NUMERICAL CONTROL MACHINE TOOL FOR MILLING AND 3D PRINTING

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1. Introduction

The project's main focus is the rehabilitation, improvement and perfecting a Computerized Numerical Control machine by implementing a modern control module, performant driver modules and extending its functionality with an additional tridimensional printing using Fused Deposition Modeling. At the same time, it was proposed to strengthen the constructive structure of the CNC machine in favor of increasing the milling resolution.

2. Current state

In the current state, the CNC machine was designed, assembled and optimized in Fusion360.

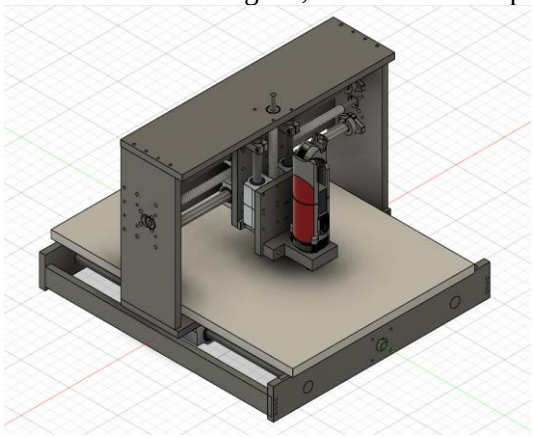

Fig. 1. Overall assembly model

The central processing unit of the machine was replaced with an integrated circuit from Espressif called ESP32. The new IC is faster and more efficient due to its 160MHz clock frequency, 32-bit memory addresses, enhanced flexibility provided by the fast GPIO pin matrix.

Fig. 2. Espressif ESP32 microcontroller [1]

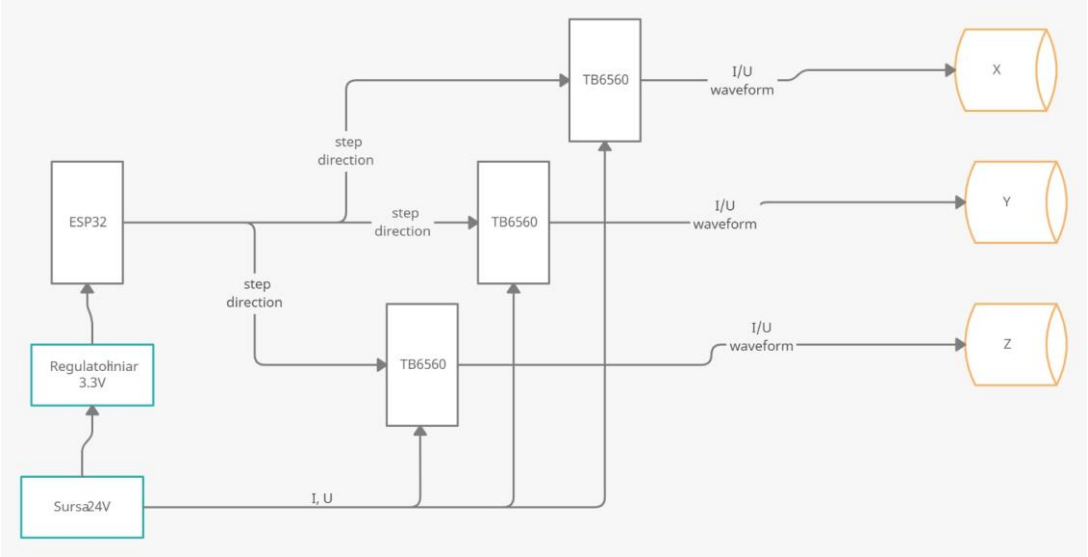

Fig. 3. Electrical block diagram

In regards to the stepper motor control subsystem they have been separated from the main control board with the discrete power drivers TB6560 [5]. These are capable of providing necessary electrical amperage to the NEMA 23 stepper motors which have a 1.8° angular step in 50% decay mode (mixed decay) thus assuring an adequate breaking force while still providing low current ripple and an accurate sine wave to the motor [6][7][8].

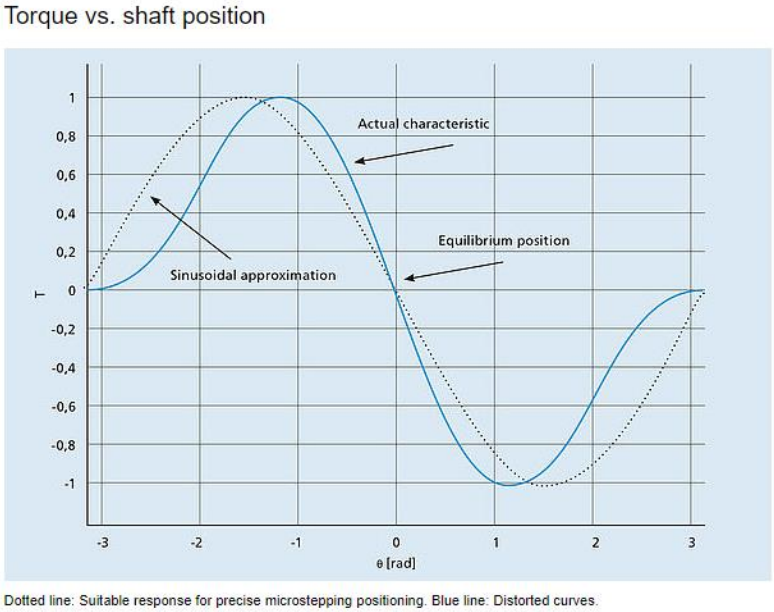

Fig. 4. Sine wave approximation by stepper drivers [3]

As for the used firmware, FluidNC is designed to be implemented on ESP32 having the ability to exploit every subsystem made for actuating the stepper motors [2]. Alongside the out-of-the-box compatibility, it implements a wireless interface which enables real-time calibration and the tramission of G-Code commands, including files.

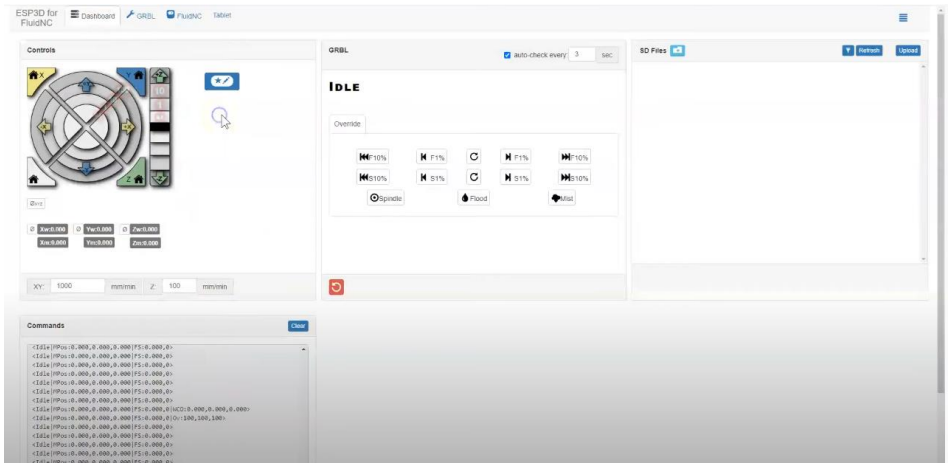

Fig. 6. FluidNC web interface [2]

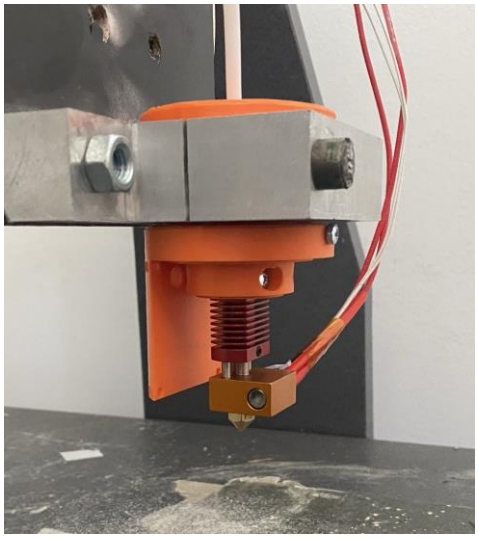
Fig. 5. Adaptor module with hot-end installed

On the subject of 3D printing, an adaptor module was designed to make the current flange compatible with a FDM print hot-end[4]. Paired with this is an aluminum plate fitted with a spring-nut leveling mechanism which serves as a bed.

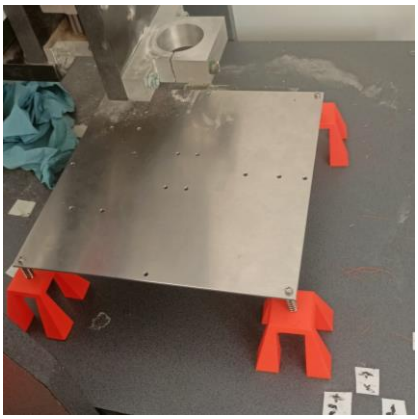
Fig. 6. Leveling bed

3. Conclusions

As for the conclusions, the robotics club now has a CNC machine with the ability to mill and 3D print which can be used in further projects. The machine can now be operated wirelessly using a friendly web interface or third-party programs.

In regards to the improvements that can be made, there is the posiblity to design an adaptor for laser engraving, the addition of an auto-leveling system, a software change to compensate for the backlash of the material and encoders for the backlash of the cinematic chain.

4. Bibligrafie

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