EXPERIMENTAL METHODS IN ENERGY AND ENVIRONMENT

TÉCNICO LISBOA

TECHNICAL REPORT

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MEMec

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Beep aWay

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Abstract

This project consists on the development of an original product under the Experimental Methods in Energy and Environment course at Instituto Superior Técnico. We focused on creating a product that could be helpful for the visually impaired, a group we feel are often overlooked as a target market. Our main concern was improving the mobility of blind people who use guide-sticks, specifically their lack of confidence when walking on public places due to constant collisions which lead to injuries and pain.

We found that the available products on the market that tackle these problems try to help blind people avoid obstacles but do this very inefficiently. Our approach was then envisioning a device that could accurately detect static objects scattered along the streets.

After much research and discussion we concluded that this could be achieved through a radio frequency communication between a transmitter placed on the objects to avoid, and a receiver in the users' possession that alerts them once they get close enough of the danger.

A functional prototype was built using simple electronic components and tested on the field with a blind person. The performed tests proved that our device fulfilled its purpose accurately and according to his experience, a product like ours could really help blind people on their day to day lives.

We concluded that for this product to be truly efficient, the transmitters would have to be placed on as many dangers as possible. Although these could be made for less than 8€, the best way to ensure a suitable distribution would be through public investments for accessibilities. The salability of the receiver is then justified by its usefulness and affordability compared to current alternatives.

Our goals for this project were achieved and we believe we managed to create something with the potential to help a lot of people in the future.

Keywords: accessibility, blind, guide-stick, investment, product, prototype, mobility, salability, target market, visually impaired.

Acknowledgment

We would like to thank some people without whom this project wouldn’t be possible. First of all we would like to thank Professor Manuel Heitor and his assistant teachers, Nate Gilbraith, Guilherme Farinha and Paulo Quental, who helped us stay focused on the final objective of this project while following it close by and always showing themselves available to help whenever needed. We are also grateful to Miguel Rodrigues for helping us head in the right direction with the prototype and to Eng. Marcelino Santos for sharing his technical expertise with us. We would also like to thank Eng. José Eduardo Fialho for being very kind in receiving us and providing us with some very useful ideas, one of which sparked the idea for this project. Lastly, we want to thank ACAPO and namely Mr. Paulo Santos for the huge support he gave us through the whole project and for patiently explaining us the whole process and problems with the mobility of blind people. In the end, and to help us prove the concept of our prototype, he put us in touch with Mr. Artur, a blind person with whom we performed the tests and to whom we are also very grateful. Both of them were present in our final presentation and Mr. Artur offered to make a small review about his experience with our prototype and the benefits our product would bring to the end users like him.

Introduction

Under the course of Experimental Methods in Energy and Environment at Instituto Superior Técnico we were required to make a project with a strong social component that also poses an engineering challenge in order to create a new and original product with applications in the world we live in. For this matter we decided to address an issue that often goes unnoticed by most: the mobility of blind people. Since blindness is a global problem, we focused on the Portuguese reality in order to study and conceive a device that could actually help these people move around from place to place on their daily lives.

While researching for products available in the market, which was crucial to understand if there was a gap somewhere, we found one technology available, a guide-stick with an ultra-sound sensor [1]. This device, using ultra-sounds, detects obstacles within a certain distance and alerts the person through a vibration in the guide stick. The problem about this is that it senses everything that stands in the person's way, even if it's nothing dangerous. For example, imagine using this guide-stick in a very crowded place; the device will alert the person of a constant danger when it's just people moving away. There is no distinction of what is dangerous or not, there's only information that something is in their way. So in a substantial number of situations this product fails by giving too much and wrong information to the user. So we saw here a gap in the market and consequently an opportunity for our product.

We decided to do a device that detects specific dangers. This meant two things: first we had to understand what dangers are there for blind people when they are moving; and that the identification of this danger implies some kind of specific communication between the object and the person. To better understand the dangers blind people face every day we met with Mr. Paulo Santos, president of delegation of ACAPO in Lisbon. This association helps blind people in their daily problems and fights strongly for accessibilities for these people. In our meeting it became clear that a big problem they face every day are collisions on the street which lead to bruises or even concussions. So our device aims to help them not only move more safely but also with more confidence that they're not going to get hurt.

First Approach

With this problem in mind, further research on blind people mobility was necessary to understand how the dislocation process works for them and how independent it could be. There are three types of blindness [2]: congenital blindness, causing its damages before the first birthday, and premature blindness, appearing after the first year of age and before the third. People affected by these either never saw or don't remember it and are used to a life of blindness. These people usually try to work out their problems as independently as they can without asking for help. Then there's acquired blindness which appears after the third year of age and is the most problematic. People with this kind of blindness try to make analogies between what they sense and what they used to see, and so they have more issues with not being able to see anymore. These people are usually afraid of walking on the streets alone and are more dependent on other people. This can lead to frustration, depression, isolation and on extreme cases, agoraphobia [3]. This is where ACAPO takes an important role as they help each person get accustomed with their usual routes (home-work for example) and give them the confidence to do it by themselves. They do that by using a checkpoint method to let them know they are in the right road moving in the right direction. These checkpoints can be places easily identifiable by sound, such as a mechanics workshop; by smell, like a bakery; or simply a pole sign standing in a corner they can easily detect with the guide-stick.

Blind people are very often set aside in what the use of new technologies is concerned, as most of these are not functional for them to use. Having that in mind, the interface of our device has to be as simple as a switch button so its use doesn't turn into an obstacle too. In the meeting with Mr. Paulo Santos he also told us that the most dangerous obstacles are the ones that stand above the waistline which the guide-stick passes through. Urban furniture elements like the new telephone booths, flag shaped advertisement placards or even trash bins randomly placed in the streets are good example of it, as shown in Figure 1.

Figure 1 - Dangers of urban furniture

We also had to keep in mind that blind people using the guide-stick have always one hand occupied, if our device is to be carried in hand, the person won't have any available hands for anything else that could be needed, for example carrying a hand bag. An efficient and simple form of communication is also required to alert the person of the danger within a certain security distance so that the user can continue his path with more caution or even with his hand up to detect the obstacles and protect his head. Facing these kind of problems we thought we were up to the task of developing a product that made these people more self-reliant and more confident to do their usual routes or even try new ones using the obstacles as checkpoints.

After having an idea of what to do, we needed to find out how to do it. The first step was to find out which technologies were more likely to fit the purpose of our product. As we wanted our product to detect static objects from a certain distance between them, we started our technology research on beacons.

A beacon is an available product in the market that works as a flyer for your smartphone. When a smartphone with its Bluetooth on passes near a beacon, it sends a message that pops up in the telephone, their most common use nowadays are advertisement and promotions [4]. For us to have access to the beacons and to know how far they are from us, we have to install an app on our phones. Similarly to the Beacon there's also the V-tag, presented on Figure 2. This one is used to track some object attached to the V-tag, for example, your keys. Then, once again, using an app you can find where you left them easily [5].

Figure 2 - V-Tag Technology

After some testing with the V-tag we found this technology to be far too complex, as it requires deep programing knowledge on apps for Bluetooth devices and with the limited time we had it would be impossible for us to come up with a prototype on time. We then decided to turn to another technology: Radio Frequency (RF).

Radio waves were first used to transmit information at the end of the 19th century and are still used today as a way of communication [6]. As it is an old technology there are large quantities of information available about it and the components for it can be found on every store for really accessible prices. For this reason it would be much easier for us to build a prototype using RF rather than Bluetooth. Although the Bluetooth communication could offer a higher quality, the RF communication is a very reliable form of doing it for a fraction of the cost.

The following research was focused in finding the electronic parts needed to build a transmitter and a receiver. The transmitter should be able to constantly send a code so the receiver can identify it. Since RF signals can travel long distances the receiver has to be able to read the intensity of the signal between receiver and transmitter so it doesn't start alerting the users from hundreds of feet away.

Afterwards we moved on to the conception of the prototype and we focused our work in making it as small as possible. The last phase of this project was the testing of the prototype by a blind person. This would be the "trial by fire" of the whole project because if in the end this product doesn't solve the problem and blind people don't approve its applicability, then the whole project would be a failure.

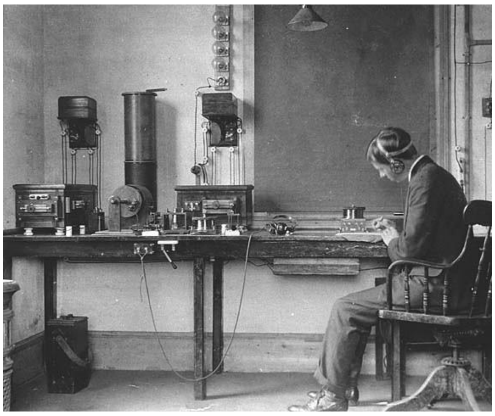


Figure 3 – First Radio

Prototype

A long research on basic electronics was done, in order to realize what types of components were actually needed to build the final prototype. So, as we decided to use the radio frequency to do the communication, we started our research by analysing the transmitters and receivers available in the market. We then chose to use a transmitter and a receiver of 433MHz, a licence-free frequency on most of the world, used by many amateur devices [7].

Radio waves have a sinusoidal shape, and propagate radially from a specific point of the transmitter, called antenna. These waves are analogic signals and propagate through the air. This means that in order to be able to send information, the transmitter has to be capable of convert a digital signal into an analogic one. Some problems of miscommunication can occur with RF as the sinusoidal waves propel themselves in any direction and reflect on any surface. In case there's something with a considerable size standing between the receiver and the transmitter the communication can be interrupted. And yet this is a very reliable technology and these interferences were not significant enough to justify a change in the technology.

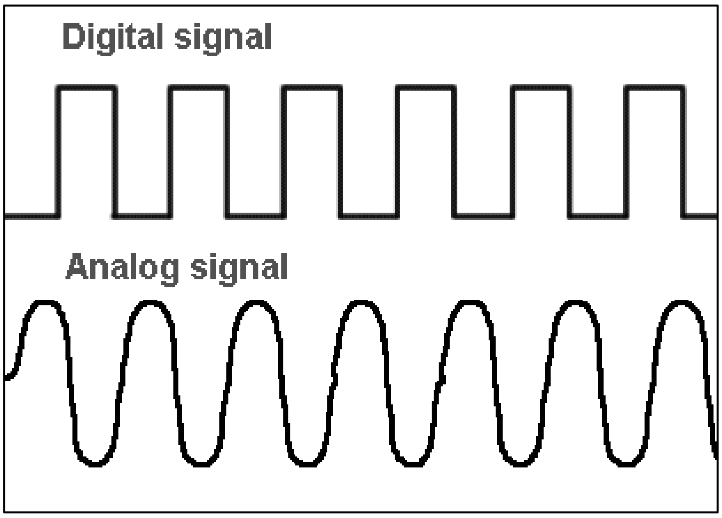


Figure 4 - Two types of Signals

To produce a digital signal it's necessary to use an encoder where a 4 bit code is converted into a digital signal. It is then received by the transmitter that, in turn, converts it into an analogic one that is now transmittable. The inverse process is then done by the receiver: collecting the analogic signal, converting it to digital to be once again converted, this time by a decoder, into the initial code sent by the transmitter as pictured on Figure 5.

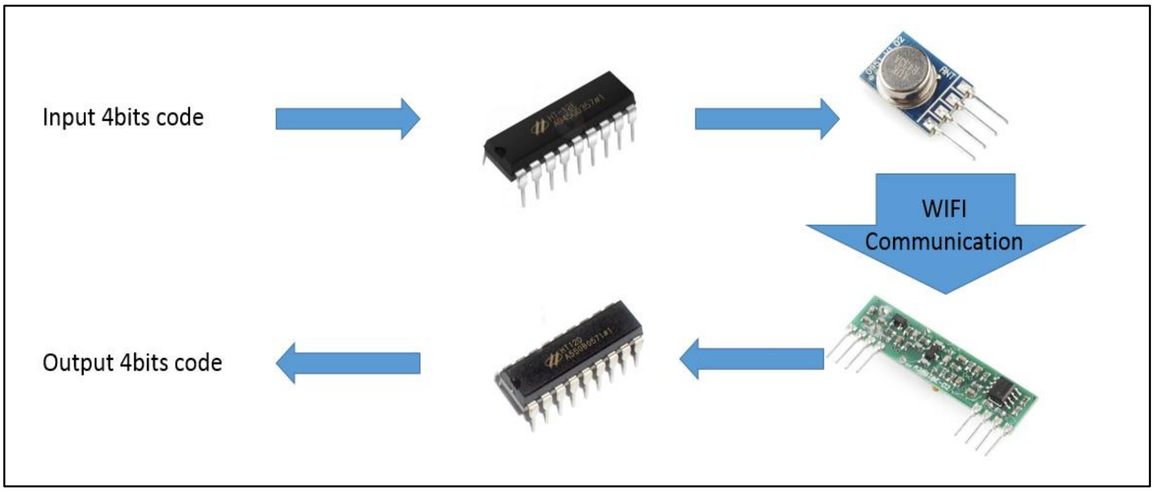


Figure 5 - Radio Communication

The next step is verifying if the code sent is the one from a dangerous obstacle. If yes a buzzer is activated alerting the user of the danger; if not, nothing happens. For the code verification a HEF4011 chip was used. This works as 4 NAND'S integrated in such a way they create a kind of switch for the actuator. With the same integrated circuits we are able to measure the strength of the signal received and create yet another switch. This way, when both switches are on, electric current is able to go through and activate the buzzer.

After applying all this concepts into the prototype it was now time to shrink the receiver and the transmitter so they can be portable, with special focus on the receiver. As our project was focused on the proof of concept and not so much in achieving a final product, the look of the prototype may seem a little bit rudimental, but it works just fine.

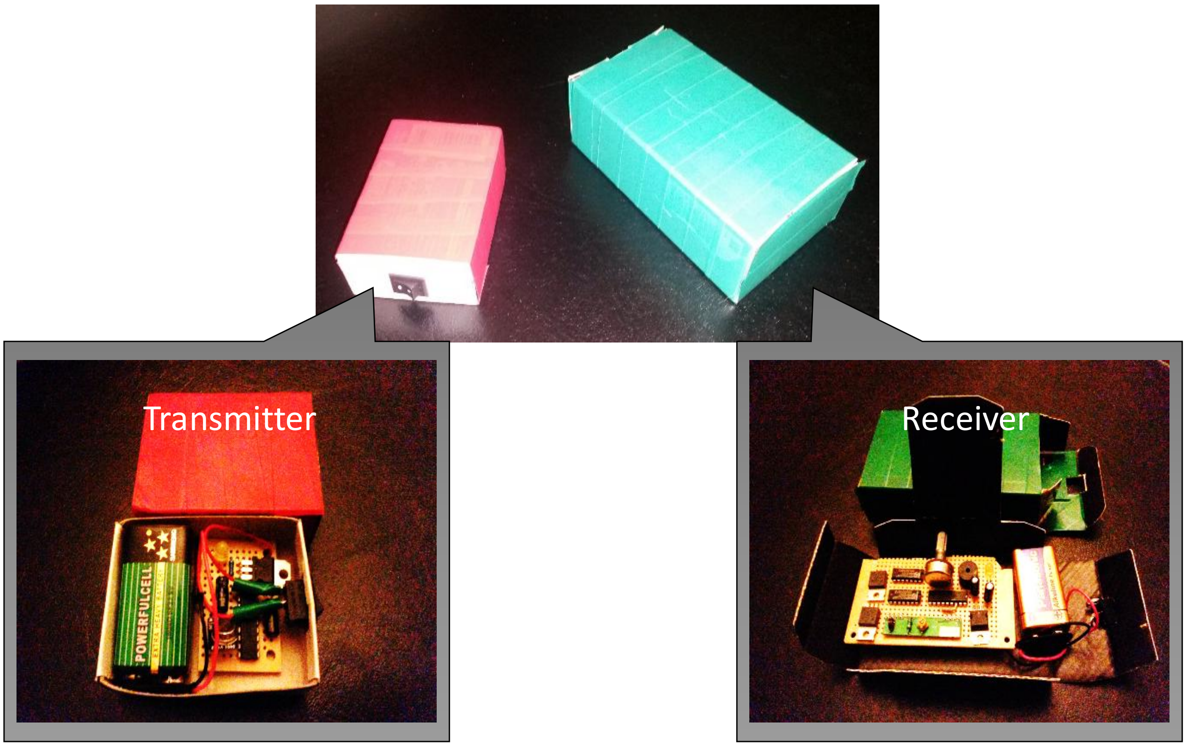


Figure 6 - Final Prototype

Prototype Tests and Feedback

After the prototype was finished, all that was left to do was getting a blind person to test it on the field. For this matter, Mr. Paulo Santos got us in contact with a friend of his, Mr. Artur, who was rather curious about the idea.

The tests were performed on a street at Mouraria. The transmitter was placed on top of a obstacle while tester held the receiver on one hand and his guide-stick on the other. Even though the final version of beep Away will let the user keep one of his hands free, this setup is a good simulation of what the final product tries to achieve.

With both devices turned on and in place, the user made his way along the street, and once he approached the obstacle, the receptor in his hand started beeping. Even though he didn't know the location of the danger, once he heard the beeps he started walking more carefully. By listening to the changes in the beep, he could sense its general direction while using his hands and stick to get a clear idea of where exactly the obstacle was and he was able to walk around it safely. Various similar tests were conducted afterwards on different obstacles with similar results.

Some indoor tests were also performed during which we noticed an increase in range of detection. This was due to radio waves being reflected on the walls and ceiling resulting in a range of about 7 meters. This however is not a big problem since it is fairly easy to reduce the power of the transmitter.

The feedback we received from the tester was overwhelmingly positive. He especially liked the fact that it started beeping at around 4 meters from the target and achieved maximum intensity at around 1 meter. He felt these distances were enough for him to beware on time. According to him, a product like this would have helped him a lot in avoiding countless injuries or even trips to the hospital. As an example he pointed out a bruise on his forehead he had sustained just the day before these tests. As such, he'd be thrilled to see this product on the market, no matter the price.

Figure 7 – Testing the prototype

Business Plan

After having successfully proven the concept of our product, we had to understand that there is a big setback that needs to be worked out is the great amount of transmitters that will need to be placed to identify the dangers. Without this our product fails its purpose. We estimate that this would be a very expensive process and to simply support it on the sales of the receiver (bracelet or guide-stick) would be a mistake, as the price to the final consumer would increase immensely and would end up being inaccessible to most people. As this is a product done to help blind people mobility, and with its benefits already proven in tests done, in partnership with ACAPO, we should be able to present this as an accessibility product and apply for social funds.

With this in mind, our first move has to be presenting the product to the city hall in collaboration with ACAPO and try to collect social funds to pay for the identification of dangers and the installation of the transmitters. Comparing with what was done to place the beeps in the crosswalks, our advantage in this case is that this product has sales to back-up the costs and that the price of the transmitters will be lower. Another import step is to cut-off a deal with a manufacturer company to develop the prototype into a final product and afterwards produce both the transmitter and receiver in a large scale basis. This way we would be able to push the final product prices down and make this a product available for everyone.

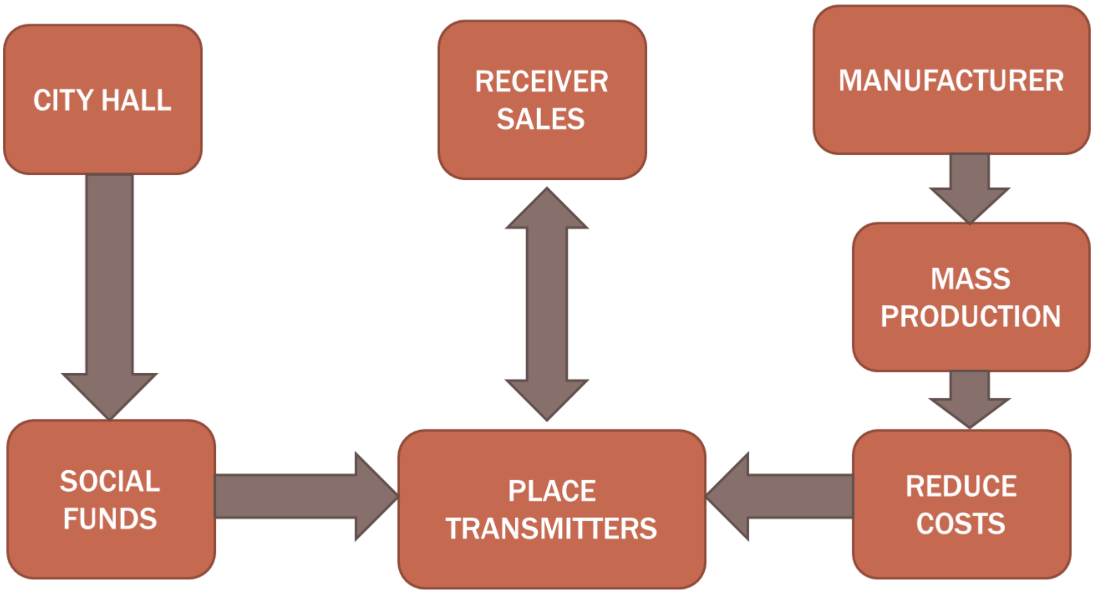


Figure 8 - Diagram for the Business Plan

As far as sales of the receiver are concerned, we have to know our target market, which are blind people in Portugal. Currently there are one hundred and sixty thousand people suffering from a visual disability, twenty thousand of which are totally blind and the rest are partially blind or amblyopic [2]. Some of these people can afford a guide-dog and don't need any other technology because the dog is autonomous enough to avoid most dangers on the street. The guide-dog is the most expensive solution and the only existing school in Portugal responsible for training guide-dogs had up to 2009 trained only 83 [8]. The people who can't afford a guide-dog are usually dependent on just the guide-stick and these are the people that make up our target market.

The transmitter is our greatest concern because it needs to be produced in large quantities to account for all the dangers. To prototype one transmitter we invested about 13.17€, the components used are presented in Table 1.

Fixed Device (Transmitter)			
Component	Qt.	€/un.	€
Transmitter 434MHz	1	4,18	4,18
Encoder HT12E	1	5,1	5,1
Capacitor de 1µF	2	0,35	0,7
Resistance 220Ω	1	0,03	0,03
Resistance 1,1MΩ	1	0,07	0,07
Mosfet	1	0,33	0,33
Switch on/off	1	0,7	0,7
Led	1	0,06	0,06
Battery 9V	1	2	2
		TOTAL:	13,17

Table 1 – Cost for the Transmitter

Because it is a prototype, this price is very rough. If it were mass produced, we estimate the cost would lower by at least 40%, to about 8€ per transmitter.

The final price for the receiver is harder to estimate because it would be produced in lower quantities. Our receiver cost about 18.61€, more 5€ than the transmitter. A list of all the components is presented in the following table.

Mobile Device (Receiver)			
Component	Qt.	€/un.	€
Receiver 434MHz	1	5,04	5,04
Decoder HT12D	1	5,1	5,1
Capacitor de 1µF	2	0,35	0,7
Potentiometer 1KΩ	1	1,25	1,25
Switch on/off	1	0,7	0,7
Blank PCB	1	1,55	1,55
Battery 9V	1	2	2
Nan Logic HEF4011C	2	0,08	0,16
Led	1	0,06	0,06
Mosfet	3	0,33	0,99
Resistance 51KΩ	1	0,03	0,03
Buzzer 5V	1	1	1
Resistance 220Ω	1	0,03	0,03
		TOTAL:	18,61

Table 2 - Cost for the Receiver

Another important point to consider is the amount of money the end users are willing to pay for a product that helps them with their mobility. We can find out the answer by comparing the price of a normal guide-stick with an ultra-sound one. The normal guide stick costs around 40€ and the other has the average price of 100€. This means that people are akin to pay at least an extra 50€ for a technology that helps them. However, based on the value of the electric components used on the receiver, we strongly believe that the price would come well below this value.

We also developed a concept for the final product. We believe that it shouldn't occupy the only hand the user has available. We've come up with two final product solutions, the receiver would be part of the guide stick, or incorporated into a bracelet. The transmitter can be a small object to be installed on the obstacles with a strong body to protect from vandalism and can either have a battery or be plugged into the grid. The following table presents our model of the final product.

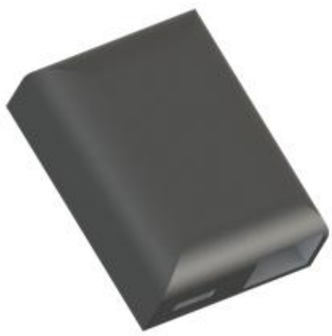
Product Parts		Concept Final Product
Receiver	Stick	
	Bracelet	
Transmitter		

Table 3 - Final product design

Conclusions and Future Work

In the beginning of this project we established originality, uniqueness, and simplicity as our own objectives. Creating a product that alerts blind people for dangers they face every day, making the way they move safer, was our way to do it. Since the vast majority of blind people are dependent on a guide-stick, these people made up our target market.

Radio frequency is a technology being used for more than a century and its applications are now fully developed, meaning the price of this technology is really accessible and served its purpose on our project.

To reach a final product the prototype still needs improvements. It has come to our attention in the end of the final presentation that the way we were doing the communication worked as a jammer and could affect other devices in the surroundings. This only stresses out the fact that there is still work to do on this product before it can reach its final stage. Despite these technical details, our goal of proving the concept and utility of this product was achieved. Both Mr. Paulo and Mr. Artur praised the prototype, hoping for it to reach the final product stage, as they understood its helpfulness to blind people.

With that said we can confirm that we’ve successfully achieved our group goals and in doing so we’ve created a device with the potential to change people’s lives.

More information about our project can be found on its own web page: http://beepaway.wix.com/beepaway.

References

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[3] http://www.destak.pt/artigo/8511

[4] http://en.wikipedia.org/wiki/IBeacon

[5] http://www.vtag.nl/

[6] http://en.wikipedia.org/wiki/Radio

[7] http://en.wikipedia.org/wiki/LPD433

[8] http://www.caesguia.org

Prototype:

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https://electrosome.com/wireless-transmitter-and-receiver-using-ask-rf-module/

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http://dlnmh9ip6v2uc.cloudfront.net/datasheets/Wireless/General/TWS-BS-3_433.92MHz_ASK_RF_Transmitter_Module_Data_Sheet.pdf

http://dlnmh9ip6v2uc.cloudfront.net/datasheets/Wireless/General/RWS-371-6_433.92MHz_ASK_RF_Receiver_Module_Data_Sheet.pdf

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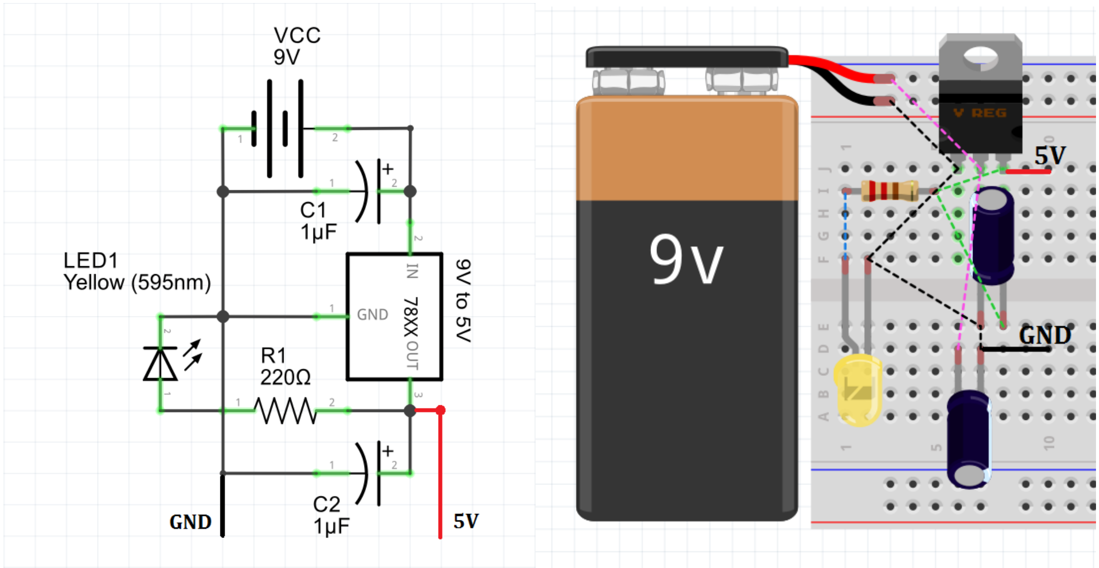
Appendix

Step by Step

This project's implementation must be divided into 4 elementary steps in order to provide coherency and ease of understanding for the final electronic scheme.

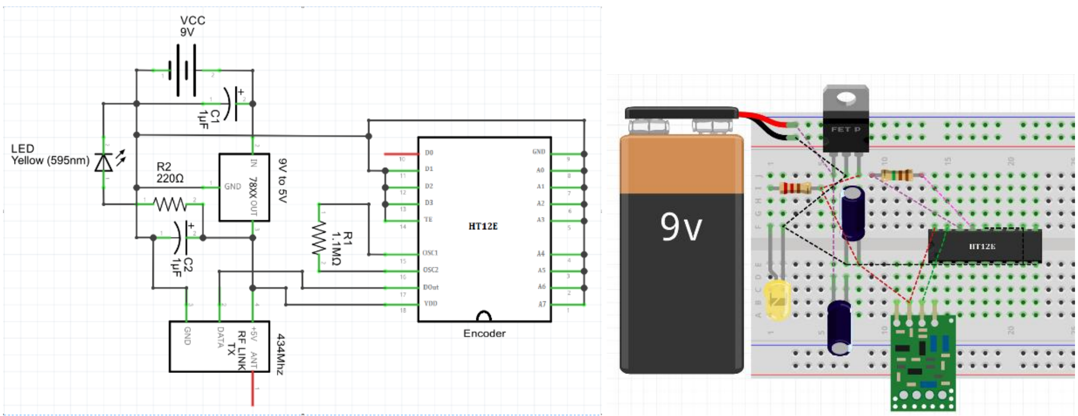
Step 1 – Power Regulator

The radio wave receiver requires a 5V constant feed and, due to the fact that we had a 9V volt battery to work with, a simple power regulator had to be constructed. The small circuit depicted in the following figure does this job.



Step 2 – Transmitter

Having done and tested our power feed, we begin by mounting the transmitter circuit as it is stated in its datasheet. This transmitter can operate with voltages between 3V and 12V but, for simplicity, we chose to feed it with the same 5V input that comes from our power regulator. The following figure represents the mounted circuit.



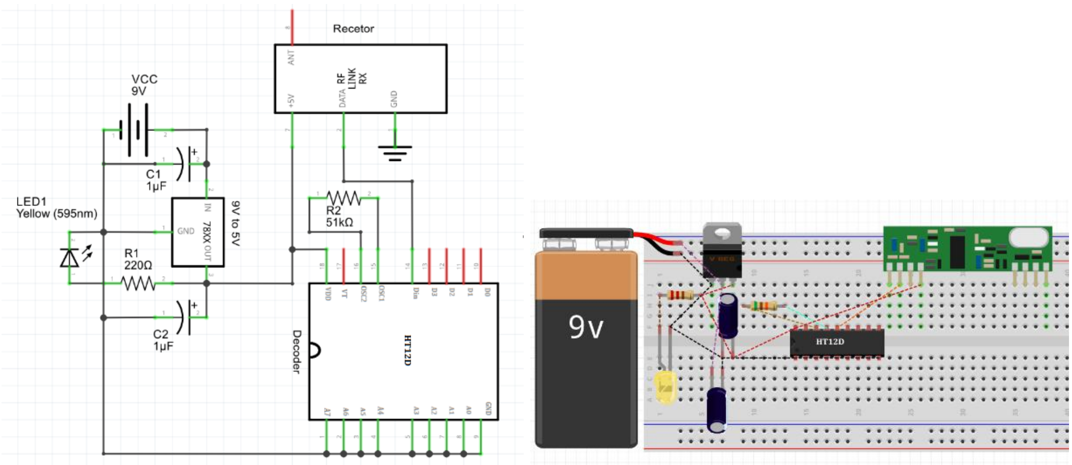
As it is possible to see in the above picture, it was necessary to use a HT12E enconder in order to manipulate the desired information to achieve correct communication between the transmitter and receiver. The enconder's function is explained in the following paragraph.

A HT12E Encoder IC will convert the 4 bit parallel data given to pins D0 – D3 to serial data and will be available at DOUT. This output serial data is given to ASK RF Transmitter. Address inputs A0 – A7 can be used to provide data security and can be connected to GND (Logic ZERO) or left open (Logic ONE). Status of these Address pins should match with status of address pins in the receiver for the transmission of the data. Data will be transmitted only when the Transmit Enable pin (TE) is LOW. A 1.1MΩ resistor will provide the necessary external resistance for the operation of the internal oscillator of HT12E.

This concludes the mounting of the transmitter circuit and, as it is possible to see, the occupied space of the circuit is minimal so it should be possible to put it in a small box.

Step 3 – Receiver

In this step we shall approach the mounting of the receiver circuit that will receive and interpret the code sent by the transmitter. The following figure depicts this circuit.

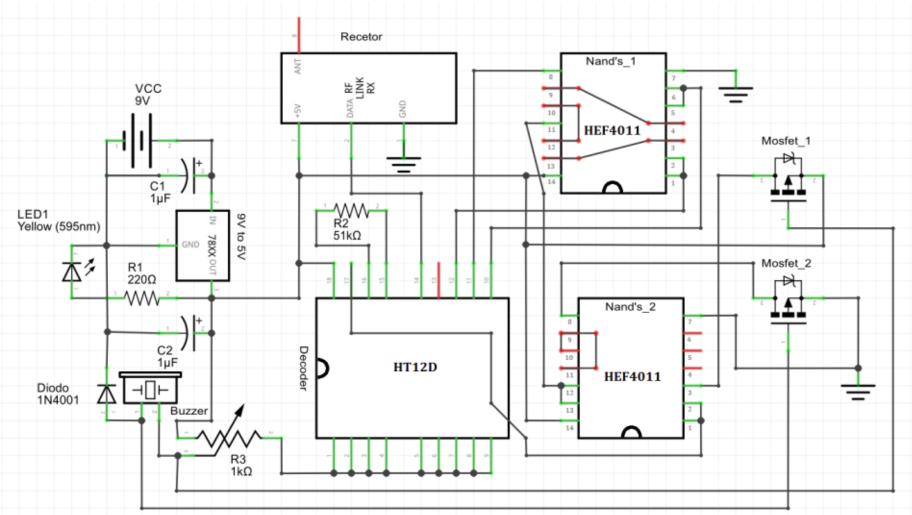


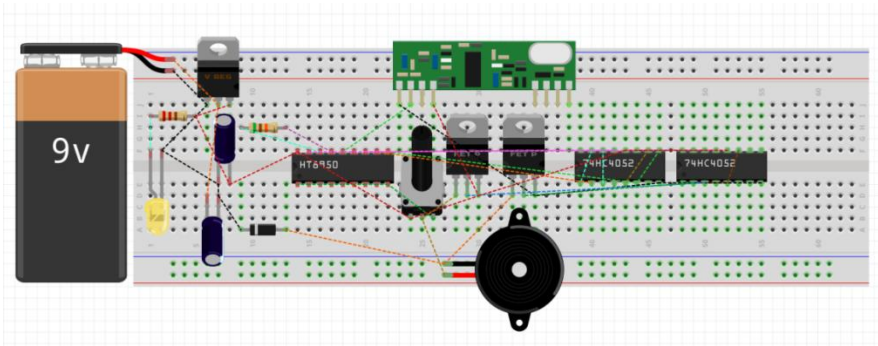
Taking into account the use of an encoder on the transmitter circuit, it is now mandatory to have an appropriate decoder in the receiver circuit. The chosen decoder is the HT12D.

A HT12D decoder will convert the received serial data to 4 bit parallel data D0 – D3. The status of these address pins A0-A7 should match the status of address pins in the HT12E in the transmitter. A 51KΩ resistor will provide the necessary resistance required for the internal oscillator of the HT12D.

Step 4 – Receiver with signal power

After being able to send a specific code to the receiver, the only thing missing is the code validation and signal strength manipulation at the receiving end. For this purpose some more complex electronic components had to be used such as a HEF4011 NAND Gate with 4 NAND's. Transistors were also required in order to boost the voltage or even to force a ground. Figure XX represents the mounted circuit as well as its final breadboard mount appearance.





Press Release

In Portugal there are over 160 000 visually impaired individuals, most of which find it very difficult to get around in public spaces. Over the past few years there has been a growing concern with the creation of accesses for these people, such as crosswalk lights with sound cues or marked stairs and elevators. Despite this efforts, still only 1 in 20 crosswalk lights have sound cues and the urban furniture (like phone booths, trash cans, ad billboards, benches, etc) is not designed with that in mind.

To solve this issue, a group of students from Instituto Superior Técnico came up with Beep aWay. This device resembles a watch, light and ergonomic, that beeps or vibrates increasingly while approaching obstacles on the street. These obstacles are equipped with a radio frequency emitter that communicates with the Beep aWay, alerting the user.

With positive feedback from the community, especially from the Association of the Blind and Partially Sighted of Portugal (ACAPO), Beep aWay revolutionizes the way blind people move around in their day to day life, giving them more mobility and autonomy in public spaces at affordable prices.

Social Networks Release

We live in an era full of wonderful technologies where unfortunately not all of us benefit from it. This is why *Beep aWay* was born – to use technology to make blind people's lives easier, project by project, leading to a new age where no one walks blindfolded. Learn more at [beepaway.wix.com/beepaway.](beepaway.wix.com/beepaway)