ROBOT DESIGN TO HELP LANGUAGE DEVELOPMENT

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SUMMARY

The following project has the purpose of developing a toy able to communicate with children with ASD (Autistic Spectrum Disorder).

The first thing to do is to understand what is ASD and how children with this disorder can react to a new toy, a new person or a new thing. It is important to do a simple design for the robot, because if it is very similar to a person's face can make children uncomfortable. After this the plastic for the exterior case will be choose as well as the sensors that will integrate the robot to make it move. Following the electronic part, the selection of the microcontroller will be done and the code to make the robot work will be explain. Finally there will be a description of the budget used for the construction of one robot, and what would it be for the construction of 1000 robots followed by a conclusion of the project.

Resumen

El propósito del siguiente proyecto es desarrollar un juguete capaz de comunicarse con niños con Desorden del Espectro Autista (ASD).

Lo primero es entender que es ASD y cómo se comportan los niños que sufren este desorden, para poder entender cómo pueden reaccionar a un nuevo juguete, a una nueva persona o simplemente a un nuevo objeto. Es importante que el diseño del robot sea simple porque si se parece demasiado a un cara humana podría llegar a incomodar a los niños. Tras esto es importante hacer la elección del plástico exterior y de los sensores que integraran el robot para hacer que se mueva. Tras la parte electrónica, se hará la selección del microcontrolador y se explicará el código que hará que el robot funcione. Finalmente se explicará el presupuesto de construir un solo robot o de construir mil seguido de una conclusión del proyecto.

Resum

El propòsit d'aquest projecte es desenvolupar una joguina capaç de comunicar-se amb xiquets amb Desordre de l'espectre autista (ASD).

La primera cosa a fer es entendre que es ASD i com es comporten els xiquets que sofreixen aquest desordre per a poder entendre com poden reaccionar amb un nou joguet, una nova persona o simplement un nou objecte. És important que el disseny del robot sigui simple perquè si es pareix massa a una cara humana podria incomodar als xiquets. Posteriorment es important fer l'elecció del plàstic exterior i dels sensors que integraran el robot per a fer-lo moure's. Després de la part electrònica es farà la selecció del microcontrolador i s'explicarà el codi que farà al robot funcionar. Finalment s'explicarà el pressupost de fer un robot o fer-ne mil, seguit de una conclusió del projecte.

KEY WORDS

KEY WORDS	PALABRAS CLAVE	PARAULES CLAU
1. Autism Spectrum Disorder (ASD)	1. Desorden del Espectro Autista (ASD)	1. Desordre del Espectre Autista (ASD)
2. Microcontroller	2. Microcontrolador	2. Microcontrolador
3. Sensors	3. Sensores	3. Sensors

1. OBJECTIVES

The main purpose of this project is developing a toy that is focused on children with Autistic Spectrum Disorder (ASD) and is thought to continue therapies at home while being funny.

The reason for this project is that on the market the similar products are very expensive therefore the idea is to develop a more affordable robot for household purposes.

The main specifications that the robot has to fulfill are:

- It has to have a neutral face in order to avoid children to get scare.
- It must be able to move forward and backward and to turn around.
- It has to have different sensors: Ultrasonic sensor to avoid objects, a light sensor to detect if there is light or not and a button to turn on and off the robot.
- It should have two motors in order to make the robot move.
- It must to be controlled by a microcontroller that in the future could be used to make the robot work with artificial vision. Also it has to be able to make sounds and to record words and phrases.
- It has to be autonomous (it cannot be connected to a plug at all times).

The project can be divided in five different parts: conceptual design, electronics, software, design and budget.

The conceptual design is the part where with the toy's specifications are defined, analyzing the capabilities that will be needed and the ways of achieving them. This part mostly takes into consideration the information gathered in the first steps of the project and it is put together in order to have a clear definition of the project and the parts that form it, always taking into account the resources that are available so the project is practicable.

The electronic part is the section where everything related to the circuitry is managed. It includes all the different circuits that are going to be implemented for the project, it includes a detailed explanation of every circuit and how they have been developed.

The programming side was based on achieving the desired behavior of the toy and to manage the input provided by the child and respond accordingly. It can be divided in the selection of the platform and the actual programming. It will be developed over a Raspberry Pi. For some modules, external libraries will be used, which are open resources available for the project.

The design part includes the selection of the plastic used and the design of the robot in a 3D printer.

In the budget section the total price of the project will be described.

In overall, the product developed during this project has to meet most of the starting requirements and also it has to be specialized, highly customizable, affordable for households and useful at the same time as funny.

2. INTRODUCTION

"*Autism is a lifelong developmental disability that affects how a person communicates with, and relates to, other people. It also affects how they make sense of the world around them.*"[1]

In other words, autism is a disability that affects 1 of every 68 children in the world, 5 times more boys than girls. Autism makes children see and sense the world in a different way than people. Most of these children have big problems to communicate, most of them do not speak, even though that most of them learn after some years.

[1] (The National Autistic Society, 2014)

Every child is different, but when it comes to children with Autistic Spectrum Disorder (ASD) this difference is bigger, they can be afraid of things that other kids would not be, such as animals, colors, textures or some kind of toys.

Autistic children have more difficulties than other children to express their feelings and what they want or need. Also they have troubles making new friends or understanding other people (the way they feel or what they think).

Two of the main therapies used to help children with ASD to improve their speech are Applied Behavior Analysis (ABA) and Picture Exchange Communication System (PECS).

ABA is one of the most used therapies in this field. It is based on a positive reinforcement in day to day actions. It helps teaching the children how to stay in a lunch table or how to behave with other people. It is usually combined with visual cards to reinforce the therapy.

PECS is based on the use of cards with different objects and words. This therapy must start with cards that only have pictures, then cards with pictures and words and finally only cards with words. These cards are mostly used for children to talk with their parents. If they want to eat they can show an apple card to their parents. It is also important to mix real pictures and drawings.

Related to that, there is a quite new trend in research called Robot-Assisted Therapy (RAT) that is studying how social robots can be used to support the traditional therapies (ABA and PECS included) with professional educators, especially in the treatment of children with ASD. This is because children with ASD cannot understand facial expressions or emotions of their interlocutor and that leads them to social anxiety. It has been observed that this feeling of social anxiety is reduced if the child interacts with a humanoid robot.

There are some applications that recently have been developed in that area but they are still too expensive and not affordable for families.

Here is where the "Smart-toy" (name this project will be referred to from now on) inserts itself: design a toy that follows the principles of the latest researches and the most effective therapies, but at a reasonable price in order to provide families having children with ASD with a household application that makes it possible to continue therapies at home, always keeping the idea of playing. The aim of the "Smart-toy" is helping children with ASD to develop speech, eliciting communication from them through game.

3. CONCEPTUAL DESIGN

The conceptual design was conceived as a part of the project in which the main features of the toy and the shape were defined. During this part of the project solutions to current sub-problems were analyzed in order to have an overall idea of the toy. In order to do so I got in touch with a psychologist specialized in ASD to established a series of parameters and sorted them by must, should and might, so the main characteristics were prioritized and decisions were taken.

Some of the most important characteristics were that the toy had to be customizable, the card communication, the main game modes, the learning packs and the use of sound and movement.

The customization was prioritized because every child is different and specially those who suffer from ASD have very different needs, so the aim was to give the parents the opportunity to choose as many characteristics as possible, including the external appearance of the toy (color and texture), the sets of cards that they want to use and the voice of the toy, giving them the opportunity to use their own.

In the future the idea could be to make the robot capable of interacting directly with the children. For this a card communication system can be use, it could be a way of getting the customization to the parents as, using a PC application and a printer, they would be able to make their own cards and sets as well as personalize existing sets.

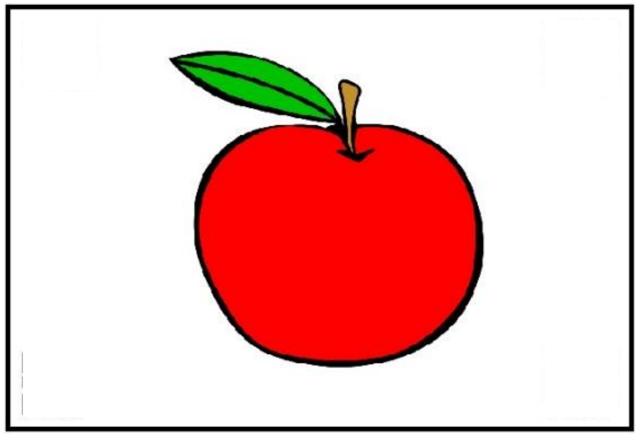

Figure 1: Apple card example

With the cards the children would be able to interact with the robot, for example the children could show the robot a card and then the robot will say what is the card, in the case of the picture above the robot would say “apple”. Also it can be the other way round, the robot could ask the children “give me an apple” and the children will have to show the robot the apple card.

The learning packs are a way of having smaller sets of cards related to each other (such as colors, fruits, animals…) so the child does not feel overwhelmed and also to allow themed learning.

At last the way that the toy would communicate with the child is via sound and movement, which is the way that it would reflect that the game has finished successfully or not, as well as give explanations, commands and reflect simple emotions (like being happy when the solution is correct).

It is important to notice that the part of the card communication is not going to be developed in this project but it is an important part of what it could be a future project and helps to understand better the complete work. During the project the main focus will be in designing the robot and making it move.

4. BACKGROUND DESCRIPTION

The first idea was to design a new toy for children. Then the main point was focused on autistic children and therefore develop a small device to help them in order to improve their social skills, the ability to interact with the environment and also the ability to learn.

After some researches, similar and already existing products have been found. There are some applications developed for research like:

- **Nao** (from 5.700 €) Designed for Special Education Schools. It is programmable and autonomous, with ability to understand speech.

- **Romibo** (from 720 €) is a small robot, still in Alpha version at the moment, and not yet available on the market. It's possible for the future user to choose its external shape and color and its main feature is that you can control it with an application for iPad. Target users are especially children with ASD.

- **Kaspar** (not for sale) Research focused robot that is developed by the UH (University of Hertfordshire). It is used for research about human interaction with robots, especially with children with ASD. One of its features is having a simplified human face, with small expressiveness, which helps the children to interact with it.

- **Lego Therapy** for autistic children is a useful program both for able-bodied and autistic children. It's usually a role playing where, under the supervision of a therapist, three children build a Lego product and play different roles, rotating from time to time: there is a builder who has the responsibility to build the device, a supplier who has the task to search the pieces the builder needs and finally there is an engineer or an architect (depending on the applications) who gives instructions to the others.

These applications are very expensive (more than 500 €) and not affordable for households. Therefore, there is a potential market for home applications which combine specialization and relatively low price because nowadays 1% of world population between 7 and 17 years old suffer from any degree of ASD (Autism Spectrum Disorder) and education programs in schools don't fully satisfy their needs. Children with this kind of disorders have big problems with speech development and this makes learning and social interactions even harder for them.

The following project will try to focus on PECS therapy and to keep in mind that autistic children have problems understanding facial expressions and this leads to social anxiety for them which can be a problem while trying to communicate with society.

5. DESIGN

The first robot design was done by hand by trying to put in a paper everything we had in our heads of how a robot had to look like. After a lot of testing, the final idea was the following:

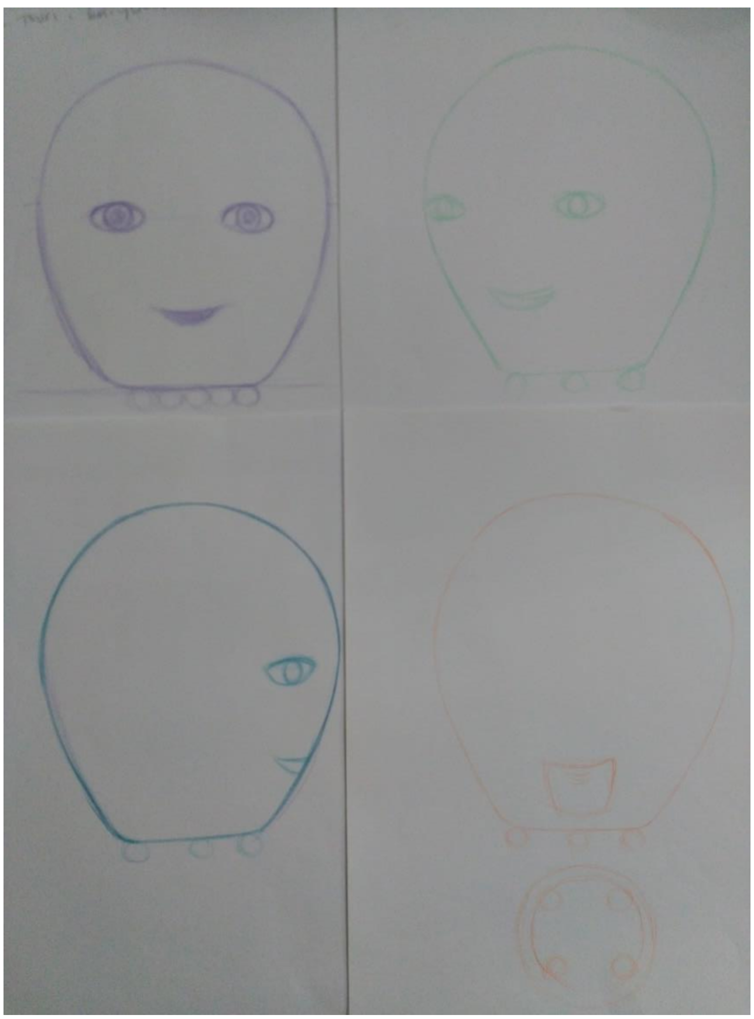

Figure 2: Freehand drawing

The design is simple but efficient with no sharp edges and no human traits that could scare or confused the kid. It has only two eyes and a mouth in order to maintain it as simple as possible. For the design I talked with some parents and a psychologist in order to make sure that it was a good idea for and ASD children, they told me that you never know how this kids can react but the simpler, the better.

5.1. PLASTICS

The idea of the design is to do a simple robot in order to avoid children to get scared with it. It must have a simple face and it has to be safe for children, that is why it must avoid to have sharpened corners.

In order to decide which plastic to use, first of all it is important to know the difference between thermoplastic and thermoset. The main difference is how the material responds to heat. Thermoplastic become liquid at a certain temperature so they can be heated, cooled and re-heat without almost degradation. They are good for injection molded because they don’t burn, before that they get liquefy and this makes them easy to recycle. On the other hand, thermoset plastics can only be heated once because while heating they experience an irreversible chemical change. As they cannot re-heat they can’t be recycled, which it is not an important point of the project, but it is not good for the environment.

After this, the best option it to use a thermoplastic. Inside this category it is possible to find multiple plastics such as PLA, ABS or PVC.

PVC is one of the most used thermoplastics. It is commonly used in construction industry, but it can also be used for healthcare applications or daily products. It is very dense (compare to other plastics) and cheap, it is also very hard and it has a good tensile strength. It can be difficult to use injection molding with it because when melted it can give off a corrosive toxic gas so it has to be treated in a very well ventilated area.

PLA is created with corn starch or sugar cane, which makes it very biodegradable (in contrast to other plastic that are usually made of petroleum). It is usually used for plastic films, bottles or biodegradable medical supplies. Its low glass transition temperature can make that even if you leave it inside a car in the summer it melts a bit, and this can be a problem for an easy transportable toy. On the other hand, it is not toxic and it is one of the most used plastics in 3D modeling.

ABS it is a very known plastic because of its used in LEGO bricks. It has a strong resistance to corrosive chemicals and mechanical impacts. It is very cheap and it is widely used for 3D modeling. Also, it is easily machined, sanded, glued and painted. As the other two, in normal conditions it is not toxic.

In the following table a simple comparison of the three plastics can be seen. In order to understand it is necessary to understand some terms:

- **Melting temperature:** This refers to the transition between solid and liquid, the lowest melting temperature, the easiest to deform with heat. This occurs in crystallines polymers, in amorphous polymers like ABS this temperature does not really exist.

- **Tensile strength:** It is the force required to pull something to the point where it breaks. The highest tensile strength, the most resistance will be the material.

- Glass transition temperature: This refers to the transition between solid and rubber state, which it is state between solid and liquid. The lowest glass transition, the easiest to deform with heat.

- Heat deflection temperature (HDF): It is the temperature at which a plastic deforms under certain load. When molding, it is usually good to remove the part from the mold once it is below its HDT. As the plastic molding occurs at high temperatures, the highest HDT, the faster demoulding.

	PVC	PLA	ABS
MELTING TEMPERATURE (ºC)	100 - 260	157 - 170	~ 230 *
TENSILE STRENGTH (Mpa)	34 - 62	61 - 66	46
GLASS TRANSITION TEMPERATURE (ºC)	85	60-65	105
HEAT DEFLECTION TEMPERATURE (ºC)	92	49 - 52	98
ADVANTAGES	- Resistant to water degradation	- No harmful fumes during processing - Shinny and smoothy appearance - Environmental friendly	- Very hard - Long lifespan - No toxic
DISADVANTAGES	- Harmful fumes when melting	- It can be deformed easily because of heat	- Made out of oil - It need ventilation because the fums when melting

Table 1: Plastics comparison

Taking into account all this considerations and data the best plastic will be ABS because it is widely used for toys, its heat deflection is the highest (even though it is closely to the one of the PVC), its melting temperature and glass transition is also the highest (it is important to notice that ABS as it is amorphous does not have a true melting temperature but it is possible to say that it starts to “melt” around 230ºC) and its tensile strength it’s between the one from the PVC and the one from PLA. Also among its advantages we can find that in can give the robot a very good finished and it is very cheap.

5.2. CIRCUIT

5.2.1. SENSORS

In order to make the robot work properly it has to have several kind of sensors. In this case the sensors used are: ultrasounds, proximity, light and on and off button.

- **Ultrasounds:** The ultrasonic sensor is used in order to avoid the robot to hit objects around it. It sends a high-frequency pulse, then measures how long it takes to the echo of the sound to come back and calculates the distance between the sensor and the object. In order to have the real distance we have to divide the value that it gives us by two (go and return of the pulse):

$$distance = \frac{time\ (go\ and\ return) * 340m/s}{2}$$

For the robot four pair of sensors (HC-SR04) are going to be used, two in the front side and two in the back side.

Figure 3: Ultrasounds sensor HC-SR04

- **Light sensor:** An LDR is used in order to turn off the robot when it has been inactive for more than 15min and the room it is completely dark, this is to avoid to leave the robot turn on during the night if the parents or the child forget to turn it off. An LDR has a resistance that decreases when there is light intensity increase, this is why it is a good solution to detect if there is light or not in the room where the robot is, also its price is very low.

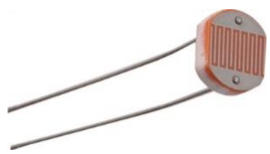

Figure 4: LDR sensor

- **On and Off Button:** A button is necessary in order to be able to turn down the power consumption of the raspberry pi.

Figure 5: ON/OFF button

5.2.2. MOTOR DRIVER

The motor driver used is DRV8835 from *Pololu*. It is a dual motor driver designed specifically for the raspberry. It can be placed above the Raspberry Pi and it allows to operate with DC brushed motors with a voltage from 1.5V to 11V and it is able to deliver a 1.5 A per peak. It also has reverse-voltage protection on motor supply and under-voltage lockout and protection against over-current and over-temperature.

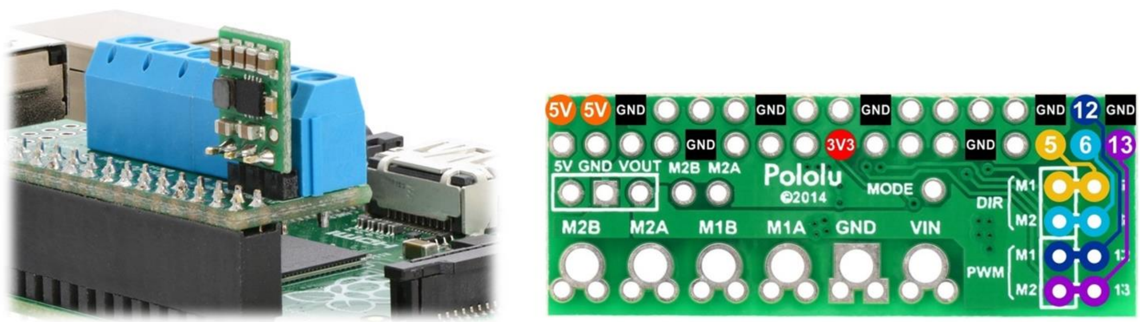

Figure 6: Motor driver DRV8835

5.2.3. VOLTAGE REGULATOR

The voltage regulator used is the S7V7F5 from *Pololu* as well. It is a 5V high pass/low pass voltage regulator that is capable of producing 5V from inputs voltages between 2.7 V and 11.8 V. It can deliver 1A when the voltage is greater than 5V and 500 mA when is lower. It has short-circuit protection and a thermal shutdown that prevents damage from overheating. It will also power the Raspberry Pi throw it.

Figure 7: Voltage regulator S7V7F5

5.2.4. RASPBERRY PI

The control of the robot is going to be done with a microcontroller. There is a very wide range of programmable platforms available for us on the market, the most widely known are the Arduino brand and the Raspberry Pi. The two platforms are going to be analyzed in this section in order to choose the most suitable one for the project.

They are both open source, what means that all the code and hardware used is available to the user to see and change to his needs. Also they are autonomous, once programmed they don't need connection to a computer in order to keep working. The main difference is the capabilities of each system, which will be explained in the following lines.

On one side Arduino is based on its own programming language (Arduino), which is based on "C", and integrates an ATMEL microprocessor and several digital and analog Input/Output ports (I/O ports). The main drawback of this system is that its processing power is relatively low compared to the Raspberry Pi and its reduced permanent memory size.

On the other side Raspberry Pi is a system that integrates a Linux based OS and supports several programming languages, including C++, Java, Python, Scratch or Ruby. It also has several characteristics that make it suitable for our project, like an integrated web-cam (it will be useful in the future for the image recognition), integrated sound I/O ports (they will be necessary in a future for the interaction between children and robot) and general purpose I/O ports (GPIO ports) (they will be useful for the connection of the different sensors).

After comparing both systems and pricings, the system is going to be developed for the Raspberry Pi because it accomplishes all the necessary requirements mentioned above and at the same time it has a low cost and it's easy to use. Also it can handle more power and the part with artificial vision can only be done with this one.

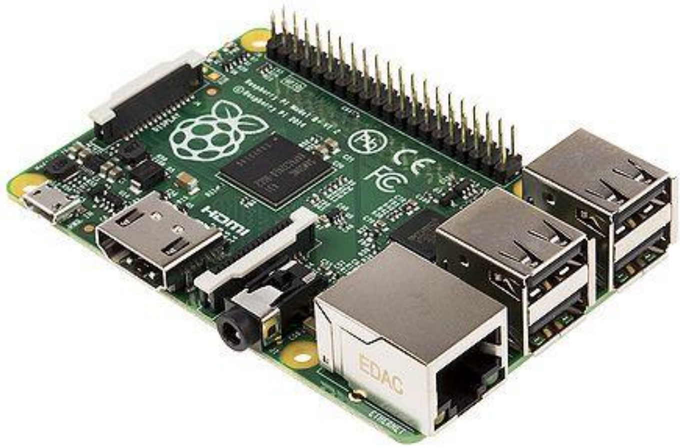

Figure 8: Raspberry pi model B+

5.2.5. ELECTRONIC DESIGN

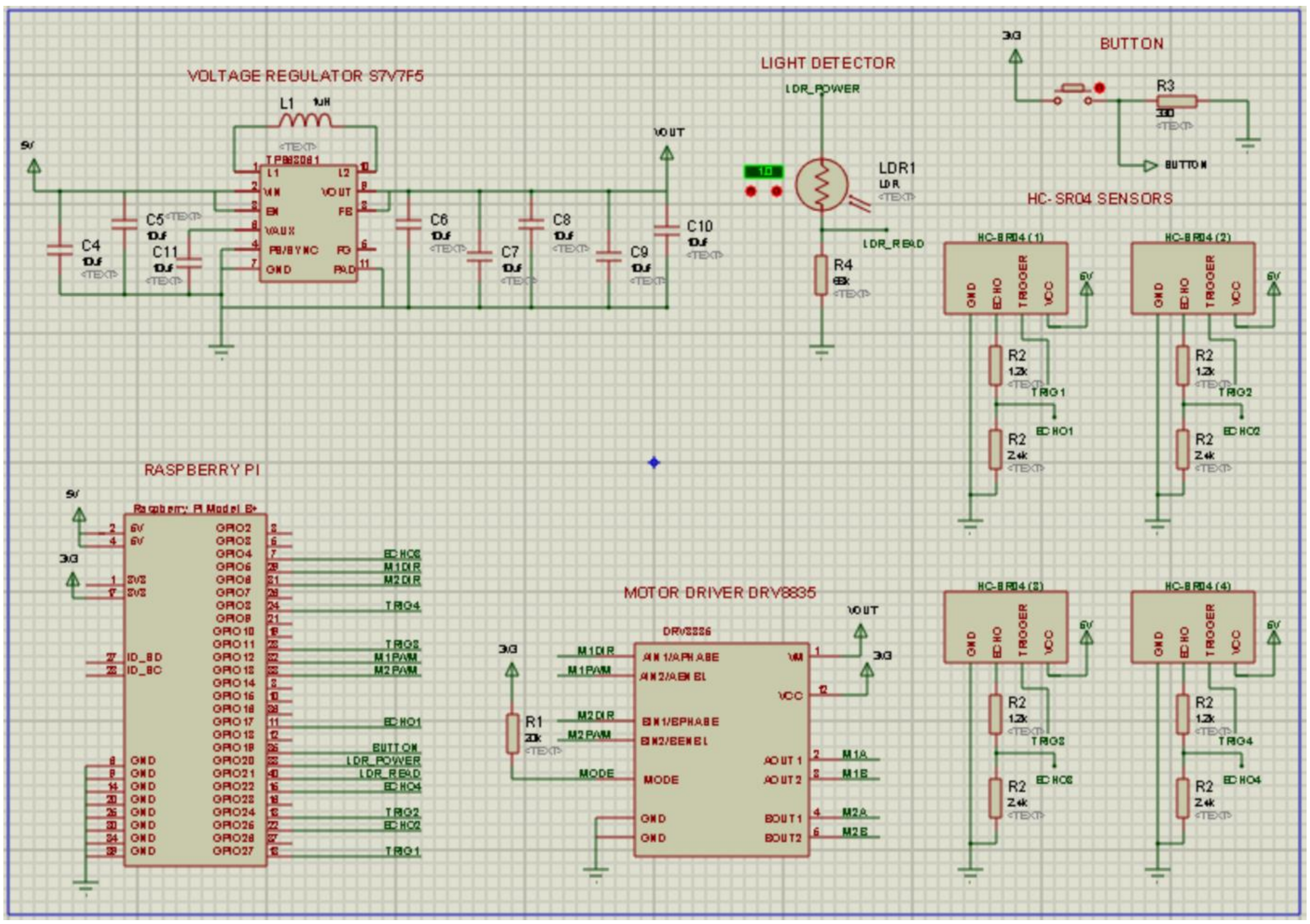

Figure 9: ISIS Proteus electronic scheme

In the ISIS scheme the different elements used in the circuit are showed with its connections. This scheme would be needed in order to do a PCB in a future.

5.3. PROTOTYPE

In order to make a more visual project it has been decided to print the robot with a 3D printer. The printer used was a Ultimaker 2 Extended + which can use PLA, ABS and CPE as material among others. Its layer resolution is 20 micron (which multiplies details of 0.02 mm) and its speed is up to 300 mm/s.

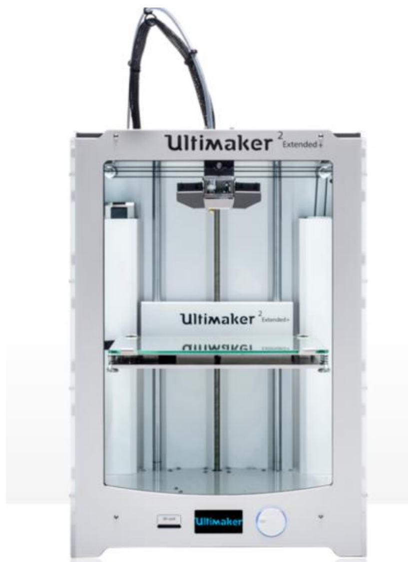

Figure 10: 3D printer Ultimaker 2 extended

It was mostly printed with ABS plastic except for the base because the printer run out of it and it was necessary to change the material. The base was printed with PLA plastic which is less resistant and it brakes easily. While printing the robot there were some problems regarding the design. The design was done with the Autocad Inventor program but when converting the file to the 3D printer format the size of the robot was reduced by two, making it very small. After realizing about this some modifications were done, but it was not noticed that even if the robot size in the 3D printer program was the correct, once printed the holes were not the correct ones, that is why it was necessary to make them bigger by hand.

In order to make the wheels it was not possible to buy some proper ones because of the lack of time, that is why they were done also with the 3D printer and then finished with some elastic bands.

In order to make the prototype the first thing was to decide how to make the easiest assembly (this is why at the end the robot was divided in two parts). Then it was necessary to choose if it was going to be cut from top to bottom or from left to right, finally it was decided to do it from left to right because it was going to make the assembling and closing process easier. After this came the necessity of making a design small enough to fit in the 3D printer and to be able to contain all the sensors, cables and objects necessary to make it work. Even though it was high enough, the base was still too small to be able to include two functional wheels plus the motors and the wheels, so it was necessary to modify the initial design and make the robot more round than in the initial idea. After printing the base it was still a bit small, that it is why it was decided to use a pin needle for the supporting wheel.

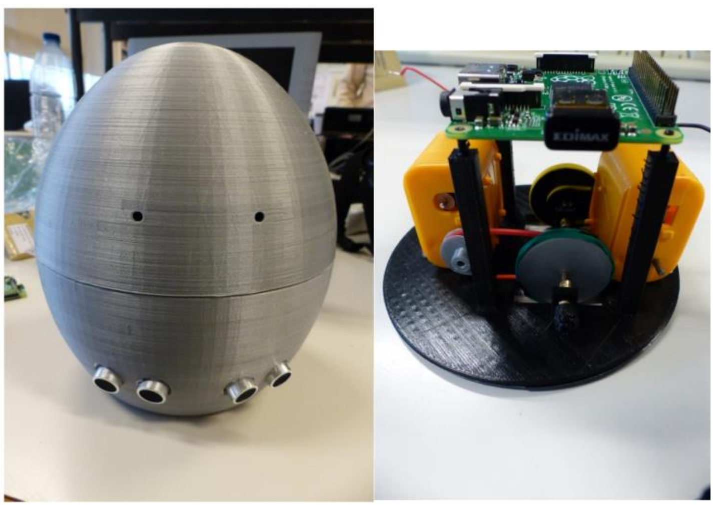

Figure 11: Robot and mechanism prototype

In figure 13 can be observed two wheels, two motors and the raspberry pi.

The wheels where made with the 3D printer as said before. Each of them has its own pulley in order to make easier the motion transmission between the motor and the wheel. If the motors were connected directly to the wheel, it would make a reduction mechanism and the wheels would move too slow.

In the real product, the wheels would be a 32x7 mm wheels from *Pololu*.

Figure 12: Wheels

The motors will be two brushed DC motors from *Pololu* with a 180:1 reduction gearbox that can work between 4 and 6 V.

Figure 13: Motor

In the other side of the base the pin needle can be seen, in order to make of third support for the base.

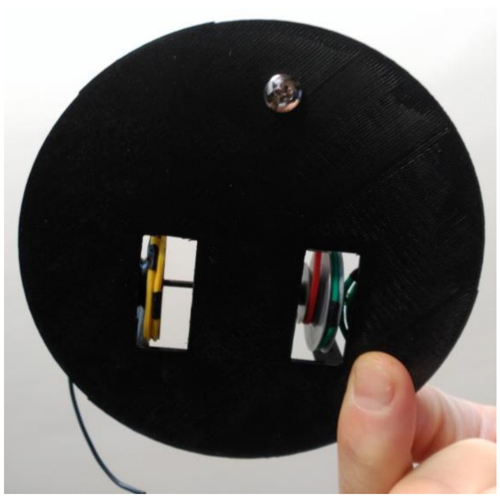

Figure 14: Base with the pin needle

The 3D printer used is the Ultimaker 2 Extended from Ultimaker.com. It can use PLA, ABS, CPE, CPE+, PC, Nylon and TPU 95A. Its layer resolution is 20 micron (which implies details of 0.02 mm) and its speed is up to 300 mm/s.

6. BUDGET

For the elaboration of this budget the following data has been taken into account:

- The prices shown have been obtained from real companies and suppliers.
- The estimation of programming and design times have been obtained from the experience of people in the field.

6.1. HARDWARE BUDGET

HARDWARE BUDGET			
Quantity	Component	Price (€/u)	Total price (€)
2000	Motor	4,67	9340
1000	DRV8835 motor driver	5,25	5250
1000	S7V7F5 voltage regulator	3,49	3490
1000	Raspberry Pi model B+	22	22000
4000	HC-SR04	2,8	11200
1000	LDR	3,2	3200
1000	Button	0,95	950
1000	Resistor 68k	0,0234	23,4
1000	Resistor 330 Ω	0,0173	17,3
4000	Resistor 1.2k	0,0214	85,6
4000	Resistor 2.4k	0,0194	77,6
1000	Resistor 20k	0,0205	20,5
2000	Power bank	10	20000
2000	Micro USB Adapter female-male	0,97	1940
2000	Wheels	3,49	6980
50 m	Cable	60,2	60,2
10 m	Tin	4,32	4,32
1000m	ABS Plastic	34,17	34170
DIRECT LABOR			
40	Diesign (Engineer hour)	28	1120
1000	Assembly (Hour of FP2 expert)	16	16000
OTHER COSTS			
	Energy Costs		200
	Amortization of equipment		2495
TOTAL			
			138.623,92 €

Table 2: Hardware budget

6.2. SOFTWARE BUDGET

SOFTWARE BUDGET			
Quantity	Component	Price (€/u)	Total price (€)
	Proteus software		393
1 month	Autocad Inventor		260
TOTAL			
			653,00 €

Table 3: Software budget

6.3. TOTAL BUDGET

TOTAL BUDGET			
Quantity	Component	Price (€/u)	Total price (€)
1	Hardware components		138.623,92 €
1	Software design		653,00 €
TOTAL			
			139.276,92 €

Table 4: Total budget

- Industrial Benefit (20%) → Total * 0,2 + Total = 166.989,66 €
- **Final Cost (1000 u)** → IB * IVA (21%) + IB = **202.057,49 €**
- **Final Cost (1 u)** → Final Cost/1000 = **202,06 €**

7. CODE

Two programs have been implemented in order to make the robot work, WorkingMain.py and Shutdown.py.

7.1. WorkingMain.py

This programs makes the robot move. It makes the robot move in an random way until it finds an object thanks to the ultrasonic sensor and changes its direction to avoid it. In the following flow chart the main structure to understand the program can be seen:

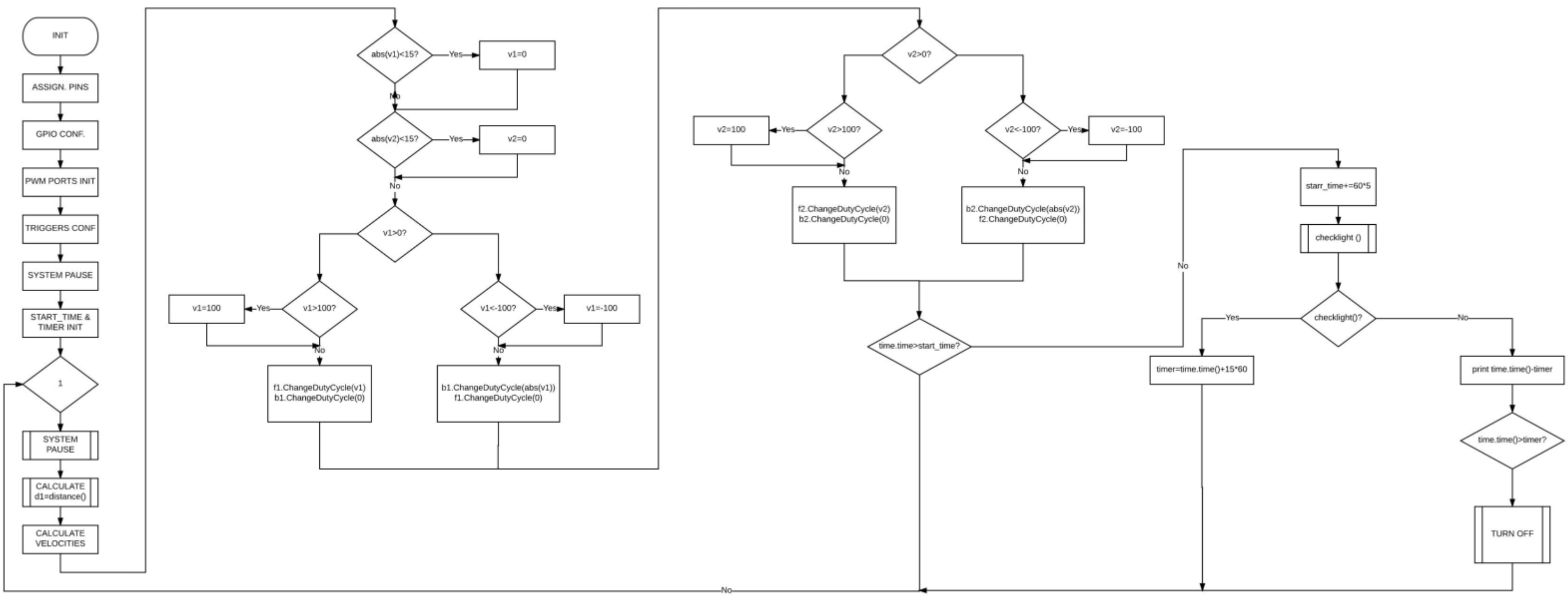

Figure 15. WorkingMain.py flow chart

The program has three main functions:

Distance(): Function that calculates the distance between the sensor and the object.

```
def distance( trigger, echo ):     #Function that calculates the distance between the sensor
and the object.

    overtime=time.time()+1         #time.time returns the actual time (this function is a
general function from the RaspberryPi)
    stop=time.time()
    GPIO.output(trigger, True)
    time.sleep(0.00001)
    GPIO.output(trigger, False)
    start = time.time()

    while GPIO.input(echo)==0 and time.time()<overtime:
        start = time.time()     #variable that keeps the start ultrasounds pulse
    while GPIO.input(echo)==1 and time.time()<overtime:
        stop = time.time()  # variable that keeps the ultrasounds pulse when it goes back

# Calculate pulse length
    elapsed = stop-start #show how far is the object by knowing how many time it cost to the
pulse to go and return

# Distance pulse travelled in that time is time multiplied by the speed of sound (cm/s)
    dist = elapsed * 34000

# That was the distance there and back so halve the value

    dist = dist / 2

#If the distance gives an error (time.time()>=overtime) will give 15 (neutral position)

    if dist<0: dist=15

    return dist;
```

Time.time(): Returns the actual time. This is a predefinied function.

Checklight(): Function that detects if there is light.

```
def checklight(power_pin , read_pin):     #Function that detects if there is light

    GPIO.output(power_pin, True)

    time.sleep(0.5)

    valor = GPIO.input(read_pin)

    GPIO.output(power_pin, False)

    return valor;

    return True;
```

7.2. Shutdown.py

This program makes the raspberry to shut down. It only has a function called Int_shutdown() that will make the raspberry to turn off. The next flow chart shows the working mode of the program:

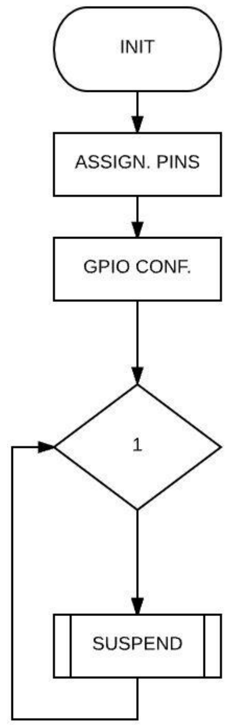

Figure 16: Shutdown.py flow chart

8. CONCLUSION

This project started as a simple assignment for a subject during my Erasmus and I thought it was such a good idea that when I returned to Spain I knew I had to keep going with it.

The main purpose was to make a robot capable of relate with children with ASD because this children have a lot of trouble trying to communicate with real people. Robots like this one already exist in the market as it was stated before but they are very expensive, so the idea will be to make it cheaper. The final price is above 200€ but even though it is cheaper than the other options in the market. It is important to have in mind that there are some costs that are not production dependent,(software budget) so the total budget can be decreased in a future.

In the beginning the idea was to produce the future robot with a molding process but with the progress that it is happening with the 3D printing I think that it will be a good idea to keep the production with it because this is not going to be a massive product so it is not necessary a huge volume of stock and using this method makes the robot more customizable if possible.

It is important to keep in mind that the robot is not completely finished because it will need the programing of the artificial vision in order to be able to recognize the targets but in conclusion I can say that this project will be very useful if its development is continued and finished in a future and I am sure that it will be able to help a lot of children.

8.1 Conclusión

Este proyecto empezó como un simple trabajo para una asignatura durante mi Erasmus y pensé que era tan buena idea que al volver a España supe que tenía que seguir desarrollándolo.

El propósito principal era hacer un robot capaz de relacionarse con niños con ASD, ya que estos niños suelen tener muchos problemas al intentar comunicarse con gente real. Robots como este ya existen en el mercado tal y como se explicó anteriormente pero son muy caros, así que la idea era ser capaz de hacer algo similar y con un precio menor. El precio final supera los 200€ pero aún con eso es mucho más barato que las otras opciones en el Mercado. Es importante tener en cuenta que hay algunos costes que no dependen de la producción (presupuesto de software) por lo que el presupuesto total puede disminuir en un futuro.

Al principio la idea era producir el robot en un futuro con un proceso de moldead pero con los avances que se están haciendo con las impresoras 3D pienso que puede ser una buena idea mantener la producción de esta forma ya que no será una producción masiva por lo que no será necesario un alto volumen de stock y además ayudar a hacer el producto más personalizable.

Es importante tener en cuenta que el robot no está completamente terminado porque necesitará ser programado con visión artificial para poder reconocer las tarjetas, pero en conclusión puedo decir que este proyecto será muy útil si su desarrollo continua y se termina en un futuro y estoy segura de que podrá ayudar a muchos niños.

8.2. Conclusió

Aquest projecte va començar com un simple treball per a una assignatura en el meu Erasmus però vaig pensar que era tan bona idea que al tornar a Espanya sabia que tenia que seguir desenvolupant-lo.

El propòsit principal era fer un robot capaç de relacionar-se amb xiquets amb ASD, ja que aquests xiquets solen tenir molts problemes al intentar relacionar-se amb gent real. Robots com aquesta ja existeixen en el mercat com es va explicar anteriorment però son molt cars, així que la idea era ser capaç de fer un producte similar però amb un preu menor. El preu final supera el 200€ però inclús amb aquest preu es molt més barat que qualsevol de les altres opcions al mercat. És important to tindre en compte que alguns costs no depenen de la producció (software costs) per la qual cosa el pressupost total pot disminuir un poc en un futur.

Al principi la idea era produir el robot amb un procés de modelatge però amb els avanços que estan apareixent amb les impressores 3D penso que pot ser una bona idea mantindre la producció d'aquesta forma ja que no serà una producció massiva i no necessitarà un gran stock, a demès açò ajudarà a fer un producte més personalitzable.

Es important tindre en compte que el robot no està completament acabar perquè necessitarà ser programat amb visió artificial per a poder reconèixer les targetes, però en conclusió puc dir que aquest projecte serà molt útil si el seu desenvolupament continua i es termina en un futur i estic segura de que podrà ajudar a molts xiquets.

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ANNEXES

TABLE OF CONTENTS

TABLE OF FIGURES

ANNEX A: CODE

WorkingMainWithoutLight.py

```
import time
import RPi.GPIO as GPIO
import os

def distance( trigger, echo ):    #Function that calculates the distance between the sensor
and the object.
                                  #time.time returns the actual time
    overtime=time.time()+1
    stop=time.time()
    GPIO.output(trigger, True)
    time.sleep(0.00001)
    GPIO.output(trigger, False)
    start = time.time()

    while GPIO.input(echo)==0 and time.time()<overtime:
        start = time.time()    #variable that keeps the start ultrasounds pulse
    while GPIO.input(echo)==1 and time.time()<overtime:
        stop = time.time()  # variable that keeps the ultrasounds pulse when it goes back

# Calculate pulse length
    elapsed = stop-start #tshow how far is the object by knowing how many time it cost to
the pulse to go and return

# Distance pulse travelled in that time is time multiplied by the speed of sound (cm/s)
    dist = elapsed * 34000

# That was the distance there and back so halve the value

    dist = dist / 2

#If the distance gives an error (time.time()>=overtime) will give 15 (neutral position)

    if dist<0: dist=15

    return dist;

def checklight(power_pin , read_pin):     #Function that detects if there is light

    GPIO.output(power_pin, True)

    time.sleep(0.5)

    valor = GPIO.input(read_pin)

    GPIO.output(power_pin, False)

    return valor;

    return True;


GPIO.setmode(GPIO.BOARD)
#echo sensor
ECHO1=11
ECHO2=22
ECHO3=23
ECHO4=24

#trigger sensor
TRIG1=14
TRIG2=18
TRIG3=10
TRIG4=16
```

```
#pines forward motor
F1=15
F2=37
#pines backward motor
B1=16
B2=36

LDR_POW = 38  #power ldr
LDR_READ = 40  #read ldr

GPIO.setup(LDR_POW,GPIO.OUT)  # Trigger
GPIO.setup(LDR_READ,GPIO.IN)  # Echo

GPIO.setup(TRIG1,GPIO.OUT)  # Trigger
GPIO.setup(ECHO1,GPIO.IN)   # Echo

GPIO.setup(TRIG2,GPIO.OUT)  # Trigger
GPIO.setup(ECHO2,GPIO.IN)   # Echo

GPIO.setup(TRIG3,GPIO.OUT)  # Trigger
GPIO.setup(ECHO3,GPIO.IN)   # Echo

GPIO.setup(TRIG4,GPIO.OUT)  # Trigger
GPIO.setup(ECHO4,GPIO.IN)   # Echo

GPIO.setup(F1,GPIO.OUT)     # Forward motor 1
GPIO.setup(B1,GPIO.OUT)     # Backward motor 1

GPIO.setup(B2,GPIO.OUT)     # Forward motor 2
GPIO.setup(F2,GPIO.OUT)     # Backwad motor 2

f1=GPIO.PWM(F1, 200)  #configuration of F1 as PWM at 200 HZ
f1.start(0)

b1=GPIO.PWM(B1, 200) #configuration of B1 as PWM at 200 HZ
b1.start(0)

f2=GPIO.PWM(F2, 200) #configuration of F2 as PWM at 200 HZ
f2.start(0)

b2=GPIO.PWM(B2, 200) #configuration of B2 as PWM at 200 HZ
b2.start(0)

# Set trigger to False (Low)

GPIO.output(TRIG1, False)
GPIO.output(TRIG2, False)
GPIO.output(TRIG3, False)
GPIO.output(TRIG4, False)

# Allow module to settle
time.sleep(0.5)

start_time=time.time()
timer=time.time()

while 1:

    time.sleep(0.5)

    d1=distance(TRIG1,ECHO1)
    d2=distance(TRIG2,ECHO2)

    d3=distance(TRIG3,ECHO3)
    d4=distance(TRIG4,ECHO4)

    v1=(d1-15)*5-(d2+15)      # velocity of motor 1 d1-15 in order to have the distance 0.
It is multiplied by 5 in order to have a bigger gain. After that d2-15 will be subsracted in
order to make the robot to back a bit.
    v2=(d2-15)*5-(d1+15)
```

```
    if(abs(v1)<15): v1=0  #it will make the motor to change its direction once the distance
is less than 15
    if(abs(v2)<15): v2=0  #it will make the motor to change its direction once the distance
is less than 15

    if(v1<0):                          #it will make the robot go backwards
        v1=v1-((d3-15)*5-(d4-15))

    if(v1>0):
        if v1>100: v1=100
        f1.ChangeDutyCycle(v1)
        b1.ChangeDutyCycle(0)

    else:
        if v1<-100: v1=-100
        b1.ChangeDutyCycle(abs(v1))
        f1.ChangeDutyCycle(0)

    if(v2<0):
        v2=v2-((d4-15)*5-(d3-15))

    if(v2>0):
        if v2>100: v2=100
        f2.ChangeDutyCycle(v2)
        b2.ChangeDutyCycle(0)

    else:
        if v2<-100: v2=-100
        b2.ChangeDutyCycle(abs(v2))
        f2.ChangeDutyCycle(0)


    if time.time()>start_time:

        start_time=start_time+60*5
        if checklight(LDR_POW,LDR_READ):  #if checklight is correct it will do
timer=timer()+15*60, 15*60=15 min
            timer=time.time()+15*60
        else:              #if not, once 15 minutes have passed it will turn off
            print time.time()-timer
            if(time.time()>timer):
                os.system("sudo shutdown -h now")
```

Shutdown.py

```
This script will wait for a button to be pressed and then shutdown
# the Raspberry Pi.
# The button is to be connected on header 5 between pins 6 and 8.

# http://kampis-elektroecke.de/?page_id=3740
# http://raspi.tv/2013/how-to-use-interrupts-with-python-on-the-raspberry-pi-and-
rpi-gpio
# https://pypi.python.org/pypi/RPi.GPIO

import RPi.GPIO as GPIO
import time
import os


LED_PIN = 33
BUT_PIN = 35

GPIO.setmode(GPIO.BOARD)
```

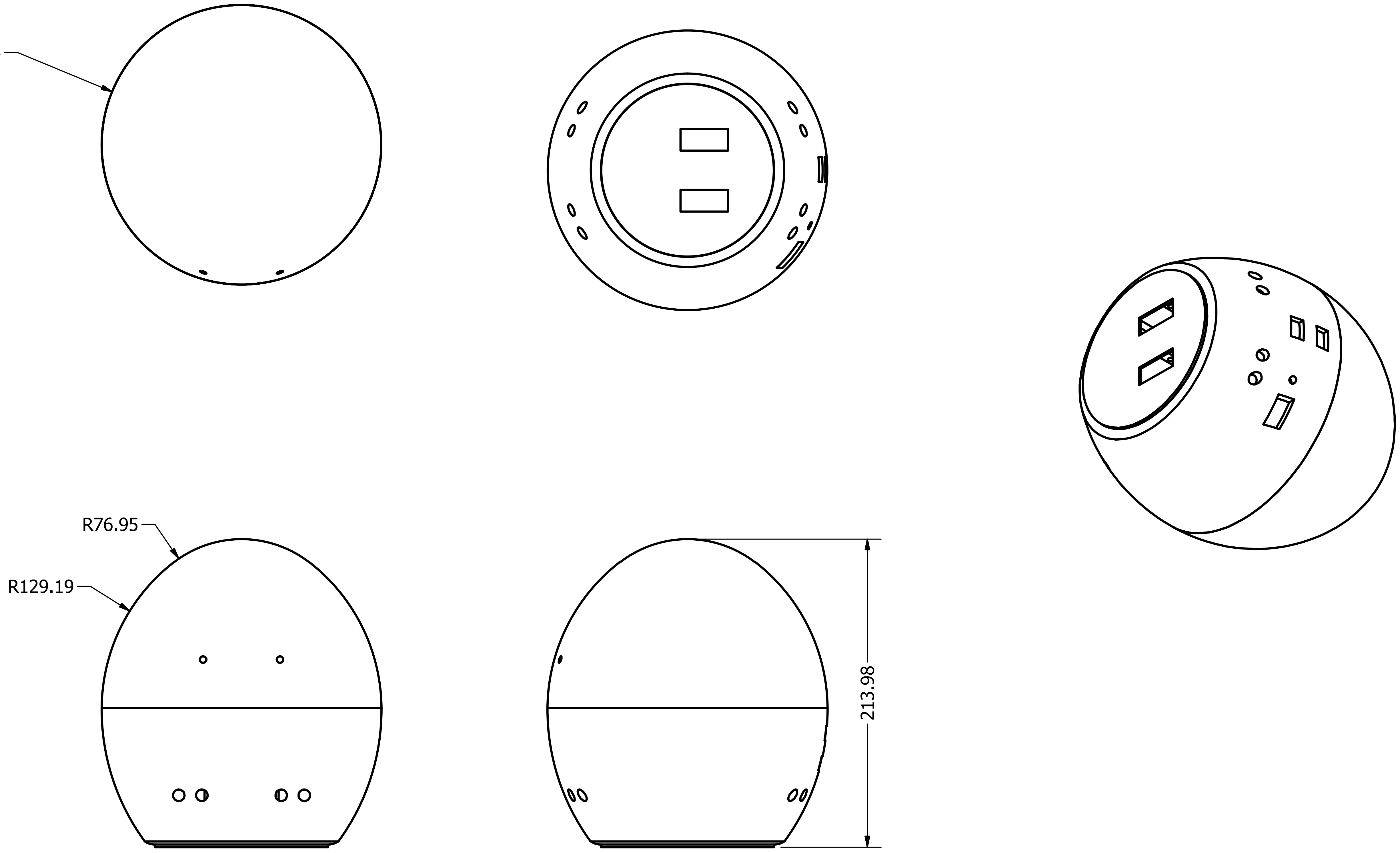
```
# Pin 35 (Header 5) will be input and will have his pull up resistor activated so
it is only need to connect a button to ground
GPIO.setup(LED_PIN,GPIO.OUT)
GPIO.output(LED_PIN, True)
GPIO.setup(BUT_PIN, GPIO.IN, pull_up_down = GPIO.PUD_UP)

# If our button is pressed, there will be a falling edge on pin 35 and it will
trigger this interrupt:
def Int_shutdown(channel):
   # shutdown the Raspberry Pi
   os.system("sudo shutdown -h now")

# Now pin 35 will be programmed as an interrupt input. It will react on a falling
edge and call the interrupt routine "Int_shutdown"
GPIO.add_event_detect(BUT_PIN, GPIO.FALLING, callback = Int_shutdown, bouncetime
= 2000)

# do nothing while waiting for button to be pressed
while 1:
        time.sleep(10)
```

ANNEX B: DRAWINGS



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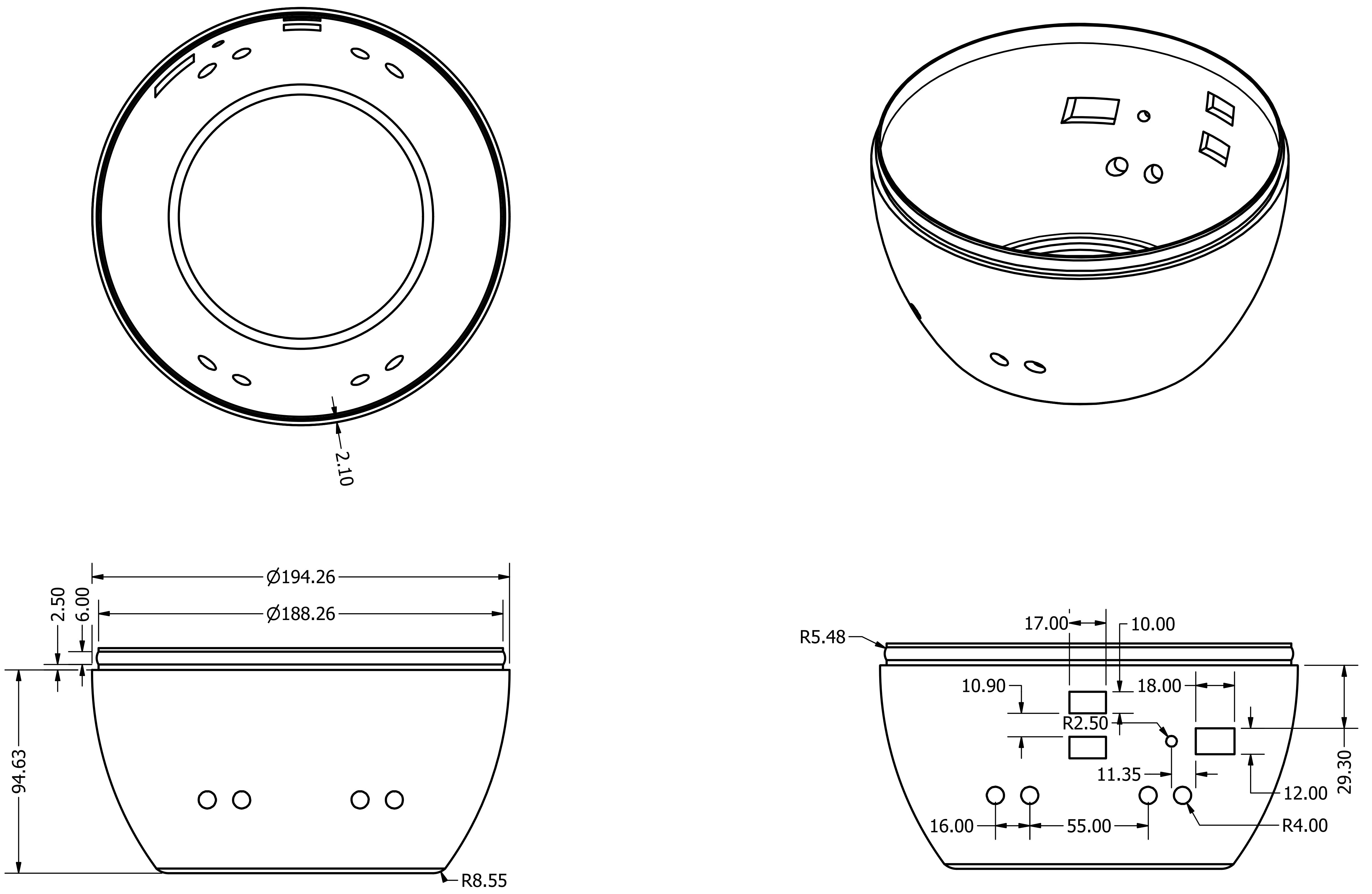

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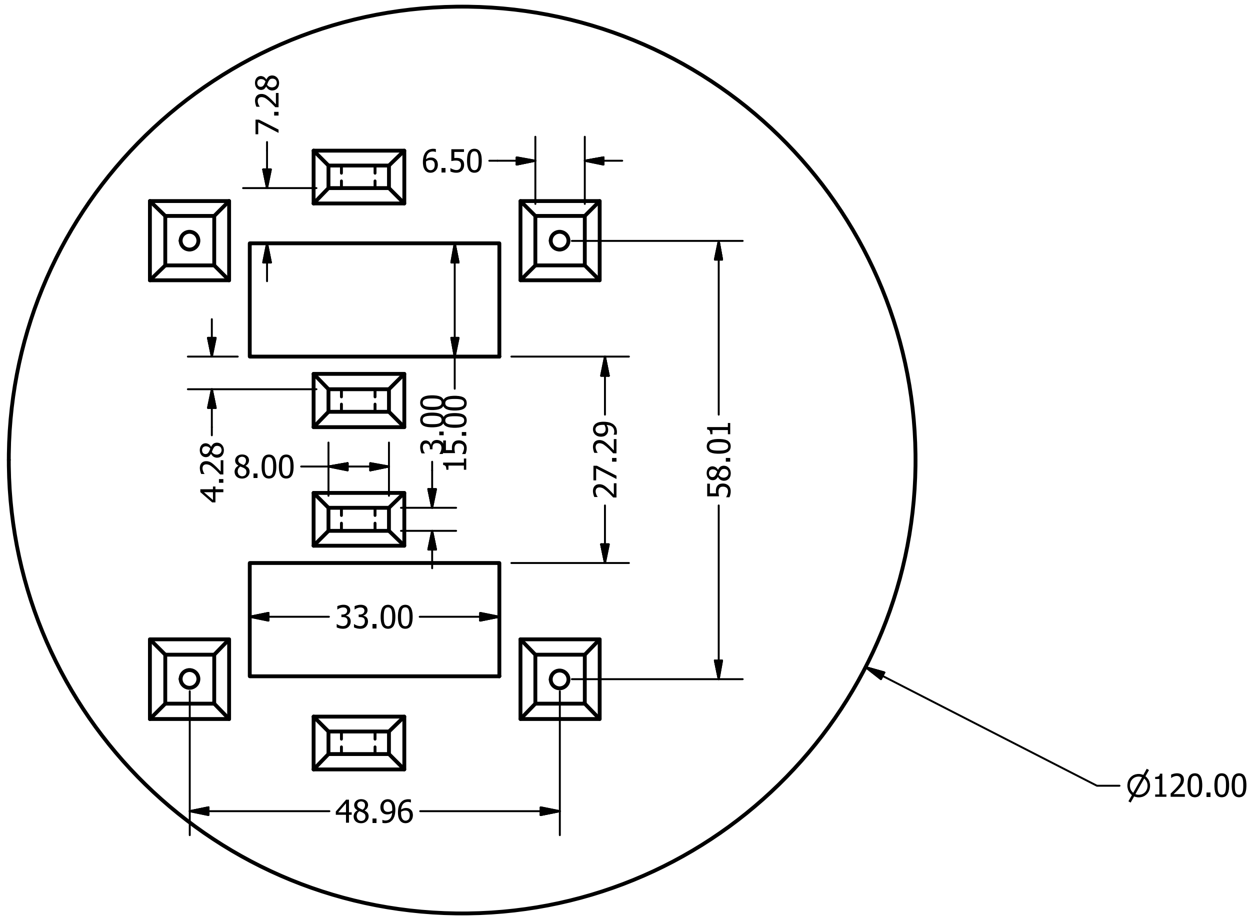
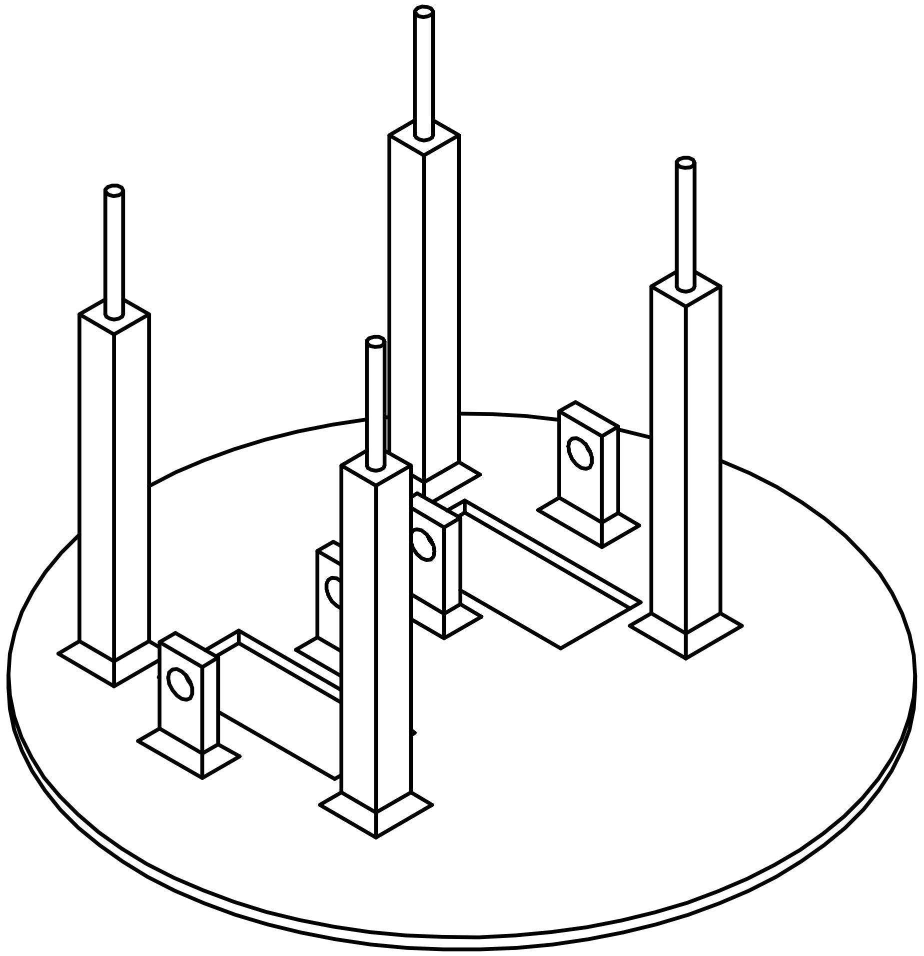
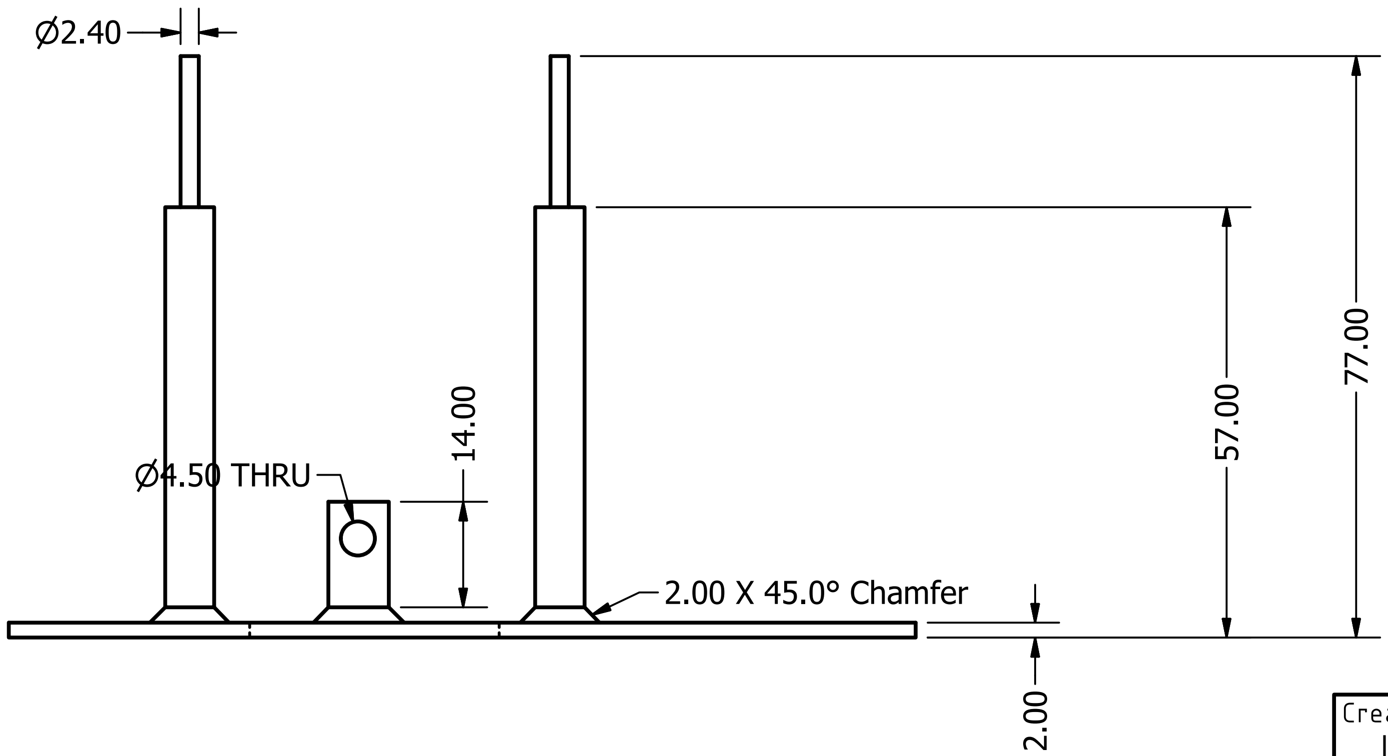
		Sheet number: 1/1







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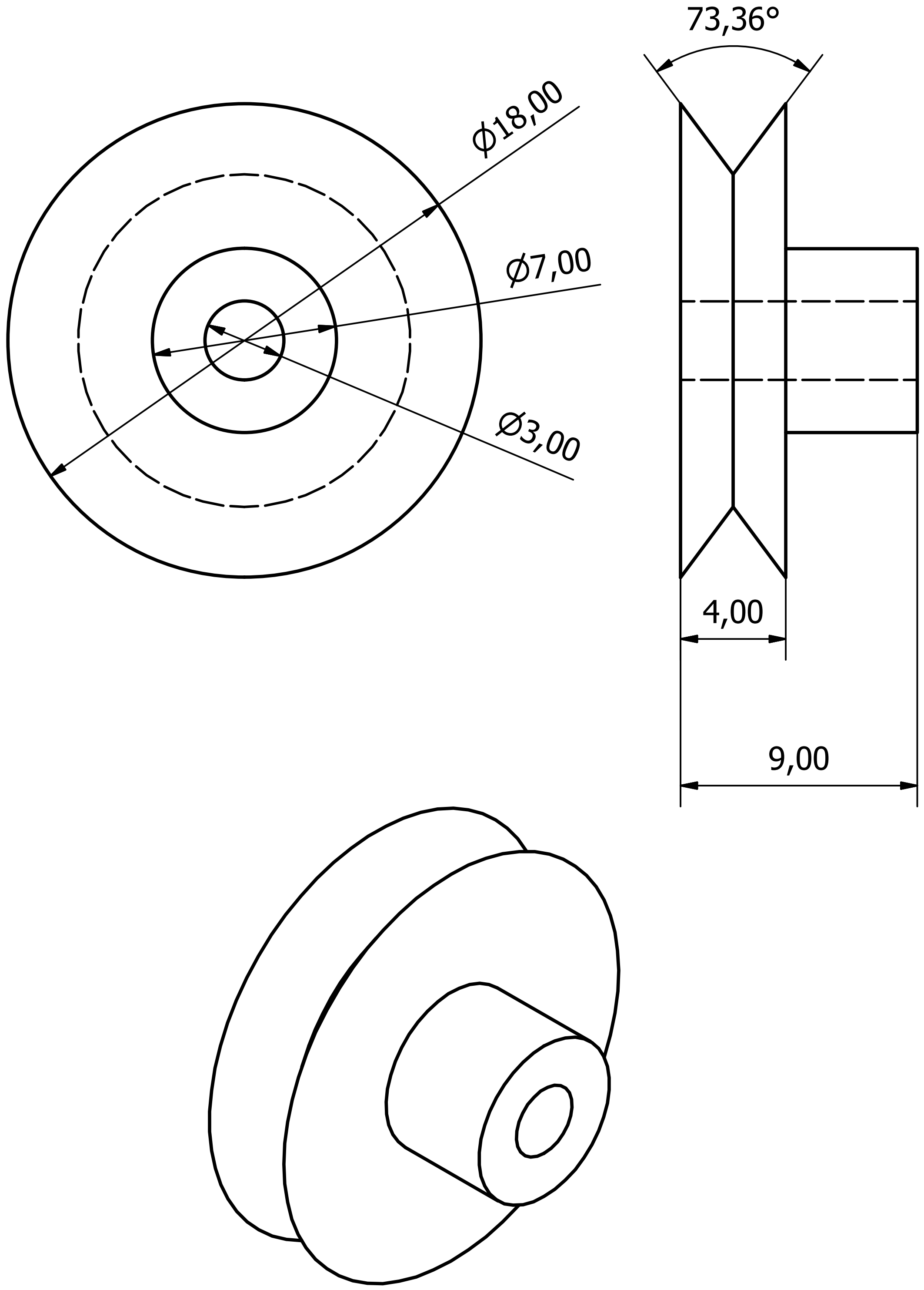
		06/02/2017	1/1



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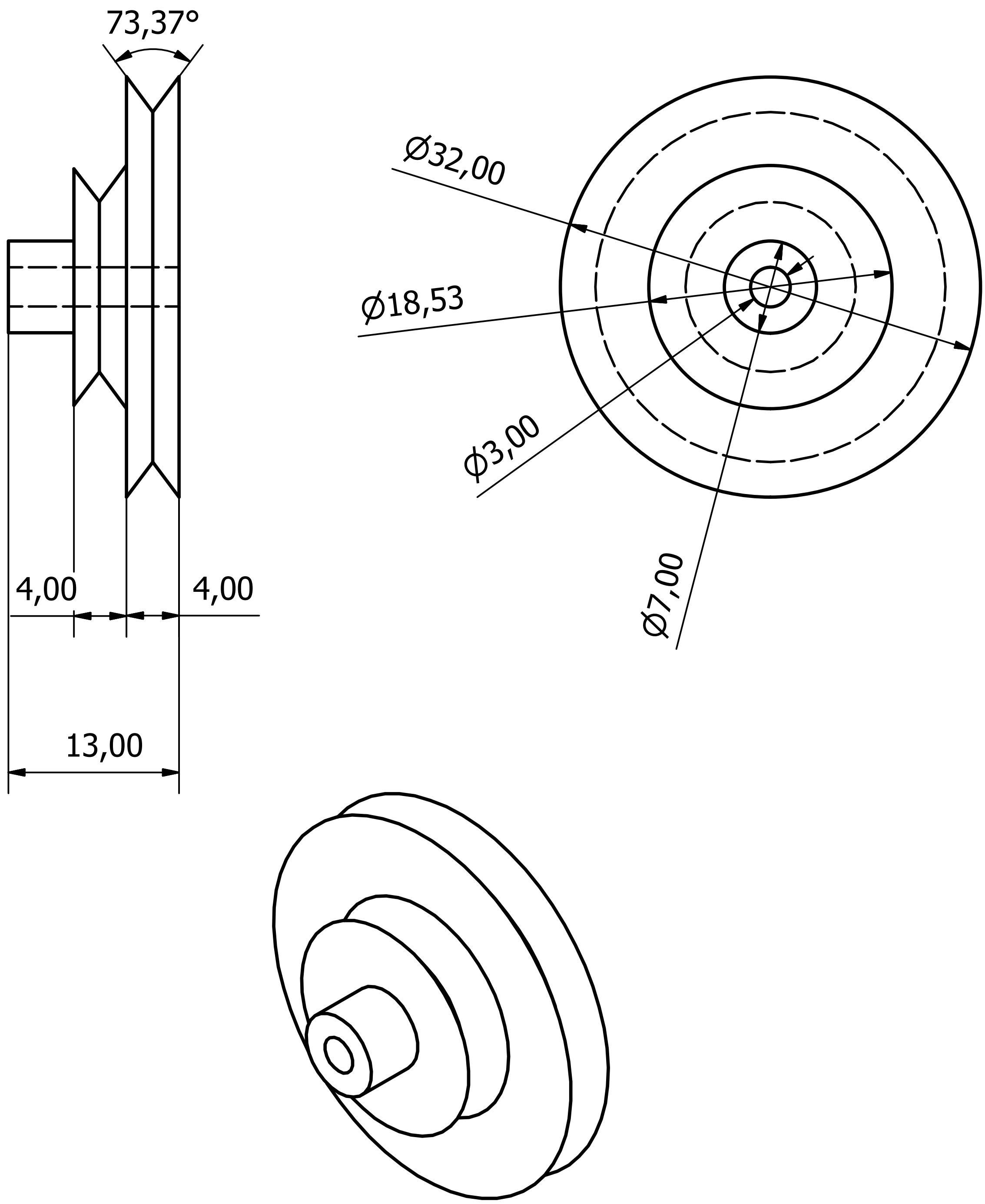
		Date: 06/02/2017 — Sheet number: 1/1



Created by LAURA HUERTA MASIA	Approved by JAVIER IBAÑEZ CIVERA	Document type DRAWING
UPV-ETSID	Title WHEEL	Part number
		Date: 06/02/2017 / Sheet number: 1/1

ANNEX C: PROTOTYPE PICTURES

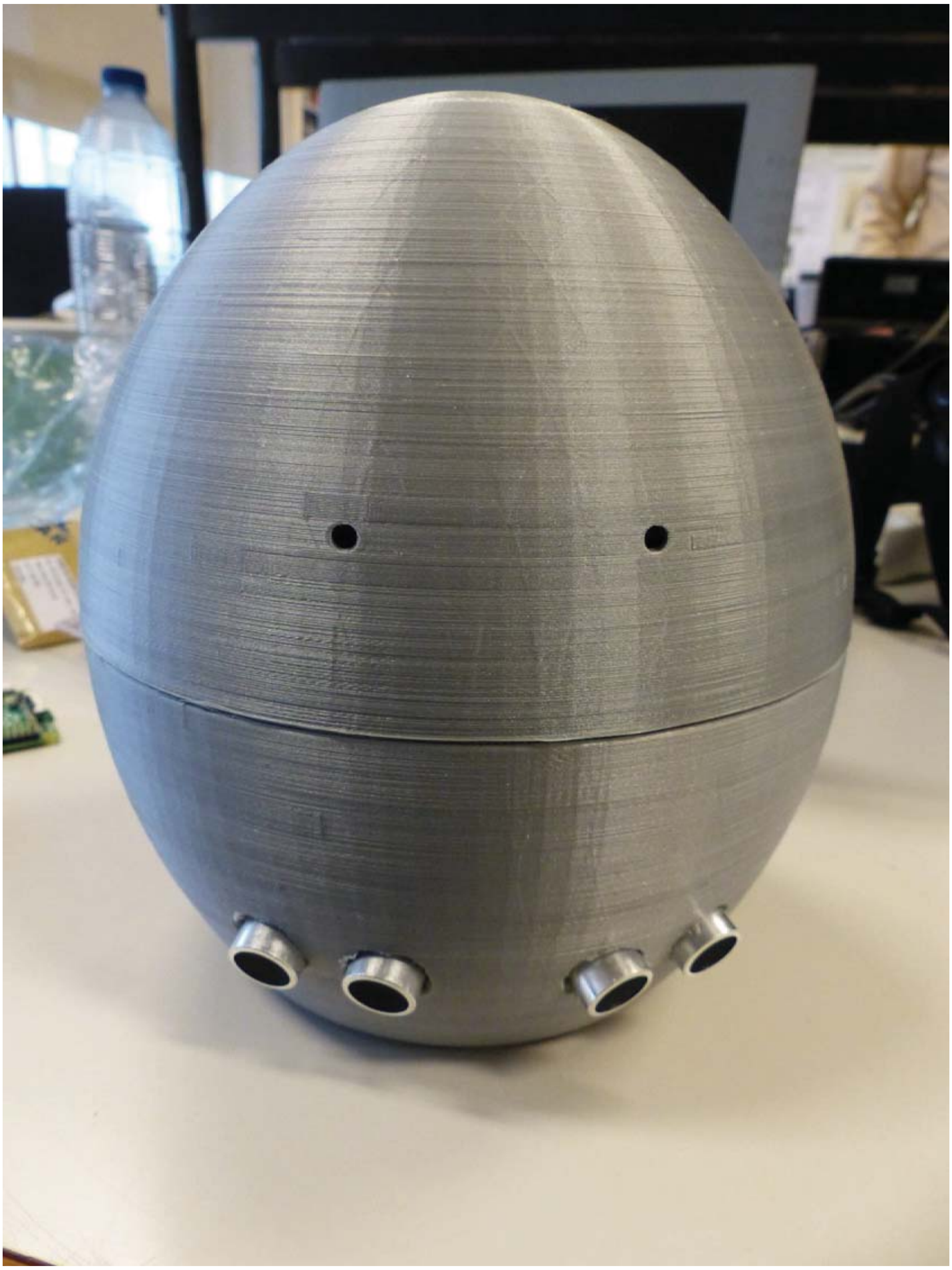


Figure 1: Prototype figure 1

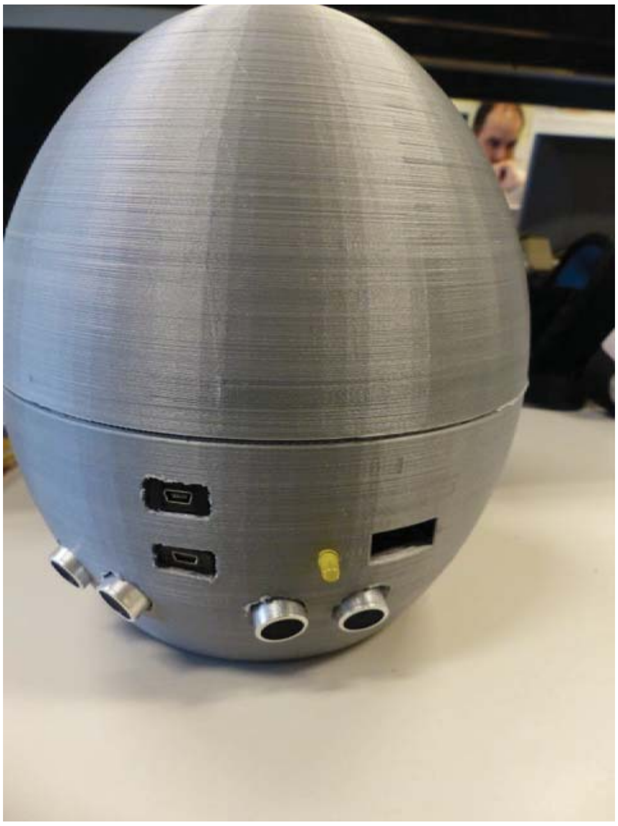


Figure 2: Prototype figure 2

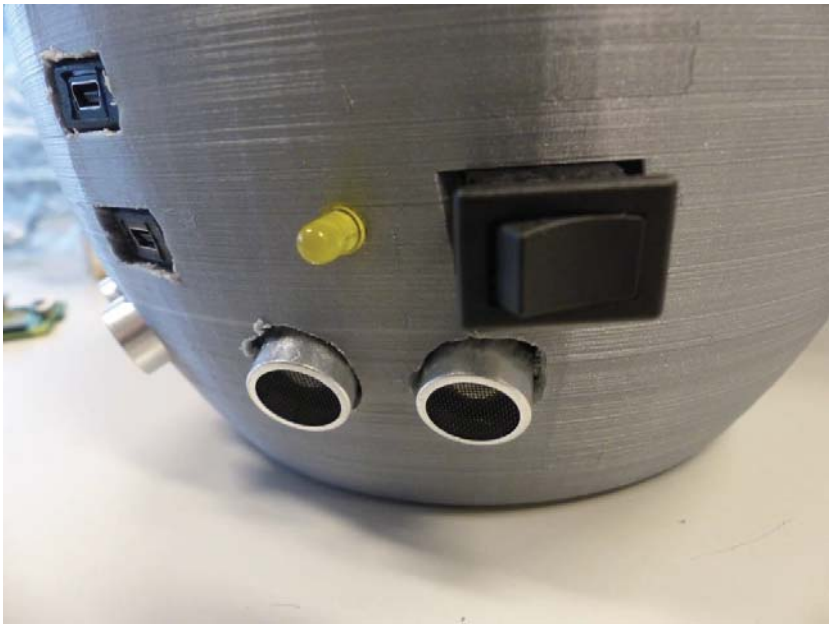


Figure 3: Prototype figure 3

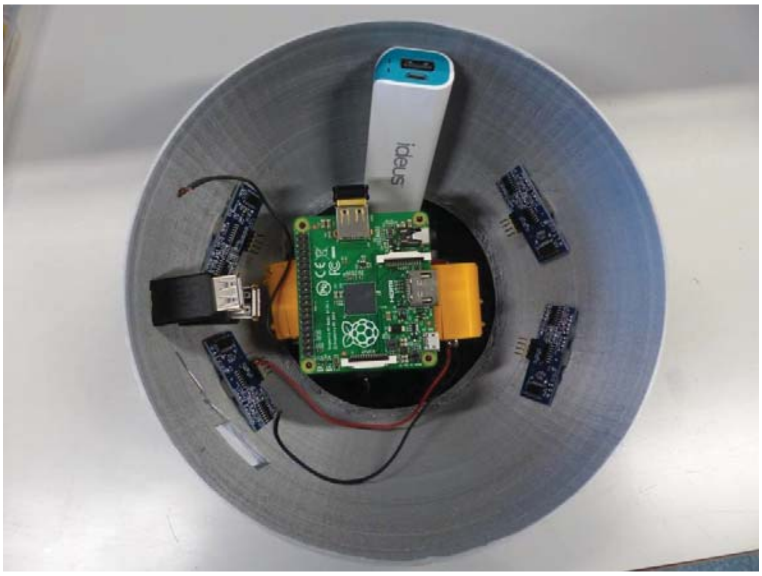


Figure 4: Prototype figure 4

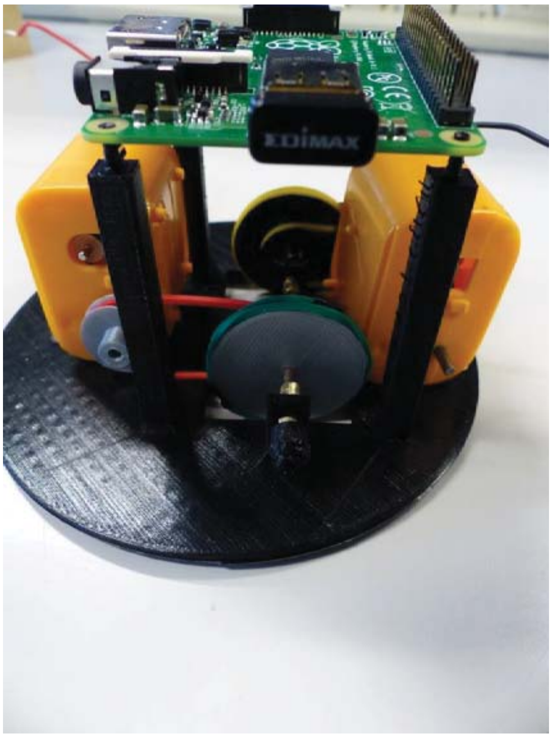


Figure 5: Prototype figure 5

ANNEX D: GLOSSARY

The following words and their definitions apply within this document:

- A Amps
- ABA Applied Behavior Analysis
- ABS Acrylonitrile butadiene styrene
- ASD Autism Spectrum Disorder
- CPE Chlorinated Polyethylene
- DC Direct Current
- GPIO General Purpose Input/output
- IB Industrial Benefit
- LDR Light Dependent Resistor
- mm Millimeters
- mm/s Millimeters per second
- OS Operating System
- PECS Picture Exchange Communication System
- PCB Printed Circuit Board
- PLA Polylactic acid
- PVC Polyvinyl Chloride
- RAT Robot Assisted Therapy
- V Volts

ANNEX E: DATASHEETS

VOLTAGE REGULATOR S7V7F5
from ***POLOLU***

HIGH INPUT VOLTAGE BUCK-BOOST CONVERTER WITH 2A SWITCH CURRENT

Check for Samples: TPS63060, TPS63061

FEATURES

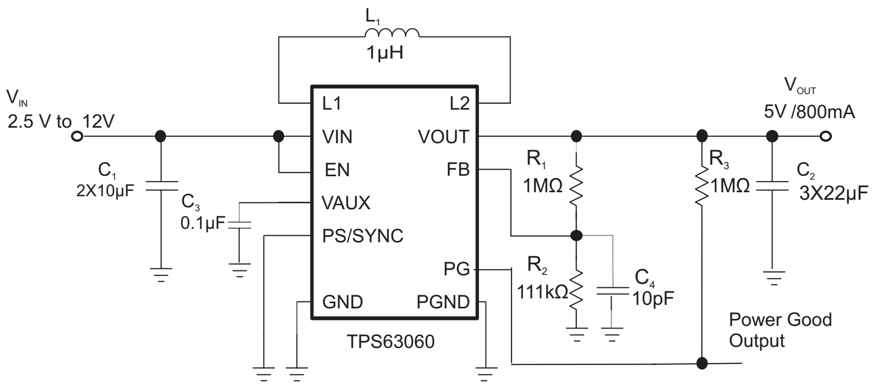
- **Up to 93% Efficiency**
- **2A/1A Output Current at 5V in Buck Mode**
- **1.3A Output Current at 5V in Boost Mode (VIN>4V)**
- **Automatic Transition Between Step Down and Boost Mode**
- **Typical Device Quiescent Current less than 30μA**
- **Input Voltage Range: 2.5V to 12V**
- **Fixed and Adjustable Output Voltage Options from 2.5V to 8V**
- **Power Save Mode for Improved Efficiency at Low Output Power**
- **Forced Fixed Frequency Operation at 2.4MHz and Synchronization Possible**
- **Power Good Output**
- **Buck-Boost Overlap Control™**
- **Load Disconnect During Shutdown**
- **Overtemperature Protection**
- **Overvoltage Protection**
- **Available in a 3-mm × 3-mm, SON-10 Package**

APPLICATIONS

- **Dual LI-Ion Application**
- **DSC's and Camcorders**
- **Notebook Computer**
- **Industrial Metering Equipment**
- **Ultra Mobile PC's and Mobile Internet Devices**
- **Personal Medical Products**
- **High Power LED's**

DESCRIPTION

The TPS6306x devices provide a power supply solution for products powered by either three-cell up to six-cell alkaline, NiCd or NiMH battery, or a one-cell or dual-cell Li-Ion or Li-polymer battery. Output currents can go as high as 2A while using a dual-cell Li-Ion or Li-Polymer Battery, and discharge it down to 5V or lower. The buck-boost converter is based on a fixed frequency, pulse-width-modulation (PWM) controller using synchronous rectification to obtain maximum efficiency. At low load currents, the converter enters Power Save mode to maintain high efficiency over a wide load current range. The Power Save mode can be disabled, forcing the converter to operate at a fixed switching frequency. The maximum average current in the switches is limited to a typical value of 2.25A. The output voltage is programmable using an external resistor divider, or is fixed internally on the chip. The converter can be disabled to minimize battery drain. During shutdown, the load is disconnected from the battery. The device is packaged in a 10-pin SON PowerPAD™ package measuring 3mm × 3mm (DSC).



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

AVAILABLE DEVICE OPTIONS(1)

T_A	OUTPUT VOLTAGE DC/DC	PACKAGE MARKING	PACKAGE	PART NUMBER(2)
–40°C to 85°C	Adjustable	QUJ	10-Pin SON	TPS63060DSC
	5 V	QUK		TPS63061DSC

(1) Contact the factory to check availability of other fixed output voltage versions.
(2) For detailed ordering information please check the PACKAGE OPTION ADDENDUM section at the end of this data sheet.

ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range (unless otherwise noted)(1)

		VALUE		UNIT
		MIN	MAX	
Voltage range	VIN, VOUT, PS/SYNC, EN, FB	–0.3	17	V
	L1, L2	-0.3	V_{IN}+0.3	V
	FB, V_{AUX}	-0.3	7.5	V
Operating virtual junction temperature range, T_J		–40	150	°C
Storage temperature range T_{stg}		-65	150	°C
ESD rating(2)	Human Body Model - (HBM)		3	kV
	Machine Model - (MM)		200	V
	Charge Device Model - (CDM)		1.5	kV

(1) Stresses beyond those listed under *absolute maximum ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *recommended operating conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods my affect device reliability.
(2) ESD testing is performed according to the respective JESD22 JEDEC standard.

THERMAL INFORMATION

THERMAL METRIC(1)		TPS63060, TPS63061	UNITS
		DSC (10 PINS)	
$θ_{JA}$	Junction-to-ambient thermal resistance	48.7	°C/W
$θ_{JC(TOP)}$	Junction-to-case(top) thermal resistance	54.8	
$θ_{JB}$	Junction-to-board thermal resistance	19.8	
$ψ_{JT}$	Junction-to-top characterization parameter	1.1	
$ψ_{JB}$	Junction-to-board characterization parameter	19.6	
$θ_{JC(BOTTOM)}$	Junction-to-case(bottom) thermal resistance	4.2	

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, SPRA953.

RECOMMENDED OPERATING CONDITIONS

	MIN	NOM	MAX	UNIT
Supply voltage at VIN	2.5		12	V
Output Current I_{out} with V_{IN} = 10V to 12V			1	A
Operating free air temperature range, T_A	–40		85	°C
Operating virtual junction temperature range, T_J Output Current I_{out}	–40		125	°C

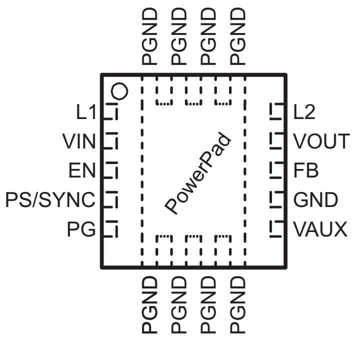
ELECTRICAL CHARACTERISTICS

over recommended free-air temperature range and over recommended input voltage range (typical at an ambient temperature range of 25°C) (unless otherwise noted)

PARAMETER			TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC/DC STAGE							
V_{IN}	Input voltage range			2.5		12	V
V_{IIN}	Minimum input voltage for startup					2.5	V
V_{OUT}	TPS63060 output voltage range			2.5		8	V
	Minimum duty cycle in step down conversion				10%	20%	
V_{FB}	TPS63060 feedback voltage		PS/SYNC = V_{IN}	495	500	505	mV
	TPS63061 output voltage		PS/SYNC = V_{IN}	4.95	5.0	5.05	V
V_{FB}	TPS63060 feedback voltage		PS/SYNC = GND Referenced to 500mV	0.6%		5%	
	TPS63061 output voltage		PS/SYNC = GND Referenced to 5V	0.6%		5%	
f	Oscillator frequency			2200	2400	2600	kHz
	Frequency range for synchronization			2200	2400	2600	kHz
I_{SW}	Average inductance current limit		V_{IN} = 5V, T_A = 25°C	2000	2250	2500	mA
	High side switch on resistance		V_{IN} = 5V		90		mΩ
	Low side switch on resistance		V_{IN} = 5V		95		mΩ
	Line regulation		Power Save Mode disabled		0.5%		
	Load regulation		Power Save Mode disabled		0.5%		
I_q	Quiescent current	VIN	I_O = 0 mA, V_{EN} = V_{IN} = 5V, V_{OUT} = 5V		30	60	µA
		VOUT			7	15	µA
	TPS63061 FB input impedance		V_{EN} = HIGH		1.5		MΩ
I_S	Shutdown current		V_{EN} = 0 V, V_{IN} = 5V		0.3	2	µA
CONTROL STAGE							
V_{AUX}	Maximum bias voltage		V_{IN} > V_{OUT}	V_{IN}		7	V
			V_{IN} < V_{OUT}	V_{OUT}		7	V
I_{AUX}	Load current at V_{AUX}					1	mA
UVLO	Under voltage lockout threshold		V_{IN} voltage decreasing	1.8	1.9	2.2	V
	UVLO hysteresis				300		mV
V_{IL}	EN, PS/SYNC input low voltage					0.4	V
V_{IH}	EN, PS/SYNC input high voltage			1.2			V
	EN, PS/SYNC input current		Clamped on GND or V_{IN}		0.01	0.1	µA
	PG output low voltage		V_{OUT} = 5V, I_{PGL} = 10 µA		0.04	0.4	V
	PG output leakage current				0.01	0.1	µA
	Output overvoltage protection			12		16	V
	Overtemperature protection				140		°C
	Overtemperature hysteresis				20		°C

PIN ASSIGNMENTS

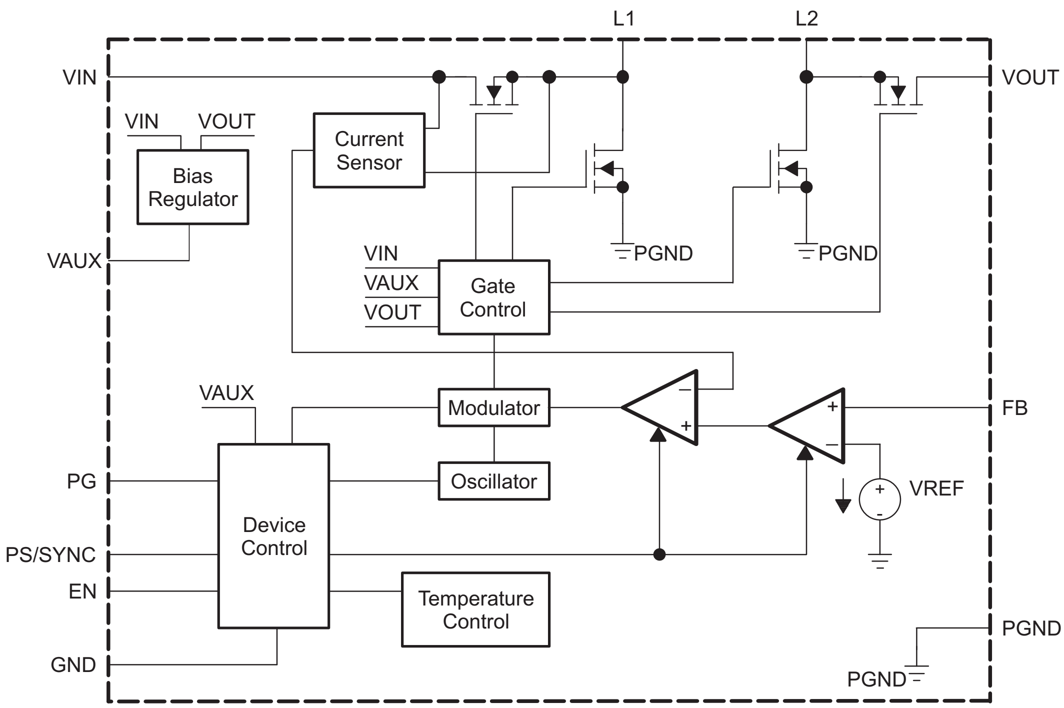
DSC PACKAGE
(TOP VIEW)



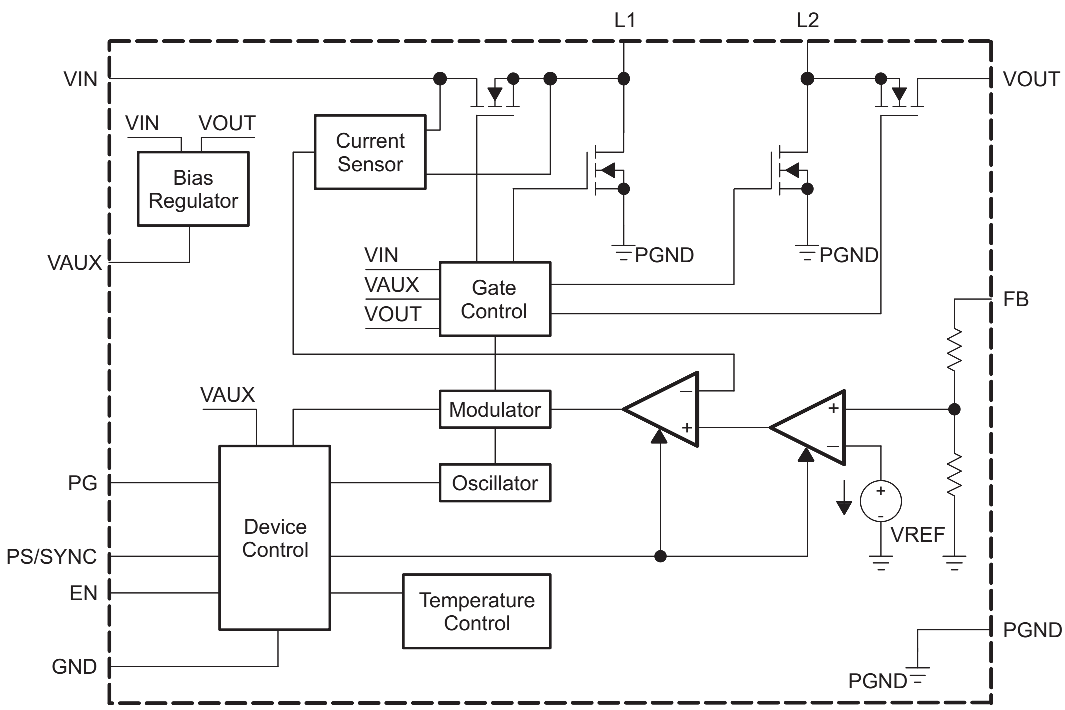
Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
EN	3	I	Enable input. (1 enabled, 0 disabled)
FB	8	I	Voltage feedback of adjustable versions, must be connected to VOUT on fixed output voltage versions
GND	7		Control / logic ground
L1	1	I	Connection for Inductor
L2	10	I	Connection for Inductor
PS/SYNC	4	I	Enable / disable power save mode (1 disabled, 0 enabled, clock signal for synchronization)
PG	5	O	Output power good (1 good, 0 failure; open drain)
PGND	PowerPAD™		Power ground
VIN	2	I	Supply voltage for power stage
VOUT	9	O	Buck-boost converter output
VAUX	6		Connection for Capacitor
PowerPAD™			Must be soldered to achieve appropriate power dissipation. Must be connected to PGND.

FUNCTIONAL BLOCK DIAGRAM (TPS63060)



FUNCTIONAL BLOCK DIAGRAM (TPS63061)



MOTOR DRIVER DRV8835
from ***POLOLU***

DRV8835 Dual Low-Voltage H-Bridge IC

1 Features

- Dual-H-Bridge Motor Driver
  - Capable of Driving Two DC Motors or One Stepper Motor
  - Low-MOSFET ON-Resistance: HS + LS 305 mΩ
- 1.5-A Maximum Drive Current Per H-Bridge
- Configure Bridges Parallel for 3-A Drive Current
- Separate Motor and Logic-Supply Pins:
  - 0-V to 11-V Motor-Operating Supply-Voltage
  - 2-V to 7-V Logic Supply-Voltage
- Separate Logic and Motor Power Supply Pins
- Flexible PWM or PHASE/ENABLE Interface
- Low-Power Sleep Mode With 95-nA Maximum Supply Current
- Tiny 2.00-mm × 3.00-mm WSON Package

2 Applications

- Battery-Powered:
  - Cameras
  - DSLR Lenses
  - Consumer Products
  - Toys
  - Robotics
  - Medical Devices

3 Description

The DRV8835 provides an integrated motor driver solution for cameras, consumer products, toys, and other low-voltage or battery-powered motion control applications. The device has two H-bridge drivers, and drives two DC motors or one stepper motor, as well as other devices like solenoids. The output driver block for each consists of N-channel power MOSFETs configured as an H-bridge to drive the motor winding. An internal charge pump generates gate drive voltages.

The DRV8835 supplies up to 1.5-A of output current per H-bridge and operates on a motor power supply voltage from 0 V to 11 V, and a device power supply voltage of 2 V to 7 V.

PHASE/ENABLE and IN/IN interfaces are compatible with industry-standard devices.

Internal shutdown functions are provided for overcurrent protection, short circuit protection, undervoltage lockout, and overtemperature.

The DRV8835 is packaged in a tiny 12-pin WSON package (Eco-friendly: RoHS and no Sb/Br).

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
DRV8835	WSON (12)	2.00 mm × 3.00 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Simplified Schematic

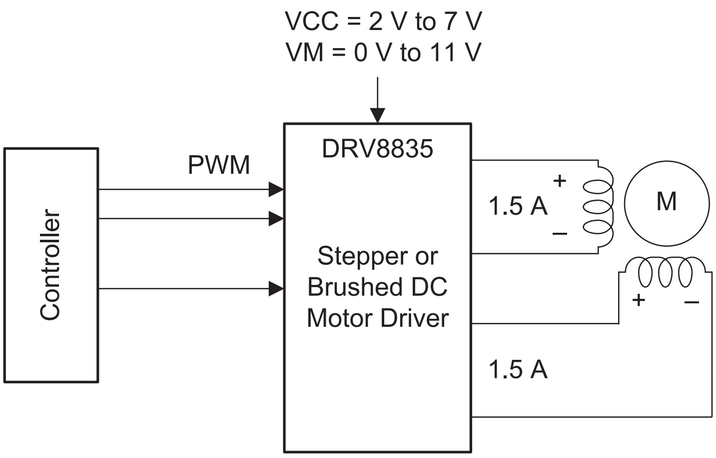


Table of Contents

4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision F (April 2016) to Revision G	Page
• Changed the *Layout Guidelines* to clarify the guidelines for the VM pin	14

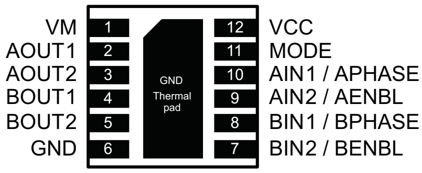
Changes from Revision E (December 2015) to Revision F	Page
• Deleted nFAULT from the *Simplified Schematic* in the *Description* section	1

Changes from Revision D (January 2014) to Revision E	Page
• Added *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section	1

Changes from Revision C (September 2013) to Revision D	Page
• Changed *Features* bullet	1
• Changed motor supply voltage range in *Description* section	1
• Changed Motor power supply voltage range in *Recommended Operating Conditions*	4
• Added t_{OCR} and t_{DEAD} parameters to *Electrical Characteristics*	5
• Added paragraph to *Power Supplies* and *Input Pins* section	13

5 Pin Configuration and Functions

DSS Package
12-Pin WSON
Top View



Pin Functions

PIN		I/O[1]	DESCRIPTION	EXTERNAL COMPONENTS OR CONNECTIONS
NAME	NO.			
POWER AND GROUND				
GND, Thermal pad	6	—	Device ground	
VM	1	—	Motor supply	Bypass to GND with a 0.1-μF (minimum) ceramic capacitor
VCC	12	—	Device supply	Bypass to GND with a 0.1-μF (minimum) ceramic capacitor
CONTROL				
MODE	11	I	Input mode select	Logic low selects IN/IN mode Logic high selects PH/EN mode Internal pulldown resistor
AIN1/APHASE	10	I	Bridge A input 1/PHASE input	IN/IN mode: Logic high sets AOUT1 high PH/EN mode: Sets direction of H-bridge A Internal pulldown resistor
AIN2/AENBL	9	I	Bridge A input 2/ENABLE input	IN/IN mode: Logic high sets AOUT2 high PH/EN mode: Logic high enables H-bridge A Internal pulldown resistor
BIN1/BPHASE	8	I	Bridge B input 1/PHASE input	IN/IN mode: Logic high sets BOUT1 high PH/EN mode: Sets direction of H-bridge B Internal pulldown resistor
BIN2/BENBL	7	I	Bridge B input 2/ENABLE input	IN/IN mode: Logic high sets BOUT2 high PH/EN mode: Logic high enables H-bridge B Internal pulldown resistor
OUTPUT				
AOUT1	2	O	Bridge A output 1	Connect to motor winding A
AOUT2	3	O	Bridge A output 2	
BOUT1	4	O	Bridge B output 1	Connect to motor winding B
BOUT2	5	O	Bridge B output 2	

(1) Directions: I = input, O = output

6 Specifications

6.1 Absolute Maximum Ratings

See [1][2]

		MIN	MAX	UNIT
	Power supply voltage, VM	–0.3	12	V
	Power supply voltage, VCC	–0.3	7	V
	Digital input pin voltage	–0.5	VCC + 0.5	V
	Peak motor drive output current	Internally limited		A
	Continuous motor drive output current per H-bridge[3]	–1.5	1.5	A
T_J	Operating junction temperature	–40	150	°C
T_{stg}	Storage temperature	–60	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) All voltage values are with respect to network ground terminal.
(3) Power dissipation and thermal limits must be observed.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001[1]	±2000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101[2]	±1500	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

T_A = 25°C (unless otherwise noted)

		MIN	NOM	MAX	UNIT
V_{CC}	Device power supply voltage	2		7	V
V_M	Motor power supply voltage	0		11	V
V_{IN}	Logic level input voltage	0		V_{CC}	V
I_{OUT}	H-bridge output current[1]	0		1.5	A
f_{PWM}	Externally applied PWM frequency	0		250	kHz

(1) Power dissipation and thermal limits must be observed.

6.4 Thermal Information

THERMAL METRIC[1]		DRV8835 DSS (WSON) 12 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	50.4	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	58	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	19.9	°C/W
ψ_{JT}	Junction-to-top characterization parameter	0.9	°C/W
ψ_{JB}	Junction-to-board characterization parameter	20	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	6.9	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, SPRA953.

6.5 Electrical Characteristics

T_A = 25°C, V_M = 5 V, V_{CC} = 3 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
POWER SUPPLY						
I_{VM}	VM operating supply current	No PWM, no load		85	200	μA
		50 kHz PWM, no load		650	2000	
I_{VMQ}	VM sleep mode supply current	V_M = 2 V, V_{CC} = 0 V, all inputs 0 V		5		nA
		V_M = 5 V, V_{CC} = 0 V, all inputs 0 V		10	95	
I_{VCC}	VCC operating supply current			450	2000	μA
V_{UVLO}	VCC undervoltage lockout voltage	V_{CC} rising			2	V
		V_{CC} falling			1.9	
LOGIC-LEVEL INPUTS						
V_{IL}	Input low voltage				0.3 × V_{CC}	V
V_{IH}	Input high voltage		0.5 × V_{CC}			V
I_{IL}	Input low current	V_{IN} = 0	–5		5	μA
I_{IH}	Input high current	V_{IN} = 3.3 V			50	μA
R_{PD}	Pulldown resistance			100		kΩ
H-BRIDGE FETS						
$R_{DS(ON)}$	HS + LS FET on resistance	V_{CC} = 3 V, V_M = 3 V, I_O = 800 mA, T_J = 25°C		370	420	mΩ
		V_{CC} = 5 V, V_M = 5 V, I_O = 800 mA, T_J = 25°C		305	355	
I_{OFF}	OFF-state leakage current				±200	nA
PROTECTION CIRCUITS						
I_{OCP}	Overcurrent protection trip level		1.6		3.5	A
t_{DEG}	Overcurrent de-glitch time			1		μs
t_{OCR}	Overcurrent protection retry time			1		ms
t_{DEAD}	Output dead time			100		ns
t_{TSD}	Thermal shutdown temperature	Die temperature	150	160	180	°C

6.6 Timing Requirements

T_A = 25°C, V_M = 5 V, V_{CC} = 3 V, R_L = 20 Ω

NO.			MIN	MAX	UNIT
1	t_1	Delay time, xPHASE high to xOUT1 low		300	ns
2	t_2	Delay time, xPHASE high to xOUT2 high		200	ns
3	t_3	Delay time, xPHASE low to xOUT1 high		200	ns
4	t_4	Delay time, xPHASE low to xOUT2 low		300	ns
5	t_5	Delay time, xENBL high to xOUTx high		200	ns
6	t_6	Delay time, xENBL high to xOUTx low		300	ns
7	t_7	Output enable time		300	ns
8	t_8	Output disable time		300	ns
9	t_9	Delay time, xINx high to xOUTx high		160	ns
10	t_{10}	Delay time, xINx low to xOUTx low		160	ns
11	t_R	Output rise time	30	188	ns
12	t_F	Output fall time	30	188	ns

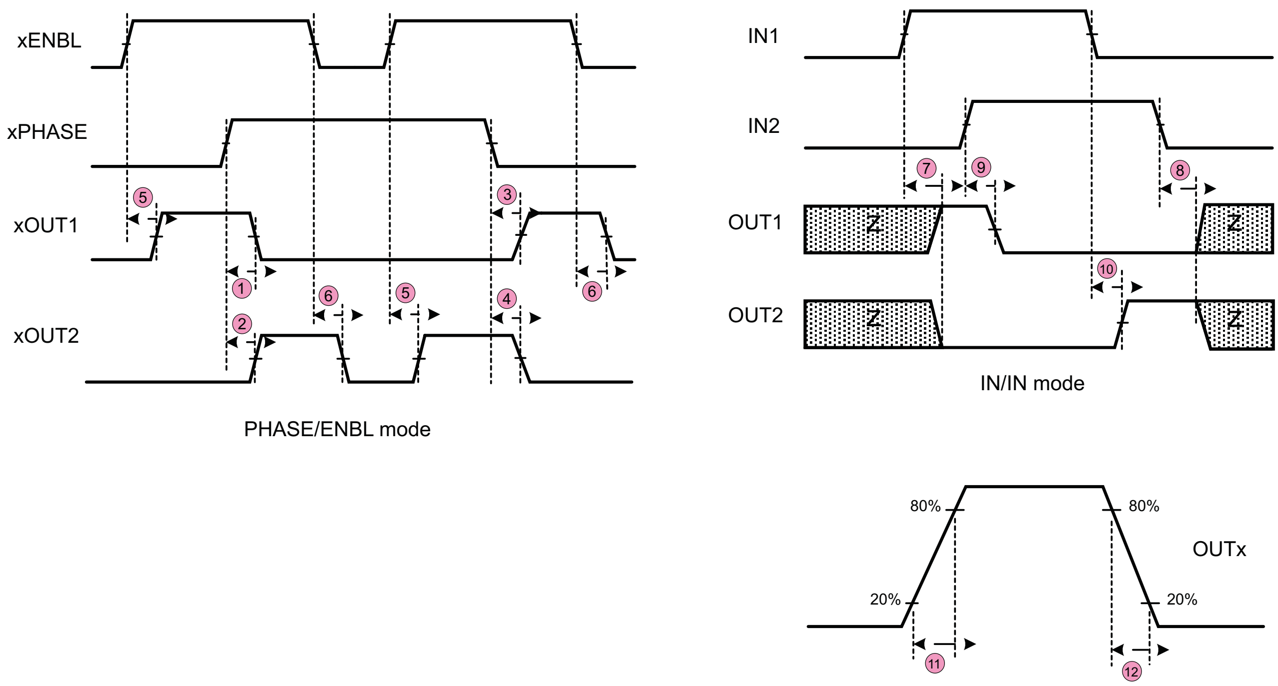


Figure 1. Timing Requirements

6.7 Typical Characteristics

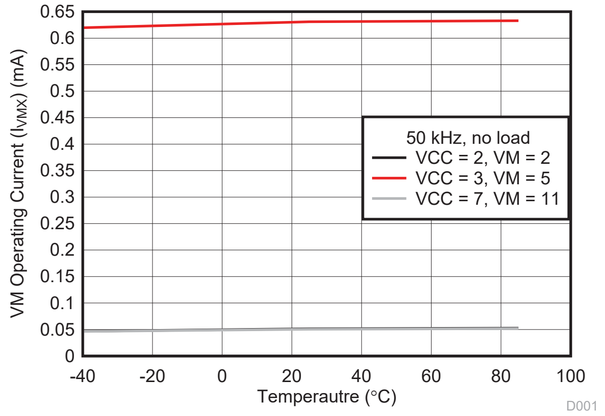


Figure 2. VM Operating Current

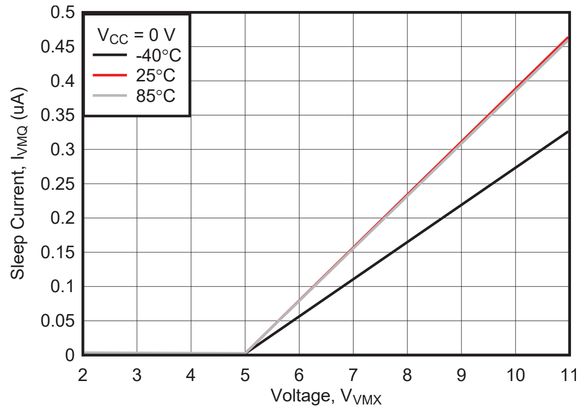


Figure 3. Sleep Current

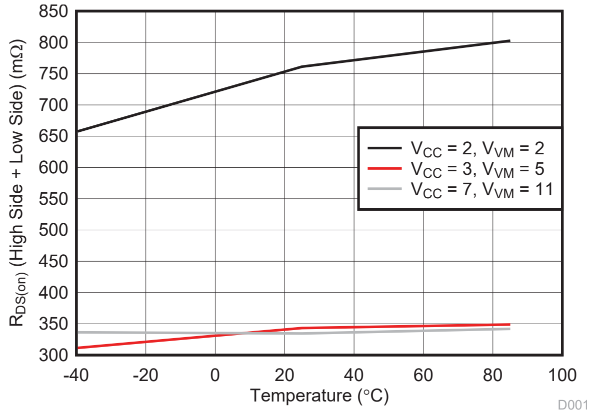


Figure 4. $R_{DS(ON)}$ (High-Side + Low-Side)

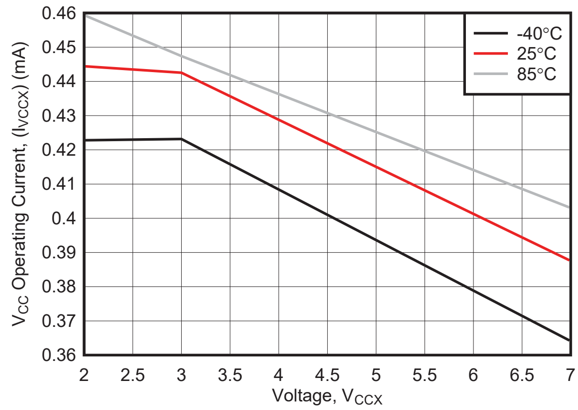


Figure 5. V_{CC} Operating Current

7 Detailed Description

7.1 Overview

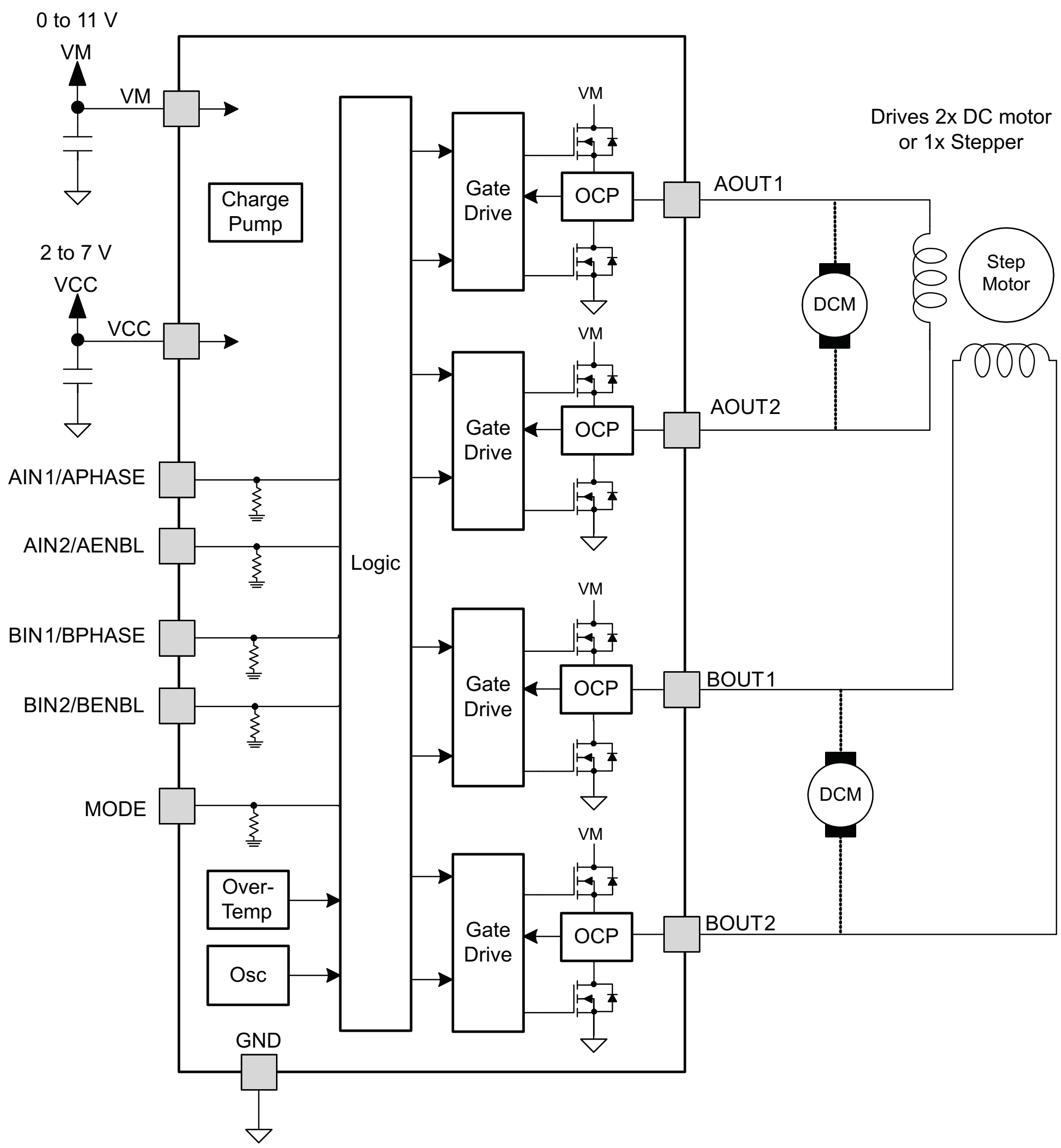
The DRV8835 is an integrated motor-driver solution used for brushed motor control. The device integrates two H-bridges, and drives two DC motor or one stepper motor. The output driver block for each H-bridge consists of N-channel power MOSFETs. An internal charge pump generates the gate drive voltages. Protection features include overcurrent protection, short circuit protection, undervoltage lockout, and overtemperature protection.

The bridges connect in parallel for additional current capability.

The DRV8835 allows separation of the motor voltage and logic voltage if desired. If VM and VCC are less than 7 V, the two voltages can be connected.

The mode pin allow selection of either a PHASE/ENABLE or IN/IN interface.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 Protection Circuits

The DRV8835 is fully protected against undervoltage, overcurrent, and overtemperature events.

7.3.1.1 Overcurrent Protection (OCP)

An analog current limit circuit on each FET limits the current through the FET by removing the gate drive. If this analog current limit persists for longer than the OCP time, all FETs in the H-bridge disable. After approximately 1 ms, the bridge re-enable automatically.

Overcurrent conditions on both high-side and low-side devices; a short to ground, supply, or across the motor winding result in an overcurrent shutdown.

7.3.1.2 Thermal Shutdown (TSD)

If the die temperature exceeds safe limits, all FETs in the H-bridge disable. Operation automatically resumes once the die temperature falls to a safe level.

7.3.1.3 Undervoltage Lockout (UVLO)

If at any time the voltage on the VCC pins falls below the undervoltage lockout threshold voltage, all circuitry in the device disable, and internal logic resets. Operation resumes when VCC rises above the UVLO threshold.

Table 1. Device Protection

FAULT	CONDITION	ERROR REPORT	H-BRIDGE	INTERNAL CIRCUITS	RECOVERY
VCC undervoltage (UVLO)	VCC < VUVLO	None	Disabled	Disabled	VCC > VUVLO
Overcurrent (OCP)	IOUT > IOCP	None	Disabled	Operating	tOCR
Thermal Shutdown (TSD)	TJ > TTSD	None	Disabled	Operating	TJ < TTSD – THYS

7.4 Device Functional Modes

The DRV8835 is active when the VCC is set to a logic high. When in sleep mode, the H-bridge FETs are disabled (HIGH-Z).

Table 2. Device Operating Modes

OPERATING MODE	CONDITION	H-BRIDGE	INTERNAL CIRCUITS
Operating	nSLEEP high	Operating	Operating
Sleep mode	nSLEEP low	Disabled	Disabled
Fault encountered	Any fault condition met	Disabled	See Table 1

7.4.1 Bridge Control

Two control modes are available in the DRV8835: IN/IN mode, and PHASE/ENABLE mode. IN/IN mode is selected if the MODE pin is driven low or left unconnected; PHASE/ENABLE mode is selected if the MODE pin is driven to logic high. Table 3 and Table 4 show the logic for these modes.

Table 3. IN/IN Mode

MODE	xIN1	xIN2	xOUT1	xOUT2	FUNCTION (DC MOTOR)
0	0	0	Z	Z	Coast
0	0	1	L	H	Reverse
0	1	0	H	L	Forward
0	1	1	L	L	Brake

Table 4. Phase/Enable Mode

MODE	xENABLE	xPHASE	xOUT1	xOUT2	FUNCTION (DC MOTOR)
1	0	X	L	L	Brake
1	1	1	L	H	Reverse
1	1	0	H	L	Forward

7.4.2 Sleep Mode

If the VCC pin reaches 0 V, the DRV8835 enters a low-power sleep mode. In this state all unnecessary internal circuitry powers down. For minimum supply current, all inputs should be low (0 V) during sleep mode.

ULTRASOUNDS SENSOR HC-SR04

Ultrasonic Ranging Module HC - SR04

Product features:

Ultrasonic ranging module HC - SR04 provides 2cm - 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The modules includes ultrasonic transmitters, receiver and control circuit. The basic principle of work:

(1) Using IO trigger for at least 10us high level signal,

(2) The Module automatically sends eight 40 kHz and detect whether there is a pulse signal back.

(3) IF the signal back, through high level , time of high output IO duration is the time from sending ultrasonic to returning.

Test distance = (high level time×velocity of sound (340M/S) / 2,

Wire connecting direct as following:

- 5V Supply
- Trigger Pulse Input
- Echo Pulse Output
- 0V Ground

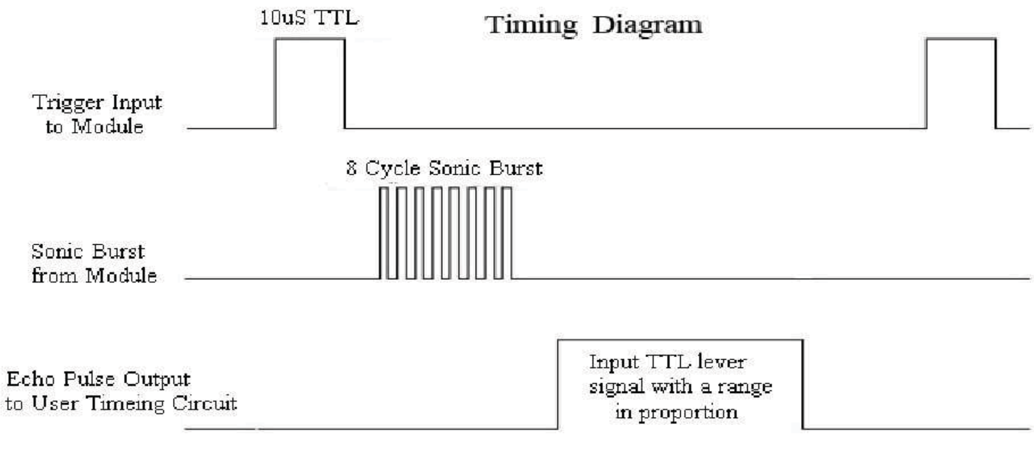
Electric Parameter

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

Vcc Trig Echo GND

Timing diagram

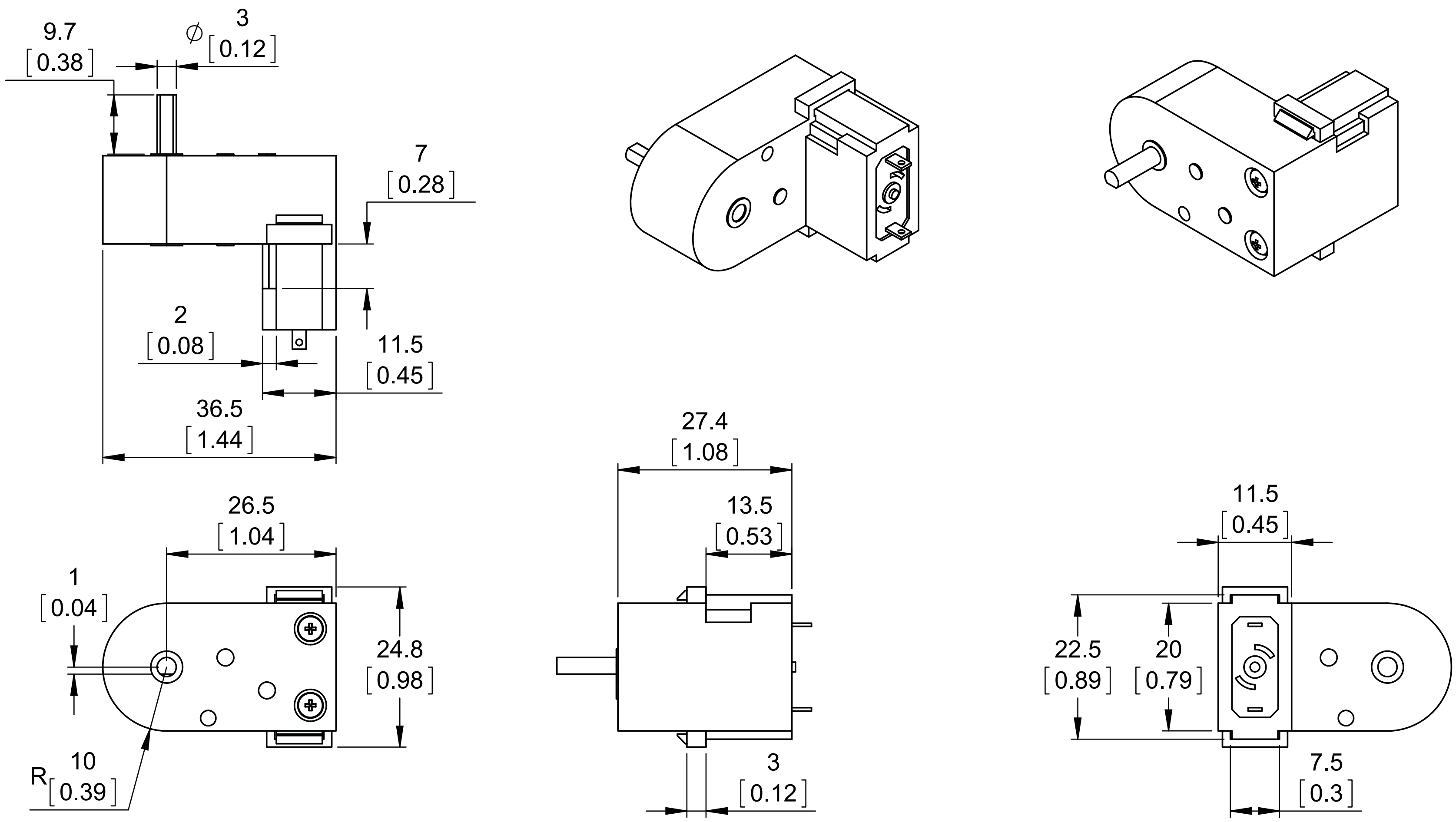
The Timing diagram is shown below. You only need to supply a short 10uS pulse to the trigger input to start the ranging, and then the module will send out an 8 cycle burst of ultrasound at 40 kHz and raise its echo. The Echo is a distance object that is pulse width and the range in proportion .You can calculate the range through the time interval between sending trigger signal and receiving echo signal. Formula: uS / 58 = centimeters or uS / 148 =inch; or: the range = high level time * velocity (340M/S) / 2; we suggest to use over 60ms measurement cycle, in order to prevent trigger signal to the echo signal.



Attention:

- The module is not suggested to connect directly to electric, if connected electric, the GND terminal should be connected the module first, otherwise, it will affect the normal work of the module.
- When tested objects, the range of area is not less than 0.5 square meters and the plane requests as smooth as possible, otherwise ,it will affect the results of measuring.

LDR and MOTOR



http://www.pololu.com/product/1512

Name: Mini Plastic Gearmotor, Offset 3mm D-Shaft Output		Item number: 1125, 1512, 1594
Drawing date: 15 Oct 2014		Pololu Robotics & Electronics
Units: mm [in]	Material: Mixed	

1. To get the specified scale, select 100% in print settings.

Scale: 1:1

Email: info@sunrom.com or sunrom@gmail.com

Visit us at http://www.sunrom.com

Document: Datasheet   Date: 28-Jul-08   Model #: 3190   Product's Page: www.sunrom.com/p-510.html

Light Dependent Resistor - LDR

Two cadmium sulphide(cds) photoconductive cells with spectral responses similar to that of the human eye. The cell resistance falls with increasing light intensity. Applications include smoke detection, automatic lighting control, batch counting and burglar alarm systems.

Applications

Photoconductive cells are used in many different types of circuits and applications.

Analog Applications

- Camera Exposure Control
- Auto Slide Focus - dual cell
- Photocopy Machines - density of toner
- Colorimetric Test Equipment
- Densitometer
- Electronic Scales - dual cell
- Automatic Gain Control – modulated light source
- Automated Rear View Mirror

Digital Applications

- Automatic Headlight Dimmer
- Night Light Control
- Oil Burner Flame Out
- Street Light Control
- Absence / Presence (beam breaker)
- Position Sensor

Electrical Characteristics

Parameter	Conditions	Min	Typ	Max	Unit
Cell resistance	1000 LUX 10 LUX	- -	400 9	- -	Ohm K Ohm
Dark Resistance	-	-	1	-	M Ohm
Dark Capacitance	-	-	3.5	-	pF
Rise Time	1000 LUX 10 LUX	- -	2.8 18	- -	ms ms
Fall Time	1000 LUX 10 LUX	- -	48 120	- -	ms ms
Voltage AC/DC Peak		-	-	320	V max
Current		-	-	75	mA max
Power Dissipation				100	mW max
Operating Temperature		-60	-	+75	Deg. C

Guide to source illuminations

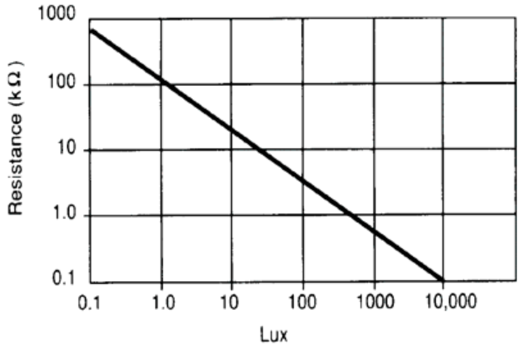
Light source Illumination	LUX
Moonlight	0.1
60W Bulb at 1m	50
1W MES Bulb at 0.1m	100
Fluorescent Lighting	500
Bright Sunlight	30,000

FIGURE 1 CIRCUIT SYMBOL

Sensitivity

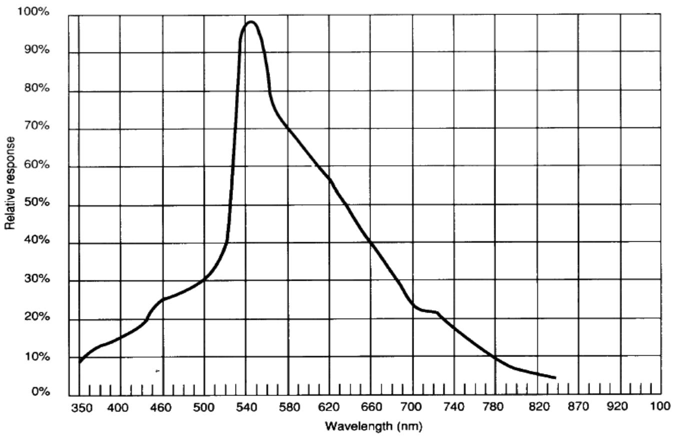
The sensitivity of a photodetector is the relationship between the light falling on the device and the resulting output signal. In the case of a photocell, one is dealing with the relationship between the incident light and the corresponding resistance of the cell.

FIGURE 2 RESISTANCE AS FUNCTION OF ILLUMINATION



Spectral Response

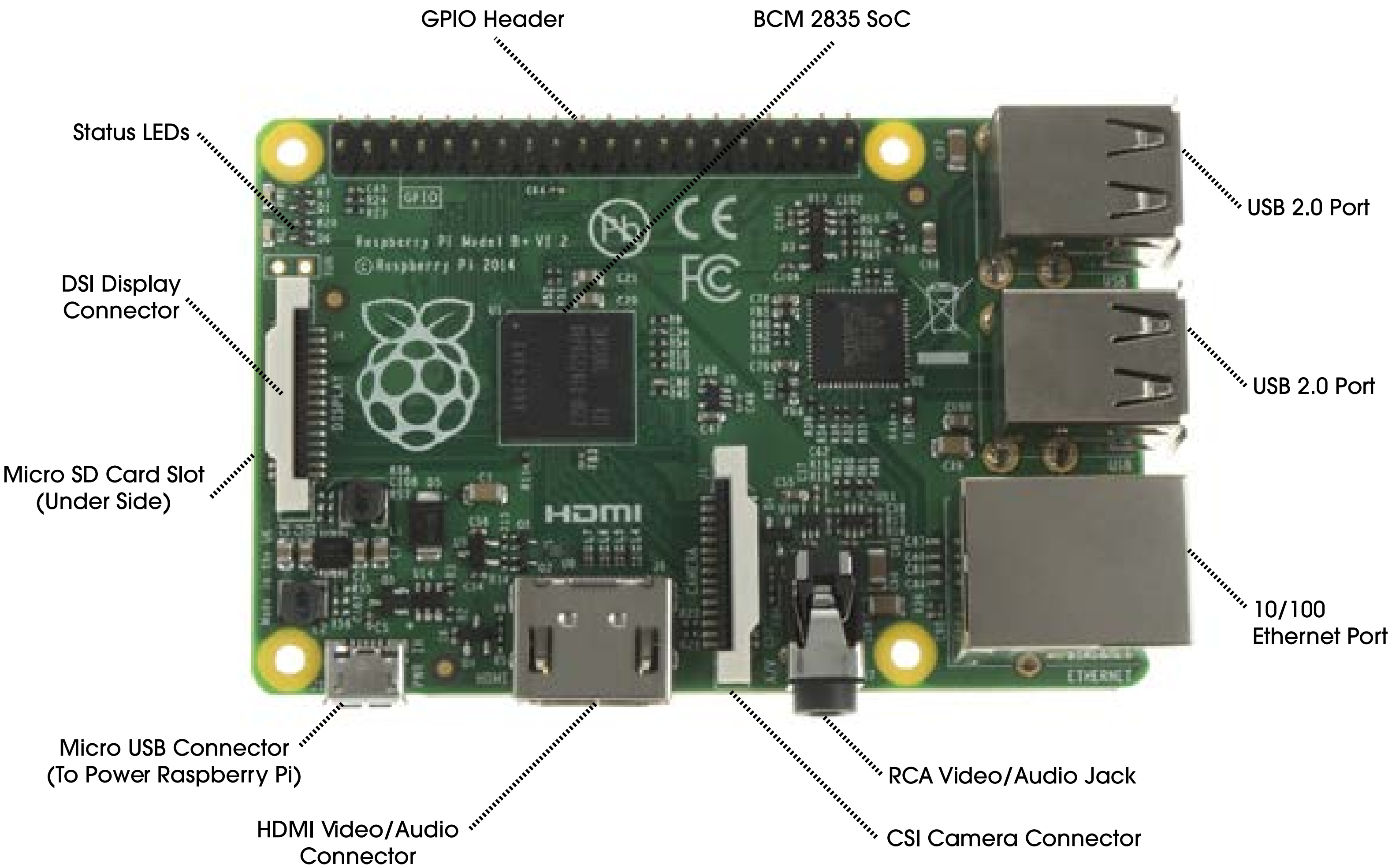
Figure 3 Spectral response



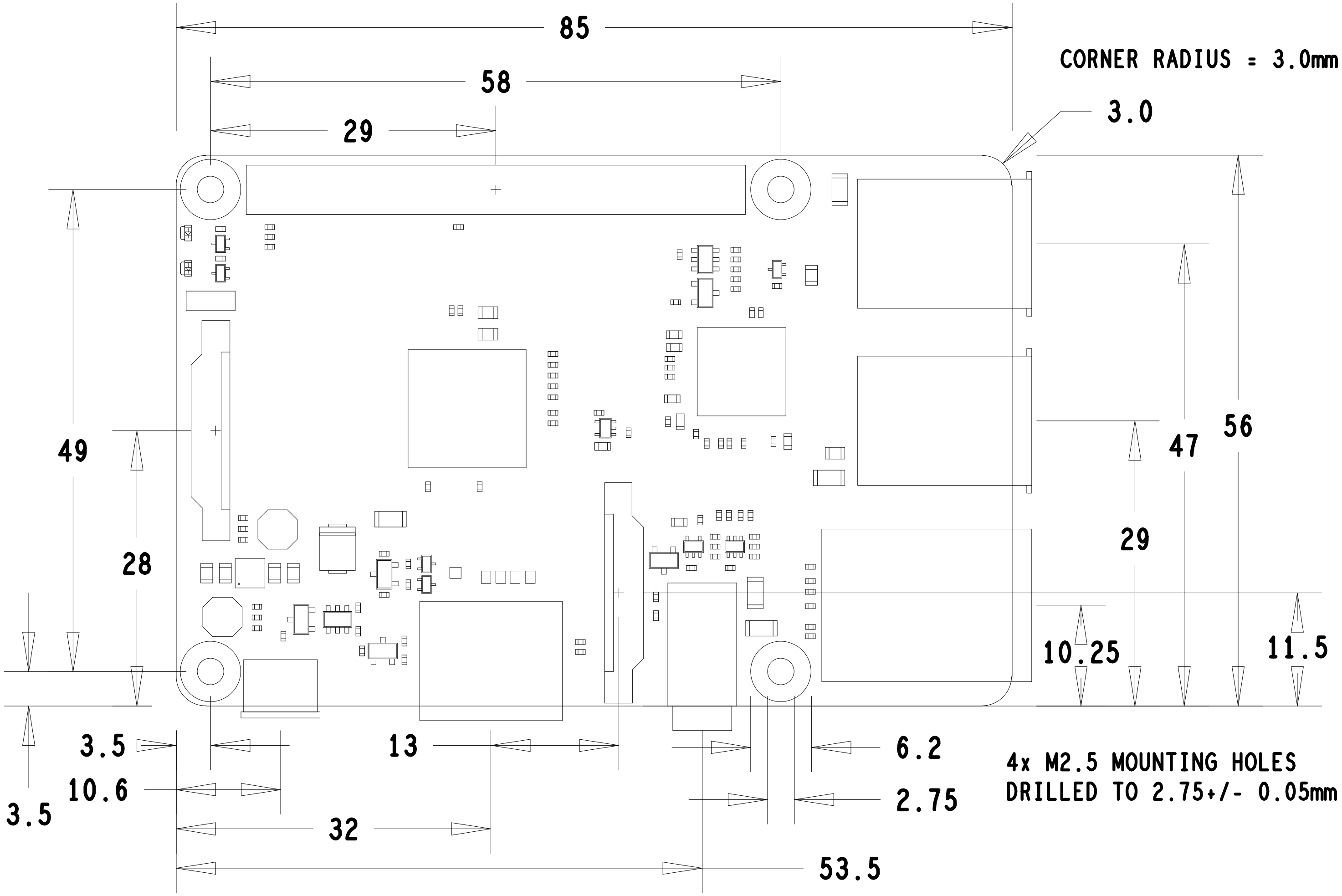
Like the human eye, the relative sensitivity of a photoconductive cell is dependent on the wavelength (color) of the incident light. Each photoconductor material type has its own unique spectral response curve or plot of the relative response of the photocell versus wavelength of light.

RASPBERRY PI

Raspberry Pi Model B+



TOP ASSEMBLY



Raspberry Pi

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TITLE	RASPBERRY PI MODEL B+		
DATE	07/03/2014	REF	RPI-BPLUS-V1_2
DRAWN	James Adams	APVD	James Adams

Raspberry Pi

MODEL B+

Product Name	**Raspberry Pi Model B+**
Product Description	The Raspberry Pi Model B+ incorporates a number of enhancements and new features. Improved power consumption, increased connectivity and greater IO are among the improvements to this powerful, small and lightweight ARM based computer.

Specifications

Chip	Broadcom BCM2835 SoC
Core architecture	ARM11
CPU	700 MHz Low Power ARM1176JZFS Applications Processor
GPU	Dual Core VideoCore IV® Multimedia Co-Processor
	Provides Open GL ES 2.0, hardware-accelerated OpenVG, and 1080p30 H.264 high-profile decode
	Capable of 1Gpixel/s, 1.5Gtexel/s or 24GFLOPs with texture filtering and DMA infrastructure
Memory	512MB SDRAM
Operating System	Boots from Micro SD card, running a version of the Linux operating system
Dimensions	85 x 56 x 17mm
Power	Micro USB socket 5V, 2A

Connectors:

Ethernet	10/100 BaseT Ethernet socket
Video Output	HDMI (rev 1.3 & 1.4)
	Composite RCA (PAL and NTSC)
Audio Output	3.5mm jack, HDMI
USB	4 x USB 2.0 Connector
GPIO Connector	40-pin 2.54 mm (100 mil) expansion header: 2x20 strip
	Providing 27 GPIO pins as well as +3.3 V, +5 V and GND supply lines
Camera Connector	15-pin MIPI Camera Serial Interface (CSI-2)
JTAG	Not populated
Display Connector	Display Serial Interface (DSI) 15 way flat flex cable connector with two data lanes and a clock lane
Memory Card Slot	SDIO