LoomOne

Everyones textile factory

The Condotier / Giovanni Bellini / 1475 – 1480

aristarco

01. Abstract

The **LoomOne** project is a **business-oriented initiative** designed to **support a textile design community**. Its primary aim is to achieve this by creating a **low-cost automated jacquard loom**, alongside offering courses, facilitating the sale of community-created designs, and developing other hardware.

The **core concept** is the development of a **CNC semi-automatic jacquard loom**, envisioned as "The Arduino for Textiles". This project is grounded in the context of Mexico's **centuries-old tradition of artisanal textiles**, particularly significant in regions like Puebla and Tlaxcala, where textile production represents an estimated 15% of companies. The Ibero Puebla University textile design programs teach students the design and production of flat fabric, starting with manual looms like the LeClerc Dorothy model, which are practical for schools and hobbyists but have design limitations. More complex designs require **Jacquard looms**. Digital jacquard looms used for prototyping, such as the **TC2 by Digital Weaving Norway**, are highly capable tools allowing for rapid creation of complex samples, but they come with a **very high cost** (around 50,000 USD).

The fundamental **challenge** LoomOne seeks to address is posed as: **¿How might we have the capabilities of a TC2 jacquard loom with the cost of a Dorothy loom?**

Previous student projects (Fab Loom 2.0, Digital Fab Loom, Mechaloom) have explored CNC loom concepts, providing important lessons regarding the suitability and energy demand of servomotors and electromagnets for heddle control, the advantages of a semi-automatic design approach, the need for effective thread gripping mechanisms, and the complexity of control software.

LoomOne targets **design schools, textile designers and students, and hobbyists** who wish to create their own designs. It aims to **combine the simplicity of the Dorothy LeClerc loom with the efficiency, precision, and complexity of the TC2 loom**. The project is planned as a **web-oriented initiative** with an objective to **launch via Kickstarter in the fourth quarter of 2025** . The main **motivation** is the current lack of an **accessible way for designers and textile enthusiasts to fabricate or prototype complex design flat woven fabrics**. Designing flat fabrics is inherently complex due to the numerous variables involved, such as different weave structures, threads, graphic designs, and tensions.

02. Acknowledgements

First and foremost, I wish to express my deepest gratitude to **my wife and my son**. Their love, understanding, and endless patience have been the pillars of support throughout this journey. The time I have invested in this adventure was time that, in many ways, I took from them, and yet they gave it freely and with encouragement. Their unwavering belief in my goals and their constant motivation have been invaluable; for that, I am eternally grateful.

I would also like to extend my heartfelt thanks to **Nuria**, an outstanding instructor whose dedication and expertise have been a guiding light throughout my academic experience. Her clarity, commitment to excellence, and passion for teaching have left a lasting impact on both my work and my personal development. It has been a privilege to learn under her guidance.

A special thanks to **Rico**, my global evaluator, for his critical insights, thoughtful feedback, and encouragement throughout the evaluation process. His perspective challenged me to push the boundaries of my work, and his support has been instrumental in helping me bring this thesis to its full potential.

Finally, I am profoundly thankful to **Anastasia**, the inspiring leader of the Fabricademy program. Her vision, innovation, and leadership have shaped an educational environment that fosters creativity, resilience, and collaboration. Completing this program has been transformative, and much of that is due to the strong and inspiring community she has cultivated.

To all of you, thank you for being an essential part of this journey. This achievement is as much yours as it is mine.

03. Introduction

Intricately patterned and sumptuously textured, jacquard fabric has a luxurious quality that is hard to beat. In contrast with printed textiles, jacquard patterns are incorporated into the weave with a slight raise, giving them a long-lasting lustre and durability that resists fading or fraying over time. A modern take on the long tradition of brocade, jacquard designs can be combined with a rich variety of fabric types, including cotton, silk, wool, and linen, while there is no limit to the range of patterns that can be made, including florals, paisleys, stripes, polka dots and more. Because it has more strength, weight, and stretch than other weaves jacquard is particularly popular for home décor such as curtains, drapery or bedding, but it has also appeared in luxury theatrical costumes, wedding dresses, and cummerbunds. [1]

1858 engravings illustrates the punched-card weaving technique developed by Joseph Marie Jacquard.General Research Division, The New York Public Library.

The history

Historically, weaving a pattern into fabric was a slow, grueling and dangerous process that produced a mere two inches of fabric per day. Master weavers helmed manual looms and instructed young assistants—called “draw boys”—to climb on top of the looms and move the threads following a specific pattern. The weaving reeds were heavy, and the draw boys were often injured or crippled by lifting more than half their body weight in machinery. In the 1760s, Jean Charles Jacquard, a well-known and respected master weaver in Lyon, France, who employed his son, Joseph Marie Jacquard, as his draw boy, realized that the hard work was too much, and sent Jacquard Jr. to apprentice with bookbinders and printers.

As Jacquard Jr. grew up and married, he dabbled in various professions, including real estate, cutlery-making and the military. After the French Revolution, he started inventing and hoped to create a loom that could operate without a draw boy. Building on the existing technology of other state-of-the-art looms at the time, Jacquard developed an automated system that used a chain of punched cards to create a sequence. The cards told the loom which threads to raise at a specific time to produce the weave, and each card corresponded to a row of the fabric’s design.[2]

04. State of the Art

The state of the art in jacquard looms available to handweavers and prototypers includes high-end, sophisticated digital machines, alongside various efforts to create more accessible, lower-cost, and often manually-operated or semi-automatic digitally-controlled looms.

At the higher end are looms like the Digital Weaving Norway TC2 and the AVL Jacq3G. These are considered highly capable digital jacquard looms used primarily for sampling, rapid prototyping, or product development. They have a high-tech feel and allow for rapid creation of complex samples with varying parameters like design scale, weave structures, and densities. The TC2, for instance, is computer-controlled but manually-operated, designed to be run by the weaver/creator. It features individually controlled heddles (pneumatically operated), automatic warp advancing via sensors and software-operated motors, and computer-controlled warp tension. Designs are created digitally and processed by control software. While highly effective, these looms come with a very high cost, with a TC2 base model starting around 45,000 USD, and the AVL Jacq3G also in a similar high price range.

Given the high cost of these advanced systems, a significant area of exploration, particularly in academic and maker spaces, involves developing more accessible CNC or digitally-assisted looms. The LoomOne project itself aims to address the challenge of achieving the capabilities of a TC2 at the cost of a simpler manual loom like the LeClerc Dorothy.

Various projects and previous iterations in this space, often focused on lower cost and tabletop sizes, have explored different mechanical and control approaches:

Some projects have attempted full automation using servomotors, but faced issues with speed and high energy demand. Lessons learned included the need to reduce component size and manage energy consumption effectively15.

Explorations into semi-automatic designs have simplified the process and reduced costs compared to fully automatic systems, however, mechanisms like electromagnets used for heddle selection sometimes resulted in extremely high energy demands that could damage electronics.

Other approaches have tested electromagnetism for heddle grip, encountering challenges with sufficient strength to lift threads, suggesting the need for alternative grip methods.

Manual Jacquard looms with digital components have been developed, such as an inexpensive tabletop loom from the Carnegie Mellon Textiles Lab that uses 3D-printed parts (<US$200) and is controlled over USB. This is described as a hand loom where a weaver still operates the process but benefits from computational patterning.

Other notable examples include the J.3D.1 (jedi) loom, a low-cost computing 3D weaving jacquard loom for sample-making, and the Weav3r Loom, built with Lego and a computerized system using a band and actuator for thread selection.

The 24-Bit Friendship Loom used electromagnets, a method noted for its very high electrical current demand, which increases significantly with more threads and can pose a risk to electronic components.

The SpeerLoom uses a series of linear actuators to raise and lower heddles. This project is also notable for its sophisticated control software, which includes algorithms to assess fabric integrity. It is presented as an open-source loom kit.

These varied projects demonstrate ongoing efforts to bring the pattern complexity of jacquard weaving into more accessible formats, often combining some level of digital control (CNC) with manual operations like weft insertion, and exploring different mechanical solutions while grappling with challenges related to cost, energy, mechanical reliability, and software complexity. Initiatives like the open-source Fab Loom and SPEERLoom, as well as the planned open software/hardware aspect of LoomOne, point towards increasing accessibility and community involvement in the development and use of these technologies.

05. The problem

who

Design schools, Textile Designers and students, Hobbyists that want to build their designs

what¶

Create a business-oriented initiative that supports a textile design community through a low-cost automated jacquard loom, courses, sale of community-created designs, creation of other hardware, etc

when

The objective is to Kickstart second quarter 2026

where

LoomOne is a web oriented initiative.

why

Textile designers, schools, and enthusiasts do not have an accessible way to fabricate or prototype Complex Design flat woven fabrics.

Flat fabric design is NOT trivial. It is a complex task with many inputs like different ligaments, different threads, different graphic designs, different tensions, etc.

06. Background

The core of the project is to create a business-oriented initiative that supports a textile design community through a low-cost automated jacquard loom, courses, sale of community-created designs, creation of other hardware, on a open software & hardware initiative.

The core idea is to develop a CNC semi automathic jaquard loom.

History

In Mexico, there is a centuries-old tradition of artisanal textiles that is very important in several states of the country. These crafts are mainly made on pedal or backstrap looms, and the designs are limited. It is estimated that in the Puebla - Tlaxcala region, where I live, 15% of the companies are dedicated to textile production, so any advancement in this sector can lead to significant economic progress.


Traditional Pedal loom in Chiautempan, Tlaxcala

The Idea

At the Ibero-American University in Puebla, where the fab lab is located, we offer a degree in textile design. One of the skills that the students must acquire is the design and production of flat fabrics. To achieve this learning, the students learn to weave on a manual loom with various frames that allow them to create their designs, both in decorative figures and in the different types of weaves used in the textile industry.

To carry out their weaving practices, the students use manual Canadian looms of the Dorothy type by LeClerc.

This loom weaves pieces up to 15¾" (40 cm) wide, a practical size for schools, hobbyists, and occupational therapy. The four harness levers may be set on either the right or left side of the loom.

The Leclerc Dorothy Table Loom is collapsible for storage. It includes 12-dent reed, 400 wire heddles, a shuttle, a reed hook, lease sticks, two beam slicks with cords, and instructions. The Dorothy is made of red birch with a colonial finish.

Dorothy loom from LeClerc loom

Once the students have learned the basics of flat weaving, they are introduced to more complex Jacquard-type fabrics.

The jaquard loom was developed in 1804 by Joseph-Marie Jacquard. The Jacquard loom is a weaving machine that lets the user create textiles with complex patterns using perforated plates that function as guides to tell the machine how to weave the treads[Wikipedia]. Of course, this explanation is vague and doesn´t really explain what it actually does. To demonstrate how this machine works I´ve found this video created by Macclesfield Museums.

In the case of prototyping jacquard looms there are two machines that hold the marker, the leader is the 50,000 USD TC2 loom by digital weaving Norway followed by the 37,000 USD AVL jaq3g. Our University decided to invest on a TC2 jacquard loom.

The Thread Controller 2 (TC2) is a Digital Jacquard loom manufactured by Tronrud Engineering Moss, Dept. Digital Weaving Norway. The TC2 loom is a tool that assists during the “Innovative or the Creative” phase of the making of the textile and is designed primarily for Sampling, Rapid Prototyping or Product Development purposes. Many of our customers also use the loom for creating one-offs/ special commissions (textile artists, for example) and mass customization. The loom is computer-controlled and manually-operated because it is designed to be operated by the creator/ designer/weaver.

The TC2 allows the user to make a perfect quality sample with the desired fibers, weave structures, warp and weft densities and colours – within hours! Changes are instant; start & stop as many times as required, without problems. The point is that with a TC2 loom, you get the samples at the latest 'next day' and you get them where the decision-makers/ customers are. One can make a sequence of samples varying for example the scale of the design, weave structures, warp and weft density/colorways etc. With the TC2 loom, it is possible to evaluate the design visually as well as the actual hand or the feel of the fabric.

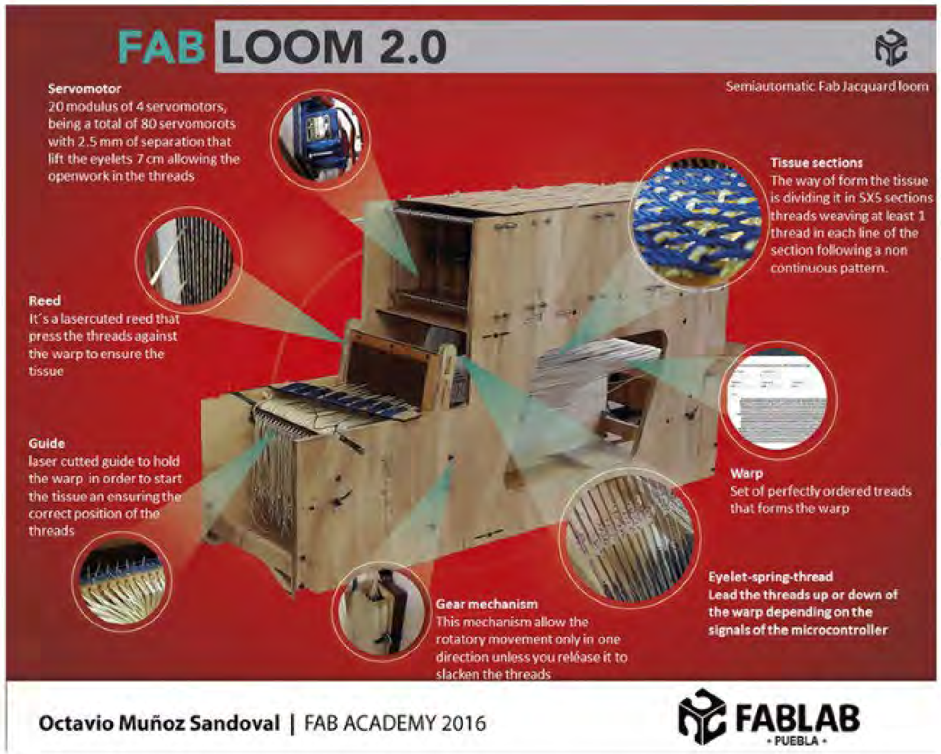
TC2 Loom

So the the challenge comes as: How might we have the capabilities of a TC2 jaquard loom with the cost of a Dorothy loom?

Previous iterations

Several students have tried different ideas for a CNC loom and have prototyped them at the Fab Academy.

Fab Loom 2.0¶



FABRICADEMY
textile and technology academy

Octavio Muñoz Fab Academy 2016

With Octavio's project, we learned several things:

The use of servomotors to change the state of the loom's heddles was not suitable due to the speed of change.

The energy demand of the device was going to be a problem, as 4 servos were needed per centimeter. If we wanted a functional device, it was necessary to reduce the size of the components needed to change the state of the loom's meshes.

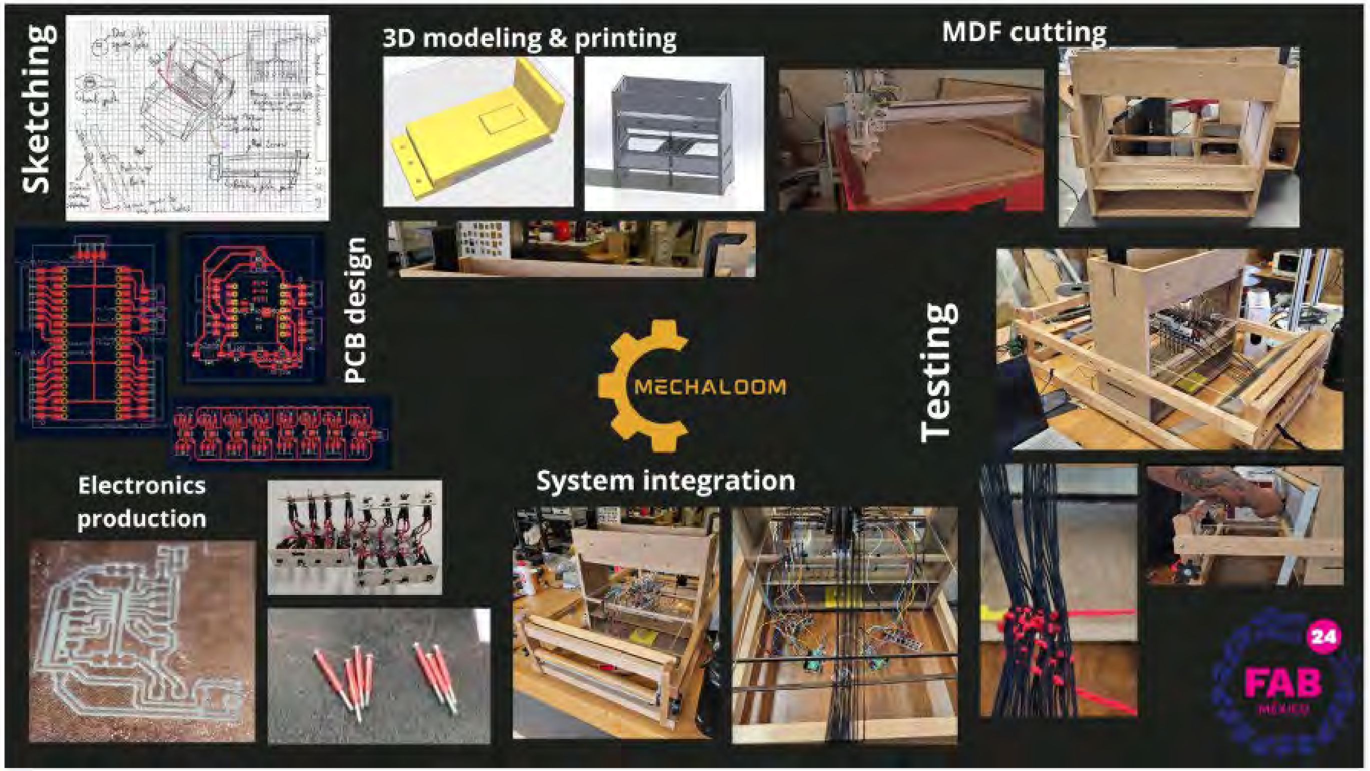
Digital Fab Loom

FABRICADEMY
textile and technology academy

Franco Robredo Fab Academy 2018

With Franco's project, we learned:
That it was possible to change the idea of the loom to something semi-automatic, moving away from the concept of current looms and greatly simplifying the design and necessary parts.
The switch to a semi-automatic loom significantly reduced the cost of the loom.
That energy was one of the main problems to solve. This loom used electromagnets to hold a small metal bead that served to select the heddles. Since there were 160 heddles, the energy demand was extremely high, vaporizing the tracks on the electronic boards.

Mechaloom



FABRICADEMY
textile and technology academy

Hector Cornejo Fab Academy 2024

Hector's Project was built after the pandemic. During the pandemic, two concepts based on electromagnetism were tested. Of which one turned out to be attractive due to its instantaneous and very low electrical consumption.

With that idea, Hector's loom was developed. With Hector's project, we learned:

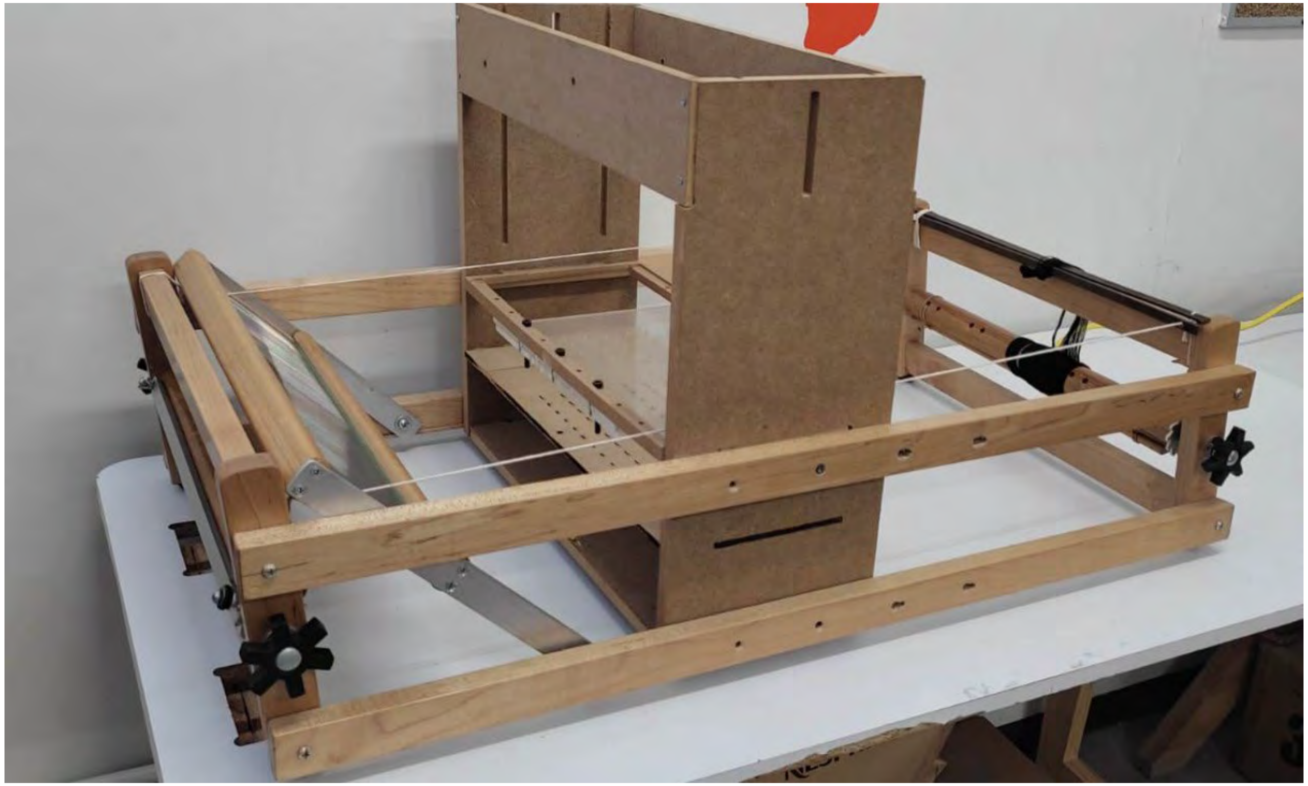
That the grip for lifting the nets would have to be more powerful since the magnets did not always have enough strength to lift the threads, which makes us think that it might not be the best method, so we need to consider a plan B for the grip of the heddles.
That a board with an H-bridge was necessary for each thread to miniaturize the design.
That the electromagnetic coils used were larger than strictly necessary.
That the loom control software is more complex than previously thought.

07. Development Process

Mechanical

With this project we found out That a board with an H-bridge was necessary for each thread to miniaturize the design, and that mechanical design was going to be an issue if we wanted the loom to be consistent.

As you can see in previous photos, the Mechaloom is a “Frankenloom”. A cross between the Dorothy loom by LeClerc and a construction of MDF, metal, and acrylic.
The idea with this iteration was to prove several concepts and find out where all the little devils would hide. Because the devil hides in the details

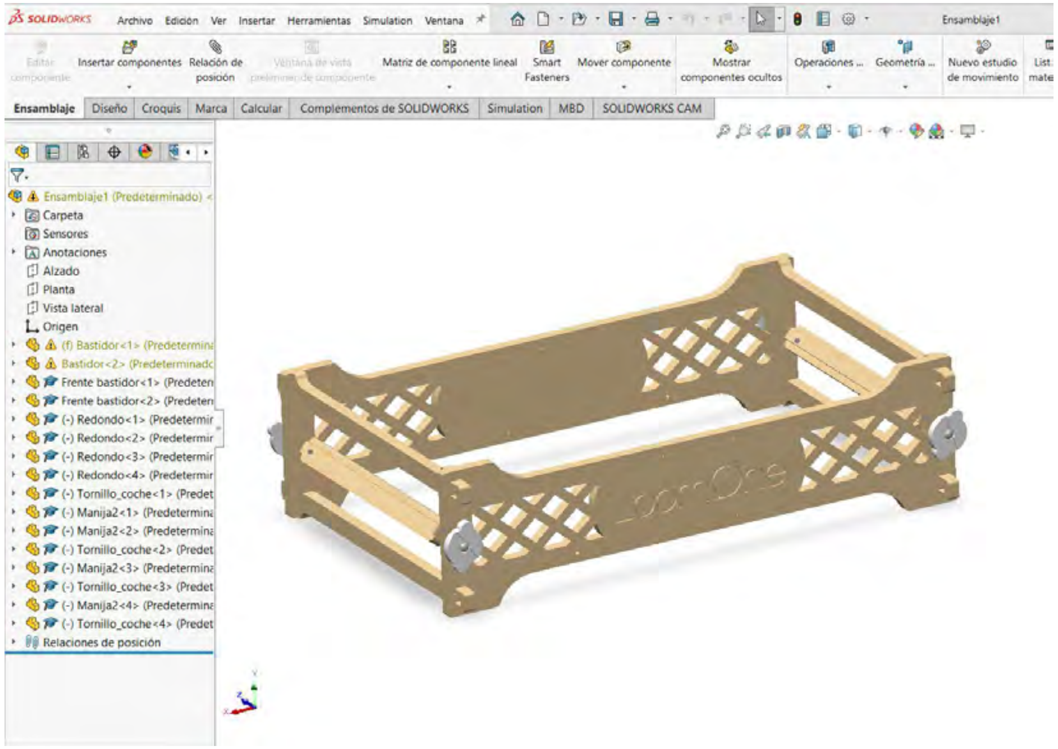


Mechaloom body

Body Re-Design

I decided to start by designing the loom frame in Solidworks, as the electronic cards were yet to arrive, which would determine the shape and size of the central body.

I decided to make the frame from an 18-millimeter plywood piece, so it could be easily replicable in any Fab Lab.
I chose a thickness of 18 millimeters because I also decided that the body of the loom should be part of the frame structure, so we wouldn't rely solely on joints that could loosen, thus giving much more rigidity to the entire loom.



Frame design

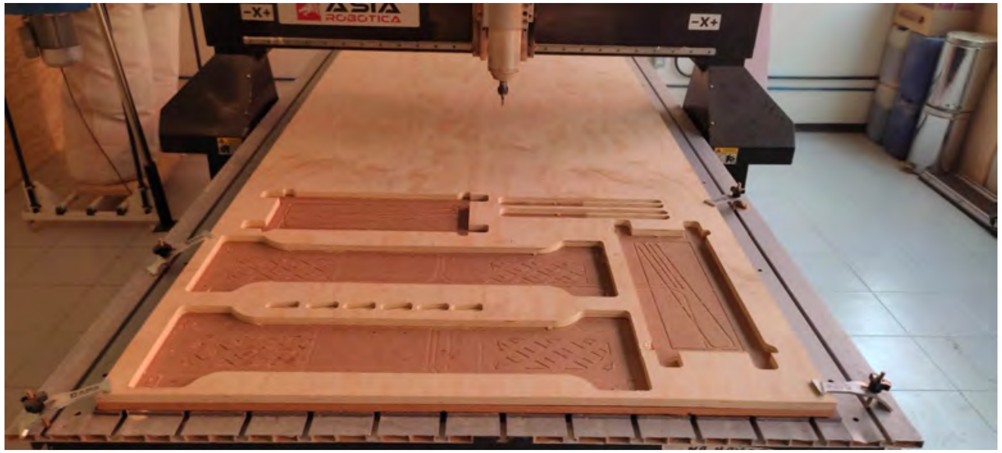
After designing I already routed the frame to start working in the body. The first attempt was a disaster. After cutting the entire frame, in the last g code disaster stroke. Apparently something with the machine voltage happened and the machine zero moved an inch to the left and the entire work was spoiled.

Routing the Frame

I had to buy a new board and routed piece by piece. The final assembly of the frame turned out very nice.

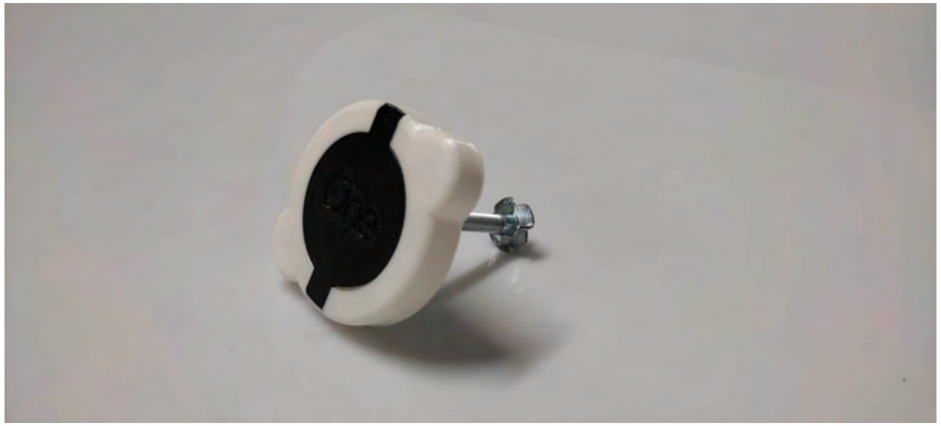
Final Assembly of The Loom One

The total amount of material I used in the frame was about 1/3 of the plywood board, that means that the cost of the frame is about 11.50 Euros.

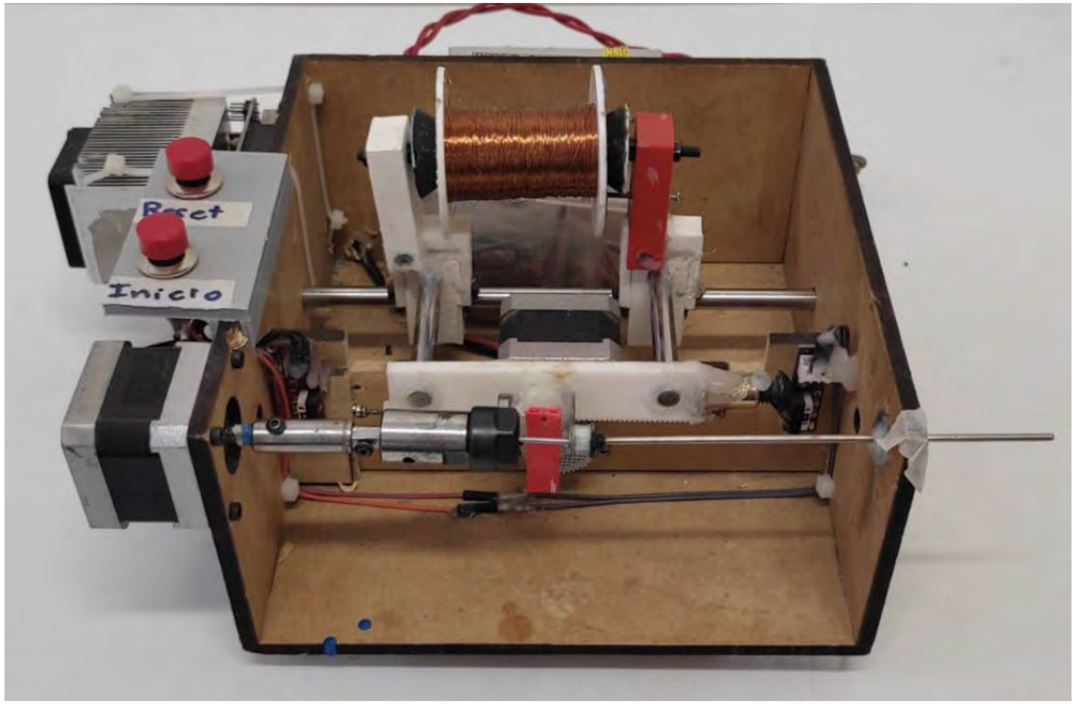


1/3 of the plywood board

To turn the crancks of Loom One there are needed some handles as you can see in the MechaLoom. I designed the handles to host the screw that turn the final fabric.

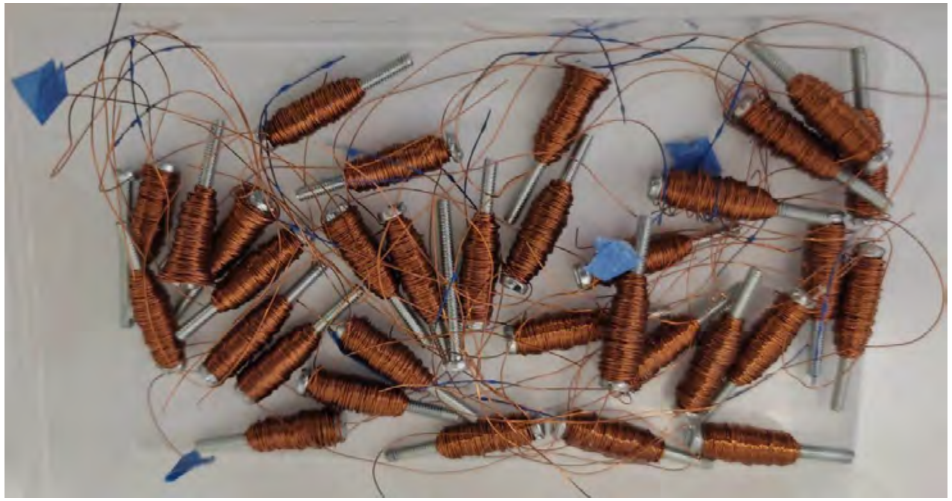

Loom One Handles

As part of the actuators that select the threads, two electromagnets with a diameter of 2mm are required.
A winding machine was developed for the FabLoom 2.0 project in 2019. I had to redo this same machine with the help of my colleague Carlos Pérez to be able to manufacture the Loom One coils. There are still some improvements to be made, but we can make the prototype with the product that is manufactured with this machine.



Electromagnet machine

Electromagnets ready to be installed in the new actuator board



2mm electromagnets

The design of the new cards required a complete redesign of the loom body because the need to place 16-pin connectors has caused each card to be extended by two centimeters, which completely changes the design of the component compared to the actuator card.

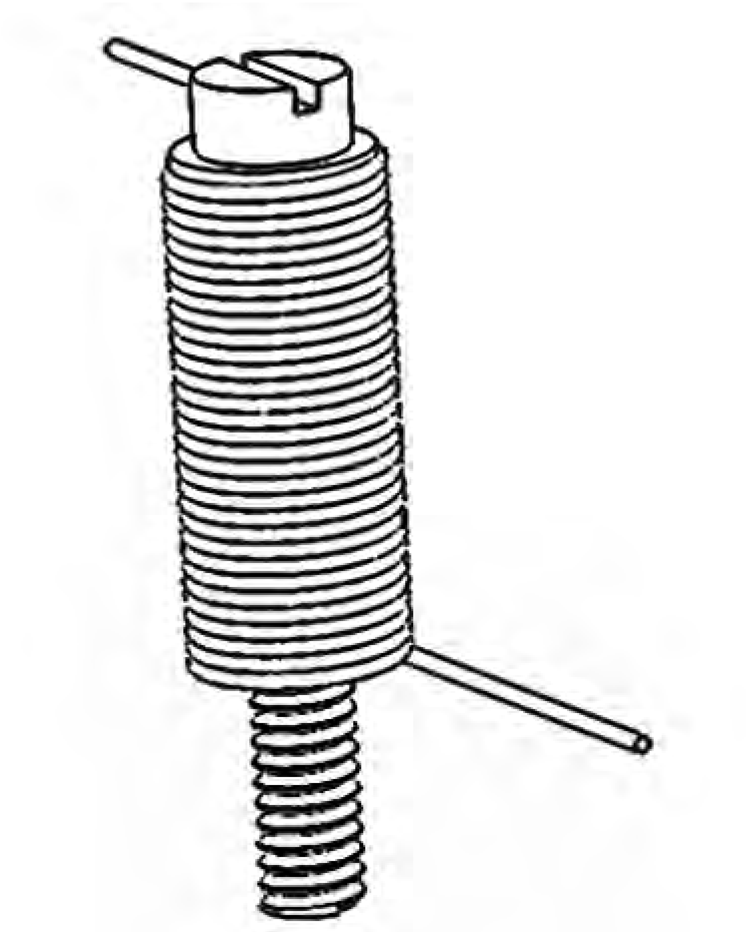
new electronic board vs old actuator board

Similarly, several designs of the meshes that separate the threads were made; the final design of these will depend on the final configuration.


Heddles

Electronics

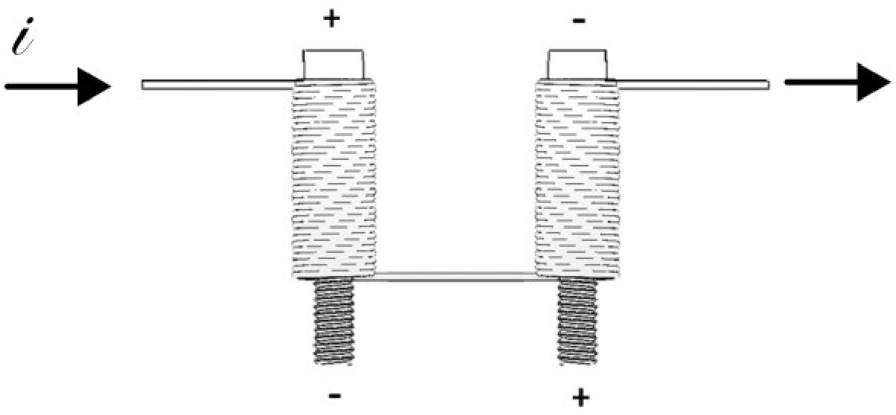
The main component of the actuator responsible for selecting the different heddles of the loom is an electromagnet that attracts or repels the actuator.



Basic unit electromagnet

The problem with using a single electromagnet is that it required a signal and two transistors to change the state of each electromagnet, with two electromagnets needed per thread, which meant that for each thread, two signals and four transistors were necessary. For this reason, I decided that instead of using single electromagnets, I would use an arrangement of two electromagnets.

The advantage of two electromagnets is that when current passes through both and they are aligned with the coils in opposite directions, the magnetic charge of each magnet is reversed, achieving the desired effect to reverse the direction of the actuator that selects the loom's meshes.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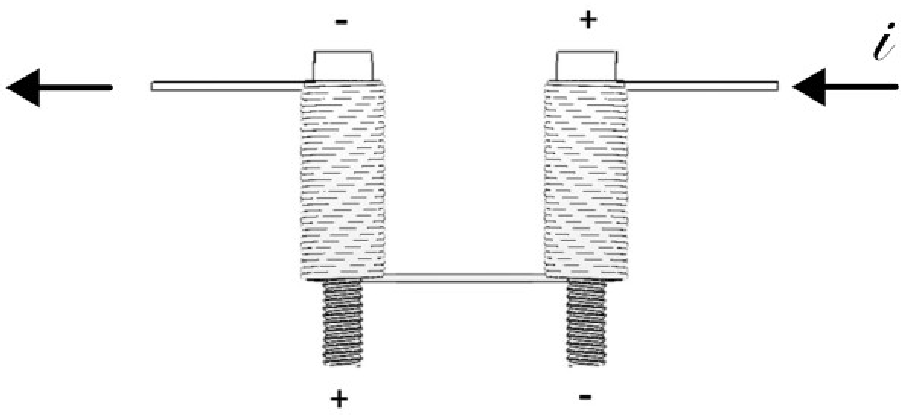
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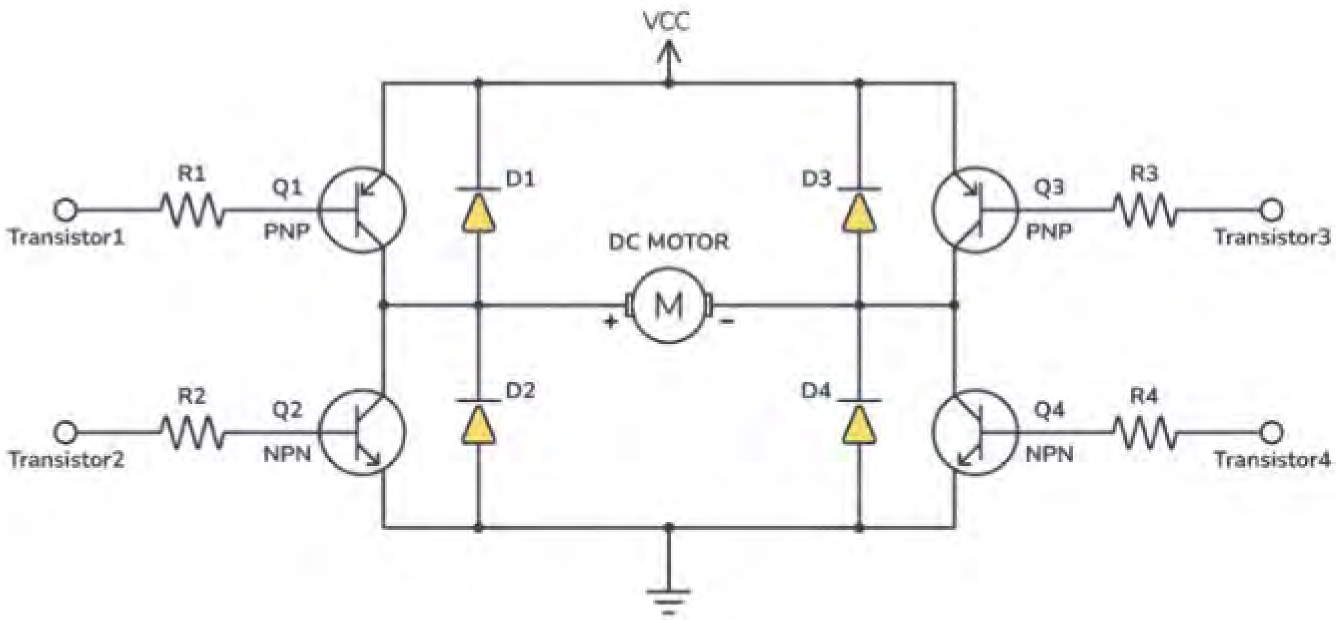
Final electromagnets design

Once the configuration of the electromagnets was selected, it was time to design the circuit that would control the direction of the current, which would cause the change in the magnetic field of the electromagnets responsible for the state change in the actuators. For this, I decided to use the same configuration of an H-bridge.

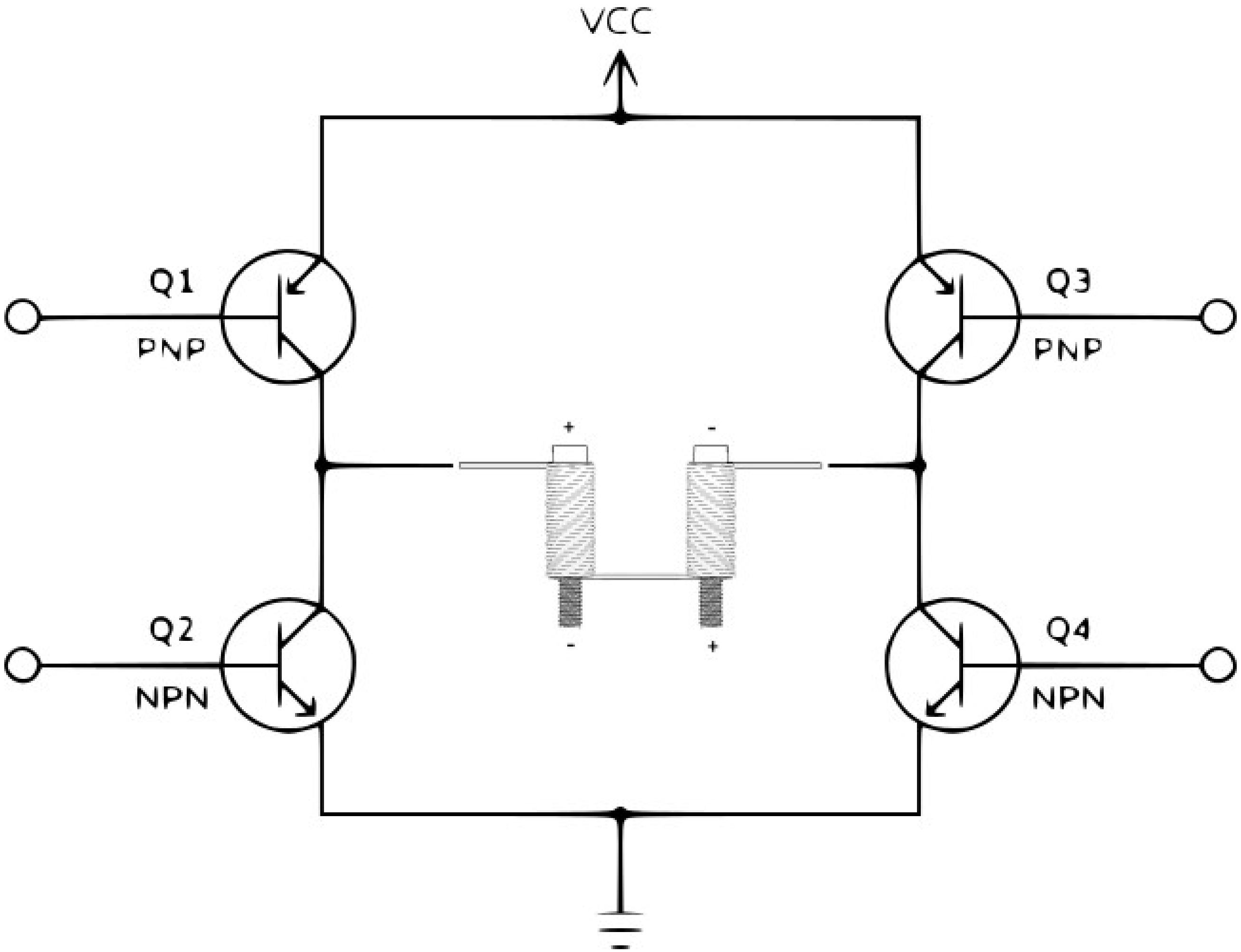
An H-bridge is an electronic circuit that switches the polarity of a voltage applied to a load. These circuits are often used in robotics and other applications to allow DC motors to run forwards or backwards.



Traditional H Bridge configuration

In the H-bridge configuration, there are 4 diodes. The H-bridge, being designed for motor movement, has the possibility that the motor, once the current is stopped, either changes direction or generates current between its terminals. This current can return to the system, which is why those 4 diodes exist, to prevent a short circuit from the current generated by the moving motor.

By conducting tests, I determined that the risk of generating a reverse current caused by the charging and discharging of the electromagnets is negligible. For this reason, I omitted the diodes from the H-bridge. Additionally, this helped me with the space required to solder the components onto the boards.



Loom One H Bridge configuration

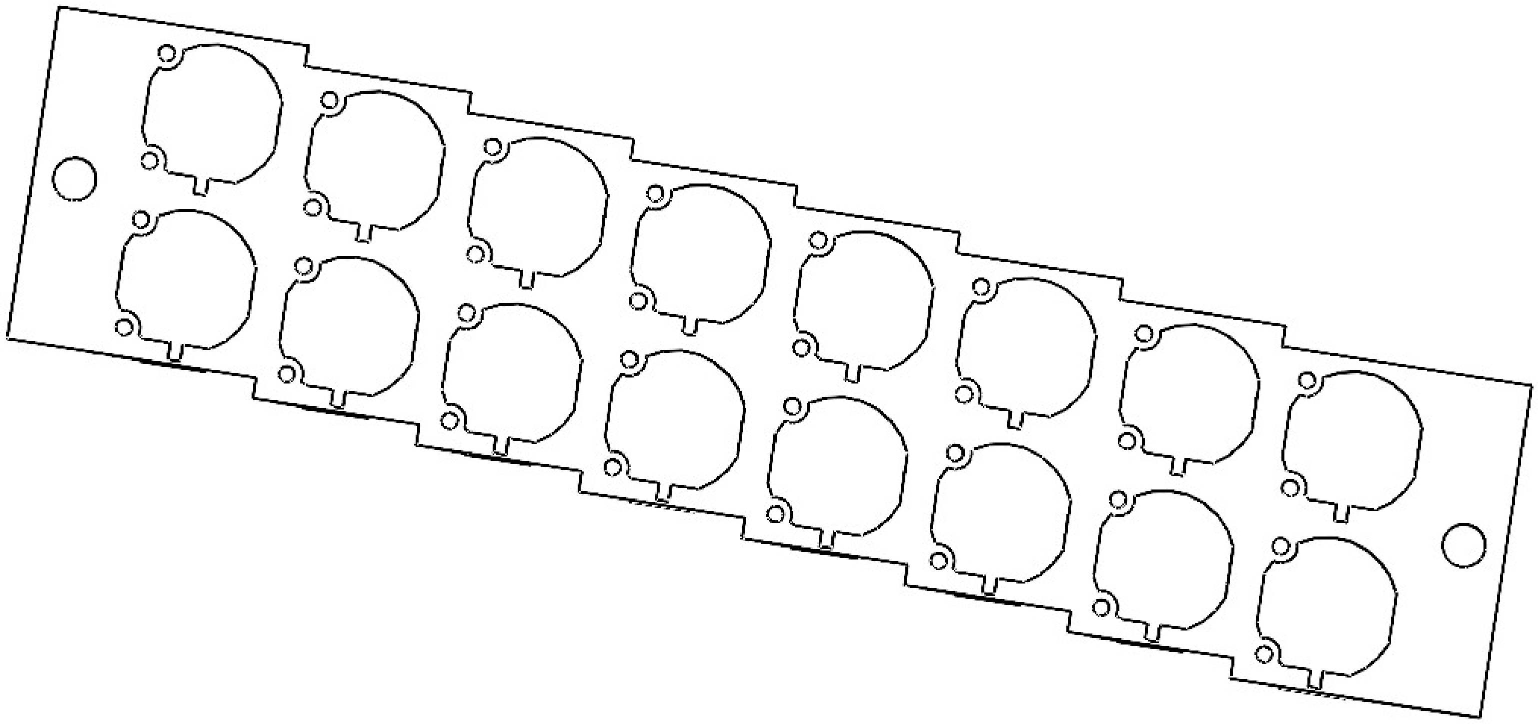
Once the circuit was determined, I decided to simulate it using the Multisim program. I built the circuit with the transistors that change the state of the mesh and with the help of a virtual oscilloscope, I was able to verify that the direction of the current changes due to the change in polarity of the circuit.

All of this is controlled by two gates that simulate the signal from the microprocessors that control the actuators.

In the video, we can see the circuit simulation, with which I test its proper functioning.

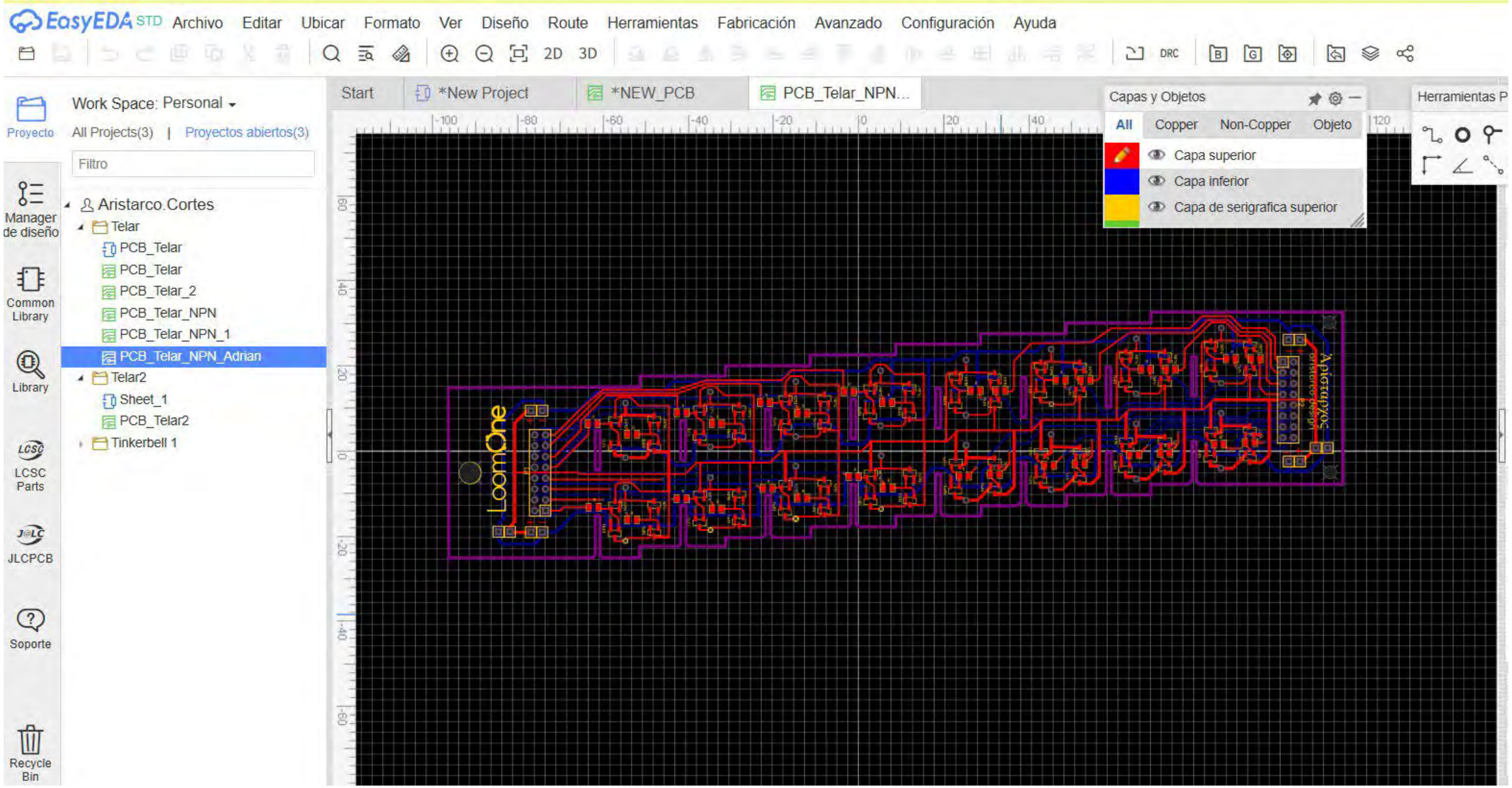
Once the control concept was tested, I decided to make the board to actuate each of the actuators guided by a signal from the slave microcontroller that is directly connected to the board.

Let's remember that in this iteration each card covers 4 cm and has 4 threads per centimeter. Since it is still a prototype, each controller measures 1 cm, so to have 4 threads per centimeter, it is necessary to stagger each of the actuators every 2.5 mm.



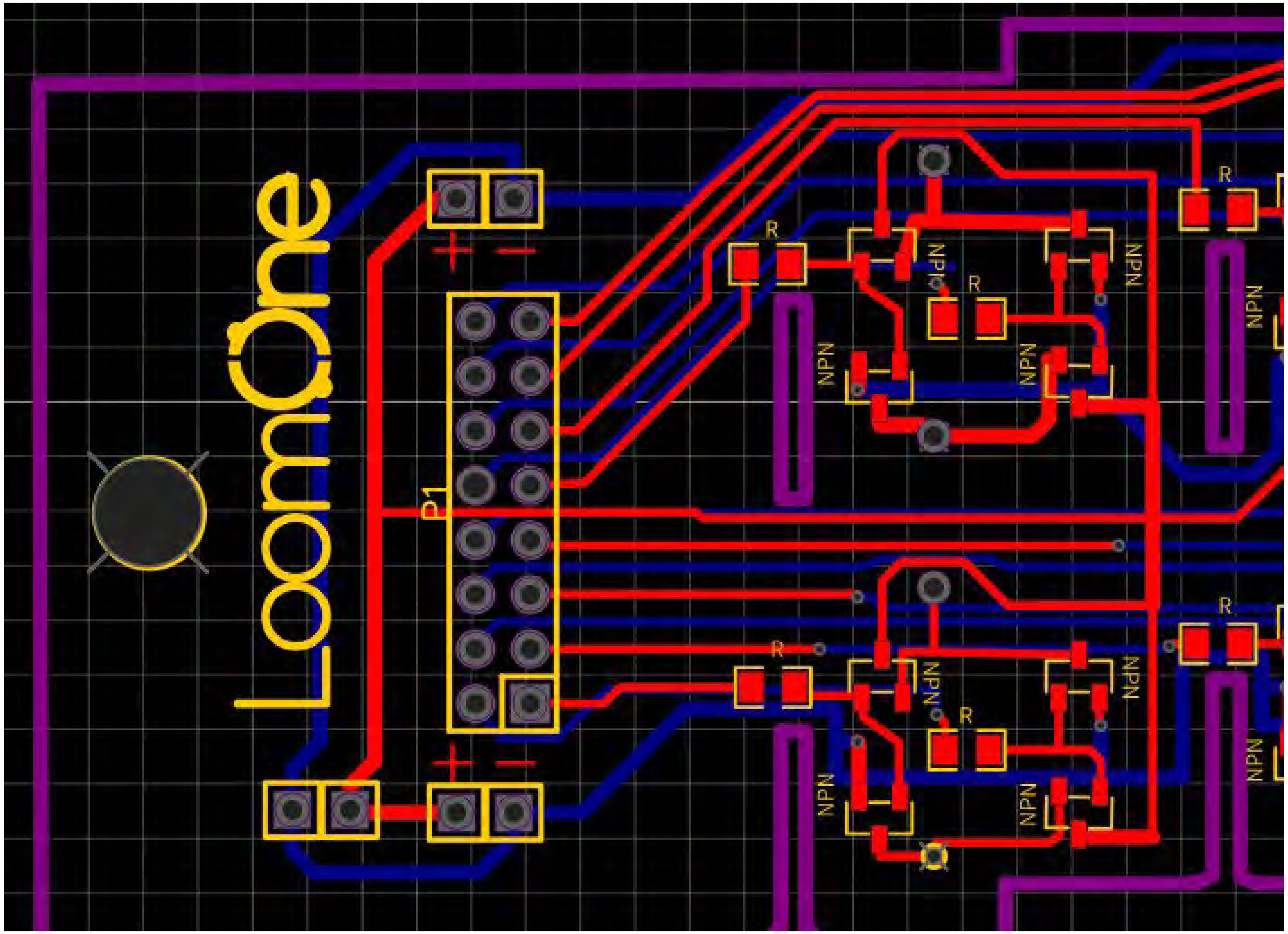
Actuators ladder configuration

The control electronic board for each of the actuators that select the meshes was made with an online program called Easy EDA and follows the same configuration as the solid on which the actuators are mounted. The holes visible on the board are for the heddles that hold the wires to pass through.


EasyEDA STD
Archivo
Editar
Ubicar
Formato
Ver
Diseño
Route
Herramientas
Fabricación
Avanzado
Configuración
Ayuda
Proyecto
Work Space: Personal
All Projects(3)
Proyectos abiertos(3)
Filtro
Aristarco.Cortes
Telar
PCB_Telar
PCB_Telar
PCB_Telar_2
PCB_Telar_NPN
PCB_Telar_NPN_1
PCB_Telar_NPN_Adrian
Telar2
Sheet_1
PCB_Telar2
Tinkerbell 1
Manager de diseño
Common Library
Library
LCSC Parts
JLCPCB
Soporte
Recycle Bin
Start
*New Project
*NEW_PCB
PCB_Telar_NPN...
Capas y Objetos
All
Copper
Non-Copper
Objeto
Capa superior
Capa inferior
Capa de serigrafica superior
LoomOne

PCB Design

If we make a closeup to the board design you can clearly recognize the H bridge configuration of the board.

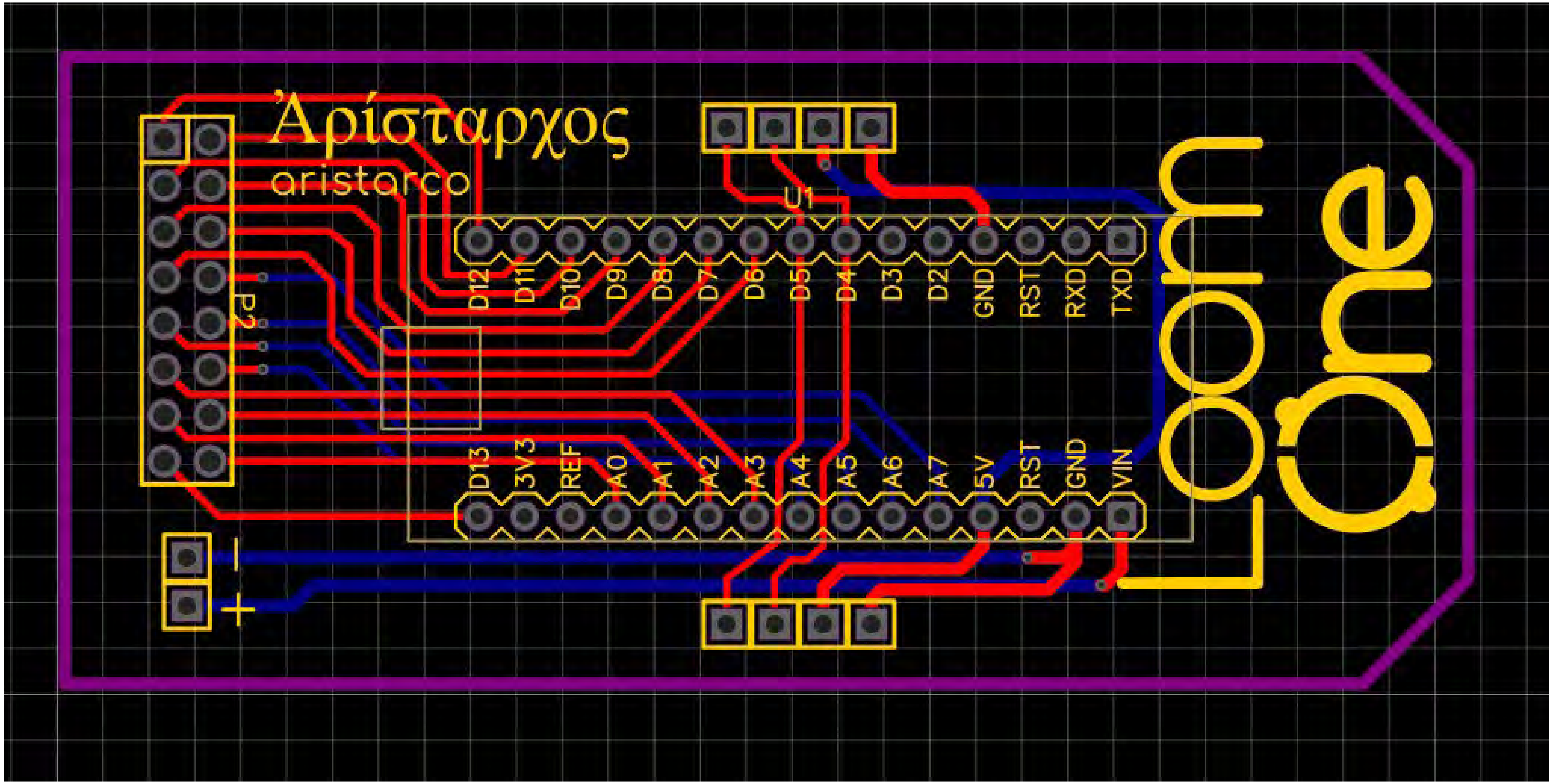


PCB H Bridge Design

By the way, I triple checked the board design and the moment I made this close up, I saw a mistake. -*Can you spot it?* :(

The electronic control card for each of the actuators that select the meshes is connected to two slave circuits that will be controlled from a master as indicated in the software section on this page.

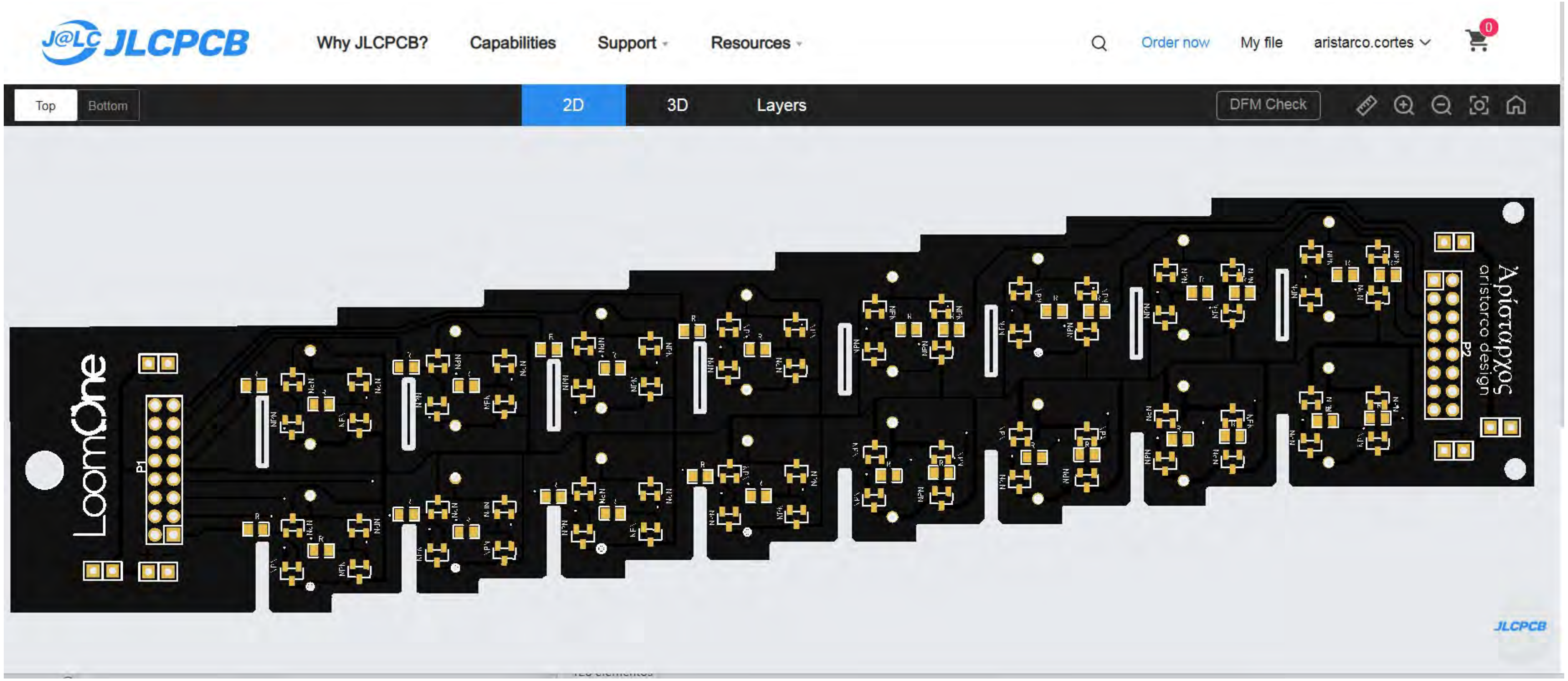
I decided that the slave cards would be controlled with an Arduino Nano board, as it had enough control pins to manage 8 wires (16 ports) plus the power and I2C communication pins. These cards were also designed in EasyEDA.



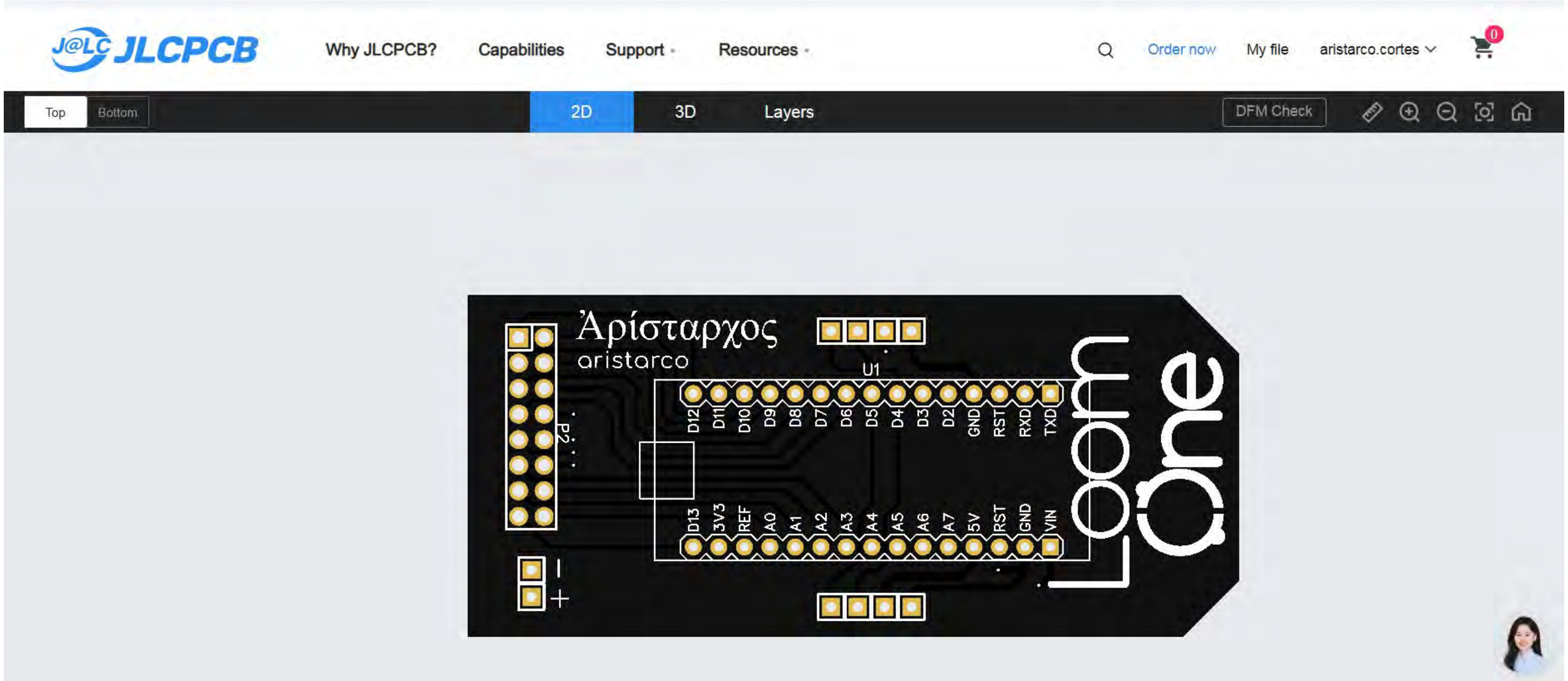
PCB H Bridge Design

Once the boards are designed with EasyEDA, the integration with the JLCPCB factory in China, which manufactures them professionally in just a week and a half.

The design of the Gerber files can be seen in the following images:



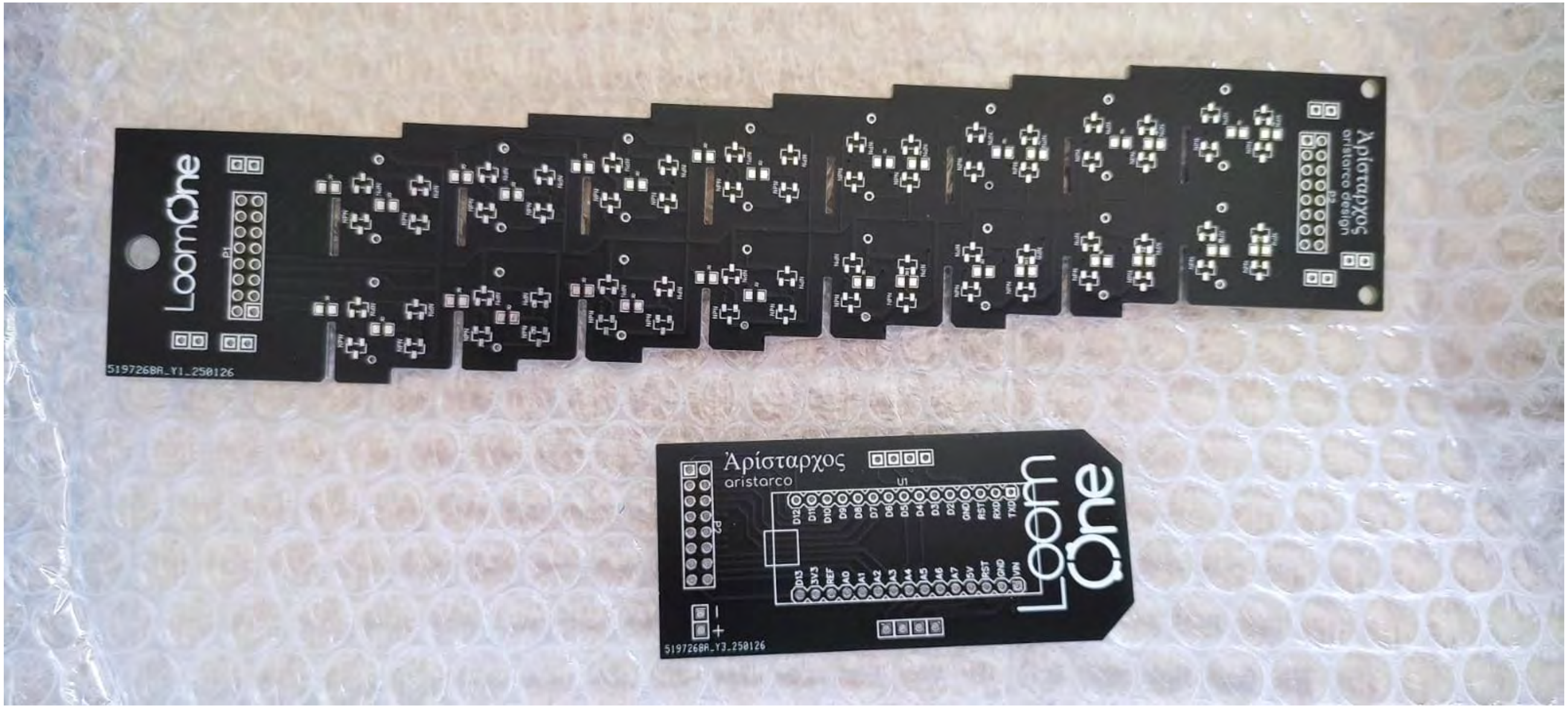
Fabrication file for Loom One controler



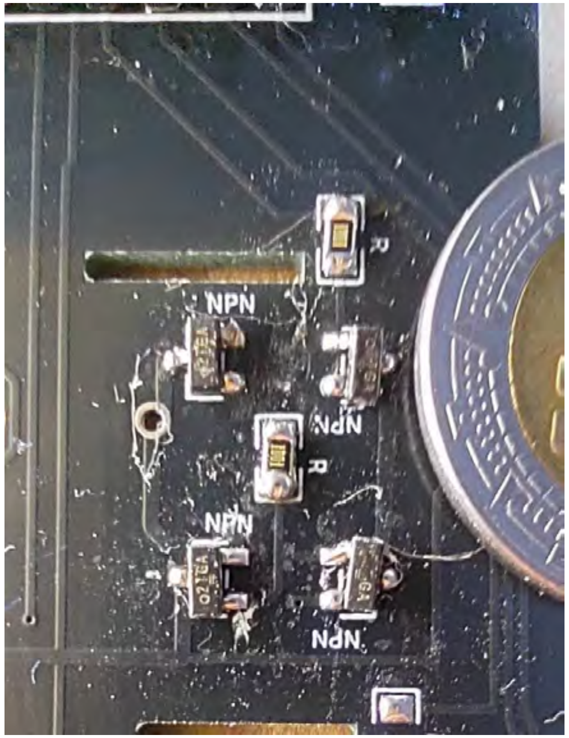
Fabrication file for slave board

It is worth mentioning that when I sent the cards to be made, I had a problem because the design of the card's print interfered with the cutting layer. I must thank **Adrian Torres** from *Fab Lab León* for helping me solve the problem and lending a hand to review the card.

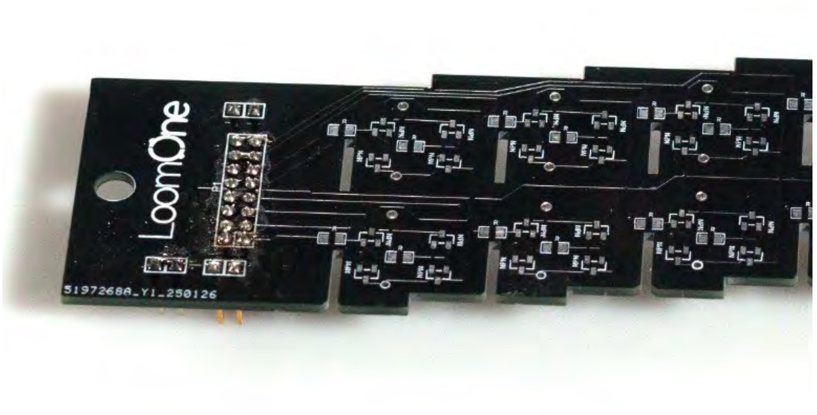
I received the PCB boards after two weeks and all the components from Mouser.



I designed the board with very small components due to the size and the amount of them that I had to insert on the board.



Finally Loom One PCB is ready to test



Arduino nano slave boards

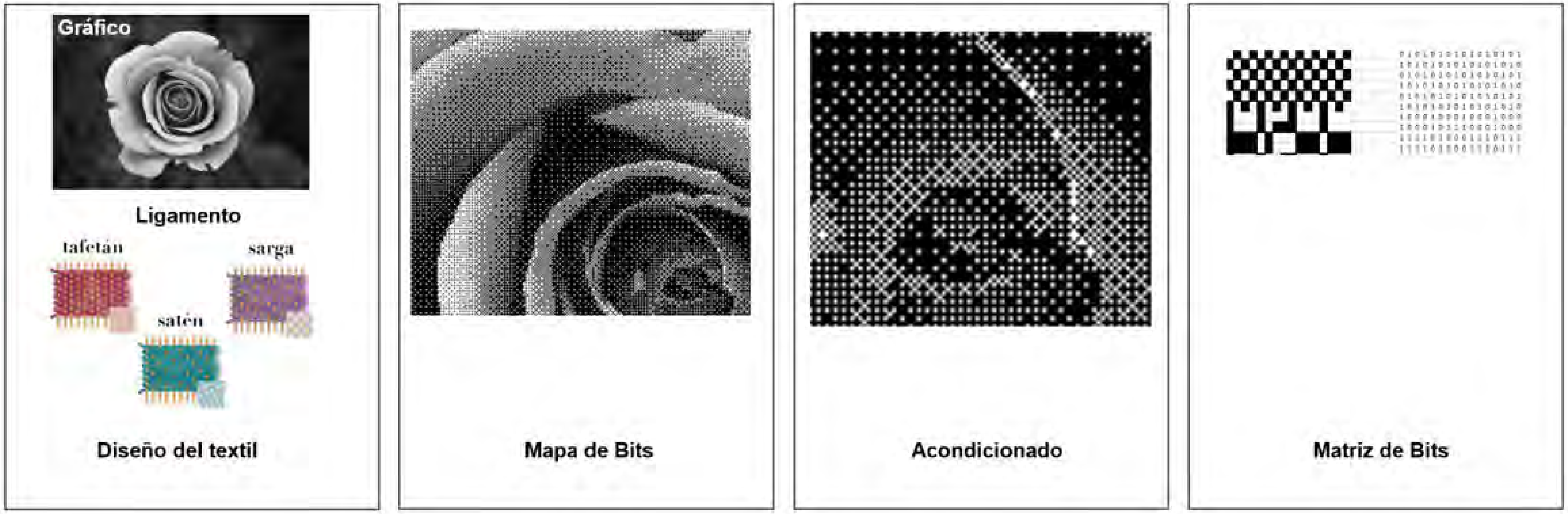
The electronic boards burned during use. The short circuit is not immediate, which suggests that for some reason the H-bridges are allowing current to pass through instantly.

Software

The process

The numerically controlled automatic loom Loom One involves a process of signal transmission to the loom that begins with the selection of an image and a type of weave to be used, with options including, for example, taffeta, twill, and satin. Subsequently, the selected image is converted into a bitmap considering the resolution and the number of colors to be used, where the resolution is determined by the number of threads per linear centimeter that the loom has in the direction of the weft. In this bitmap conversion, a first filter is applied to ensure that each pixel corresponds to a pick of each individual thread.

Subsequently, a conditioning procedure of a file is carried out to be worked on the loom conditioned by the design and the selected weave, where this conditioning can be done automatically, partially automatically, or manually, depending on the complexity or effects intended for the fabric finish. Finally, the color matrix in pixels is converted into bits of zeros and ones, where this conversion is done line by line of the design, respecting the order of these lines since each bit represents the pick in each of the weft threads. The resulting matrix of zeros and ones will be interpreted by the loom's processor line by line to carry out the weaving.



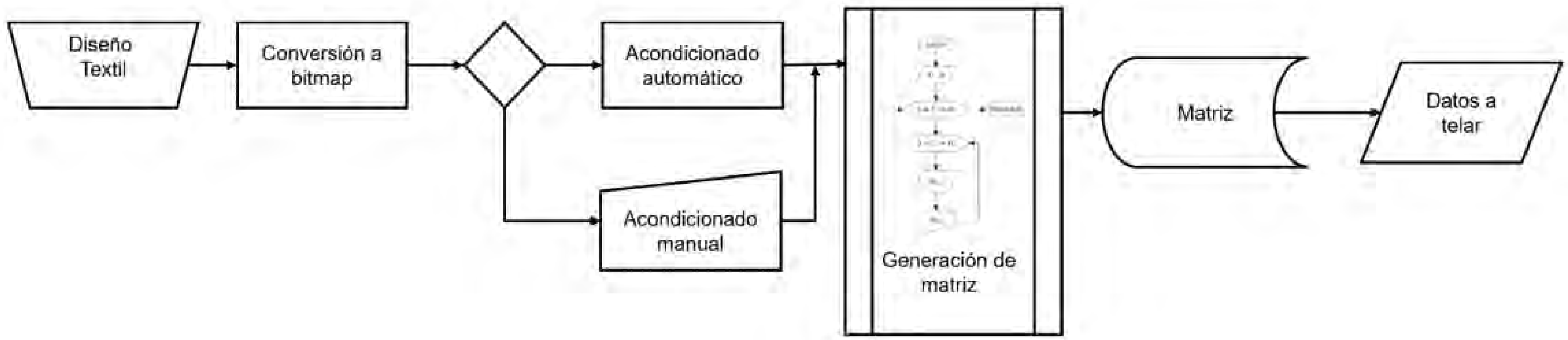
Loom One software configuration

In other words, the process of sending transmission signals to the loom begins at a textile design stage where a user creates, defines, or selects a pattern that serves as a base for weaving. This textile design can be crafted using specialized graphic tools, allowing the designer to precisely define the visual elements that characterize the fabric, such as colors, shapes, geometric patterns, and the chosen weave type. This textile design is the visual representation that will later be transformed into detailed instructions for the loom.

Once the textile design has been completed, the next step is to convert it into a bitmap, where the initial textile design, which could be in a vector or raster format, is transformed into a bitmap (bitmap) format. This format is particularly relevant as it represents the image as a grid of pixels, where each pixel is interpreted as an individual point in the design. In this bitmap conversion stage, the design is broken down into a series of discrete points, each corresponding to a specific action of the loom. The conversion to bitmap not only adapts the textile design for digital processing but also optimizes the file for use in the subsequent stages of the process.

After the conversion to a bitmap, the signal is transferred to an automatic conditioning stage (90) where a series of automatic adjustments are made to the file to ensure it is in the best condition to be processed by the loom. This conditioning may include correcting any distortion that occurred during the bitmap conversion, optimizing the color palette to match the loom's capabilities, and adapting the design to the specific dimensions of the fabric to be produced. Even in alternative implementations, there are automatic adjustments to the image resolution, ensuring that every detail of the design remains intact during the weaving process. Automatic conditioning (90) is important to minimize errors and prepare the design for precise interpretation by the machine.

In some cases, automatic conditioning may not be sufficient to ensure that the design is reproduced with the desired fidelity in the final fabric. Therefore, an auxiliary phase of manual conditioning is included, which allows for operator intervention to review the automatically prepared file and make additional manual adjustments. These adjustments may include correcting minor undetectable errors, adapting certain design elements to better fit the characteristics of the material to be used, or modifying details to ensure that the final design meets the client's or project's expectations. Manual conditioning is a crucial stage to ensure that the final design perfectly meets the specific needs of textile production.



Loom One software configuration

Subsequent to the design being fully conditioned, the process is taken to a matrix generation stage, which is an essential stage in the process, as it involves the creation of a data structure in the form of a matrix that maps each part of the design to specific instructions that the

The Matrix generation

The matrix generation includes a start, where the dimensions of the matrix are defined using the variables "m" and "n," these variables being fundamental since "m" indicates the total number of rows the matrix will have representing the number of threads the weft in the fabric will have, while "n" determines the number of columns obtained by multipling the number of threads per centimeter and the with of the fabric. At this point, after the start, only the necessary foundations for what will come next are established, without yet performing any concrete operation.

Next, the sequence of matrix generation enters a loop that controls the iterations over the rows of the matrix, and this loop starts with a primary assignment where i = 1, indicating the beginning of work with the first row. This assignment will ensure that each row of the matrix is processed, iterating from i = 1 to i = m, and each time an iteration over a row is completed, the index "i" is incremented by one, thus moving to the next row.

Moreover, within the row cycle, the sequence enters a secondary assignment that controls the columns of the matrix where this assignment starts with j = 1, it is responsible for iterating over all the columns of the current row, just as the row cycle ensures that each row is processed, the column cycle guarantees that all cells within a row are assigned correctly where this sequence continues as long as "j" is less than or equal to "n", and with each iteration, the index j is incremented, moving to the next column.

A crucial stage within this cycle is the tertiary assignment for the value of a cell a(i, j) in the matrix, as it is here where the matrix generation sequence truly "builds" the matrix, filling each cell with a specific value and where this value could be constant, generated, or derived from a mathematical function, depending on the particular application of the sequence and where the reference to (i, j) identifies the specific cell in the matrix where "i" corresponds to the row and "j" to the column.

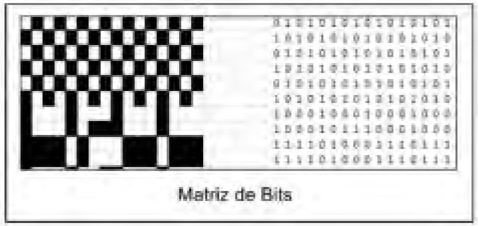
Once the value has been assigned to a(i, j), the column loop continues, processing the next cell in the same row, and when all the columns of a row have been processed, the column loop completes, and control returns to the row loop. At this point, the index "i" is incremented, and the process of traversing the columns starts again, but now for the next row.

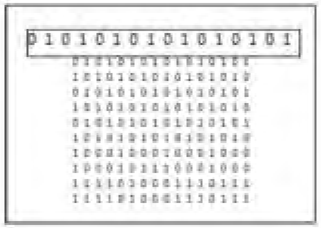
This iterative process continues until all the rows and columns of the matrix have been processed, ensuring that each cell has been filled and subsequently, the sequence has an end. Preferred implementations of matrix generation include one or more validation stages to ensure that the matrix has been generated correctly and, depending on the environment, it may also be necessary to release resources such as memory or processes that were used during the execution of the sequence. The result of this process is a fully formed matrix of size m x n, where each cell a(i, j) contains a value assigned according to the rules defined in the assignment step.

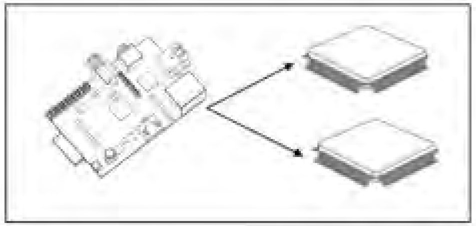
The final step¶

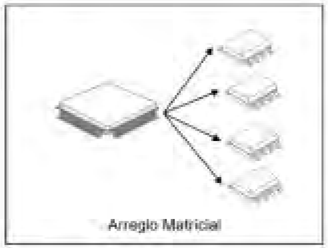
Finally, once the fully formed matrix has been generated, it becomes a dataset for the loom, as this data is essential for the loom's operation, providing all the necessary instructions to accurately reproduce the textile design. The loom uses this data to control the movement of the threads and the creation of the pattern on the fabric. During this process, the loom follows only the instructions provided by the fully formed matrix, ensuring that each thread is placed in the correct position, with the appropriate tension, and in the specified order, resulting in a fabric that faithfully reflects the original design, from the shapes and colors to the smallest details.

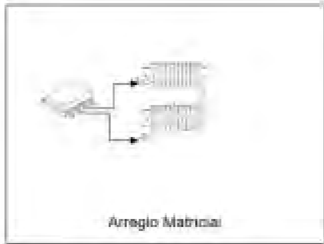
Subsequently, the fully formed matrix is introduced to a master loom circuit for interpretation, where the first line of instructions is separated to divide the information among the slave circuits distributed in a matrix, depending on the number of threads assigned, the corresponding instruction will be given.











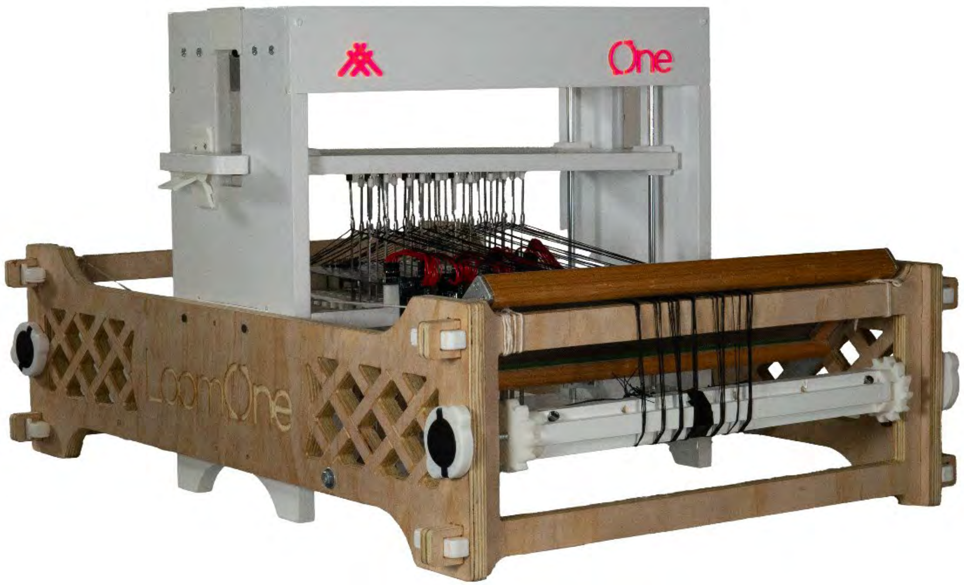
Information transfer process

Subsequently, there is a transfer of information corresponding to each slave microprocessor; this assigns to the controller, corresponding to the electromagnets of the actuators, the state of the central arc to be positive, negative, or floating, as the case may be, where it will act to one side, the other, or nothing will happen. This configuration is in view of the matrix arrangement of the actuators, which allows reducing the number of circuit components.

Once the actuators have changed state, the frame is raised to take the free meshes and lift the corresponding threads from the foot using the magnetic or spring mechanism, and then the weft is manually woven.

At the lower limit switch of the frame, there is a switch, preferably a micro switch, that sends a signal to the master microcontroller to read the next line and continue the weaving process until the entire information matrix is complete.

08. Results



The outer frame

Finally, an exterior frame was built with ideal characteristics to be manufactured in a Fab Lab.The frame with the appropriate measurements was made with plywood and the Sashimono technique was used with 3D-printed pieces that fit together to give the frame structural integrity.

The frame with the appropriate measurements was made with plywood and the Sashimono technique was used with 3D-printed pieces that fit together to give structural integrity to the frame. The inner frame

The inner frame

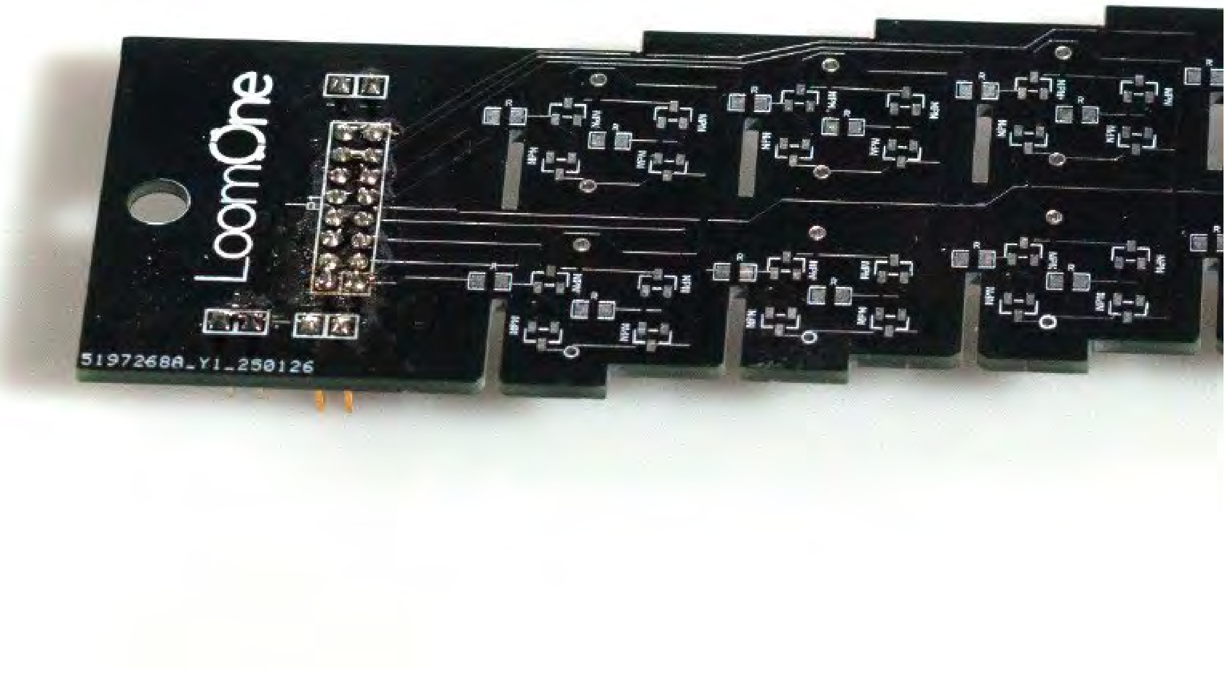
The inner frame was modified to hold the heddles and the cards.It was increased in height and new guides for the heddles were fixed.The frame was also made of veneered plywood so it could be built in a Fab Lab.

Development of new heddles

The heddles were redesigned to match the new measurements of the loom's central frame.The heddles were cut with a water jet and matched the new measurements.

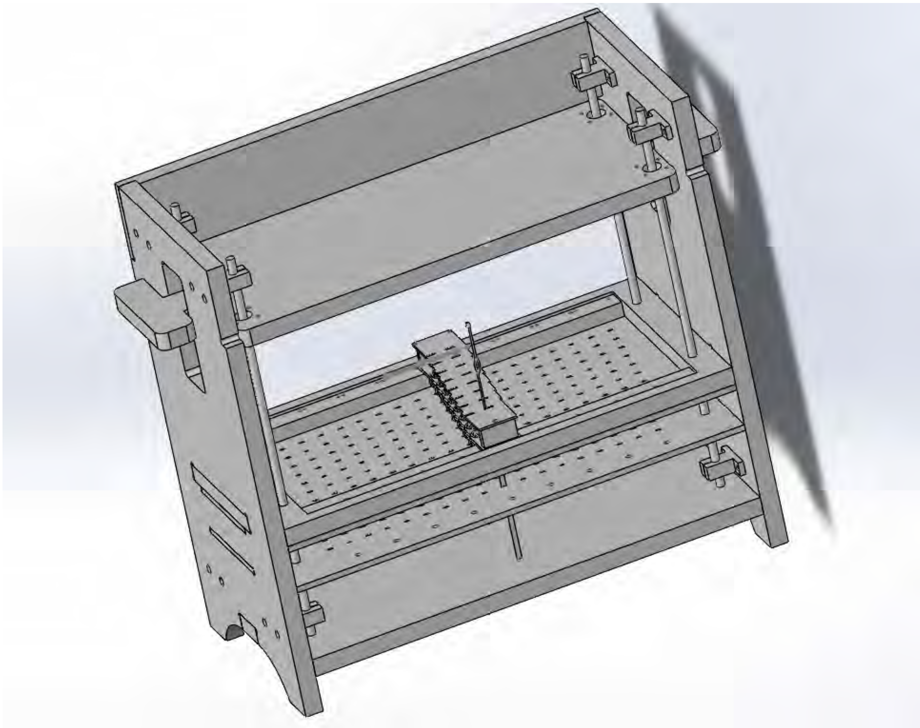
Development of master and slave electronic cards

New master and slave electronic boards were designed and developed.In the case of the slave cards, it was decided to use H-bridges to control the polarity of the electromagnets that change the state of the electromagnetic actuators.Additionally, the decision was made to use Arduino Nano as masters for each half slave card due to the number of free pins that were needed.



Development of a new board to lift the heddles

A new method for raising the heddles is being developed.Although the previous magnetic method was retained, the new plate was designed with 8 mm linear guides that run on a guide similar to 3D printers.



Magnets

The gripping system of the magnets to the heddles was also modified to accommodate a slightly larger magnet, and it is worth noting that no supports were used during the printing.Not using supports in the printing was a success since the magnets are better horizontally leveled, which causes the attraction to the plate that lifts the magnets to be much more uniform.

Tension system

The complete tension system was also designed similarly to the one used by Dorothy LeClerc.The system proves to be complex to maintain uniform tension on all the threads.I assume that this tension is possible in the Dorothy because in each frame the same number of heddles is always raised, which makes the tensions of the threads similar.

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09. Opportunities & Next steps

There are many lessons in this iteration of LoomOne that will help in the construction, hopefully, it will be the final one for the next loom.

1. **Body.** The construction in plywood can be beautiful and manufacturable in a fab lab, but it is not functional for experimentation. In this iteration, two complete versions of the loom frame had to be built, along with several more versions of some parts. Likewise, the forming frame had to be modified by hand due to issues with assembling the complete system. Additionally, beside CNC router, using plywood involves many hours of post-processing, such as sanding, conditioning, painting, etc.

   For this reason, the next iteration will be done with a 20mm ITEM profile. The ITEM profile is an aluminum extrusion that allows for easy assembly, disassembly, and modification of equipment and prototypes quickly and effortlessly. All the joints will be made using 3D printing to reduce costs and facilitate design.

All joints will be made using 3D printing to reduce costs and facilitate design. 2. Mesh lifting plate.

2. **Mesh lifting plate**. In this iteration, the plate that lifts the meshes was designed with four 8-millimeter linear bearings with their respective guides so that the plate would lift homogeneously. Unfortunately, the linear bearings have a slight play that causes the guide plate to lift unevenly, which makes the upward movement non-uniform and hinders the movement of the meshes.

   In the next iteration, the plate that lifts the meshes will be supported by three bearings that will rest inside each of the four rails of the ITEM profile that holds the plate.Similar to the design of Prusa-type 3D printers (i.e., Ender 3).

3. **Reed**. The reed was designed as in the other iterations. It functions like an inverted pendulum; in the next iteration, the feasibility of it being like a device that travels horizontally, similar to the TC2´s reed. This idea will be evaluated. With this horizontal movement, it is possible to conduct experimentation with a mobile reed similar to that carried out by Gali Cnaani and Yoav Sterman

from the Faculty of Architecture and Town Planning, Technion, Haifa, Israel.

4. The 3x4mm **magnet** used in this iteration to lift the heddles seems to be successful. The printed part without supports helped ensure that the adhesion between the magnet and the piece was flat and improved the grip on the plate that lifts the heddles. It's something to repeat and evaluate more extensively.

5. The gap between the release of the half-moon gripping mechanism and the electronic card is approximately 2.5cm, a space sufficient for the heddle to slightly rotate and cause it to stumble over the openings of the electronic plate, sometimes preventing the lifting of the heddles.

   To ensure proper functioning, it is necessary to design a piece that serves as a guide for the heddles from de actuator board to the opening of the electronic plates. This needs to be done in the next iteration.

6. The electronic boards burned during use. The short circuit is not immediate, which suggests that for some reason the H-bridges are allowing current to pass through instantly. The above may be due, we believe, to the fact that the transistor is not initialized to ground at the beginning of the

process, which should all be grounded to prevent current from passing. The second hypothesis is that the response speed of the transistor to the control signal is slower than programmed, causing the connections to momentarily short-circuit.

Work is being done to solve the puzzle for the next iteration.

7. The warp tension system was designed similarly to the one used in traditional looms. At the time of the test, this made it difficult to achieve the correct tension of the foot threads. There are differing opinions on whether these looms should have individual tension for each thread, as is the case with the SpeerLoom. In the next iteration, a system for individual thread tension will be evaluated and, if necessary, designed, as is the case with the Speerloom. Certainly, this system allows for experimentation starting from the warp.

8. It is necessary for the winding of the electromagnets that move the loom actuators to be more uniform. It will be necessary to redesign the winding machine to give repeatability to the operation and thus standardize the process.

9. The design of the electronic connections between the cards and the master was designed to be vertical. The new design should be at 90 degrees since the connection takes up too much space and can interfere with the passage of the warp threads.

All these findings will be taken into account for the next iteration, the LoomOne V5.

10. References

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11. About me

I am a mechanical-electric engineer with MBA studies and aspiring polymath. I have over 30 years of working experience in different sectors, such as industry, government, and universities. I am an entrepreneur, in love with fabrication processes, *Fab Academy alumni*, and **hard-core Maker**. After being director of the biggest makerspace in the world, the Innovation, Design, and Technology Institute, IDIT, at the Jesuit Iberoamericana University of Puebla, Mexico, today I develop entrepreneurial tech, social and innovation projects.

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