ISABELA MOREIRA

ANATOMY OF A MECHANICAL KEYBOARD ⌨

SMK 2019

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Can I get a show of hands - how many people is this their first keyboard meetup or are new to mechanical keyboards? Perfect, this talk is for you!

HI 👋

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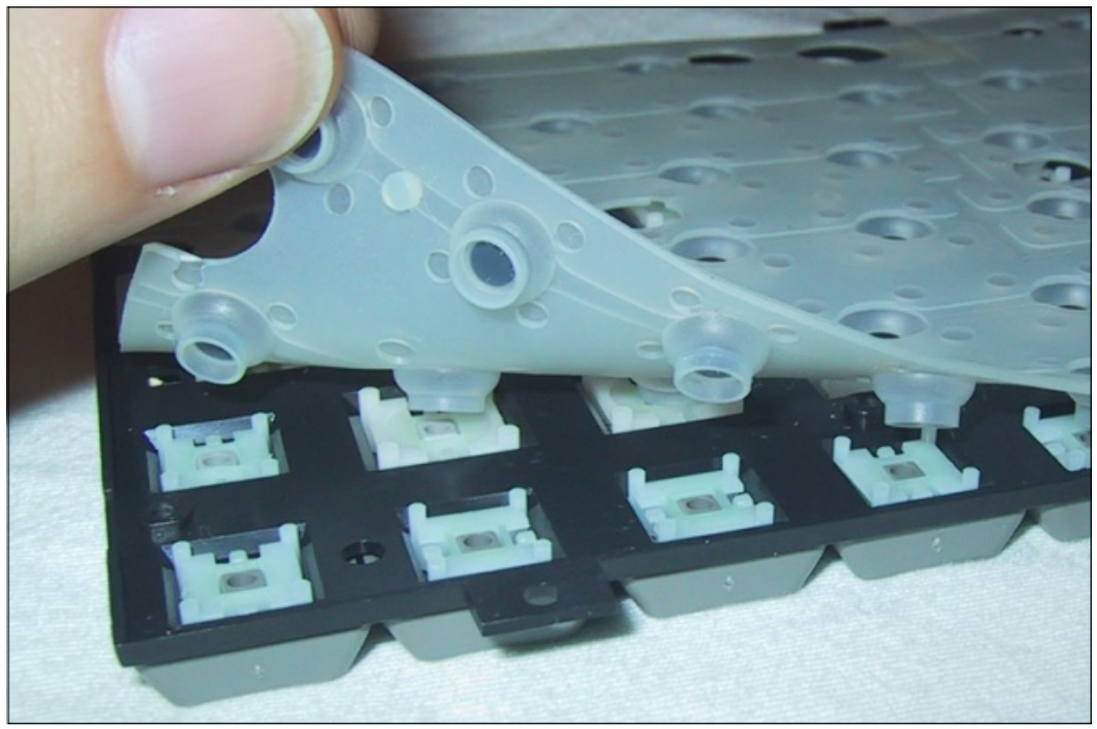
Intro about myself

RUBBER DOMES 🥶



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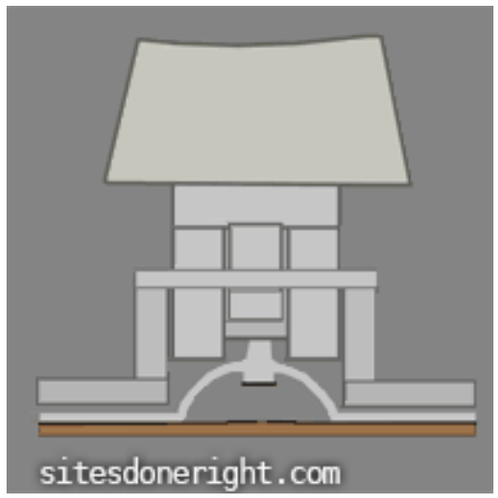
Before we dive into mechanical keyboards, I want to give you a little overview of how “normal” keyboards work. Normal keyboards are usually “membrane” keyboards, meaning they have a rubbery layer that sits between the PCB and the keycaps, separating the circuit on the PCB from the contact on the rubbery layer.

RUBBER DOMES 🥶



When you press all the way down on a keycap, the rubbery layer squishes down and the contacts meet and the signal goes to the computer.

WHAT'S A MECHANICAL KEYBOARD?

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Since this is a beginner talk, I want to go over the basics of what a mechanical keyboard is.

It's a work of art! It's a highly durable, highly customizable keyboard that feels great when you type on it. It has high quality construction and uses a special mechanism to send the keypress signal to the computer.

Today, we're going to dive a little deeper and look at the pieces that make up a mechanical keyboard and things to consider when thinking about building your own.

MECHANICAL SWITCHES ❤️

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So! In mechanical keyboards, this is what the switches look like. They’re made of actual mechanical moving parts and are soldered directly onto the PCB.

MECHANICAL SWITCHES ❤️

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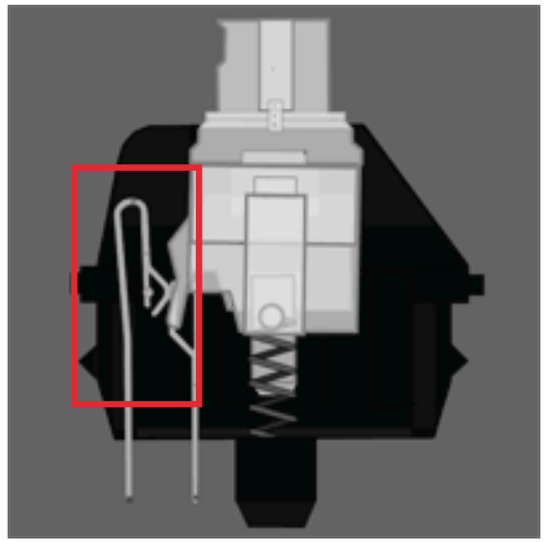
I’ve highlighted the three main components of the switch here. On the left, is the leaf spring. It’s kind of like an upside U made of metal. It’s kind of hard to tell in this slide, so the next slide has a better view. But here we also have the slider in the middle, and the spring on the right.

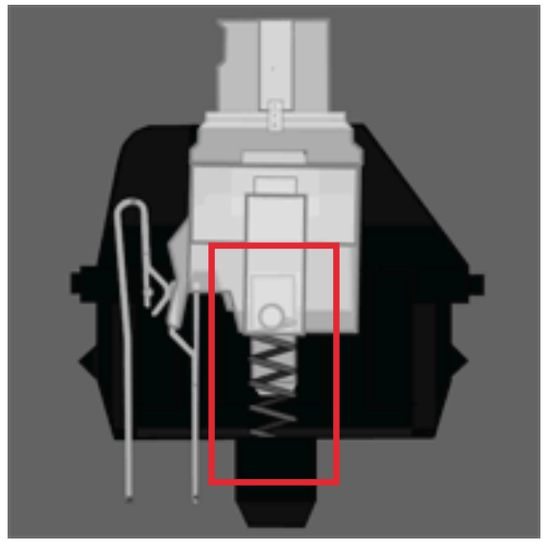
Let’s look at how all these work together to send the a signal from your keyboard to the computer.



Here’s what the leaf spring looks like from the side. You can see that there’s a gap between the legs. When that gap closes, the circuit is completed and the signal is sent to the computer.

You can see from the gif that this gap gets closed when the slider is pushed down, compressing the spring, enough for the little leg on the left of the slider to hit the side of the leaf spring. When you release the slider, the spring pushes the slider back up to open up the gap again.

MECHANICAL SWITCHES ❤️



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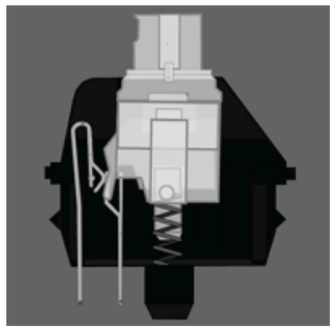
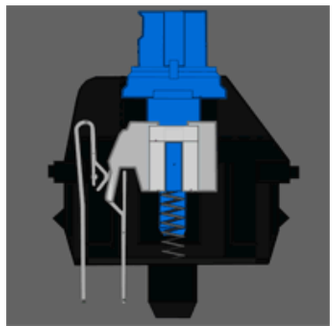
You can also customize how much force you need to put on a switch in order for the signal to be sent to the computer.

Since you need to compress the spring enough for the leg to activate the leaf spring, you get a switch with a heavier or lighter spring that's more difficult to compress or easier to compress. Springs that make it more difficult to compress create a category of switches called heavy switches, because you need a lot of force to press down on them. Springs that are easier to compress create a category called light switches. You can tell how heavy or light a switch is by its actuation force – it tells you how many grams of force are needed to complete the circuit.

CAN'T STOP THE FEELING



Tactile



Clicky

Linear

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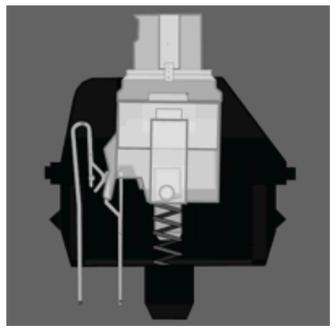
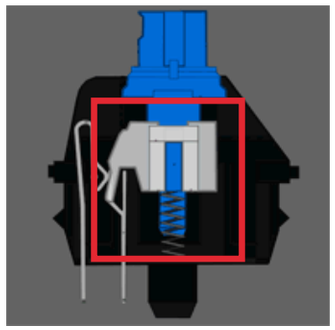
Finally, switches usually all fall into 3 separate categories, depending on how you want them to feel and sound.

1. Clicky (stereotypical click clack sound)
2. Tactile (you can feel a bump when you press down, but it's quiet)
3. Linear (no bump or sound)

CAN’T STOP THE FEELING



Tactile



Clicky

Linear

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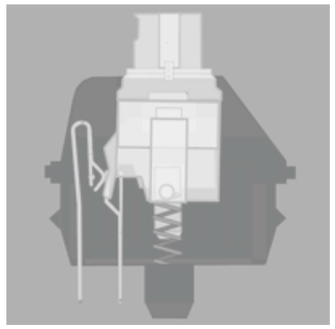
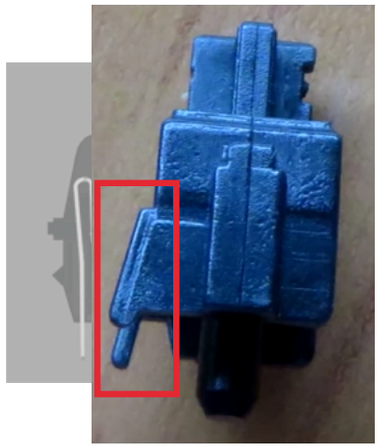
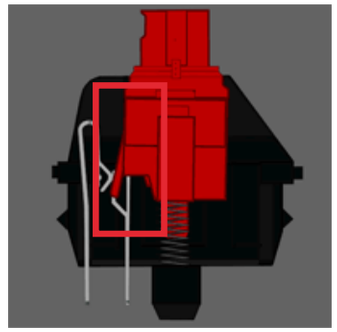
You can see that the only switch here that makes the clicky sound is the middle switch. That’s because its slider has a floating middle part. When the slider is pressed down, that floating middle part hits the bottom of the switch making the clicky sound.

CAN’T STOP THE FEELING



Tactile





Linear

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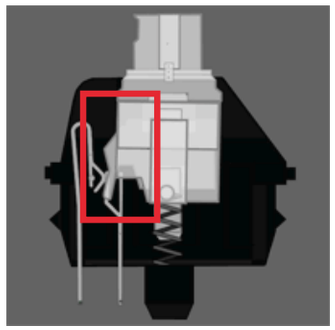
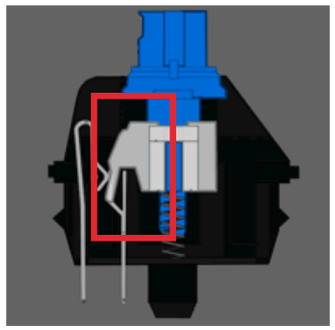
You can also tell what type of switch it is by looking just at the slider! If the slider’s leg has no bumps, then it’s a linear switch.

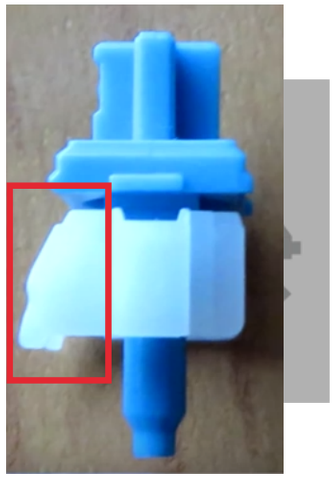
CAN’T STOP THE FEELING



Tactile



Clicky



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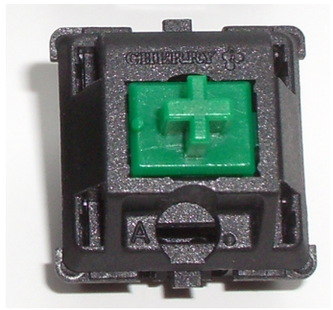
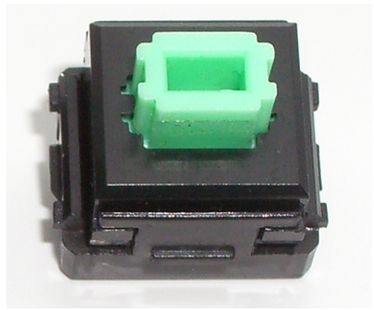
Otherwise, if the leg does have a bump, it’s a tactile switch (but not necessarily clicky). This one happens to be click because it has that floating slider we talked about earlier.

STEMS



MX



Alps

Topre

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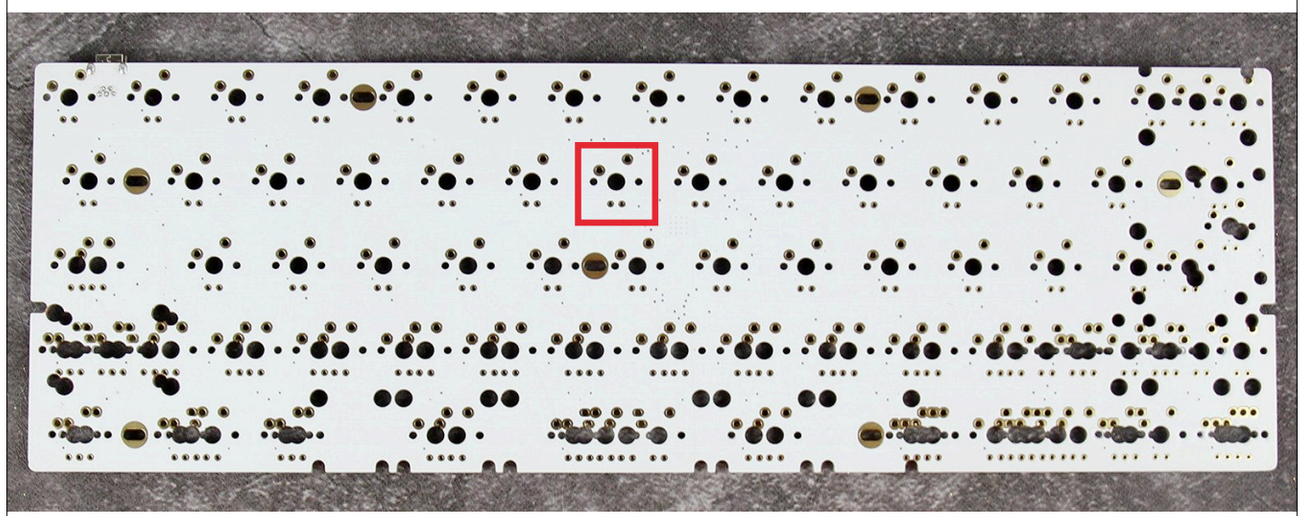
There’s also a few different types of stems, which is the part that sticks out of the switch housing and attaches to the keycap. The most common is probably MX stems. There’s also Alps and Topre stems.

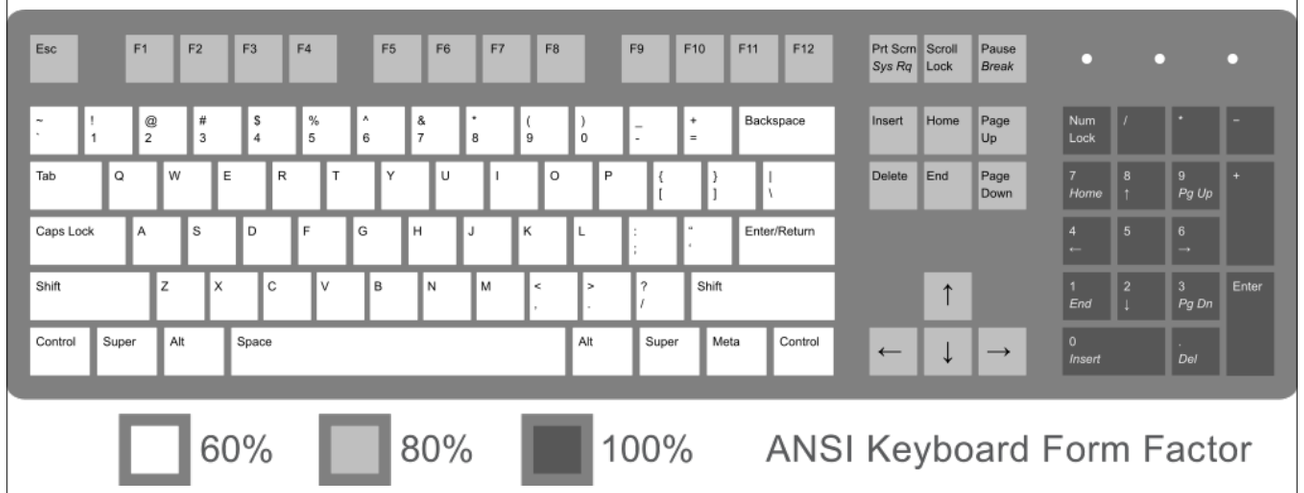
This is important to keep in mind because if you really like the feeling of a certain switch with Topre or Alps stems, you might have a harder time finding fancy keycaps since those are usually made for MX stems.



So now we have some background knowledge on what makes a mechanical keyboard mechanical and we know way too much about how the switches work.

So let’s look at the other components that make up a mechanical keyboard.
To have any kind of keyboard, we need a circuit. Mechanical keyboards have PCBs.
The PCB is the actual circuit board where the switches are soldered on.

I highlighted the area on the PCB where each of the switches will be soldered on.



Before deciding what PCB to buy, it's important to decide the size of the board you want (full, TKL, 60%, etc). You'll also want to double check that the PCB you get is compatible with the type of switch you want. If you're also interested in LEDs, you'll want to check if the PCB comes with LEDs presoldered (Sentraq is a good example of this) or if the PCB supports you soldering on your own LEDs.

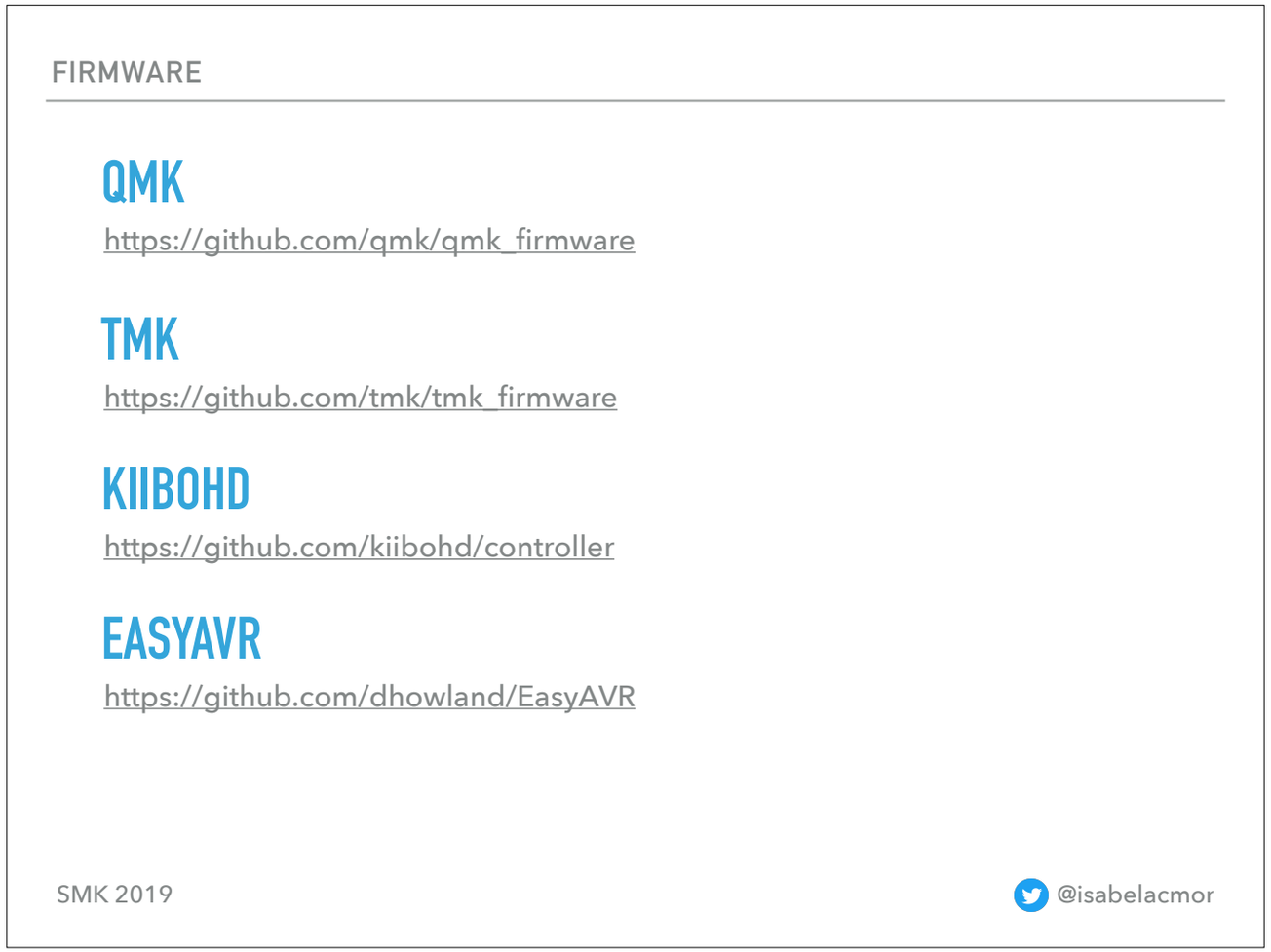
Ortholinear

Ergo

Staggered

There’s also a bunch of different layouts in each size category.

Choosing a layout is a super personal decision. Like, some people can’t live without arrow keys, so they need something bigger than a 60%. Some people like to practice stenography, so ortholinear layouts are really good for that.

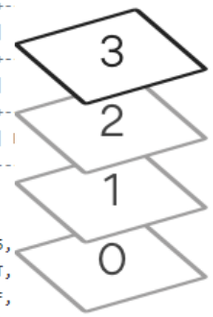


One last note about PCBs…

If you plan on programming your keyboard with custom macros and layouts, it's important to make sure that you get a PCB that runs on highly customizable firmware. Here's a list of the most popular ones. Other boards, like those made by Vortex, don't run on customizable firmware and they only way to program them is through various key combinations you do on the board itself.

QMK KEYMAP EXAMPLE

```
/* Qwerty
 * ,-----------------------------------------------------------------------------.
 * |  Esc |  1  |  2  |  3  |  4  |  5  |  6  |  7  |  8  |  9  |  0  | Bksp |
 * |------+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+------|
 * | Tab  |  Q  |  W  |  E  |  R  |  T  |  Y  |  U  |  I  |  O  |  P  |  \   |
 * |------+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+------|
 * | Esc  |  A  |  S  |  D  |  F  |  G  |  H  |  J  |  K  |  L  |  ;  |  "   |
 * |------+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+------|
 * | Shift|  Z  |  X  |  C  |  V  |  B  |  N  |  M  |  ,  |  .  |  /  |Enter |
 * |------+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+------|
 * | Brite| Ctrl | Alt  | GUI  |Lower |    Space    |Lower |  Left | Down |  Up  | Right |
 * `-----------------------------------------------------------------------------'
 */
[_QWERTY] = LAYOUT_preonic_mit( \
  KC_ESC,    KC_1,    KC_2,    KC_3,    KC_4,    KC_5,                    KC_7,    KC_8,    KC_9,    KC_0,    KC_BSPC, \
  KC_TAB,    KC_Q,    KC_W,    KC_E,    KC_R,    KC_T,                    KC_U,    KC_I,    KC_O,    KC_P,    KC_BSLASH, \
  LT(_RAISE, KC_ENT), KC_A,    KC_S,    KC_D,    KC_F,                    KC_H,    KC_J,    KC_K,    KC_L,    KC_SCLN, KC_QUOT, \
  KC_LSFT,   KC_Z,    KC_X,    KC_C,    KC_V,    KC_B,          KC_N,     KC_M,    KC_COMM, KC_DOT,  KC_SLSH, KC_ENT, \
  M(M_BL),   KC_LCTL, KC_LALT, KC_LGUI, LOWER,      LT(_LOWER, KC_SPC),      RAISE,   KC_MINUS, KC_EQUAL, KC_LBRC, KC_RBRC  \
),
```



The whole concept of programming keyboards is based on layers. You can set yourself to be either permanently or temporary on a certain layer, so let's say layer 2. From there, when you press a key, the firmware starts at layer 2 and see if that key has a value assigned to it on layer 2. If it doesn't, it moves down the stack of layers until it finds the first layer with a value assigned to the key and uses that value.

Here's an example of what it might look like to customize your layout if you're running QMK. First, you have your standard QWERTY layout. You can see the code at the bottom and the chart of what that code maps to above it.

Next, imagine that we want to add a num pad layer. But we don't have any keys left!

QMK KEYMAP EXAMPLE

```
/* NUMPAD
 * ,-----------------------------------------------------------------------------------.
 * |  Esc |   /  |   *  |   -  |   4  |   5  |   6  |   7  |   8  |   9  |      |      |
 * |------+------+------+------+------+------+------+------+------+------+------+------|
 * |   7  |   8  |   9  |   +  |   R  |   T  |   Y  |   U  |   I  |   O  |   P  |  \   |
 * |------+------+------+------+------+------+------+------+------+------+------+------|
 * |   4  |   5  |   6  |   +  |   F  |   G  |   H  |   J  |   K  |   L  |   ;  |  "   |
 * |------+------+------+------+------+------+------+------+------+------+------+------|
 * |   1  |   2  |   3  | Enter|   V  |   B  |   N  |   M  |   ,  |   .  |   /  |Enter |
 * |------+------+------+------+------+------+------+------+------+------+------+------|
 * |   0  |   0  |   .  | Enter| Lower|    Space    | Raise|   -  |   =  |   [  |   ]  |
 * `-----------------------------------------------------------------------------------'
 */
[_NUMPAD] = LAYOUT_preonic_mit( \
  KC_ESC, KC_PSLS, KC_PAST, KC_PMNS,  _______, _______, _______, _______, _______, _______, _______, _______, \
  KC_P7,  KC_P8,   KC_P9,   KC_PPLS,  _______, _______, _______, _______, _______, _______, _______, _______, \
  KC_P4,  KC_P5,   KC_P6,   KC_PPLS,  _______, _______, _______, _______, _______, _______, _______, _______, \
  KC_P1,  KC_P2,   KC_P3,   KC_PENT,  _______, _______, _______, _______, _______, _______, _______, _______, \
  KC_P0,  KC_P0,   KC_PDOT, KC_PENT,  _______,     _______,     _______, _______, _______, _______, _______  \
),
```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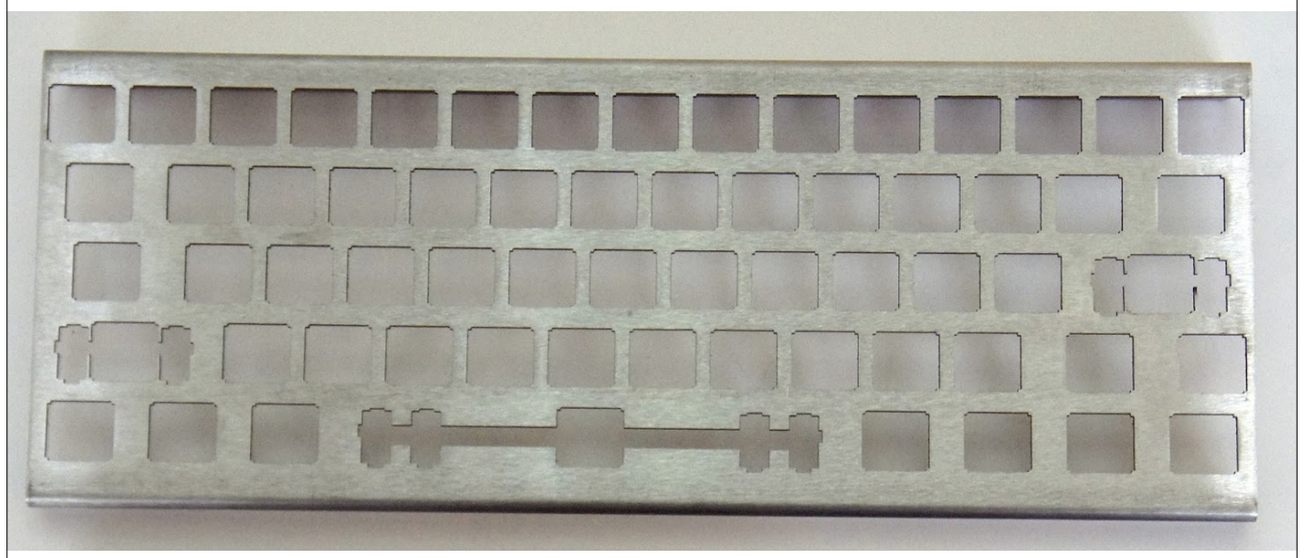
We can create a new layer that maps all the keys on the left side of the board to what you'd find on the num pad. As you can see in the code, tons of keys on the right side of the board are left blank. Since those keys are left blank, if you're in the num pad layer, the input will go through the num pad layer and to the QWERTY layer, giving you the letters you see in the chart above.

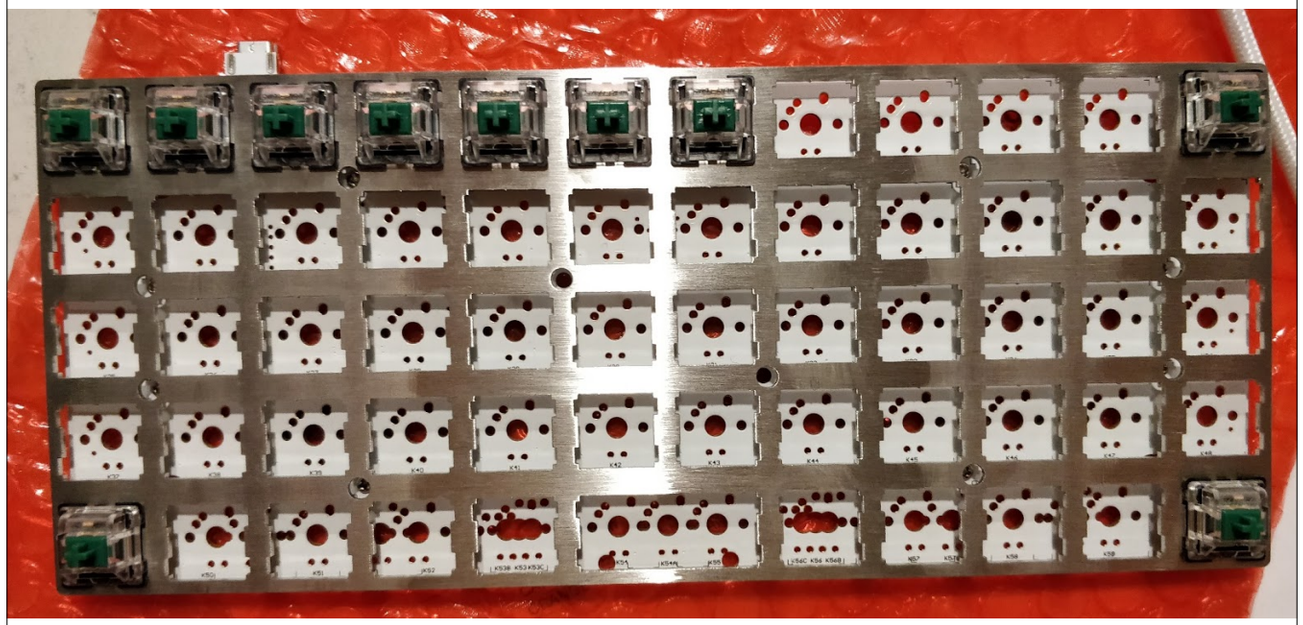


Okay, now that we've covered the PCB, we can talk about the plate.

The plate sits over the PCB inside the case. It protects the PCB and acts as a guide when soldering the switches on the PCB. You don't always need a plate, but it's usually recommended.

Be sure that the plate you're buying fits the PCB. The cutouts on the plate should line up with where the switches will be soldered on the PCB (the red area I pointed out earlier).

PLATE



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This is what your board should look like once you start assembling. You can see that the place nicely outlines where each switch goes on the PCB. Once all the switches are popped into place, you just need to turn the PCB over and solder the switches to the PCB on the back.

CASE

The case is what holds all the other components of the keyboard together. The case you get will depend on the size of the keyboard you're building. It needs to fit the PCB in it snugly.

Cases all come in tons of different materials. Aluminum is a popular choice because its heavy and durable. Wood, acrylic, and plastic are also used. You can even build your own case with a 3D printer, laser cutter, or even Legos.

KEYCAPS

DSA Milkshake

MT3 /dev/tty

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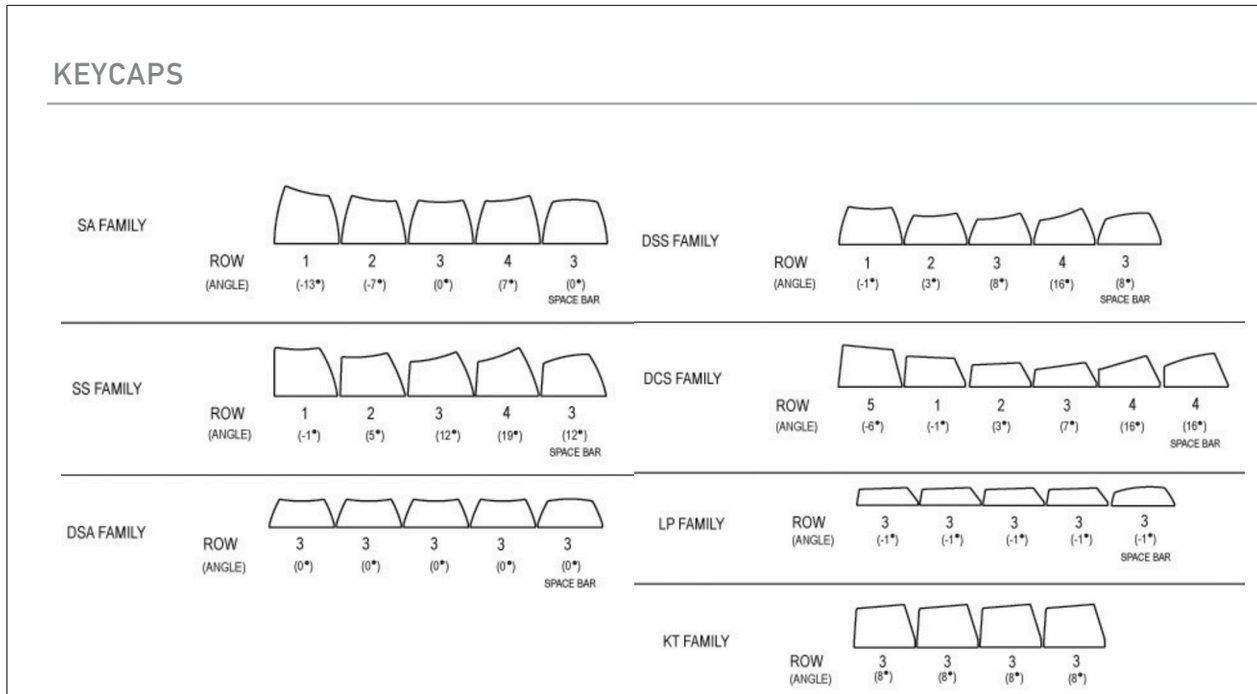
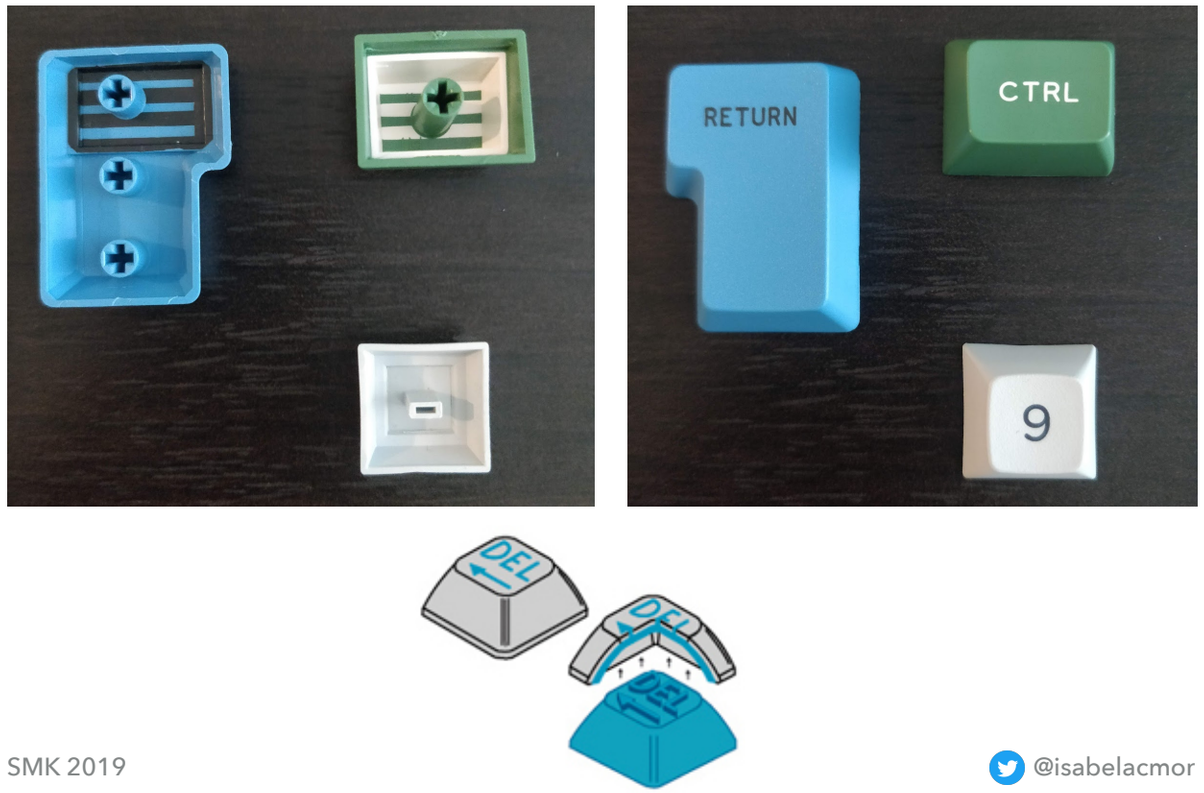
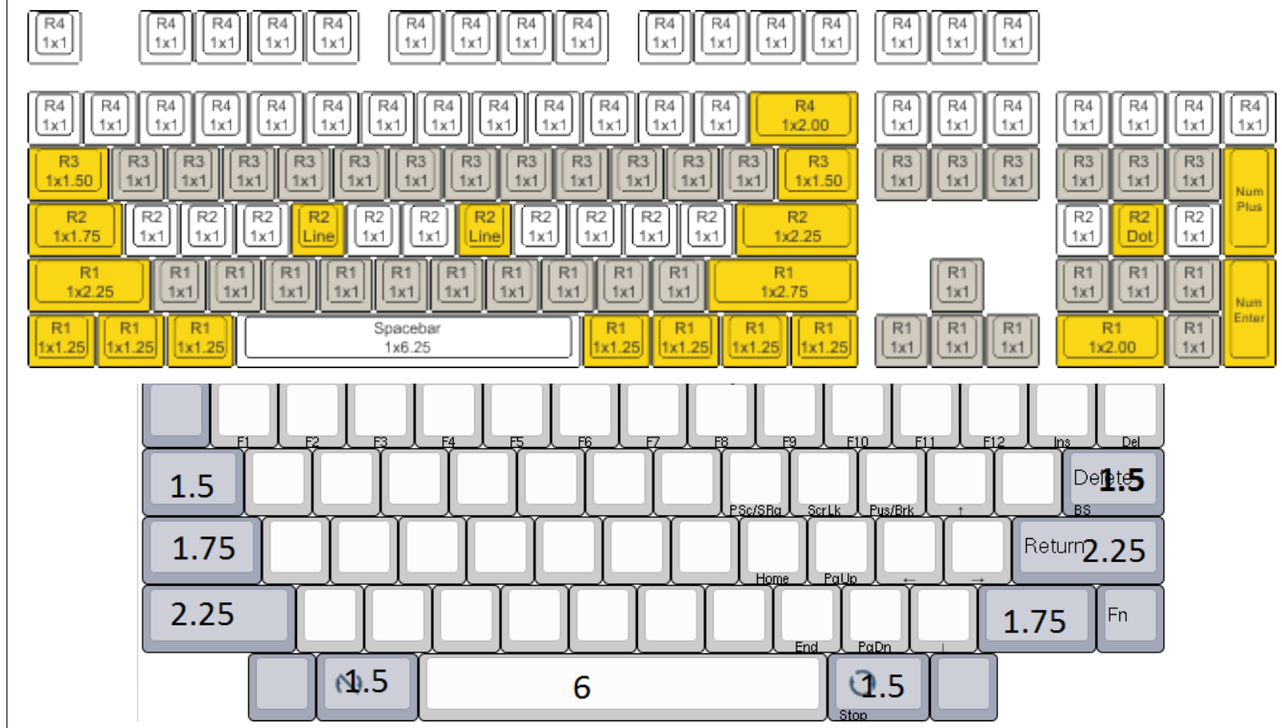


Here you can see some of the different types of profiles you can get. My favorites are DSAs and SA, depending on which board I'm using. To me, SAs feel really sturdy and DSAs feel more light and minimalistic.

Keycaps can also be made from different materials. The most common is either ABS or PBT plastic. PBT keycaps are usually considered higher quality because they don't wear as easily, don't show shine, and don't yellow.



Another thing that makes a big difference in the quality of keycaps is how the legends on the caps are done. They can either be printed on or they can be doubleshot. You can see the blue and green keycaps in the pictures are doubleshot because they have this extra layer of plastic that makes up the legend, and then the rest of the keycap plastic is filled in around it. This makes the legends much more durable because you know they can never wear off. But if you have printed legends like the 9 keycap in the picture, it’s just a matter of time before they wear off.

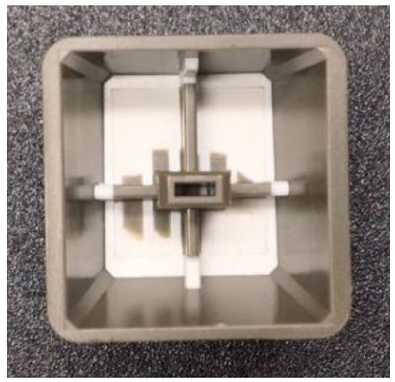


Before you go and buy a bunch of keycaps, you have to take into account what layout your keyboard's PCB has. Keycaps are measured based on the size of the alpha keys, which are 1 unit. Keys like "Enter" are usually 2.25 – meaning they're the size of 2 and ¼ alpha keys.

Different layouts have different sized keys. The top is an example of a WASD board and the bottom is a Happy Hacking board.

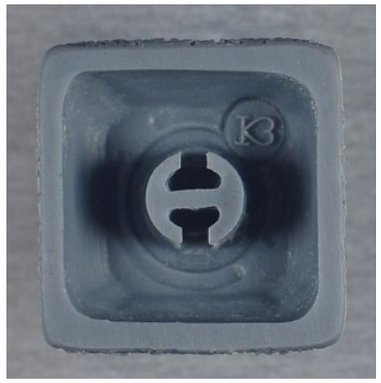
The Preonic board we talked about earlier is all 1 unit keys, except for the spacebar, which can be 2 units.

KEYCAPS



Alps stem

MX stem



Topre stem

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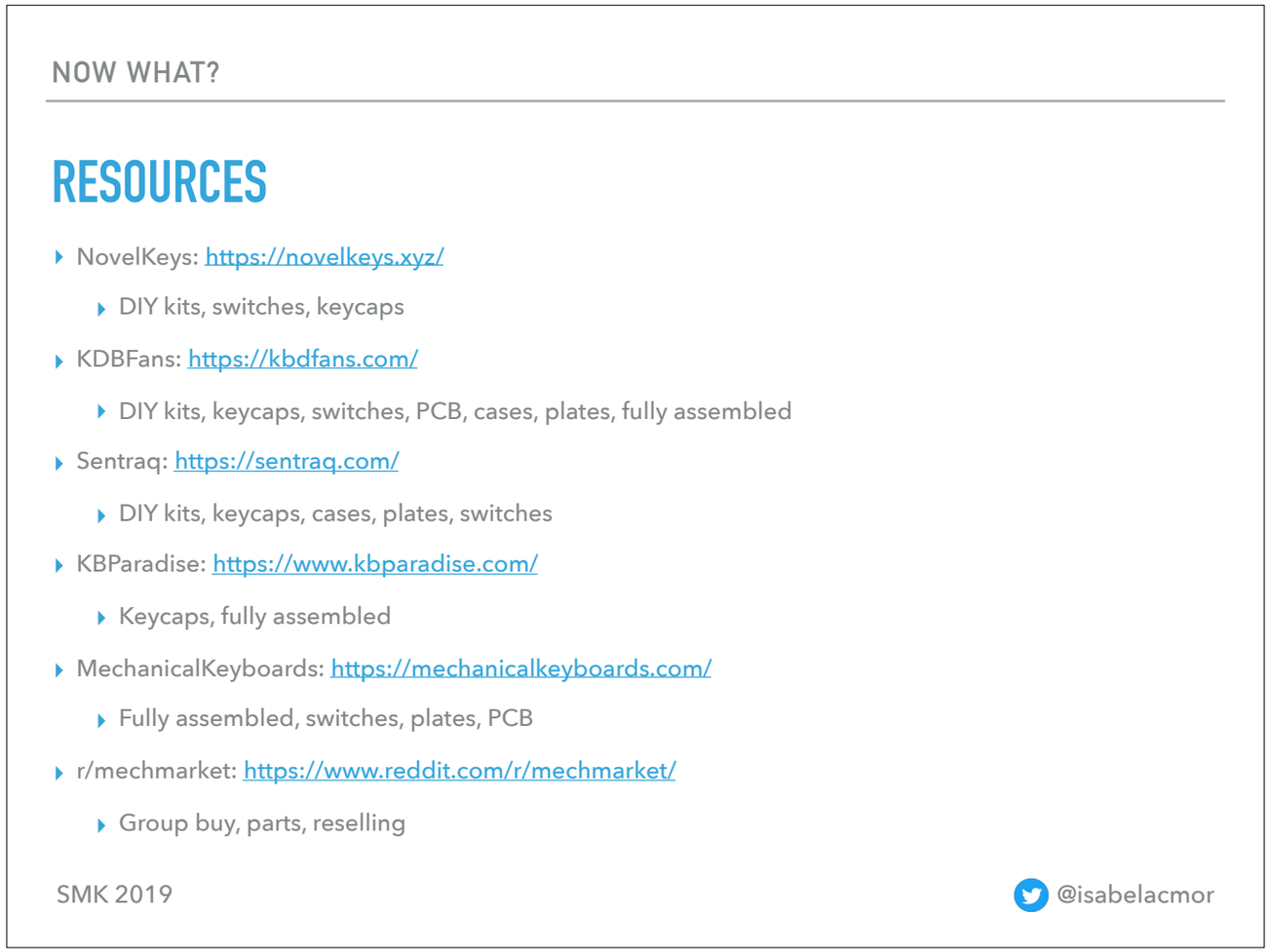
One last thing to consider before you buy keys caps is what switches your keyboard has. If you look at the bottom of the keycap, you can see that the stems are different. These stems fit on top of the sliders on the switches we saw earlier. Usually, most of the popular keycap sets are sold with MX stems.



So that’s basically all the pieces you need to know about. But a question I get a lot is… now what?

It can be hard to know where to go to find all the pieces you need or even where to find a prebuilt board when you’re just getting started. So I wanted to give some recommendations on where you can find everything you need. Keep in mind, these are my personal recommendations - I’m not affiliated with any of these companies or getting paid by them. Some might disagree with them, but I think they’re good starting points, especially if you’re just starting out.

GOTTA CATCH EM ALL

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Once everything’s assembled, you’ll end up with a beautiful 100% customized board and you’ll actually know how it works inside and out!

It’ll be everything you’ve ever wanted…. Until the next board you get.

THANKS

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