

Anduril Flashlight Firmware + FSM Flashlight UI Toolkit

Anduril is a user interface for flashlights. It is written with FSM, a UI toolkit for flashlights.

What is FSM? The “SM” means “Spaghetti Monster”, and the “F” can be any F word you like, such as “Flashlight” or whatever suits your mood. FSM also means “Finite State Machine”, which is the type of abstraction used for defining user interfaces. It is like a flowchart turned into executable code.

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Using Anduril

Anduril has many features, but the only things a person *really* needs to know to use it are:

- Click for on/off
- Hold to change brightness

For more in-depth use, read its user manual for full details.

If you want to know what changed recently, check the [ChangeLog](#).

For info about hardware-specific features, like what the channel modes are on multi-channel lights, browse into the `hw/` directories to find the hardware model and any hardware-specific documentation.

Flashing Firmware

Get the latest updates by flashing new firmware!

A few things are needed to flash firmware:

- A firmware “.hex” file. Here’s how to find the right .hex file.
- A flashing adapter. The type of adapter depends on which MCU chip your light uses. It may be an UPDI 3-pin adapter (attiny1616 and newer) or an AVR ISP 6-pin adapter (attiny85, attiny1634).
UPDI typically uses a “pogo pin” adapter, with spring-loaded pins to hold against copper pads on the driver circuit.
AVR ISP typically has two parts – a USB device (like a USBASP), and a physical adapter (like a pogo pin adapter or SOIC8 clip). SOIC8 is the least convenient, and is mostly only used on old models with attiny85 chips.
- A firmware flashing program. A few compatible programs include [avrdude](#), [pymcuprog](#), and [ZFlasher](#).
- A computer or phone. Almost any modern computer or phone should be able to do it, as long as you can plug the adapter in and run a flashing program.

One particularly useful guide is at <https://anduril.click/>

More info about installing flashing programs is below, in Flashing Programs.

Compiling

The firmware can be deeply customized by modifying it and compiling your own versions, and this is encouraged.

To compile the firmware, it is strongly recommended that you use a Linux computer, ideally running Debian or Ubuntu (but almost any distro should work). Virtual machines work well, such as running WSL inside Windows. There is also a Docker container available (TODO: add link(s) here), if that is more convenient.

Prerequisites

- AVR toolchain packages:
`sudo apt install gcc-avr avr-libc binutils-avr`
- Other misc packages:
`sudo apt install git wget unzip bash`

- Atmel DFPs (Device Family Packs). A small script is included to download and install these for you:
`./make dfp`

Building

Use the `make` script included in this repo. Run `./make --help` for details about how to use it. In most cases though, you should be able to just run `./make` by itself to compile all available build targets. Or give it a search term to limit builds to only a few, like `./make hank boost` to build all firmwares for Hanklights with optional boost drivers.

The compiled firmware goes into the `hex/` directory, ready to be used by any firmware flashing program.

Customizing Settings Per User

The build can be customized per user by placing overrides into the `users/myname/` directory and letting the build script know your username. That way, your favorite settings can be applied automatically without having to modify the original source files.

Flashing Programs

AVRdude

Usually avrdude installs in a single command:

```
sudo apt install avrdude
```

PyMCUprog

If you use `pymcuprog` to flash firmware, a few extras are needed:

```
1 sudo apt install python3 python3-pip python3-venv
2 python3 -m venv .venv
3 source .venv/bin/activate
4 pip install pymcuprog
```

You'll need to `source .venv/bin/activate` every time you start a fresh shell, if you want to use `pymcuprog`. The activation lasts until the shell is closed or until you run `deactivate`.

Contributing

If you'd like to help, there are several ways...

- ToyKeeper has a Patreon site for donations, to help figuratively and literally keep the lights on.
- Send pull requests or patches, to improve things directly. These can be code, documentation, tools, or anything you think is useful.
- File bug reports for any problems you find.
- Answer people's questions on public forums. If the same questions come up a lot, consider adding it to the documentation here.
- Ask manufacturers to use this firmware, and to support its development.

Anduril User Manual

Anduril is an open-source firmware for flashlights, distributed under the terms of the GPL v3. The sources can be obtained here:

- <https://toykeeper.net/anduril>

The URL above redirects to the actual project site. Even if the project hosting needs to migrate again, it should continue to work. As of late 2023, this is where it redirects to:

- <https://github.com/ToyKeeper/anduril>

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Quick Start

After putting a battery in the light and tightening the parts together, the light should quickly blink once to confirm it has power and is now operational.

After that, basic usage is simple:

- **Click** to turn the light on or off.
- **Hold** the button to change brightness.
- **Release and hold again** quickly to change brightness the other way.

That is all the user needs to know for basic use, but there are many more modes and features available for people who want more.

For a full list of button mappings, scroll down to the UI Reference Table at the end of this file.

Button presses

Button presses are abbreviated using a simple notation:

- **1C: One click.** Press and then quickly release the button.
- **1H: Hold.** Press the button, but keep holding it.
- **2C: Two clicks.** Press and release quickly, twice.
- **2H: Click, hold.** Click two times, but hold the second press.
- **3C: Three clicks.** Press and release quickly, three times.
- **3H: Click, click, hold.** Click three times, but hold the final press.

The same pattern is used with higher numbers too.

For example, 10C means ten clicks... and 10H means ten clicks but hold the final press.

The *number* is how many times to press the button.

The *letter* tells whether to release the final press (C) or keep holding it (H).

Factory Reset

If you get lost, or if you want to auto-calibrate the temperature sensor, do a factory reset. This is a good idea to do as soon as you turn on a new light for the first time, to ensure it has a sane configuration.

The process for this is:

- **Loosen** tailcap
- **Hold** button
- **Tighten** tailcap
- **Keep holding** button for about 4s

Or:

- 13H in “Off” mode, and keep holding for about 4s

The light should flicker while getting brighter, then briefly burst to full power. Hold until it reaches full power to do a reset, or let go of the button early to abort.

On some lights, like products where the tailcap method is impossible, use 13H from Off to do a factory reset. If this is difficult, try counting it like music to make it easier:

1	1 2 3 4
2	2 2 3 4
3	3 2 3 4
4	HOLD

Simple UI is enabled after each factory reset.

Simple UI

By default, the light uses a simple UI. This is useful if you lend the light to someone else, or if you just don't want to bother with any crazy disco modes.

Simple UI has all the basic functions needed to work as a flashlight, but the minimum and maximum brightness are limited by default to make it safer, and any complex or advanced functions are blocked.

Simple UI Diagram

For the Simple UI Diagram of Anduril v2 please check Appendix A: Anduril 2 Simple UI Diagram at the end of this file.

Usage

Functions available in Simple UI include:

- 1C: On / off
- 1H: Ramp up (or down, if button was released less than a second ago)
- 2H: - If light is on : ramp down - If light is off: momentary high mode
- 2C: Double click to go to / from highest safe level
- 4C: Lockout mode.

Some other modes and functions are available too. When the light is off, these are the options:

- 3C: Battery check mode. (displays voltage once, then turns off)
- 4C: Lockout mode.
- 10H: Switch to Advanced UI.

- 15C or more: Version check.

In Lockout mode with Simple UI, there are a few functions:

- 1H: Momentary moon
- 2H: Momentary low
- 3C: Unlock and turn off
- 4C: Unlock and turn on
- 4H: Unlock and turn on at low level
- 5C: Unlock and turn on at high level

To change between Simple UI and Advanced UI, turn the light off and then do one of these:

In Simple UI:

- 10H: Go to Advanced UI.

In Advanced UI:

- 10C: Go to Simple UI.

Extended Simple UI

Some lights have additional features enabled in Simple UI, at the manufacturer's request. This typically includes:

- Ramp -> 3C: Toggle smooth or stepped ramp shape.
- Ramp -> 5H: Sunset timer.
- Off -> 7C/7H: Change the aux LED pattern.
- Lockout -> 7C/7H: Change the aux LED pattern.

Old versions (before 2024-08) also allowed access to strobe/mood modes, which can be dangerous, so if you have one of those, *think twice about letting kids use it*. Those modes were never intended to be child-safe, and can reach full power with no thermal regulation.

Configuring Simple UI

Simple UI can be configured in several ways, but not while Simple UI is active. So go to the Advanced UI, configure things, then go back to Simple UI.

In Advanced UI's "Off" mode:

- 10H: Configure Simple UI.

Configurable options include:

- floor level
- ceiling level
- number of steps (in stepped ramp)
- turbo style

Other options are inherited from Advanced UI, so change these options normally and they will carry over to Simple UI:

- ramp style (smooth / stepped)
- smooth ramp speed
- ramp-after-moon style
- memory settings
- auto-lock settings
- aux LED settings
- voltage calibration
- thermal regulation settings
- hardware-specific “misc menu” settings

Advanced UI

Most of the information below this is for the Advanced UI. Anything not already noted above is blocked in the Simple UI.

Advanced UI Diagram

For the Advanced UI Diagram of Anduril v2 please check Appendix B: Anduril 2 Advanced UI Diagram at the end of this file.

Ramping / Stepped Ramping Modes

Anduril's ramping mode uses a smooth ramp or a stepped ramp, depending on which style the user prefers.

Each ramp has its own settings – floor (lowest level), ceiling (highest level), and the stepped ramp can also have a configurable number of steps.

Additionally, Simple UI has its own ramp settings for floor, ceiling, and number of steps. The smooth/stepped style is inherited from the Advanced UI's ramp.

There are four ways to access ramping mode when the light is off:

- **1C**: Turn on at the memorized brightness.
(see below for details about what “memorized” means)
- **1H**: Turn on at the floor level. Let go after the light turns on to stay at the floor level, or keep holding to ramp up.
- **2C**: Turn on at the ceiling level.
- **2H**: Turn on at full power, turn off when released. (momentary turbo)
(in Simple UI, this uses the ceiling level instead of turbo)

While the light is on, a few actions are available:

- **1C**: Turn off.
- **2C**: Go to or from the turbo level.
(or if it has regulated down, “bump” back up to turbo)
(turbo level / behavior is configurable)
- **1H**: Change brightness (up).
If the button was released less than a second ago
Or if it’s already at the ceiling, it goes down instead.
- **2H**: Change brightness (down).
- **3C**: Switch to the other ramp style. (smooth / stepped)
(or activate the next channel mode, when more than one is enabled)
(then use **6C** instead, for smooth / stepped toggle)
- **6C**: Switch to the other ramp style. (when **3C** is mapped to next channel)
- **3H**: Momentary turbo (when current channel has no tint to ramp).
- **3H**: Tint ramping (only when current channel has adjustable tint).
- **4H**: Momentary turbo, when **3H** is mapped to tint.
- **4C**: Go to lockout mode.
- **5C**: Go to momentary mode.
- **5H**: Start a sunset timer. Details are below in the Sunset Timer section.
- **7H**: Ramp config menu. - Item 1: Floor level. - Item 2: Ceiling level. - Item 3:
Stepped ramp: Number of steps. Can be 1 to 150.
Smooth ramp: Ramp speed. - 1 = Full speed, ~2.5s from end to end. - 2 = Half speed, ~5s from end to end. - 3 = Third speed, ~7.5s. - 4 = Quarter speed, ~10s.
- **10C**: Activate manual memory and save the current brightness.
- **10H**: Ramp extras config menu. - Item 1: Disable manual memory and go back to automatic memory.
(doesn’t matter what value the user enters at the prompt) - Item 2: Configure the manual memory timer.

Sets the timer to N minutes, where N is the number of clicks.

A value of 0 (no clicks) turns the timer off. - Item 3: Configure whether to ramp up after **Off** -> **1H**.

0: Ramp up after moon.

1: Don't ramp up, just stay at the floor level. - Item 4: Configure Advanced UI's turbo style:

0: No turbo, only ceiling.

1: Anduril 1 style. **Ramp** -> **2C** goes to full power.

2: Anduril 2 style. **Ramp** -> **2C** goes to ceiling, or goes to full power if user ramped up to ceiling first. This value also affects momentary turbo in Ramp and Off modes. - Item 5: Configure "smooth steps".

0: Disable smooth steps.

1: Enable smooth steps.

Memory determines which brightness level the light goes to with 1 click from off. There are three types of brightness memory to choose from:

- Automatic: Always uses the last-ramped brightness. (does not memorize levels accessed by a shortcut, like turbo, **2C** for ceiling, or **1H-from-off** for floor)
- Manual: Always uses the user's saved brightness.
- Hybrid: Uses the automatic memory brightness if the light was only off for a short time, or resets to the manual memory level if it was off for a longer time. The timer for this is configurable from 0 to ~140 minutes.

Another way to think of it is: There are three styles of memory for the last-ramped brightness level...

- Always remember (automatic)
- Remember for N minutes (hybrid)
- Never remember (manual)

To choose a memory style, set the configuration accordingly:

mem type	manual mem	manual mem timer
automatic	off	any
manual	on	zero
hybrid	on	non-zero

If "smooth steps" is enabled, the stepped ramp uses a smooth animation between steps, and turning the light on/off has the edges smoothed off too. With "smooth steps" turned off, these brightness changes are immediate.

Sunset Timer

In the ramp mode or candle mode, it's possible to make the light turn itself off after a while.

To activate the timer, go to the brightness you want and then use a 5H action. Keep holding the button, and the light should blink once per second. Each blink adds 5 minutes to the timer.

In ramp mode, it slowly dims until it's at the lowest level, then shuts off. In candle mode, it stays at the same brightness until the final minute, at which point it dims and dies out.

The user can change the brightness while the timer is active. If this happens during the final few minutes, it also "bumps" the timer up to a minimum of 3 minutes. So if it's getting really dim and you need a little more time, you could do a 5H to add 5 minutes, or simply ramp up to the desired brightness.

Other Modes

Anduril has several other modes too. To access these, press the button more than 2 times when the light is off:

- 3C: Blinky / utility modes, starting with battery check.
- 3H: Strobe modes, starting with the most recently used strobe.
- 4C: Lockout mode.
- 5C: Momentary mode.
- 6C: Tactical mode.
- 7C / 7H: Aux LED configuration.
- 9H: Misc Config menu. (only on some lights)
- 10H: Simple UI configuration menu.
- 13H: Factory reset (on some lights).
- 15C or more: Version check.

Lockout Mode

Click 4 times from Off to enter Lockout mode. Or 4 times from Ramp. This makes the light safe to carry in a pocket or a bag or anywhere else the button might be pressed by accident.

To exit lockout mode, click 4 times. The light should blink briefly and then turn on at the memorized level. Or hold the final press to turn on at the floor level instead:

- 3C: Unlock and go to "Off" mode

- **4C**: Go to ramp mode (memorized level).
(uses manual mem level if there is one)
- **4H**: Go to ramp mode (floor level).
- **5C**: Go to ramp mode (ceiling level).

Lockout mode also doubles as a momentary moon mode, so the user can do quick tasks without having to unlock the light. The brightness in lockout mode has two levels:

- **1H**: Light up at the lowest floor level.
- **2H**: Light up at the highest floor level.
(or the manual mem level, if there is one)
- **3H**: Next channel mode (if more than one is enabled).

It is also possible to make the light lock itself automatically after being turned off. To enable this, go to lockout mode and use a **10H** action to activate the auto-lock config menu. Release the button after the first blink. Then at the prompt, click N times to set the auto-lock timeout to N minutes.

- **10H**: Auto-lock config menu. Click N times to set timeout to N minutes.
A value of zero disables the auto-lock feature.
So, to turn off auto-lock, don't click at all.

And on lights which have aux LEDs, there may be additional functions:

- **7C / 7H**: Change Lockout Mode's aux LED pattern. More details on this below, in a separate section.

Blinky / Utility Modes

Click 3 times from Off to access Anduril's blinky / utility modes. This always starts at battery check and the user can proceed to other blinky modes if Advanced UI is enabled. The sequence is:

- Battery check.
- Temperature check (if light has a temperature sensor).
- Beacon mode.
- SOS mode (if enabled).

In all of these modes, some basic actions are available:

- Click: Turn off.
- 2 clicks: Next blinky mode.

Additionally, in battery check and temperature check modes:

- **7H:** Go to the voltage config menu or thermal config menu.

In more detail, this is what each blinky / utility mode does:

Battery check Blinks out the battery voltage per cell. Full is 4.2V, empty is about 3.0V. The light blinks the whole-number digit first, pauses, then blinks out the “tenths” digit. Then a longer pause, and it repeats. So for 4.2V, it would be “blink-blink-blink-blink .. blink-blink”.

A “zero” digit is represented by a very quick blink.

On lights with more than one set of LEDs, pressing **3C** during batt check mode can select which set of LEDs (which channel mode) it uses to blink out numbers.

The voltage config menu has these settings:

1. Voltage correction factor. This adjusts the battery measurement sensor, allowing the user to add or subtract up to 0.30V in 0.05V steps. Click N times to enter a value: **1C**: -0.30V
2C: -0.25V
3C: -0.20V
4C: -0.15V
5C: -0.10V
6C: -0.05V
7C: default, 0V
8C: +0.05V
9C: +0.10V
10C: +0.15V
11C: +0.20V
12C: +0.25V
13C: +0.30V
2. Post-off voltage display timeout. (only on lights with RGB aux)
This setting determines how many seconds the RGB aux LEDs display the voltage color after the torch goes to sleep. Click once per desired second, or zero times to turn this function off.

Temperature check Blinks out the current temperature in degrees C. This number should be pretty close to what a real thermometer says. If not, it would be a good idea to enter the thermal config menu and calibrate the sensor. Or let the light settle to room temperature, then use factory reset to auto-calibrate the sensor.

The thermal config menu has two settings:

- **Current temperature.**
Click once per degree C to calibrate the sensor.
For example, if the ambient temperature is 21 C, then click 21 times.
- **Temperature limit.**
This sets the maximum temperature the light can reach before it will start doing thermal regulation to keep itself from overheating.
Click once per degree C above 30.
For example, to set the limit to 50 C, click 20 times.
The default is 45 C, and the highest value it will allow is 70 C.

Beacon mode Blinks at a slow speed. The light stays on for 100ms, and then stays off until the next blink. The brightness and the number of seconds between pulses are configurable:

- **Brightness** is the user's memorized ramp level, so set this in ramping mode before activating beacon mode.
Follows the same memory rules as ramping – automatic, manual, or hybrid.
- **Speed** is configured by holding the button.
The light should blink once per second while holding the button.
Release it after the desired amount of time has passed, to set a new beacon speed.
For example, to do a 10-second alpine beacon, hold the button for 10 seconds.

SOS mode Blinks out a distress signal. Three short, three long, three short. Repeats until light is turned off or until battery is low.

The memorized ramp level determines the brightness of SOS Mode.

Strobe / Mood Modes

Anduril includes a few extra modes for a variety of purposes:

- Candle mode
- Bike flasher
- Party strobe
- Tactical strobe
- Lightning storm mode

Click 3 times from Off to access these, but hold the third click for a moment.

Click, click, hold.

The last-used strobe mode is remembered, so it will return to whichever one you used last.

In all of these modes, a few actions are available:

- **1C**: Turn off.
- **2C**: Next strobe / mood mode.
- **1H**: Increase brightness, or strobe faster. (except lightning)
- **2H**: Decrease brightness, or strobe slower. (except lightning)
- **4C**: Previous strobe / mood mode.
- **5C**: Go to momentary mode, for a momentary strobe.
(this is useful for light painting)

Additionally, candle mode has one more action:

- **5H**: Activate Sunset Timer, and/or add 5 minutes to the timer.

In more detail, here is what each mode does:

- **Candle mode**
Brightness changes randomly in a pattern resembling a candle flame.
If a timer is set, it will run until the timer expires, then get dimmer for one minute, then sputter and turn itself off.
Without a timer, candle mode runs until the user turns it off.
Brightness is configurable.
- **Bike flasher**
Runs at a medium level, but stutters to a brighter level once per second.
Designed to be more visible than a normal ramping mode, but otherwise works mostly the same.
Brightness is configurable.
- **Party strobe**
Motion-freezing strobe light.
Can be used to freeze spinning fans and falling water. Speed is configurable.
- **Tactical strobe**
Disorienting strobe light.
Can be used to irritate people.
Speed is configurable, and the duty cycle is always 33%. Be careful about heat in this mode, if using it for a long time.
- **Police strobe (on some lights)**
2-color police style strobe.
Only works on lights with 2 or more colors.
- **Lightning storm mode**
Flashes at random brightness and random speed to simulate lightning strikes during a busy lightning storm.

Do not look directly at the flashlight when this mode is running, because it may suddenly go to full power without warning.

Momentary Mode

Click 5 times from Off to enter Momentary mode. Or 5 times from Ramp, or 5 times from a strobe mode.

This locks the flashlight into a single-mode interface where the LEDs are only on when the button is held down.

It is intended for Morse code, light painting, and other tasks where the light should be on only for a short time and probably in a pattern.

Momentary mode does either a steady brightness level or a strobe, depending on which was active before going to momentary mode.

To select which one, go to the mode you want to use, adjust the brightness and speed and other settings, then click 5 times to enter momentary mode.

In steady mode, brightness is the memorized ramp level, so adjust that in Ramp Mode before entering momentary mode.

In momentary strobe mode, the settings are copied from the last-used strobe mode, such as party strobe, tactical strobe, or lightning.

To exit Momentary Mode, physically disconnect power by unscrewing the tailcap or battery tube.

Tactical Mode

Click 6 times from Off to enter Tactical Mode, or 6 times in Tactical Mode to exit and go back to “Off”.

Tactical Mode provides instant momentary access to high, low, and strobe, but each of these is configurable.

The inputs are:

- 1H: High
- 2H: Low
- 3H: Strobe

Each of these only lasts as long as you hold the button.

Other commands in Tactical Mode are:

- 6C: exit (go back to Off Mode)

- **7H**: Tactical Mode config menu - 1st blink: configure tactical slot 1 - 2nd blink: configure tactical slot 2 - 3rd blink: configure tactical slot 3

To change what is in a tactical slot, press **7H**, then release the button after the 1st, 2nd, or 3rd blink. Then enter a number.

Each click adds 1, and each hold adds 10.

The number can be:

- 1 to 150: set the brightness level
- 0: last-used strobe mode
- 151+: go directly to a specific strobe mode
 - 151 = party strobe
 - 152 = tactical strobe
 - 153+ = other strobes, in the same order they're in in the **Off** -> **3H** strobe group

This assumes the light has a ramp 150 levels long.

Strobe modes start at the ramp size plus 1, so it may be different if a light has a different ramp size.

Configuration Menus

Every config menu has the same interface. It has one or more options the user can configure, and it will go through them in order. For each menu item, the light follows the same pattern:

- Blink once, then go to a lower brightness.
The user can keep holding the button to skip this menu item, or release the button to dive in and enter a new value.
- If the user released the button: - Stutter or “buzz” quickly between two brightness levels for a few seconds.
This indicates that the user can click one or more times to enter a number.
It will keep buzzing until the user stops clicking, so there is no need to hurry.
The actions here are: - click: add 1 - hold: add 10 (only in versions 2021-09 or later) - wait: exit

After entering a number, or after skipping every menu item, it waits until the button is released then exits the menu.

It should return to whatever mode the light was in before entering the config menu.

Ramp Config Menu

While the light is on in a ramping mode, click 7 times (but hold the final click) to access the config menu for the current ramp.

Or, to access the ramp config for Simple UI, make sure the Simple UI is not active, then do a 10H action from Off.

For smooth ramping mode, there are three menu options:

1. Floor.
(default = 1/150)
2. Ceiling.
(default = 120/150)
3. Ramp speed.
(default = 1, fastest speed)

For the stepped ramping mode, there are three menu options:

1. Floor.
(default = 20/150)
2. Ceiling.
(default = 120/150)
3. Number of steps.
(default = 7)

For the Simple UI mode, there are four menu options. The first three are the same as stepped ramping mode.

1. Floor.
(default = 20/150)
2. Ceiling.
(default = 120/150)
3. Number of steps.
(default = 5)
4. Turbo style.
(default = 0, no turbo)

Default values are different for each model of flashlight. The numbers above are only examples.

To configure the floor level, click the button equal to the number of ramp levels (out of 150) at which the floor should be. To set the lowest possible level, click once.

To configure the ceiling level, each click goes one level lower. So 1 click sets the highest possible level, 2 clicks is the 2nd-highest, 3 clicks is the 3rd-highest level, etc. To set the default of 120/150, click 31 times.

When configuring the number of steps, the value can be anything from 1 to 150. A value of 1 is a special case. It places the step halfway between the floor and ceiling levels.

Version Check Mode

This allows people to see which version of the firmware is installed on their light. The format for this is usually a model number and a date. `MODEL.YYYY-MM-DD`

- `MODEL`: Model number
(usually `BBPP` where `BB` is the brand ID, and `PP` is the product ID)
- `YYYY`: Year
- `MM`: Month
- `DD`: Day

The version number format has changed a few times, so write down the version info and check it against the formats below.

The model number is very important when flashing new firmware. Make sure the new firmware has the same model number as the old firmware. More details on this are in Which Hex File. Use the MODELS file to map a model number to the name of a .hex file.

Version Check Formats

The Version Check function should blink out a series of numbers in one of several formats:

- `MODEL-YYYY-MM-DD-SINCE-DIRTY` Anduril 2 from 2023-12 or later. “SINCE” and “DIRTY” may be omitted. Punctuation makes a “buzz” between sections. - `MODEL`: model number - `YYYY-MM-DD`: Year, month, day. This uses the most recent release tag from git, not the build date. - `SINCE`: How many commits since the last official release tag? - `DIRTY`: Adds a “-1” to the end if the repository was locally modified without committing changes.
- `NNNN-YYYY-MM-DD` Anduril 2 from 2023-05 or later.
It’s a model number and build date, with “buzz” flashes between sections. - `NNNN`: model number - `YYYY`: year - `MM`: month - `DD`: day
- `YYYYMMDDNNNN` Anduril 2 from 2023-05 or earlier.
It’s a build date and model number.
- `YYYYMMDD` This is an old Anduril 1 version. It’s just a build date.
If the model name isn’t obvious, try looking it up in the PRODUCTS file.
- `1969-07-20` The date of first human contact with the moon. This value indicates that the person who built the firmware probably made some sort of error.

If the version doesn’t include a model number, you may be able to find the model in the PRODUCTS file to see which firmware model it probably uses:

<https://bazaar.launchpad.net/~toykeeper/flashlight-firmware/anduril2/view/head:/PRODUCTS>

Protection Features

Anduril includes low voltage protection (LVP) and thermal regulation.

LVP makes the light step down to a lower level when the battery is low, and if the light is already at the lowest level, it shuts itself off. This activates at 2.8V. LVP adjustments happen suddenly, in large steps.

Thermal regulation attempts to keep the light from overheating, and otherwise adjusts output to stay as close as possible to the user-configured temperature limit. Thermal adjustments happen gradually, in steps so small they are difficult for humans to perceive.

Aux LEDs / Button LEDs

Some lights have aux LEDs or button LEDs. These can be configured to do different things while the main emitters are off. There is one aux LED mode for the regular “off” mode, and another aux LED mode for “lockout” mode. This allows the user to see at a glance whether the light is locked.

Aux LED modes typically include:

- Off
- Low
- High
- Blinking

To configure the aux LEDs, go to the mode you want to configure and then click the button 7 times. This should change the aux LEDs to the next mode supported on this light.

- **7C**: Next aux LED mode.

If the aux LEDs can change color, there are additional actions to change the color. It is the same as above, but hold the button on the last click and then let go when the desired color is reached.

- **7H**: Next aux LED color.

On most lights, the colors follow this sequence:

- Red
- Yellow (Red+Green)
- Green
- Cyan (Green+Blue)
- Blue
- Purple (Blue+Red)

- White (Red+Green+Blue)
- Disco (fast random colors)
- Rainbow (cycles through all colors in order)
- Voltage (uses color to display battery charge)

In voltage mode, the colors follow the same sequence, in the same order as a rainbow... with red indicating a low battery and purple indicating a full battery.

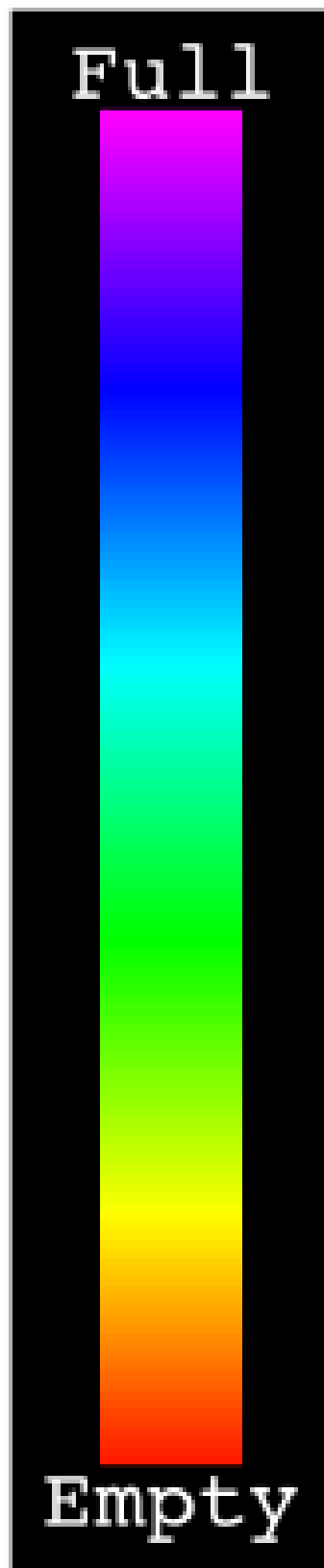


Figure 1: battery charge colors

For lights with a button LED, the button LED typically stays on while the main emitters are on. Its brightness level is set in a way which mirrors the main LED – off, low, or high.

For lights with a RGB button LED, the button LED indicates battery charge during use in the same manner as the aux LED voltage mode.

For lights with front-facing aux LEDs, the aux LEDs typically stay off when the main emitters are on, and when the light is otherwise awake. The aux LEDs on most lights only turn on when the light is asleep.

When a light has a single-color aux LED and no RGB, it fast-blinks the aux LED in “off” modes when voltage is low.

Misc Config Menu

Some models may have an extra config menu for settings which don’t fit anywhere else. This menu is located at “Off -> 9H” in the advanced UI.

These settings are, in order:

- Tint ramp style: (on some lights) 0 : smooth ramp (blend channels in any proportion)
1 : middle tint only
2 : extreme tints only (only one channel active at a time)
3+: stepped ramp with 3+ steps - Jump Start level: (on some lights) Some lights are prone to starting up slowly at low levels, so they have an option to “jump start” the engine by pulsing a higher power level for a few milliseconds when changing from off to a low level. This setting specifies how bright that pulse should be.

The value can be from 1 to 150, but is usually between 20 and 50.

These settings are hardware-specific and may not be present on all lights. The number of settings in the Misc Config Menu depends on the hardware model and the firmware version.

Channel Modes (a.k.a. Tint Ramping or Multi Channel controls)

Some lights have more than one set of LEDs which can be adjusted to change the beam color, shape, or other properties. These lights have features like tint ramping and channel modes.

On these models, there are some global button mappings which work at all times unless they’re overridden by the mode the light is in:

- 3C: Next channel mode
- 3H: Adjust current channel mode (ramp tint, for example)
- 9H: Channel mode config menu

Details depend on the exact type of light used. For example, if a light has LEDs in cool white, warm white, and red... that light might have a few channel modes:

- White blend (adjustable CCT / tint ramping)
- Red only
- Auto-tint

On a light like this, the user could press 3C to rotate through these different channel modes... white, then red, then auto, then back to white.

Additionally, in the “white blend” mode, the user could press 3H to manually adjust the balance between warm white and cool white.

Finally, if the user decides they don’t want all of the modes, they can turn some off. Press 9H (while on) to start the channel mode config menu. To disable the auto-tint mode, for example, it is the 3rd mode... so wait for the 3rd blink, then release the button. Then at the prompt, enter a value of 0 (wait for the prompt to time out without clicking anything). Afterward, the auto tint mode should no longer be in the channel mode rotation. To turn the mode back on later, do the same thing, but enter a value of 1 (click 1 time at the prompt).

A light can have many different channel modes, so don’t be shy about turning off any modes you don’t use. It makes all the others easier to reach.

If you turn off channel modes until only 1 remains, the Ramp → 3C action reverts to its single-channel behavior – switching between a smooth or stepped brightness ramp. Additionally, when a channel mode has nothing to adjust with 3H, the 3H action also reverts to its single-channel behavior – momentary turbo.

The Misc Config Menu (Off → 9H) may also have a setting to choose a tint ramp style. There are a few styles available, by entering different numbers into that config menu:

- 0: smooth ramp
- 1: middle tint only
- 2: extreme tints only
- 3+: stepped ramp with 3+ steps

This setting only applies to modes with channel ramping (i.e. tint ramping), and only when that mode uses the default 3H event handler. Custom channel modes may work differently.

UI Reference Table

This is a table of all button mappings in Anduril, in one place:

“Off” Mode

Mode	UI	Button	Action
Off	Any	1C	On (ramp mode, memorized level)
Off	Any	1H	On (ramp mode, floor level)
Off	Any	2C	On (ramp mode, ceiling level)
Off	Simple	2H	On (momentary ceiling level)
Off	Full	2H	On (momentary turbo)
Off	Any	3C	Battcheck mode
Off	Full	3H	Strobe mode (whichever was used last)
Off	Any	4C	Lockout mode
Off	Full	5C	Momentary mode
Off	Full	6C	Tactical mode
Off	Full	7C	Aux LEDs: Next pattern
Off	Full	7H	Aux LEDs: Next color
Off	Full	9H	Misc Config menu (varies per light): ?1: tint ramp style ?2: jump start level
Off	Full	10C	Enable Simple UI
Off	Simple	10H	Disable Simple UI
Off	Full	10H	Simple UI ramp config menu: 1: floor 2: ceiling 3: steps 4: turbo style

Mode	UI	Button	Action
Off	Any	13H	Factory reset (on some lights)
Off	Any	15+C	Version check

Ramp Mode

Mode	UI	Button	Action
Ramp	Any	1C	Off
Ramp	Any	1H	Ramp (up, with reversing)
Ramp	Any	2H	Ramp (down)
Ramp	Any	2C	Go to/from ceiling or turbo (configurable)
Ramp	Full	3C	Change ramp style (smooth / stepped)
Ramp	Full	6C	(same as above, but on multi-channel lights)
Ramp	Full	3H	Momentary turbo (when no tint ramping)
Ramp	Full	4H	Momentary turbo (on multi channel lights)
Ramp	Any	4C	Lockout mode
Ramp	Full	5C	Momentary mode
Ramp	Full	5H	Sunset timer on, and add 5 minutes
Ramp	Full	7H	Ramp config menu: (for current ramp) 1: floor 2: ceiling 3: speed / steps

Mode	UI	Button	Action
Ramp	Full	10C	Turn on manual memory and save current brightness
Ramp	Full	10H	Ramp Extras config menu: 1: switch to automatic mem, not manual mem 2: set manual mem timeout 3: ramp after moon or not 4: advanced UI turbo style 5: smooth steps

Multi-channel Lights

Mode	UI	Button	Multi-channel lights only!
Any	Any	3C	Next channel mode (i.e. next color mode)
Any	Any	3H	Tint ramp (if this mode can)
Any	Full	9H	Channel mode enable/disable menu: N: click (or not) to enable (disable) mode N

Lockout Mode

Mode	UI	Button	Action
Lockout	Any	1C/1H	Momentary moon (lowest floor)
Lockout	Any	2C/2H	Momentary moon (highest floor, or manual mem level)
Lockout	Any	3C	Unlock (go to “Off” mode)

Mode	UI	Button	Action
Lockout	Any	3H	Next channel mode (if more than one enabled)
Lockout	Any	4C	On (ramp mode, memorized level)
Lockout	Any	4H	On (ramp mode, floor level)
Lockout	Any	5C	On (ramp mode, ceiling level)
Lockout	Full	7C	Aux LEDs: Next pattern
Lockout	Full	7H	Aux LEDs: Next color
Lockout	Full	10H	Auto-lock config menu: 1: set timeout in minutes (0 = no auto-lock)

Strobe Group Modes

Mode	UI	Button	Action
Strobe (any)	Full	1C	Off
Strobe (any)	Full	2C	Next strobe mode
Strobe (any)	Full	3C	Next channel mode (saved per strobe mode)
Strobe (any)	Full	4C	Prev strobe mode
Strobe (any)	Full	5C	Momentary mode (using current strobe)
Party strobe	Full	1H/2H	Faster / slower
Tactical strobe	Full	1H/2H	Faster / slower
Police strobe	-	-	None (brightness is Ramp Mode's last-used level)
Lightning	Full	1H	Interrupt current flash or start new one

Mode	UI	Button	Action
Candle	Full	1H/2H	Brighter / dimmer
Candle	Full	5H	Sunset timer on, add 5 minutes
Biking	Full	1H/2H	Brighter / dimmer

Blinky Modes

Mode	UI	Button	Action
Batt check	Any	1C	Off
Batt check	Full	2C	Next blinky mode (Temp check, Beacon, SOS)
Batt check	Full	3C	Next channel mode (for number blinks only)
Batt check	Full	7H	Voltage config menu 1: voltage correction factor ... 5: -0.10V 6: -0.05V 7: no correction 8: +0.05V 9: +0.10V ... 2: post-off voltage display seconds

Mode	UI	Button	Action
Temp check	Full	1C	Off

Mode	UI	Button	Action
Temp check	Full	2C	Next blinky mode (Beacon, SOS, Batt check)
Temp check	Full	7H	Thermal config menu 1: set current temperature 2: set temperature limit

Mode	UI	Button	Action
Beacon	Full	1C	Off
Beacon	Full	1H	Configure beacon timing
Beacon	Full	2C	Next blinky mode (SOS, Batt check, Temp check)

Mode	UI	Button	Action
SOS	Full	1C	Off
SOS	Full	2C	Next blinky mode (Batt check, Temp check, Beacon)

Momentary Mode

Mode	UI	Button	Action
Momentary	Full	Any	On (until button is released)
Momentary	Full	Disconnect power	Exit Momentary mode

Tactical Mode

Mode	UI	Button	Action
Tactical	Full	1H	High (tactical slot 1)
Tactical	Full	2H	Low (tactical slot 2)
Tactical	Full	3H	Strobe (tactical slot 3)
Tactical	Full	6C	Exit (go back to Off Mode)
Tactical	Full	7H	Tactical Mode config menu: 1: tactical slot 1 2: tactical slot 2 3: tactical slot 3

Config Menus

Mode	UI	Button	Action
Config menus	Full	Hold	Skip current item with no changes
Config menus	Full	Release	Configure current item (goes to Number Entry menu)
Number entry	Full	Click	Add 1 to value for current item
Number entry	Full	Hold	Add 10 to value for current item

Appendix A: Anduril 2 Simple UI Diagram

The following diagrams is authored by containerfan <https://github.com/containerfan/anduril2-diagrams>

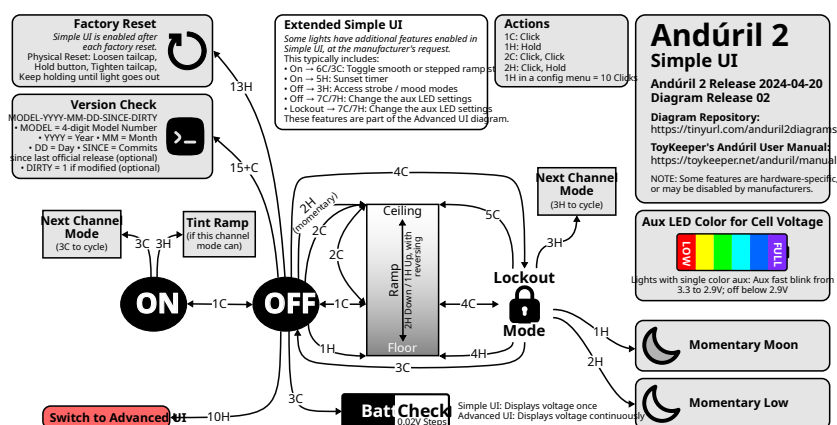


Figure 2: Anduril 2 Simple UI Diagram

Appendix B: Anduril 2 Advanced UI Diagram

The following diagrams is authored by containerfan <https://github.com/containerfan/anduril2-diagrams>

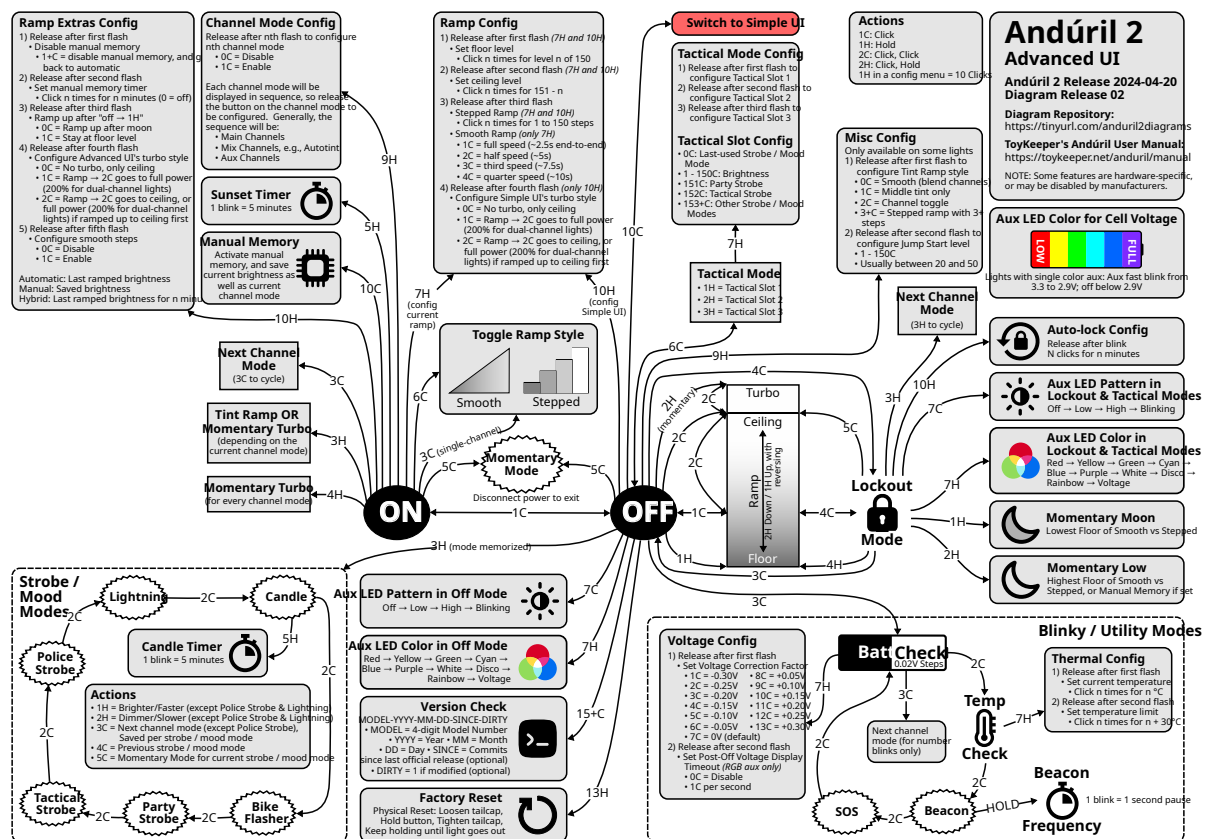


Figure 3: Anduril 2 Advanced UI Diagram

Per-User Configuration

(write me)

How to figure out which .hex file to use

Using the wrong firmware will make the light stop working, so when flashing firmware, **be sure the model number matches!**

The name of a product is *not* enough information to find the right .hex file. Ask the light what firmware it needs:

1. Use the Version Check function (15 or more clicks from Off) to find out which flavor of the firmware the light has installed.

WRITE THIS DOWN.

2. Look up the model number in the MODELS file, to get the name and MCU type.
3. Find (or build) the newest firmware for that model.
<https://github.com/ToyKeeper/anduril/releases>

The Version Check format has changed a few times. Use this section of the manual to learn about those formats and how to use them. In most cases, it should have a model number and a date... and **you need the model number** to find the correct .hex file.