UNIVERSIDAD
COMPLUTENSE
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PROJECT MEMORY: ELECTRONIC DRUMKIT

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1 INTRODUCTION

This project is aimed at the construction of a playable electronic drumkit: something which allows the production of grooves. Similarly to commercial companies which sell electronic drumkits, our product's operation is going to take advantage of piezoelectric effects in order to be able to convert the hits on the different elements to signals which may then be amplified and used to simulate the sounds.

For simplicity, the kit design shall include only the pads one may find in a standard jazz kit: this is four drums and four cymbals, namely a bass drum, a snare drum, two toms, the hi-hat, a crash cymbal and a ride cymbal.

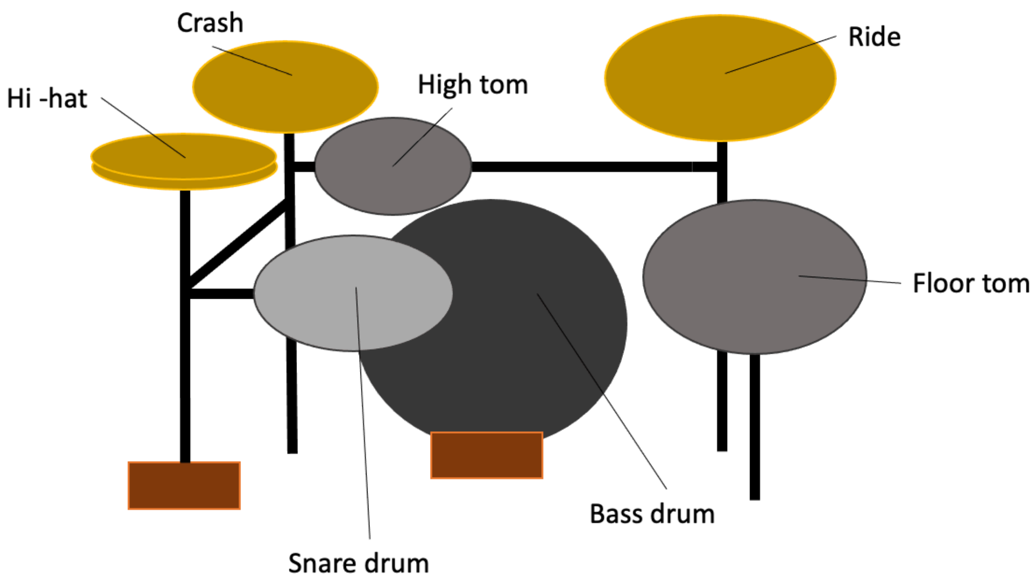

Figure 1: Diagram of the fundamental elements of a classic jazz drumkit

2 METHODOLOGY

The construction of the product can be divided into three main issues:

1. Building the structure of the kit, this is, setting up the rack which is to hold the drum pads in place.
2. Building the pads
3. Adding the electrical modules to the product

Additionally it is important to consider another issue which would correspond to the preparation of the presentation material, which in this case was decided to be a website.

Even though everyone contributed in some way to every of these major tasks, each team member focused mainly at one task, according to the workload distribution:

- Sebastián: Structure construction, product design, storage
- Johannes: Pad construction, product design
- Guillermo: Electrical setup, product design
- Mario: Product website development, product design

The project has been set up focusing on the two major dates: November the 17th, when an initial proposition of the project idea was to be presented, and of course the final date, about one month later. Due to the schedules of the members, most working days have been Thursdays, and the holidays of December have also come useful for the working plan. The time plan has been mainly sequential, for many chores within the principal labours could not be done until reaching a certain point in the product development: for instance, the pads could not be added to the structure until the entire structure was built, or the image maps could not be added to the website until the final product was assembled, but some duties could be synchronously achieved.

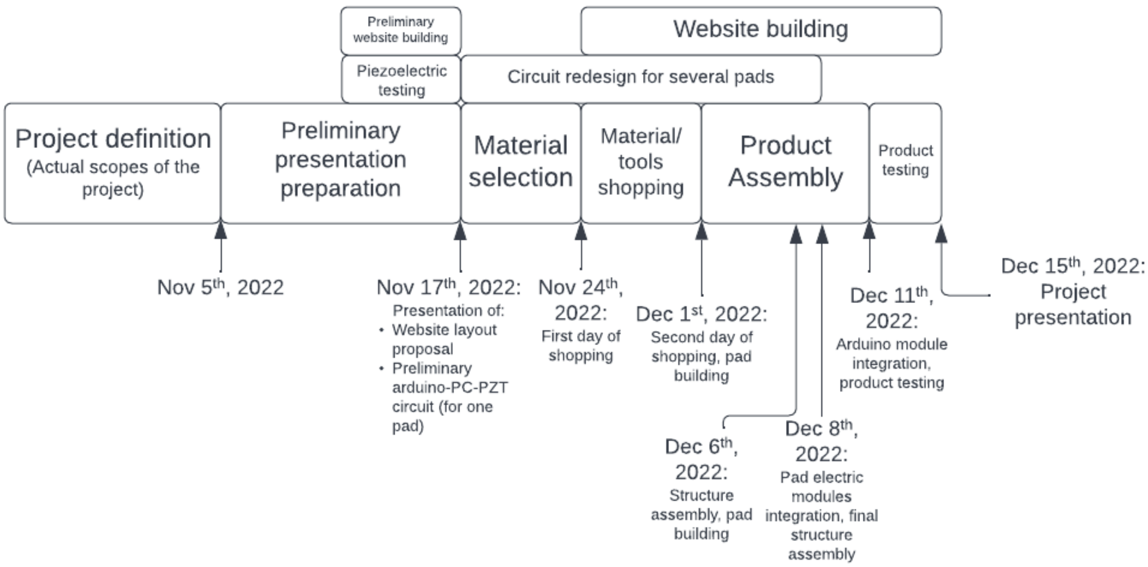

Figure 2: Simplified chronogram

2.1 MATERIALS

To select the materials with which we were going to build our electric drum kit, we had to take into account our limitations, which were the budget, the lack of tools, an adequate construction space and time. Because of this we had to evaluate several material options for each part and choose the most suitable one.

An electric drum kit typically has a rack made of aluminum or steel tubes, and the pads have a rubber or mesh head that simulates the hit and bounce of an acoustic drum kit. Therefore, we had to look for low-cost materials that are easy to manipulate and that simulate these functions in the best possible way.

2.1.1 LEAD-ZIRCONATE-TITANATE (PZT)

From a materials standpoint, piezoelectrics are the most important materials for this project. These materials are ferroelectric ceramics that originate electrical charges when brought under any sort of mechanical stress. This way, piezoelectric materials conform an easy way to convert mechanical energy into electrical energy, through what is known as the direct piezoelectric effect.

We can use these piezoelectrics as sensors, connecting them to a module capable of reading electrical inputs and converting them to sound. Each pad shall have their own piezoelectric disc acting as a hitting sensor, which shall then deliver an electrical signal to a processing unit (in this case, an Arduino nano plate).

As stated, compressing a piezoelectric material produces electricity. A piezoceramic material is placed between the two metal plates.

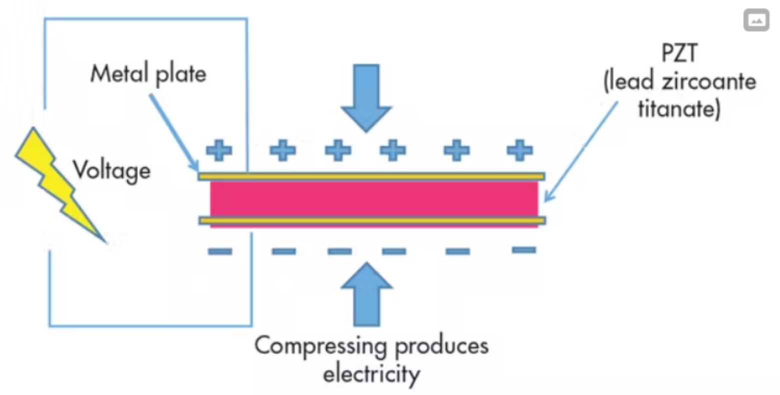

Figure 3: Direct piezoelectric effect

In piezoelectric crystals, the electrical charges are perfectly balanced, therefore piezoelectric crystals are electrically neutral. However, stretching or squeezing a piezoelectric crystal deforms the structure, pushing some of the atoms closer together or further apart. This upsets the balance of positive and negative, and causes net electrical charges to appear. This effect continues through the whole crystal structure so net positive and negative charges appear on opposite, outer faces of the crystal.

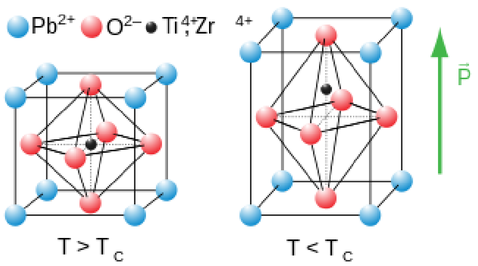

Figure 4: Reaction of PZT to mechanical stress

2.2 STRUCTURE ASSEMBLY

2.2.1 RACK

As a material for the rack we decided to use thin plastic tubes since these are light and comparably easy to cut and assemble and also within our budget. While designing the structure of the drum-kit we decided that that it would be very helpful if it´s possible to assemble and disassemble the rack. Especially for the transportation this was essential.
To achieve this we used matching counter pieces to put the different parts of the tubes together. So they were stable enough to carry the weight of the rack and the pads and also did not fall apart when the drum-kit was played. Also we glued the closures of the pipe-ends to the surfaces of the pads which so just could be twisted open and the pads be removed from the rack. Figure 5 shows the whole construction.

Figure 5: Structure of the Rack

2.2.2 PADS

The pads were made out of different circular layers of materials. The first layer was a cork-plate where the drum-kit was played on. Beneath it there was a wooden plate for stability and for even pressure spread. On the middle of this plate the piezoelectric sensor was glued so the pressure could be determined precisely. The sensor was surrounded with a layer of foam to protect the sensor and also isolate the construct. The final part was again a wooden plate where also the closures of the pipe was fastened, like mentioned in section 2.2.1. The total construct is visualised in figure 6.

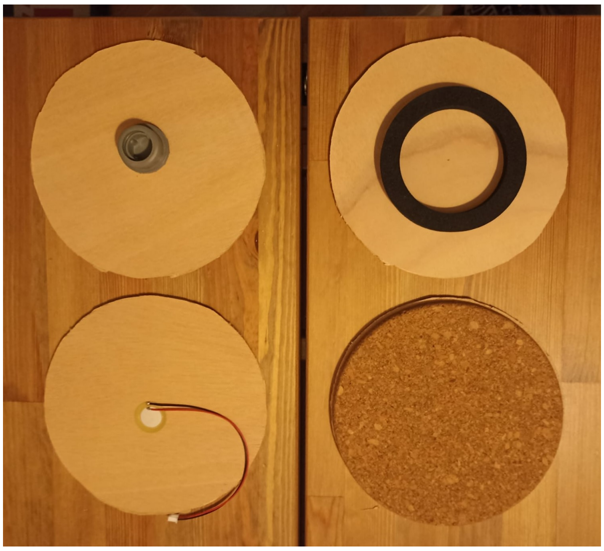

Figure 6: Schematic construction of a pad

2.3 CIRCUITRY

The electronics that made playable the drum-kit consisted in three main sections:

2.3.1 Piezoelectric sensors and connections.

For each pad, a piezo sensor was placed below, so that each hit in each pad resulted in an actual voltage pulse. The sensors were arranged with a $1M\Omega$ resistor, and a $5.1V_{zener}$ Zener diode, which had the task of sending directly to ground the voltage exceeding 5.1V in reverse polarity. This limit was introduced because the micro-controller could only read up to 5V, and higher voltages could damage it. The grounds of all the sensors where connected together with the micro-controller ground, and each live of each sensor was connected to each analog input of the arduino.

2.3.2 Arduino coding.

The strategy was to use the arduino controller as a MIDI instrument. MIDI stands for Musical Instrument Digital Interface and it is a binary protocol used as a convention to connect all kind of musical instruments. Each note has a byte value, as well as the intensity of the note, also every instruction involving control of musical notes has its own byte in this MIDI language but in this case we are only interested in the notes and velocity (in music the intensity of a note is called velocity). The code is made in such a way that the micro-controller is continuously reading the voltage of all the sensors, and when any of these exceed a certain threshold, a MIDI command is sent through the USB connection of the arduino. This MIDI command has 2 bytes of information, one is the note and the other is the velocity, which is a value from 0-127 that is determined by reading the voltage of the sensor and mapping it in this range.

2.3.3 Computer as a sound library.

The arduino is connected through USB to the computer. Then, by installing a couple of programs one can set that USB port as a virtual MIDI port that reads the serial commands of the arduino, which turn out to be MIDI commands.

The final part is to choose a music program that has instruments in it. In this presentation, the program Kontakt was chosen and was equipped with a library of drum sounds (notes are assigned to different drum sounds). One just has to select the virtual MIDI port as input, and tweak the arduino code so that each pad triggers the note assigned to the correct sound in this library.

2.4 WEBSITE

Since the portability of the product could not be clear until the structure was built, it was decided to write a website on the project for the final presentation. The website was written in vanilla HTML, CSS and JavaScript, only making use of jQuery 3.6.1 and the maphilight plugin (https://github.com/kemayo/maphilight) to build the image maps. The deployment has been carried out with the GitHub Pages environment. The site includes:

- A short introduction to the piezoelectric effect, specifying its usefulness for this task in particular
- Image maps in which the different materials of the final of the elements of the product are specified
- Complementary information on the materials of commercial kits

The website can be both accessed from its domain link http://lufthansadrums.com or the GitHub Pages link http://host-msdrumkit.github.io. The code is publicly hosted at https://github.com/host-msdrumkit/host-msdrumkit.github.io.

3 RESULTS

The overall performance of the product is satisfactory, it fulfilling the task in question: during the test session “Are you gonna be my girl?” by Jet and “Back in black” by AC-DC were played on the kit.

However, it has a remarkable flaw: the vibrations of the kit under pad hitting make parasite sounds on the high tom and the upper cymbals. This issue can be partly solved by reducing the threshold of the mentioned pads, although this forces the drummer to be a hard-hitter for these pads to sound adequately. This actually limits greatly the playing dynamics, deeming the kit unusable for jazz drumming, but it is still fair for punk, for instance. This is likely an issue coming from the hollow PVC tube structure. Better solutions may be to stuff the tubes with vibration-damping materials or using more compact materials.

3.1 FURTHER IMPROVEMENTS

The main improvements the product would need would be the addition of a bass drum pad and a digital pedal for the hi-hat to alternate between open hi-hat and closed hi-hat sounds, giving a more realistic and versatile character to the kit. It was indeed intended to add such hi-hat pedal, but unfortunately the code would not work properly.

Regarding the bass drum, one could just use a digital pedal like the hi-hat's, which would deliver the signal to the Arduino module when pressed, or place a vertical pad like the rest of them drums. In the initial designs, this bass pad would be held by an additional PVC bar parallel to that holding the high tom , but placed at a lower height.

Finally, the high cymbal pads could be made of only one wood disc and the cork pad, with a hole close (but not on) its centre. These pads would be slightly loosely held by a thin tube going through this oval hole, as figure 7 shows. The point of this design is that the cymbals move slightly when hit, resembling the motion of real cymbals, thus giving a more realistic feel to the kit. In order to implement this design, one needs to make sure the vibration issue is not a problem anymore.

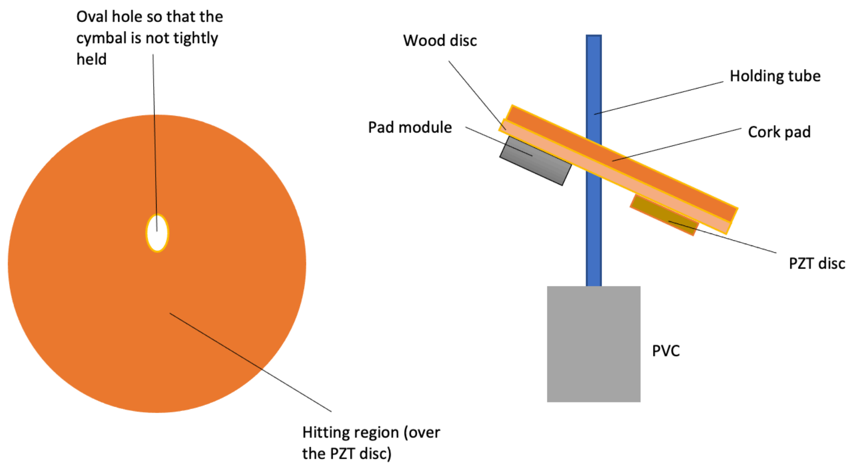

Figure 7: Cymbal pad redesign. Left: top view. Right: lateral view