FLASHKA KEYCHAIN FLASHLIGHT · BUILD GUIDE

Build Guide v0.7

Order the parts, cast the keys, install the firmware, assemble, use the presenter mode - no experience needed



Render of the design, not a photo: FlashKa has not been built yet.

For builders without electronics or programming background.

FlashKa Keychain v0.7 · 2026-10-23

Source: docs/build_guide_v0.7.md (+ docs/firmware.md of v0.6, sections 2 and 9.3)

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This guide takes you from "I have never ordered a circuit board" to a working flashlight and slide remote in your hand. You do not need to know electronics or programming. You need patience, a soldering iron and a computer with the Chrome or Edge browser. Read the whole guide once before you order anything.

> **Status: designed, not yet built.** Nobody has assembled a FlashKa yet. Everything in this guide is checked by software only (chapter 14, section 14.10), so you may be the first to build one. Where a step or a behaviour is untested, the guide says so. The light figures are simulated from datasheets, not measured. Please tell the project what you find (section 18).

Render, not a photo: FlashKa has not been built yet. Every picture of the light in this guide is a computer render made from the design files. The finished light seen from below: 99.2 × 20 × 18 mm, a faceted octagon of black anodised aluminium with textured panels, three keys on the centre line of the bottom face (the clear main key glows in the ring colour), USB-C charging on the side, a white LED behind a lens and a small green laser in the head, and Bluetooth for the phone app and for presenting.

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0. What you are building

FlashKa is a keychain flashlight with a green laser pointer. It has a second job: it turns slides. In *presenter mode* the light is a Bluetooth keyboard, and the laser stays the pointer. Version 0.7 is the 1000 lm FlashKa: a strong LED behind a lens (a "TIR optic") throws a narrow beam far. It runs on one 14500 lithium-ion cell, the size of an AA battery. The three keys sit on the centre line of the bottom face, the body is a faceted octagon with a rugged surface, and no part of the light is 3D-printed.

Size	99.2 × 20 × 18 mm, an octagon with eight flat faces; about 62 g (an estimate: 32.7 g of housing parts from the CAD, 1.7 g for the optic and the LED board, about 22 g for the cell and 6 g of electronics; not weighed)
Keys	three keys in a row on the bottom face: **^** next (black rubber), ● main (clear acrylic with a glowing ring), **v** previous (black rubber)
Ring	two RGB LEDs under the clear main key light up a frosted ring on its face and show what the light is doing
Main light	Luminus SST-20 Gen 2 LED under a LEDiL TIR optic, from 3 mA (moonlight; 2 mA in the Endurance profile) to a 2,850 mA turbo: about 1,045 lm out of the front at switch-on and about 966 lm once the LED is hot, a beam that reaches about 160 m. High: about 600 lm for about three and a half minutes, then about 280 lm for more than two hours. Turbo is weaker when the cell is half empty: about 775 lm (all simulated, not measured)
Laser	green 520 nm module, Class 2 (≤ 1 mW), with a hardware safety switch
Presenter mode	the light is a Bluetooth keyboard: ^ next slide, v previous slide, ● black screen; the laser is the pointer
Battery	one 14500 lithium-ion cell (Vapcell INR14500 F15, 1,500 mAh, 3 A), with two nickel strips welded to its ends; a circuit on the main board protects it
Charging	USB-C, about 500 mA (a full charge in about 3.5 hours), status shown on the ring
Brain	ESP32-C3 module with Bluetooth Low Energy
Phone and computer app	a web page: no app store, works in Chrome or Edge (Android, Windows, Mac, Linux)
Firmware	FlashKa firmware 0.7.0, installed from a web page over the same USB-C cable: no programmer needed. The installer asks which FlashKa you have: choose **"FlashKa v0.7 - three keys in the middle"**

How it is made:

- **Two circuit boards in one panel** are made *and fitted with all their small parts, on both sides*, by JLCPCB: the main board (24 × 16.5 mm) with the LED driver and the battery protection, and a small **key board** (19 × 14.8 mm) that carries the three key switches and the two ring LEDs. Six gold spring contacts ("pogo pins") on the key board press on six gold pads of the main board, so no cable joins them. You only solder a few wires by hand.
- **The aluminium body** (two parts: tray and lid) is machined and anodised black by JLCCNC. It carries no marking at all.
- **The clear main key and three small black plastic parts** are machined by JLCCNC too, as two "machining kits" (the parts hang on small tabs in a frame, because the shop does not take parts that small one by one).

- **The two rubber side keys** you cast yourself, four at a time, in a small mould: two resin plates that JLC3DP prints once and ships in the same parcel as the JLCCNC parts. A thin stainless-steel plate glued into each key makes it stiff.
- **The LED board, the TIR optic, the laser, the cell, the screws, two silicone pads, the rubber and the glue** are bought ready-made (for example on AliExpress, from an electronics distributor and in EU shops).

Hold the light with the bottom face up and the head pointing away from you (at the screen, when you present). The keys then read, from the head to the tail: **^ next · ● main · v previous**. The chevron on each rubber key points along the light: on the next key, nearest the head, it points to the head and reads **^**; on the previous key, nearest your hand, it points to you and reads **v**. Next is towards the screen, previous towards you.



Render. The bottom face, tail with the lanyard slot on the left, head on the right. The three keys sit in one shallow frame (the bezel): v previous, ● main with its ring (shown cyan), ^ next. Seen this way the chevron of the next key points right, to the head, and that of the previous key left, to the tail. The textured panel next to the keys also hides the radio window of the floor: a black plastic plug fills it flush. No screw or hole shows near the head: the laser set screw sits under the lid.

If you know the v0.6 guide: chapter 14, section 14.1 lists what changed and why.

1. Before you spend money

Cost. The workbook `FlashKa_Parts_List_v0.7.xlsx` lists every part and every fee. The short version (delivery to Lithuania, EU, 21 % VAT; prices read on 2026-10-23, unchanged parts on 2026-10-14, 2026-10-18, 2026-10-21 and 2026-10-22):

	one light	two lights	five lights
Everything, including shipping, VAT and set-up fees	859.28 USD (768.04 EUR)	1,014.92 USD (907.15 EUR)	1,496.35 USD (1,337.46 EUR)
Per light	859.28 USD	507.46 USD (453.58 EUR)	299.27 USD (267.49 EUR)
Tools you may not have yet (one-time)	about 204 USD (164 USD without the spot welder)		

The 1000 lm design and the one-cell body made the light about 60 USD cheaper than the first v0.7 design (918.89 USD for one light), although they added the lens, the stronger driver and the battery protection: the casting mould is now a cheap resin print, the casting rubber is a cheaper one of the same hardness, the housing parcel of one light stays below the EUR 150 customs line, and the glass window and the spacer ring are gone. The one 14500 cell, instead of the two small pouch cells drawn before, costs about 4 USD more for one light (the battery shop's own parcel and the nickel strip) and saves about 4 USD per light for five. Version 0.6 cost about 620 USD for one light. v0.7 costs about 239 USD more:

- about 88 USD for the casting supplies of the rubber keys and other consumables (a 0.86 kg rubber kit, pigment, mould release, stainless shim, glue, cups, syringes and polishes; 24 AWG wire, thermal paste, nickel strip). You buy the casting supplies once: one rubber kit casts many keys, so you can share it with other builders;
- about 63 USD for the circuit boards: the key board in the same panel, six gold pogo pins, the stronger LED driver with the battery protection, the panel fee and the surcharge for two designs in one file;
- about 69 USD more shipping, VAT and customs, because the orders are dearer, and the lens and the cell come from their own shops in their own parcels;
- about 9 USD for bought parts: the lens, the 14500 cell, the key-board screws and the mould's bolts;

- about 10 USD for the housing: the bigger octagonal body, the two plastic kits and the resin mould (once per builder) replace the stainless caps, the resin print kit and the laser marking of v0.6.

A builder who already has a mould and the casting supplies (a second batch, or a mould shared with a friend) pays about 746 USD for one light. One light is expensive because the fixed costs (assembly set-up, stencils, the rubber kit, several parcels from the shops and the marketplace) are paid once, whatever the quantity. JLCPCB makes at least 5 panels and assembles at least 2. Building with friends brings the price down a lot. The workbook also prices cheaper options (no panel texture, economy shipping, a cheaper pogo pin, Sugru for the keys) and says what each costs in quality.

> **Many prices are estimates.** The shops show their price only after you upload the files, and some pages could not be read. The aluminium parts, the two plastic kits, the resin mould, the bare panels and the two-design surcharge, the courier fees of the lens and of the battery shop, the spot welder, the shipping and the marketplace parts are estimates. The workbook marks them (blue on amber). Replace them with the real quotes before you pay.

Time and the order of the orders. Building takes two or three evenings, plus a night in which the rubber of the keys cures; the waiting takes longer. Order in this sequence (the workbook's sheet *Ordering checklist* has the same steps):

1. **Day 1:** order the bought parts (section 6), including the lens from the electronics distributor and the cell from the EU battery shop; order the casting supplies (section 5) and the circuit boards (section 3), about 2 weeks.
2. **When the cell, the LED board, the lens and the laser have arrived** (2–5 weeks from AliExpress): measure them (section 8). They must match the specification, because the body is made for them.
3. **Then** order the body, the two plastic kits and, once, the resin casting mould in one merged order (section 4; 10–12 days).
4. **When the mould is there**, cast the side keys first (section 9): the rubber cures overnight, and you can do the electronics meanwhile.

At every checkout choose shipping with **taxes and duties paid (DDP / "tax included")**. The cost figures above assume it.

Skills. Soldering wires to pads and to nickel strips (practise on scrap first), spot-welding two nickel strips onto the cell if it comes without tabs (practise on scrap strip first), using a small screwdriver, cutting two tiny pieces of rubber with a sharp knife, mixing a small amount of casting rubber with two syringes (like a two-part glue), cutting thin stainless sheet with tin snips, gluing with a very small amount of glue, and following instructions exactly. Nothing else.

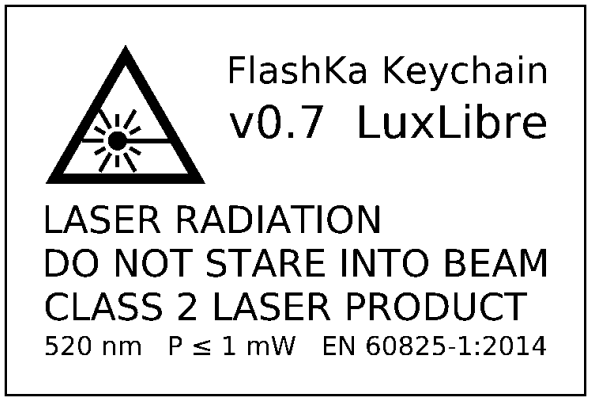
Safety — read this. The project's safety notes are in SAFETY.md at the root of the LuxLibre repository. The design rules named in this guide (for example LAS-1) are in `docs/design-rules.md` at the same root.

- **A lithium cell** can burn if it is short-circuited, punctured, crushed or charged wrongly. The 14500 cell of v0.7 has **no protection board of its own**: until it is connected to the main board, nothing protects it, and a short circuit can drive more than 10 A through a tool, a wire or a ring on your finger. The whole metal can is the minus (−) and the small raised cap at one end the plus (+): never let a piece of metal touch the cap and the can at the same time, and never let a red and a black wire touch. **Never solder onto the cell:** the heat of an iron damages it. Its strips are spot-welded on (section 10); you solder only to the strips. Keep one strip covered with Kapton tape while you work on the other. Never use a cell with a torn sleeve (the plastic skin) or a dented can. Keep a metal box or a sand-filled pot nearby while you work. Stay near the light during its first charges.
- **The laser** is a real laser. Class 2 is safe for an accidental glance, but never look into it or point it at people, animals, cars or aircraft. Wear 520 nm laser safety glasses while testing. Buy only a module whose seller states **Class 2 / ≤ 1 mW**, and measure it if you can (LAS-1, LAS-3). Its warning label is printed below (*Laser safety*).
- **The main light is very bright.** About 1000 lm in a narrow beam: never shine it into someone's eyes, and do not look into the lens from close range. The head gets hot in turbo and on High; the firmware limits the temperature (the body stays below about 47 °C in still air, simulated), but do not wrap the light in your hand or in a pocket while it runs.
- **The keys sit a little below the bottom face** (the main key 0.15 mm, the side keys 0.30 mm, inside a 0.5 mm deep frame), so a table does not press them. A hard press in a pocket can still switch the light on. Lock the light before you carry it: 4 clicks on ● (section 15). The design rule is MEC-6; the lockout is BAT-7.

- **Casting rubber, mould release, epoxy and super glue** are chemicals. Read the safety data sheet of the rubber before you open it, wear nitrile gloves and eye protection, and work in a room with fresh air. Keep the cyanoacrylate ("super glue") away from the clear main key and the lens: its vapour leaves a white bloom on clear plastic. Use two-part epoxy for the lens.

Laser safety

The laser of FlashKa is a green **520 nm** module of **Class 2** (EN 60825-1:2014): its output is at most **1 mW** (P ≤ 1 mW). Class 2 means that the blink reflex protects the eye from an accidental glance; do not stare into the beam. The light itself carries no marking, so its warning label is printed here, and it belongs on the packaging too:



The laser warning label, black on white. The picture is made from the artwork of the optional lid label in `order_files/optional_laser_label/`, which marks it on the lid.

Its text, beside the laser warning sign: "FlashKa Keychain", "v0.7 LuxLibre", then **"LASER RADIATION"**, **"DO NOT STARE INTO BEAM"**, **"CLASS 2 LASER PRODUCT"** and **"520 nm P ≤ 1 mW EN 60825-1:2014"** (the wavelength, the highest output power and the standard).

- Never look into the beam, and never point it at people, animals, vehicles or aircraft. Arm the laser only when you need it (slide switch S2, section 15.2).
- **A light that you give or sell to other people needs this label on the light itself** (EN 60825-1). That is what the optional label file is for: order the lid with the label laser-marked, from `order_files/optional_laser_label/` (its README says how; section 4).
- LuxLibre allows Class 1 and Class 2 lasers only (LAS-1), so there is no label for a stronger class. A module that measures more than 1 mW must not be used: send it back and buy another one (LAS-3).

2. The files

Everything you upload is ready in the folder `order_files/` of the package, one subfolder per shop. The paths below start in that folder.

Shop	File	What it is
JLCPCB	`1_JLCPCB/FlashKa_panel_gerbers.zip`	the drawings of the panel with both circuit boards (Gerber files)
JLCPCB	`1_JLCPCB/BOM_JLCPCB.csv`	list of the parts to mount (35 lines, 79 parts per panel)
JLCPCB	`1_JLCPCB/CPL_JLCPCB.csv`	where each part goes and how it is turned
JLCCNC	`2_JLCCNC/FlashKa_tray.step` + `FlashKa_tray.pdf`	aluminium tray: 3D model + drawing (2 sheets)

Shop	File	What it is
JLCCNC	`2_JLCCNC/FlashKa_lid.step` + `FlashKa_lid.pdf`	aluminium lid: 3D model + drawing
JLCCNC	`2_JLCCNC/FlashKa_pmma_kit.step` + `.pdf`	three clear main keys on tabs in a frame (one kit = one light and two spare keys)
JLCCNC	`2_JLCCNC/FlashKa_pom_kit.step` + `.pdf`	the black POM-C parts of one light on tabs in a frame: two radio window inserts (one spare) and the antenna spacer
other shop	`2_JLCCNC/FlashKa_key_main.step`, `FlashKa_rf_window.step`, `FlashKa_antenna_spacer.step` and their drawings	the same parts one by one, for a shop that takes small parts
other shop	`2_JLCCNC/FlashKa_laser_sleeve.step`	only if your laser module is thinner than 6 mm
JLC3DP, once	`3_rubber_keys/FlashKa_key_mould_resin_cavity.stl` + `FlashKa_key_mould_resin_lid.stl`	the two resin plates of the casting mould (the default; same merged order as JLCCNC)
JLCCNC, once (option)	`3_rubber_keys/FlashKa_key_mould_cavity.step` + `FlashKa_key_mould_lid.step` + `FlashKa_key_mould.pdf`	the aluminium mould instead: dearer, but it lasts for many pours
you	`3_rubber_keys/README.txt`, `FlashKa_key_side.pdf`	how to cast the side keys; drawing of the key and its stiffener
nobody	`optional_laser_label/`	a laser label for the lid, only for a light that you sell or give away (section 1, *Laser safety*)

Files you keep:

File	What it is
`hardware/flashka-keychain-v06/app/flashka-flasher.html`	the firmware installer (open it in Chrome or Edge); it holds the firmware of both FlashKa v0.7 and v0.6 and asks which one you have
`hardware/flashka-keychain-v06/app/flashka-app.html`	the phone and computer app (open it in Chrome or Edge); it recognises a v0.7 by itself
`FlashKa_Parts_List_v0.7.xlsx`	every part, price, link and fee

(The same files, with all the source data behind them, are also in `production/` and `cad/`. `order_files/README.txt` describes every folder; `2_JLCCNC`, `3_rubber_keys` and `optional_laser_label` also have a short `README.txt` of their own.)

3. Order 1 — both circuit boards in one panel (JLCPCB)

1. Make an account at **jlcpcb.com** and log in.
2. Click **Order now** (or "Instant quote") and **Add gerber file**. Choose `order_files/1_JLCPCB/FlashKa_panel_gerbers.zip`. Wait until the picture appears: one panel of about 45 × 32.5 mm with the small key board on the left, the main board on the right and a rail along the top and the bottom.
3. Set these options (leave everything not listed at its default):

Option	Choose
Base material	FR-4
Layers	**4**
Delivery format	**Panel by Customer**, panel format 1 × 1 (the file already is the panel)

Option	Choose
Different design	**2** (two different boards in one file; JLCPCB adds a surcharge, shown in the price)
PCB qty	5 (the minimum)
PCB thickness	**0.8 mm**
PCB Color (the solder mask)	**Black solder mask**, white silkscreen (the design and all renders use black boards; a colour surcharge, if any, shows in the price)
Surface finish	**ENIG** (flat gold pads: needed for the Bluetooth module, the small chips and the pogo-pin pads)
Outer / inner copper	1 oz / 0.5 oz (1 oz inner copper is an option: it halves the resistance of the battery strip inside the board, which the board does not need)
Via covering	Tented
Min via hole size/diameter	the value JLCPCB detects (no surcharge)
Remove order number	No (the default). JLCPCB prints a small number on a free spot; it stays inside the closed body

4. Scroll down and switch **PCB Assembly** on:

Option	Choose
PCBA type	**Standard** (parts on both sides need Standard)
Assembly side	**Both sides**
PCBA qty	2 (the minimum), or as many lights as you build if more
Tooling holes / edge rails	by customer: the rails of the panel already carry 3 fiducials and 4 tooling holes. If JLCPCB's review asks for a bigger panel, accept the rails it offers
Confirm parts placement	**Yes** (an engineer checks the orientation of every part; recommended)

5. Click **Next**, then upload **BOM** = `order_files/1_JLCPCB/BOM_JLCPCB.csv` and **CPL** = `order_files/1_JLCPCB/CPL_JLCPCB.csv`. Click **Process BOM & CPL**.
6. The parts list appears: 35 lines. Every line should show a matched part with stock.

   These lines need a closer look:

   - **C22100007**: the six gold pogo pins P1–P6 (Harwin P70-1010045R). LCSC had only 100 on 2026-10-21, and JLCPCB's own stock was not checked. If the line shows no stock, buy the pins into your JLCPCB parts library first (*Parts Manager*, order them from LCSC stock), then come back and place the order.
   - **C139643, C351410, C238645**: the LED driver U2 (TI TPS62095RGTR), the battery protection chip U6 (DW01A) and its double transistor Q3 (SE8830A). They make the 1000 lm possible. Check their stock; if one shows none, buy it into your parts library as for the pogo pins, or wait. **The SE8830A has no simple substitute:** a common "8205A" double transistor has about twice the resistance, and the protection would then cut the light off in turbo (at about 2 to 3 A). **Check its pin order before you order:** its LCSC data sheet shows the pins only in a picture, and they must be S1, D, S2, G2, D, G1 (pins 1 to 6, as on the FS8205A); the board is made for exactly this order, and another one would switch off the protection or short the cell. If you are not sure, ask in the project (section 18).
   - **C115357**: the three key switches SW1–SW3 (Alps SKRKAEE020). Its shop pages could not be read. There is no simple substitute: ask in the project before you pick another switch, because the footprint must match.
   - **C25104**: the two 330 Ω resistors. Any 330 Ω, 1 %, 0402 resistor can replace it.

   If another part is out of stock, the workbook (sheet *Panel BOM*) names an alternative. For example, the Bluetooth module **C2838502** (ESP32-C3-MINI-1-N4) can be replaced by **C41349510** (ESP32-C3-MINI-1-H4X), a drop-in alternative. Four small parts had low or zero *retail* stock at LCSC on 2026-10-14 (C15850, C15195, C1525, C11702). JLCPCB has its own warehouse, and the upload page shows its real stock.
7. **Check the placement preview.** JLCPCB draws every part on the panel. For each chip, the small dot or line that marks pin 1 must sit on the pin-1 mark of the board. The pads of every part must fall on the pads of the board. If a part is turned, select it and use *Rotate*.

Look closest at the parts whose drawing in JLCPCB's library is often turned against KiCad's (DFM-7): on the main board the Bluetooth module **U4**, the small chips **U1, U2, U3, U5, U6**, the transistors **Q1, Q2, Q3, Q4, Q5** and the USB-C socket **J1**. The LED driver **U2** (top side) is a 3 × 3 mm chip with no legs: its pin 1 is at the corner nearest the coil L1, towards the USB-C opening. On the bottom side the protection chip **U6** sits right above the double transistor **Q3**, both turned the same way, pin 1 of each on the side nearer the battery pads. On the key board (the left board) check the three switches **SW1, SW2, SW3** and the two ring LEDs **LED3, LED4** on its bottom side, and the six pogo pins **P1–P6** on its top side. The six round gold pads **J6** on the bottom of the main board get no part: that is right.

If you are unsure, do not worry. With "Confirm parts placement" an engineer checks it and sends you a picture before production.

8. Save to cart, pay. The order (5 bare panels, 2 of them assembled, all parts included) costs about 237 USD before shipping and VAT (the workbook, sheet *JLCPCB order*, shows every line; the bare-panel price and the two-design surcharge are estimates). Choose a shipping method with taxes paid (DDP).

> **Why one panel?** Both boards carry parts on both faces. Ordered on their own, each board would pay its own set-up fees and stencils. In one panel they share one order, one set-up per side and one stencil per side, and you upload one Gerber, one BOM and one CPL. (Each board on its own is in `production/` as a fall-back.)
>
> **Why the gold surface (ENIG)?** The Bluetooth module and the LED driver sit on flat pads under their bellies, and the pogo pins press on the six gold pads J6. Tin (HASL) surfaces are bumpy and can tarnish. ENIG costs a few dollars more and avoids both problems.

4. Order 2 — the aluminium body, the keys, the small plastic parts and the mould (JLCCNC + JLC3DP)

Everything comes from `order_files/2_JLCCNC/`, except the mould plates, which are in `order_files/3_rubber_keys/`. One merged order holds all of it: JLCCNC machines the metal and plastic parts, JLC3DP prints the resin mould, and both come in **one parcel** (put both in the same cart and use JLC's merged ordering: select "All" in the cart, and the cart calculates one shipping rate for the merged order).

1. Go to **jlccnc.com**, log in with the same account, *Instant quote → CNC machining*.
2. **Tray and lid.** Upload `FlashKa_tray.step` + `FlashKa_tray.pdf` and `FlashKa_lid.step` + `FlashKa_lid.pdf`. JLCCNC matches a drawing to a 3D file by its name, which is why both are called the same. The drawings carry the threads and the tolerances.

Option	Choose
Process	CNC milling
Material	Aluminum **6061-T6**
Surface finish	**Bead blasting + anodizing, black** (the drawings ask for type II, 8–12 µm). **No marking** of any kind
Tolerance	ISO 2768-m (standard); the critical values are on the drawings
Threads	yes. Write in the remark: "Tray: 4 × M1.6×0.35 for the lid, 2 × M1.6×0.35 BLIND in the key-board bosses (must not break through the floor), 1 × M1.6×0.35 from the head-block top into the laser bore (under the lid); see drawing; tapped before anodising, screws must fit after finishing"
Texture	write in the remark: "panels with a 0.2 mm 90° V texture and 0.3 mm V grooves, one V engraving cutter, before blasting and anodising (drawing FK-H-01 sheet 2)". If the shop cannot cut it, the parts still fit and work. To save money you may leave it out on purpose (the workbook prices it, about 13 USD for one light): then write "skip feature 17 (texture) of drawing FK-H-01", because the 3D files carry the texture
Quantity	one of each per light. Order **one set first**, test-fit it with your real parts, then order the rest

Bead blasting shoots tiny glass beads at the part for a matt surface. *Anodising* grows a hard, black oxide layer on the aluminium.

3. **The clear main keys (PMMA kit).** Upload `FlashKa_pmma_kit.step` + `FlashKa_pmma_kit.pdf`.

Option	Choose
Material	**Acrylic (PMMA), clear**, cast (not extruded)
Surface finish	**polished** (drawing FK-H-03 asks for a vapour or flame polish; the frosted ring stays matte). If the shop offers only machine polishing, take it, or "as machined" and polish at home (section 12)
Quantity	1 kit (three keys) for 1 or 2 lights, 2 kits for 5 lights: kits = (lights + 1) ÷ 3, rounded up

4. **The black plastic parts (POM-C kit).** Upload `FlashKa_pom_kit.step` + `FlashKa_pom_kit.pdf`. Material **POM (acetal), black**, as machined. One kit per light. It holds the radio window insert of the lid (plus a spare) and the antenna spacer with the plug for the floor window.

   The shop machines plastic parts only from 30 × 20 × 8 mm up, which is why the small parts come in a frame on thin tabs (the kits are 52.8 × 22 × 8.5 mm and 45.4 × 39.3 × 17 mm). Ask in the quote whether it accepts parts on tabs. If it refuses, any CNC shop that takes small parts can make the single files from the same folder.

5. **The casting mould, once per builder (JLC3DP).** Open *3D printing* (jlc3dp.com, the same account) and upload `FlashKa_key_mould_resin_cavity.stl` and `FlashKa_key_mould_resin_lid.stl` from `order_files/3_rubber_keys/` as two parts.

Option	Choose
Process	**SLA (resin)**, a standard resin
Orientation	write in the remark: "print with the flat parting face up; supports only on the ribbed back" (the parting face carries the key cavities and must stay smooth)
Quantity	1 of each. Leave the mould out if you can borrow one

   The plates are 48 × 28 mm, 6.0 and 5.0 mm thick, with ribs on the back; together they cost about 3 USD (estimate). Four **M3 × 16** socket head screws with washers and nuts (section 6) close the mould: the resin carries no threads. A print does not hold the ±0.02 mm of a machined mould, so you try the first key in its opening (section 9).

   Durable option: the aluminium mould from JLCCNC (`FlashKa_key_mould_cavity.step` and `FlashKa_key_mould_lid.step` as two parts, `FlashKa_key_mould.pdf` attached; aluminium 6061-T6, cavity half fine glass-bead blasted, lid as machined, no anodising, 4 × M3 threads in the cavity half, cavities ±0.02 mm, chevron groove with a 0.6 mm end mill). It costs about 40 USD more, lasts for many pours and needs two dowel pins and four M3 × 12 screws instead of the bolts. Order one mould or the other, not both.

6. JLCCNC answers with a price within a day. Things that can come up:
   - Walls: every metal wall is at least 0.5 mm, JLCCNC's absolute minimum. Two are below its recommended 0.8 mm: the two front lid threads behind the lens bore keep 0.51 mm of metal at the root of the thread (to the floor of the bore and to the rear face of the head), and the upper LED wire groove keeps 0.751 mm under the lid seat (drawing FK-H-01, note 7). Name both in the quote chat. If the shop says a wall is too thin for it, do not order: tell the project (section 18).
   - The lid rests on two narrow flat seats on top of the side walls of the tray: they must be flat to 0.05 mm (drawing FK-H-02), or a gap shows along the edges of the facets. On the top face of the lid, the countersinks of the two rear screws come within 0.3 mm of the chamfer of the lanyard slot: the drawing asks to break that edge lightly (note 5).
   - The drawing asks the shop to cut every thread (drawing FK-H-01, note 3: tapped before anodising, checked after finishing). If they say M1.6 threads are not possible, accept plain holes: the drawing gives the tap-drill size (1.25 mm), and you cut the threads yourself with M1.6 hand taps (about 10 USD). The two key-board holes are blind: they are drilled only 2.375 mm deep, and the screw needs 1.7 mm of full thread. A normal (taper or plug) tap cannot cut full thread that close to the bottom, so you also need a **bottoming tap** (only one or two tapered threads at its tip): start with the normal tap, finish with the bottoming tap, turn gently and stop when it reaches the bottom. The laser set-screw hole runs through into the laser bore, so the normal tap is enough there.

- **Customs.** The merged order of one light (tray, lid, two kits and the resin mould) is estimated at about 133 USD (EUR 118.79), below the EUR 150 line: the VAT and a flat EUR 3 per customs line are paid at the checkout, with no carrier fee. If the real quote is more than about 35 USD higher, the parcel goes over the line and through formal customs clearance (about 21 USD more). For two or more lights the parcel is above the line anyway; splitting it pays only with economy shipping (the workbook, section "EUR 150" in `docs/bom_notes.md`).

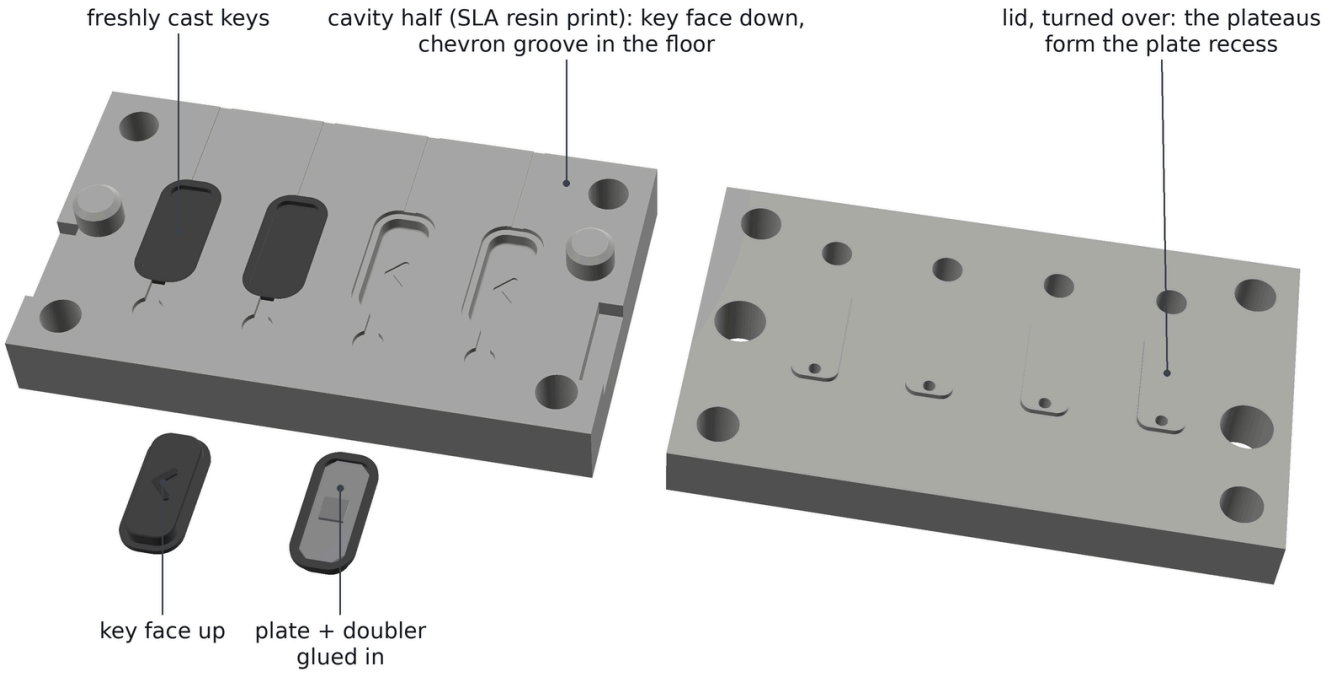
> **Laser label.** The light itself carries no marking. The laser warning label (Class 2, EN 60825-1) is printed in this guide (section 1, *Laser safety*) and belongs on the packaging, which is fine for a light you build for yourself. A light that you sell or give to other people needs the label on the light: then order the lid with laser marking from `optional_laser_label/` (its README says how).

5. Order 3 — the rubber for the side keys

The two side keys are cast at home in the mould of section 4: one pour gives four keys (two for the light, two spares). What you need, once:

Item	Specification	Where
Casting rubber	**Smooth-On ECON 80**, 0.86 kg trial unit (part A + part B): urethane rubber, Shore 80A, mixed **1 part A to 1 part B by volume**, pot life about 13 minutes, cured overnight	an EU shop that sells Smooth-On rubber, for example kaupo.de (EUR 28.56 on 2026-10-22)
Black pigment	**Smooth-On SO-Strong black** (a pigment made for urethane rubber; without it the keys come out translucent)	the same shop
Mould release	a release made for urethane rubber, for example **Universal Mold Release** (spray)	the same shop
Mixing cups, two 5 ml syringes, wooden sticks, toothpicks, nitrile gloves	small disposable cups; one syringe for part A, one for part B	any shop
Stainless steel shim	**0.3 mm**, stainless (1.4301 / 304), a small sheet (100 × 100 mm makes dozens of stiffeners)	AliExpress or a model shop
Cyanoacrylate	rubber-toughened grade (a "super glue" for rubber and metal)	any shop
Polish and abrasive paper	a metal polish (paste) for the chevron grooves of the mould, wet-and-dry paper 400 for the mould and 1000–3000 with a plastic polish for the main keys	any shop
Mould bolts	**M3 × 16 socket head** (ISO 4762), 4, with 8 washers and 4 nuts, stainless	AliExpress or a hardware shop

Read the technical bulletin and the safety data sheet of the rubber before you buy (they are on the maker's page). The rubber, the pigment and the release come in one parcel from inside the EU: no customs. The workbook prices the casting supplies at about 86 USD and the resin mould at about 3 USD (estimate). Smooth-On **PMC-780 DRY** (Shore 80A, 2 : 1 by weight) works as well but costs more and needs a 0.01 g scale. **Sugru** (pressed in by hand, petroleum jelly as release) is the cheapest option, but its keys are softer (Shore 70A) than the drawing asks for.



Render. Left: the resin cavity half with two freshly cast keys still in it and two empty cavities; the keys lie face down, so the chevron is a groove in the cavity floor. Front: a key face up, and one turned over with its stainless plate and doubler glued in. Right: the lid, turned over; its four small plateaus form the recess for the plate in each key.

6. Order 4 — parts you buy ready-made

Search these on AliExpress, Kaidomain or any electronics shop; the cell and the nickel strip come from an EU battery shop. The workbook (sheet *Bought parts*) has a search term, a link example and the typical price for each. Order them first (section 1) and **measure what you receive** before you order the aluminium body.

Part	Exact specification	Quantity per light
Li-ion cell	**Vapcell INR14500 F15**: one cylindrical 14500 lithium-ion cell (the size of an AA battery), 3.6 V, 1,500 mAh, **3 A continuous**, **flat top**, **no protection board** (the main board protects it), 14.0 × 49.0 mm. Buy it from an EU battery shop that ships lithium cells (for example nkon.nl, EUR 3.10 without VAT on 2026-10-23); it comes in the shop's own parcel. **If the shop offers it with welded tabs, take that:** then you need no spot welder. Not a button-top or a protected cell: they are longer. Alternative: the **Vapcell INR14500 K10** (1,000 mAh, 8 A, flat top), which keeps the full turbo to a lower charge but runs about a third shorter; no EU shop had it in stock	1 (+1 spare)
Nickel strip	**pure nickel strip, 0.2 × 5 mm** (not nickel-plated steel), 1 m from the same shop: two pieces of about 15 mm per light, welded to the ends of the cell	about 30 mm
LED board	**Luminus SST-20 Gen 2**, 6500 K, on a **10 mm** round copper DTP board (direct thermal path), **1.6 mm** thick. Ask for the **G1** flux bin. Not the older SST-20 (Gen 1), and not a 16 or 20 mm board (it does not fit)	1 (+1 spare)
TIR optic (the lens)	**LEDiL LISA3-RS-PIN** (LEDiL code FP16558): round, 10.0 mm, 6.9 mm high, clear lens in a black holder with two pins. **Not** the clip version LISA3-RS-CLIP16 (too tall). Sold in packs of 5 by electronics distributors (for example RS, stock no. 186-2699)	1 (a pack of 5)
Laser module	520 nm green, **6 × 12 mm** body, **with a built-in constant-power (APC) driver for a 3.0–4.2 V supply**, **Class 2 (≤ 1 mW)**, with wires. Ask the seller for a measured output power	1
Lid screws	**M1.6 × 6 mm countersunk** (ISO 7046 / DIN 965), stainless steel. Not shorter: the lid is 3.4 mm thick where they pass	4 (+4 spare)
Key-board screws	**M1.6 × 2.5 mm pan head** (ISO 7045 / DIN 7985), stainless steel. **Not longer:** the two holes are blind	2 (+4 spare)
Laser set screw	**M1.6 × 5 mm set screw**, flat point (ISO 4026) or cup point (ISO 4029), hex socket for a 0.7 mm key, stainless steel. **Not longer:** it sits under the lid, and a longer screw stops the lid from closing	1 (+4 spare)

Part	Exact specification	Quantity per light
Wire	**24 AWG PTFE**, red and black (usually sold as 5 m rolls; one light needs about 0.4 m). The thicker wire carries the 3 A of turbo. The laser keeps its own thin leads	–
Thermal paste	non-curing silicone paste, a small syringe: a thin film under the LED board	a little
Kapton tape	polyimide tape, 0.05 mm thick, 5–10 mm wide: on the two rails of the cell bay, over the strips and every joint, and in the corner where the black cell wire runs	a little
Closed-cell foam	**0.5 mm** thick, soft (PE or EVA), a small sheet: you stack a few layers into a strip that presses the cell down under the lid and a pad at the tail end (section 14.9)	a little
Two-part epoxy	**5 minute**, small syringe: fixes the lens in the head. **Not cyanoacrylate** (white bloom)	a little
Silicone gap pad	**1.5 mm** thick, **Shore 00 70–80** (soft; the thermal rating does not matter), a sheet of at least 20 × 20 mm. You cut **8.8 × 12.4 mm** from it for the module-can boss	1 piece
Silicone rubber sheet	**1.0 mm** thick, **Shore A 70** (firmer), at least 20 × 20 mm. You cut **3.7 × 3.0 mm** from it for the front boss	1 piece
Silicone adhesive	small tube, **neutral cure** (no vinegar smell: the acid kind can attack the copper of the board). Sticks the two pads	a drop per pad
Split ring or lanyard	stainless split ring, 20–25 mm, wire at most about 1.5 mm thick (its double coil must pass the 3.6 × 4.6 mm tail slot), or a thin cord	1 (+1 spare)

The two pads hold the main board down against the six pogo pins of the key board (section 14.6). The firmer pad goes on the small boss, the softer one on the big boss. The casting supplies and the mould bolts are in section 5.

Another cell: any flat-top 14500 lithium-ion cell from a known maker, with a datasheet, fits if it measures at most 14.5 mm across and 50.4 mm long (without its strips); the foam takes up the difference (section 14.9). The battery numbers of the firmware are made for the F15.

7. Tools

Tool	Why	About (USD)
Soldering iron with a fine tip (temperature-controlled, e.g. Pinecil or TS101)	the wires, also onto the nickel strips (never onto the cell)	35
Solder 0.5 mm with flux core	clean joints on small pads	8
Flux (gel syringe or pen)	makes the solder flow on small pads and on the nickel strips	6
Desoldering braid (wick)	to remove solder if a joint goes wrong, and the temporary wires of the test	3
Fine tweezers	hold small parts and wires	5
Flush side cutters	wires, the tabs of the two kits, the two pins of the lens, the stubs of the cast keys	5
Wire stripper (fine), for 24 AWG	strip the wires without cutting the strands	7
Hobby knife or scalpel and a small cutting mat	cut the two silicone pads and the foam to size, trim the cast keys	7
Precision screwdriver and hex key set	M1.6 lid and key-board screws (check the head type you bought); 0.7 mm hex key for the M1.6 laser set screw; 2.5 mm hex key for the M3 mould bolts	8
Digital caliper	measure the cell, the LED board, the lens, the laser, the pads and the cast keys	12
Multimeter	check cell voltage, polarity and shorts	15
Laser safety glasses for 520 nm (OD 4 or better, CE / EN 207 marked)	laser tests	14
Isopropyl alcohol 99 %, cotton swabs	cleaning flux, the mould and the glue faces	6

Tool	Why	About (USD)
USB-C cable that carries data	firmware; many cheap cables only charge	4
Small vice with soft jaws	flatten the cut shim	15
Small straight tin snips	cut the stiffener plates from the 0.3 mm shim, and the nickel strip	8
Small spot welder for nickel strip (not needed if the cell comes with welded tabs, or a shop welds them)	weld the two nickel strips onto the ends of the cell: **never solder onto the cell**. Practise on scrap strip first; wear safety glasses	40
Needle files	file the tab stubs of the kits and the shim pieces	6
Computer with **Chrome or Edge** (Windows, macOS, Linux or ChromeOS)	firmware installer	–

These tools add up to about 204 USD (164 USD without the spot welder). Optional and not counted: a 0.01 g pocket scale (about 10 USD, only for PMC-780 DRY), a magnifier or USB microscope (about 15 USD; good for checking the small parts and the cast chevrons), a bench power supply with a current limit (about 30 USD, for a careful first power-up), a laser power meter for 520 nm (about 45 USD, to check that the module is really Class 2), M1.6 hand taps, a normal one and a bottoming tap (about 10 USD, only if JLCCNC cannot cut the threads, section 4), and a small vacuum chamber with a pump (about 60 USD) to take the air out of the mixed rubber.

8. When the parcels arrive — check

- **Panel:** break the two boards out of the rails at the small perforated tabs (hold the board, bend the rail) and file the 0.3 mm nubs flush, two on each long side of each board. Look at both sides of both boards under good light (a phone camera zoom works): no part missing, no part crooked, no solder bridges between pins of the Bluetooth module, the LED driver U2 or the USB-C socket. The **key board** (the small one) has three small push switches in a row and two tiny ring LEDs beside the middle one on one side, and six gold spring pins and eight tiny resistors on the other, with the white print **"← HEAD"** and **"PINS: S2 SIDE"** (section 12.4 needs it). Press each spring pin lightly with a fingernail: it must spring back. The **main board** has six round gold pads in a row on its bottom side (the side with the USB-C socket), with no part on them. The slide switch S2 must move with a click.
- **Body:** the main board must drop into the tray (section 14.8 shows how) and the lid must close flat. The four lid threads must accept a screw by hand, and so must the small thread in the top of the head block for the laser set screw: it sits in front of the front lid-screw hole on the S2 side and opens into the laser bore. The two small round bosses on the floor inside (one each side of the middle key opening) must accept the **M1.6 × 2.5** screws by hand; they are blind, so stop when the screw is snug. The floor has a shallow frame with three openings: a square one in the middle (7.0 × 7.0 mm) and two long ones (4.4 × 10.3 mm). Behind them, towards the tail, is a rectangular window, 5.1 × 10.8 mm, and in the cell bay two low rails run along the floor. In the head, the big bore (10.1 mm) for the LED board and the lens must be clean and flat at its bottom: that face carries the heat of the LED. The edges must be clean, with no burr.
- **Plastic kits:** three clear keys in the PMMA frame, and in the black frame two radio window inserts and one antenna spacer. No cracks. Do not cut them out yet (section 12).
- **Mould:** two resin plates, 48 × 28 mm; the cavity half with four key shapes and two printed pins, the lid with four small raised plateaus and two sockets for the pins; four through holes for the M3 bolts. The parting faces must be smooth, without support marks.
- **Pads:** the gap pad is 1.5 mm and the rubber sheet 1.0 mm thick (check with the caliper).
- **Cell:** measure it with the multimeter: 3.0–4.2 V is normal for a new cell (they are often shipped about half charged). Measure its diameter and its length with the caliper and write them down: an F15 is about 14.0 × 49.0 mm (13.8–14.2 × 48.7–49.3 mm), and section 14.9 picks the foam for your cell from these numbers. The sleeve must be whole and the can without dents. Keep it away from coins, keys and tools.
- **LED board:** 10.0 mm diameter, 1.6 mm thick, the "+" and "−" marks are readable.
- **Lens (TIR optic):** 10.0 mm diameter, about 6.9 mm high, the two small pins on its back. Keep it in its bag: the clear lens must stay clean and free of scratches.

- **Laser:** 6.0 mm diameter, at most 12 mm long. Red wire = +, black wire = −. If you have a power meter, measure the output now; it must be 1 mW or less.

9. Step 1 — Cast the side keys

Start with the keys: the rubber cures overnight before the mould can be opened, and you can do steps 2 and 3 meanwhile. The numbers below come from the rubber maker's data. **Casting has not been tried with this mould yet** (section 18: tell the project how it went). The same steps, a little shorter, are in `order_files/3_rubber_keys/README.txt`; it also gives the steps for PMC-780 DRY and for Sugru.

9.1 Prepare the mould (once)

1. **Try the plates.** Put the lid on the cavity half: the two printed pins go into the two sockets, one way only. Push the four M3 bolts through: they must pass freely. Take it apart.
2. **Polish the chevron grooves.** Each key shape has a small V-shaped groove in its floor: it becomes the raised chevron of the key. Sharpen a toothpick to a chisel tip narrower than the groove (0.6 mm), dip it in metal polish and rub it along the groove until the floor shines. The chevron of every key then comes out glossy. Without this step the chevron is matt and still reads by touch.
3. **Matt key faces.** The key face takes the surface of the print. For the matt face of the pictures, rub each cavity floor (around the groove, not in it) with 400-grit paper on a flat stick.
4. Wipe both plates with isopropyl alcohol and let them dry.

9.2 Mix and pour (four keys per pour)

Wear gloves and eye protection, work in fresh air, and keep the room at about 23 °C.

1. Check that the small pour and vent holes of both plates are free. Spray mould release on every face that touches rubber: the four cavities, the small channels, the flat faces and the lid's plateaus and holes. Let it dry as its label says. Without release the rubber sticks to the resin.
2. The four keys need only about 0.22 cm^3 of rubber, far too little to measure. Draw **5 ml of part A** into one syringe and **5 ml of part B** into the other (1 : 1 by volume), empty both into a cup and add the **black pigment** at the maker's dose (a few drops; too much can stop the cure).
3. Mix for the time the bulletin gives, scraping the sides and the bottom of the cup several times. You have about **13 minutes** (the pot life) to pour: do not wait.
4. Optional: put the cup in the vacuum chamber to take the air out (the rubber rises before it settles, so use a cup that holds several times the rubber).
5. Lay the cavity half flat, key shapes up. With a toothpick, work a little rubber into the chevron groove of each cavity first, so that no air stays in it. Then pour slowly, in a thin stream, into one corner of each cavity and let the rubber run across the floor. Stop when it is level with the flat face.
6. Lower the lid over the pins slowly. Its plateaus push the extra rubber out through the pour and vent holes. Fit the four M3 bolts with a washer under each head and each nut, and tighten them evenly, in turn: **firmly, not hard** (the plates are resin). Rubber should now show in every hole; fill a hole that stays empty with the toothpick.
7. Leave the mould flat and still overnight (**24 hours** at 23 °C). A colder room takes longer.

9.3 Open the mould and trim

1. Take the bolts out, put a flat screwdriver into one of the two slots at the short ends and twist gently until the lid lifts. Pull each key out by its flange (the thin rim around it).
2. Trim with a sharp scalpel or the flush cutters: the small stub at the end of the flange where the rubber came in, the stub at the other end, and the stub on the floor of the recess, each flush. **Check each key face:** no bubble, chevron complete. A key with a fault goes into the spares box; pour again.
3. **Try the first key in its opening** in the floor of the tray (when the body has arrived): it must drop through with a hair of play. A printed mould does not hold the exact size of a machined one; if the key is too tight, tell the project

(section 18).

4. Clean the mould at once: push the cured stubs out of the holes with a pin.

9.4 The stiffener: plate and doubler

A rubber key alone would bend when you press it near one end, and it would feel soft. A thin stainless plate glued into the key makes it rock as one stiff part, so it clicks wherever you press it. Each key gets two pieces of the 0.3 mm shim:

- the **plate**: 3.6 × 9.4 mm, with the four corners cut off at 45° (0.8 mm along each edge). It must fit the 3.8 × 9.6 mm recess in the back of the key, so cut it to the line or a hair smaller (up to 0.2 mm), never bigger;
- the **doubler**: 2.0 × 2.0 mm. It is the part that presses the switch.

1. Mark the outlines on the shim with a fine marker and a steel rule. Cut just outside the line with the tin snips, then file or sand to the line. Deburr both faces and press the pieces flat between two smooth blocks in the vice (the snips curl thin sheet).
2. Wipe the recess of the key and both pieces with isopropyl alcohol (it removes the mould release), roughen the glue faces lightly with fine abrasive paper, and wipe again.
3. Glue the doubler on the centre of the plate with a small drop of cyanoacrylate and press it flat.
4. Glue the plate into the recess with a thin film, **doubler up** (away from the key face), and hold it flat until the glue has set. Wipe any glue off the flange: the flange must sit flat on the floor of the tray.

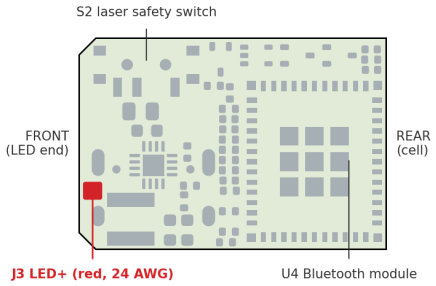
You should see: the plate lies a little below the rim of the flange and the doubler stands a little above it (0.15 mm each way in the model). Make four keys this way: two for the light and two spares. (A sheet-metal shop can also laser-cut the plates from `FlashKa_key_stiffener.step`.)

10. Step 2 — Prepare the cell

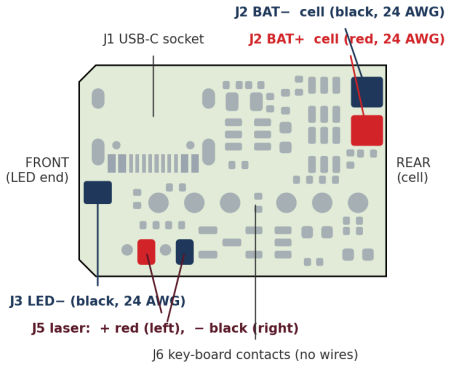
The flashlight takes its power from the cell, also while you install the firmware, so the cell comes first. The 14500 cell of v0.7 has no protection board of its own. Two nickel strips on its ends carry the current; you solder one wire to each strip, and the two wires go to the two cell pads of the main board, where the protection circuit sits.

The pads you will solder. The front end of the board is the end with the LED pads J3 (the head of the light). The rear end is the end with the cell pads J2. Keep this picture next to you. Sections 13 and 14 use it again.

TOP side (lid side, with the Bluetooth module) — seen from above



BOTTOM side (with the USB-C socket) — board turned over along its long edge



red = + (plus), dark blue = − (minus); grey = other pads. J3: LED+ on top between the USB-C socket's two front legs, LED− underneath behind the socket.

A drawing of the two sides of the main board, not a photo (the real board is black). Red pads are +, dark blue pads are −. J2: the two cell pads, one wire on each; J3: the LED, LED+ on the top side between the two front legs of the USB-C socket and LED− on the bottom side behind the socket; J5: the laser. The row of six round pads on the bottom side is J6, where the key board makes contact: no wires there. The small "+" and "−" printed on the board are tiny: trust the picture.

How the cell lies in the light. It lies on two low rails along the floor of the bay, its **+ end (the small raised cap) towards the head**. The **+ strip** leaves the cap towards the USB-C side and bends forward into the open channel of the antenna spacer, the black plastic part between the board and the bay; the red wire is soldered to it there. The **− strip** leaves the flat end at the tail downwards into the lower corner of the bay on the USB-C side; the black wire is soldered to it there and runs forward along that corner, beside the cell, to the board. The two wires never cross. Cut the antenna spacer out of its kit now (section 12.1 shows how): you need it, and the tray, to try the shape of the strips.

1. **Check the cell.** The small raised cap is **+**; the flat other end and the whole metal can under the plastic sleeve are **−**. Confirm with the multimeter: red probe on the cap, black probe on the flat end, the reading must be positive, between 3.0 and 4.2 V. The sleeve must be whole: never use a cell with a torn sleeve or a dented can.
2. **The two nickel strips.** *If your cell came with welded tabs*, check that they hold (tug gently) and go on with step 3. *If not*, weld 0.2 × 5 mm pure nickel strip onto both ends with the small spot welder (or have a battery shop do it). Cut two pieces of about 15 mm. Practise first on two scrap pieces of strip until a weld holds when you tear them apart. Then weld one piece onto the middle of the + cap with two or three spots, and the other onto the middle of the flat − end. Wear safety glasses. **Never solder onto the cell:** the heat of an iron on the cap or the can damages its seal and its safety vent, and the cell can fail later.
3. **Insulate the + end.** The thin rim of the can around the + cap is − (it is part of the can). Cover that rim with a small piece of Kapton tape, so that the + strip can never touch it.
4. **Bend the strips.** Put the antenna spacer into the empty tray (section 14.8, step 1) and lay the cell on its two rails, + end towards the head. Bend the **+ strip** sideways along the cap towards the USB-C side and then forward, so that its free end lies in the open channel of the spacer. Bend the **− strip** down the flat end into the lower corner of the bay

on the USB-C side and then forward along that corner. Take the cell out again and trim the strips so that their ends just reach the channel and the corner. Cover the − strip with Kapton tape where it runs over the edge of the can.

5. **Wires.** Cut one red and one black 24 AWG wire, strip 3 mm at both ends, twist the strands and tin them with solder. The black wire must reach from the end of the − strip along the corner of the bay and up through the spacer's channel to the J2 pads: about **60 mm** between the two joints in the design, so cut it about **75 mm** and shorten it in step 8 if needed. The red wire is short: less than **10 mm** between the end of the + strip and the J2 + pad in the design, so cut it about **25 mm**. Hold the cell, the spacer and the board in place in the tray to check the lengths: a little slack is good, a loop is not.
6. **Solder the wires to the strips, one at a time, never to the cell.** Cover the − strip with Kapton, put a little flux on the free end of the + strip and solder the red wire to it: hold the tinned wire on the strip and touch with the iron for 2–3 seconds, no longer, as far from the cell as the strip allows. Let it cool and cover the joint with Kapton. Then uncover the − strip and solder the black wire to its free end the same way, and cover that joint too. **Never let the two wires, or a wire and the can, touch each other.**
7. **Check the board for a short.** Set the multimeter to the beep (continuity) setting and touch the two J2 pads (see the picture above). It must **not** give a steady beep. (On the resistance setting, a reading near 0 Ω is a short. A reading that climbs slowly is normal: the capacitors on the board are charging from the meter.) If it beeps, stop and look at the board under a magnifier. Do not connect the cell.
8. **Solder to the board.** The cell pads J2 are the two big pads at the rear end, in the corner on the **bottom side** (the side with the USB-C socket). **J2 − (the black wire)** is the pad nearer the long edge with the USB-C socket; **J2 + (the red wire)** is the pad nearer the middle of the board (see the picture). Put a little flux on the pad, hold the tinned red wire on the + pad and touch with the iron for 2–3 seconds; then the black wire on the − pad. Red first, then black. Each pad takes one wire.
9. The board is now powered. Nothing lights up: the ring LEDs are on the key board, and the firmware is not installed yet. (The protection chip on the board may also start switched off; the first time you plug in USB, in section 11, wakes it.) Lay the board and the cell on a non-metal surface.

> **If anything gets hot, smells or smokes:** pull the cell away with pliers by its wire and put it in the metal box. A reversed cell destroys the board. That is why the picture and step 8 matter: the − pad of v0.7 is the one nearer the USB-C edge.

Optional, for the first power-up. Nobody has powered a FlashKa yet. If you own a bench power supply with a current limit, you can follow the bring-up of the LuxLibre testing guide (bring-up of a new board) before you solder the cell: set about 3.7 V and a current limit of 100 mA on the J2 pads. The protection chip may hold the board off when power first reaches J2 (the supply then shows almost no current): plug in USB for a moment, or connect the supply's minus to the board ground (the USB-C shell) instead of J2 −. This guide goes on directly with the cell.

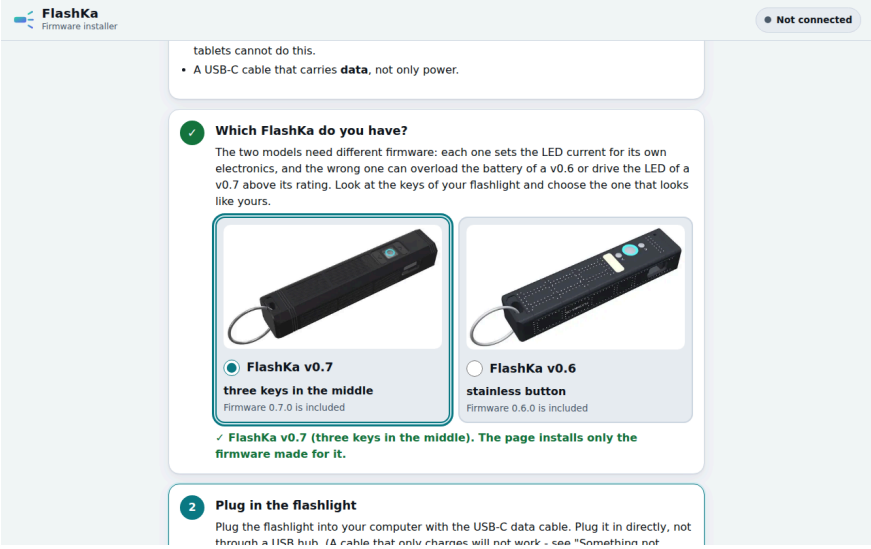
11. Step 3 — Install the firmware (no experience needed)

The firmware is the program that runs in the flashlight. v0.7 runs **FlashKa firmware 0.7.0**: the FlashKa firmware built for the v0.7 electronics (its LED driver, its levels, its battery). You install it from a web page, through the flashlight's own USB-C socket. Nothing to download, nothing to install on your computer. **Never install the v0.6 firmware on a v0.7:** the two set the LED current differently. The installer makes sure of it.

You need: the main board with the cell soldered on (step 2), a USB-C cable **that carries data**, and a computer with **Google Chrome** or **Microsoft Edge**. (Firefox and Safari cannot do this, and phones cannot flash.)

1. Open the installer. The project publishes it at `https://dompka.github.io/LuxLibre/flashka/flashka-flasher.html`. The same page is the file `app/flashka-flasher.html` of the v0.6 folder: open it in Chrome or Edge (double-click the file; if it opens in another browser, right-click → *Open with* → Chrome). You can also put the `app` folder of v0.6 on any website with https (see web_apps.md of v0.6).

2. Choose your FlashKa. The page asks **"Which FlashKa do you have?"** and shows two pictures. Choose **"FlashKa v0.7 - three keys in the middle"** (firmware 0.7.0). Nothing can be installed before you choose.



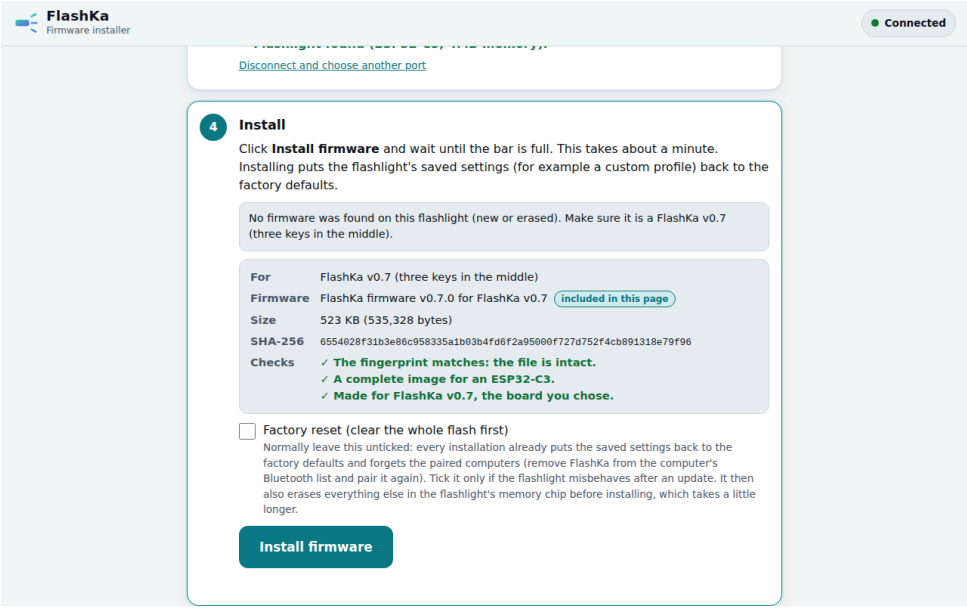
The installer asks which FlashKa you have (a screenshot of the page). Choose FlashKa v0.7, three keys in the middle.

3. Plug in. Connect the board's USB-C socket to the computer. (The ring that shows charging is on the key board, so you see nothing on the bare main board. That is normal.)

4. Connect. Click **Connect**. A small browser window lists the serial ports. Choose:

- on Windows: **"USB Serial Device (COM3)"** (the number can differ),
- on macOS: **"USB JTAG/serial debug unit"** (`cu.usbmodem…`),
- on Linux and ChromeOS: **"USB JTAG/serial debug unit"** (`ttyACM0`),

and click **Connect** in that window. The page says **"Flashlight found (ESP32-C3, 4MB memory)"**. It also reads the firmware already on the light: a new board has none. If it finds the firmware of the other FlashKa, it warns you, and you can install only after you tick that you have checked your light.



The installer after Connect (a screenshot of the page): it names the firmware inside the page (FlashKa firmware v0.7.0 for FlashKa v0.7, 535,328 bytes) and shows three green checks.

5. Install. Leave the box "Factory reset" **unticked** (every installation already puts the settings back to the factory defaults). Click **Install firmware**. A progress bar runs for about one minute. Do not unplug while it runs.

6. Done. The page says "Installed and checked". Unplug the cable.

That's it. To update the firmware later, do exactly the same with a newer installer page.

> **Every installation resets the saved settings** (your custom profile) to the factory defaults **and makes the light forget the paired computers.** After an installation, remove "FlashKa" from the Bluetooth list of each computer and pair it again (section 15).

If "Connect" shows no port

- **The cable.** Most failures are charge-only cables. Try another cable. One that can move files to a phone is a data cable.
- **Another USB port**, directly on the computer (not through a hub).
- **Windows 7/8** have no built-in driver for this USB serial port; use Windows 10/11.
- **Linux:** your user must be allowed to use serial ports: `sudo usermod -a -G dialout $USER`, then log out and in again.

If the port appears but connecting or installing fails

Force the chip into its built-in installation mode (it cannot be broken this way): a key must be held while the USB cable is plugged in. In v0.7 the key switches are on the key board, so:

1. Do step 4 (keys and key board into the tray) first, then lay the main board into the tray as in section 13 and hold it down with a fingertip.
2. Unplug the USB cable. **Press and hold the main key ●** from below.
3. While holding it, **plug the USB cable in** through the opening in the side. Keep holding for about a second, then release.
4. Click **Connect** again and choose the port. Then **Install firmware**.
5. When it is done, unplug and replug the cable.

In a closed light it works the same way: hold ● while you plug in. Why this works: plugging in USB restarts the chip (a small circuit on the board does that), and a chip that starts with a key pressed waits for new firmware instead of running the old one. Every press of any of the three keys pulls the same pin low. (The pin reaches the key board through the last of the six round J6 pads, the one nearest the rear end; the first one, nearest the front end, is ground.)

What happens inside (for the curious)

The ESP32-C3 has a USB port built in. The installer page uses your browser's *Web Serial* feature and the open-source **esptool-js** to write one file (`flashka-fw-v0.7.0-merged.bin`, 535,328 bytes: bootloader, partition table and program) to address 0 of the module's 4 MB flash memory. The file sits inside the page, next to the v0.6 firmware. The page checks its fingerprint (SHA-256, `6554028f31b3e86c958335a1b03b4fd6f2a95000f727d752f4cb891318e79f96`) and that it was made for the board you chose before writing.

12. Step 4 — Keys and key board

The three keys go into the floor from the inside, and the key board, screwed to two bosses of the floor, holds them in place.

12.1 Cut the kits

Cut the parts out of the two frames with the flush cutters, close to the part, and file the stub of each tab flush with a needle file. The tabs sit on faces that are hidden in the light. Never cut or file the outer face of a clear key or its frosted ring. The frames are scrap.

12.2 Polish the main key (only if the shop did not)

The clear key carries the light of the ring, so its faces should be clear and smooth. Polish with fine wet-and-dry paper (1000, then 2000 and 3000, wet) and plastic polish. Keep the frosted ring matt. Clean the key with water and a little mild soap only: solvents (also isopropyl alcohol) can craze acrylic, and cyanoacrylate vapour leaves a white bloom.



Render, close-up of the bottom face (head to the upper right). The keys sit in a shallow frame: the previous key (left), the clear main key with the frosted ring (shown lit cyan; the switch is visible through it) and the next key (right). The chevrons point along the light: on the next key towards the head, on the previous key towards the tail.

12.3 Keys into the floor

Lay the tray open side up on a towel.

1. **Main key:** drop it into the square opening from inside, outer face (with the frosted ring) first, until its flange (the thin rim) rests on the floor. It must drop in by its own weight, with a hair of play, and its face ends a little below the bottom face. **Turn it the right way:** the square key fits the opening every way round, but the pocket in its inner face is 4.4 × 3.4 mm, and its long side must run along the light (from the head to the tail). The key is clear, so you see the rectangular pocket, with the round nub in its middle, when you look through the key. Turned by 90°, the pocket is too short for the switch (3.9 × 2.9 mm): the key blocks the switch, and the key board cannot come down onto its bosses. Never force it with the screws.
2. **Side keys:** the two are the same part, turned round. Drop each into a long opening from inside, face (with the chevron) first, plate and doubler up. **Turn them so that, seen from outside, both chevrons point along the light:** the key nearer the head points to the head (it is the next key, **^**), the key nearer the tail points to the tail (the previous key, **v**). Look from below and compare with the picture above.
3. Tilt the tray a little: each key moves freely in its opening, without catching. Do not turn the tray over now: the keys are loose until the key board is on.

12.4 The key board

1. Hold the key board with the **switches and the two ring LEDs down** (towards the keys) and the six gold pins up. Its two holes go over the two round bosses beside the main key.
2. **Turn it the right way round.** The board fits the bosses both ways, but only one is right: the row of six gold pins goes to the **S2 side** (+Y, the side wall with the slot of the slide switch, on the laser side), away from the USB-C opening. (In the picture of section 14.6 the S2 side is the upper wall; the USB-C opening is in the lower one.) The white print on the board shows it: on the pin side **"← HEAD"** (the arrow points to the head, where the LED sits) and **"PINS: S2 SIDE"**; on the switch side an arrow between the switches that points to the head as well. The drawing `production/FlashKa_keys_assembly_top.pdf` shows the pin side. Turned the other way, the switches of ^ and v change places, the pins miss their six gold pads, and two of them hit the USB-C socket of the main board, so the main board cannot go down onto its ledges. Never force it.

3. Lay it on the bosses. The switches come to rest just above the keys.
4. Fit the two **M1.6 × 2.5** pan-head screws and tighten them gently, in turn: **snug only**. The threads are blind holes in aluminium and strip easily. Never use a longer screw.

12.5 Check the keys

Turn the tray over and press each key from outside with a fingertip. **You should feel:** a hair of free movement (0.15 mm for the main key, 0.25 mm for the side keys), then a clear click. Press each side key near its two ends too: it must still click (that is the job of the stiffener). No key may stay down, and none may click by itself when the tray lies on the table.

13. Step 5 — Test in the open tray (lid open)

Find a fault now, while the light is still open. The switches are on the key board, so the test runs with the main board lying in the tray on the six pogo pins. **This way of testing is new and untested.** Work on a non-metal surface. Keep the USB cable unplugged unless a step says so.

Lay the board in. The cell stays outside the tray for now, beside it on the table.

1. Hold the main board with its bottom side (USB-C socket) down, front end (LED pads) towards the head. Tilt it a little (about 5°) with the **S2 side low** (the side opposite the USB-C socket).
2. Push the front edge under the head step and guide the **S2 knob into its slot** in the side wall first. Swing the USB-C side down: the socket goes into its opening in the wall, and the board comes down on the six spring pins.
3. **Hold the board down** with a fingertip on the big metal can of the Bluetooth module (the place where the big pad will press later). The pins push back with about 7 N (the force of a small bag of sugar); only when the board lies on its ledges do the pins make good contact.

How to click a key. Hold the board down with one hand and press the keys from below with the other (lift the tray a little, or turn it on its side). A **click** is a press shorter than 0.4 s; the pause between the clicks of one gesture is at most 0.4 s. A hold is longer. If a gesture does not work, you were too slow: click faster, like a double-click.

13.1 Charging and the ring

1. Plug in the USB cable through the opening in the side. **You should see:** the ring on the clear main key breathes red slowly, about once in 3 seconds. That means charging. Steady green means the cell is full. If the ring stays dark, press the board down more firmly (the pins must touch the six gold pads).
2. Unplug the cable.

13.2 Ring colours and gestures (no wires needed)

With the light off, do each gesture and look at the ring:

You do	You should see
● 4 clicks	red × 3 (lockout on)
● 4 clicks again	green × 3 (lockout off)
● 3 clicks	blue × 2 (a Bluetooth window opens for 2 minutes), then a blue double blink every 3 s
^ or v click	nothing: ^ and v do nothing while the light is off

Red, green and blue must look like red, green and blue. **If a colour is wrong** (for example the lockout shows green first), the pad map of the ring LED differs from the plan. That is a known open point of the design (chapter 14, section 14.12). Do not assemble. Write down what you see and report it (section 18). The mixed colours (white, yellow) may look tinted: the colour balance is not tuned yet.

To check Bluetooth with the app (optional): open the app (section 16) in Chrome or Edge on a computer, click ● three times (ring blue × 2), click **Connect** in the app and choose **FlashKa-XXXX**. **You should see:** the battery percentage, the voltage and the temperature, and the app knows that it is a FlashKa v0.7.

Do not click ● once for now. A single click switches the main LED on, and no LED is connected yet. Nobody has tried that on a real board, so leave it for the LED test below.

13.3 LED and brightness levels (recommended)

1. Lift the board out (the pins push it up; hold the cell). Solder a red 24 AWG wire (60 mm) to the **+** pad and a black one (60 mm) to the **−** pad of the LED board, on the LED side, with the wires pointing away from the board's centre. You will use the same wires in the body later.
2. Solder the red wire (LED +) to the **J3 +** pad on the **top** side, between the two front legs of the USB-C socket, and the black wire (LED −) to the **J3 −** pad on the **bottom** side, behind the socket (see the picture in section 10).
3. Lay the board into the tray again as above, with the LED board lying on the table in front of the head, LED up, and hold the board down.
4. Click ● once. **You should see:** the LED lights at Low (40 mA), and the ring shows green for 2 seconds (battery above 50 %; yellow means 20–50 %, red below 20 %).
5. Click ^ **once**: one step brighter (Medium, 250 mA). Click v twice: Low, then Moon (3 mA, very dim). A third v does nothing: the levels do not wrap.
6. Click ● again: the LED goes off. Now click ^ and v: **nothing happens** (no light, no ring).

Do not run High or Turbo on the bench, and keep Medium to a few seconds. Outside the aluminium body the LED board has nothing to shed heat into, and High puts more than 4 W into the LED. Do not look into the bare LED.

13.4 Laser with the safety switch (recommended)

> **Warning — laser.** Put on the 520 nm safety glasses first. Point the module at a matt dark card at the end of the table. Nothing shiny in the beam, nobody in line with it. Never look into the beam. The laser is on only while you hold the gesture.

1. With the board out of the tray, solder the module's wires to **J5**, the pair of narrow pads on the bottom side: **red to the pad nearer the front end (+)**, black to the other one (−). Lay the board into the tray again and let the module lie on the table, pointing at the card.
2. Push the knob of the slide switch **S2** towards the **rear (cell) end**: ARM. (The v0.7 body carries no SAFE and ARM marks: towards the head is SAFE, towards the tail is ARM.)
3. With the light off and not locked: click ●, then press ● again and **hold** it. **You should see:** a green dot on the card and the ring steady red, for as long as you hold. Let go: both go off.
4. Push S2 to the **front end**: SAFE. Repeat the gesture. **You should see no green dot.** (The ring may still turn red: the firmware cannot see S2.)
5. If the dot comes on with S2 at the front end, your switch works the other way round. Do not use that light as it is. Report it (section 18).

13.5 Presenter mode (pairing and keys)

Unplug the USB cable first: plugging in USB restarts the chip and ends presenter mode. The cell must be above 3.20 V (presenter mode is refused below that: one red blink).

1. Press ^ and v **together** for 2 seconds (two fingertips). **You should see:** the ring blinks magenta twice, then breathes cyan, slowly. The light waits for a computer.
2. On the computer open the Bluetooth settings and pair **FlashKa-XXXX** (XXXX is the end of the light's Bluetooth address). On Windows 10 or 11: *Settings → Bluetooth & devices → Add device → Bluetooth*. There is no PIN; the computer may ask you to confirm. The steps for other systems are in section 15.4. **You should see:** the ring blinks cyan twice and goes off.
3. Open a text editor with a long text. Click ^ (quick press): the page moves down by one screen (Page Down). Click v: it moves up (Page Up). Click ●: a letter **b** is typed. Each key press makes a short white blip on the ring. Each click must give **exactly one** key.

4. Hold ^ for about a second: **one** F5 is sent. Hold v for about a second: **one** Esc.
5. Press ^ and v together for 2 seconds: the ring blinks magenta twice. The light is a flashlight again.

Nobody has tried the pairing with a real FlashKa yet; if it does not work, see section 17.

13.6 Clean up

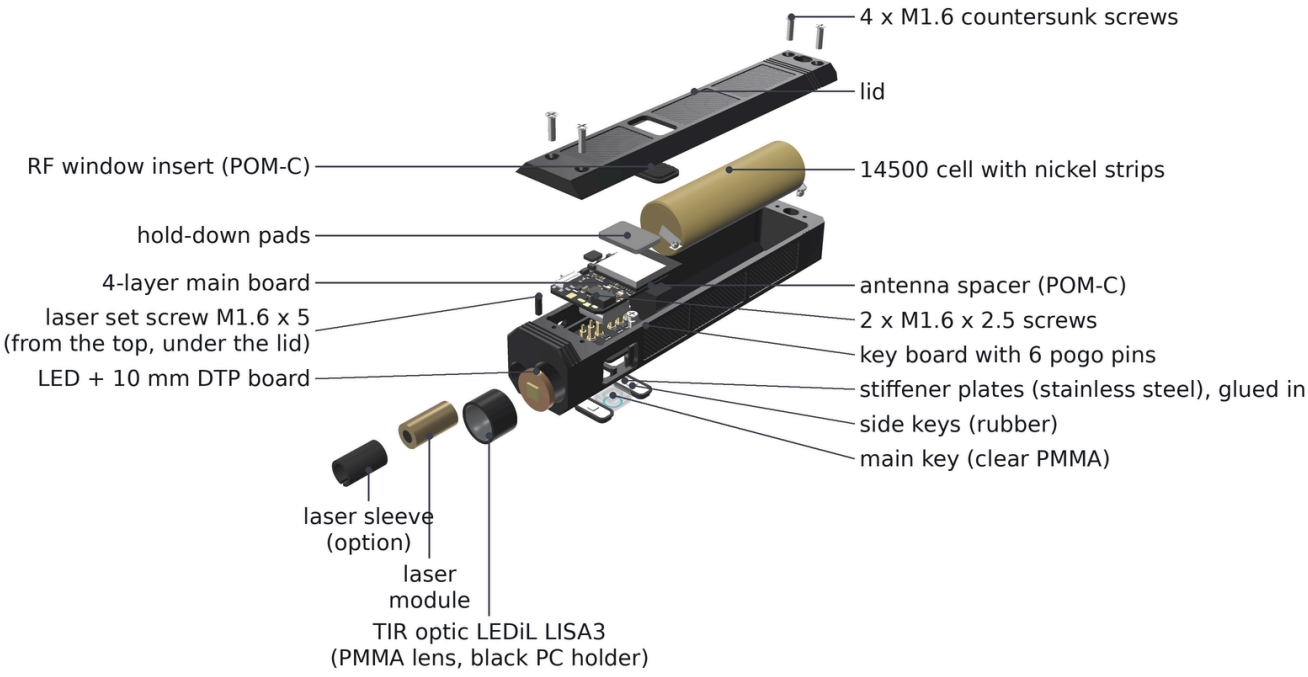
Lock the light (4 clicks on ●, red × 3): it stays locked until section 15. Lift the board out and unsolder the LED wires from **J3** and the laser wires from **J5** with the desoldering braid: you need them with free ends in section 14. Check that nothing bridges the pads. The keys and the key board stay in the tray.

14. Step 6 — Assemble

Work on a clean towel. The order matters, because some joints cannot be reached later. Two steps use glue (the lens and the two pads): give each the time on its pack to harden, and do the other work meanwhile. Close the lid last.

14.0 Make it safe first

The cell is connected, so the board is live. Push the knob of the slide switch **S2 towards the front (LED) end: SAFE**. The light is locked since section 13.6 (if not: lay the board into the tray, hold it down and click ● 4 times, red × 3).



Render, exploded view. From the front into the head: the TIR optic (the lens), the LED on its 10 mm board, and the laser module (with the optional sleeve); above the head block the laser set screw (M1.6 × 5), which goes in from the top, under the lid. Below the tray, ready to go into its floor from inside: the clear main key and the two rubber side keys with their glued-in stainless plates. In the tray: the key board with its six pogo pins, held by two M1.6 × 2.5 screws. Then the main board with the hold-down pads drawn above it, the antenna spacer, the 14500 cell with its nickel strips, and the lid with its radio window insert and four M1.6 × 6 countersunk screws.

14.1 Keys and key board

They are already in (section 12). Check once more that every key clicks.

14.2 LED board

If you did not do this in section 13.3: solder a red 24 AWG wire (60 mm) to the **+** pad and a black one (60 mm) to the **−** pad of the LED board, on the LED side, with the wires pointing away from the board's centre. Keep the joints small and flat: the lens stands on this face.

14.3 Into the head

Look into the big bore from the front. Its wall has two narrow grooves that end in two small holes at the bottom: seen from the front, the **upper groove at about 11 o'clock** (tilted towards the laser) and the **lower one at about 5 o'clock**.

1. **Turn the LED board** so that its **+ pad faces the upper groove and its − pad the lower one**: the wires then run straight into the grooves and never pass under the board.
2. Push the red wire into the upper groove and on through its hole into the inside of the body, the black wire through the lower groove and hole.
3. Put a thin film of **thermal paste** on the back of the LED board (the face without the LED) and push the board to the bottom of the bore, wires pulled gently from inside. It must lie flat on the bottom: that face carries the heat of the LED. If the board does not drop into the bore, sand its edge lightly and try again.

14.4 The lens (TIR optic)

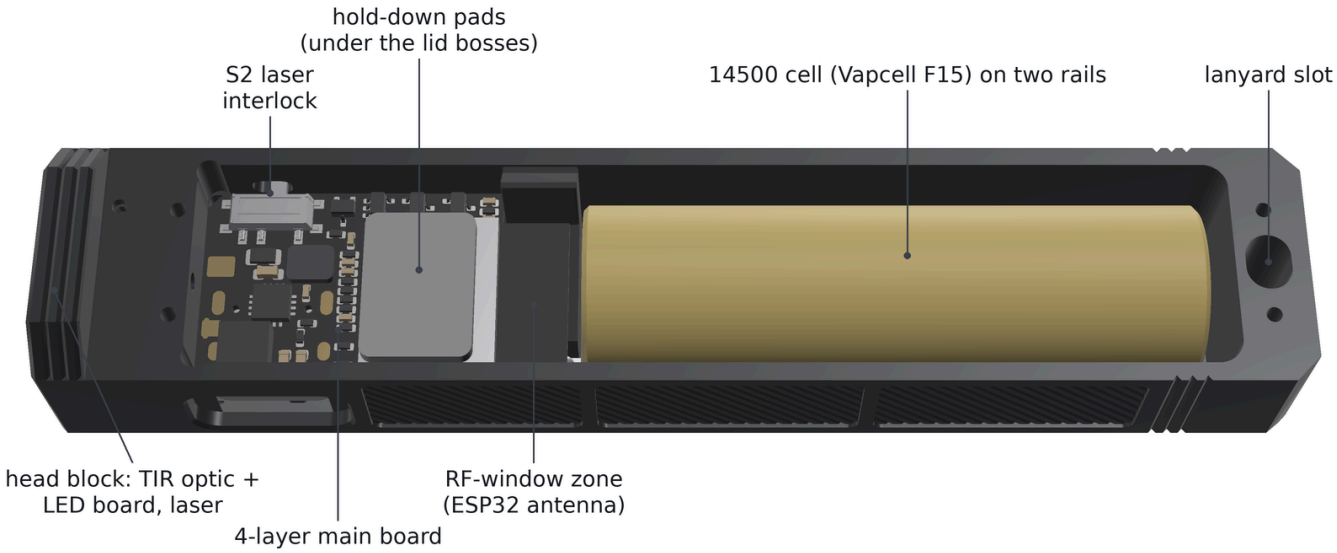
1. **Cut the two pins** on the back of the lens holder off flush with the flush cutters: the LED board has no holes for them, the bore holds the lens in place. Do not touch the clear lens faces.
2. **Try it dry.** Push the lens into the bore, clear face out, until its black holder stands on the LED board. Its face ends about 0.2 mm inside the front face of the body (0.0 to 0.4 mm): it must never stand out. It must stand flat. If it rocks on the two solder joints of the LED board, take it out and file two small notches into the rim of the holder where the joints are.
3. **Glue it.** With the lens in place, press it gently onto the LED board with a fingertip on a clean tissue, and put three or four tiny dots of mixed **two-part epoxy** with a toothpick into the gap between the black holder and the bore wall. Keep epoxy off the lens face. Hold it pressed until the epoxy has set (see its pack). **Never use cyanoacrylate here:** its vapour fogs the clear lens. The glued lens also holds the LED board on the bottom of the bore.

14.5 Laser

Push the module into the small bore beside the LED bore, on the S2 side, from the front, wires first, until its front sits about 0.3 mm behind the front face (no thermal paste needed: a Class 2 module makes almost no heat). If you use the plastic sleeve (only for a module thinner than 6 mm), turn its slit down, away from the screw.

Then fix it with the **M1.6 × 5 set screw**, now, while the lid is off. The screw goes into the small thread in the **top of the head block** (the face that the front end of the lid covers), in front of the front lid-screw hole on the S2 side; look into it and you see the laser module at the bottom. Turn it in with the 0.7 mm hex key until it presses on the module: **snug only**, the module body is soft brass. In the model the screw then ends 0.77 mm below the top face, so the lid closes over it and nothing of it shows on the closed light. A screw that stands out of the top face is too long: use an M1.6 × 5.

14.6 Lid: pads, and the radio window insert



Render, the open tray seen from the lid side, head on the left. The two hold-down pads are drawn on the board, where the lid bosses press: the big grey one on the metal can of the Bluetooth module and the small one nearer the head. Behind the board: the radio-window zone over the antenna and the 14500 cell on its two rails.

Pads. Under the lid there are two raised blocks, the **bosses**. A boss presses on the board through its pad: the big one is 8.8 × 12.4 mm and goes over the metal can of the Bluetooth module; the small one is 3.7 × 3.0 mm and goes at the front of the board.

1. Cut the pads on the cutting mat with the knife and a ruler, in one firm stroke per edge (do not saw). Measure with the caliper:
   - from the **1.5 mm silicone gap pad** (soft): **8.8 × 12.4 mm**, for the big boss;
   - from the **1.0 mm silicone rubber sheet** (firmer): **3.7 × 3.0 mm**, for the small boss.
2. Put a small drop of **neutral-cure silicone adhesive** on each boss, spread it thin, and press the matching pad on. Keep the adhesive off the board and off the rim of the lid.
3. Leave the lid face up until the adhesive has skinned over (see the pack; this is a good moment to do the other steps). The pads must stay on the lid when you open it later.

When the lid closes, the big pad is compressed from 1.5 to 1.15 mm and the small one from 1.0 to 0.75 mm. Together they press the board down with about 40 N (calculated): five times the push of the six pogo pins, so the board stays on its ledges.

Radio window insert. The black insert closes the window of the lid; the Bluetooth signal passes through it. It is **not glued**: its plug fits the window, its flange sits in a pocket on the inside, and the antenna spacer below holds it when the lid is closed. Put it in from the inside just before you close the lid (section 14.10), with the textured face out.

14.7 Wires to the board (bottom side first)

- **Laser:** J5 is the pair of narrow pads side by side on the bottom side (see the picture in section 10): **red to the pad nearer the front (LED) end (+)**, black to the other one (−). Shorten the wires so that about 15 mm of slack remains.
- **LED black (−):** to the **J3 −** pad on the **bottom** side, behind the USB-C socket. The black wire comes out of the lower hole and runs under the USB-C socket to it.
- **LED red (+):** to the **J3 +** pad on the **top** side, between the two front legs of the USB-C socket. The red wire comes out of the upper hole and bends a little sideways to the pad. You can also do this one after the board is in; the top side stays reachable.

Shorten the LED wires so that they lie flat without loops.

14.8 Antenna spacer, cell and board

The antenna spacer goes in **before** the board. The antenna of the Bluetooth module sticks out of the board's rear edge and lies just above the spacer once the board is in, so the spacer cannot go in afterwards. The two cell wires run through the open channel of the spacer, which the board then covers. The cell goes in together with the board, because the short red wire joins them.

1. **Antenna spacer.** Push it into the tray right behind the key board, the textured plug down, its tall side towards the S2 side and its low, open channel along the USB-C side. The plug drops into the window in the floor and must end level with the floor (turn the tray over and look).
2. **Tape.** Put a strip of Kapton tape along the top of each of the two rails in the bay, and one into the lower corner of the bay on the USB-C side, where the black wire will lie.
3. **Tail pad.** Make the tail pad of section 14.9 (8 × 8 mm) and press it against the tail wall of the bay.
4. **Cell.** Hold the main board above the tray, bottom side (USB-C socket) down, front end (LED pads) towards the head. Lower the cell into the bay, + end towards the head: tail end first, pressing the tail pad together, then the front end down onto the rails. Press the black wire into the lower corner on the USB-C side all along the cell. Lay the + strip with its joint and both wires into the open channel of the spacer: they must lie below the top of the channel.
5. **Board.** Tilt the board a little (about 5°) with the **S2 side low**. Push the front edge under the head step and guide the **S2 knob into its slot** in the side wall first.
6. Swing the USB-C side down. The USB-C socket goes into its opening in the wall, the antenna comes down over the spacer, and the board meets the six spring pins of the key board and pushes them down as it goes. Do not force it. If it does not go down, look for a wire in the way: the cell wires must stay in their channel, the LED wires flat.
7. Press the board onto its ledges with a fingertip on the module can. It must lie flat. Without the lid the pins lift it again when you let go: that is normal.

14.9 Foam on the cell

The cell must not rattle, and the lid must close without force. Two small stacks of the 0.5 mm foam sheet do both: a **strip** under the lid, about 6 × 46 mm, that presses the cell onto its rails, and the **tail pad**, about 8 × 8 mm, between the − end and the tail wall. Use the size of your cell that you measured in section 8:

Your cell (diameter × length)	Foam strip under the lid	Tail pad
13.8 × 48.7 mm (the smallest F15)	3 layers (1.5 mm)	7 layers (3.5 mm)
14.0 × 49.0 mm (a typical F15)	3 layers (1.5 mm)	6 layers (3.0 mm)
14.2 × 49.3 mm (the largest F15)	2 layers (1.0 mm)	5 layers (2.5 mm)
14.3 × 50.4 mm (the largest K10)	2 layers (1.0 mm)	1 layer (0.5 mm)

1. Cut the layers with the knife and stack them (a touch of double-sided tape between them, or none: the lid holds them).
2. Lay the strip on top of the cell, along its middle.
3. The cell stands about 1 mm above the rim of the tray: the lid has a pocket for it. Check that no strip, joint or wire stands above the cell or outside the bay.

The way of the strips and the cell wires has not been tried on a real light. If it does not fit, report it (section 18).

14.10 Close the lid

1. Put the radio window insert into the lid (section 14.6) and the lid on the tray: the end with the slot for the split ring is the tail. The lid rests on the flat tops of the two side walls, and its edges meet the tray at the edges of the facets.
2. The pads and the foam push back. **Press the lid down firmly** with one hand and start the four **M1.6 × 6** countersunk screws with the other, two at the head and two at the tail. Start all four, then tighten them in turn. **Snug only:** the threads are in aluminium and strip easily.

You should see: the lid flat on the tray, no gap along the edges of the facets, no wire pinched in the joint. Shake the light gently: the cell must not rattle (if it does, add a foam layer).

14.11 Test every key

1. Unlock the light: **4 clicks on ●**, ring green × 3.
2. Click ●. **You should see:** the LED lights at Low. Click ^: brighter (Medium). Click v twice: Low, then Moon. Click ●: off.
3. Every key should move a hair (the free play) and then click. No key may stay down, and the light must not switch on by itself when you put it on the table or turn it over.
4. Push S2 to SAFE and lock the light again (4 clicks, red × 3).

If a key does not work or feels wrong, see section 17 (keys).

14.12 Split ring

Thread a split ring (wire at most about 1.5 mm) or a thin cord through the slot in the tail.

15. Step 7 — First use

Plug in the USB cable and charge the light until the ring is **steady green**. Then:

15.1 Flashlight mode

- ● **one click:** on (Low the first time). **One click** again: off.
- ● **hold** while off: on in Moon. **Hold** while on: steps Low → Medium → High → Low, every 0.6 s.
- **^ and v** while the light is on: one level up or down (Moon, Low, Medium, High). They do not wrap and never go into Turbo. While the light is off or locked they do nothing.
- ● **double click:** turbo, about 1000 lm (2,850 mA in the default profile). It lasts at most 60 s; in a room the temperature regulation starts to turn it down after about 57 s, and at 60 s the light steps down to High by itself. Another double click goes back. **Turbo is brightest with a full cell:** one cell cannot give the full current when it is half empty, so turbo then gives about 775 lm instead of 966 lm. That is normal.
- **High** (about 600 lm) runs for about three and a half minutes in a room before the temperature regulation turns it down. Then the light keeps about 280 lm for more than two hours (about 137 minutes from a full cell, simulated), with the body warm but not hot (about 46 °C in still air, simulated): it holds its temperature just below the profile's limit. Outdoors in a cool wind it stays bright longer.
- ● **triple click** (off): Bluetooth for 2 minutes (ring blue × 2). While the light is on, a triple click shows the battery on the ring: 1 to 5 blinks, green, yellow or red.
- ● **four clicks:** lockout (red × 3); four clicks again unlock (green × 3). A locked light ignores everything else. **Lock it before you carry it in a pocket.**

The levels of the default profile: Moon 3 mA (about 1 lm), Low 40 mA (19 lm), Medium 250 mA (119 lm), High 1,530 mA (601 lm), Turbo 2,850 mA (966 lm with the LED hot, about 1,045 lm in the first second). These are estimates from the LED's datasheet, not measurements. All levels and profiles are in Appendix A, section A.9.

15.2 Laser check



Render, the laser side (+Y), head on the right, tail with the split ring on the left. Near the head, the small slot of the slide switch S2. There are no marks on the body: knob towards the head = SAFE, towards the tail = ARM.

The laser warning label and what it means are in section 1 (*Laser safety*). With the light off, **click ●, then click and hold ●**: the laser is on while you hold. The ring is steady red. The slide switch S2 in the side wall must be **armed**: knob pushed **towards the tail** (ARM). With the knob towards the head (SAFE) the laser cannot come on, whatever the software does: the switch cuts the laser's supply in hardware (LAS-2). The laser stops after 60 s, above 60 °C, below 3.2 V and in lockout.

Check it once with the safety glasses on and the light pointed at a wall (unlock first: 4 clicks, green × 3): knob towards the head → no green dot; knob towards the tail → the dot appears. If the laser comes on with the knob towards the head, your switch works the other way round. Do not use the light as it is, and report it (section 18).

15.3 Presenter mode

In presenter mode FlashKa is a Bluetooth keyboard that turns slides. The laser stays the pointer. Hold the light like a presenter, keys up under your thumb and the head towards the screen: the key nearest the head shows **^** and goes to the next slide, the key nearest your hand shows **v** and goes back.

Enter it: hold **^ and v together for 2 seconds**. The ring blinks magenta twice and then breathes cyan, slowly: the light waits for a computer. The main LED cannot be switched on in presenter mode.

What the keys do (the key set "Page keys", the default):

You press	Key sent
^ click	next slide: **Page Down** (key set "arrows": Right arrow)
v click	previous slide: **Page Up** (key set "arrows": Left arrow)
^ hold 0.8 s	start the show: **F5** (sent once)
v hold 0.8 s	end the show: **Esc** (sent once)
● click	black screen on or off: **B**
● hold	**laser** while you hold (S2 on ARM)

Every key goes out once, as a quick press and release, so holding a key never makes the computer repeat it. Keys are sent only while a computer is connected (ring off). While the ring breathes cyan, presses are dropped.

15.4 First pairing (untested on real systems)

Pairing works only in presenter mode. The light uses a pairing method without a PIN ("Just Works"): the computer asks you to confirm. When the computer is connected, the ring blinks cyan twice and goes off. The steps below come from

the documentation of each system. **Nobody has tried them with a real FlashKa.** If your screen differs, trust your system and tell the project.

System	Steps	Note
Windows 11, Windows 10 (1803 or newer)	Settings → Bluetooth & devices → Add device → Bluetooth → "FlashKa-XXXX" (keyboard icon)	older Windows 10 cannot pair
macOS	System Settings → Bluetooth → "FlashKa-XXXX" → Connect	close the Keyboard Setup Assistant if it opens
Android 6 or newer	Settings → Connected devices → Pair new device → "FlashKa-XXXX" → Pair	
iPhone, iPad (iOS 9 or newer)	Settings → Bluetooth → "FlashKa-XXXX" (Other devices) → Pair	the on-screen keyboard hides while the light is connected
Linux (BlueZ, kernel 3.19 or newer)	`bluetoothctl`: `scan on`, `pair <addr>`, `trust <addr>`, `connect <addr>`	

The light remembers up to **4 computers**; a fifth replaces the one paired longest ago. After the first pairing, entering presenter mode is enough: the computer reconnects by itself and the ring blinks cyan twice.

15.5 Keys for your program

Which keys suit which program has **not been tested**. Choose the key set in the app (section 16).

Program	Key set	Note
PowerPoint (Windows, Mac), LibreOffice Impress	Page keys (default)	B is the black screen, Esc ends the show
PDF viewers	Page keys (default)	
Keynote, Google Slides	arrows (Right / Left)	on a Mac, F5 does not start a show: start it on the computer
A program that ignores Page Up and Page Down	arrows	

F5 starts a show in Windows and Linux programs only. If the slides do not move, try the other key set.

15.6 Leaving presenter mode, and forgetting computers

Presenter mode ends when:

- you hold **^ and v together for 2 seconds** (ring magenta × 2);
- you press nothing for the idle time (30 minutes by default, 5–120 minutes in the app);
- the battery stays below 3.20 V for 2 seconds (five fast red blinks);
- you click ● four times: that locks the light, so it also leaves presenter mode;
- you plug in USB (the chip restarts). Enter presenter mode again; the computer reconnects.

Presenter mode keeps the radio on, about 20 mA (an estimate, not measured), which is about 50 to 70 hours from a full cell (calculated with the 1,400 mAh that the firmware assumes).

Forget all paired computers: hold ^ and v together for **10 seconds**. The ring blinks white × 3. On the way the light changes mode at 2 seconds (ring magenta × 2), as for any 2-second hold: from flashlight mode it enters presenter mode and stays there, ready to pair a new computer; from presenter mode it leaves. Also remove "FlashKa" from the Bluetooth list of each computer, otherwise that computer keeps trying the old key.

16. The app

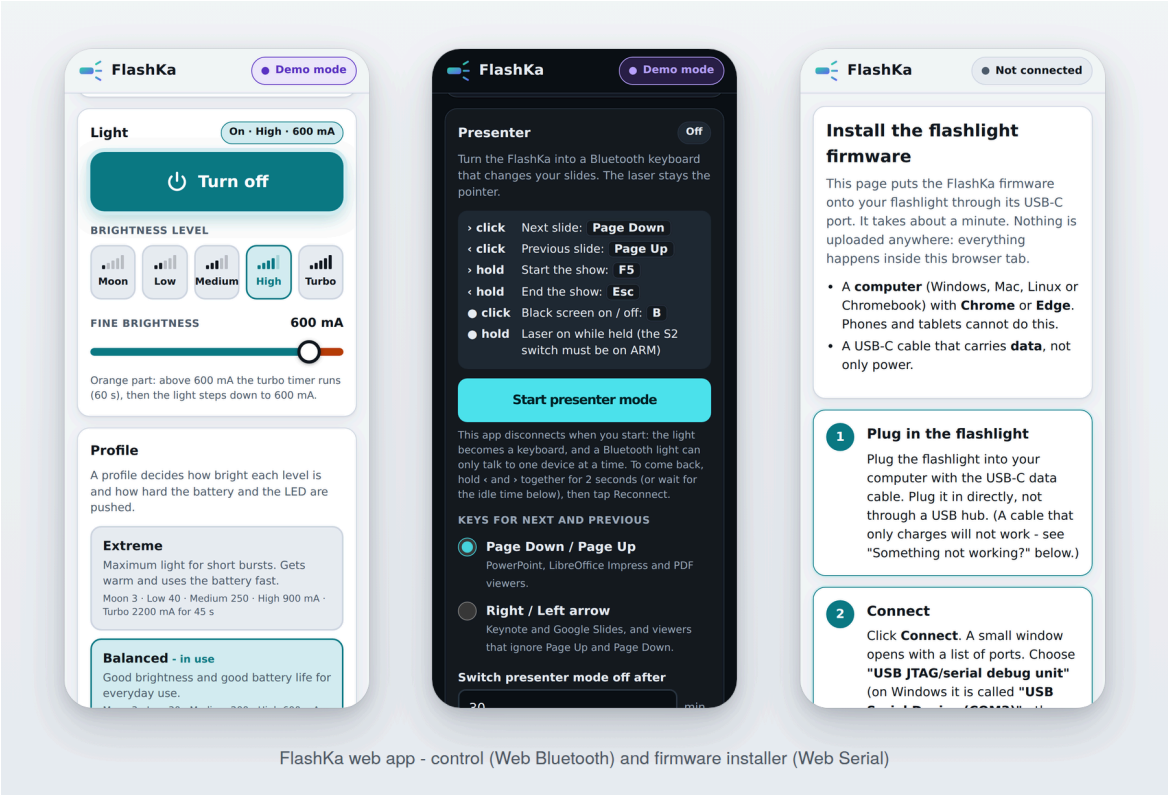
The app serves both FlashKa v0.7 and v0.6 and recognises your light by itself. **On a computer** (Windows, Mac, Linux, ChromeOS with Bluetooth): open `app/flashka-app.html` of the v0.6 folder in Chrome or Edge. **On a phone** the page must come from a web address (https). The project publishes it at `https://dompka.github.io/LuxLibre/flashka/flashka-app.html`. Open that address in Chrome on Android, or in

the free **Bluefy** browser on an iPhone or iPad. You can also put the `app` folder of v0.6 on a web site of your own (free on GitHub Pages, about 10 minutes, step by step in web_apps.md of v0.6, section 4).

The light listens for the app only in short Bluetooth windows: while it is on, for 2 minutes after it was switched off, after a triple click, or while USB is connected. So switch it on (or triple-click it) before you tap **Connect**. The app cannot connect while presenter mode is on: a light has one Bluetooth connection at a time.

What the app shows and does (the picture below shows the pages):

- **Battery, voltage, temperature, runtime left** at the top.
- **On/Off and the levels**, with the current and, on a v0.7, the estimated light out of the front (for example "1530 mA · 601 lm"; estimates, not measurements). The key on the light always wins: for 3 s after you press it, the app cannot switch or dim the light ("the button has priority").
- **Profiles:** *Extreme* (the most light: High 1,800 mA, turbo 2,850 mA), *Balanced* (default), *Endurance* (longest battery life, the LED never runs above 500 mA, no turbo), *Custom* (your own: every level, the turbo current (at most 2,850 mA on a v0.7) and time, the temperature limit, the battery limits - the battery current limit is 2,800 mA in the built-in profiles of a v0.7; if the battery protection ever cuts the light off in turbo, use 2,500 mA; then **Save to flashlight**).
- **Presenter card: Start presenter mode** (the app disconnects, because the light is now a keyboard; to come back hold ^ and v for 2 seconds, then tap **Reconnect**), the keys for next and previous (Page keys or arrows), the idle time, **Swap** (exchanges next and previous), how many computers are paired (N of 4), **Forget paired computers**, and a short help for pairing. **Save to flashlight** stores your choices.
- **Demo mode** shows the app without a flashlight; it can simulate a FlashKa v0.7 with its cell.



FlashKa web app - control (Web Bluetooth) and firmware installer (Web Serial)

Screenshots of the web pages in demo mode, not of a real light. Left: the light controls and the profiles. Middle: the Presenter card (dark theme). Right: the firmware installer.

17. Troubleshooting

Power, charging and the ring

What you see	What to do
Nothing at all when you click	Charge it (USB). The ring breathes red while charging.

What you see	What to do
USB does not charge	Charging pauses above 45 °C (it goes on at 43 °C) and below 0 °C, and while the LED runs above 500 mA. Check the cable.
Charging pauses, or a full charge takes more than 4 hours	Normal with a nearly empty cell: the charger warms the board next to the temperature sensor, so charging pauses above 45 °C until it cools to 43 °C. A full charge takes about 3.5 hours at room temperature, up to about 3.8 hours with the pauses, and longer in a warm room.
A short red flash when you click ●	Locked: four clicks unlock it (green × 3).
Five fast red blinks	Battery empty: charge it. (It also means that presenter mode ended because the battery fell below 3.20 V.)
One red blink	The light refused a request: turbo when too hot, the laser when not allowed, switch-on with an empty battery, presenter mode in lockout or below 3.20 V.
^ or v do nothing	Normal while the light is off or locked. They step the levels while the light is on, and turn slides in presenter mode.
The ring flickers red for a moment when the light starts	Normal: the boot message runs over that pin.
A very short press on ^ or v switches the light on	Known: from deep sleep a very short press counts as ●. Hold a little longer when you wake the light.
Light gets dimmer by itself	Normal: in turbo the temperature regulation takes over after about 57 s and the turbo time ends at 60 s; High steps down after about 3.5 minutes (210 s); then the light holds about 280 lm at a steady temperature. A low battery also steps it down.
Turbo is weaker when the cell is not full	Normal: one cell sags under the turbo current, and below about 3.7 V the driver cannot hold the full current. From a half-full cell turbo gives about 775 lm instead of 966 lm (simulated). A high-drain cell such as the Vapcell K10 keeps the full turbo longer, but runs shorter.
The light goes dark during turbo and no key wakes it	The battery protection on the board cut the cell off and stays off: the light has no power switch, so only USB power resets it. Plug in USB for a moment; the light then works again. It should not happen in normal use: report it (section 18) and use High until the cause is known (or set the Custom profile's battery current limit to 2,500 mA).
After connecting the cell nothing reacts	Before the firmware is installed this is normal. Plug in USB once: it also wakes the protection chip.

What the ring shows (the complete table is in Appendix A, section A.5):

Ring	Meaning
red, slow breathing / green, steady	USB connected: charging / charge complete
red × 3 / green × 3	lockout on / off
green, yellow or red for 2 s after switch-on	battery above 50 % / 20–50 % / below 20 %
red blink every 4 s while the light is on	battery below 10 %
blue × 2	Bluetooth window opened (● 3 clicks while off)
blue double blink every 3 s	flashlight mode: Bluetooth window open, nobody connected
cyan (dim), steady	flashlight mode: the app is connected
cyan × 3	"Identify" from the app
magenta × 2	presenter mode entered or left
cyan, breathing	presenter mode: waiting for the computer
cyan twice, then off	presenter mode: computer connected
short white blip	a presenter key was sent
white × 3	paired computers forgotten
red, steady	laser on
one red blink	request refused
five fast red blinks	battery empty

Presenter mode and pairing

What you see	What to do
The computer does not list FlashKa	The ring must breathe cyan (waiting). If not, enter presenter mode (^ and v together, 2 s). One red blink means the light refused: it is locked, or the battery is below 3.20 V. Bluetooth must be on in the computer.
Pairing fails, or the computer says it cannot connect	**Remove FlashKa from the computer's Bluetooth list and pair again.** Do this after every firmware installation too: the installation makes the light forget its computers, but the computer still holds the old key.
A computer cannot pair at all	A computer that only supports old ("legacy") pairing cannot pair: Windows 10 before 1803 and Android before 6. The light uses only LE Secure Connections.
Paired, but the keys do nothing	The ring must be off (connected). Cyan breathing means no computer is connected, and keys are dropped. Click into the slide window first so that it has the keyboard focus. Try the other key set in the app.
F5 does not start the show	F5 starts a show in Windows and Linux programs only. On a Mac start the show on the computer.
The app cannot connect	One connection at a time: the app cannot connect while presenter mode is on. Leave presenter mode first (^ and v together, 2 s). A paired computer in range may also hold the link for up to 10 s; wait, or switch off its Bluetooth.
Presenter mode ended by itself	The idle time ran out (30 minutes by default), the battery fell below 3.20 V, or USB was plugged in.
A computer should forget the light	Hold ^ and v together for 10 s (ring white × 3) and remove FlashKa in the computer's list.

Laser, installer and app

What you see	What to do
Laser does not come on	S2 must be armed (knob towards the tail). The gesture is click, then click-and-hold from off (● hold in presenter mode). It stops above 60 °C, below 3.2 V and after 60 s, and never works in lockout.
Installer: no port	Data cable, other USB port (section 11).
Installer: connection fails	Hold the main key while plugging in (section 11).
Installer: it says the firmware on the light belongs to the other FlashKa	Check your light: a v0.7 has the three keys in the middle of the bottom face. If it is a v0.7, tick the box that says you have checked it, and install.
Installer: it refuses a file you chose yourself	The file was made for the other FlashKa. Use the firmware inside the page.
Installer: "The firmware inside this page is damaged"	Get the page again (a changed file fails the check).
App: "the button has priority"	Wait 3 seconds after pressing a key, then try again.
App finds no flashlight	Bluetooth is off to save power: switch the light on, or click ● three times (ring blue × 2), then *Connect*. It also finds nothing in presenter mode.

Head, lens and cell (new in v0.7)

What you see	What to do
The LED board does not drop into the bore	Sand its edge lightly on fine paper, turning it, and try again.
The lens rocks or stands out of the front face	It stands on the solder joints of the LED board: file two small notches into the rim of its holder (section 14.4), or make the joints flatter.
The lens is foggy or white	Cyanoacrylate vapour, or epoxy on the face. Use a spare lens (they come in packs of 5), and only epoxy, in tiny dots at the rim.
The beam has a dark spot or a ring	The LED board is turned or not flat on the bottom of the bore, or the lens does not stand on the board. Report what you see (section 18).

What you see	What to do
The lid does not close over the cell	The foam strip is too thick for your cell (take a layer off, section 14.9), a strip or a joint stands out (bend it flatter, into the channel or the corner), or the cell is not on its rails. Never press the lid down onto the cell by force.
The cell rattles	Add a layer of foam to the strip or to the tail pad (section 14.9).
A strip came off the cell	Weld it on again (or have it welded). Never solder it onto the cell.

Keys, key board and pogo pins (new in v0.7)

What you see	What to do
The ring stays dark and no key works, but USB charging starts	The pogo pins do not reach the main board. With the lid closed the pads press the board down; with the lid open, press the board onto its ledges. Check that no pin is bent and that the six gold pads J6 are clean (wipe them with isopropyl alcohol). Are the key-board screws in and the board flat on its bosses? Is the key board the right way round, its pins on the S2 side (section 12.4)?
One key does nothing, the others work	Open the lid, take the main board out and look at that switch on the key board: is it soldered on all pads? Is a cast stub or a drop of glue between the key and the switch?
A key sticks or does not come back	Take it out: it must drop through its opening by its own weight. Look for a burr in the opening, a tab stub on the clear key, or glue on the flange of a side key. A cast key that is too big (the resin mould) can be trimmed carefully at its edge, or cast again.
The main key is blocked, or the key board does not sit flat on its bosses	The main key is turned by 90°: the long side of the pocket in its inner face must run along the light (section 12.3).
A key clicks by itself, or the light switches on when it lies on the table	The free play is gone. Check that the key flange lies flat on the floor (no stub or glue under it), that the side key's doubler is not too thick (only one layer of 0.3 mm shim) and that the key-board screws are not overtightened. The main key has a calculated worst case of a light touch on its switch (chapter 14, section 14.4.4): report it.
A side key clicks in the middle but not at its ends	The stiffener is missing or loose: glue the plate and the doubler again (section 9.4).
A side key shows its chevron the wrong way	Turn it round (section 12.3): the key nearer the head points to the head (^), the other to the tail (v).
The ring is dim, uneven or only a spot	Not known yet: nobody has seen a real ring through the clear key. Check that the key is the right way up (frosted ring outside) and clean. Report what you see (chapter 14, section 14.12).
The lid does not close flat	The board is not flat on its ledges, a wire is under it, the antenna spacer is not down or is turned (its tall side goes to the S2 side), a pad is too thick (1.5 mm and 1.0 mm), the foam on the cell is too thick, or the laser set screw stands out of the head block (use an M1.6 × 5).

Casting the side keys

What you see	What to do
The rubber stays sticky after a day	The mix ratio was wrong (equal volumes of A and B, from two syringes), the room was too cold, or there was too much pigment. Clean the mould and pour again.
Bubbles on the key face, or an incomplete chevron	Work rubber into the chevron grooves with the toothpick before pouring, pour slowly into one corner, and degas the rubber if you can. ECON 80 sets fast: pour right after mixing. Keep the good keys as spares.
A key tears or sticks in the mould	Not enough mould release: spray every face that touches rubber and let it dry before each pour. Without release the rubber sticks hard to the resin.
A thin film (flash) on the edge of the key	Trim it with the scalpel. Tighten the four bolts evenly next time.
The key face is glossy or shows lines of the print	Rub the cavity floors with 400-grit paper (section 9.1); the key still works.
The chevron is matt	Polish the chevron grooves of the mould (section 9.1); the key still works.

18. Where to read more

- `docs/ch14_v0.7_keys_and_skin.md`: the design story of v0.7 (why every decision was made, the 1000 lm design and the 14500 cell with their simulated numbers, the cost), the checks that were run and the open points of the first prototype (section 14.12). It is also printed as `FlashKa_v0.7_Hardware_Package.pdf`.
- `docs/bom_notes.md`: where every price in the workbook comes from, what got cheaper, the options, and what to re-check.
- `docs/housing_v07_notes.md`: the housing files, the moulds and how to rebuild them.
- `order_files/3_rubber_keys/README.txt`: the casting steps with the rubber maker's numbers.
- The firmware and the apps, in the v0.6 folder: firmware.md (how the firmware works, the user manual in section 2, the bench test plan in section 7 and everything about the v0.7 in section 9; the manual and the v0.7 levels are also **Appendix A** at the end of the PDF of this guide), ble_protocol.md (the Bluetooth protocol, for anyone who wants to write their own app) and web_apps.md (the app and the installer, and how to put them on GitHub Pages).
- The LuxLibre testing guide (`docs/testing.md` at the root of the repository): the bring-up of a new board and the optical safety checks.
- The previous design: FlashKa v0.6 (`hardware/flashka-keychain-v06/` in the repository).

Tell the project what you find. No FlashKa had been built when this guide was written, so every result helps: what you ordered and what the shops said, how the casting went, what worked, what you measured, what went wrong. Open a **Build report** in the issue tracker of the LuxLibre repository (`https://github.com/DomPka/LuxLibre/issues`).

Appendix A. How the light works (user manual)

From `docs/firmware.md` of v0.6 (`hardware/flashka-keychain-v06/`), section 2. v0.7 runs firmware 0.7.0, built from the same code: every gesture, colour and protection rule, presenter mode included, works as described here, except the temperature dimming (a regulator on a v0.7); the levels of v0.7 are in A.9. A button here is a key of v0.7: ^ is the next key (nearest the head), v the previous key, ● the main key. The file paths in A.8 are in the v0.6 folder.

A.1 The three buttons

All three are on the **bottom face**. With the floor up and the head away from you the row reads, head -> tail: **^ ● v** (^ next is towards the screen when presenting).

- ● main key (the clear key with the glowing ring on its face): it works like the main button of v0.5 and v0.6.
- **^** next and **v** previous: level up / down while the light is on; slide keys in presenter mode.
- **^ + v** pressed together: mode change (2 s) and "forget computers" (10 s).

Click = press shorter than 0.4 s (●) or 0.8 s (^ and v). *Hold* = longer. Contacts are debounced (25 ms). The main button always wins: while ● is pressed, ^ and v are ignored until every button has been released. A ^ or v click counts when you release it, so pressing ^ + v never sends a click of the first button.

A.2 Flashlight mode (default after power-up)

Light is OFF	
● 1 click	On at the remembered level (Moon / Low / Medium / High).
● hold	On in Moon.
● 2 clicks	Turbo (High if the profile has no turbo or the board is too warm).
● click, then click-and-hold	**Laser** while held (max 60 s; see A.6). The main LED stays off.
● 3 clicks	Opens a 120 s Bluetooth window for the app (ring blinks blue twice).
● 4 clicks	Lockout on (red x3) / off (green x3).
^ or v	Ignored: no light, no LED (pocket safety).
^ + v held 2 s	Presenter mode (A.3).

Light is ON	
● 1 click	Off (settings are saved if they changed).
● hold	Steps Low -> Medium -> High -> Low ... every 0.6 s (as v0.5).
● 2 clicks	Turbo on / back to the previous level.
● 3 clicks	Battery check on the ring: 1-5 blinks in green / yellow / red.
^ click (or hold)	One level up: Moon -> Low -> Medium -> High. No wrap; never into Turbo. From Turbo: nothing.
v click (or hold)	One level down: High -> Medium -> Low -> Moon. No wrap. From Turbo: High.
^ + v held 2 s	Presenter mode: the main LED goes off.

A ^ / v step counts as a button action: it blocks app commands that switch or dim the light for 3 s and cancels an exact current set by the app (stepping then starts from the remembered level). The level you step to is remembered. A ^ / v hold steps once (at 0.8 s), not repeatedly.

In lockout	
● 4 clicks	Unlock (green x3).
anything else	Ignored. ● clicks give one short red flash; holds, ^ v and ^ + v give nothing.

From deep sleep any button wakes the chip, and the first ADC sample tells which one is still held. A press that is already over at that sample (shorter than the ~0.2 s boot) counts as one ● click — the chip cannot tell which button it was

(firmware.md of v0.6, section 8).

A.3 Presenter mode

FlashKa becomes a Bluetooth keyboard that turns slides; the laser is the pointer.

Input	Action (key sent)
^ click	next slide: **Page Down** (key set "arrows": Right Arrow)
v click	previous slide: **Page Up** (key set "arrows": Left Arrow)
^ hold 0.8 s	start the show: **F5** (sent once, at 0.8 s)
v hold 0.8 s	end the show: **Esc** (sent once)
● click	black screen on / off: **B**
● hold	**laser** on while held — same rules as in flashlight mode (S2 armed, max 60 s, not hot, not flat, never in lockout); works with or without a computer
● 4 clicks	lockout on; this also leaves presenter mode
^ + v held 2 s	leave presenter mode
^ + v held 10 s	forget all paired computers (ring white x3)

- Every key goes out as two reports: key down, then key up 10 ms later. Holding a button never holds the key down, so the computer's key repeat cannot flip several slides.
- ● 2 or 3 clicks send nothing (two B presses would cancel each other anyway).
- The main LED cannot be switched on in presenter mode.
- Keys are sent only while a paired computer is connected (ring off); while the light is waiting (cyan breathing) presses are not stored.
- The app setting "swap" exchanges ^ and v (clicks and holds).
- Presenter mode ends by itself after the idle time (default **30 min** without a button press, 5-120 min in the app) and when the battery is empty (below 3.20 V for 2 s; five red blinks). It is refused below 3.20 V (one red blink).
- The radio stays on in presenter mode: about **20 mA (estimate, untested)**, that is about 30-40 h with the 800 mAh pack of a v0.6 and about 50-70 h with the 14500 cell of a v0.7 (calculated with the 1,400 mAh of its estimates). The light does not sleep in presenter mode.
- The phone app cannot connect while presenter mode is active (one connection; the light advertises as a keyboard, not with the app's service UUID).

Forget and the 10 s hold. The 2 s mode change happens while you keep holding: from flashlight mode the light enters presenter mode at 2 s and forgets the computers at 10 s (it stays in presenter mode, ready to pair a new one). From presenter mode it leaves at 2 s and forgets at 10 s. Also remove "FlashKa" on the computer, otherwise it keeps trying the old keys.

A.4 First pairing (untested on all systems)

Pairing works only in presenter mode. Enter it with ^ + v for 2 s (magenta x2, then **cyan breathing**). The light uses LE Secure Connections "Just Works": there is no PIN; the computer asks you to confirm. When the computer is connected the ring blinks **cyan twice and goes off**.

System	Steps	Notes
Windows 10 (1803 or newer) / 11	Settings > Bluetooth & devices > Add device > Bluetooth > "FlashKa-XXXX" (keyboard icon)	Older Windows 10 cannot pair: trouble-host 0.6 supports only LE Secure Connections.
macOS	System Settings > Bluetooth > "FlashKa-XXXX" > Connect	The Keyboard Setup Assistant may open: close it. Keynote: choose the "arrows" key set in the app; F5 does not start a Mac show (use the computer for that).
Android 6 or newer	Settings > Connected devices > Pair new device > "FlashKa-XXXX" > Pair	
iOS / iPadOS 9 or newer	Settings > Bluetooth > "FlashKa-XXXX" (Other devices) > Pair	iOS starts pairing when the light answers "insufficient authentication"; the on-screen keyboard hides while a keyboard is connected.
Linux (BlueZ, kernel 3.19+)	`bluetoothctl`: `scan on`, `pair <addr>`, `trust <addr>`, `connect <addr>`	

- Up to **4 computers** are remembered (in flash, with their notification settings); pairing a fifth replaces the one paired longest ago.
- After that, entering presenter mode is enough: the computer reconnects by itself (cyan double blink).
- Which keys suit which program: PowerPoint (Windows/Mac) and LibreOffice Impress: Page Up / Down, B, Esc (F5 starts PowerPoint and Impress on Windows/Linux). Keynote and Google Slides: use the "arrows" key set. PDF viewers: Page Up / Down.
- The PnP ID uses the pid.codes test PID 0x1209:0x0001. **Apply for a free PID at pid.codes before distributing the firmware.**

A.5 Ring colours

The ring (two RGB LEDs under the clear ● key, driven together by the three v0.5 status-LED GPIOs) shows, highest priority first:

Pattern	Meaning
Red steady	laser on
White x3	paired computers forgotten
Cyan double blink, then off	presenter mode: computer connected
Short white blip (40 ms)	presenter key sent
Magenta x2	presenter mode entered / left
Red x3 / green x3	lockout on / off
Cyan x3	"Identify" from the app
Blue x2	Bluetooth window opened (● 3 clicks while off)
1-5 blinks green / yellow / red	battery check (● 3 clicks while on)
One red blink	request refused (turbo too hot, laser not allowed, switch-on refused, presenter mode refused)
Five fast red blinks	battery empty: switched off, switch-on refused, or presenter mode ended
Short red flash	● click while locked
Cyan breathing (2 s)	presenter mode: waiting for the computer
Green / yellow / red for 2 s after switch-on	battery > 50 % / 20-50 % / < 20 % (profile flag)

Pattern	Meaning
Red slow breathing (3 s)	USB connected, charging
Green steady	USB connected, charge complete
Red blink every 4 s (light on)	battery below 10 %
Cyan (dim) steady	flashlight mode: app connected
Blue double blink every 3 s	flashlight mode: Bluetooth window open, nobody connected

One-shot patterns (the blinks) overlay the steady and breathing states. A presenter one-shot is not cut short by a lower one in the table (the white x3 is never hidden by a key blip). Blue is the weakest colour of this LED (4.5 mcd at 2 mA), so presenter states use cyan. The red resistors are now 330 Ω (more red behind the clear key); the colour balance (`RGB_FULL_*`) is not tuned yet **(untested)**.

A.6 Levels, profiles, turbo, laser, protection, charging, battery (as v0.5)

The numbers in this section are those of the v0.6 board. On a v0.7 the levels, profiles and limits are those of A.9, and a regulator holds the temperature limit instead of the linear dimming described under "Protection" (A.9); the other rules work the same way.

Levels and profiles

	Extreme	Balanced (default)	Endurance	Custom
Moon / Low / Medium / High	3 / 40 / 250 / 900 mA	3 / 30 / 200 / 600 mA	2 / 15 / 100 / 300 mA	set by the app, default = Balanced
Turbo	2200 mA for 45 s	1200 mA for 60 s	none (turbo = High)	
After the turbo time	900 mA	600 mA	—	
Temperature limit	55 °C	50 °C	45 °C	40-70 °C
Low-voltage step-down	3.30 V	3.35 V	3.40 V	3.10-3.60 V
Cell current limit	2600 mA	1600 mA	800 mA	200-3000 mA
Flags	turbo, remember, battery display	turbo, remember, battery display	remember, battery display	

The profile is chosen in the app (there is no button gesture for it). ^ / v step through the four levels of the active profile.

Turbo

Turbo runs at most the profile's turbo time, then the light steps down to the profile's step-down current (the app shows "automatic" as the reason). Two clicks then return to the level used before turbo; two more clicks start a new turbo. Thermal derating, the cell current limit and low-voltage protection apply on top at all times.

Laser

Flashlight mode: ● click, then click-and-hold while the light is off; presenter mode: ● hold. The laser is on while the button stays held — at most 60 s per press (release and repeat the gesture to continue). It goes off above 60 °C or below 3.20 V and stays off until the button is released. Never in lockout, never from Bluetooth. The slide switch S2 must be armed as well; the firmware cannot see or override S2.

Protection (what you notice)

- **Hot**: above the profile's temperature limit the brightness falls smoothly, reaching Low 15 °C above the limit; above 70 °C Moon; above 80 °C the light switches off and cannot be switched on again until it has cooled below 75 °C.
- **Battery low**: below the profile's step-down voltage (measured with the LED running) the light drops one level every 5 s; below 3.10 V Moon; below 3.00 V it switches off (five red blinks) and refuses to switch on until the battery rests above 3.30 V or USB is connected. Choosing a level again lifts the step-down; it comes back if the voltage is still low.
- **Cell current**: the estimated battery current `V_LED(I)·I / (0.9·V_BAT)` with `V_LED = 2.75 V + 0.15 V/A·I` is kept below the profile's limit (the output is reduced).

Charging

USB-C charging at ~300 mA (nominal; the SoC estimate assumes 280 mA; v0.7: about 500 mA, 9.4) between 0 °C and 45 °C (resumes 2 °C inside the window after a temperature pause). Charging pauses while the LED runs above 500 mA. Plugging USB in resets the MCU (VBUS-edge reset), keeps it awake and keeps Bluetooth reachable while connected. Without firmware (e.g. a completely flat cell) the charger trickles at 10 mA.

Battery percentage and runtime

The percentage comes from the LiPo open-circuit curve (4.20 V = 100 % … 3.30 V = 0 %) with a load correction of +0.12 V per A of estimated cell current while the LED is on (and -0.12 V/A of charge current while fast-charging), filtered so that it does not jump (at most 0.5 %/s, small dead band, and it only moves "backwards" for differences above 3 %). "Charge complete" reads 100 %. Runtime = 800 mAh x SoC / (estimated LED cell current + 20 mA for the MCU and radio); the MCU term matters at Moon, where the LED itself draws ~2 mA from the cell. The v0.7 (one 14500 cell) uses that cell's curve, 0.13 V per A and 1400 mAh (9.4).

A.7 Bluetooth windows and sleep

Flashlight mode: as v0.5 — the radio advertises for the app only in windows (light on; 120 s after it is switched off; 120 s after ● 3 clicks; while USB is connected; while the app is connected and 30 s after; KEEPALIVE). Fast 100 ms for the first 30 s, then 500 ms.

Presenter mode: the radio advertises as a keyboard whenever no computer is connected: 30 ms for the first 30 s (after entering the mode or after a disconnect), then 152.5 ms (the intervals Apple QA1931 and Windows Swift Pair ask for). No sleep.

When the light is off, presenter mode is off, no window is open and no USB is connected, the MCU goes to deep sleep. Any button or USB wakes it. A button held for 10 s while it does nothing (lockout, or ^ / v with the light off — e.g. in a pocket) counts as stuck: the MCU then sleeps without the button as a wake source and checks it every 20 s.

A.8 Flashing

Hold ● (any button works: every press pulls GPIO9 low) while plugging in USB: the ROM starts download mode. Write the image of **your board** at offset 0x0 with the web installer (it asks for the board first and checks the firmware already on the light, `web_apps.md` section 2), or:

```
espflash write-bin 0x0 firmware/dist/flashka-fw-v0.6.0-merged.bin   # FlashKa v0.6
espflash write-bin 0x0 firmware/dist/flashka-fw-v0.7.0-merged.bin   # FlashKa v0.7
espflash monitor            # firmware log over USB-Serial-JTAG
```

Never write one board's image to the other board: the two firmwares set the LED current with different scales and limits (firmware.md of v0.6, section 9.2).

Writing the merged image erases the settings **and the paired computers** (the `nvs` region is 0xFF in the image); remove FlashKa on each computer and pair again. To keep both, flash only the app: `espflash flash --partition-table firmware/partitions.csv firmware/dist/flashka-fw-v0.6.0.elf` (`flashka-fw-v0.7.0.elf` on a v0.7).

A.9 Levels and profiles of the FlashKa v0.7 (firmware 0.7.0)

From section 9.3 of the same document. The gestures of A.1 to A.8 are the same on both boards; on a v0.7 these levels replace the table of A.6, the runtime estimate uses 1,400 mAh (one Vapcell INR14500 F15), and the cell-current estimate uses the v0.7 LED and driver (firmware.md, section 9.4). On a v0.7 the temperature limit is the set point of a regulator: the light keeps full output until the temperature it predicts 8 s ahead reaches the limit, then holds it just below (firmware.md, section 9.11). In 25 °C still air turbo holds full output for about 58 s and High for about 210 s; then the light settles at about 280 lm (simulated, firmware.md, section 9.6). Turbo dims as the cell empties: about 775 lm from a half-full cell. The battery current limit is 2,800 mA; if the battery protection ever trips in turbo, set the Custom profile to 2,500 mA. After a trip of the battery protection the light stays off until USB is plugged in (firmware.md, section 9.4). Charging takes about 3.5 h at about 500 mA; with a nearly empty cell it pauses while the board is above 45 °C, which is normal.

	Extreme	Balanced (default)	Endurance	Custom
Moon / Low / Medium / High	3 / 50 / 400 / 1800 mA	3 / 40 / 250 / 1530 mA	2 / 15 / 100 / 500 mA	set by the app, default = Balanced
out of the front (estimate)	1 / 24 / 187 / 683 lm	1 / 19 / 119 / 601 lm	1 / 7 / 48 / 230 lm	
Turbo	2850 mA (966 lm) for 60 s	2850 mA (966 lm) for 60 s	none (turbo = High)	at most 2850 mA
After the turbo time	1800 mA	1530 mA	—	
Temperature limit (held)	50 °C	50 °C	47 °C	40-70 °C
Low-voltage step-down (under load)	3.15 V	3.20 V	3.25 V	3.10-3.60 V
Cell current limit	2800 mA	2800 mA	800 mA	200-3000 mA
Flags	turbo, remember, battery display	turbo, remember, battery display	remember, battery display	

Lumens "out of the front" = the LED model of firmware.md, section 9.5 (junction at 85 °C) × the optic's 87 %. They are estimates; the control app shows the same numbers on a v0.7.