User's Manual for the Automated Heart Frequency Logger, V2.32, 13 Mar 2025

System Overview

The Automated Heart Frequency Logger is designed for non-invasive cardiac activity monitoring of hard-shelled invertebrates, such as mollusks and crustaceans, through photoplethysmography - PPG (Figure 1). It records heartbeats using infrared (IR) sensors and stores data automatically for subsequent analysis using the R package `heartbeatr`.

Figure 1: Front panel view showing amplification knobs and control buttons.

Components

- **Main Unit:**
  - IP64 waterproof enclosure.
  - Ten independent channels with individually adjustable amplification.
  - LCD screen for monitoring signals in real-time.
- IR sensors (Vishay CNY70 or equivalent).
- MicroSD card slot for data storage.
- WiFi connectivity for remote data access and configuration.

Quick Setup Guide

1. Connect the provided 12 V DC power supply to the red socket on the logger.
2. Connect up to ten IR sensors to the blue sensor sockets.
3. Attach sensors to the organism's shell directly over the heart using cyanoacrylate glue (Figure 2).

4. Turn on the system by pressing the green power button.
5. Select and view different channels using the Forward and Back buttons.
6. Adjust amplification knobs (numbered 1–10) to optimize signal amplification and clarity.
7. Access recorded data via MicroSD card or via WiFi FTP.

Figure 2: IR CNY70 sensor glued on a mussel with cyanoacrylate (superglue).

Operation Instructions

Turning the Logger ON/OFF

- Press the green Power button to turn ON. The button's LED indicator will light up (Figure 3).
- Press the same button to turn OFF.

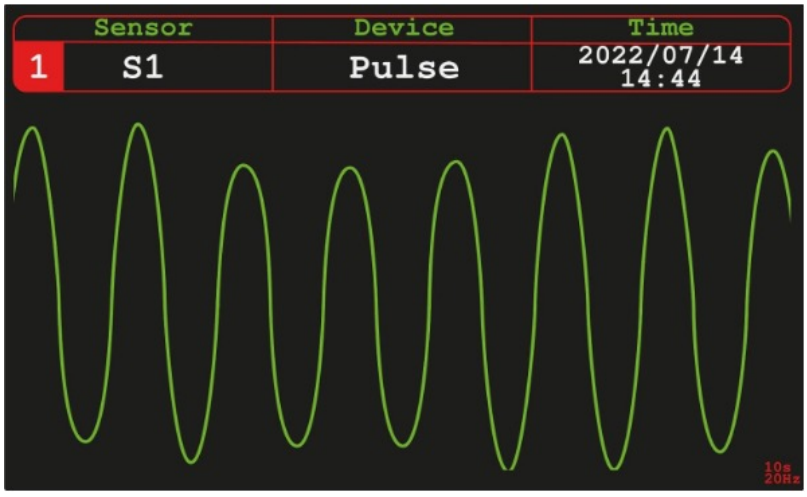

Figure 3: Example of IR sensor signal display on the LCD.

Channel Selection

- Forward and Back buttons allow scrolling through sensor channels.
- Press both buttons simultaneously to toggle Auto-scroll through channels.

Adjusting Signal Amplification

- Rotate front knobs to adjust the signal amplification for each individual channel:
  - **Insufficient amplification:** weak or undetectable heartbeats.
  - **Excessive amplification:** distorted or clipped signals.

Recording Modes

Configured via `settings.txt` on the MicroSD:

- **Continuous Mode:**
  - Logs data continuously into hourly CSV files.
- **Session Mode:**
  - Alternate between data recording (`Record`) and rest (`Sleep`).
  - Data is stored in individual CSV files per session.

Pausing Recording

- Press the Pause button to temporarily halt recording without losing data already recorded.
- Resume by pressing the Pause button again.
- Note: no data is recorded while in Pause!

Remote Access Mode (WiFi)

Connecting to the device

- Install Filezilla from `https://filezilla-project.org`.
- Press and hold the Back button for 5 seconds to activate the Remote Access Mode (Figure 4).
- Connect via FTP using an FTP client (e.g., FileZilla).
- If no external WiFi is configured, the logger creates its own network (`Pulse_EB`, IP: `10.10.10.10`).

FTP Setup (Using FileZilla)

- Open FileZilla and create a new FTP connection:
  - Host: Logger's IP address (displayed in Remote Access Mode).
  - User/Password: both set as `Pulse_EB`.
  - Encryption: **Use plain FTP (insecure)**.
  - Limit simultaneous connections.
- Access, edit, or download files directly.

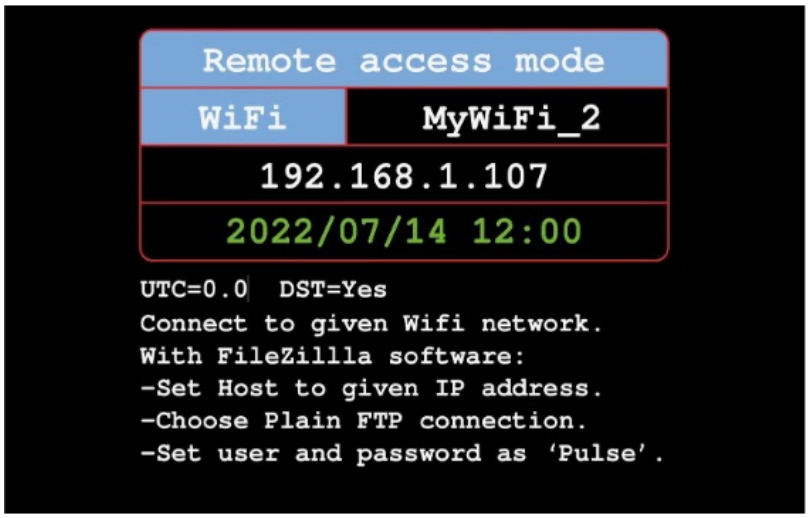

Figure 4: Remote access mode display showing WiFi network status and IP address.

Settings Configuration (`settings.txt`)

Modify settings directly via FTP or MicroSD:

- `Device_name`: Logger identifier (max. 12 characters).
- `Rate_Hz`: Sensor sampling rate (5–25 Hz, recommended 20 Hz).
- `Sessions`: Yes (session-based logging) or No (continuous).
- `Wifi` and `Wifi_pass`: Network credentials.
- `Local_time_zone`: UTC offset (-12 to +12).
- `DST`: Enable Daylight Saving Time adjustment (Yes/No).
- `Display_duration`: Display window length (5–60 sec).
- `Record` and `Sleep`: Define session length and pause duration.
- Sensor labels (`S1`–`S10`): Custom sensor names.
- Press and hold the Forward button for 5 seconds to activate the Settings Display Mode (Figure 5).

Sensor Attachment Guidelines

Placement and Attachment

- Position the sensor directly over the animal's heart:
- Clean and dry attachment surface.
- Test several positions for optimal signal.
- Use a thin layer of liquid cyanoacrylate glue.
- Depending on the species, wait 5–30 min after attaching each sensor to allow for signal stabilization.

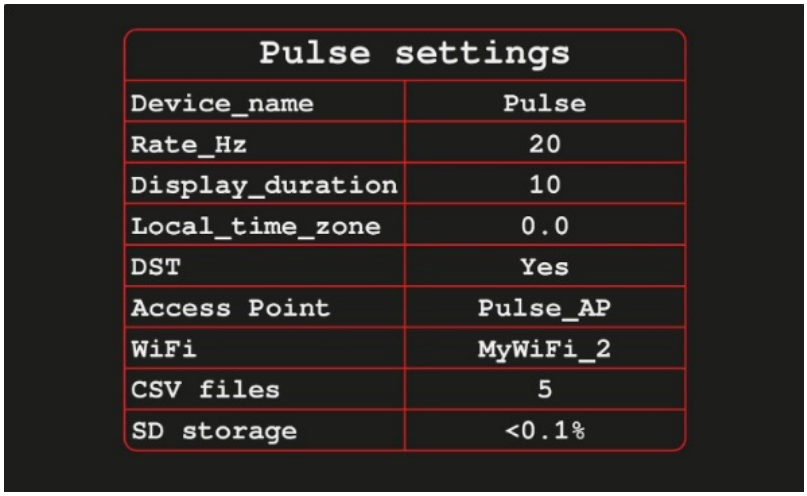

Figure 5: Settings display mode.

Testing Signal Quality

- Place a sensor gently between the index and middle fingers, touching the thumb, to confirm proper operation through detection of operator´s heartbeat.

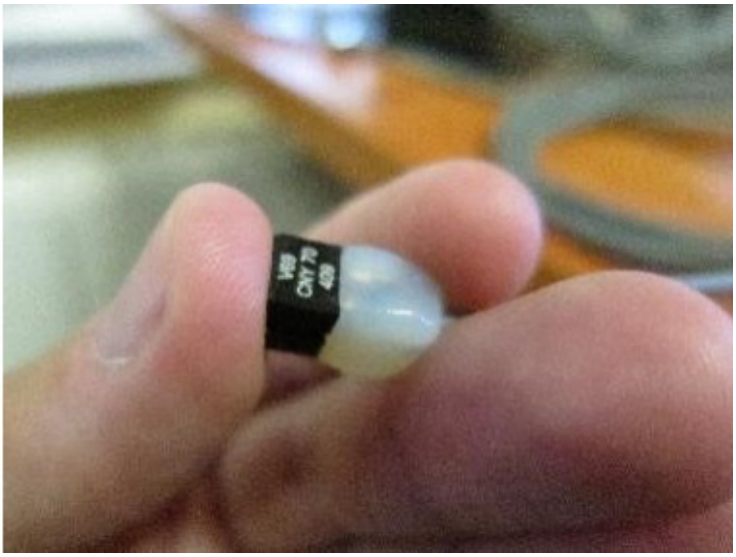

Figure 6: Quick signal check using a human finger.

Data Access and Analysis

Data Structure

- Recorded as CSV with hourly/session intervals.
- Files named: `YYYMMDD_HHMMSS.CSV`.

Data Content

Each file contains: - Device and sensor identifiers. - Timestamps with millisecond precision. - Raw IR sensor readings.

Data Processing

Use the associated `heartbeatr` R package for automated data analysis: - Noise reduction. - Peak detection. - Heartbeat frequency estimation and classification. - Post-processing and data normalization.

Firmware Updates

Regular updates ensure optimal functionality. To do so: - Download the latest firmware from the support website (`update.bin`). - Then, Update can either be done through the microSD card or WiFi

Update through the microSD card

- save the `update.bin` in a microSD card.
- insert the microSD card in the device.
- reboot. the firmware will be updated automatically.

Update through WiFi

- Enter Remote Access Mode (described above).
- In your browser, open the firmware upload page served by the device (`http://Device.IP/update`).
- Select and upload the firmware file.

Maintenance and Sensor Care

- Regularly clean sensors between uses.
- Light sanding removes glue remnants from sensor heads (maintain IR transparency).
- Sensors can be re-glued multiple times if well-maintained.

Troubleshooting

Issue	Action
Poor signal	Adjust amplification; reposition sensor
WiFi connection failure	Verify settings; ensure correct IP
MicroSD undetected	Re-insert card; restart system
No signal or erratic readings	Check sensor placement, amplification
Sunlight interference	Shield sensors from direct sunlight

Technical Specifications

Parameter	Specification
Channels	10 independent IR channels
Connectivity	WiFi (Bluetooth in development)
Amplification	Adjustable per channel
Storage	MicroSD (32 GB max recommended)
Sampling Rate	5–25 Hz (Default: 20 Hz)
Dimensions	160 x 100.6 x 133.6 mm
Operational Temp.	-10°C to +60°C
Waterproof Rating	IP64

Support

For further support and technical questions, contact the research team at our institutional email.