**Project plan: Mechanical keyboard**

Pyry Koivistoinen, 100648540

Abstract

This project is about designing and manufacturing a mechanical keyboard from scratch. Project includes mechanical and electrical design with some programming. The aim of the project is to make a functional keyboard, learn mechanical design in the limits of what is possible to manufacture, learn electrical design and about keyboard matrices.

Introduction

* Motivation, why did I decide to make this project
  + I had over 7 years old Rantopad MXX keyboard and I didn’t like the loud switches it had. I mostly use a keyboard for typing, so the switches need to feel good and they need to be silent. I had been planning on buying a new mechanical keyboard soon, but I decided it would be more fun to try to build one myself instead of buying one. I could learn mechanical and electrical design at the same time and create something myself from the scratch.
* Inspiration
  + Early inspiration for this project was Varmilo VA88M. Its sleek and simple design pleased the eye, and it does fit well with simplified pc aesthetics. Keyboard layout is TKL, tenkeyless, or 80%, meaning that it doesn’t have number pad on the right side of the keyboard. Example of this board can be seen in **figure.** The color theme in CMYK model was pleasant: White background and colorful accents. Another inspiration came from TGR Jane v2. The case’s shape and angle looked good. Additionally, Jane v2 had a F13 extra function key, that seemed like a nice addition. Jane v2 uses ANSI layout for the keys which looks more compact than ISO layout.
* Requirements and budget
  + When doing the research, Varmilo VA88M was around 120 euros. The plan was to aim at similar price, keeping in mind that there might be mistakes in the design process, and redesigns would cost more.
  + More expensive keyboard use aluminum or brass cases or have extra weights attached to the case. This keeps the keyboard steady while typing, makes the case more rigid, which reduced differences in key presses and makes the overall quality feel better.
  + Most important requirements for the keyboard are as follows:
    - Heavy aluminum case.
    - TKL with ANSI layout.
    - Sleek and aesthetically good-looking design.
    - Tactile and silent switches.
    - USB C cable.

All requirements should be met. Keyboard assembly should be as cheap as possible when requirements are met.

* Tools in use?
  + For this project it was necessary to have a way to machine the case and assemble the PCB. For my disposal there was a machining center and soldering equipment.

Methods, mechanical section

* Component design
  + Component design was done by using Siemens NX and PCB design using KiCad.
  + Case
    - I wanted to make the case from one piece to ease the manufacturing. The weight of the keyboard was important. It needed to feel heavy, so the keyboard stays firmly in place and doesn’t move around while typing. The whole construction needed to feel sturdy. Material chosen for the case was Al6082 for its accessibility and mechanical properties. The estimated weight for the case would be **\_\_\_ g.** Keyboard layout is TKL, tenkeyless, or 80%. This layout was chosen because of its compact size, nice aesthetics and there was no need for number pad in daily use.
    - Securing: Case acts as a base for the whole keyboard, so all other components needed to be able to be secured to the case. For securing method, four shafts that had a thread inside were machined inside the case. Keyboard’s PCB and plate were constrained with these holes and pressed down with bolts that prevented the components from moving. Cross section of the constraining method can be seen in **figure.**
    - For best typing experience the keys need to be angled slightly towards the typer, usually angle being 5-7 degrees. Since the case was made in one piece, everything inside the case had to be angled. Limiting factor was the available aluminum billet, that had a height of 30 mm. Inside these limits the case angle was chosen to be **7 degrees.**
  + Keycaps
    - Varmilo VA88M has color combination that was pleasant, so it was chosen to have something similar. The bright colors are too intensive, so it was chosen to have a white base with blue or green pastel accents. In ebay there was a PBT keycap set that had the correct color theme. The keycap set can be seen in **figure X.**
  + Keyboard matrix
    - It would be inefficient to use own diode of every individual switch. This is why BAV70 diodes were chosen. By having two diodes in a compact package, it reduces the number of components on the board, which makes routing traces easier.
  + Switches
    - My previous keyboard had Kailh Blue switches. The switch type is tactile and loud. I like the tactical bump while typing but prefer more silent keys.
    - The best option was Holy Panda switches which are advertised as the most tactile switches in the world [1]. There was no opportunity to test these switches out, but based on the sound tests they seemed good. Unfortunately, whole set of these switches would’ve costed 70 euros, which made them inaccessible for this project.
    - Going with the budget of the board next option was Cherry MX Brown switches. They are tactile, more silent compared to blue switches and very common. Because of their commonness they are accessible with competitive price.
    - One of the requirements for the keyboard was to make it as cheap as possible. Because of this it was decided to buy old keyboard which had the desired switches instead of buying them new. Cheap used keyboard was found from tori.fi that had the desired switches. It was bought and switches removed. The PCB also had leds for every key, which can be used as indicator leds.
  + Keyboard units
    - One key is 1 unit etc. :D
  + Plate
    - Plate is the piece locking the keycaps in place and keeping them from moving. Plate is secured to the case. Plate will be visible at least in the right side of the keyboard when fully assembled. Since the case is made from aluminum, the plate should be too. This matches the materials and gives better structural properties compared to e.g. PLA plastic.
    - I didn’t know where to start with the PCB design, so I searched online for open-source PCB projects. I found one that was based on Hineyboard h88. Differing from normal TKL, this keyboard had F13 extra function key. The keyboard layout was what I wanted, the board looked good, and the project well made, so I decided to order the board from JLCPCB. While testing the board, it turned out that the switch matrix was completely off, every second key was the same as the key before. Because of this I needed to redo the matrix with correct connections. This required a lot of time because I wasn’t familiar with keyboard PCB design.
    - There were still few mistakes in PCB version 2. Two buttons were still tied to the same row and column, which made them register as the same button. This was fixed by cutting the column trace on the PCB and rerouting it to the correct column using jumper wire.
  + Switch stabilizers
    - For longer keycaps that are longer than 2 units, it is required to have switch stabilizer. The stabilizer consists of two buttons and a rod connecting them. When the key is pressed, the keycap is supported from the whole area, and it makes the keypress more stable and haptically better.
    - Problem with plate.
  + PCB
    - It is possible to buy readymade keyboard PCBs, but I wanted to make my own, because:
      * I have experience in PCB design.
      * It is cheaper to make one yourself.
      * I wanted to know how keyboards work.
      * I designed the case, so I needed the PCB to fit and be able to be secured to the case.
    - Requirements:
      * Wanted to use BAV70 diodes, since less components would be needed. It makes the PCB more clean and easier to route the traces.
* Component manufacturing
  + Case and jig CAM
    - All mechanical parts were designed using Siemens NX. CAM was done using Siemens CAM feature.
  + Case machining
    - Case was machined using HAAS UMC750 milling center. It has a capability of milling in five degrees of freedom, but only 3 was needed. Forth dof was helpful for cutting the angles.
  + Plate laser cutting
    - First test version was 3d-printed. It had to be in two parts because the whole plate didn’t fit the 3d-printer. Tolerances for the holes were bit off and some filing work needed to be done to fit the switches into the holes in the plate. Test plate fit nicely, and switches aligned well with the PCB. Next the plate was cut out of aluminum with laser cutting.

Methods, electrical section

* PCB design
  + Problem in v1
* Testing and debugging
  + Communication via USB

Programming section

* Flashing MCU
  + Arduino ISP
  + QMK MSYS
* QMK firmware
  + Mapping kb matrix
* Mapping keys

Discussion

* What was the price?
  + Excel list of components
* How does it look and function?
  + Pictures and video?
* What could be improved?
  + Teams list

Switch design: The best option was Holy Panda switches which are advertised as the most tactile switches in the world. There was no opportunity to test these switches out, but based on the sound tests they seemed good. Unfortunately, whole set of these switches would’ve costed 70 euros, which made them inaccessible for this project.

Linkit:

[1] https://drop.com/buy/drop-invyr-holy-panda-mechanical-switches?defaultSelectionIds=977750