Rochester KLUG Keyboard Meetup

Tim Anderson

Prices Digikey for Hardware Cost

Tim Anderson

Who am I?

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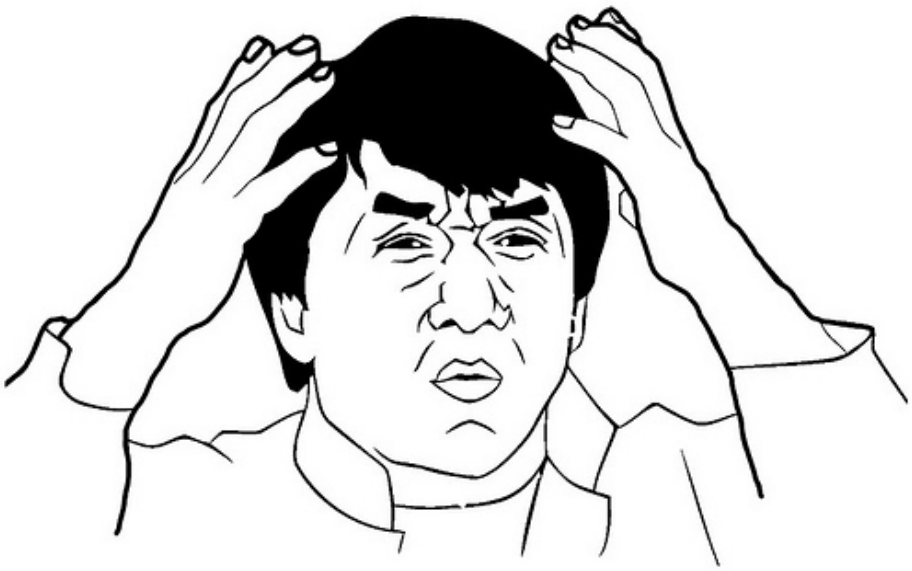
I don't think there's much to tell about myself. I've worked 8 years in manufacturing for a local furniture manufacturer. About 6 of those years I've worked as a machine operator. I own a reasonably sized 3D printer; I tinker with electronics & free software on my free time. You can follow me through the following links. You won't find me on Facebook or Twitter, so don't bother looking for me there.

So, what is this Dactyl Keyboard thing?

- And why should I care?

Parameterized, Split-Hand, Concave, Columnar, Ergonomic Keyboard

- Written in Clojure



Those are a lot of fancy words. What does all of that mean? Well we'll look at the project & see how it compares to a regular keyboard to answer that. But first I'll talk a little bit about the project.

History & Background

yt:uk3A41U0iO4

- https://www.youtube.com/watch?v=uk3A41U0iO4
- Started March 2015
- Made as an attempt at improving on the Kinesis Advantage2? @adereth
- Written in Clojure by using a wrapper arond OpenSCAD

The Dactyl project was originally started in 2015 by a guy named Matt Adereth. I haven't seen what his motivations for starting this were, but I would guess you could find some clues to that on his Twitter page. There are some obvious similarities between this and another keyboard commercially available that I'll show later on, and I think he drew inspiration & motivation from that.

If you're wondering what it means, dactyl means finger, toe or digit.

The really interesting thing about this project is that the mesh was written in Lisp. If you're not familiar with OpenSCAD, it's free software which interprets

functions and creates geometry from that. Obviously it uses a lot of math & complex geometry for more complex objects. Matt didn't like the language that OpenSCAD used, but was able to serindipitously find a wrapper to go around the program that would interpret Clojure and convert it into the language that OpenSCAD understands.

Where is the Project Now?

- Last commit was in 2017
- Left in unfinished state & appears to be abandoned
- Documentation is left unfinished
- OpenSCAD functions don't stay consistant between versions or otherwise play nice with lisp wrapper.
- Most challenging build to take on

So the repository appears to be abandoned since 2017. There are some pull requests left open, and the physical build documentation has been only partly provided by community members. Once you understand the basics of how the electronics work, it's not too complicated, but it reqiures quite a bit of research from dispirate sources.

The documentation for setting up the workflow to be fairly complete, but changes between versions of OpenSCAD seem to break significant functionality and make using the workflow with the wrapper difficult. Many of the meshes other than the standard one currently have holes in them because of these issues.

Because of all of these reasons, and the shape of the keyboard & minimal internal clearance for components, in my opinion this is probably one of the most challenging DIY keyboard projects you could take on.

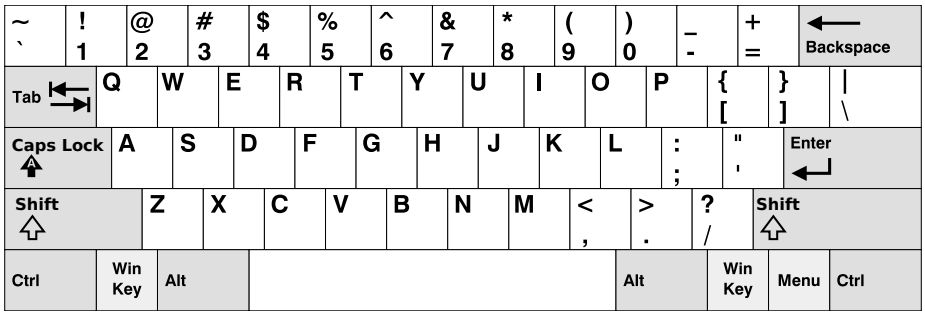
Why Tho?

During my research into this other ergo keyboards I see a recurring question: "Why would you need/want that.", and I think that it's a fair question. It smacks of iPhone ownership or RGB lighting: Do you really need that? To the outside observer it might look like an expensive, showy & unnecessary gadget. But I think there are real health benefits to using a proper ergonomic keyboard, and befor I go any further into my build I'd like to justify myself in the eye of reason.

Before I do that, I should state that I am not a doctor. I do know how to use Google, so I might as well be one–but obviously, this is my understanding from my cursory research. It's not medical advice. Consult your doctor before making any changes to the ergonomics of your workstations. Also, I don't experience RSI issues, nor have I ever. I'm just a guy who thought building my own keyboard would be both a fun & educational project, with a very practical benefit of protecting myself from injury in the future. I take the usefulness of my

hands pretty seriously & I want to be proactive with protecting myself from any unnecessary harm. I use a computer a lot, and I would like to continue using a computer a lot with as few negative affects as I can manage. I had the means to build my own badass keyboard, so I did.

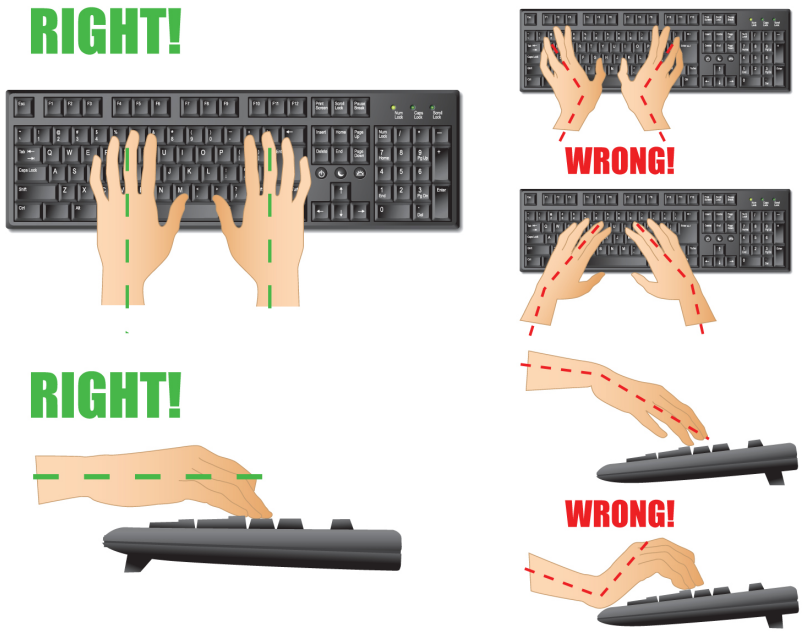
So, let's look at a regular keyboard



- Single board is cost effective & efficient, but can encourage unhealthy posture
- Offset rows are holdovers from typwriters

So this is a regular keyboard, or what would be a regular keyboard if it were an actual image of one. The two things I want to point out here is the width of the design & the offset rows. The offset rows are holdovers from the days of typewriters. The letters were offset like that to allow for the armatures to clear each other when striking the paper. In terms of repetetive strain injury, this is unnecessary & bad, because with today's application this no longer serves any practical purpose, and it's bad becaus you're reaching for those keys that could otherwise be set in a straght vertical column, which would reduce the amount of reaching you need to do while typing. It might not seem like much, but the repetition of an unnecessary movement will probably contribute to the risk of RSI. After looking at the other options available I just think this is a bad, outdated design. If your careers or hobbies depend on your ability to type, it would arguably be wise to foster that capability & invest at least some time into developing healther habits, before it's too late.

Good Habits Vs. Bad



The reason I've included this is to demonstrate how a regular keyboard can encourage a certain posture, and hopefully you can see how the designs of these other ergonomic keyboards I'm about to show you are informed by those issues. I think you'll see how they attempt to mitigate some of these habits through better design. Most of these are other open source keyboards that you can build yourself.

Notable Mentions

So the original Dactyl design is what I chose to go with, and I'll go over my reasons for that later on. But first I'd like to quickly show everyone some other options available out there & what I like and don't like about them.

Kinesis Advantage2

- Advantages: Widely considered one of the best commercially available ergo keyboards for poeple suffering from RSI
- Disadvanteges: $320.00 USD, some reviews describe feeling 'cheap'
- Open Source: No

As I first started really focusing on learning tools like bash & emacs, I started hearing allusions to RSI, & more than a few references to this keyboard. It's probably the best commercial ergo keyboard you can get, but it comes at a price. Also, I think it was a review by Linus Tech Tips where he describes the feel of the plastic being light & inexpensive. Not something you want to hear when you drop over $300 on something exclusively commercial.

ErgoDox (EZ)

- Advantages: Lots of support if building from scratch, also may be a better product than Advantage2
- Disadvantages: Also about $300 if purchased commercially (depending on the options)
- Open Source: Both commercially available & open source

One of the most popular ergo keyboards I've seen. It's garnered the attention & a review from Linus Tech Tips, and has a long open source history. As far as I can tell, the Ergodox project kickstarted the idea of open source keyboard hardware. You see references to it everywhere, and its popularity on the ergo keyboard space is unavoidable. Almost any split, open hardware design available has borrowed something from the ErgoDox. If you go the DIY route, you can find blank PCBs somewhat readily, and the rest of the parts can be easily sourced yourself.

Let's Split

- Advantages: Split-hand, simple, affordable design (~$100 USD)
- Disadvantages: Not concave
- Open Source: Yes

This was my first introduction to the idea of an open source keyboard. I was browsing thingiverse (A place where people share their 3D print designs), and someone had shared a brakcket they used to attach this keyboard to their laptop. I remembered that, and after looking at the previou Kinesis keyboard, I wondered if anyone had started a project similar to that design, but open source & with a split form factor. Someone had, and that's why I'm here.

Atreus

- Advantages: Small, single-board form factor
- Disadvantages: Not a split design?
- Open Source: Yes

This is another keyboard I saw referenced a lot. It's a single board & not split, but it's small (the website shows it fitting in someone's jeans pocket). The single board design could be an advantage or disadvantage depending on what you're using it for. It's potentially less comfortable to use, but I see it being easy to grab & go if you're using it in a mobile set-up.

Signum 3 (Troy Fletcher)

- Advantages: Very simple design (solder on components, nothing else to worry about)
- Disadvantages: PCB is $80, no case for protection
- Open Source: Yes?

The guy who makes this is a freelance programmer based in Kentucky. He has a youtube channel that's pretty interesting if you're into vlogs. The notable differences between this & Atreus on the previous slide are the thumb cluster positions and the exposed PCB. It does look like the entire board is covered with a solder mask, but it won't be as protected if dropped. It looks like there is a repo made for this on github, but there's not much in it. You may need to contact the author for product designs if you need them.

Other Dactyl Variations

Dactyl Ergodox

- Advantages: Reuse your Ergodox keycaps (finding correct amount of keys can be difficult)
- Disadvantages: Incomplete design
- Open Source: Yes

This was a pull request by Joe Devivo (One of the writers of the earlier build guides). He was attempting to add some changes to fit the Ergodox keycaps, but the latest update to the pull was from 2017. /u/chrystalhand has apparently made more updates to the design and is trying to market it on Reddit and OhKeycaps.com. I don't know if he's made the source available.

Lightcycle Dactyl

- Advantages: Slightly smaller footprint (fewer keys)
- Disadvantages: STL files for 3D printing appear to need more repair than basic model
- Open Source: Yes

In the main repository you'll find this as an option along with the 'cherry' option for the same version. The LightCycle version of the Dactyl has fewer thumb cluster switch positions and one less row of keys It was originally designed to match with the Matias ALPS-inspired mechanical keyswitches. The 'cherry' version of this is the same design, but are meant to be fit with Cherry MX mechanical switches.

Dactyl Manuform

- Advantages: Thumb clusters are brought down to a more natural position, Case is larger making wiring less tedious
- Disadvantages: Must be wired by hand, all of the challenges that come with original Dactyl
- Open Source: Yes

I think probably the best designed of all of the options I've seen. The Manuform retains all of the features you would look for in the original, but lowers the thumb clusters so that you hands can remain in a more natural position. Notable hardware differences between this & the original are the use of DSA keycaps used and the use of 2 Pro Micros for the microcontroller. I'll probably build & switch to this in the future.

More Do-it-Yourself Options

`There is a very nice list of other ergonomic keyboards, with pictures, on Xah Lee's website.`

- http://xahlee.info/kbd/diy_keyboards_index.html

Reasons for Choosing Dactyl

- Open Source
- Looked like the most comfortable design
- Kinesis Advantage form factor, but open source (non-commercial)
- Also looked hella cool

My Reasons for Building by Hand Instead of Purchasing

- At the time there were none being manufactured
- Sense of self-satisfaction
- I already own a 3D printer
- Screw paying someone else >$300, I'll just build my own!
- One year later joke

Build Overview

Shell/Case

- The body of the keyboard is 3D printed by me
- There are 4 parts to print, each took 21 hours to complete on a RepRap style Cartesian 3D printer
- Material is PLA infused with wood fibers.

The body of the keyboard is 3D printed in PLA with infused with wood fibers, so at some point I want to try and stain it. There is a top and bottom to each half, and each top and bottom piece took 21 hours each to print. My main challenge here was finding the correct amount of support material to use. For a slicer I used Slic3r, and your options for support material are somewhat limited. In my first attempt I used too high of a resolution and the support was so fine that it was impossible to separate from the print. My second attempt was the bottom left half and I think it turned out pretty good.

Hardware

For hardware connecting the halves, there was no documentation for it so I referenced some build videos on YouTube and dug through my collection of computer hardware & screws and found that 3mm female motherboard standoffs that were 6mm tall worked great with these 3mm countersunk screws. I took a soldering iron and heated the screws up while pushing them into the hole in the plastic to create a countersink. Without that countersink there would be clearance issues with keycaps, so the keycaps would hit the head of the screw when pressed down. I also added some 1/8" heatshrink tubing to the standoffs so that they wouldn't cause any shorts with the wiring.

Switches

- Fits Cherry MX switches

So Cherry MX is the most popular switch manufacturer on the market.

Keycaps

- Go over keycap profiles
- Keycap material, count & price

PCB Design

So this was obviously the most tedious part. To start with, some of the designs in the PCB design are flipped the wrong way around, and for some reason they weren't consistantly flipped. I found this out after my first etching attempt and I had cut out all of the individual pieces and was trying to apply them to be soldered. If you were using the toner tranfer method it would make sense to mirror the entire design, but some pieces were flipped one way while others were correctly oriented. I searched imgur.com for completed builds and was able to find 2 very nice photos of a nearly completed build. I used those to cross-reference the design, and I used Inkscape to flip each piece individually.

Etching

- Xerox printer, not direct print
- 1:1 ratio of 3% Hydrogen Peroxide & Acid Magic (Marketed as 'safer' Muriatic Acid, found on Amazon.)
- All etching tutorial info (Storage & reuse)
- PCB etching (I probably went the most expensive route.)
- PCB design

Etching Process

Make sure to 'add the acid', you can see the copper lifting here, you'll notice the color of solution turning green with copper at this point, here you see the Kapton tape backing and some remaining copper, after you're done you should

put the sheet in a water bath to stop the acidic reaction and clean any off any residues left from the precess. I chose to sand off the wax with 220 grit sandpaper because it was mixing with the solder and I got annoyed by it. You probably want some kind of coating over the copper to prevent corrosion.

Wiring

Oh boy. One challenge I faced was how to choose resistors to match up with the LEDs, and what size LEDs to buy. LEDs need resistors paired with them so that they draw a steady current and don't become overloaded. You won't likely be able to find the current draw unless you purchase them with a documented current draw. I got mine from Digikey.com. I used on online calculator to calculate the correct resistance, but the formula is pretty simple. R=I/V. Almost all USB hubs are going to power your devices at 5V DC, so if you take the current rating for your LED and devide it by 5V you should get the resistance value needed for your LED. I wanted the LEDs to fit into the slot provided by the key switch, so I looked it up and the T-1 LED form factor is what you want to use. This is also the type of LED you would use to backlight your keycaps. There is also a discrepency in pin position for some of rows between the photos I used for referencing the PCB design and the wiring diagram shown in the guide in the repo. I attribute this to updates in the QMK firmware, but I don't know. It's something to be aware of.

PSA: TRRS != TRS!

file:img/TRRS.JPG

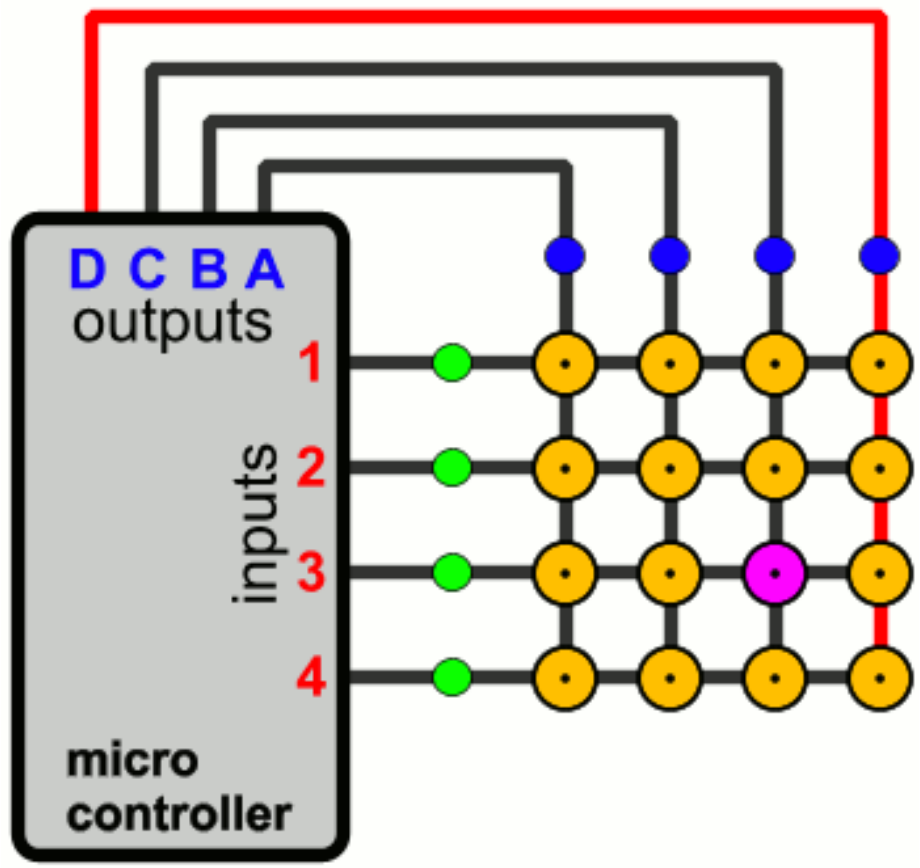
So when I ran my first tests after completing the wiring ane firmware, OSX kept complaining about the USB device drawing too much current. It was selfishly holding power to the USB hub hostage until I unplugged the device. This is why. This is the cable that connects the two halves together so the MC can communicate with the left half. The letters TRS stand for Tip, Ring & Sleeve. The documentation calls for a TRRS cable. Originally I mistook it for a basic 3.5mm stereo audio connector, but as you can see it doesn't have the necessary contact points and was causing a short inside the input jacks. The way I solved this on short notice was by running to Menards and buying 2 sets of cheap earbuds with microphones built in, cutting off the earbud half ande soldering the 2 ends together.I'm still not getting input from the left half, but I think that's more likely due to a short in the right half that I still need to diagnose.

Firmware

#+BEIGN$_{\text{NOTES}}$ So I have a spare Teensy 2.0 here, and I think instead of describing the flashing process I'll just show you. I'll be loading QMK firmware onto this. It's the most popular and widely supported keyboard firmware available that I've found at least. They have a huge list of hardware that the project supports.

#+END$_{\text{NOTES}}$

How Does it Work?



So there are two ways in which you can wire up your key matrix, which are row-driven & column-driven. A row-driven matrix is one where current travels from the microcontroller, through the switch & diode & then back into the MC via the column. A column-driven matrix is the inverse. While wiring the key matrix, one big challenge was trying to figure out the orientation of the diodes. If you're not familiar with what a diode is, it basically works to only allow current to flow in one direction. The way they're used here is to insure that the input and output sent and recieved by the microcontroller only flows in one direction. The orientation of the diodes is entirely dependent on how you wire your rows & columns and whether you choose to send output through the switch from the rows or the columns. In my case I went with a row-driven matrix, as that seems to be most common, and I read allusions to it being a more efficient option in the QMK firmware. With that decided, I wired the Cathode, or negative end with the stripe facing away from the switch pin on the column. As long as all

the diodes are consistantly wired, it really shouldn't matter how you wire your matrix. You can easily flip it in the QMK firmware.

Was It Worth It?

- Parts table

Resources

- Drop.com (formerly MassDrop)

Crowd sourced, limited manufacturing.

- OhKeycaps.com

Working with members of the reddit mechanical keyboard community to commercialize different Dactyl variations.

- MehKee.com

Seems to be the primary vendor for the Let's Split PCBs `I have no affiliation or experience with the above. YMMV!`

Tutorials

- Etching with Muriatic Acid & Hydrgen Peroxide
- HongKongGhost
- AfrotechMods on resistanc
- https://www.instructables.com/id/Making-flexible-PCBs-with-a-laser-jet-printer-or-c/
- https://www.instructables.com/id/DIY-Flexible-Printed-Circuits/

Hardware & Accessories Vendors

- https://kbdfans.com
- https://aliexpress.com https://digikey.com
- https://pimpmykeyboard.com/
- https://mechanicalkeyboards.com/shop/index.php?l=product_list&c=9