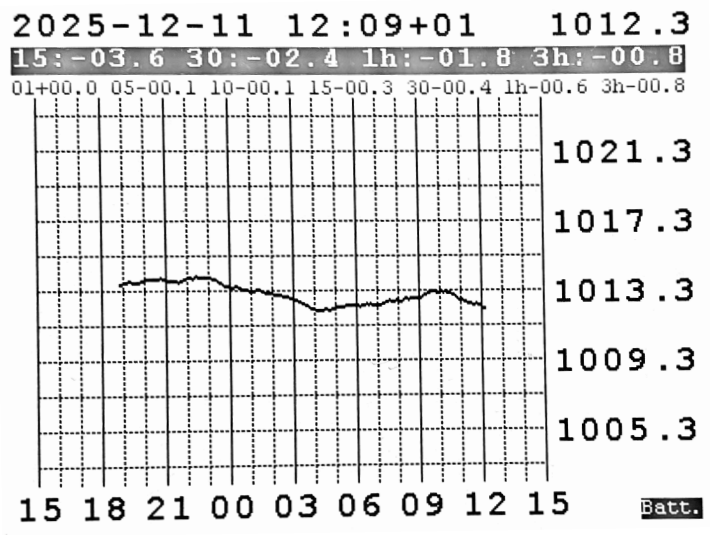
mBarograph



BUILD AND OPERATION MANUAL

Contents

Third-Party Software and Components

This package includes or references third-party software and components. Such third-party materials remain the property of their respective copyright holders and are distributed under their original licenses.

In particular, the redistributed *bootloader.bin* file is the Arduino® Nano 33 BLE Sense bootloader and remains subject to the applicable Arduino license. The original source is available at https://github.com/arduino/ArduinoCore-mbed.

The compiled firmware provided with the mBarograph incorporates software components from the Arduino® (https://www.arduino.cc), Adafruit (https://www.adafruit.com), and Waveshare (https://www.waveshare.com) ecosystems. These components remain subject to their respective licenses and copyrights. No unmodified third-party source code is redistributed as part of this package, except for the Arduino® bootloader binary described above.

Genoa, September 2026

1 Functional description

The mBarograph is a fully electronic digital barograph that measures the atmospheric pressure at regular intervals and records it. The records can be visualised in a 24 h graph or alternatively in a 4 d graph. The 4 d are 3 d plus the current day. The atmospheric pressure values are recorded and displayed every 5 min for the 24 h graph and displayed every 20 min for the 4 d graph. The pressure sensor has a built-in IIR filter to minimise short-term disturbances due to wave motion or wind gusts.

Pressure changes from now to 1, 5, 10, 15, 30 min, 1 and 3 h ago are calculated and visualised. Based on the pressure change from 15, 30 min and 1 h ago the pressure tendency over 3 h is estimated. If any of these and/or the effective 3 h pressure tendency is above or below the preset tendency limit an alarm bar appears on the screen and an acoustic alarm is sounded. In the alarm bar the estimated tendency values are visualised.

The device includes a high accuracy real time clock. Visualization is done on a high-contrast sunlight readable 4.2-inch e-paper screen and the device can be powered by a standard USB Type-C cable. It has an internal Li-Polymer Battery to run the mBarograph independent from the power supply for about 10 d.

The firmware can be updated by the user using a personal computer.

The mBarograph is only an aid for the prediction of weather conditions. It can only integrate a proper weather forecast and continuous nowcasting!
It remains paramount to have proper preparation for adverse weather conditions!

2 Technical data

Operating pressure range	900 hPa to 1100 hPa
Absolute pressure accuracy	±0.30 hPa
Relative pressure accuracy	±0.06 hPa
Offset temperature coefficient	$\pm 0.50\,\mathrm{Pa\,K^{-1}}$
Temperature stability pressure	±0.10 hPa within 1 year
Altitude correction range	0 m to 50 m
Time accuracy better than	±5 s per month
Leap-Year Compensation	Up to 2100
Built-in battery	Li-Polymer 3.7 V ≥2 A h
External power supply	USB Type-C ≤1.5 A
Clock backup battery	Coin Cell CR1220
Active viewing area on display panel	85 x 64 mm
Graphic resolution of display	400 x 300 pixel
Timescale	24 hours or 4 days
Pressure viewing range	22 hPa over 24 hours
	220 hPa over 4 days
Resolution of pressure value	0.1 hPa
Resolution of pressure curve	0.1 hPa per pixel 24 hours
	1.0 hPa per pixel 4 days
Operating temperature range	−10 °C to 45 °C
Dimensions (W x H x D)	101 x 107 x 22 mm
Weight approximate	160 g

3 Building the mBarograph

The following section describes, step by step, how to build a fully functioning mBarograph from the provided Materials. Additional components, equipment, and tools are required and are clearly identified throughout the section.

It should be noted that a basic familiarity with the assembly and programming of electronic devices is assumed. While the individual procedures are straightforward and do not require advanced technical skills, a general understanding of electronic components and firmware installation will help ensure a successful build.

Before you begin: A complete step-by-step assembly video is available on the mBarograph website (https://bombasaro.org/mBarograph). While not required, watching the video before starting the build may help to familiarise yourself with the assembly and programming process.

3.1 PCB

Within the folder *01_PCB*, all files required for PCB fabrication and component assembly are provided.

The file *mBarograph_v1.0_GerberFiles.zip* contains the complete set of Gerber files together with the drill file required for PCB manufacturing. The file *mBarograph_v1.0_bom.csv* contains the Bill of Materials (BOM), listing all required components along with a recommended manufacturer and part number for each item.

The specified manufacturers are provided for reference only; equivalent components from other manufacturers may be used, provided that their electrical, mechanical, and environmental characteristics remain unchanged and fully compatible with the design requirements.

The file *mBarograph_v1.0_cpl.csv* contains the component placement data for automated assembly. Please note that components *Sc0* and *Sc1*, which correspond to the push-button caps, are not included in the component placement file and must be installed separately after PCB assembly.

In addition to the components listed in the BOM, a 4.2-inch black-and-white E-Paper display is required. A suitable display module is the *GDEY042T81* manufactured by GooDisplay (https://www.good-display.com). Equivalent displays from other manufacturers may also be used, provided they are electrically and mechanically compatible with the design and offer comparable functionality and performance.

The PCB fabrication and component assembly may be performed by any qualified PCB manufacturing and assembly service provider. Numerous suppliers worldwide offer suitable fabrication and assembly capabilities. Particular attention shall be given to the pressure sensor, which is a delicate and sensitive component. The selected assembly provider must be capable of handling and placing the pressure sensor in accordance with the manufacturer's recommendations.

If a conformal coating or any other protective coating is applied after assembly, the pressure sensor must be adequately masked or otherwise protected to ensure that its sensing port remains unobstructed and that its performance is not adversely affected.

3.2 Additional Items

After the PCB has been fabricated and assembled, the following additional items are required to complete the build:

- USB Type-C cable suitable for both data transfer and battery charging.
- CR1220 coin cell battery for backup power of the real-time clock (RTC).
- Li-Polymer battery, nominal voltage 3.7 V, with a capacity of at least 2 A h.

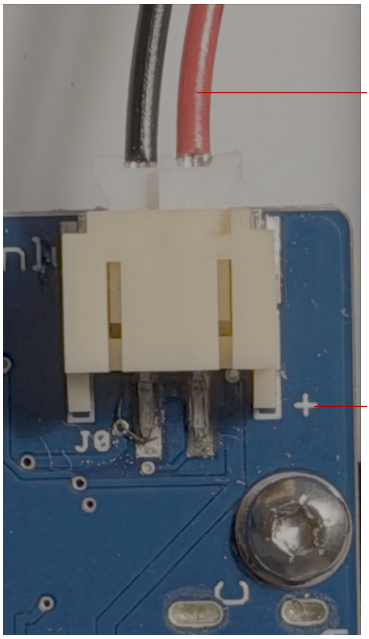
The Li-Polymer battery shall not exceed the following dimensions:

- Width: 51 mm
- Length: 63 mm
- Thickness: 8.1 mm

The battery shall have a minimum capacity of 2 A h. A suitable battery type is the *805060*.

Particular attention must be paid to the polarity of the JST-PHR-2P battery connector (2 mm pin spacing). Unfortunately, there is no universally adopted polarity convention for Li-Polymer batteries equipped with this connector, and different suppliers may provide batteries with opposite wiring configurations.

The correct battery polarity is shown in the figure below. The positive terminal of the JST-PHR-2P connector is also clearly marked on the PCB silkscreen.



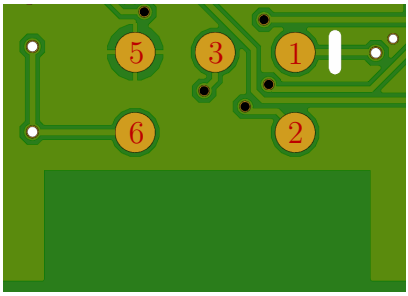
Before connecting the Li-Polymer battery, verify both the polarity of the JST-PHR-2P connector and that the battery meets the specified minimum capacity requirements. Connecting the battery with reversed polarity may cause immediate and irreversible damage to the electronics and the battery itself. The use of an incorrectly wired battery, or a battery that does not meet the specified requirements, may result in improper operation, overheating, fire, explosion, personal injury, or property damage. The user is solely responsible for verifying the battery polarity and suitability prior to connection.

3.3 Bootloader

The mBarograph uses the same bootloader as the Arduino® Nano 33 BLE Sense. The bootloader binary file, *bootloader.bin*, is provided in the *02_firmware* folder for convenience. The original bootloader is part of the Arduino® Core for Mbed OS and is available from the official Arduino repository at https://github.com/arduino/ArduinoCore-mbed. The bootloader remains subject to its original license and copyright. Once the bootloader has been programmed onto the microcontroller, the mBarograph is recognised by the Arduino® development environment as an Arduino® Nano 33 BLE Sense and can be programmed accordingly. It should be noted, however, that the mBarograph is not an Arduino® Nano 33 BLE Sense. While both devices share the same microcontroller and bootloader, the peripheral hardware, sensors, and pin assignments differ substantially.

The bootloader can be programmed using a J-Link EDU Mini debug probe (https://www.segger.com/products/debug-probes/j-link/models/j-link-edu-mini/) together with the SEGGER J-Flash Lite software (https://www.segger.com/downloads/jlink/).

To program the bootloader, five connections must be made between the mBarograph PCB and the J-Link programmer. The programming header pinout on the PCB is shown below:

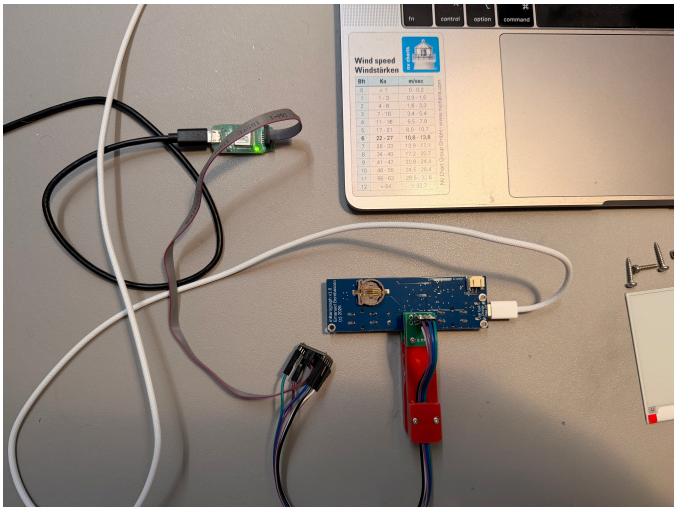


The mapping is:

Pin	mBarograph	J-Link EDU
1	3.3V	Vref
3	SWDIO	SWIO
2	SWCLK	CLK
5	Ground	GND
6	Reset	RST

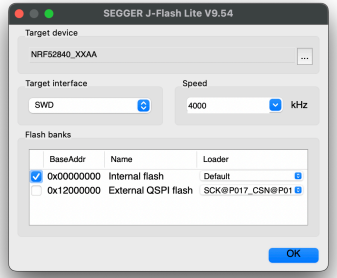
To establish a reliable programming connection, it is recommended to use an adapter that converts the standard 2×5 SWD connector (0.05″ / 1.27 mm pitch) used by the J-Link programmer to the mBarograph programming interface. A suitable solution is a 2×5 SWD adapter in combination with a 2×3 pogo-pin probe clip with 0.1″ (2.54 mm) spacing. The use of a pogo-pin probe clip eliminates the need to solder a programming header to the PCB and provides a convenient and repeatable method for bootloader programming and debugging.

See image below showing the complete wiring.



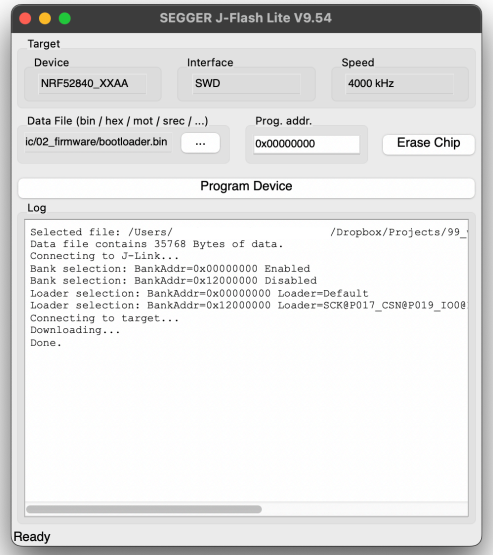
During bootloader programming, neither the CR1220 backup battery nor the Li-Polymer battery shall be connected to the mBarograph. Once all programming connections have been made, connect the USB Type-C cable to power the mBarograph and launch the SEGGER J-Flash Lite software.

In J-Flash Lite, select *NRF52840_XXAA* as the target device. Set the target interface to *SWD* and the communication speed to 4000 kHz. Configure the Flash Banks as shown in the figure below.



Next, browse to and select the *bootloader.bin* file located in the *02_firmware* folder. All remaining settings may be left at their default values.

After verifying the configuration, click *Program Device* to begin the programming process. Upon successful completion, a log similar to the one shown below should be displayed.



3.4 Firmware

To install the firmware, the Arduino IDE (https://docs.arduino.cc/software/ide/) is required. After installing the Arduino IDE, connect the mBarograph to the computer using a USB Type-C cable and launch the application. Depending on the Arduino IDE version, it may be necessary to install the **Arduino Mbed OS Nano Boards** package. This can be done through the *Boards Manager* by searching for and installing *Arduino Mbed OS Nano Boards*. Once the board package has been installed, verify that the mBarograph is recognised by the operating system as an Arduino Nano 33 BLE Sense compatible device. The precompiled firmware image, *mBarograph_v1.00.ino.bin*, is located in the *02_firmware* folder.

The firmware image *mBarograph_v1.00.ino.bin* can be uploaded using the same upload utility employed by the Arduino IDE for the Arduino Nano 33 BLE Sense.

The same procedure applies when updating the firmware to a newer version. In the examples shown throughout this document, the firmware file is named *mBarograph_v1.00.ino.bin*, corresponding to firmware version 1.00. When a newer firmware release becomes available, simply replace the firmware file referenced in the upload command with the newly downloaded firmware file. No other changes to the procedure are required. The bootloader does not need to be reprogrammed unless explicitly stated in the firmware release notes.

After installing the Arduino IDE and the *Arduino Mbed OS Nano Boards* package, connect the mBarograph to the computer using a USB Type-C cable.

To determine the upload command used by the Arduino IDE, enable verbose upload output:

1. Open the Arduino IDE.

2. Select *Arduino IDE* → *Settings* (macOS/Linux) or *File* → *Preferences* (Windows).
3. Enable *Show verbose output during upload*.
4. Select *Arduino Nano 33 BLE Sense* as the target board.
5. Perform a normal upload of an empty sketch.
6. Copy the upload command displayed in the output window.

The command displayed in the output window looks similar to the example shown below. Depending on the Arduino IDE version, operating system, installation path, and selected serial port, the exact command may differ.

macOS/Linux

```
"/Users/.../1.9.1-arduino2/bossac" -d --port=cu.usbmodem14301 -U -i -e -w "/Users/.../D83A7987038B92FBD76D579E7F274015/sketch_jun24a.ino.bin" -R
```

Windows

```
"C:\Users\...\1.9.1-arduino2/bossac.exe" -d --port=COM7 -U -i -e -w "C:\Users\...\2FFA98E158E4E5C6C71BC3D1161844FB/sketch_jun24a.ino.bin" -R
```

The copied command can then be executed directly from a terminal (macOS/Linux) or Command Prompt (Windows) after replacing the firmware file name and path with *mBarograph_v1.00.ino.bin*. Before executing the upload command, the mBarograph must be placed into bootloader mode. This is accomplished by momentarily shorting pin 5 (*GND*) and pin 6 (*RESET*) of the programming header twice in quick succession. Once bootloader mode has been entered successfully, the device is ready to accept a firmware upload.

Take care not to short any pins other than *GND* and *RESET*. Accidental short circuits may damage the device or interfere with the programming process.

The modified command should look similar to the example shown below. Depending on the Arduino IDE version, operating system, installation path, and selected serial port, the exact command may differ.

macOS/Linux

```
"/Users/.../1.9.1-arduino2/bossac" -d --port=cu.usbmodem14301 -U -i -e -w
    "/Users/.../02_firmware/mBarograph_v1.00.ino.bin" -R
```

Windows

```
"C:\Users\...\1.9.1-arduino2/bossac.exe" -d --port=COM7 -U -i -e -w "C:\
    Users\...\02_firmware/mBarograph_v1.00.ino.bin" -R
```

After a successful firmware upload, disconnect the mBarograph from the computer. The E-Paper display and both batteries may now be installed.

Carefully connect the E-Paper display to the PCB and verify that it is properly seated and aligned. When the PCB is placed on a flat surface with the push buttons facing upwards, the display must also face upwards. Ensure that the display connector is fully inserted and secured before proceeding.

Next, install the CR1220 backup battery and connect the Li-Polymer battery, ensuring that the battery polarity is correct as described in the previous section.

If the Li-Polymer battery is sufficiently charged, the mBarograph will automatically power up after connection. Following a brief startup sequence, the device is ready for final assembly.

3.5 Housing

The housing consists of three individual parts: the Front Panel, the Screen Panel, and the Back Panel. The corresponding CAD models are provided as STEP files in the *03_housing* folder:

- *mBarograph_v1.0_BackPanel.step*
- *mBarograph_v1.0_FrontPanel.step*
- *mBarograph_v1.0_ScreenPanel.step*

The housing components may be manufactured either by 3D printing or CNC machining. Black ABS plastic is the recommended material for the Front Panel and Back Panel. The Screen Panel may also be manufactured from ABS plastic or alternatively from 9600 Resin.

The PCB is secured to the Front Panel using three *DIN 7981 A2 C 2.2×6.5 TX6* self-tapping screws. The Front Panel assembly is secured to the Back Panel using four *DIN 7982 A2 C 2.9×16 TX6* self-tapping screws. All screws should be manufactured from A2 stainless steel or an equivalent corrosion-resistant material.

To prevent the E-Paper display and Li-Polymer battery from moving or vibrating within the housing, it is recommended to place approximately 1 mm thick foam padding behind both components. The foam should provide light mechanical support without exerting excessive pressure on the display or the battery. Particular care should be taken not to apply excessive force to the E-Paper display, as this may damage the display panel. Similarly, the Li-Polymer battery must not be compressed, bent, punctured, or otherwise mechanically stressed.

The assembly procedure for the housing and installation of the electronic components is described in Section 4.2.

4 Using the mBarograph

The absolute atmospheric pressure value alone is known to have little influence upon wind and weather. What does have meteorological significance, however, is the extent of any alteration in pressure on a unit-time basis, i.e. the pressure tendency. This is why barographs are superior to straightforward barometers, as the atmospheric pressure is graphically visualised at regular intervals.

Alongside typical fields of application onboard ships, at meteorological stations and in alpine mountaineering huts, the mBarograph is equally at home in your living room or on your desk.

The mBarograph automatic pressure tendency prediction system allows the detection of local winds much sooner (useful for e.g. yachts riding, at anchor during the night, farmers, mountain climbers etc.).

4.1 Precautionary measures

Avoid exposing the unit to direct sunlight and/or high temperatures. Never use solvents for cleaning the unit.

When used in ocean-going yachts, the unit should be located in the splash-proof navigation area and properly fixed (i.e. not break free in stormy weather) at least 1 m from transmitter antennas. The same holds if the unit is used outdoors.

It is essential that the electrical connection and supply voltage are correct! Only use the correct batteries! Use a proper USB charger with at least 2 A power output and quality USB Type-C cables. Only charge the battery (connect the power through the USB Type-C cable) when the temperature is within 6 °C to 40 °C. Charge frequently, do not leave the Li-Polymer Battery in an uncharged state for too long.

Avoid shaking, knocks or exposure to vibrations as this can lead to damage of the pressure sensor.

Never press down onto the e-ink display panel as this can cause irreparable damage.

Never leave graphics on the e-ink display when removing the internal battery and having no power connection for an extended period of time (24 h), see section 4.4 for how to store the mBarograph properly.

4.2 First use

Before the mBarograph can be used, a few simple steps must be carried out. Disassemble the unit by removing the four screws on the Front Panel. Once the Front and Back Panel are separated the Back Panel can be mounted, see section 4.3.

Before reassembling the Front and Back Panel the Li-Polymer Battery needs to be connected to the circuit board. Connect the JST PH connector carefully!

Once the Li-Polymer Battery is connected the unit will power up. In case it does not, connect the USB Type-C cable to provide power to the unit. Keep a careful look at the startup screen sequence. Flickering is normal and clears ghosting from the previous image so to ensure better clarity and legibility for the new image.

Reassemble the unit, do not squeeze any cable and tighten the Front Panel screws carefully.

Connect a USB Type-C to charge the Li-Polymer Battery. Full charging will take about 6.5 h. With a full charge the mBarograph will last about 10 d without needing to be recharged.

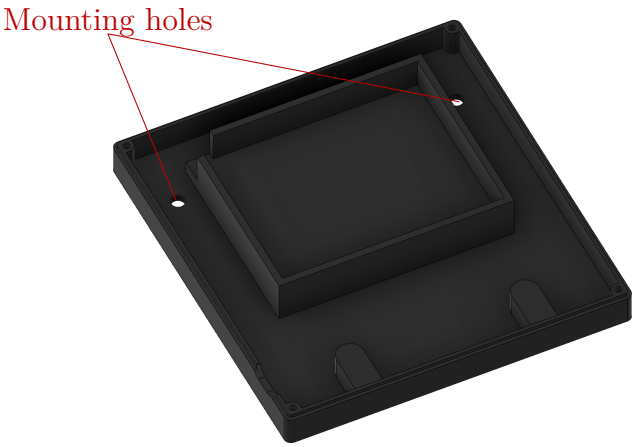
Remember, if the mBarograph is not powered through the USB Type-C cable while disconnecting the Li-Polymer Battery the mBarograph will reset and lose all pressure recordings and settings!

To protect the screen, it is turned OFF after 5 min if no button is pressed. Press any button to turn the screen ON again. The screen will turn ON automatically in case an alarm is triggered.

4.3 Mounting

The mBarograph must remain in a fixed location, even small changes in elevation (such as carrying the device from floor to another or passing through a lock with the yacht) will influence the pressure measurement, see section 9 for further explanations.

The mBarograph is designed so that it may be specially mounted on a wall. The Back Panel has two holes ∅4 mm through which the Back Panel can easily be fastened.



4.4 Storage

If the mBarograph is not used for a longer time, ensure that both the batteries (Li-Polymer battery and Coin Cell) are removed after the screen has turned itself off.

How to properly turn OFF the mBarograph

1. disassemble the device
2. wait for the screen to turn OFF (after last button press, it takes 5 min)
3. unplug the Li-Polymer battery. Use pliers to disconnect the JST PH connector carefully. Remove also the Coin Cell.

Store the device horizontally in a dry place. Store the Li-Polymer Battery separately from the device and keep it in a charged state all the time.

4.5 Maintenance

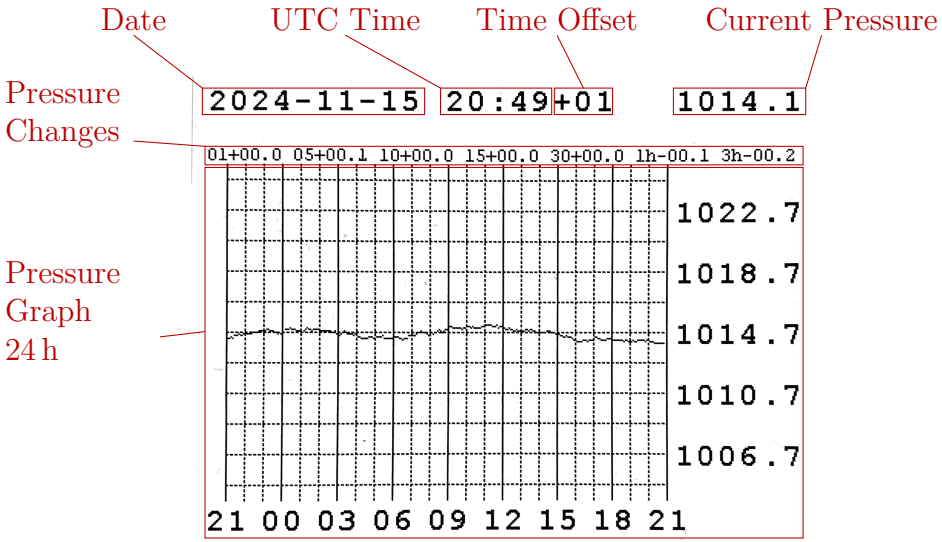
The mBarograph should be cleaned using a soft cloth or tissue. No cleaning solvents should be used!

Apart from charging and, when required, changing the batteries, the mBarograph does not require any maintenance.

The firmware can be updated, see section 3.4. Check the https://bombasaro.org/mBarograph if a new firmware version is available, see section 7 where to find the installed firmware version.

5 Basic Operation

When you turn on the mBarograph a welcome screen is visualised. After that the system is started up, and several checks are performed. Verify that all displayed tests are passed successfully and no warnings are shown. After that, the mBarograph switches into 24 h view.



Date shows the current date

UTC Time displays the current UTC time

Time Offset offset in h from UTC time to local time

Current Pressure is displayed and updated every 1 min

Pressure Changes the differences between the Current Pressure and the pressure measured 1 min, 5 min, 10 min, 15 min, 30 min, 1 h and 3 h is shown. The values are displayed as

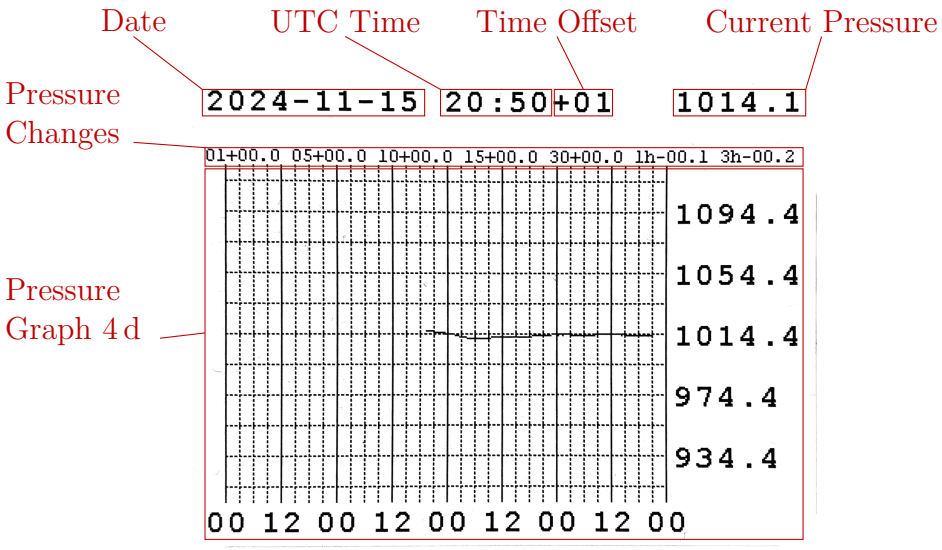
ttspp.p, where tt is the time, s the sign (positive or negative) and pp.p the pressure change value. If the pressure difference is negative (−), the pressure in the past was higher than now, if the pressure difference is positive (+) the pressure in the past was lower than now.

Pressure Graph 24 h showing the pressure trend for the past 18 h and the pressure in the current 3 h epoch. The pressure trend line is plotted inside the Pressure Graph. The line is composed of two pixels the upper pixel is the one in the vertical position corresponding to the recorded pressure.

The horizontal dashed lines are spaced 2.0 hPa, for every 4.0 hPa the corresponding numeric pressure value is shown on the right. These pressure values are regularly updated to keep the pressure trend line centred on the screen.

The graph is composed of solid and dashed vertical lines corresponding to 1 h intervals. The 3 h intervals are the solid lines. The rightmost 3 h interval is the current epoch. In this case the interval is starting at 18:00 and ends at 21:00, the last pressure data point was drawn at 20:45 and the next will be drawn at 20:50. Every 3 h the graph will move to the left and a new 3 h epoch, i.e. time of the rightmost line will become 00 the one before 21.

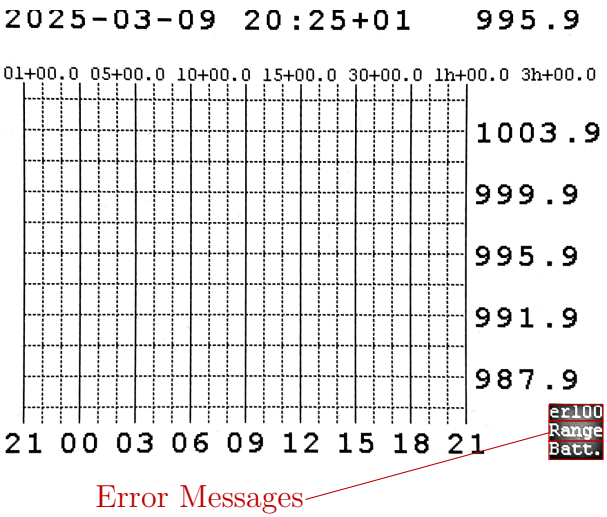
With a short press (hold and count till one) on the left button the mBarograph switches into the 4 d view. Always wait a few seconds before switching view again.



Pressure Graph 4 d showing the pressure trend for the past 3 d and the pressure trend in the current day. The horizontal dashed lines are spaced 20.0 hPa, for every 40.0 hPa the corresponding numeric pressure value is shown on the right. These pressure values are regularly updated to keep the pressure trend line centred on the screen.

The graph is composed of solid and dashed vertical lines corresponding to 3 h intervals. The solid lines are at midnight 00 and midday 12. The rightmost 1 d interval is the current day. Every day at midnight the plot is moved to the left 1 d.

The mBarograph shows in case of errors following independent messages.



er100 is shown in case the pressure sensor cannot perform a reading. The error should disappear at the next pressure reading, i.e. after about 1 min. If the error message persists, see section 8.

Range is shown when some part of the pressure trend line is outside the pressure graph area. The error is shown individually on the 24 h or 4 d graph, i.e. the error may only appear on one of the two. All values within the graph area are shown as normal. No operator input is necessary; the error will disappear once the trend line fits in the graph area again.

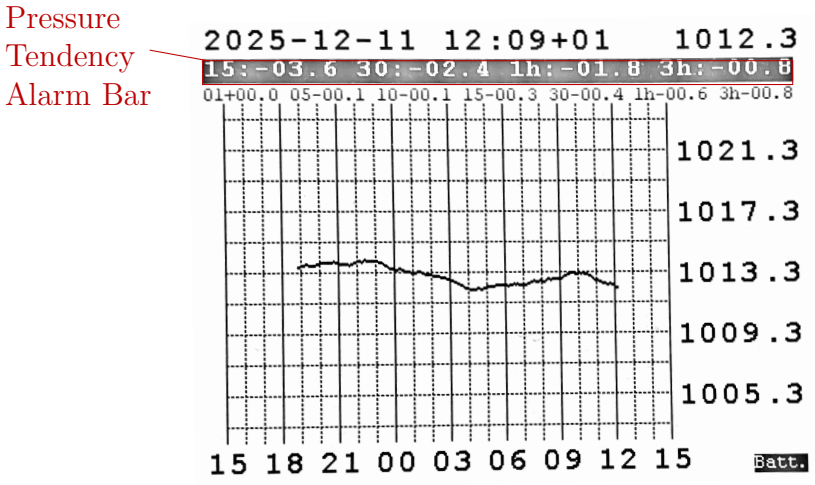
BatXX is shown with XX=LO once the internal Li-Polymer Battery is running low, XX=NO none is connected and XX=CH while charging. On low battery, charge the soonest to not lose the atmospheric pressure recordings. Fully charging the empty battery takes about 6.5 h. Updated only every 1 min.

6 Pressure Tendency Alarm

The mBarograph based on the pressure change from 15, 30 min and 1 h ago extrapolates the pressure tendency over the future 3 h. If any of these and or the effective 3 h pressure tendency is above (Rising) or below (Falling) preset tendency limit (if a value is set) an alarm bar appears on the screen, and an acoustic alarm is sounded (if Buzzer is turned ON in settings).

This allows the user to become aware of dangerously rapid pressure changes before the effect can be felt and thus be prepared.

The acoustic alarm can be acknowledged by pressing any button. The alarm will start to sound again every time the mBarograph new pressure tendency alarm is identified.



Looking at the pressure tendency alarm bar, we understand that if the pressure will continue to decrease at the same rate as in the last

15 min we will have 3 h tendency of −3.6 hPa/3h, the last
30 min we will have 3 h tendency of −2.4 hPa/3h, the last
1 h we will have 3 h tendency of −1.8 hPa/3h and
we have an effective 3 h tendency of −0.8 hPa/3h.

The tendency alarm was triggered by the 15 min estimation which is below the set falling alarm limit of −3.5 hPa/3h.

The above example is shown for falling atmospheric pressure, exactly the same holds if rising (pressure increase) is analysed.

The estimation based on the 15 min shows to be particularly sensitive and triggers the alarm quite frequently. As much this may be annoying, it is these predictions which allow to protect against sudden and difficult to predict events.

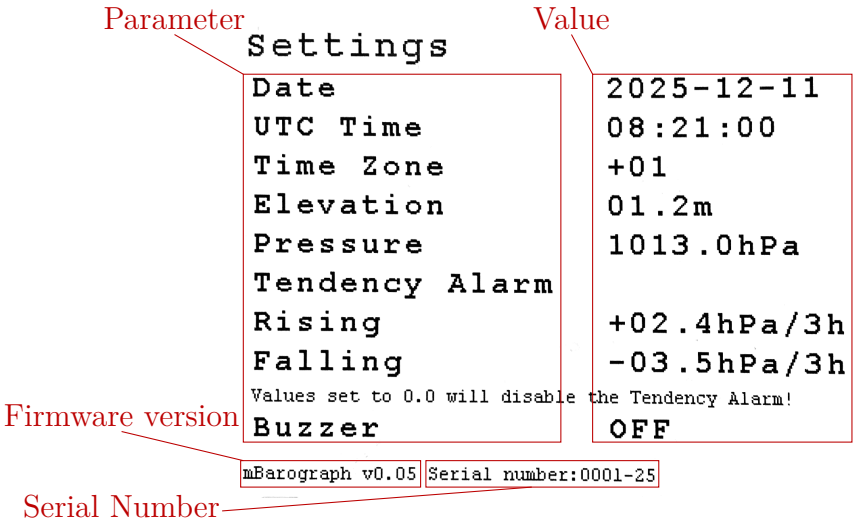
The pressure tendency alarm value for Falling is chosen highly dependent upon the operating location and the extent of personal experience. The following non-binding standard values apply to:

On open sea: −1.5 hPa/3h to −3 hPa/3h
In wind-exposed areas on land: −1.5 hPa/3h to −6 hPa/3h
In built-up and hilly areas: −3 hPa/3h to −10 hPa/3h

For the Rising pressure tendency alarm value, it is up to the personal experience. Or in case not of interested can be disabled by setting it to 0 hPa/3h.

7 Settings

With a long press (hold a count till four) of the left button the mBarograph enters the settings screen. Inside the setting screens the right button is used. Always wait a second before taking the next action. A short press on the left will exit the setting screen.



Note the display will be updated every 1 min.

Date User set Date. If a non-existing date is entered the system will correct to the next closest existing date.

UTC Time User set UTC hours and minutes, seconds are set to 00 at every change. When the time is changed the pressure trend is cleared. It is highly recommended to keep the UTC time and only correct possible second offset overtime and account for local time using the Time Zone setting.

Time Zone User set offset in h from UTC time to local time, allowed from −12 h to +12 h. Default value +1 h.

Elevation User set elevation above sea level at which the mBarograph is installed. Allowed values 0 m to 50 m.
Once an elevation is set the pressure value displayed and recorded by the mBarograph is the atmospheric pressure at a station-level reduced to sea level according to the *standard atmosphere*, see section 9. In case the mBarograph is installed more than 50 m above the sea level, the elevation should be set to zero and the correction made by adjusting the pressure. Default value 1.2 m.

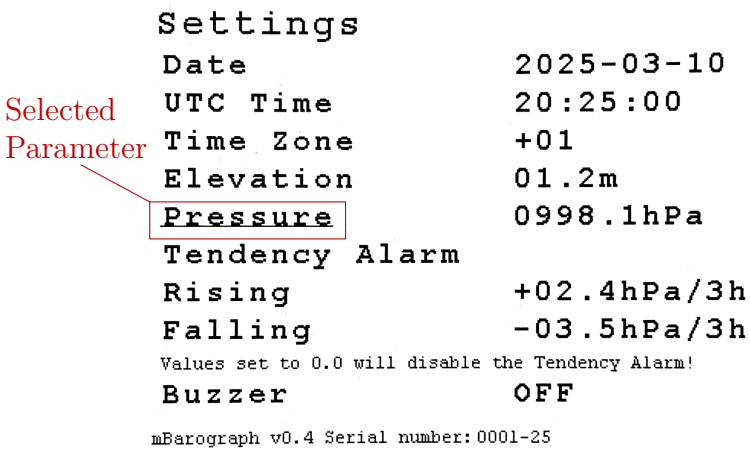
Pressure The atmospheric pressure at sea level (i.e. corrected to sea level in case Elevation is set). The user can change these values in case a reliable atmospheric pressure reading is available and differs from this reading. The values should be changed after the Elevation is set. The entered values must be the atmospheric pressure at sea level. Allowable values 900 hPa to 1100 hPa. However, remember it is not about having the absolute pressure value correct (this is not a metrological station), what is of importance is the pressure tendency.

Rising User set level at which the Rising pressure tendency alarm is triggered. Allowed values 0 hPa/3h to +99.9 hPa/3h, setting 0 hPa/3h disables the alarm. Default value 0 hPa/3h.

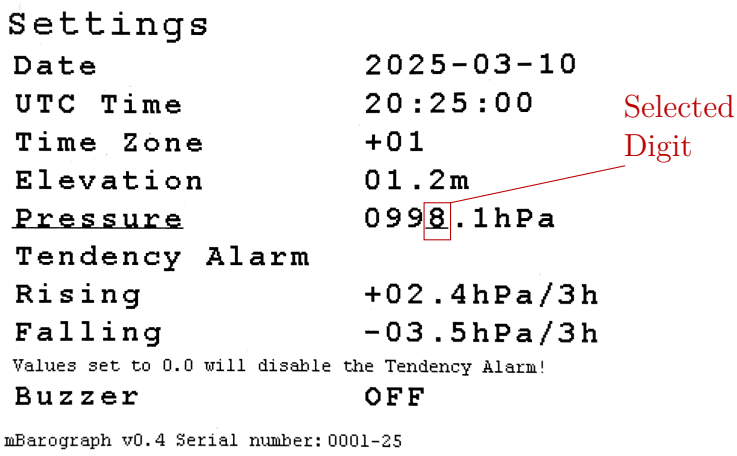
Falling User set level at which the Falling pressure tendency alarm is triggered. Allowed values 0 hPa/3h to −99.9 hPa/3h, setting 0 hPa/3h disables the alarm.
Default value −3.5 hPa/3h.

Buzzer If ON, an acoustic alarm is sounded when a Pressure Tendency Alarm is triggered. If OFF, no acoustic alarm will be sounded. Default value OFF.

With a short press of the right button (remember to wait a few seconds after every press) the first parameter is selected. The selected parameter is underlined.

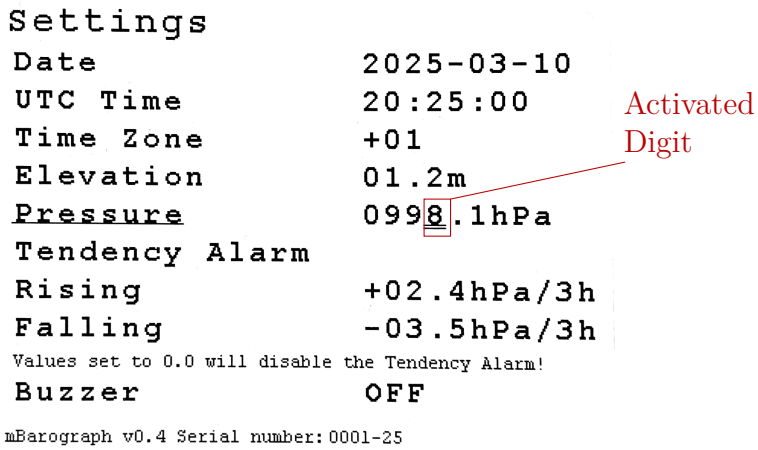


With a long press on the right button the value associate with the parameter is selected.
In case of Time Zone or Buzzer the whole value is underlined and shown as selected.
In case of Elevation, Pressure and Tendency Alarms an individual digit is selected. With a short press on the right button one can jump to the next digit.
In case of Date and UTC Time the complete number of minutes, hours, days, month or the last two digits of the year are selected.



With a short press on the right button one can jump to the next element.

With a long press on the right button the value, digit or element is activated. Short presses on the right button change the value. A long press on the right button exits the value selection. Every change is immediate, i.e. as the value is changed it takes effect immediately.



After the UTC Time, Elevation and or the Pressure was changed, the device will not predict accurately the pressure tendency. Wait at least 3 h to get reliable predictions.

Changing the settings is somewhat cumbersome; however, the settings need to be adjusted only once and in future software releases the possibility to change the settings using a mobile app is considered.

8 Troubleshooting

Below is a list of possible problems the mBarograph could run into and what actions to take to resolve the problems. How to execute the solutions is described below the table.

er100 is shown for a prolonged time.	Restart the device.
The mBarograph either malfunctions or does not function at all after being switched on for the first time with USB type-C cable connected.	Restart the device.
The mBarograph does not turn on without the USB Type-C cable connected.	Replace the battery.
The Barograph only lasts a few hours before the battery needs to be recharged.	Replace the battery.
The mBarograph freezes.	Restart the device.
After restarting the device (or turning on for the first time) the clock shows completely wrong time.	Replace backup battery.
During startup, the warning *REAL TIME CLOCK lost power, check the Backup Battery!* is shown.	Replace backup battery.

Restart the device To restart the device, disconnect the external power (USB Type-C cable) and remove the internal battery. Use pliers to disconnect the JST PH connector carefully. Wait a few seconds and reconnect the battery.

Replace battery Connect the mBarograph to external power (USB Type-C cable) to not lose any data. Use pliers to disconnect the JST PH connector carefully and remove the battery. Install and connect new battery to the device. **Dispose of the old battery in accordance with local laws and regulations! Do not dispose in trash!**

Replace backup battery While the mBarograph is powered either externally (USB Type-C cable) or internally (battery) remove the backup battery of CR1220 type. Install the new backup battery, only CR1220 type are allowed. **Dispose of the old battery in accordance with local laws and regulations! Do not dispose in trash!**

In case the above is not solving the issue contact support via e-mail at mBarograph@icloud.com clearly describing the faced problem.

9 Notes

This short section recalls some parts of relevance from *Guide to Instruments and Methods of Observation Volume I – Measurement of Meteorological Variables* WMO-No. 8, 2023 edition.

As per section *3.1.2 Units and scales* the basic unit for atmospheric pressure measurements is the pascal (Pa) (or newton per square metre, $\mathrm{N\,m^{-2}}$). It is accepted practice to add the prefix "hecto" to this unit when reporting pressure for meteorological purposes, making the hectopascal (hPa), equal to 100 Pa, the preferred terminology. This is largely because one hectopascal equals one millibar (mbar), the formerly used unit.

For reference following conversion factors apply:

1 hPa	=	0.750 062 mmHg
1 mmHg	=	1.333 224 hPa
1 hPa	=	0.029 530 inHg
1 inHg	=	33.8639 hPa
1 mmHg	=	0.039 370 08 inHg

In analogy to section *3.11.2 Low-level stations* for low-level stations (namely, those at a height of less than 50 m above mean sea level), pressure should be corrected to mean sea level. This is done by multiplying the measured pressure with

$$1 + H_p \frac{g}{R\,T_0}$$

to obtain the pressure at mean sea level. Where in the above equation H_p station elevation in m, $g = 9.80665$ standard acceleration of gravity $\mathrm{m\,s^{-2}}$, $R = 287.05$ gas constant of dry air $\mathrm{J\,kg^{-1}\,K^{-1}}$ and as a general value (and thus not location and condition specific) $T_0 = 288.16$ average sea level standard temperature K.

10 Acknowledgements and Inspiration

The development of the mBarograph was inspired by and draws upon concepts found in several existing electronic barographs, in particular the Meteograf (https://www.p-raeber.ch/Barograph_E/barograph.html), the Vetus Baroscope (also marketed as the Meteo Liner), and the BG1512 (http://www.bohlken.net/bg/bg1512_en.htm). The objective was to study the strengths and characteristics of these instruments and combine their most useful features into a single device.

Special thanks are due to Arduino (https://www.arduino.cc) for providing a robust and accessible hardware and software ecosystem upon which the project could be built. Appreciation is also extended to Adafruit (https://www.adafruit.com) for their extensive range of electronic components and high-quality open-source libraries, Waveshare (https://www.waveshare.com) for their E-Paper display libraries and documentation, SEGGER (https://www.segger.com) for their excellent J-Link debug probes and software tools, and Nordic Semiconductor (https://www.nordicsemi.com) for providing comprehensive documentation and development resources for the nRF52840 platform that forms the core of the mBarograph.

The electronic and mechanical design of the mBarograph, including the PCB and housing, was developed using Autodesk Fusion (https://www.autodesk.com/products/fusion-360/).

The author would also like to thank the broader open-source hardware and software community, whose shared knowledge and contributions have made projects such as the mBarograph possible.