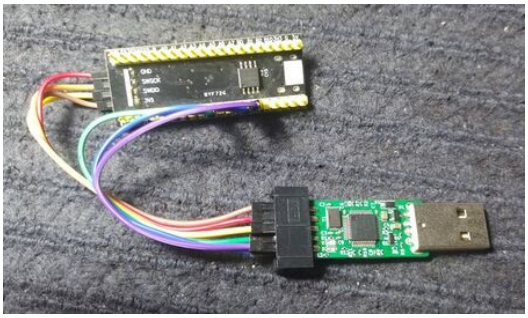
Black Pill

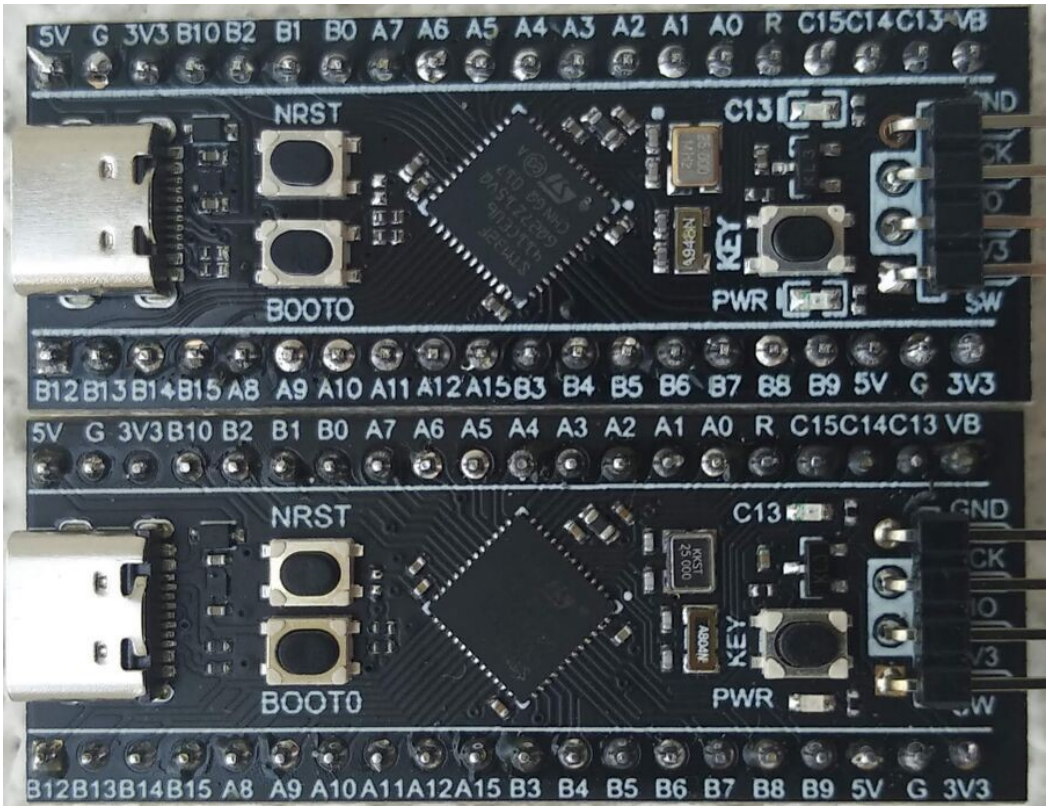
The Black Pill development board is a good choice.

Of the commercially available development modules, this is one of the best and most certainly the cheapest reasonable option out there. It was designed by WeAct Studio, but like the Blue Pill many different versions exist. Unlike the Blue Pill, at least at the time of writing this, they all appear to be using genuine STM32 processors (read: no cheaper clones exist).

Here are two different ones, both of which I suspect are clones (and both of which are working just fine):



Blackpill board with ST-Link - SWD and UART hooked up.



Contents

Videos

The Black Pill board is used in several (not all) of our tutorial videos.

You can watch the video on youtube here: https://www.youtube.com/watch?v=O6cNvE9ZrVU (https://www.youtube.com/watch?v=O6cNvE9ZrVU) (full series here).

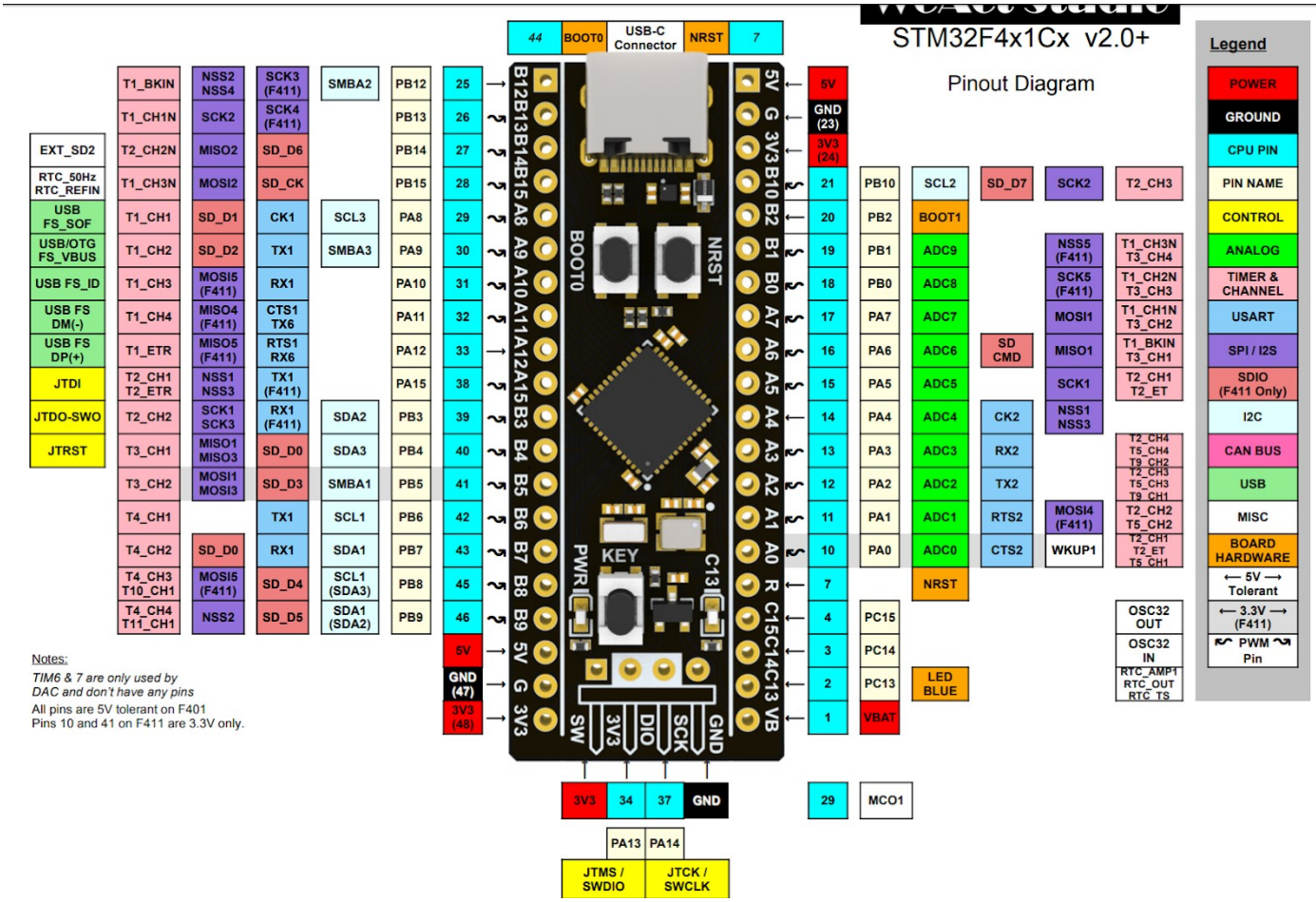
Features

The Black Pills are typically based on a STM32F401 or STM32F411 (both of the above are the F411 version) and offers the following specs:

- STM32F4 (STM32F401 or STM32F411) processor
- Same footprint (I/O pins)
- 25 MHz main crystal
- 32.768 kHz RTC crystal
- 512 kB Flash (STM32F411 version)
- 128 kB RAM
- 1 ADC (no DAC)
- USB-C connector
- Programming header (no SWO)

Pinout

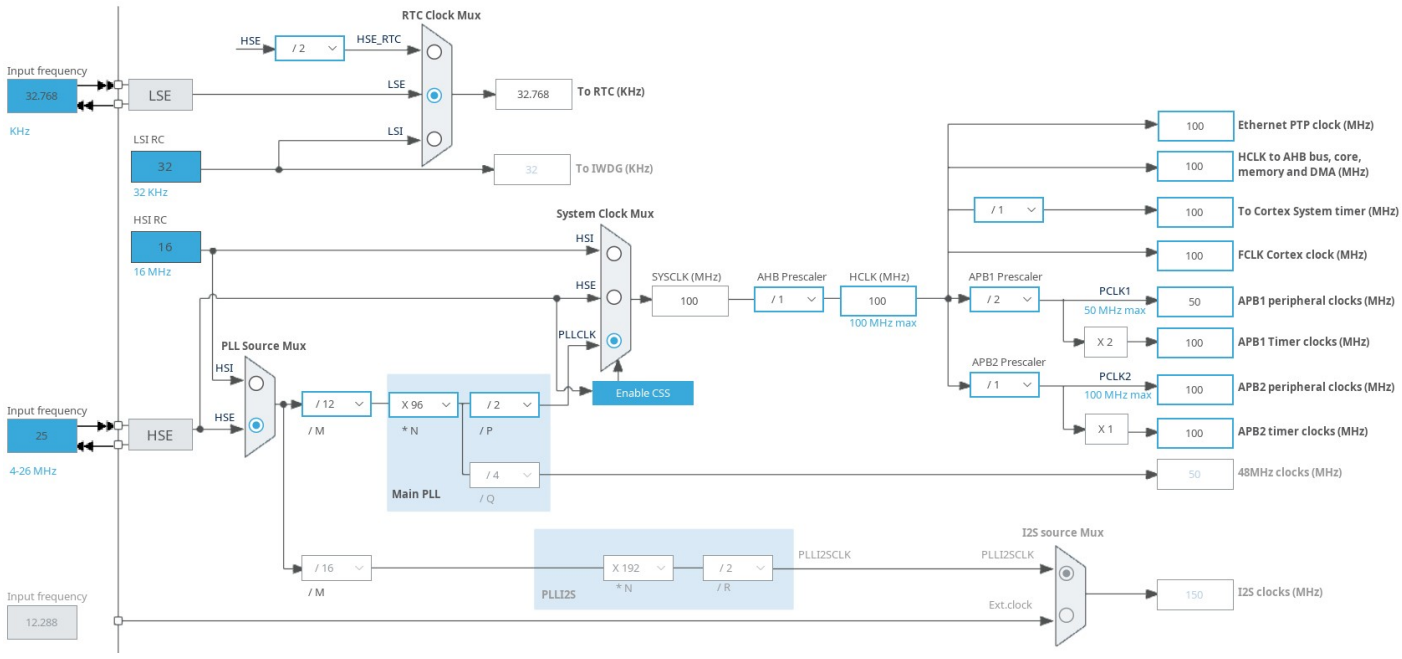
The pinout of all the Black Pill boards are defined like this:



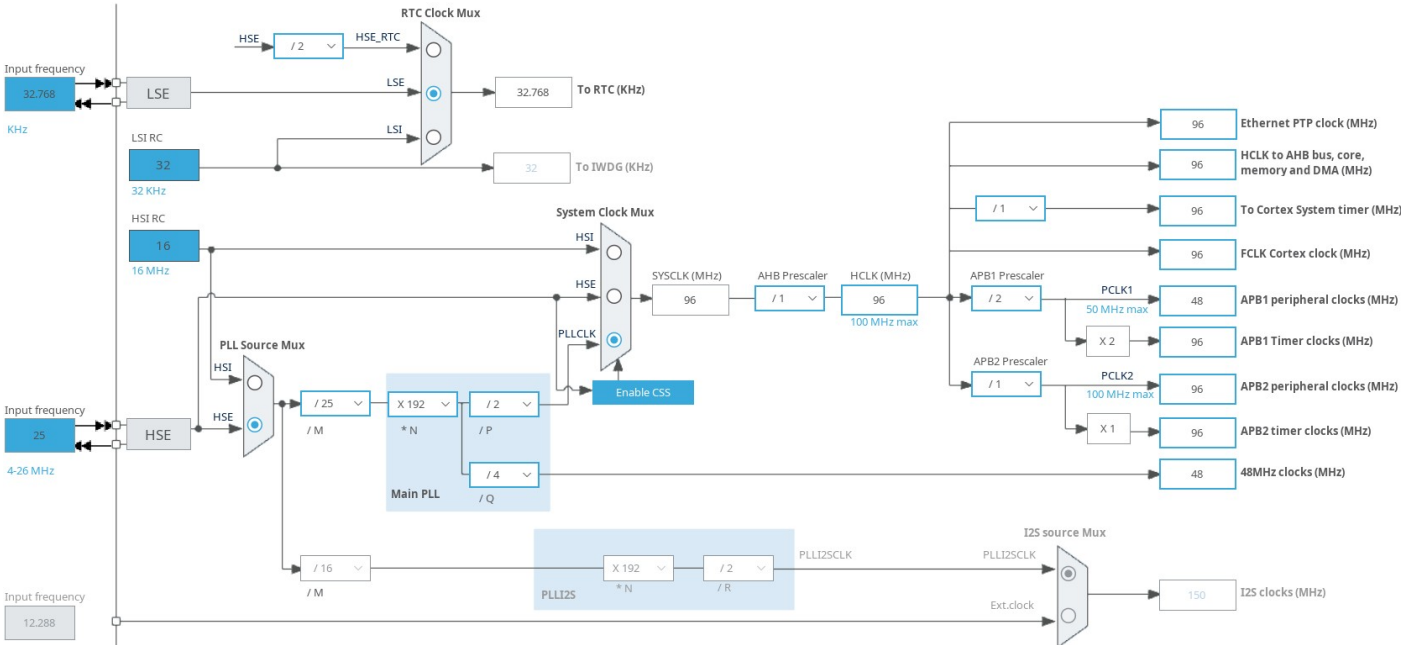
Always look at the actual silk-screen print on the board itself as there **might** be minor differences.

Clock Oddity

The Black Pill boards are built around a STM32F411 MCU. These MCUs are equipped with a 25 MHz crystal and they can be clocked up to 100 MHz like shown in the following screen shot:



The devices are also equipped with a USB port. Unfortunately, USB peripheral require a very precise 48 MHz clock and it is impossible to derive a 48 MHz clock from a 25 MHz crystal when that is configured for 100 MHz core frequency. The only way to fix this is by lowering the MCU frequency to 96 MHz from which 48 MHz is easy to derive.



Therefore, the Black Pill boards *can* run at 100 MHz, but *if* USB is enabled, the maximum MCU clock is 96 MHz.

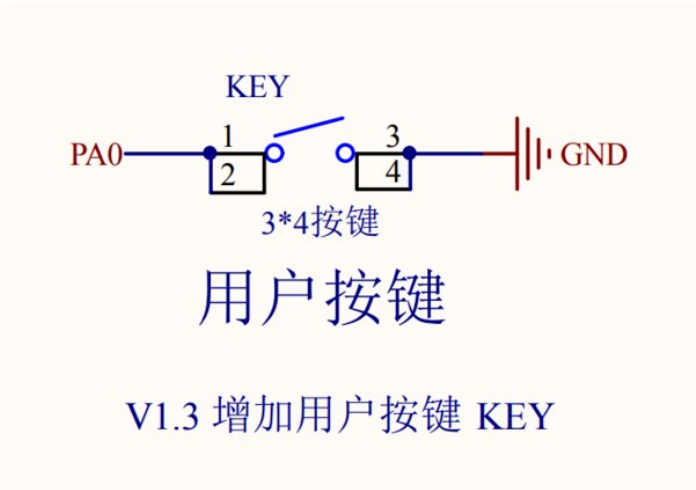
Built-in LED

Notice, the Black Pill board have got a built-in LED attached to PC13. This is perfectly Ok, if you want to toggle the LED on or off. Unfortunately, no timer channel is connected to this pin, so it is not normally possible to regulate the intensity using PWM.

Fortunately, it **is** possible to do PWM by bit-banging the pin. See STM32 bit bang PWM for an explanation on how this can be done.

User Button

Some (but not all) Black Pill boards include a so-called "User Button". It is wired up like this:



Two things are important to notice here. First of all, the button simply shorts to GND when activated, but in order for that to actually result in a change, the internal pull-up resistor **must** be activated. Secondly, there are no form of electrical debounce circuitry, so if relying on interrupts, the debounce must happen in software.

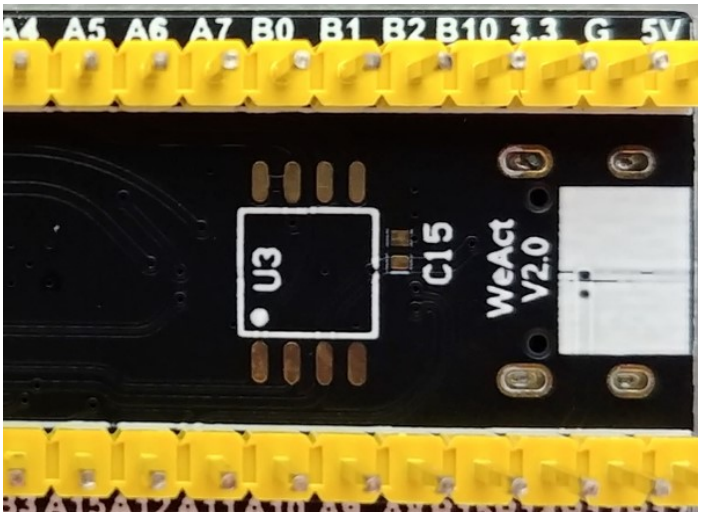
Flash Layout

Table 4. Flash module organization (STM32F411xC/E)

Block	Name	Block base addresses	Size
Main memory	Sector 0	0x0800 0000 - 0x0800 3FFF	16 Kbytes
	Sector 1	0x0800 4000 - 0x0800 7FFF	16 Kbytes
	Sector 2	0x0800 8000 - 0x0800 BFFF	16 Kbytes
	Sector 3	0x0800 C000 - 0x0800 FFFF	16 Kbytes
	Sector 4	0x0801 0000 - 0x0801 FFFF	64 Kbytes
	Sector 5	0x0802 0000 - 0x0803 FFFF	128 Kbytes
	Sector 6	0x0804 0000 - 0x0805 FFFF	128 Kbytes
	Sector 7	0x0806 0000 - 0x0807 FFFF	128 Kbytes
System memory		0x1FFF 0000 - 0x1FFF 77FF	30 Kbytes
OTP area		0x1FFF 7800 - 0x1FFF 7A0F	528 bytes
Option bytes		0x1FFF C000 - 0x1FFF C00F	16 bytes

EEPROM Footprint

The Black Pill board usually have an unpopulated footprint on the reverse side of the PCB intended for a generic SPI Flash:



On the Board Info (https://stm32-base.org/boards/STM32F411CEU6-WeAct-Black-Pill-V2.0.html) page, this is documented as:

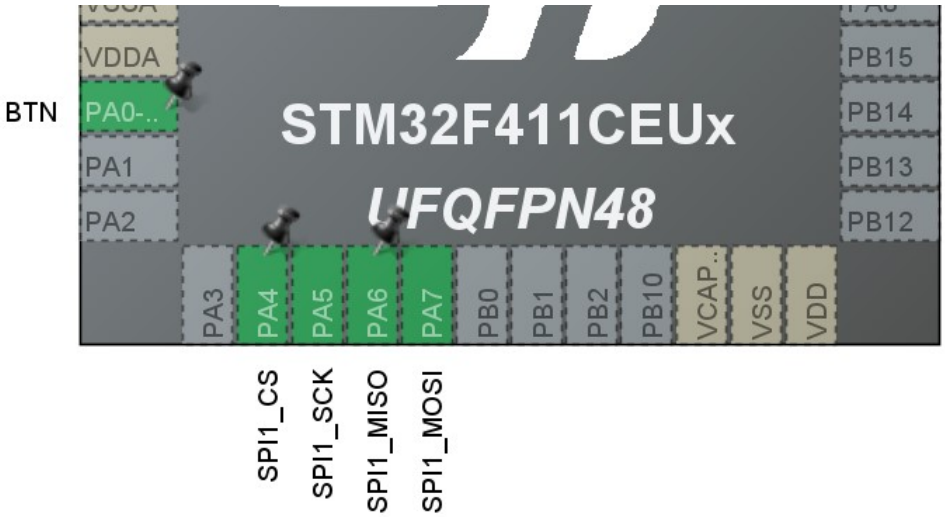
Generic EEPROM properties *footprint*

Name	Unknown
Reference	U3
Manufacturer	Unknown
Part	Generic EEPROM
Marking	Unknown
Datasheet	Unavailable
Package	SOP 8 pins
Description	Generic I2C EEPROM

Generic EEPROM pins *footprint*

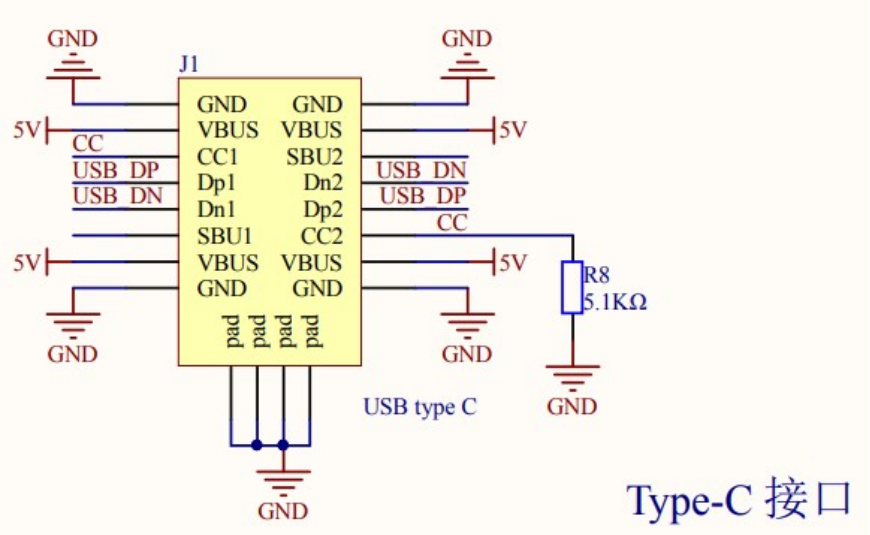
#	Name	Function	Connected to
1	-	/CS	PA4
2	-	DO	PB4
3	-	/WP	+3.3V rail
4	-	GND	Ground plane
5	-	DI	PA7
6	-	CLK	PA5
7	-	/HOLD	+3.3V rail
8	-	VCC	+3.3V rail

Unfortunately, the clone Black Pill boards are wired up different. The DO (MISO) is **not** wired up to PB4 as indicated but rather PA6 (which makes more sense anyway). Using STM32CubeMX, the right configuration is:



USB

The STM32F411 MCU on the Black Pill boards can in principle run in USB Host mode. However, it is worth having a look at the schematics:



Both the CC lines are pulled to GND using a 5.1k resistor, which signals that this is a device, *not* a host. Also, there is no way to control the power delivery. In short, while the MCU on these boards **can** operate in USB Host mode, there is no way this can be reliably done on the Black Pill boards.

Miscellaneous Links

- Board Info (https://stm32-base.org/boards/STM32F411CEU6-WeAct-Black-Pill-V2.0.html)
- Original Schematics ver. 2.0 (https://stm32-base.org/assets/pdf/boards/original-schematic-STM32F411CEU6_WeAct_Black_Pill_V2.0.pdf)
- Original Schematics vers. 1.2 (https://stm32-base.org/assets/pdf/boards/original-schematic-STM32F401CCU6_WeAct_Black_Pill_V1.2.pdf)
- STM32F411x Datasheet (https://www.st.com/resource/en/datasheet/stm32f411ce.pdf)
- STM32F411xC/E advanced Arm®-based 32-bit MCUs Reference Manual (https://ipfs.io/ipfs/QmUGduV94vdwiX5FpM5uAbNPBNw48gFXgJZyFJFeLJrbws/dm00119316-stm32f411xc-e-advanced-arm-based-32-bit-mcus-stmicroelectronics.pdf)
- Bare metal coding on the STM32F411/Black Pill (https://github.com/trebisky/stm32f411)
- Bit-bang PWM on built-in LED (https://github.com/lbthomsen/blackpill/tree/master/bitbang_pwm)

Notice, most - if not all - clone boards match the 1.2 schematics.
