Transforming 3D printed CNC prototype into a plotter

LI Culda[1], ES Muncut (Wisznovszky)[1], GM Erdodi[1]

[1]University "Aurel Vlaicu" of Arad, Department of AIITT B-dul Revoluției Nr. 77, 310130, România. P. O. BOX 2/158 AR,

lavyy_99@yahoo.com

Abstract. We often hear about numerical control or CNC abbreviated. With this type of control, we can automatically control various processing tools such as: drills, lathes, milling cutters, rapid prototyping printers, etc. The instructions they need to receive will be in the form of a Gcode sequential program generated by the CAD / CAM drawing and manufacturing program. In the case of 3D printers, the CAD / CAM information is passed through a slicer specific to that printer, which "cuts" the object into printing slices. CNC systems are used today for virtually any process that has movements and operations, including laser cutting, hole punching, fabric cutting, welding, etc. because most CNC systems built today are 100% electronic. 3D printing of a CNC was a real challenge that aimed to understand the principles of obtaining and operating a CNC. I found that we basically have 3 devices with the same basic principles: CNC milling cutter, 3D printer and plotter. So I created a CNC that I turned into a plotter just to highlight the above.

1. 3D CNC design

In the industry we often hear about numerical control or abbreviated CNC. With this type of control, we can automatically control various processing tools such as: drills, lathes, milling cutters, rapid prototyping printers, etc.

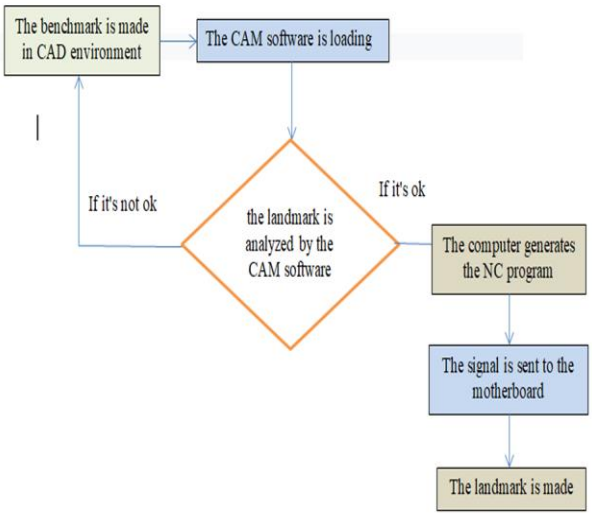
The command is coded in Gcode via a computer and has the advantage that we can process various materials: metal, plastic, wood, etc. without a human operator to perform the processing operation directly.

CNC control, even if it has become commonplace nowadays, brings a significant improvement in production compared to the classic processing method. The design of a part is done with CAD systems and then the overall data, processing speed, geometry, etc. are translated into values and commands necessary for manufacturing through the CAM software and loaded into the machine software.

The instructions they need to receive will be in the form of a Gcode sequential program generated by the CAD / CAM drawing and manufacturing program. In the case of 3D printers, the CAD / CAM information is passed through a slicer specific to that printer, which "cuts" the object into printing slices.

CNC systems are used today for virtually any process that has movements and operations, including laser cutting, hole punching, fabric cutting, welding, etc. because most CNC systems built today are 100% electronic.

Starting from these known data, we started to realize the concept of 3D printed CNC. The basics of a CNC lathe or 3D printer are the same significant difference being the mode of operation and control.



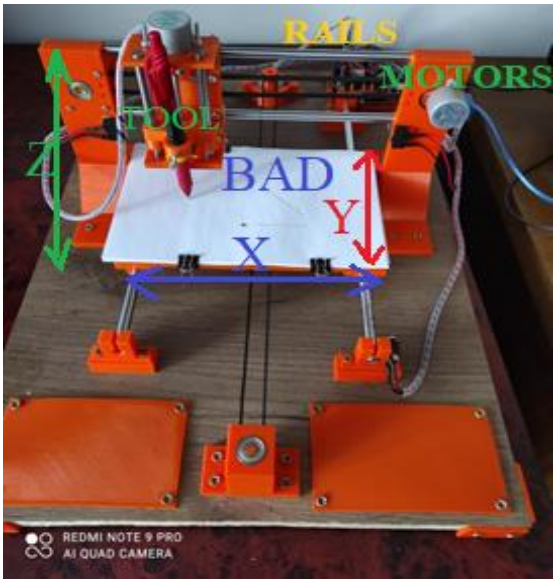


Figure 1.Logical scheme

Figure 2.Construction of 3D printed CNC

The movement I want to control is on the x and y axis (mass) and on the Z the tool. The position of the tool is driven by stepper motors with direct drive or actuators to provide precise movements, the control in the open loop works as long as the forces are kept small enough and the speed is not too high.

2. Making CNC components using 3D printing

To make the components of the CNC we used 3D printing with filament. Printing is done after the landmark is created in a CAD environment.

For my project I used CAD drawings made in Fusion 360 and I printed the parts on CTC printer.

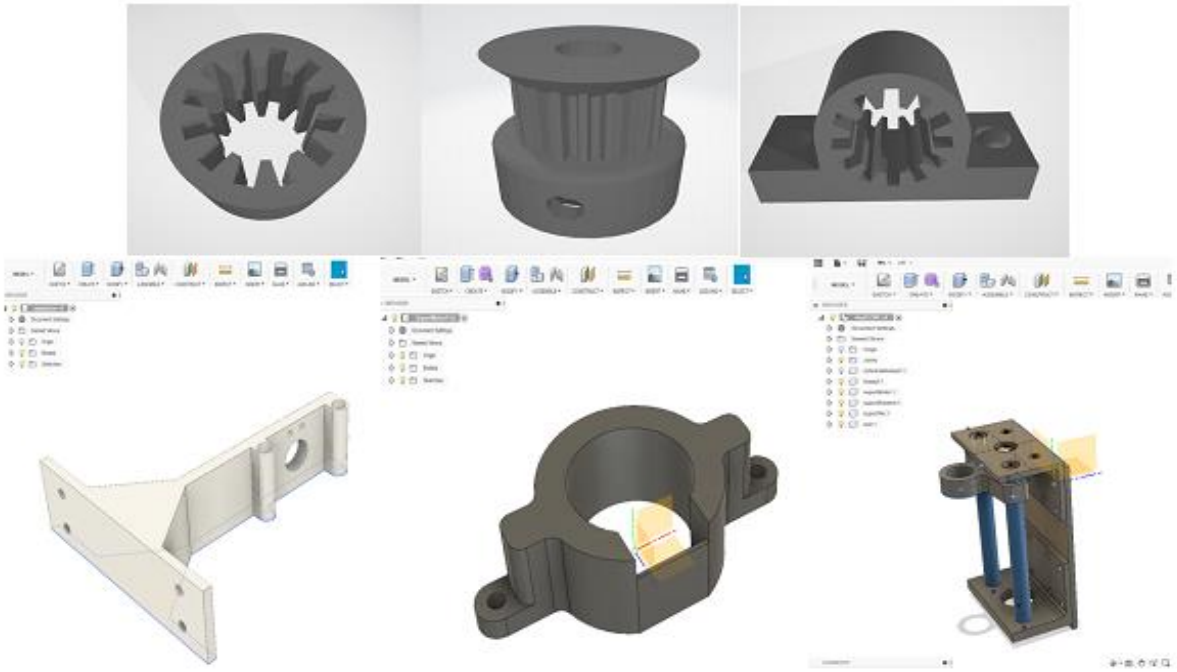


Figure 3.CAD drawings

To print them, each drawing was saved as an STL and passed through the CURA printer software

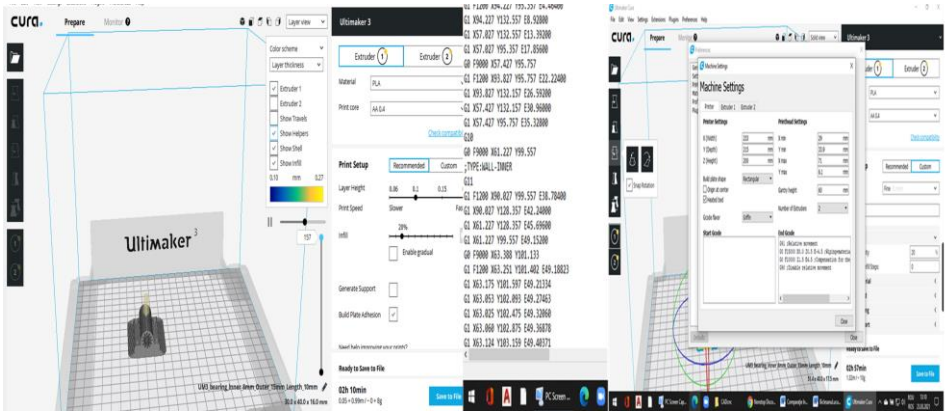


Figure 4.Cura (Cura printer software, 2021)

The Gcode is generated and the landmarks are printed

3. Realization of 3D printed CNC

After 3D printing of the components, the CNC was assembled**.**

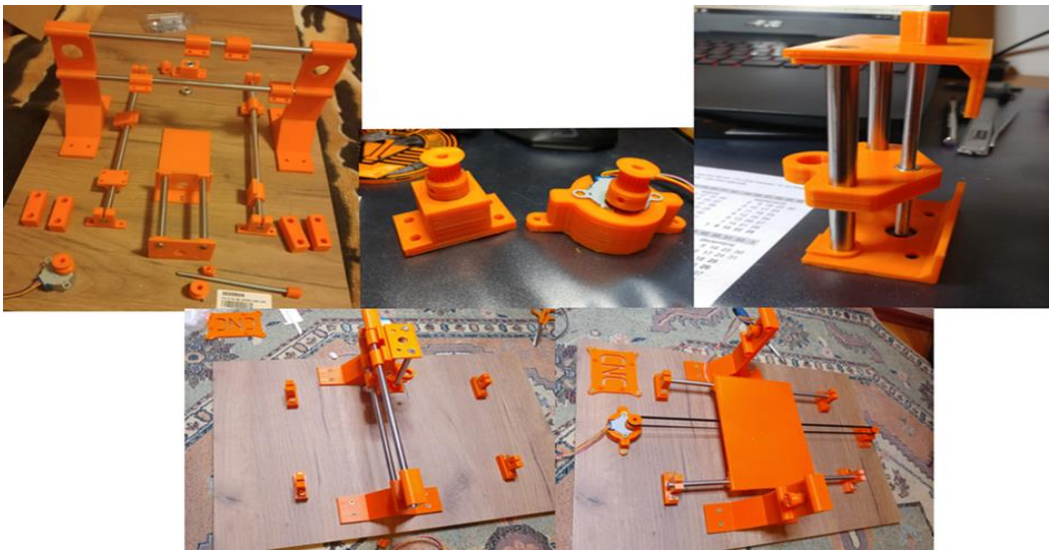


Figure 5. Realization of 3D printed CNC

The printed parts were used to mount the CNC prototype:

- Printed constructive landmarks
- Guiding and joining elements
- Stepper motors 28BYJ-48: are among the most used in various hobby-electronics applications, 3D printers, but also on certain industrial machines ex mini-conveyors, medical equipment, air conditioning systems, etc.

Figure 6.Stepper motors 28BYJ-48

- **Development board Arduino UNO.** The Arduino UNO microcontroller will represent the "brain" of this prototype. I chose the Arduino UNO version, because it is very different from the previous boards, in the sense that it does not use a USB-to-serial FTDI driver chip. Instead, it has the built-in Atmega8U2 microcontroller programmed as a USB-to-serial converter. The Arduino UNO module is a development board based on the ATmega328 microcontroller. Arduino UNO has 14 digital pins, of which 6 can produce pulse width modulation (PWM - Pulse with modulation) and 6 analog pins. Data transmission on the Arduino UNO board is done via a USB cable, connected between the board and the USB port on the computer.

Figure 7.Arduino UNO (Microcontroller Arduino Uno, 2021)

- **Arduino CNC Shield V3**. Arduino CNC Shield V3 is a platform specially designed for the Arduino UNO board that is to be used in the construction of CNCs with various applications of cutting, milling, drilling but it can also be adapted to marking CNCs , laser engraving or cutting, 3D printers, etc. This Shield is capable of supporting up to 4 drivers that can be used for 4 DC / Stepper motors and separately a servo motor, besides all this being a platform designed for CNC has adapted and the connection of mechanical limiters for each axis (+/- X, Y, Z), coolers, emergency button and supports a voltage supply between 12 and 36 V which gives it the possibility to be interconnected with a wide variety of motors in CNC applications. I chose this shield due to the fact that it was designed for Arduino UNO, giving it 100% compatibility in CNC applications that will be run through this shield, but also the ease of connecting the shield with Arduino UNO and drivers for engines. Basic knowledge of electronics is required to connect motors, mechanical limiters and certain safety buttons.

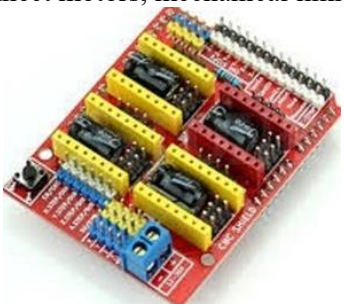


Figure 8 (Arduino CNC Shield V3, 2021)

- **Driver A4988**. The A4988 driver provides a motor drive solution for printers, scanners and other automated applications. The device has two integrated H-bridge drivers and a micro-step indexer and is designed to drive a bipolar stepper motor. The driver output block consists of MOSFETs - N-channel configured as complete H-bridges to drive the motor windings. A4988 is capable of conducting up to 2.5 A current on each output (with a corresponding cooling to 24V and 25 ° C). A simple STEP / DIR interface allows easy connection to control circuits. There is a reduced sleep mode, which stops the internal circuit to obtain a very low current draw. This standby mode can be set using the dedicated nSLEEP pin. Internal shut-off functions are provided for overcurrent, short circuit, voltage lock and high temperature. The fault conditions are indicated by the nFAULT pin.

Figure 9.Driver A4988 (Driver A4988- pine configuration, 2021)

For this project I chose the Arduino UNO microcontroller, together with a shield designed for CNCs capable of controlling up to 4 steering axes, Arduino CNC Shield V3, three stepper motors 28BYJ-48 controlled via the Arduino CNC Shield platform V3 driven by three drivers of A4988 motors and a scanner source 12V - 1.2A to supply the prototype, I also used four limiters for the X, Y axes, for the mechanical part of the X and Y axes we opted for guide axes and linear bearings of 8 mm. The rest of the mechanical parts were designed in Fusion 360 and printed in 3D. The stand that will serve as a foundation for the prototype will be built of chipboard (Particleboard).

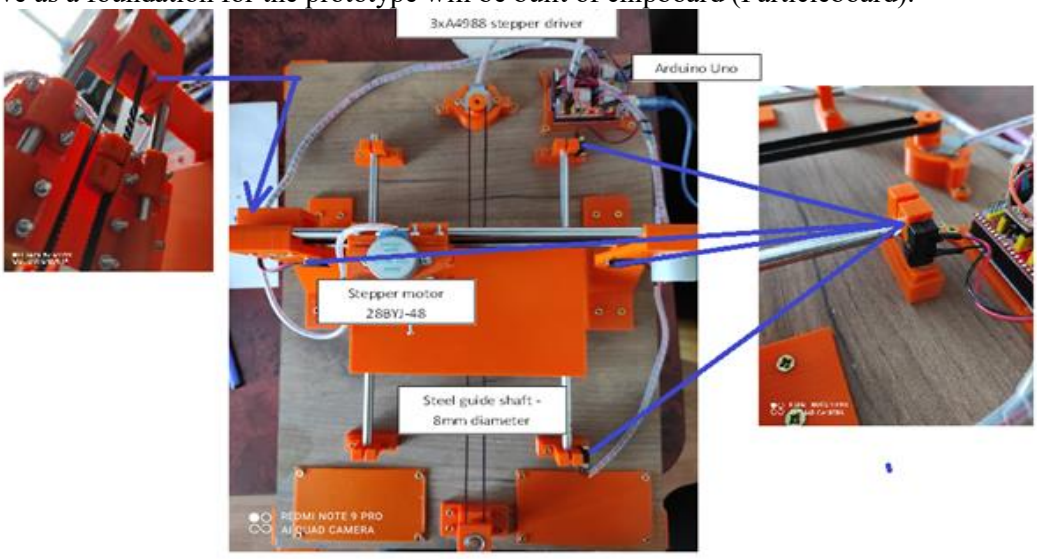


Figure 10.CNC prototype

4. Transformation of the CNC prototype into a Plotter

Because for CNC testing we did not want to attach tools, I transformed the CNC prototype into a plotter.

A plotter allows us to draw with a writing tool: pen, coloured pencil, pencils, markers, etc.

The drawing support can be on different materials: paper, cardboard and even glass. I opted for paper.

The attachment to the writing instrument is done as reliably as possible, so as not to disturb the printing. The writing object is with a small M3 screw.

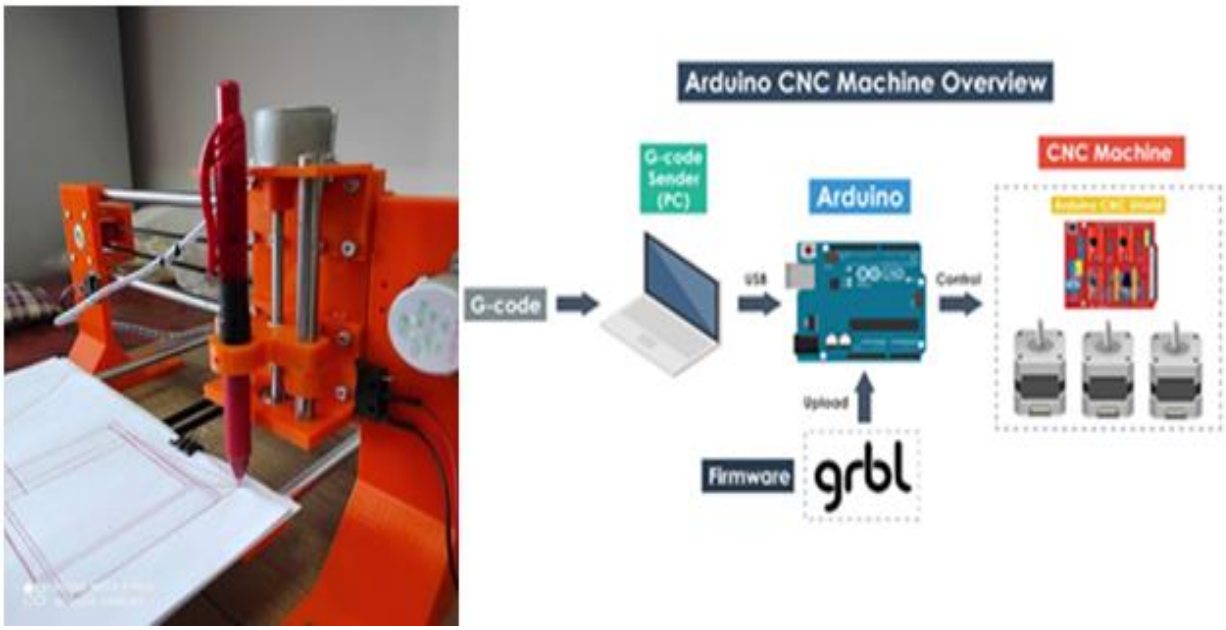


Figure 11.Plotter (Howtomecatronics.com, 2021)

After successfully mounting the writing instrument on the printer, it is time to calibrate it and find the optimal print height. We installed the LaserGRBL v4.2.1 firmware's that our Arduino board can read the G code used by the created CNC prototype.

The choice of the printing model is made taking into account the fact that we will have to obtain a svg vector format. You can also convert JPEG and PNG images to SVG.

In the LaserGRBL software I had the advantage that no svg conversion was needed and I could use jpg images. We uploaded the Image file - Open File - Import Rate Image - we choose vectorization and Crop image to frame the image on the next page - we make the settings of the print mark - generated, at which point the plot code is generated. Choose Send to Machine and start plotting.

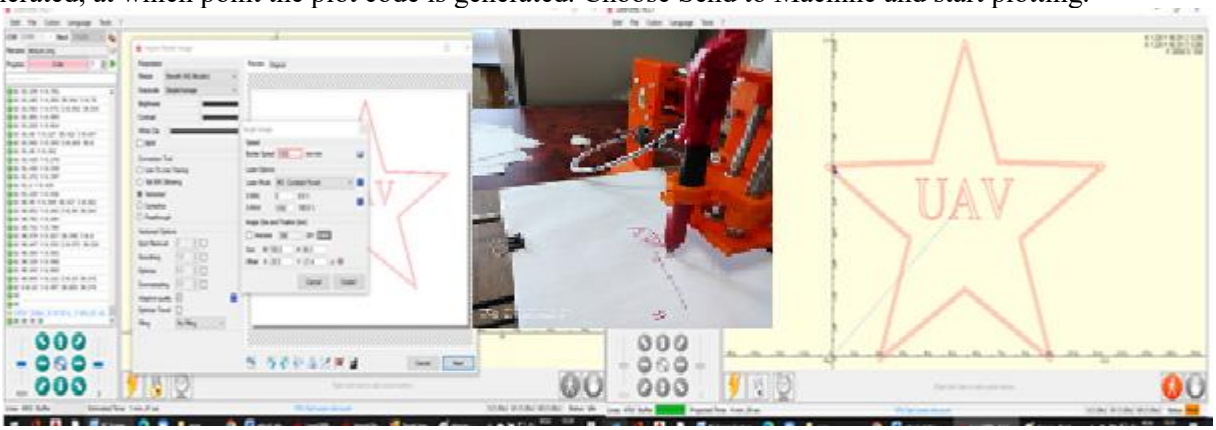


Figure 12.LaserGRBL software

5. Conclusion

3D printing is a new technology but with a very fast growth compared to traditional methods due to the relatively low costs. Although it cannot be used in series production, it allows a freedom of action, which makes it increasingly used in all fields.

The present project aimed to create from scratch a CNC prototype created, printed and assembled, which would allow us to test the degree of adaptability of our CNC to various transformations. Thus, the CNC prototype came to life thanks to the Arduino Uno boards and by mounting a writing device, it became a plotter. If we put a tool on him, he'll cut. So with low costs you can create various devices for teaching or research purposes. This method of obtaining the CNC prototype is recommended to be used in teaching so that engineering students can practically apply what they have learned in specialized courses.

References

[1] Mortoiu Doina, Săbăilă Lavinia, Babanatsas Theoharis, Gal Lucian, AutoCad 2006 Partea I – Modelarea 2D, Îndrumător pentu uzul studenţilor, 84 pagini, Editura Universităţii "Aurel Vlaicu",Arad, ISBN (10) 973 – 752-092-0, 2006

[2] Muncut Elena Stela; Erdodi Geza Mihai; Culda Lavinia Ioana; Komjaty Andrei; Sirghie Cecilia, Determination of speed and accelaration for a plane mechanism with the instantaneous rotation center method and euler's graf-analytical method using autocad mechanical, Source: eLearning & Software for Education., Vol. 2, p420-427. 8p., 2020

[3] Barbu Ionel; Komjaty Andrei; Fogorasi Magdalena Simona; Culda Lavinia; Bucevschi Adina; Kaminszky Robert, Teaching and e-learning about open-end spinning machine., Source: eLearning & Software for Education. Vol. 3, p285-293. 9p., 2020

[4] E S Muncut, L I Culda, G M Erdodi and G Sima, 8D complaint solving method in an automotive component processing company, Annual Session of Scientific Papers "IMT ORADEA 2019" IOP Conf. Series: Materials Science and Engineering568 (2019) 012020, IOP Publishing doi:10.1088/1757-899X/568/1/012020, 5pg

[5] Mortoiu D, Sima G, Săbăilă Lavinia. Holonic Manufacturing System for Safety Sistems Annals of DAAAM for 2009& Proccedings of the 20 th DAAAM International World Symposium, Austrian Society of Engineers and Architects –OIAV 1848, volume 20, nr.1,ISBN 978-3-901509-70-4,ISSN 1726-9679, pag.983-984,Vienna 2009

[6] T V Boshhenko and P V Chepur, Technology infusion of intellectual 3D printersbased prototyping of products into learning process, IOP Conf. Ser.: Mater. Sci. Eng. 327 022020, 2018

[7] *Arduino CNC Shield V3*. (2021). Retrieved from https://ardushop.ro/ro/electronica/148-cnc-shield-v3.html?gclid=Cj0KCQjwo-aCBhC-ARIsAAkNQisHGL1X8jQBPVyJPJc4Il4tuToO3CCz_B69ZDCtI27eTYphrFFSH0waAiVlEALw_wcB

[8] *Driver A4988- configurație pini*. (2021). Retrieved from https://www.sigmanortec.ro/Driver-Stepper-DRV8825-p125423334?gclid=Cj0KCQjwo-aCBhC-ARIsAAkNQiuuf-JhhiKChtQGWzTpx6sztpuZCZyOegiX0UuZnEIoWl7lXlOAUBsaAonBEALw_wcB

[9] *Expeditor universal Gcode*. (2021). Retrieved from https://winder.github.io/ugs_website/#universal-gcode-sender

[10] *Howtomecatronics.com*. (2021). Retrieved from https://howtomechatronics.com/tutorials/how-to-setup-grbl-control-cnc-machine-with-arduino/

[11] *Microcontroller Arduino Uno*. (2021). Retrieved from https://ardushop.ro/ro/home/29-placa-de-dezvoltare-uno-r3.html?gclid=Cj0KCQjwo-aCBhC-ARIsAAkNQitnFZAg4TFZf006Id6QCWg90b9UWagG6-0WTKbM700VNEqp8qzoXwoaArD_EALw_wcB