Master Clock ESP32

User Manual – v3.0

BEL.4567.CZ

1. First Start and WiFi Setup

On first power-up (or if no WiFi network is stored), the device automatically starts in Access Point mode. It creates its own WiFi network named Master-Clock. The LED blinks rapidly.

Step	Procedure
1	Connect your smartphone or computer to the WiFi network Master-Clock (no password required).
2	A captive portal opens automatically. If not, open a browser and navigate to 192.168.4.1
3	Select your WiFi network from the list (clicking fills in the SSID). Enter the password.
4	Optionally change the secret settings path and the device network name.
5	Click SAVE & CONNECT. The device restarts and connects to your WiFi.

If no networks appear, click the Refresh button to trigger a new scan without restarting the device.

Note down your secret path – without it you cannot access the settings. It can contain accented characters (e.g. /my-czech-path). Reset is possible via serial monitor command AP, or by double power cycling (see chapter 8).

2. Web Interface

After connecting to WiFi, the interface is available at the ESP32 IP address or via mDNS name. The IP address is printed to the serial monitor on startup.

Address	Description
http://master-clock.local/	Home page – displays current NTP time and clock status.
http://master-clock.local/ [secret path]	Settings and controls. The mDNS name is configurable in settings.
http://[IP address]/	Fallback access via assigned IP – if mDNS is not working.

mDNS (.local addresses) works natively on Windows 10+, macOS, and Linux. On older Windows, install Bonjour from Apple.

3. Home Page

The home page displays the current NTP-synchronised time, the clock hands position (dial time), and a status indicator. The NTP time updates every second directly in the browser without contacting the ESP32. Status information refreshes approximately once per second.

Status Indicator

Status	Colour	When it occurs
SYNCHRONIZED	green	Dial matches NTP time, waiting for the next minute.
CATCHING UP (-N min)	blue	Clock is behind, rapidly sending pulses. Shows remaining gap.
WAITING TO SYNC (+N min)	grey	Clock is ahead, waiting for real time to catch up.
RUNNING – waiting for NTP	grey	Running but NTP sync has not yet completed after startup.
STOP	orange	Automatic pulses are paused.
SETUP REQUIRED	red	Hand position not set. Enter the time using SET.

The Last sync field turns red and bold if NTP synchronisation has not occurred for more than 2x the configured interval.

LED Indicator (on-board LED)

Pattern	Status
Rapid blinking	Access Point mode – waiting for WiFi configuration.
Slow blinking	Connecting to WiFi after startup.
Brief flash	Normal operation – each flash = one pulse sent to the clock mechanism.
2x blink + pause	NTP synchronisation problem (no sync for more than 2x the interval).
3x blink + pause	Clock is running but hand position has not been set.
5x blink + pause	Flash memory write error (NVS).

4. Clock Controls

Setting Hand Position

Enter the time currently shown by the clock hands into the Set clock hands field and click SET. This tells the system where the hands physically are. The change takes effect immediately without a restart.

Button	Function
START	Starts automatic minute pulse generation. Only active if hand position has been set.
STOP	Pauses automatic pulses. Hand position is preserved.
SET	Saves the entered time as the current hand position. Immediate effect, no restart needed.

Manual Step – STOP mode only

Button	Function
+ Pulse	Sends one positive pulse (RPWM / GPIO16 HIGH). Dial display turns red.
- Pulse	Sends one negative pulse (LPWM / GPIO17 HIGH). Dial display turns green.
Auto	Sends a pulse according to the polarity setting – correct alternation for the electromagnetic mechanism.

5. Output Pins

Pin	Description
GPIO16 (RPWM)	Positive pulse – active HIGH for the pulse duration.
GPIO17 (LPWM)	Negative pulse – active HIGH for the pulse duration.
GPIO18 (RPWM_INV)	Positive pulse inverted – active LOW (for relay modules triggered by ground).
GPIO19 (LPWM_INV)	Negative pulse inverted – active LOW.
GPIO12 (BELL)	Bell output – active HIGH for the configured duration.
GPIO13 (BELL_INV)	Bell output inverted – active LOW.
GPIO2 (LED)	Status LED – normally off, briefly lights on each pulse.

Idle state: RPWM / LPWM / BELL = LOW, RPWM_INV / LPWM_INV / BELL_INV = HIGH. Safe for both output module types.

6. Settings

NTP – Time Synchronisation

Parameter	Description
NTP Server	Time server address. Default: pool.ntp.org. Empty field is automatically filled with the default.
Time zone	UTC offset from -12 to +14. Example for CET: UTC+1.
Summer / Winter time	Automatic DST switching. Enable for regions that observe daylight saving time.
Sync interval (min)	How often the clock synchronises with NTP. Default: 30 min.

Parameter	Description
	Empty or 0 is automatically set to 30.

Pulse Parameters

Parameter	Description
Pulse (ms)	Duration of the electrical pulse. Default: 1200 ms. Empty or 0 is automatically filled. Too short a pulse will not advance the hand.
Gap (ms)	Pause after each pulse before sending the next one (during catch-up). Default: 1000 ms. Empty or 0 is automatically filled.

Pulse Polarity

Determines the pulse direction for each minute. Electromagnetic mechanisms require alternating polarity.

Option	Description
Store (alternating, remembered)	Polarity alternates after each pulse and is saved to Flash. Suitable for stand-alone clocks.
Pulse to even minute = positive (RPWM)	Polarity is always derived from the current dial time. The pulse that advances the hand to an even minute is always positive. Does not depend on Flash.
Pulse to even minute = negative (LPWM)	Same logic, opposite phase. For mechanisms with reversed polarity.

Options 2 and 3 are ideal for multi-clock systems – all clocks will always have the same polarity for a given minute, even after a power failure.

Position Backup and Power Failure Alert

Parameter	Description
Save hand position	After each minute pulse, saves the position to Flash. After a power failure the clock automatically catches up to current time.
Failure threshold (min)	Sends an email if a gap of >= the set number of minutes is detected after startup. Value 0 = always send.

Email Alerts

Parameter	Description
SMTP server	Outgoing mail server address. Example: smtp.gmail.com
SMTP port	Server port. Common values: 465 (SSL), 587 (TLS). Default: 465.
Login email	Sender account address.
Password / App pwd	Password or app password (recommended for Gmail). Empty = keep current.
Recipient	Address to receive power failure or setup-required notifications.

WiFi and Access

Parameter	Description
WiFi SSID	WiFi network name. Empty password = keep current.
Secret path	URL path to the settings page. Default: /settings. Recommended to change to something hard to guess.
Network name	Device hostname – available as name.local and visible in the router. Default: master-clock-XXXX.

7. Bell Schedule

The bell schedule is accessible via the Bell schedule link in the settings menu. There are 30 independent entries. The bell output is on GPIO12 (active HIGH) and GPIO13 (active LOW for relay modules).

Column	Description
Mon – Sun	Check the days of the week on which the entry should be active.
Time	Hour and minute of activation.
Duration (s)	Bell duration in seconds. Value 0 = entry is disabled.

> *IMPORTANT: The bell schedule is governed by internet time (NTP), not by the time shown on the physical clock hands (dial). The bell will ring at the correct time even if the clock is catching up or running ahead.*
>
> *Each entry is independent – different days and times can be freely combined. For example: Monday–Friday at 08:00 for 10 seconds and at 12:00 for 30 seconds.*

Manual Alarm

Above the schedule table there is a panel for manually triggering a repeating alarm – for example as an alert or a test ring.

Control	Description
Tone (s)	How long the output is active in each cycle.
Pause (s)	How long the silence lasts between tones.
🔔 **ALARM**	Starts the cyclic repeating alarm. Button turns red. A red ALARM banner appears on both the home page and settings page.
■ **STOP**	Stops the running alarm.

> *The alarm cycles continuously (tone → pause → tone → ...) until stopped with the STOP button or the STOP command in the serial monitor. Tone and pause settings are saved together with the SAVE BELL SCHEDULE button.*
>
> *The alarm cannot be started if an automatic bell schedule entry is currently active.*

8. Device Reset – Restoring Access

If you have forgotten the secret path or want to change the WiFi network, there are three ways to restore access.

Option 1: Double power cycle (recommended, no cable needed)

Disconnect and reconnect power twice in quick succession – the second connection must occur within 3 seconds of the first. The ESP32 detects the double restart, clears the stored WiFi, resets the secret path to /settings, and enters AP mode.

Step	Procedure
1	Disconnect power from the ESP32.
2	Reconnect power.
3	Within 3 seconds, disconnect and reconnect power again.
4	LED starts blinking rapidly – the device is in AP mode.
5	Connect to the Master-Clock WiFi network and complete the setup.

> *On every normal startup there is a brief 3-second pause while the ESP32 waits to see if a second restart is coming. It then continues normally.*

Option 2: Serial monitor (USB cable required)

Open the serial monitor (baud rate 115200) and enter one of the following commands:

Command	Function
STATUS	Prints current status: IP, mDNS, WiFi, NTP, dial state, backup, email.
RESET	Resets the secret path back to /settings. Takes effect after the next restart. WiFi credentials are kept.
AP	Clears stored WiFi and restarts into AP mode. Use to change the WiFi network.
ALARM	Starts the repeating alarm (tone and pause as configured on the bell schedule page).
STOP	Stops the running alarm.

Option 3: Direct IP access

If you know the ESP32 IP address (visible in the router or in the serial monitor after startup), you can access it directly via http://[IP address]/[secret path] even without working mDNS.

9. Troubleshooting

Problem	Solution
Clock does not connect to WiFi	Check SSID and password. Use the AP serial command or double power cycle to re-run WiFi setup.
Forgot the secret path	Use the double power cycle (within 3 seconds) – the path resets to /settings and WiFi is cleared. Or connect USB and send the RESET command via serial monitor.
No networks shown in AP portal	Click the Refresh button to trigger a new scan without restarting the device.
Hands do not advance	Check the Pulse (ms) value – try increasing to 1500 ms. Verify output wiring.
Time does not synchronise	Check NTP server and internet connection. Click the time display on the home page to trigger an immediate sync.
Last sync field is red	NTP sync has not occurred for more than 2x the configured interval. Check network and NTP server.
No email received	Verify SMTP settings. For Gmail use an app password and port 465.
Wrong time after power failure	Start the clock (START) – it will automatically catch up. If backup was disabled, enter the current hand position manually via SET.
Bell does not ring	Check that the correct time and day are set. The bell uses NTP time, not the dial time. Make sure duration is not 0.
Alarm cannot be stopped	Send the STOP command via serial monitor or click the ■ STOP button on the bell schedule page.
LED blinks 5x repeatedly	Flash memory write error. Position backup is not working. Try restarting the device.