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DISEÑO DE UN PRODUCTO CONECTADO

CONNECTED PILL DISPENSER

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Declaro, bajo mi responsabilidad, que el Proyecto presentado con el título

DISEÑO DE UN PRODUCTO CONECTADO: CONNECTED PILL DISPENSER

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El Proyecto no es plagio de otro, ni total ni parcialmente y la información que ha sido tomada de otros documentos está debidamente referenciada.

Fdo.: Nora Segura Vallejo Fecha: 22/08/2020

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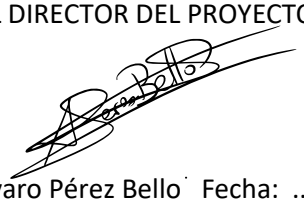

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CONNECTED PILL DISPENSER

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ABSTRACT

The aim of this project is to design a connected product that could benefit our society. This product is a connected pill dispenser directed towards old people, although it can be useful for everyone.

It has been designed a physical dispenser that perfectly controls the descent of the pills and their storage, apart from an electronic system that controls the whole dispenser and that manages to have a good monitoring of the doses. In addition, it has been designed an application where the physical dispenser is set, and moreover, all the information shared between both parts is specified in this memory.

Finally, a business model has been chosen to develop a start-up based on the production and sale of this connected dispenser, as well as doing an expenses and incomes prevision for the first year of the business. Other dispensers have been compared and eventually, the points that make this dispenser stand out above the rest have been outlined.

RESUMEN DEL PROYECTO

El objetivo de este proyecto es el de diseñar un producto conectado que pueda beneficiar a nuestra sociedad. Este producto es un dispensador de medicamentos conectado, dirigido más específicamente a las personas mayores, aunque puede ser útil para cualquier persona.

Se ha diseñado un dispensador físico que controla a la perfección la bajada de las pastillas y el almacenamiento de estas, además de un sistema electrónico que controla todo el dispensador y que consigue mantener un buen seguimiento de las tomas. Por otra parte, se ha diseñado una aplicación en la que se configura el dispensador físico y, así mismo, en esta memoria se especifica toda la información compartida entre ambas partes.

Por último, se ha elegido un modelo de negocio para poder desarrollar una start-up en torno a la fabricación y venta de este dispensador conectado, así como también se ha realizado una previsión de gastos e ingresos para el primer año de esta empresa. Se han comparado distintos dispensadores y finalmente, se han resaltado los puntos por los cuales este dispensador destaca frente al resto.

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Introduction

Nowadays, almost every elderly must take habitually medication, something that did not happen 50 years ago, as now people live longer because of these medications or the advanced technology. But it can sometimes be very problematic, because these old people, in general, could make mistakes while taking it. Some of these mistakes could be not to take their medication at the correct time, or they could forget one of their doses. This is very usual in old people who live alone, if they do not have someone who take care of them, someone as a carer, or someone of their family. According to various studies, 50% of elderly who live alone do not correctly take their medication (1). This is a huge problem in our society, since making mistakes while taking their medication could damage a lot their delicate health. Due to this problem, this project is going to be about making a connected pill dispenser.

Objectives

The objective of this project is to make a connected dispenser of pills to help old people not forgetting their medication. One of the main objectives is to make a dispenser that is able to make a pill descend with control. Another objective is no to be very pricy and that almost everyone could afford it. The third objective is to make it personalized, as old people take different pills which have different sizes. Finally, the last objective is to be connected to an application, a clear application, to control the physical dispenser correctly.

Functionalities of the dispenser

Functionalities of the physical dispenser

One of the most important functionalities the dispenser may have is a compartment to place the pills. The number of compartments may be chosen by the person who is going to use it, depending on how many different types of pills he or she needs to take. On each compartment are going to be placed the same type of pills.

The second and the most important functionality is going to be the dosage system. This system is going to be a bit different on each compartment, as the dosage system may be different for each pill. The whole system will be the same, but the size of the different pills will be taken into account when making this system for each compartment.

Apart from that, the physical system may have some other functionalities to have a great control of the doses old people must take.

The first of these functionalities is a notification at the correct time of the dose. There must be 2 different notifications, a visual notification and a sound notification. This is very important because old people sometimes do not see or hear correctly.

The second of these functionalities is the monitoring of their doses. This consists on knowing if the person who must take de pill has already taken it or not. This functionality is very important to have a perfect control of the doses, and to know if they are taking it on time and every time they must to.

The last of these functionalities is to indicate if the compartment is running out of pills. If this happens, the dispenser may have to notice the person that he or she may place more pills into the compartment.

The last part of functionalities is to be notice if there is a problem in the dispenser, or if the dispenser has low battery. For this, there are also going to be some visual and sound notifications.

Functionalities of the dispenser´s software

The dispenser´s software is very important to correctly control the physical dispenser.

On one hand, this software must control the dosage system. If the control of this physical system is not correct the pill is not going to descend from the compartment and the person is not going to take it whenever he or she must to.

On the other hand, this software must have to monitor correctly if the pill has been taken or not and it must send this information to the application for a correct control.

The software also must control the visual and the sound notifications. The time for these notifications may be given by the application, and the software must take care that these notifications are on time.

Apart from that, the software must control and notice with a visual and sound notification if the physical dispenser is running out of pills. This information is given by the physical dispenser to its software and the software must return this information to the physical dispenser as a form of visual and sound notifications. It also has to send this information to the application.

The final function of this software is to be able to control that everything on the system is going as it must to and that the system has enough battery. If the battery is low or there is any problem on the system, it must return this information as a form of visual and sound notification.

Functionalities of the application

The application is going to be used by a member of the family or a carer of the old person, and it must have some simple but very useful functions.

Firstly, the application must have the function of letting the person who is going to use it to choose the different doses for each pill, and the exact time of those doses.

Other important function is to choose the different tones of the sound notification to take de pill, and the different types of visual notification.

For a good monitoring of the doses the application must have the function to show if the pill has descended or not and if the person has taken it or not.

The last functionality of the application is to show if the physical dispenser is low of battery. Apart from this, if the dispenser can notice any mistake on its working, the application also must show it.

Study of different types of pills

Before thinking of the design of the dispenser, it is necessary to know which different sizes and forms of pills exist on the pharmaceutical market. This is very important for this project, because the purpose of it is to reach a whole dispenser which can be able to dispense all types of pills, and where the only difference between each compartment will be the dosage system. This dosage system is going to vary depending on the type of pill the compartment is dispensing.

Firstly, it is important to difference pills in 2 categories: capsules and tablets.

The capsules have only one unique form, they have an oval form, and their size goes from number 5 to number 000, being this last size the biggest on the market. The biggest capsule measures in longitude 26,1 mm and the smallest one measures 11,1 mm. The diameter of the middle of the capsules vary also with their longitude, being 9,9 mm the biggest diameter, and 4,9 mm the smallest (2).

The tablets are more varied in forms and sizes. When tablets were invented there were only tablets with a disc form, but nowadays there are tablets with more forms, colours and sizes to distinguish each type of medicine. An article says that there are tablets with a longitude between 4,4 mm and 25,5 mm, apart from their different forms. About their thickness it is not said too much, but it is between 0 mm and 10 mm, at the most (3).

For this project, the important information is to know the longitude and the thickness. On pills which have an oval form, this longitude will be the largest one, and on pills with a disc form the longitude will be the diameter of the disc. Therefore, the extreme cases would be for a longitude of 4,4 mm and 26,1 mm. The maximum thickness will be 10 mm.

Design of the dispenser

Design of the physical dispenser

The general idea for the physical dispenser is to make first the compartment in an assembly line, as every compartment is going to be equal. The second part of the process would be to add the dosage system, that will be the unique component which will change.

Different methods of dosage

This part is one of the most important parts in the project, as it is the system that will make descend only one pill by a time. The chosen system would have to:

- Be able to take a pill, but only one pill from the rest of pills placed on the compartment.
- Be able to make the pill descend to the place where it must be taken.
- Small object, with simple design, and be able to fit together with the compartment.

It is important to know, that for each type of pill this system will vary, therefore this system must be created and not bought. The perfect fabrication system would be to print it in 3D.

3 different methods are going to be analyse: a small wheel system, a gate system and a cylinder system.

Small wheel system

This system is very common in dosage system for spherical chewing gums, for example. It is used to buy chewing gums from a machine like in Figure 1. The system is very simple; first, you put inside a coin. When the coin is inside the system it releases a lock and the wheel can be rotated by hand. When it is rotated, the intern system, rotates and the chewing gum descends. This works with a simple mechanism of gears, that are connected to the wheel that is rotated by hand, and to the shaft of the intern system. In this case, the intern system has 3 holes, where the chewing gums are placed while it is rotating. When a chewing gum gets to the front hole, it descends.

Figure 1: Chewing gum dispenser

For this project, the part of the coin would be eliminated, and it could be used the intern system with an electronic device that rotates it. The pills would be placed upside this system and then it would be rotated, and the pills would be placed on the different holes. There would be a hole under the mobile front hole to descend the pill. Each hole of the system, the mobile ones and de non-mobile hole, would have the form of a circle and the diameter of this circle would be the maximum longitude of the pill.

This system is simple and effective, as there are loads of chewing gum machines around the world that work with it. However, there are some problems with this system. One of them is that it is not small, and to fabric it with a 3D printer it would spend too much time and cost too much money. Another important thing about it is that to fit it together with the compartment, the non-mobile hole and the mobiles ones should be very accurate. In addition, the assembly of the system and the compartment would be a bit difficult because this system needs a compartment with its floor closed, except from the non-mobile hole, and it might be put inside before the compartment is closed, so it complicated the assembly line too much.

Gate system

This system is the simplest system to make, as it is only a small piece that would open and close when the pill had to descend.

The compartment would have a small hole, with a variable diameter depending on the size of the pill. Then a small piece would be put on it, with an electronic component that made it move.

It is a very simple design to fabricate, and the variable hole would be the last thing to make on the compartment done. Then it would be added the gate with the electronic component, that would be also variable in size depending on the pill.

There are 2 main problems with this system. Firstly, 2 things would be variable with this system, the hole on the compartment, and the size of the gate, and this is not an ideal thing on the

assembly line. The second and greatest problem is that this system is not very reliable. If the pills were pilled up in the closed gate, then when the gate was opened the pills could descend and it would be very difficult to control that only one pill had descended. Although the gate was opened for a little instant of time it would be very difficult to control how many pills passed through the gate.

Cylinder system

This system is composed by an only piece with a cylinder form. It is not a common system, but it could be very effective for this project.

The system consists on a cylinder with a hole on its middle, as can be seen in Figure 2. This hole would not be running through all the cylinder, it would have a depth of the thickness of the pill. All cylinders would have the same size, and the only thing that would change would be the hole, depending on the size of the pill. The compartments would have a hole under them, but this hole would be the same for every type of pill, as it would be a hole for the cylinder. This cylinder would be also the piece that obstructs the path of the pills.

Figure 2: Cylinder system for dosage

When the pills were upside the cylinder in the compartment, then one pill would be placed on the hole of the cylinder, as the diameter of the hole would be equal to the maximum longitude of the pill, and its depth would be a bit bigger than the thickness of the pill. The cylinder would be rotated by an electronic component, and when this happened only the pill placed on the hole would descend.

This system seems to be effective, it is not too big, and, in addition, the only thing different in the whole physical dispenser, compartment and dosage system, would be the hole on the cylinder. The cylinder could be added to the compartment at the end of the fabrication process, so this helps the assembly line being faster.

Dosage system

The chosen option is the cylinder system, as it can be very effective, simple and helps the assembly line going faster. The piece will be done by a 3D printer, as it is not very big and can be print quickly in 3D. It cannot be done by a mould, because the hole is going to vary, so 3D printing is the perfect method.

The design of this piece is shown in Figure 3. The diameter and the longitude are the magnitudes that will not change for the different type of pills. To choose the diameter is needed to see which is the maximum longitude of pills, which is 26,1 mm. Therefore, the diameter needs to measure at least 26,1 mm. For this dosage system is going to be used a diameter of 30 mm. The longitude of the cylinder is going to depend on the horizontal length of compartment, as this system is going to be added under the compartment. When the dimensions and forms of the compartments are selected, this length will be selected too.

The variable measures will be the depth and the diameter of the hole. The diameter will be 0,5 mm more than the maximum longitude of the pill, to guarantee that the pill gets in correctly. The depth of the hole will be a 50% greater than the thickness of the pill, to assure that it can pass though the hole of the compartment while de cylinder is rotating.

The plan for this cylinder is at the end of this project.

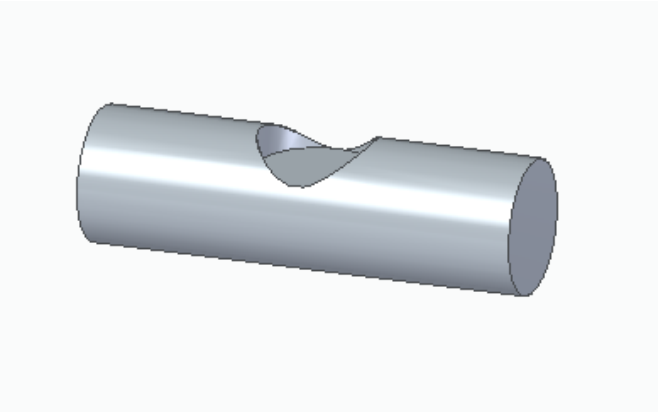


Figure 3: Design of dosage system

Compartments

There can be loads of different types of compartments to place pills. For this project, each compartment is going to be equal for each different type of pill, and the objectives on its design must be:

- Not too big, because there are going to be some of them arranged in series and the transport of all of them should be easily done.
- Enough big to place enough pills for 1-2 weeks at least.
- Easily accessible the hole where the pills get in the compartment.
- A simple design, which allows the pills descend to the dosage system correctly.
- To have a little slope where the pill is going to descend and wait until it is taken.

For these objectives, the simplest designs could be a rectangular box or a spherical box. The compartments should not have too much altitude, because the pills are going to be placed into by a hole upside the compartment. This hole must be enough big to place into easily all types of pills. To choose one of these simple designs they must be compared.

Rectangular box

This type of compartment would have a square base and the height would be larger than the other sides. Upside the compartment would be a hole to get in the pills, and it would have a hole on two parallels sides to put the dosage system. These two holes would have the diameter of the cylinder plus 0,5 mm to guarantee that the cylinder fit in correctly. Apart from this, the compartment would have a slope from the height where the cylinder is put to the floor to descend the pills.

This compartment would be perfect because it is not very big, and it could be arranged some of them in series and do not take up much space. Having a good height, it can be placed enough pills for 2 weeks, and it would not be necessary to be very tall.

There is an important problem with this compartment, the pills would accumulate on all the upside area of the cylinder, and it would be a bit difficult to assure that one pill had been placed on the hole of the cylinder.

One solution for this problem is to put inside something like a funnel to carry the pills to the hole. But there are 2 problems with this. Firstly, it would be another piece to make, and secondly, the funnel would be variable, depending on the size of the pills, and the objective is to make a compartment valid for every type of pill.

Spherical box

This option has things in favour and against in comparison with the other option. The point against it is that if the compartment has the same height as the rectangular box, this compartment is going to be as tall as width, as it is spherical. Therefore, this compartment is going to be more width than the other one, so it is going to take up more space than the other, an important point to take into account.

However, there is a great point in favour of it. In the other option, the problem is that it is not easy to know if one pill has been placed on the hole of the cylinder, and with this spherical design, its walls would carry the pills to the hole.

Apart from that, the diameter of the sphere can be reduced to a diameter that makes the compartment do not take up too much space. However, it must not be reduced to the point that it is not able to place pills for 1-2 weeks at least.

Regarding the points in favour and against both designs, it is chosen the spherical compartment.

Dimensions of spherical compartment

The complete design of the compartment will be as shown in Figure 4. The plan for the compartment is at the end of the project.

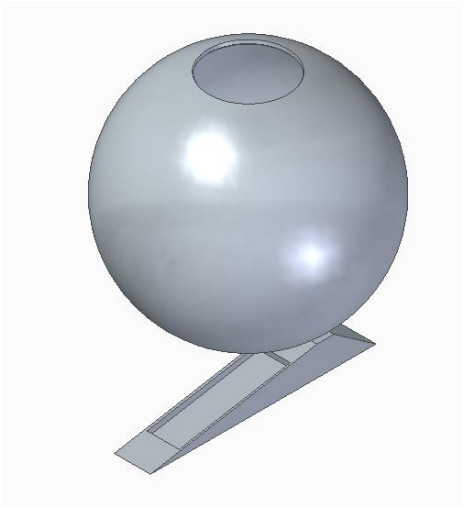


Figure 4: Spherical compartment

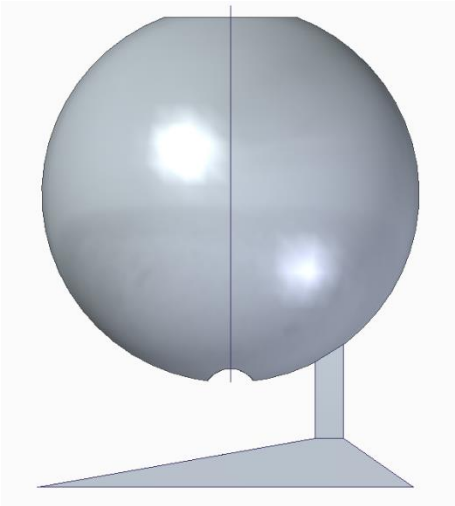


Figure 5: Profile of spherical compartment

The compartment has 2 parts: the sphere with 2 different holes and the bracket with a ramp where the pills are going to descend.

The first part is going to be bought. There are a lot of web sites to buy a set of plastic spheres with a diameter of 15 cm. Then, the holes will be done on the spheres. The first hole is the hole to get in the pills, and it will be a circle. This circle will have a diameter of 35 mm, enough big to put the pills, as the longest pill measures 26,1 mm. The other hole is the hole where the dosage system will be added. This hole has the form of the cylinder, as it can be seen in Figure 6, but only 10 mm of it will be inside the compartment.

Figure 6: Hole for the dosage system

The second part consists on a vertical column and a triangular piece to hold the compartment as it is shown in Figure 7. Apart from this functionality, the frontal part of the triangular piece is a slope where the pills are going to descend and wait until they are taken.

The column has a rectangular base of 15x20 mm, and the height is 48,65 mm on the highest part and 40 mm on the lowest part. The triangular piece has a rectangular base of 32x170 mm. In the slope there is an empty space of 7 mm of depth where the pills are going to descend. It is rectangular and its dimensions are 29x96,6 mm.

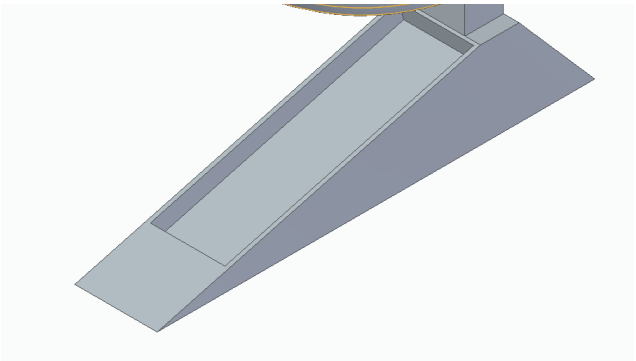


Figure 7: Slope where the pill descends

Assembly and fabrication of physical dispenser

To fabricate the whole physical dispenser, it is needed a rod that will connect the dosage system with the servomotor, placed on the PCB. This rod will hold the dosage system, as it can be seen in Figure 8, and place it in assembly with the spherical compartment. This rod will make the dosage system rotate because of the servomotor placed on the other side of it.

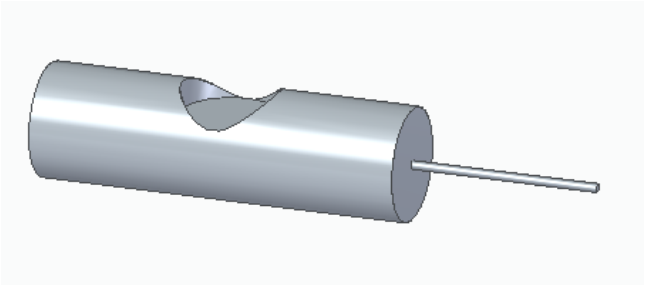


Figure 8: Assembly of the dosage system

The final assembly of the whole dispenser will be as in Figure 9. It is not completed, because of the rod, that will be connected to the servomotor and in that way the physical system will achieve to work.

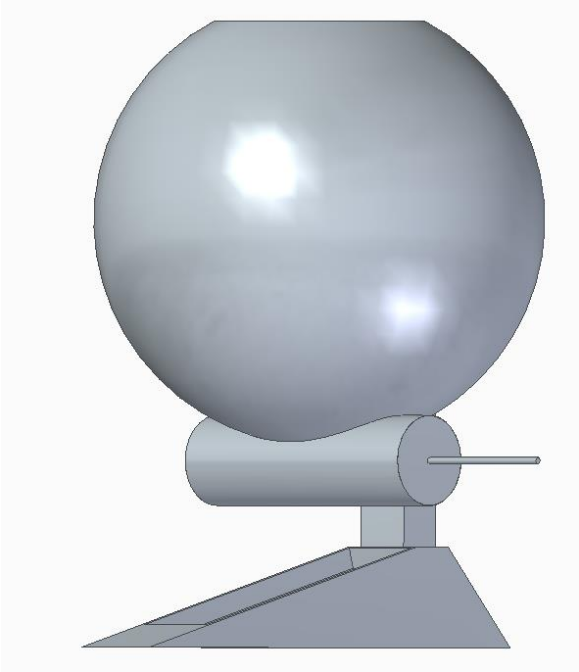


Figure 9: Assembly of the physical dispenser

Electronic components

Apart from the physical dispenser, the whole dispenser will have some electronic components that will allow the correct working and monitoring of it. There will be some leds and a speaker to notify the time of the dose, or other problems that could happen. Another important part of these components is the IR sensors to monitor if the pill has descended or not, and to know when the dispenser is running out of pills. There will be also a servomotor to make the physical dosage system work. Finally, a microprocessor will be used to control by a program all these different electronic components.

Schematics and functioning of the electronic components

Leds

There are 3 leds connected to the PCB, as shown in Figure 10:

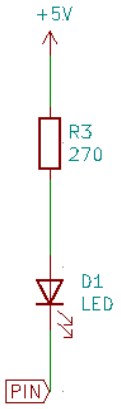


Figure 10: Circuit of the led

The led is connected to a pin of the microprocessor and to a resistance, which is connected to 5V of voltage. When the microprocessor gives to this pin some voltage, the led switches off, and when it has 0V on the pin the led switches on, as the current must go from the anode to the cathode of the led. The cathode is represented in Figure 10 as a horizontal line, and the anode is the other side of the led.

There are chosen 3 different colours for the 3 leds connected to the PCB: a red led, a green led, and an orange led. The red led switches on at the time of the dose, and it switches off when the pill is taken from the dispenser. When this happens, the green led switches on for a moment, as a symbol of good working. If there is any problem in the dispenser the orange led switches on.

Speaker

The speaker is connected to the PCB as shown in Figure 11 (4):

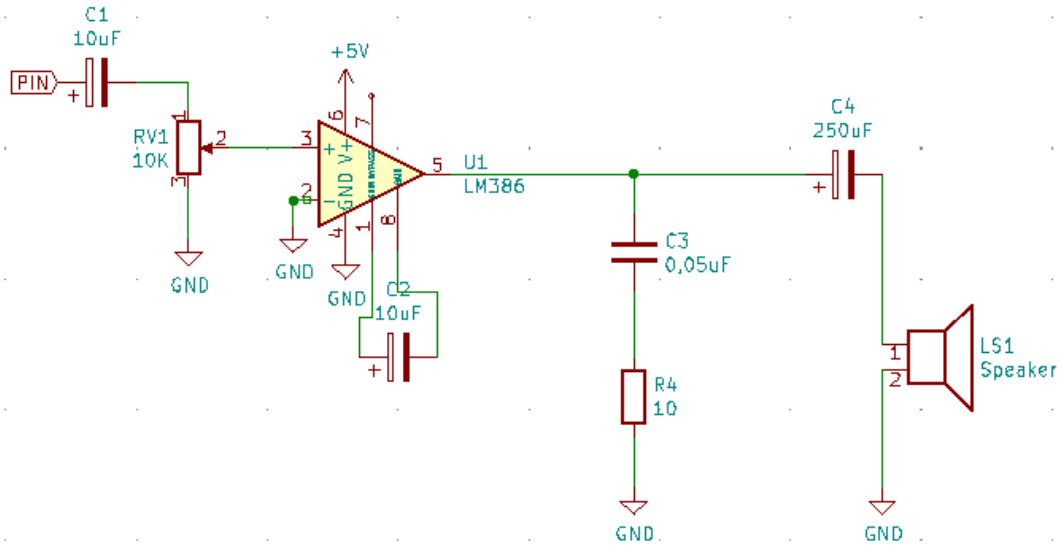


Figure 11: Circuit of the speaker

The speaker is connected to some capacitors, to a resistance of 10 Ω, to a potentiometer of 10 kΩ and to an amplifying. The purpose of the whole circuit is to reach that the old person, who will use the dispenser, can increase or decrease the volume by hand rotating the potentiometer. This will be beneficial for the old people as it is a simple form to change the volume if they want.

The selected amplifying is the LM386, as it is the most common used amplifying for these types of connections and it is not expensive. The amplifying makes the voltage that comes from the pin of the microprocessor amplify, and it will be amplified depending on the potentiometer. When the potentiometer is rotated to one side or to the other side the resistance of it changes and then the voltage that enters to the amplifying also changes.

Apart from this, the capacitor that is connected between the pins 1 and 8 of the amplifying makes the amplifying amplify until 200V/V, instead of 50V/V that is its normal amplification.

When the microprocessor gives voltage to the pin where this circuit is connected, the current enters from the first capacitator of 10uF and goes to the potentiometer, to the amplifying, and for last, to the speaker.

IR sensors

The schematic of the IR sensor is shown in Figure 12 (5):

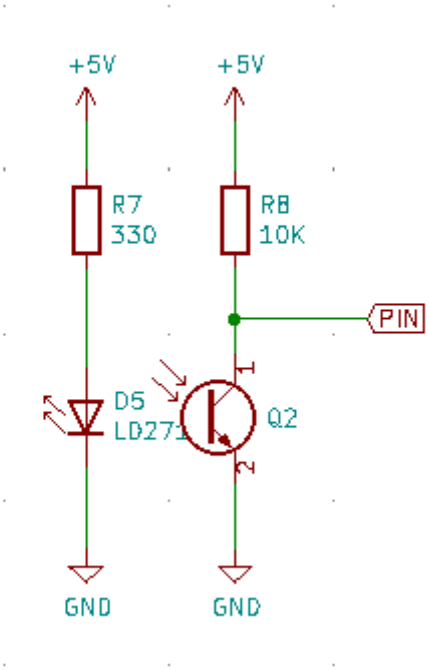


Figure 12: Circuit of the IR sensor

In the dispenser there are 2 IR sensors, one connected on the end of the slope where the pills descend, and the other one connected inside the compartment to monitor the amount of pills inside it.

In Figure 12 it is shown that there are 2 parts of this sensor: the part of the IR led and the part of the phototransistor. The first part is connected just like the leds, figure 11, although it is not connected to any pin of the microprocessor, it only uses the ground and the 5V of the PCB for its working. Its objective is to have the IR led on all the time, as it emanates infrared lightning.

The second part is very similar except for the phototransistor and that this circuit is connected to a pin of the microprocessor. It is also connected to ground and to 5V, as the first part of the whole sensor. The phototransistor works similar to a normal transistor; it works as a closed gate when it is resting, and when it is excited by a light it works as an opened gate.

The assembly of these 2 parts of the sensor is very simple, for example in the slope: the first part is put on one side of it and the second in the other side, letting the IR led and the phototransistor to be in front of each other. The IR led is on all the time, so the IR lightning must pass through the place where the pill will be when it descends. When there is no pill the lightning will pass and the phototransistor will be excited by it. When a pill descends the lightning will not pass and the phototransistor will be resting.

In the first option, if there is no pill, the phototransistor will work as an opened gate, so for the microprocessor this will be as a 0. If there is a pill the phototransistor will work as a closed gate, letting the 5V pass through the pin to the microprocessor, and for it this 5V will be as a 1.

Servomotor

The schematic of the connection of the servomotor is shown in Figure 13:

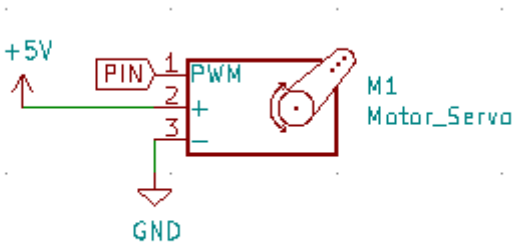


Figure 13: Circuit of the servomotor

This connection is very simple, one pin of the servomotor goes to 5V, other to ground and the third one to a pin of the microprocessor that controls it.

The functioning of a servomotor is shown in Figure 14 as a block diagram (6):

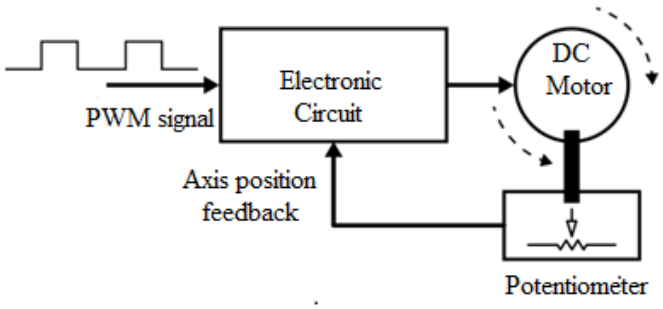


Figure 14: Block diagram of the servomotor

First, the microprocessor sends a PWM signal to the servomotor and an electronic circuit transform this signal into another one that makes the DC motor work. In this case, the potentiometer is used to make a voltage divisor with the DC motor, so the voltage at the exit of the divisor will vary depending on the position of the DC motor. This allows the electronic control circuit to feedback with the position of the DC motor.

This electronic component allows the dosage system to rotate. When a pill must descend, the microprocessor sends the PWM signal to the servomotor and then it works and rotates the rood that is connected to the dosage system.

It only rotates from an angle of -90º to an angle of 90º, so for this servomotor are going to use only these 2 positions, as the cylinder, which is the dosage system, only needs to be with the hole inside the compartment, and rotated 180º.

Microprocessor

This component will allow to control all the different electronic components by a program.

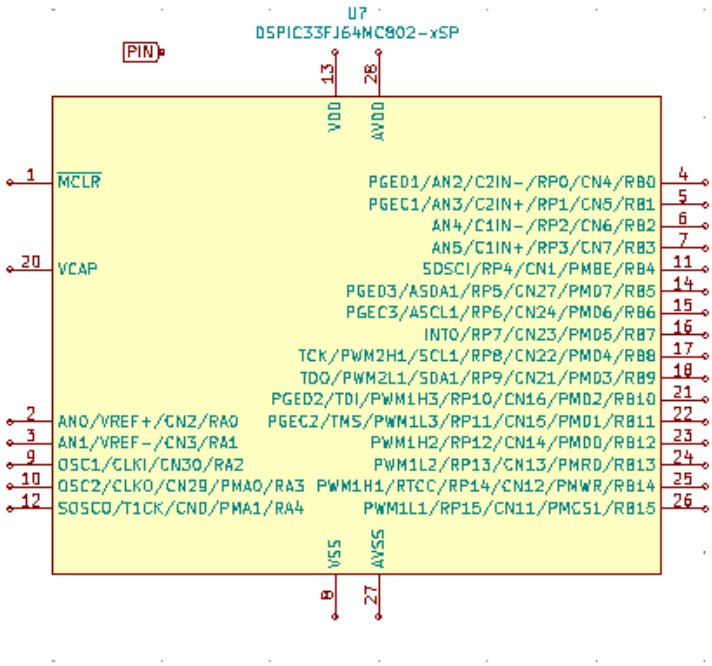


Figure 15: Pins of the microprocessor

To choose the microprocessor, it is important to know how many of its pins will be used. For this project, the number of devices connected to it is 7, apart from the ground and 5V pins.

The IR sensors go to pins 2 and 3 (AN0 and AN1), as these sensors need an analogical pin. The leds go to pins 4,5, and 6 (RB0, RB1 and RB2), they only need a digital pin. The speaker and the servomotor go to pins 25 and 26 (PWM1H1 and PWM1L1), in this order. Finally, ground (GND) goes to pin 8 (Vss) and the 5V goes to pin 13 (Vdd).

Completed schematic

The schematic shown in Figure 16 is the final design of the PCB:

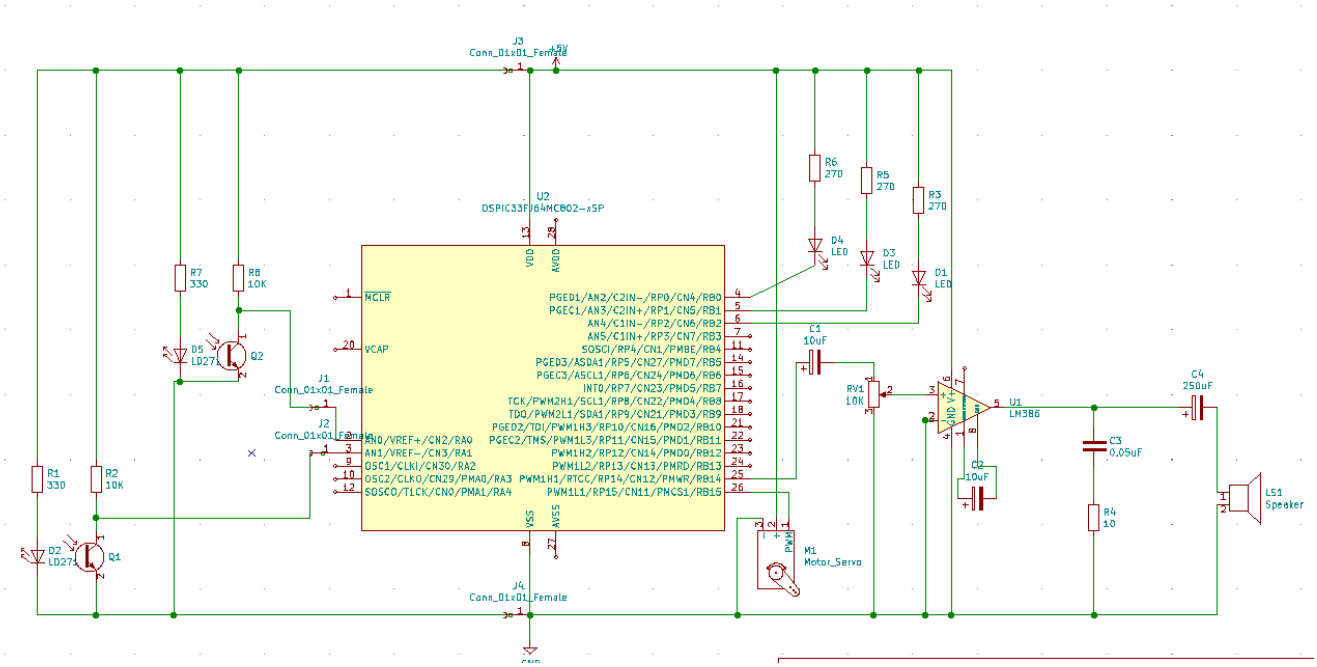


Figure 16: Completed circuit of electronic components

As it can be seen in Figure 16, the IR sensors are connected to the microprocessor, to the ground and to 5V by 4 connectors. As the IR sensors are placed on the physical dispenser, they cannot be on the PCB, and for this reason there are connectors on the PCB, to allow the connection between the IR sensors and the PCB by some wires.

The other components are directly connected to the microprocessor and are in the PCB.

Wifi module

Apart from the other components, a wifi module is needed to connect the PCB to the internet to make the connection between the physical dispenser and the application possible. The selected wifi module is the HLK-RM04. This module is very easy to connect to the microprocessor, since it has 2 ports, RX and TX, which must be connected to the pins with the same name of the microprocessor.

In Figure 17 the HLK-RM04 wifi module can be seen:

Figure 17: Wifi module for the Internet conection

PCB

The final design of the PCB and the IR sensors is shown in Figure 19. In Figure 18 it can be seen all the connections with the courtyards on the PCB, in the front layer, and the 2 IR sensors outside the PCB, but connected to it.

In Figure 20, there is a 3D displaying of the PCB.

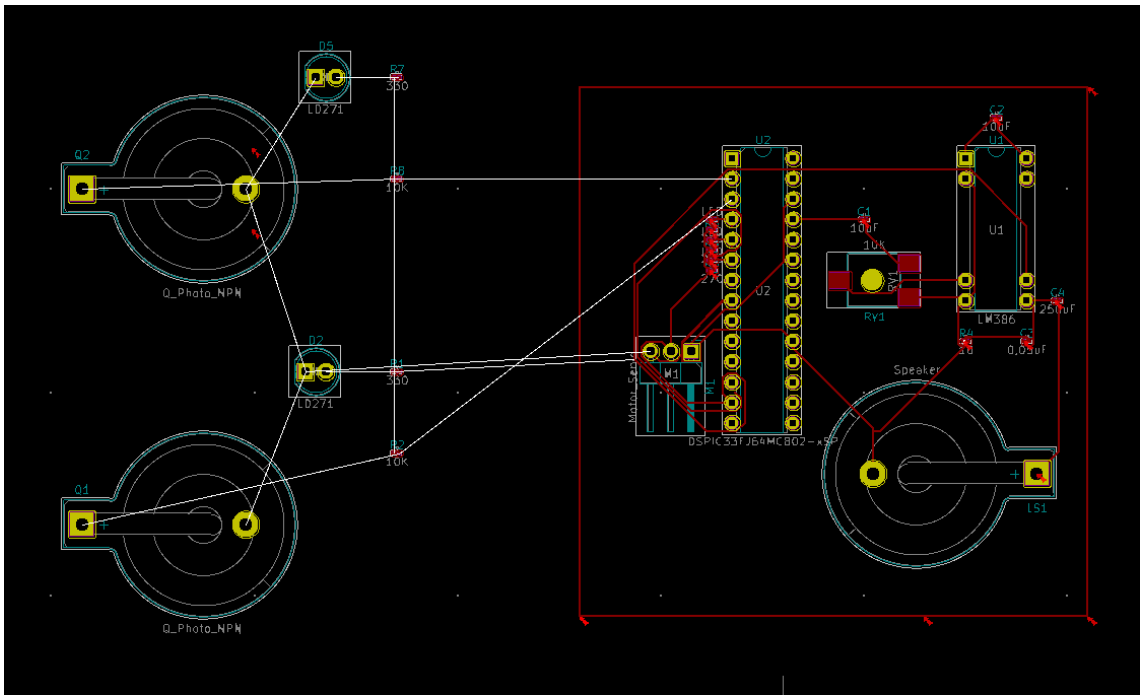


Figure 18: First design of the PCB

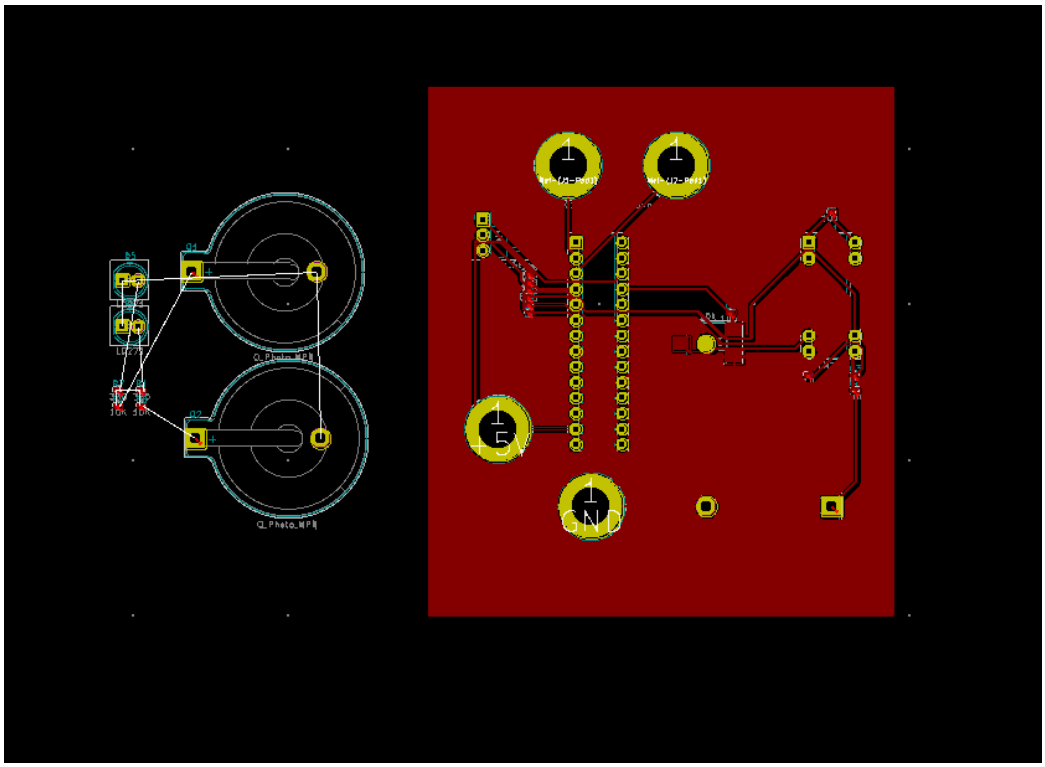


Figure 19: Final design of the PCB

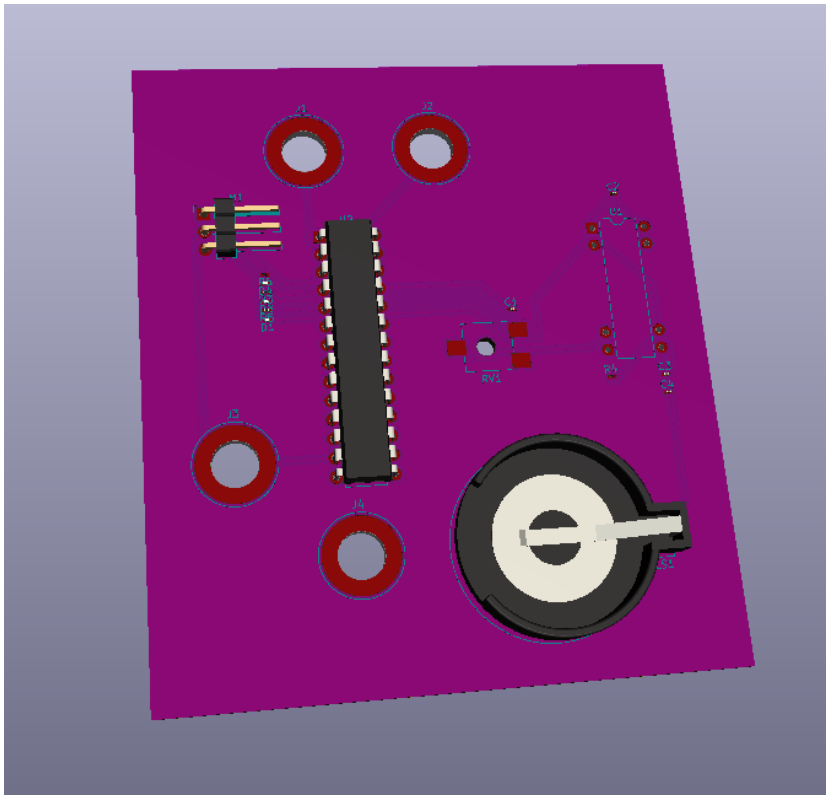


Figure 20: PCB in display screen

Assembly of the PCB and the physical dispenser

There are 3 elements that must be connected to the physical dispenser: the IR sensors, the servomotor and the PCB.

IR sensors

There will be 2 IR sensors to place in the dispenser: firstly, the sensor that is used to control if the pill has descended or not, and secondly, the one that controls if the compartment is running out of pills.

IR sensor of the slope

This sensor is also used to control if the pill has been taken from the slope or not, apart from controlling if the pill has descended or not. The sensor is placed in both sides of the slope, the IR led in front of the phototransistor. The connection between the PCB and this sensor is done by the connectors placed in the PCB and some wires that are going to connect all the components of this sensor and the sensor with the PCB. In Figure 21 it is shown the exact place where the sensor is.

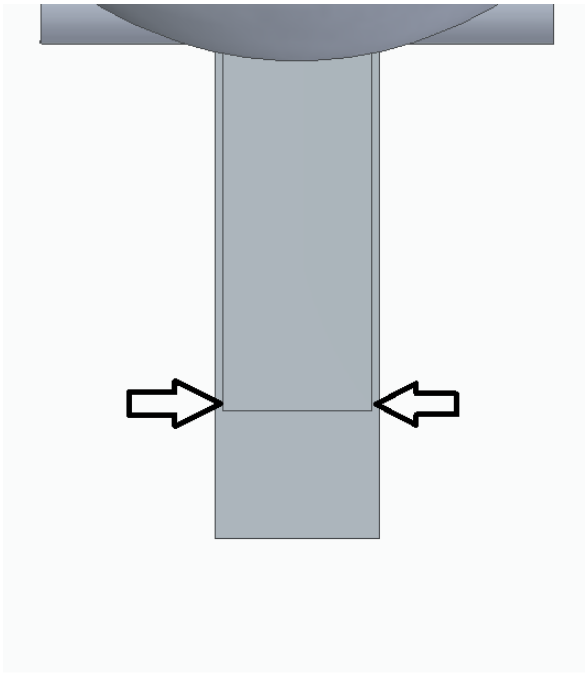


Figure 21:Assembly of the IR sensor with the slope

IR sensor of the compartment

This sensor is only used to control de number of pills inside the compartment. The sensor is placed inside the compartment, the IR led in front of the phototransistor, as in the other IR sensor. In Figure 22 it is shown the place where this sensor is put.

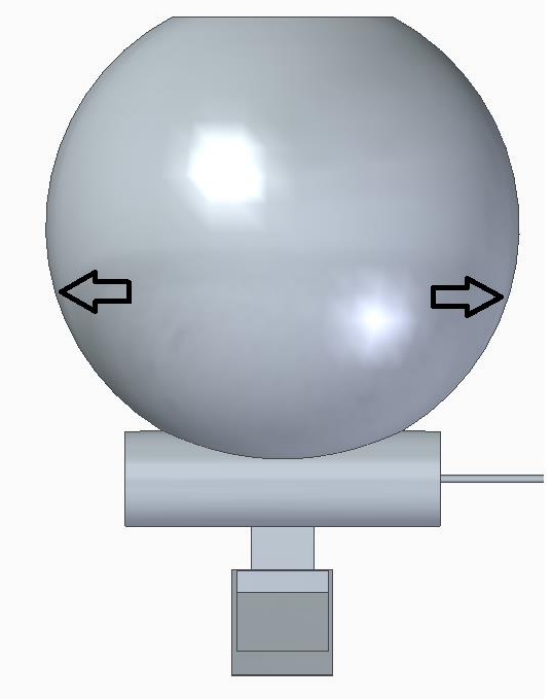


Figure 22: Assembly of the IR sensor with the compartment

When the pills are under the line that connects the IR led and the phototransistor, then the sensor sends the message that there are not pills obstructing the IR lightning and that it is needed to put more pills inside the compartment.

As the other sensor, this sensor is connected to the PCB by some wires and the connector in the PCB.

Servomotor

The servomotor is connected to the cylinder by a rod. As the rod that is hooked to the cylinder is in horizontal, and the rod that is connected to the servomotor is in vertical, it is needed a pair of gears, to convert the vertical rotation to an horizontal rotation and in that way the cylinder could rotate.

The servomotor is placed on the PCB, so its location will depend on the place where the PCB will be.

PCB

The PCB must be placed somewhere in the physical dispenser fixed to it. It must take into account that in the PCB is placed the servomotor, so it is important to know the dimension of the PCB and the distance to the servomotor. The dimensions of the rod that connects the servomotor with the cylinder is also going to calculate in this chapter.

Firstly, it is important to know the dimensions of the PCB; they are shown in Figure 23:

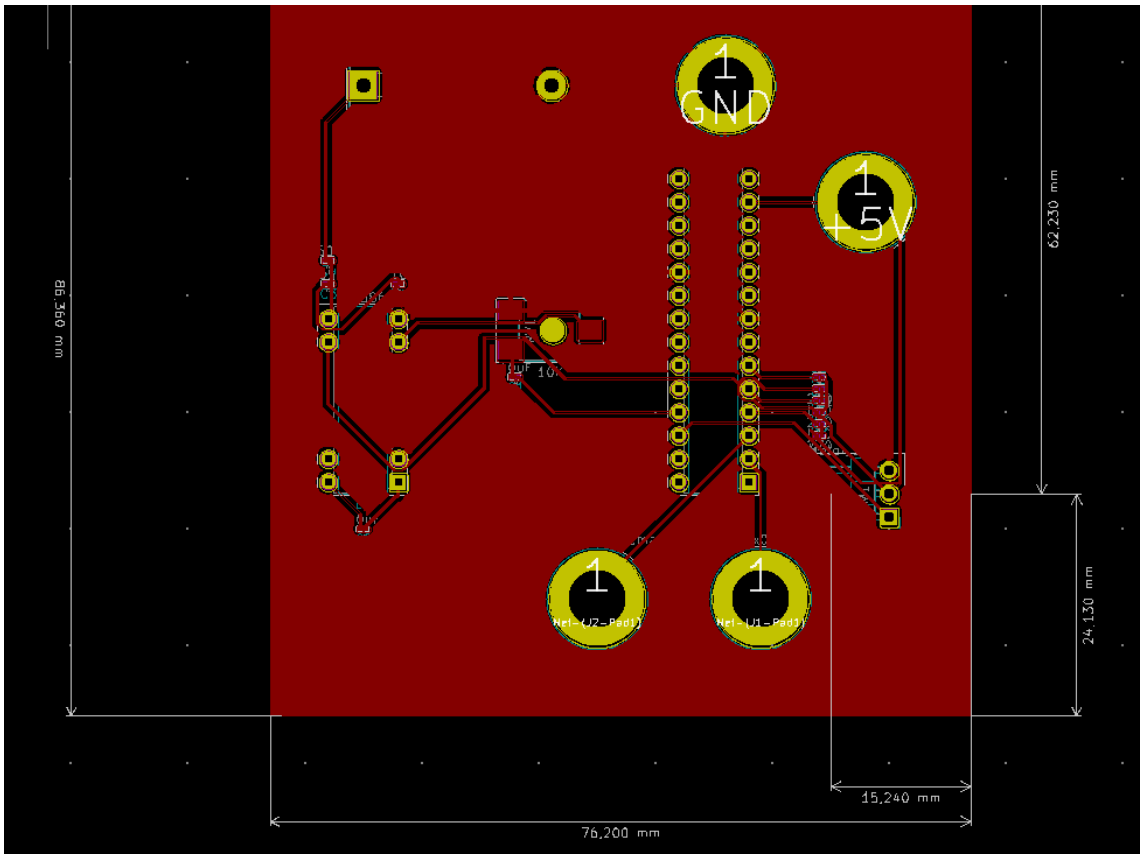


Figure 23: Dimensions of the PCB

The servomotor is placed in the 2 other dimensions that are shorter than the sides of the PCB. The idea is to put the PCB in the place where the line is in Figure 24and in Figure 25:

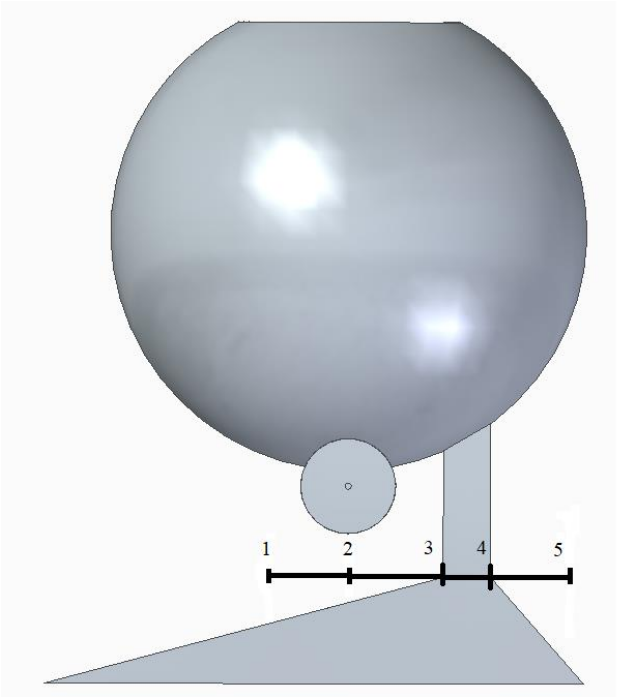


Figure 24: Assembly of the PCB with the physical dispenser

In this first figure, in Figure 24, the line shows the 76,2 mm that measures the short side of the PCB. Point 1 is the side of the PCB which is not the closest side to the servomotor. From point 1 to point 2 it measures 6 mm, from point 2 to point 3 it measures 34 mm, in total 40 mm. The servomotor is 60,96 mm from point 1, so the rod of the cylinder may measure:

$$Lrod = 60{,}96 - 40 = 20{,}96\ mm$$

As it can be seen in Figure 25, the vertical rod may measure from the centre of the cylinder to the line that is painted vertically. This measures exactly 28,82 mm, so this is the measure that the second rod must have.

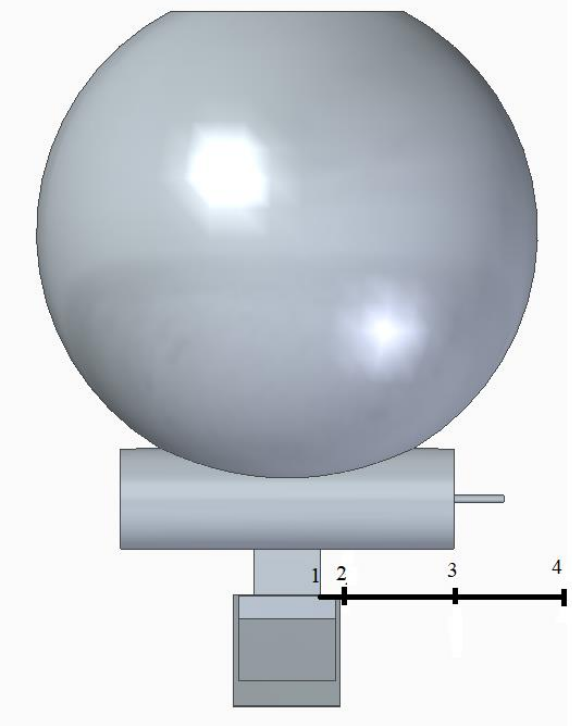


Figure 25: Other side of the assembly of the PCB with the physical dispenser

In Figure 25 is also calculated the exact position of the PCB, as this line is the largest side of the PCB which measures 86,36 mm, as it is shown in figure 23. Point 2 is just where the servomotor is placed on the PCB, so from point 1 to point 2 it measures 24,13 mm. From point 2 to 3 it measures 29,94 mm, and from point 3 to point 4 15 mm. So in total, from point 2 to point 4 it measures 44,94 mm, and from point 2 to point 5 (from the servomotor to the side on the PCB) it measures 62,23 mm. Point 5 is from point 4 in a distance of:

$$P5 = 62{,}23 - 44{,}94 = 17{,}29\, mm$$

Design of the application

The design of the application has been done by a program called Illustrator, so the next figures will be a demonstration of how the application could work connected to the physical dispenser and how the screens of it will be.

Register

The first thing that must be done in the application is the register or the log in. Firstly, the application will wait until it is charged, and then it will ask about the user and the password. There will be the option to sign in a new user, or the option to log in with a user that is already registered.

Figure 26 shows the screen where the application loads, and in Figure 27 the log in or the register to enter on it.

Figure 26: Loading screen of the application

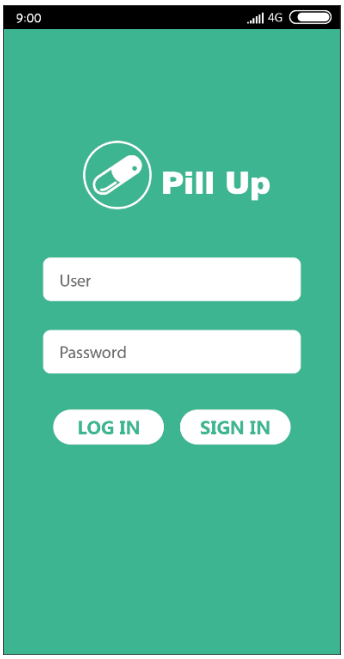


Figure 27: Log in/sign in screen of the application

Main screen

After logging in there is a main screen, Figure 28, which has all the options: the settings and the notifications.

When the dispenser is bought it is necessary to set it for its correct working. The variables which need to be set are the choice of the days and hours of the doses of each pill and the choice of the different alarm tones for the speaker. Apart from the initial setting, it is possible to change any setting whenever needed. In the upper and right part of the screen there are 3 lines where it is possible to access to the settings, as it is shown in Figure 29. It has also another option, the main menu option. This allows to come back to this main screen at the wished moment from any other screen, as these 3 lines with settings and main menu options appear in all the screens.

The other functionality of this screen is to show any notification that is sent from the physical dispenser to the application. If there is any notification it is shown in this screen, and if there is not any, the message that is shown in this screen is “you have no notifications”.

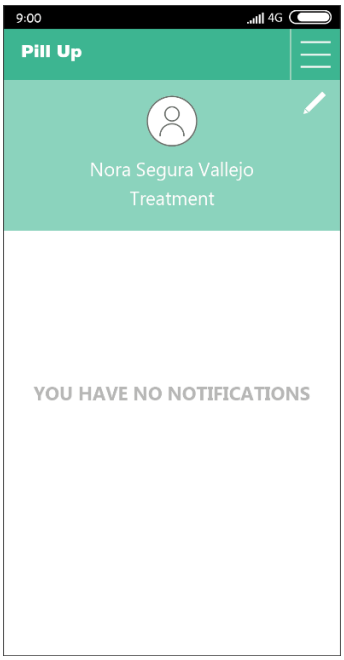


Figure 28: Main screen of the application

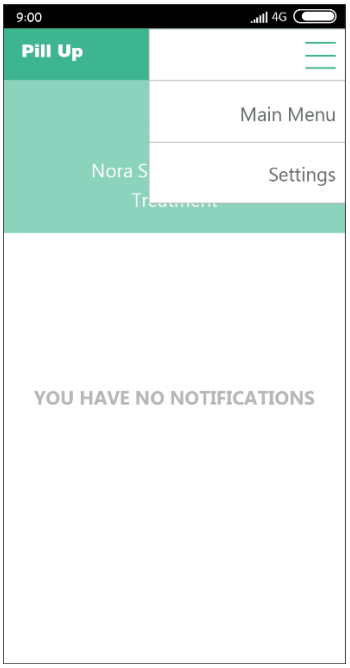


Figure 29: Options of the main screen of the application

Settings

Now, the first part of the application will be explained, the settings.

Settings option has 2 options to choose: doses and speaker, Figure 30. The first option is used to set the times of the doses of each different pill. This first setting is the most important one and the first thing to do when the dispenser is bought, as until doses are not set the dispenser will not work. The second option of the settings is related to the different alarms of the speaker, since there must be 2 different alarms for 2 different things, that will be explained later.

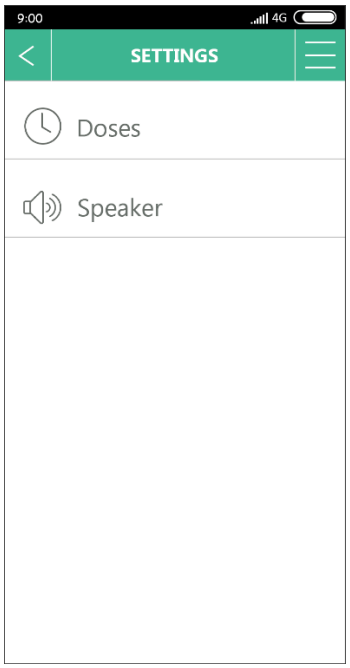


Figure 30: Settings screen of the application

Doses

Compartments

After choosing the doses option in the settings screen, the application shows another screen with the option of choosing the compartment of the pill that will be set. This has a great importance, as each compartment will have inside each different type of pill, and each pill has its time of the dose, so it is important to know exactly where each pill goes to set all the different doses correctly.

The number of compartments depends on how many different types of pills the old person is taking. Knowing this, the application will be noticed about this information, so the number of options of this screen will change depending on the person. In Figure 31 there is an example of

a dispenser with 4 compartments, that implies that in this case, the old person takes 4 different pills. Now, it is necessary to choose one of them to set the times of the doses of the pill that is inside it.

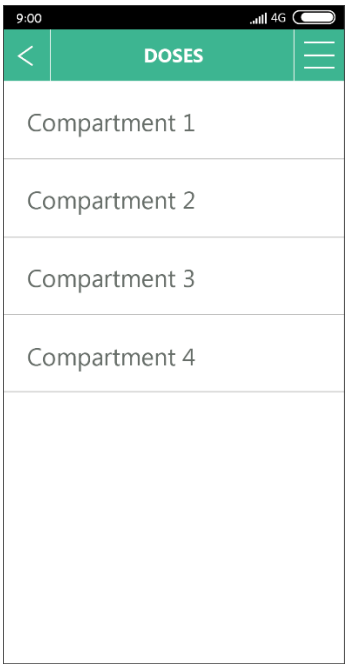


Figure 31: Compartments screen of the application

Times

After choosing the compartment that will be set, the application shows the screen to set the doses. It shows a calendar of one week where any day of the week can be chosen, touching it, to set the dose of the pill of that day. When touching one day the screen shows 3 different hours to take the dose. These 3 different hours are 8:00, 14:00, and 20:00. These coincide with the approximate times when old people have breakfast, lunch and dinner. It is supposed that these times are more or less the times when they take their different pills.

In Figure 32 there is an example of the setting of one day. The chosen day is Monday, as it can be seen, MO is in a green colour to distinguish that this day is being set. In this example there is a 1 in breakfast time, a 0 in lunch time and a 2 in dinner time. This means that at 8 AM the dose is one pill, at 2 PM there is not any dose, and at 8 PM the dose is 2 pills. There can be written any number for each different hour and each different time. It is important to set every day of the week and to put the number of pills that are needed at the 3 times that appears in the screen.

Finally, in the lower part of the screen, there appears the number of pills that the old person must take at the 3 different hours. This information will be sent to the physical dispenser for its correct working.

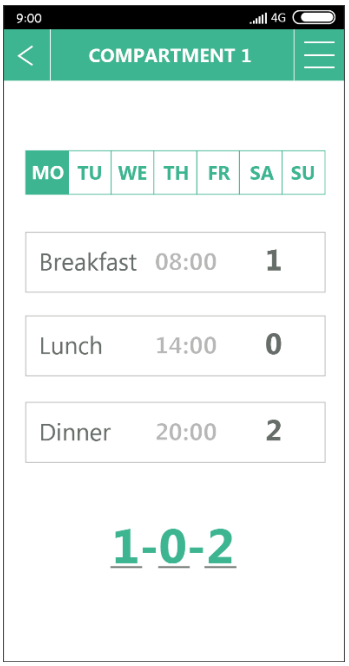


Figure 32: Times screen of the application

Speaker

The other option of the settings is the option to set the alarm of the speaker. When entering to this option there are 2 more options: the alarm for the doses and the alarm for warnings, Figure 33.

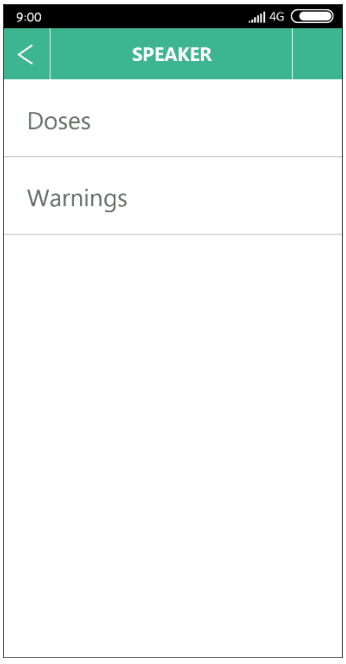


Figure 33: Speaker screen of the application

Doses

Apart from the red and green leds for notifications there is a speaker to notify that it is time for the dose. The working of the leds is simple; when it is time to get the dose the red led will switch on and when the pill is taken from the slope of the dispenser the red led will switch off and the green led will switch on as a sign of good working.

In this screen it is possible to set the tone of the alarm desired to notify that it is time to take the pill. There will be some different type of sound of alarms to choose, as it is shown in Figure 34.

Figure 34: Doses screen of the speaker option

Warnings

The warnings are also notified by the physical dispenser, with the orange led and with the speaker, but with a different tone from the notification of the dose. The orange led will switch on when there is any problem, and the speaker will sound with a different tone from the doses alarm, to know that something goes wrong. These 2 alarms will not be the same, as the alarms of each option (doses and warnings) are different alarms. In Figure 35 the other options for the warnings alarm can be seen.

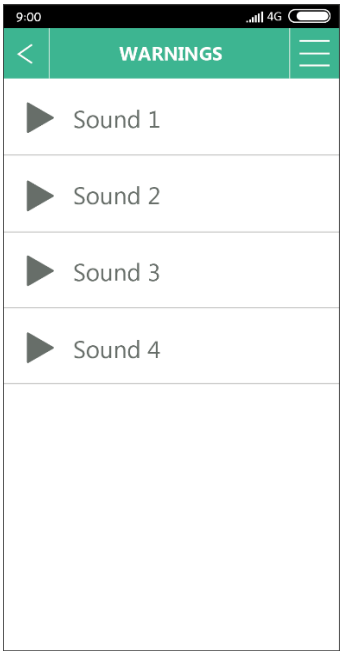


Figure 35: Warnings screen of the speaker option

In both screens, doses and warnings screens, the alarm is heard when touching the different options, and the last sound touched will be the one selected for the alarm.

Notifications

Coming back to the main menu screen the notification option will be explained.

There are 2 type of notifications, a notification with a message that the pill has been took and there is not any problem with the dispenser, and notifications with different messages about some problems with the dispenser.

When there is a notification it appears in the main screen as it is shown in Figure 36. In this example the are 2 notifications, one has the borders green and the other one red, this means that the first one is about the good working of the dispenser and the second one is a warning about a problem.

Apart from this, in the notifications appear the time when the good working or the problem has happened, the breakfast (8:00), the lunch (14:00) and the dinner (20:00).

It is possible to touch the notifications to read all the notification, as it can be seen in Figure 37, and then, if it has been read, it can be removed from the screen swiping it with the finger.

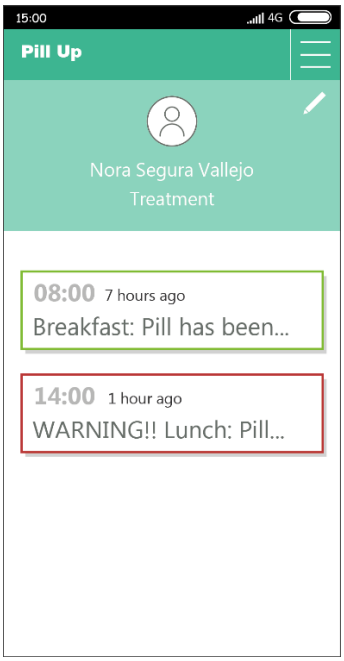


Figure 36: Example 1 of notifications

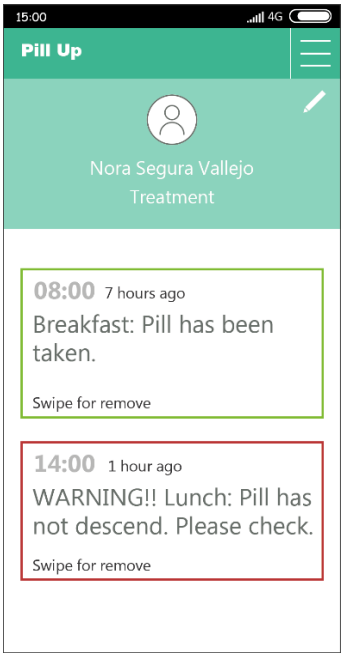


Figure 37: Example 2 of notifications

In Figure 37 can be seen one of the warnings notifications. The first problem that can occur is that the pill has not descended. If this notification appears the error in the physical dispenser could be that the cylinder is not working correctly with the servomotor or that the hole of the cylinder has not caught any pill. In both cases it would be necessary to examine the physical dispenser.

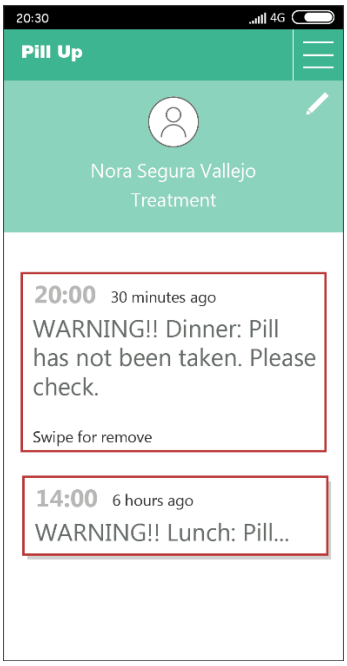


Figure 38: Example 3 of notifications

In Figure 38 a second warning can be seen. This problem is not a problem of the dispenser; in this case the problem is that, although the pill has descended, the old person who must take the pill has not taken it.

In Figure 39 there are the other 2 problems that can occur. The first one is about the battery and the second one about the pills on the compartment.

The first one is when the battery has a 20% of battery and it is necessary to plug in the dispenser.

The second one is when a compartment is running out of pills and a person must put more pills in the compartment.

The information for the first 2 warnings is given by the IR sensor of the slope, and the IR sensor of the compartment sends the information about pills in the compartments.

In any case, it is important to verify the correct working of the dispenser, and maybe to send it to be repaired.

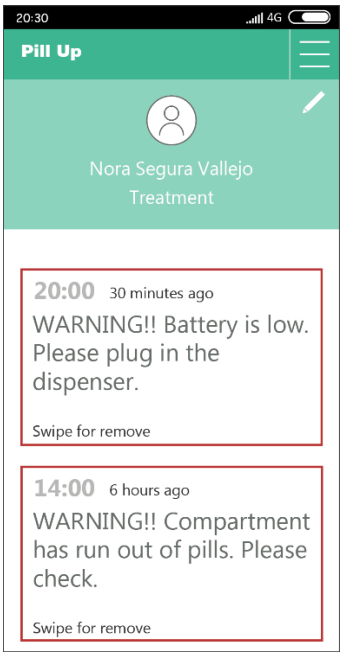


Figure 39: Example 4 of notifications

Business model

Market research

Nowadays, there are not many connected dispensers of pills, so in this chapter some of them will be studied, their characteristics and their price.

The first one is the one shown in **¡Error! No se encuentra el origen de la referencia.**. This dispenser has the next characteristics (7):

- It is automatic
- 6 different visual and sound alarms
- It is easy to use and the speaker sounds 30 minutes
- It has some keys to set it

Figure 40: Example 1 of dispenser in the market

This dispenser costs 79,99€.

The second one is shown in Figure 41. This one has these other characteristics (8):

- Intelligent management
- Settings with an application
- It has a function of voice to interact with the dispenser
- The application monitors the doses and the carers or familiars can do video calls with the old person.
- It has 28 slots for the pills.

Figure 41: Example 2 of dispenser in the market

This dispenser and one month of application costs 559€ and then, the application costs 9,99€/month.

The third one can be seen in Figure 43. This dispenser has the next characteristics (9):

- The cover has a key
- It has 6 alarms on a day
- It has an indicator of low battery
- It dispenses the pills to the cup of steel
- It has 28 compartments for pills.

Figure 42: Example 3 of dispenser in the market

This dispenser costs 289,95€.

The last dispenser is the one shown in Figure 43. This last dispenser has these characteristics (10):

- Automatic dispenser
- It is connected to an app by Bluetooth
- The person must be at 10 m or less from the dispenser because of the Bluetooth connection
- The cover has a key
- It has 6 alarms on a day
- It has battery for 2 months and has a warning of low battery
- It has 28 compartments to deposit the pills

Figure 43: Example 4 of dispenser in the market

This dispenser costs 249,95€.

It is normal that the second dispenser is the most expensive dispenser, as it has more things to make life easier to old people. The biggest difference between this one and the other dispensers is the connection to internet and to the application, apart from being the only one where it is possible to interact with the dispenser by voice.

The fourth one is also controlled by an application, but in this case the dispenser is not connected to internet, it is connected to Bluetooth. This type of connection is not the perfect one, as it can be seen in the characteristics of this dispenser, the mobile phone must be at 10 m or less from the dispenser.

This one and the third one are very similar in price. The biggest difference between both dispensers is the way to set the dispenser, the application in the first case and the keys in the second case. It is better to have an application to set the dispenser, but in this case, using Bluetooth for the connection is not the best option.

The first dispenser is the cheapest one. This one has a reduced price and it does almost the same as the other dispensers. It is the cheapest because it is simplest than the others.

There is not much information about this sector, as it is very new and many companies are just trying to develop a great connected dispenser. Nowadays, there are not many people who have a connected dispenser, as it costs too much, and because almost everyone has a normal pill dispenser.

Conclusions of the market research

In the next table, the most important things of the dispensers and the comparison between them is shown:

Dispensers	Positive things	Negative things	Comparisons
1 **Figure 40**	**It is affordable** It warns you with an alarm Its cover opens at the time of the dose	**You must take the pill from the compartments** It has not much space in each compartment Functionalities are too simple There is not a monitoring	It is not expensive, but it is very simple, and it is similar to the common manual dispenser, the only difference is the alarm and the cover that opens itself.
2 **Figure 41**	It can be set from an application **The functionalities are very complete** A voice interaction with the dispenser and a video call with familiars is able	**Very expensive** It has not much space in each compartment	The dispenser is very complete and it monitors all the doses, but it is not affordable for everyone
3 **Figure 42**	It warns you with an alarm **The pills descend to a cup when the doses time**	**It has no application to set it** It has not much space in each compartment	The price is medium and the dispenser makes the pills descend, but there is no application to monitor the takings of the doses
4 **Figure 43**	It warns you with an alarm **The pills descend to an opening** **There is an application to set it**	**The phone with the application must be at 10m from the dispenser to work** It has not much space in each compartment	The price is medium, it has an application to monitor the doses and the dispenser makes the pills descend, but the phone with the application must be at 10m to work

Apart from these comparisons, every dispenser has very small compartments. This is a problem, since old people must remember to enter the pills each day or 2 days.

Choosing a business model

To begin with a new business the first thing to do is to choose the business model, as it will be necessary to know the target market where the product will be sold. There are 2 types of business models: business to business and business to customer (11). These business models will be analysed for this product to choose the best one.

B2B (Business to business)

This type of model consists on selling the product to other businesses. There are some pros and cons for this type of model.

In one hand, there will be less expenses for the transport, as the transport will be only to some places and in huge amounts. In addition, the expenses for a physical shop or for more employees than the ones that make the product will be non-existent, so the initial investment will not be high. This is very important, since for the initial investment it will be necessary to look for some investors or to ask for a loan, and the less the investment is the easier to have the money.

Apart from this, a profit will be something much more certain, as before starting the new business an agreement could be done with other businesses. The success of the business will be very reliable.

In the other hand, there are some negative things with this model. One of them is that the profit margin will not be very high, as the selling price of each product will be low taking into account that the products will be sold in big amounts. Apart from the margin profit, it is important to take into account if there is a big market related with the product or not.

In this case, other businesses that could be interested in buying this product will be pharmaceutics or private clinics for their own usage, or other businesses that make this type of product to buy it to consumers.

B2C (Business to consumer)

In this business model the product is sold to consumers, and not to other businesses.

There are some negatives things about this model. Firstly, the initial investment will be higher than the one involved in the other business model. In this case, the first decision is how to sell the product, as it can be sold in a physical shop, by internet or in these 2 ways at the same time. For these 3 options more money must be invest, as for the physical shop a shop should be hired or bought plus some employees must be taken on and for the option of selling the product by internet the transportation to each consumer will be expensive. In addition, it will be needed a strong marketing for consumers to get to know the product, so more money must be invest.

Other negative consequence of choosing this model is that the success of the business is not guarantee. After announcing the product by a strong marketing and after opening the business and making the investment if consumers do not buy it the business will fail.

In contrast to these negative consequences, in case of having success the margin profit of the business would be high, as it would be sold with a higher price than in the other model.

Selected model

After having analysed both models it is clear that the B2B model is less risky than the B2C model, and it could be very beneficial for this business.

The product could be sold to other different businesses that sell this type of products, but it could be more beneficial to sell it to the pharmacies, where the clients that take pills go to buy them. However, pharmacies cannot sell products that are not medicines, but the parapharmacies can sell products related to health, as this connected dispenser (12).

The benefits for the business selling the product to parapharmacies are:

- The business will only require a local to make the dispenser
- The number of employees needed will be reduced, as there will not be needed employees to sell the dispenser in a physical shop or to help clients.
- The transport to the parapharmacies will cost less than a transport of each dispenser to each client house.
- Making a deal with parapharmacies will make the business safe and with a constant profit.

Target market

After choosing the business model and knowing that the parapharmacies will be the target market where the product will be sold, it is important to know the size of this market and the percentage of people who could pay for this product to make a good sale prevision.

To start with the business the product will be sold in the parapharmacies of Madrid. Firstly, it will be sold to some of them, one per area. If this success, more parapharmacies will be interested in the product, and then, the business could grow to other cities of Spain.

The parapharmacies will buy separate dispenser with different hole on the dosage system for each type of pill. Then they will sell the whole product depending on the needs of the clients. As their sector sells pills, they will have enough information to know how many dispensers for each pill they will need to start.

Looking on Google Maps, Figure 44, it can be seen that there are 19 parapharmacies in Madrid. It could be good to make an agreement with 8 of these 19 parapharmacies to start with the business.

Figure 44: Location of parapharmacies in Madrid

Apart from the number of parapharmacies where the product can be sold, it is important to know how many clients go to buy pills to these places or to pharmacies, and then some predictions of sales will be done analysing it from an optimistic position or a pessimistic position.

In Madrid there are 3,2 million people more or less, and from these amount of people a 20,3 % have more than 65 years old (13). More or less, there are 650.000 old people in Madrid city, who will be able to go to the parapharmacies to buy the dispenser. There is another report from 2013-2014 (14) with the next statistic, shown in Figure 45.

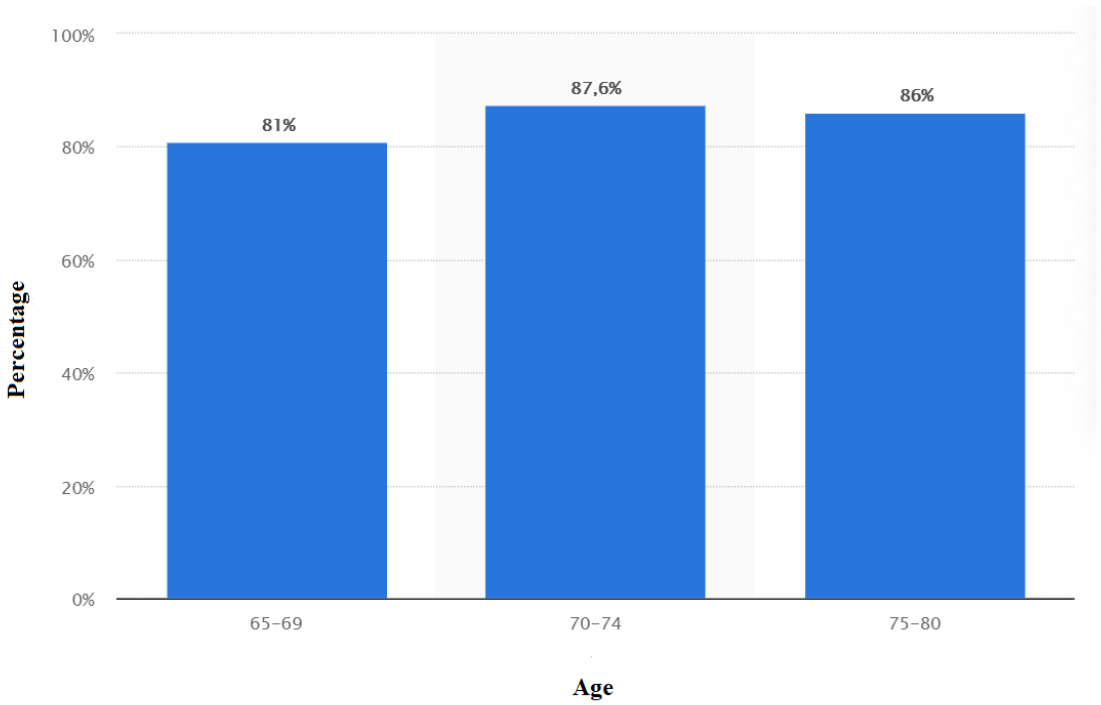


Figure 45: Statistics of old people going to pharmacies

After being 65 years old, more than the 80 % of people go to the pharmacy to buy pills. So, from 650000 old people who live in Madrid city, 520.000-570.000 people go to the pharmacies or parapharmacies. A great amount of these people needs something like this dispenser to ensure that the pills they must take have been taking on time.

Although this product is done for old people, it can be sold to everyone who wants an easy method to take a pill regularly. Another article says that 42% of Spanish people take medication (15), so if this information can be taken into account in Madrid, 1,3 million people take pills in this city.

These information gives the total number of possible clients in Madrid, being 520-570 thousand of old people and, in total population, 1,3 million people.

4 P's

Now, 4 concepts will be analysed: the product, the price, the distribution and the promotion.

Product

The product is a connected dispenser of pills. The dispenser is connected to an application by internet and the settings are made in this application. It dispenses the dose at the time and warns if there is any problem. Its characteristics are:

- It makes the pill descend at the time of the dose
- It has a compartment for each different type of pill
- It controls if the pill has descended and if it has been taken
- It controls if each compartment is running out of pills
- It has different sound alarms to choose and visual notification with leds
- It passes all the information to the app

The benefit of this product is that old people could take their medications with no problem or mistake. With this product their carers or familiars can monitor their doses from any place and see if everything goes well.

Apart from this, the dispenser can be personalized. The unique difference between each compartment is that the hole of the dosage system changes depending on the type of pill of the compartment. So, if one person takes 5 different pills routinely, this person can buy 5 compartments for his or her 5 different pills, with their measures.

The other point that changes in comparison with other dispensers is the space that each different type of pill has on each dispenser. In other dispensers it can be put only a few pills of each type, but in this one there can be put pills for one or two weeks, something very beneficial for the clients, as they will not need to enter more pills each day. In addition, when more pills are needed the dispenser will warn the client.

Price

This table is the table where all the components to make one dispenser are shown with their prices:

Component	Type	Unids	Price per unid €	Total price
Sphere	8cm	1	0,42	0,42
Infrared	5mm 940nm	2	0,04	0,08
Speaker	0,5W 8Ohm	1	2,17	2,17
Potentiometer	10k Ω	1	1,32	1,32
Amplifying	LM386	1	1,05	1,05
Leds	Red	1	0,11	0,11
	Green	1	0,11	0,11
	Orange	1	0,08	0,08
Resistances	270 Ω	3	0,04	0,12
	10 Ω	1	0,04	0,04
	330 Ω	2	0,04	0,08
	10k Ω	2	0,027	0,054
Capacitors	10uF	2	0,17	0,34
	0,05uF	1	0,502	0,502
	250uF	1	0,02	0,02
Servomotor	SG90	1	2,9	2,9
Microprocessor	dsPIC33FJ64MC802	1	4,37	4,37
Connectors	DC IP65 Hembra	4	0,55	2,2
Rod	2mmx40mm	1	0,0407	0,0407
Gear		2	2,89	5,78
Wire	20mm	6	0,11	0,66
Wifi module	HLK-RM04	1	5,01	5,01
Final price				27,4567

The price of the product will be 27,5€. But for all the dispenser it is needed the second part of the physical dispenser, the column and the triangle base with the slope. It must be done by a mould and it will be of plastic material, as the sphere. This will raise the price of the whole dispenser a bit, but not too much. It can be supposed that the total price of the components of one dispenser is 30€.

Apart from the expense of the dispenser there are other expenses, as the machines to make some parts of the dispenser, the salaries or the local.

Machines

It will be needed some machines to make the physical dispenser. First of all, a 3D printer, to print the dosage system, the cylinder with the hole. The needed machine is not the best 3D printer in the market, it can be bought a cheap 3D printer, as for example the Easythreed NANO 3D printer, that costs 111,99€. It works well and it is small as it can be seen in Figure 46, so it is perfect to make the cylinder, as it is very small. Besides, it is needed plastic for the cylinder, for example ABS plastic. It can be bought easily and is not very expensive, 1kg of this plastic can cost 18€.

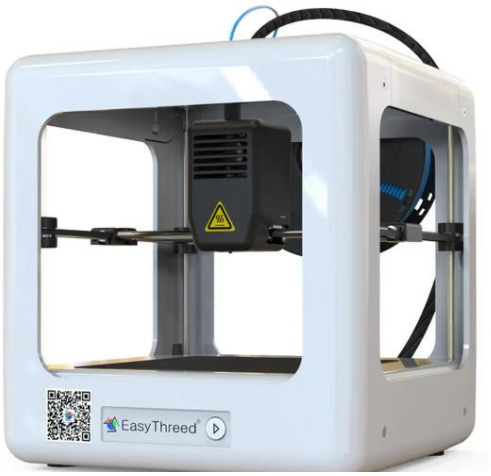


Figure 46: 3D printer to print the dosage system

Apart from the cylinder it is necessary something to cut the sphere. The sphere can be sent and cut in a cutting company. The laser cut is not expensive and it can be a good option. The price of it is 50€/h, and one sphere can be cut in some minutes, so it will be cheap. In addition, the laser cut is very precise, something important for the hole where the dosage system is. The excess of plastic can be sold, so this operation is not going to change the price too much.

Workers

There must be some workers and their salary must be taken into account. One person must be in charge of the purchase and the paperwork, another person must print and assemble the physical dispenser. There must be other person to make the programs and to solve any problem that any dispenser could have.

The first one must buy all the components, manage the accounting, and control that everything is right and the dispensers are making without mistakes. This person will be in charge of the communications with the paraphamarcies.

The second one must assemble the physical dispenser, but to do that first the column and the triangle base must be done with a mould and plastic. Then, the cylinder must be printed in the 3D printer, and finally it must be assembled with the rest of the physical dispenser. Apart from this the PCB must be assembled with the physical dispenser, but this will be the last thing to do.

The third person will make all the programming for the dispenser. First, the firmware, the software of the electronic components, must be done. Then the application must be created, and something very important, the connection between the application and the physical dispenser. This connection will be done by internet.

At least, there must be 3 workers with their salary. If the business gets bigger, then there will be more workers than 3, but to start 3 are needed.

Local

It must be hired a local to make the dispensers. The local must not necessarily be big, but a place where people can work comfortably. A small local can be hired for 500€ per month. This will increase the price of the dispenser, as the salary of the workers and the machines needed.

Distribution

At first, the distribution will be to 8 different points in the same city, and a lot of dispensers will be bought at the same time to the parapharmacies, so this cost will be very low.

The distribution of them will be in packs, each pack will have some of the same type of dispenser, for the same type of pill, and for each parapharmacy these packs will be delivered.

The same truck will be in charge of the correct distribution of all the dispensers, and it will be done in the same day. The estimation of the cost of the distribution could be 15€/month.

Promotion

Knowing that the dispensers will be sold to parapharmacies, they will be in charge of putting some posters to advertise the dispenser in their locals. Apart from this, as the product is related to health it could be also possible to promote it in different pharmacies. It would be great to promote it in more different ways.

To promote the product there are many options. The typical options are advertisements on TV or in the radio, but there are more options.

In this case it can be promoted in different commercial fairs to make the product known. Apart from this it could be a great idea to make the product known in the medicine sector. If it is well known among doctors and pharmacist these people will talk to their patients about it, something that benefits a lot the product and the business.

Pricing

To calculate the final price there are a lot of factors that must be taken into account. Comparing this dispenser with others that are in the market, it can be said that this is simpler, but it fulfils the objectives that any dispenser must have. It dispenses the dose at the time, it separates the different pill into some compartments, and it is connected to an application where the dispenser is controlled. Apart from this, this dispenser has an extra point because of the option of personalizing the dispenser. There are no other dispensers that can be personalized, so this makes the dispenser a new product in the market. In addition, as it has a mini dispenser for each pill, there can be a lot of pills at the same time and the person who uses it do not need to enter new pills each day.

Taking into account that the chosen price will not be the final price of the product in the market, the price should be smaller than the prices of other dispensers in the market. As this business will follow a B2B model business, the price per each dispenser will be lower, and then, the parapharmacies will choose the final price for the clients.

The cheapest dispenser of the market costs almost 80€, and the others are much more expensive, costing 559€ the most expensive dispenser. Knowing that at the start the product will be sold to 8 parapharmacies of Madrid the price will be low to gain more clients in the future and then if the dispenser success in the market the price will be raised.

At first, it will be followed a cost-based pricing, so each dispenser will cost 35€ for the parapharmacies. In this way, the total profit will be 5€ per dispenser. The other costs, as the 3D printer, the laser cut, the employees, the local, the distribution and the promotion will be paid at first with some investments or with a loan. If a loan is used to obtain the money for these costs, the money will be given back with the obtained profit of the product. Most of these expenses will be fixed costs, and they will be also paid with the profit each month, as the salaries, the laser cut for the spheres and the rent of the local. The expenses of the distribution and promotion will be low, as the parapharmacies will help with the promotion and the distribution will not be expense, as it is explained in the distribution chapter.

If everything goes well the price will be able to be raised to 40€ or more, and then the earnings of the business will be bigger.

Sale prevision

To make a reliable sale prevision there are some quantitative methods, but these different methods are based on the past sales of the business (16). As the business is a start-up there is not a historical data to make a prevision with it. Other methods for a qualitative prevision exist, but for this sale prevision 2 scenarios will be described and analysed for the first year. One will be the optimistic one, and the second a pessimistic one.

After the first year the price will be raised and if it goes well the product will be known among people and the number of clients will also raise.

Optimistic scenario

In this scenario, it will be supposed that a 6% of the total possible clients, described in the target market chapter, will buy the dispenser in the parapharmacies. First, 2 groups must be separated from the total possible clients: people who are more than 65 years old, and the other ones. These 2 groups must be done, as the number of pills they take is very different, so for the first group more dispensers will be sold to the parapharmacies and for the second group less of them will be sold.

Focusing in the first group, if there are 550 thousand of possible clients, 33.000 of them will buy a personalised dispenser to the parapharmacies. But to make each of the dispensers for the clients there will be needed more than one compartment, as this group take more than one pill regularly. It can be supposed that they will buy a dispenser with 4 compartments in average, so the total compartments that will be sold to the parapharmacies will be 132.000.

The second group is for young people, and in this case, the compartments needed will be only 1 in average. This group of possible clients is the difference between all the people who take pills in Madrid and the old people who take pills, 750.000 more or less. So, if a 6 % of these people buy one compartment, the total compartments sold to the parapharmacies for this group will be 45.000.

In total, 177.000 compartments will be sold to the parapharmacies, so taking into account the total profit of each dispenser, 5€, the total earnings of the business will be of 885.000€ in the first year. With this amount of money, the employees will have their salary paid and the other costs will be also paid.

Pessimistic scenario

Now, a new scenario where only a 1% of the possible clients will buy the dispenser will be described. It will be done the same separation of the possible clients as in the optimistic scenario.

In the first group, being 550 thousand of people, only a 5,5 thousand people will buy the dispenser. If each one buys a dispenser with 4 compartments in average, the total number of compartments that will be sold to parapharmacies will be 22.000.

In the second group, being 750 thousand people, only a 7.500 people will buy a dispenser. So, the total amount of compartments sold to the parapharmacies will be 7.500.

In total, the total number of compartments sold to the parapharmacies will be 29.500. Multiplying it to the total profit of each compartment sold, the total earnings in one year will be 147.500€.

Estimated final profit

The next table contains the expenses taken into account in this project and the optimistic and pessimistic estimations of the income. Finally, a total estimation of the profit is done in both scenarios.

Type	Concept	First year
Expenses	Components needed optimistically	30€/unit 177.000 compartments **5.310.000€**
	Components needed pessimistically	30€/unit 29.500 compartments **885.000€**
	3D printer	**111,99€**
	Workers	**80.000€**
	Local	500€/month **6.000€**
	Distribution	15€/month **180€**
Income	Optimistically	35€/unit, 177.000 compartments **6.195.000€**
	Pessimistically	35€/unit, 29.500 compartments **1.032.500€**
Estimated final profit	Optimistically	**798.708€**
	Pessimistically	**61.208€**

The expenses of the promotion are not taken into account in this table, as they are very small as explained in the promotion chapter.

For the next years, the production of the compartments could be increase, like the sales, and the start-up could be expanded. The earned money in the first year could be used to make the dispenser more known, to promote it more and in more places, and to make new improvements in the product and in the business model if required.

Conclusions

The project concludes having designed a connected product which could be very useful for the society, and its business model to make it something that could be real. The final product fulfils the first objectives of the project, although the first idea of the product is not similar to its final design. Now, some positives and negative aspects of the process of making it will be described above.

Firstly, the thing that most has changed of the whole dispenser is the physical design. When starting the project, it was thought to be a rectangular compartment with a little gate to descend the pill, but this design did not assure a correct descend of the pills. The fact of having pills with different dimensions was a huge problem to make a design that could achieve the objectives of the project. Finally, it was reached a solution with a spherical compartment and the cylinder system as the dosage system. The spherical compartment could make the pill descend while carrying it to the hole, thanks to the form of its walls. The final design of the dosage system ended up being simple and easy to make, but effective.

The second part of this project was to think about the PCB design to make all the physical dispenser work correctly and to give information to the app by some sensors. This part was done taking into account the information that must arrive in the application and the information that the application gives to the PCB for the correct working of the dispenser. The general idea of the information shared by the PCB and the application was clear, and then, the components were selected to fulfil the objectives of it.

Apart from this, the assembly between the PCB and the physical dispenser was done. This assembly had the problem that the servomotor was in the PCB, and the servomotor needed to be next to the dosage system, as it controls the rotation of the cylinder. Finally, it was seen a perfect site to place the PCB with the servomotor next to the dosage system.

The design of the application was not as imagine, since the general idea of the objectives of the application to fulfil needed to be something more definite. It was complicated to order the ideas and to make for each idea one or some screens of the application. However, as it has been said, a small part of the process of the design was done while doing the design of the PCB, so starting with it was not really hard.

The last part of this project was about how to choose a good business model and how to take everything into account while thinking of a start-up selling the final product. This part was the part where most information was looked, as it was all new and the general idea at first was to make the dispenser economically viable and to make it not too expensive for the clients.

After reading reports and information about the different business models, pricings and sale previsions the idea of a B2C business model changed to the opposite B2B business model. The new model was more secure and viable for the product and the final pricing was cheap, one of the main and first objectives of the project.

The main and first objectives of the product are fulfilled:

- The final product can make a unique pill descend, thanks to the form of the compartments and to the dosage system connected to the servomotor.
- The PCB controls correctly the dispenser and shares the correct information with the application thanks to the sensors and alarms.
- The application has all the necessary options for the correct working of the whole system.
- The whole dispenser is economically viable and it is functional and simple. In addition, it is a cheap product in comparison with other dispensers

Finally, 2 new objectives have been added while doing the project.

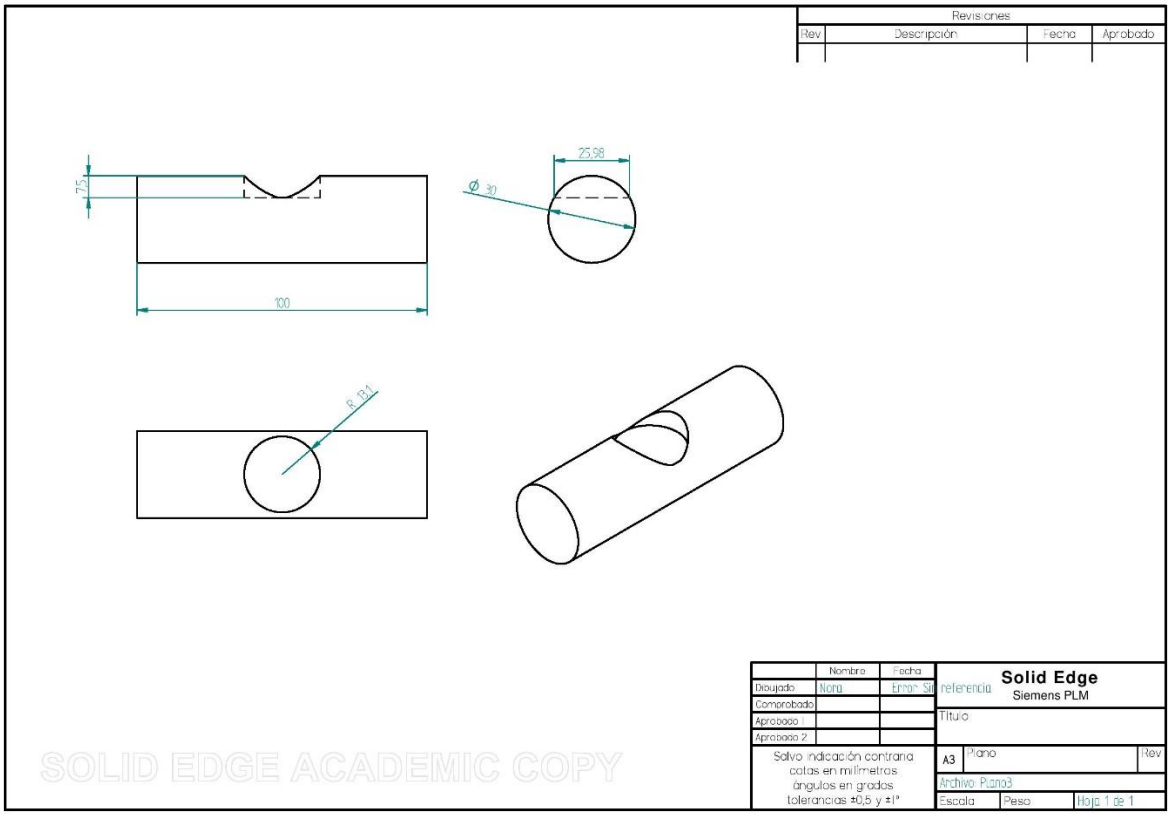
The first one is to make the dispenser personalised. Each compartment is almost equal to the rest, the unique difference is the hole in the dosage system, as the dimensions of the hole will depend on the type of pill that goes inside the compartment. When someone buys a dispenser, he or she will buy the same number of mini compartments as the number of pills she or he takes.

The second final objective is related with the first one above. As each pill has is own mini dispenser, each compartment has enough place for 1 or 2 weeks of medication. With this system the person who uses it do not need to put pills inside the compartments every day.

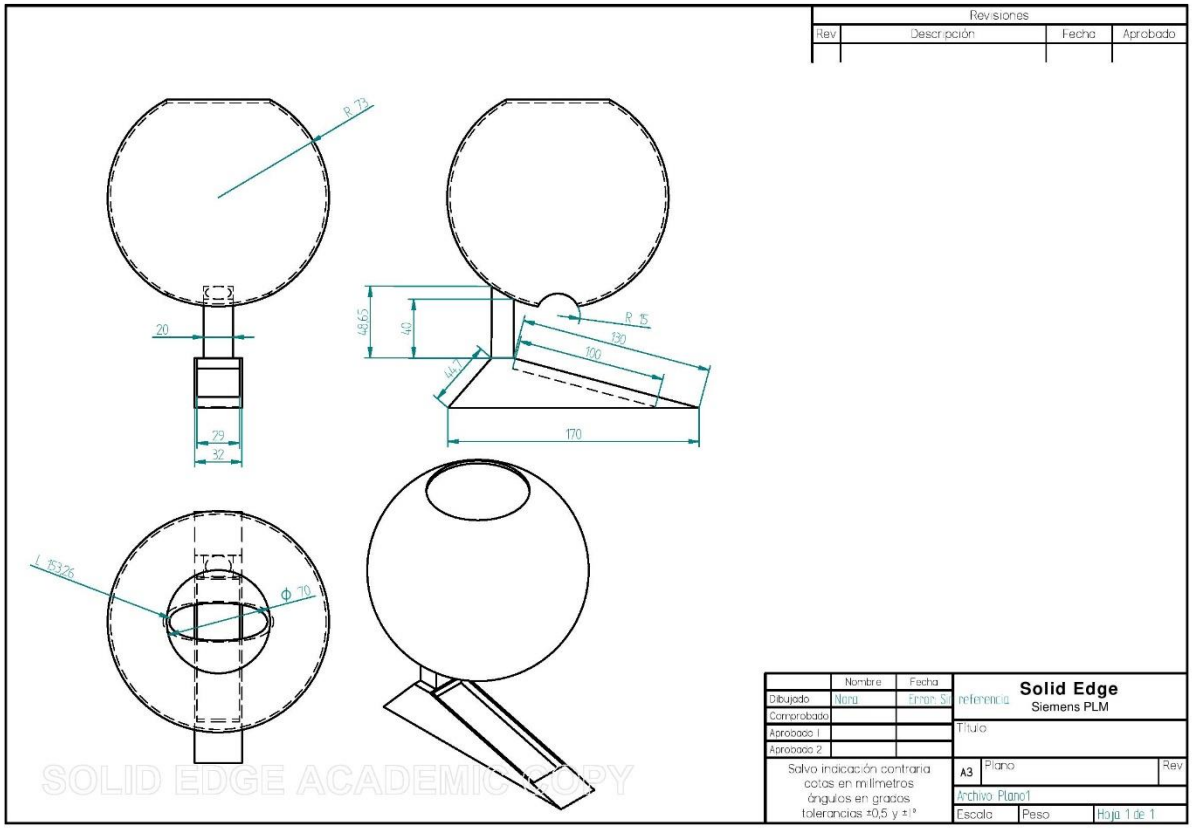
These 2 points are the points that make the difference between this dispenser and the rest of dispensers of the market.

Annexes

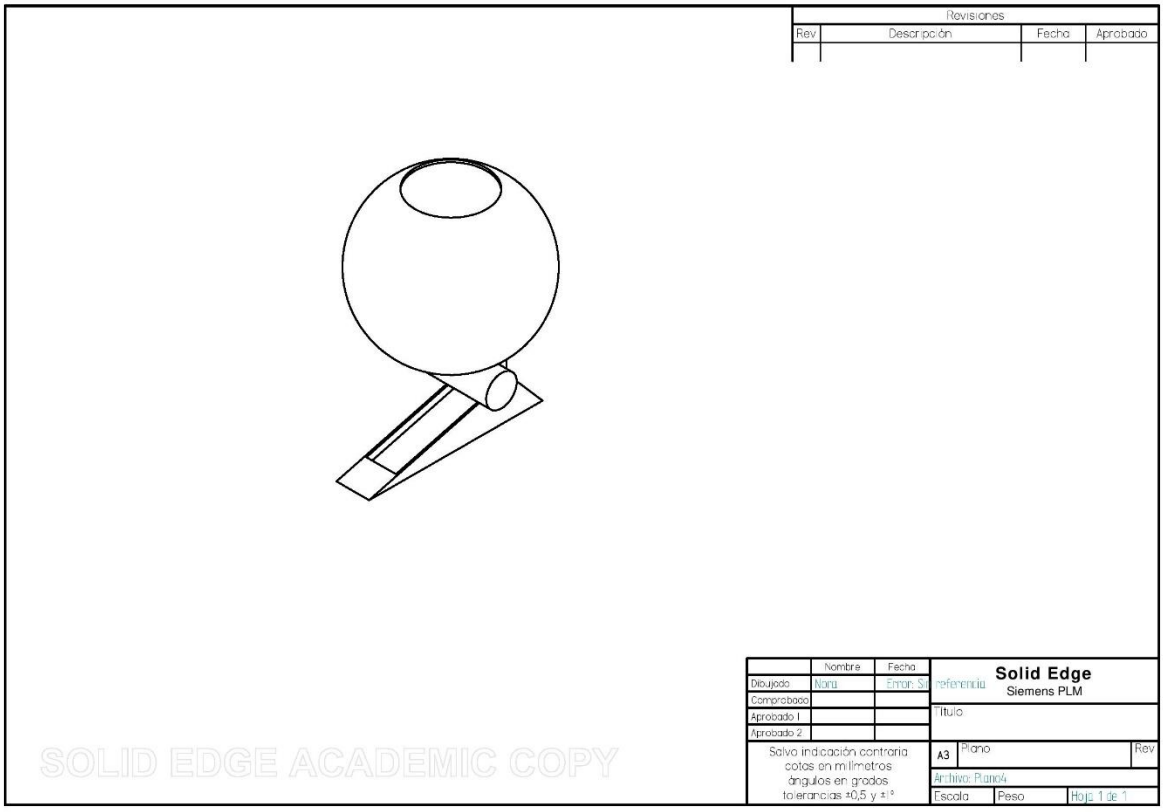
Annex 1: Dosage system



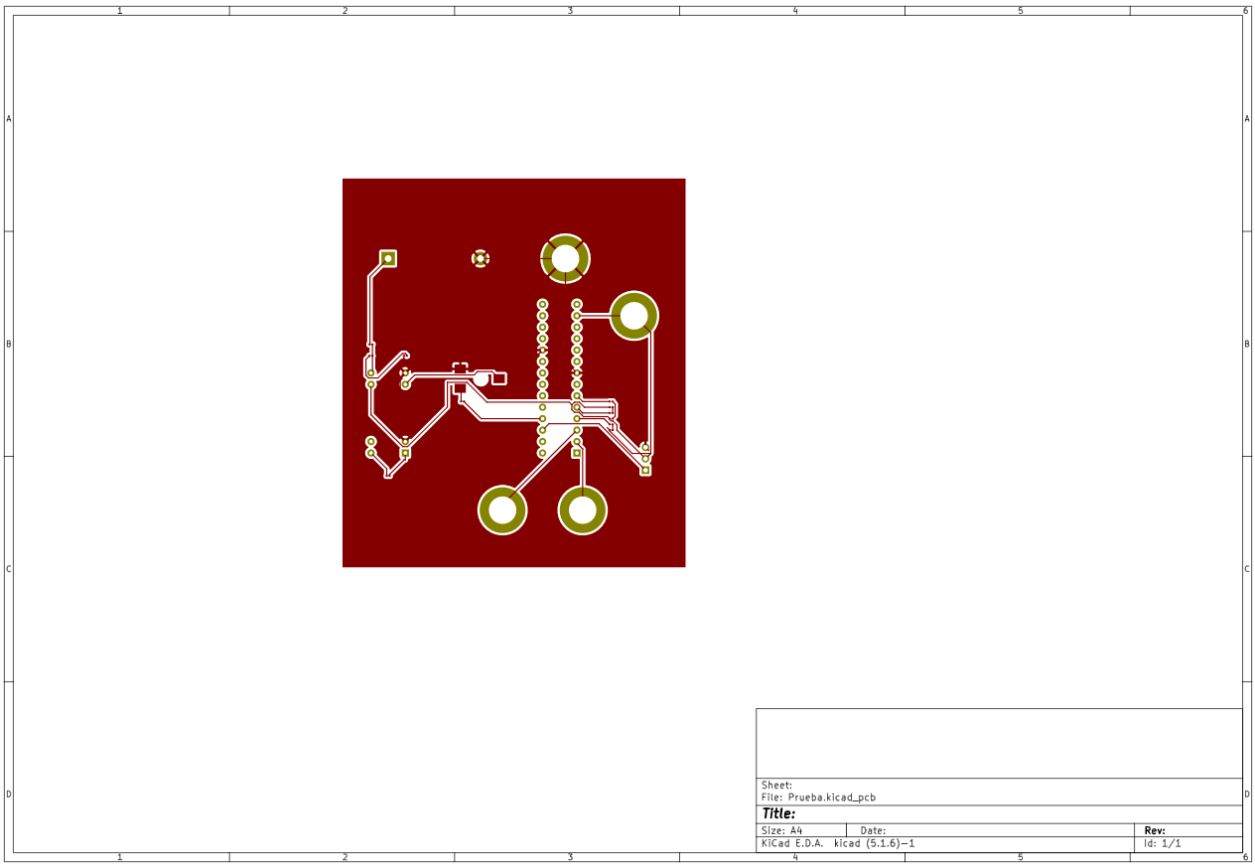
Annex 2: Spherical box



Annex 3: Assembly



Annex 4: PCB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Annex 5: Sustainable developments goals

Nowadays, it is important to bear in mind the sustainable developments goals of the UN while creating a new start-up. This project is focused on the third goal of the global goals for sustainable development. This goal is about the good health and well-being of people around the world.

The final product of this project consists on a connected dispenser for old people, although it can be useful for everyone. Old people take a lot of medication and there can be a lot of problems while taking it. The consequences in health of taking their medication wrongly are terrible, as their health is weak. For this reason, it is important to take care of old people and help them as much as it is possible to achieve the good health and the well-being of the third goal of these sustainable development goals.

These seventeen goals are very important for our society and while creating a new product or a new business it would be great for the future of the world to take them into account. If everyone helps a little bit, the world will be a better place.

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