vilnius TECH	Álvaro Díez Redondo			MERS BM 23 01 01.02.00.00 SP		
MRfuc-19	Checked	Doser	Rev.	Date	Lang.	Sheet
	Ernestas Šutinys		A	10-05-2023	en	1/2

70

Format	Area	Item No.	Mark	Title	Quantity	Note
				Other components		
		1		Bearing PCCJ25	2	Schaeffler
		2		Gearbox MG23-G10-D8	1	Stepperonline
		3		Motor EMG49	1	Robot Electronics

Responsible agency	Consultant	Document type		Document status	
MERS Department		Specification		Educational	
Owner	Compiled	Title		Mark	
Vilnius TECH	Álvaro Díez Redondo			MERS BM 23 01 01.02.00.00 SP	
MRfuc-19	Checked	Doser		Rev. A	Date 10-05-2023 · Lang. en · Sheet 2/2
	Ernestas Šutinys				

1113

1599

1053

3

4

1356

913

986

40

981

2

1

-Working voltage of the motor: 24V DC
-Rated motor current: 2100mA
-Rated motor power: 34.7W
-Feeder power supply: 220V AC
-Feeder current need: 200mA
-Endlees screw rotation speed: 12.2rpm
-Flow of material (with a density of 0.9): 0.306 kg/min
-Container maximum filling mass: 450Kg
-Feeder aproximate mass: 185 Kg

	File Nº	Additional information	Material		Scale 1:5
Responsible agency MERS Department	Consultant	Document Type		Document status Educational
			General View		
Owner Vilnius TECH MSRfuc-19	Compiled Álvaro Díez Redondo	Title Automatic Feeder	Mark MERS BM 23 01 01.00.00.00 GV		
	Checked Ernestas Šutinys		Rev. A	Data 10-05-2023	Lan. en	Sheet 1/8

SECCIÓN A-A

1311

1180

1030

100

7

1

8

15

13 4 2 5 10

3

100

1000

120

16

6

14

156

A

A

SECCIÓN B-B

12

9

□47

200

43

115

43

11

14 H7/h8

DETALLE C

DETALLE D

1

Ø 52 H7
Ø 25 k6
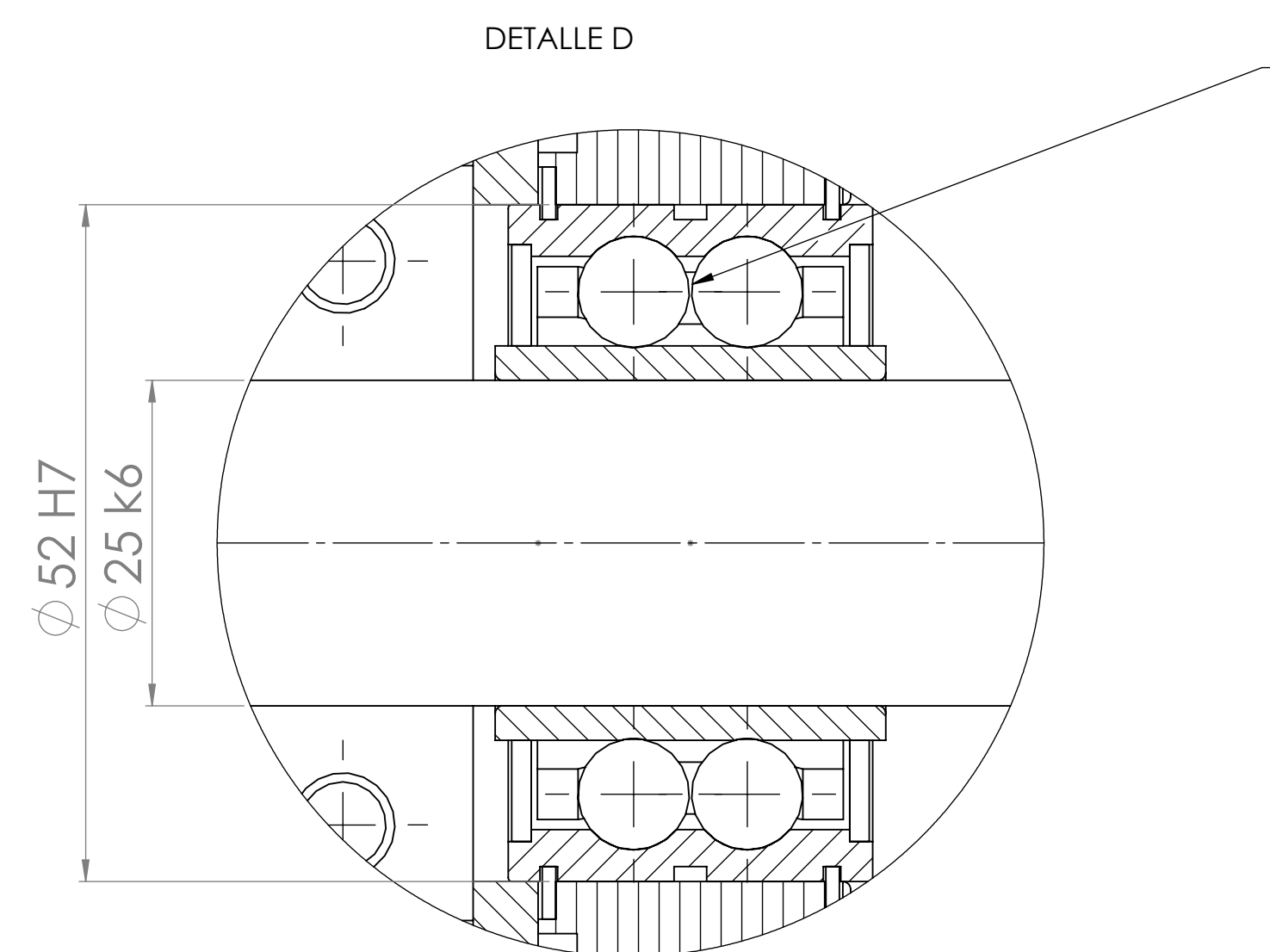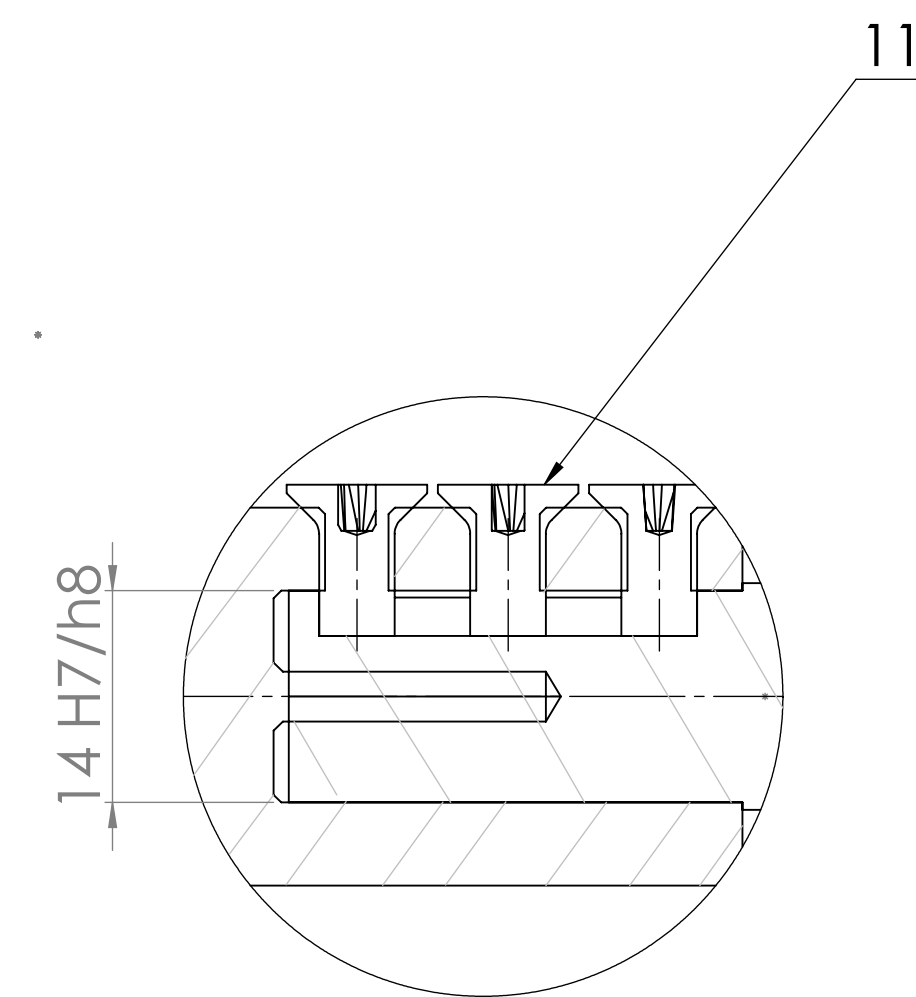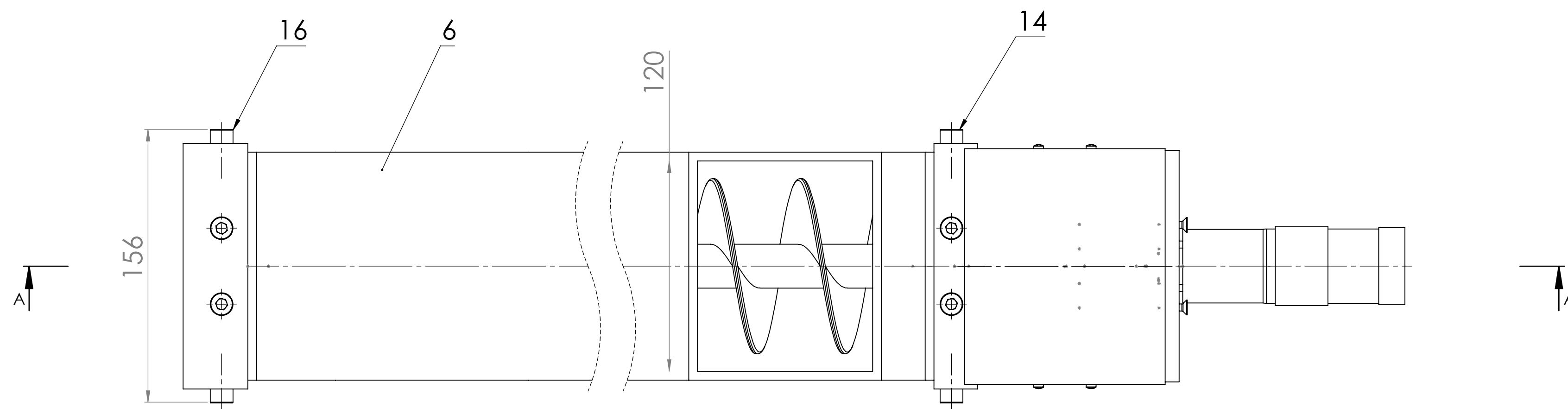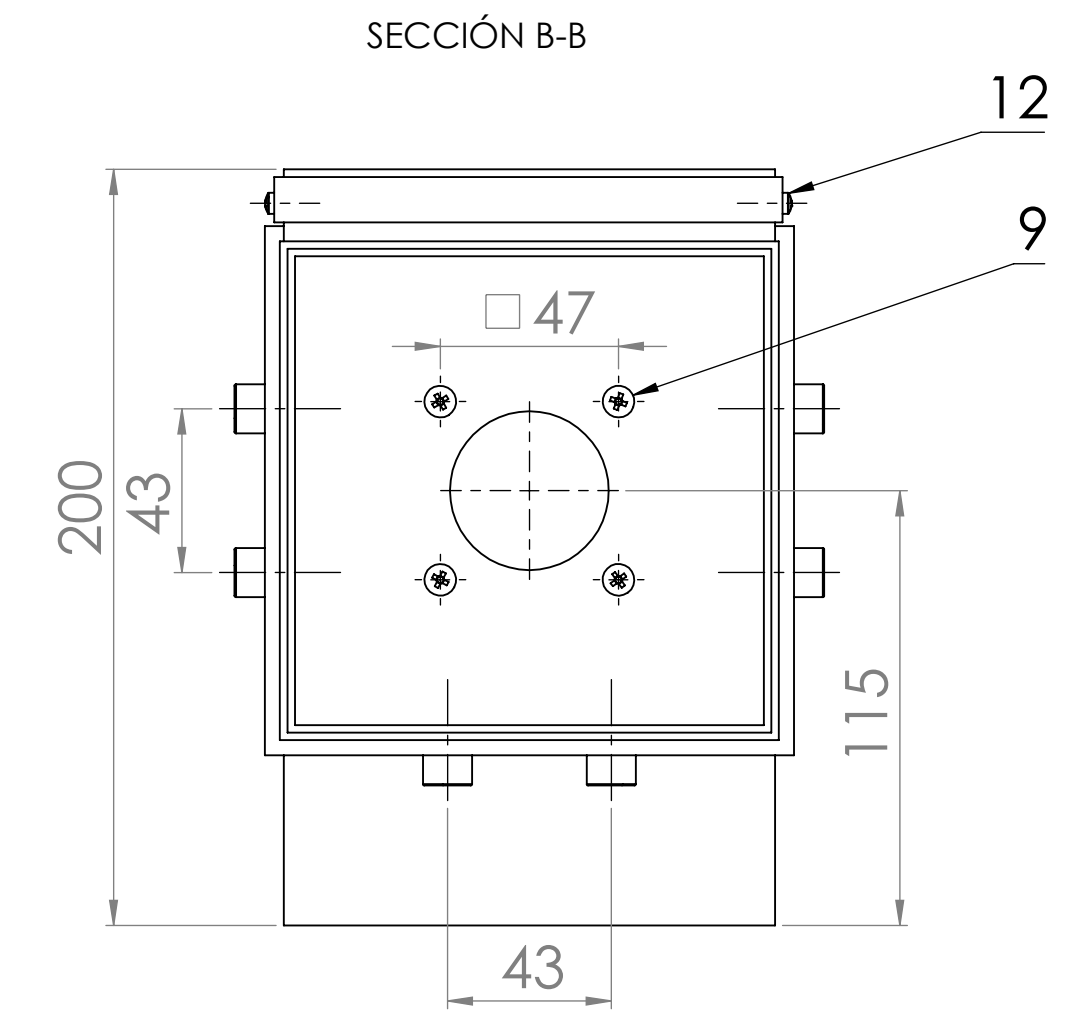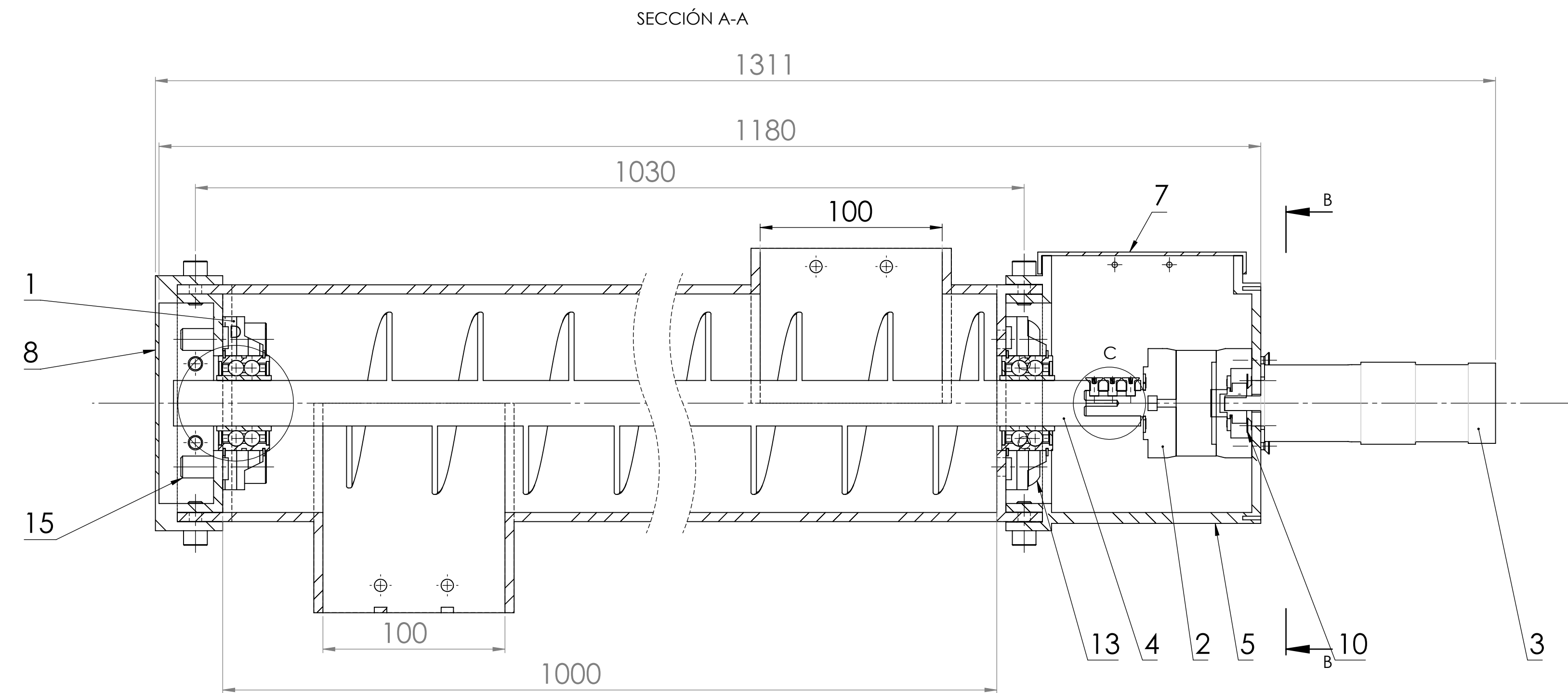
-Assembly mass: 36kg
-Endlees screw rotation speed: 12.2rpm
-Gearbox relation: 10:1
-Motor rated rotation speed: 122rpm
-Working voltage of the motor: 24V DC
-Rated motor current: 2100mA
-Rated motor power: 34.7W
-Flow of material (with a density of 0.9): 0.306 kg/min
-Filling area of the transporter: 0.00283m2
-Transporter travel speed: 0.01m/s

File Nº	Additional information	Material		Scale 1:2
Responsible agency MERS Department	Consultant	Document Type	Assembly drawing	Document status Educational
Owner Vilnius TECH MSRfuc-19	Compiled Álvaro Diez Redondo	Title	MERS BM 23 01 01.00.00.00 AD	
	Checked Ernestas Šutinys	Assembly drawing	Rev. A	Data 10-05-2023	Lan. en	Sheet 2/8

Kinematic Scheme (top-left)

Number	Component
1	Motor EMG49
2	Gearbox
3	Joint
4	Endless Screw
5	Bearings

GB
M

Title block (top-left):
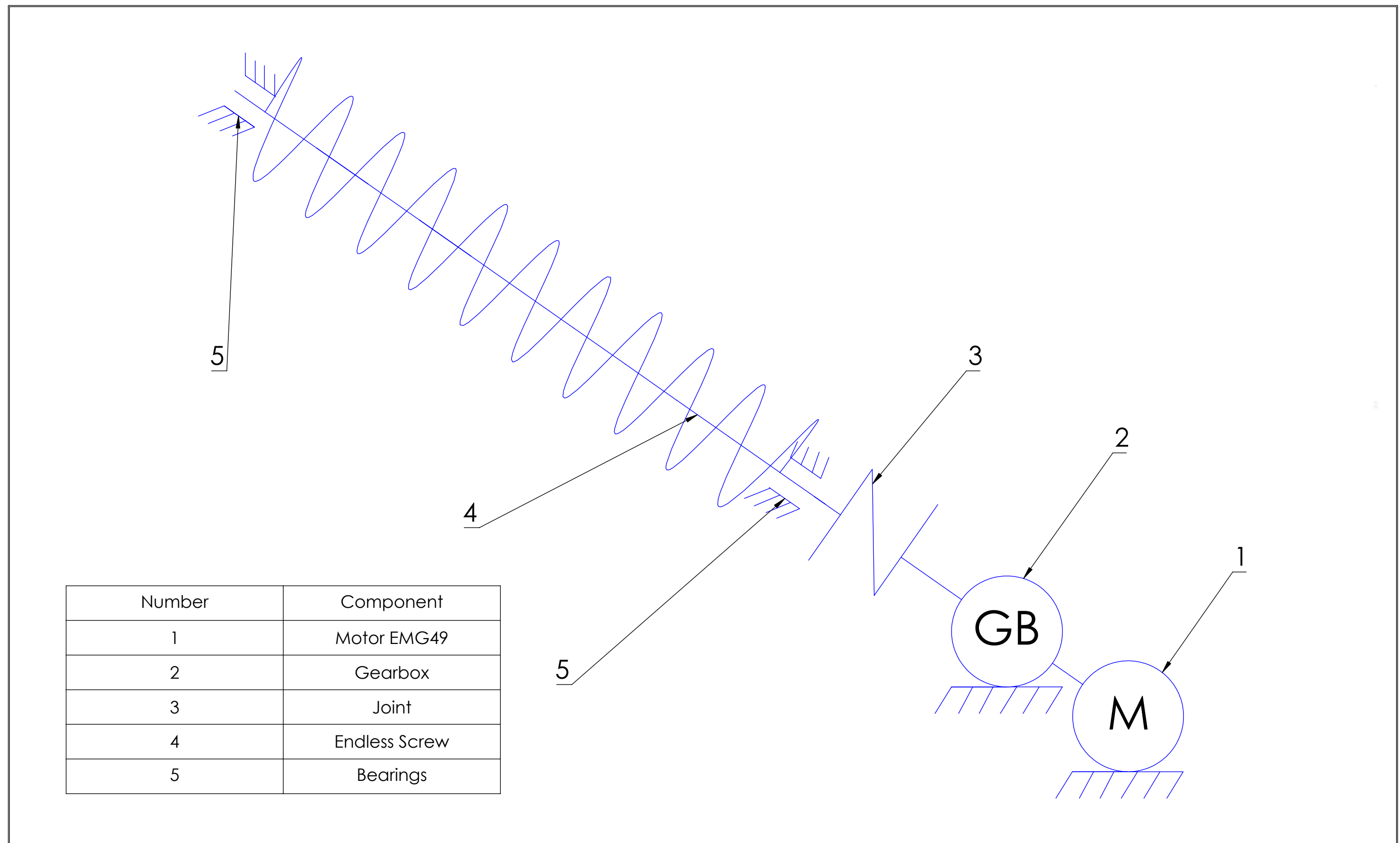
File Nº	
Additional information	
Material	
Scale	
Responsible agency: MERS Department	Consultant
Document Type	Kinematic Scheme
Document status	Educational
Owner: Vilnius TECH MSRfuc-19	Compiled: Álvaro Díez Redondo
Title	Kinematic Scheme
Mark	MERS BM 23 01 01.00.00.00 KS
Checked: Ernestas Šutinys	
Rev. A	Data 10-05-2023	Lan. en	Sheet 3/8
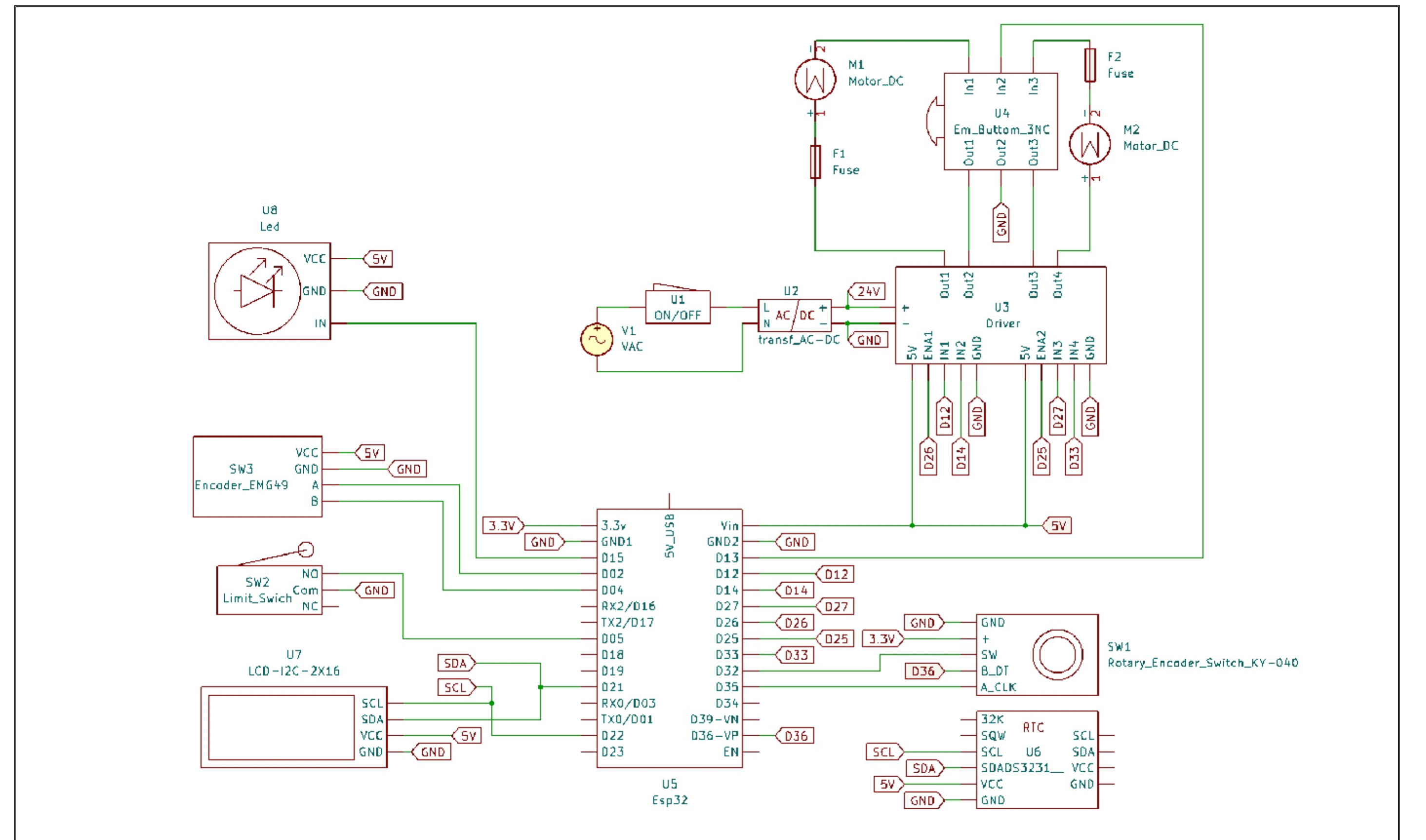
Electric Block Scheme (top-right)

Title block (top-right):

File Nº	
Additional information	
Material	
Scale	
Responsible agency: MERS Department	Consultant
Document Type	Electric Block Scheme
Document status	Educational
Owner: Vilnius TECH MSRfuc-19	Compiled: Álvaro Díez Redondo
Title	Electric Block Scheme
Mark	MERS BM 23 01 01.00.00.00 EBS
Checked: Ernestas Šutinys	
Rev. A	Data 10-05-2023	Lan. en	Sheet 4/8
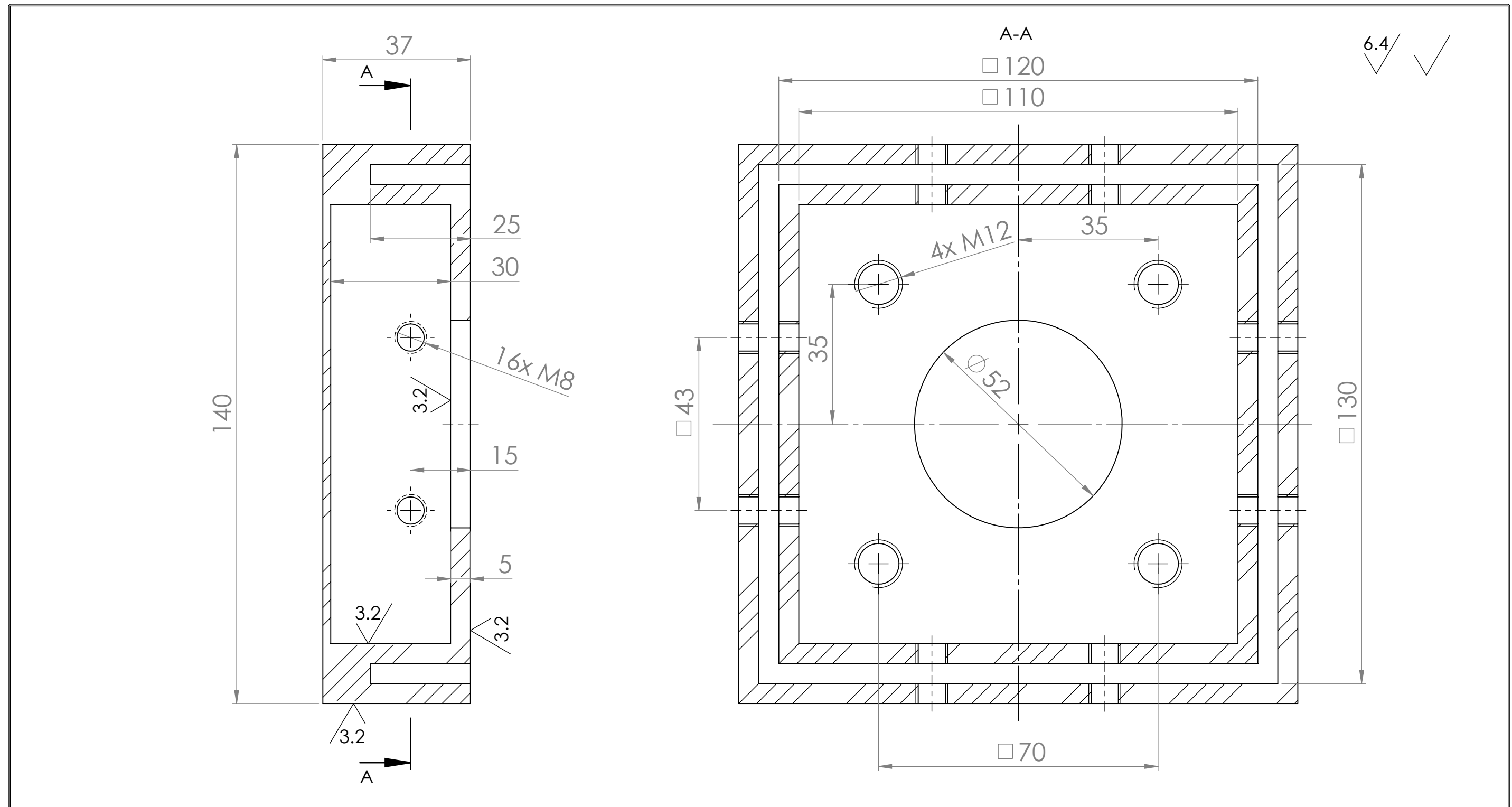
Endless Screw Housing Cover (bottom-left)

A-A

37, 25, 30, 15, 5, 140
4x M12, 16x M8
□120, □110, □130, □70, □43, □35, 35
⌀52
3.2
6.4

1) Not determined tolerances according to LST EN 227 68-mK.
2) 1mm chamfer is applied on all sharp edges.

Title block:

File Nº	
Additional information	
Material	Stainless Steel 316 ISO 15510:2010
Scale	1:1
Responsible agency: MERS Department	Consultant
Document Type	Work drawings
Document status	Educational
Owner: Vilnius TECH MSRfuc-19	Compiled: Álvaro Díez Redondo
Title	Endless Screw Housing Cover
Mark	MERS BM 23 01 01.02.00.08
Checked: Ernestas Šutinys	
Rev. A	Data 10-05-2023	Lan. en	Sheet 5/8
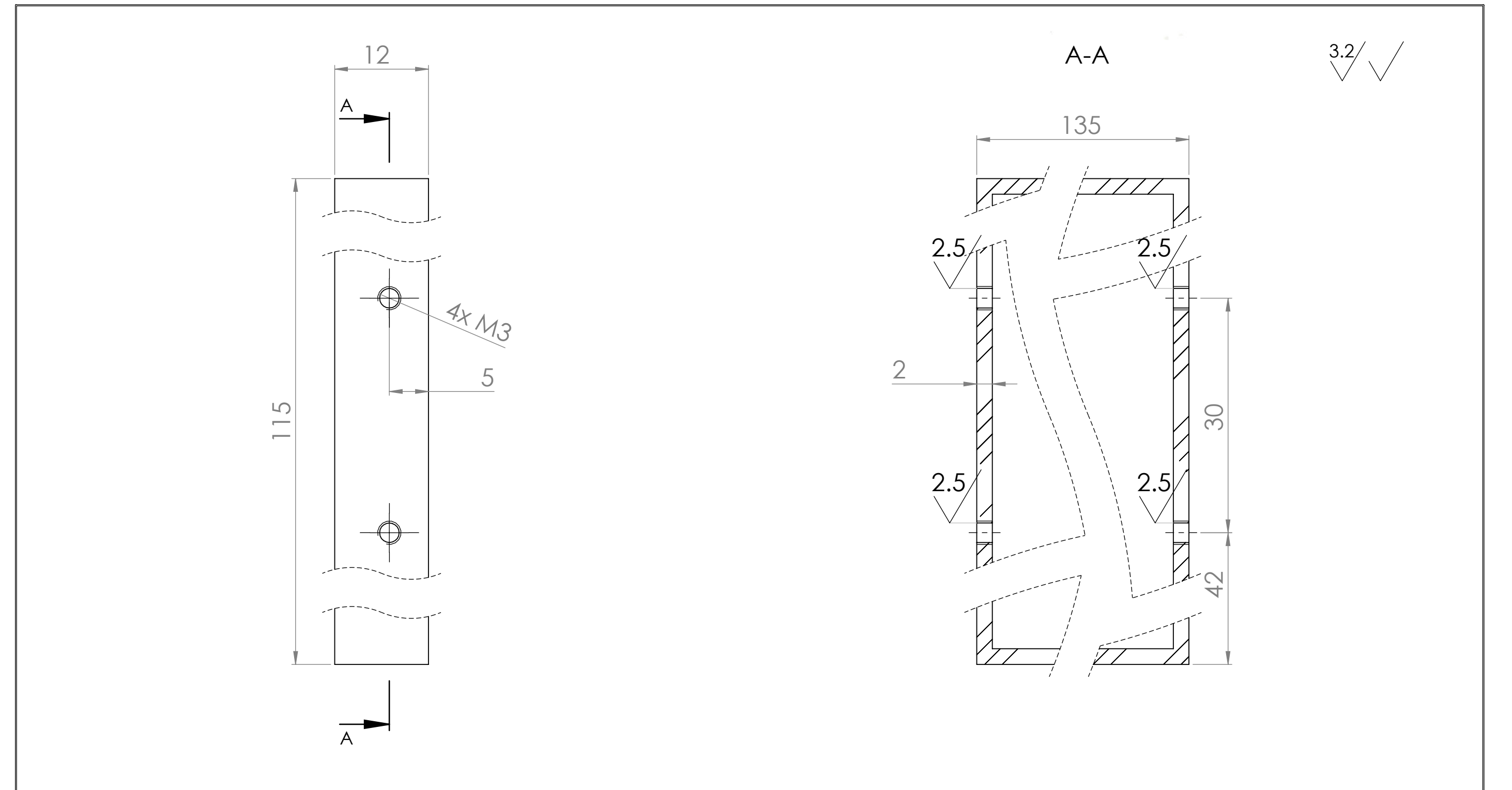
Top Gearbox Housing Cover (bottom-right)

A-A

12, 115, 135, 30, 42, 5
4x M3
2.5, 2.5, 2, 2.5, 2.5
3.2

1) Not determined tolerances according to LST EN 227 68-mK.
2) 1mm chamfer is applied on all sharp edges.

Title block:

File Nº	
Additional information	
Material	Stainless Steel 316 ISO 15510:2010
Scale	2:1
Responsible agency: MERS Department	Consultant
Document Type	Work drawings
Document status	Educational
Owner: Vilnius TECH MSRfuc-19	Compiled: Álvaro Díez Redondo
Title	Top Gearbox Housing Cover
Mark	MERS BM 23 01 01.02.00.07
Checked: Ernestas Šutinys	
Rev. A	Data 10-05-2023	Lan. en	Sheet 6/8

Logic Scheme — Control algorithm of object

Switch on the button

-Initialize LCD
-Initialize Rotary Encoder
-Initialize Esp32 Pins
-Initialize Motors
-Read EEPROM
-LED ON

Ask thought the LCD if the hour is correct while the hour is show.

Show the option of changing the hour

Correct hour — No → •Detect when the encoder button is push → Save the new hour

Yes

Show the hour.

Read Emergency Botton variable

-LED Flashing
-Show "Emergency" in the LCD

Read top cover variable

Emergency button push — Yes / No

Emergency button push — Yes

Rotary encoder button has been pushed — Yes → Show main Menu

No

Read the hour

Hour of a meal — Yes → Read top cover variable

-LED Flashing
-Show "Close the container" in the LCD

Read top cover variable

Cover is closed — Yes → Cover is closed — Yes

-Motor ON for the specified time.
-Fan ON for the specified time

Menu mode — Meals Mode → Show the meals submenu

Hour mode → Show the hour submenu

End Mode

Hour submenu mode

Hour submenu mode

Change hour mode

Show the option of changing the hour

Detect when the encoder button is push

-Save the new hour
-Show "Hour has been changed"

Hour submenu mode

Change number of meals mode

Show the option of changing the number of meals

Encoder button push

-Save the new number of meals
-Create a new variable i=0

End Mode

i<number of menu — No

- i=0+1
-Show " Hour of meal i"

Detect when the encoder button is push

-Save the new hour for meal i
-Show "Minutes of dispensing for meal i"

Detect when the encoder button is push

Save the new miinutes of dispending for meal i

Yes

End of the menu

Responsible agency	Consultant		Document Type		Document status
MERS Department			Control algorithm of object		Educational
Owner	Compiled Álvaro Díez Redondo		Title		Mark MERS BM 23 01 01.00.00.00 CA
Vilnius TECH MSRfuc-19	Checked Ernestas Šutinys		Logic Scheme		Rev. A / Data 09-05-2023 / Lan. en / Sheet 7/8

Total cost

- Components and Materials
- Employee
- Energy
- Packaging
- Tool material consumption
- Salaries
- Rent
- Solidworks
- Software
- Tools and Machinery
- Office and services

90,78%
3,27%
3,27%
0,55%
0,11%
0,17%
0,01%
1,29%
0,00%
0,04%
0,52%

Brake-point graph

478107,50 €
235 u

Legend: Unit sold — Fixed Cost — Total Variable Cost — Total cost — Total Revenues

Responsible agency	Consultant		Document Type		Document status
MERS Department			Economic Calculations		Educational
Owner	Compiled Álvaro Díez Redondo		Title		Mark MERS BM 23 01 01.00.00.00 EC
Vilnius TECH MSRfuc-19	Checked Ernestas Šutinys		Economic Calculations		Rev. A / Data 13-05-2023 / Lan. en / Sheet 8/8