

Installation and operation manual for COHIRADIA

Version RFCorder_v2.0

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This documentation is accompanied by a supporting video tutorial, also available at radiomuseum.org

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1 SYNOPSIS

COHIRADIA is an acronym for **CON**servation of **H**istorical **RA**diofrequency bands by **D**igital **A**rchiving.

The goal of the project is to give interested radio enthusiasts and collectors the opportunity to play back original radio signals that were recorded in the past, on historical radio receivers. These signals do not just represent a single station (which could be easily achieved just by modulating a carrier with a simple signal generator), but an entire frequency band with all the radio stations contained therein on the original carrier frequencies existing at the time of recording. The archive of the author contains more than 20 hours of recordings from the years 2006 - 2009 as well as new recordings starting from 2021 on long, medium and short wave up to 40 MHz. Until 2009 the antenna signals were recorded in analog form on a video recorder and digitized with a Software Defined Radio (SDR, STEMLAB125-14) from RedPitaya with 14 bit resolution in 2021. From 2021 on the author has made all records exclusively by direct digitalization with the SDR.

Any person who also possesses a STEMLAB125-14 can now play back the data after downloading them from radiomuseum.org. The small single-board computer can be purchased from several Internet platforms, currently for about 400 euros. The necessary hardware and software as well as all installation steps are described in this document. A first version of a reasonably user-friendly software for playback is available under Windows10 as well as an updated version of a combined program for playback and recording. The author has written the sources in Python and plans to publish them as an open source project on GITHub in the near future. This would make it possible to port it to LINUX as well.

Detailed information in context to this manual can be found in the video tutorials included in the respective installation packages. The first two packages contain the simple player and the combined player/recorder. The functionality of the apps will be extended in future updates, but the basic installation procedure will remain the same. So, if you want to try COHIRADIA for the first time, it is always recommended to watch the basic tutorials

COHIRADIA_Installation_Guide_part1_playback.mp4

This movie is unfortunately not yet updated and refers from minute 11 to the previous version Cohiradia_RFCorder_v1.2.exe. A new video tutorial is planned, but not yet finished due to time constraints.

However, until minute 11 (configuration of the STEMLAB) all information is still valid also for newer software versions.

So it is still recommended to watch the videotutorial if you want to try COHIRADIA for the first time.

2 REQUIRED HARDWARE

(1) RedPitaya STEMLAB125-14 Starter Kit consisting of:

- STEMLAB125-14 Main board
- STEMLAB power supply
- LAN-cable
- SD-card with typ. 16GB and operating system pre-configured

(2) Optional: Case (acrylic or metal) for the main board

(3) AM-Radio with external connectros for ‚antenna‘ and ‚earth ground‘

(4) coaxial cable for coupling between the SMA output of the STEMLAB and an RF transformer (e.g. a 1:9 balun), optionally adapters from SMA to BNC are required, depending on the cable type used.

(5) PC with sufficient disk space for the data files.

(6) isolating RF transformer (e.g. a balun) with suitable turns ratio from the 50Ω output of the STEMLAB to the radio. Usually an impedance transformation 1:9 to 1:16 (turns ratio 1:3 or 1:4) works for typical tube devices. In principle any balun suitable for the frequency range can be used, if primary and secondary are completely isolated (no common ground !). The author uses in his video tutorial a pot core transformer with turns ratio 1:4 with an inductance of $64\mu\text{H}$ on the low impedance side and ca. 1 mH inductance on the high impedance side (radio receiver). The following transformers were successfully used by other RM members:

(a) toroid FT240/77, primary 10 turns , secondary 30 turns with a 0.5mm enameled copper wire. This was tested by Franz Wolf with an amplitude modulated signal generator RF1 from HEATHKIT and a CD player on a LOEWE Opta-Kantate, the result was rated by him as very satisfactory.

(b) Gerald Gauert reports successful playback from STEMLAB via a ferrite toroid, primary $65\mu\text{H}$, secondary 1.3mH. However, he reproduced on a *Stafurter Mikrohet* built in 1928, which has a loop antenna. So the coupling is done from the transformer to a second loop antenna for inductive coupling. Therefore, it is still unclear whether the transformer is optimal for this mode of operation.

Gerald Gauert also reports that in several old devices the antenna contributes significantly to the resonator capacitance and thus the mere coupling of the STEMLAB via a balun may cause unwanted damping and frequency shifts of the tuning circuit. Significant signal perturbations may also result. These findings could be confirmed by the author with an *Atwaterkent10* from 1924. In such cases it is recommended to place a series of a 220pF capacitor and a $2.2\text{k}\Omega$ resistor between the balun output and the antenna input of the radio. This measure usually can fix the problem.

3 INSTALLATION OF THE SERVER SOFTWARE ON THE STEMLAB125-14

Normally, an SD card with the operating system (Ubuntu) is included when purchasing a STEMLAB125-14. This card must be inserted into the SD card slot of the STEMLAB. If you don't have this SD card, you have to create one yourself, the instructions for writing the respective image to an empty SD-card as well as the a downloadable image file can be found at:

<https://redpitaya.readthedocs.io/en/latest/quickStart/SDcard/SDcard.html>.

Afterwards that you can connect the STEMLAB to the internet and call an installation script kindly created by Ueli Kurmann. The connection can be established either by Ethernet cable or by WLAN dongle via a common WLAN router. Then the following steps have to be taken:

- (1) Start a web browser (e.g. Mozilla Firefox) on the PC. On the web browser, enter `http://rp-#####.local` in the address field, where ##### stands for the MAC address (e.g. `rp-f03e17.local`). The MAC address is printed on the Ethernet connector of each STEMLAB.



- (2) Wait for the STEMLAB apps to be loaded in the web browser (this can take a while). The view should resemble the adjacent figure.



- (3) Afterwards click the icon „System“ and then open the App „Network Manager“ which allows for reading off the IP address assigned to the STEMLAB by the WLAN router.



- (4) Open a command line terminal in Windows and login to the STEMLAB per ssh with the IP-adress assigned by the WLAN router. Username and Password are ‚root‘ and ‚root‘, respectively (Port = port22). Typical command:

```
ssh root@###.###.###.###, Password: root
```

###.###.###.### is the IP-adress.

- (5) After the response of UBUNTU with a command line prompt, you should perform a system update with `apt update` and then a package installation with `apt upgrade`. This update is strongly recommended because otherwise the installation script by Ueli Kurmann may not run correctly. This step needs only be done once at the first startup.

- (6) Enter the following command in a single line after the command prompt:

```
curl --silent --cookie "SCHLUESSEL=1"
https://cohiradia.radiomuseum.org/install.sh |bash
```

This will cause STEMLAB to run the installation script and create a directory with the necessary shell scripts, the server program, and the bit file for the FPGA. Now the system is ready for use in the context of COHIRADIA.

(7) After successful installation please shut down the STEMLAB properly with the command:

```
halt
```

When the terminal reports that the connection has been closed (this takes some time) and when the red flashing LED on the STEMLAB (th 'heartbeat') stops flashing the power supply can be disconnected.

Afterwards the system is ready for use in the context of COHIRADIA.

4 INSTALLATION OF THE APPS FOR PLAYBACK AND RECORDING OF RADIOFREQUENCY BAND DATA

So far there have been available two older versions of software for the PC under Windows10, i.e. ,cohiradia_v1.1 '.zip and ,cohiradia_v1.2 '.zip.

This manual refers only to the extended version 2.0 of the pure playback software (originally v1.1) and the author recommends to use only this version for playback.

- (1) Download the ZIP file, here ' RfCorder_v2_0.zip' from the Radiomuseum and unpack it into a directory on your PC, for which you have all access rights.
- (2) Extract the file to a local directory (I call it ~\LOCAL). Here the files
 - The app Cohiradia_RfCorder_v2_0.exe
 - the RfCorder_v2_user_manual.pdf
 - the videotutorial for the basic installation
 - config_wizard.yaml
 - templatewavheader.wav
 - and all icons as png-files.

All these files must be present for the program to work.

There is not yet a version available for LINUX, but the author plans to publish the underlying Code in the framework of an open source project on GitHub.

- (3) Now a desired AM broadband data file must be downloaded from the radio museum and saved. It is recommended to save this file in the same directory ~\LOCAL as well, because then it can be found most conveniently from the playback app (default search path).

5 ASSEMBLY OF THE HARDWARE

- (1) Disconnect the STEMLAB from the router and connect it directly to the LAN socket of the PC via the LAN cable. **)
- (2) Connect SMA output jack 'OUT1' to the low impedance side of the RF isolation transformer/balun via a 50Ω coaxial cable.
- (3) Connect the antenna input of the AM radio to the high-impedance side of the RF isolation transformer/balun.
- (4) Connect the power supply of the STEMLAB to the micro USB port for 'Power'. Alternatively, the STEMLAB can be powered directly from a USB port of the PC using a suitable micro USB cable.

For additional help see also the first 11 minutes of the video tutorial.

COHIRADIA_Installationsanleitung_Teil1_Wiedergabe.mp4

**) According to the manufacturer, a WLAN connection can also be set up as an alternative to the LAN cable if a WLAN dongle has been purchased. However, the author has not yet tried out this option.

As a second alternative, the STEMLAB can probably remain connected to the WLAN router, but then the IP address assigned by the router would have to be used. This mode is probably rarely used in practice, since the radio receiver is probably not located right next to the router. Also this mode has not been tested by the author.

6 PLAYBACK OF WIDEBAND RECORDINGS WITH THE RADIO RECEIVER

6.1 SETUP OF THE SOFTWARE COHIRADIA_RFCORDER FOR PLAYBACK/RECORDING

- (1) Connect the RP power supply to the mains, RP starts up, wait until the yellow LED stops flickering and the 'Heartbeat' (red) LED flashes regularly;
- (2) When using a direct Ethernet connection via the LAN cable, deactivate the WLAN to be on the safe side, otherwise connection errors between STEMLAB and PC may occur. This is not always the case, but unfortunately the problem appears very often with the author's system.
- (3) Start a web browser (e.g. Mozilla Firefox) on the PC. On the web browser, enter

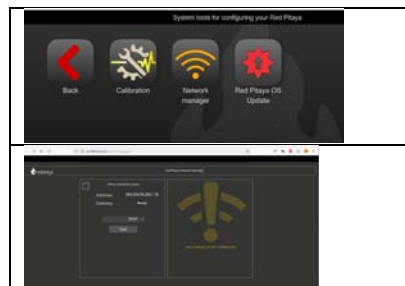
`http://rp-#####.local`

in the address field, where ##### stands for the MAC address (e.g. rp-f03e17.local). The MAC address is printed on the Ethernet connector of each STEMLAB.

- (4) Wait for the STEMLAB apps to load in the web browser (this can sometimes take a while). The view should be something like in the adjacent figure.



- (5) Then click the "System" icon, call up the "Network Manager" app there and read out the **STATIC** IP address there. This address should be different from the one assigned by the router in chapter 3 and is required for operation with the COHIRADIA app. Normally these addresses start with 169.254..... Should the app still show the address assigned by the router, enter a new STATIC address of your own choice. The fields 'Subnet mask' and 'DNS server' can be left empty.



- (6) Start the app Cohiradia_RFcorder_v1.1b.exe from the ~\LOCAL directory. The first time you do this, you will immediately be prompted to enter the correct IP address from step (5). Activating the button 'Set IP Address' allows to enter the IP address in the field above. Afterwards just press 'Save IP-Address'. The address remains stored for further calls in the configuration file 'config_SLsettings.txt'.

It may happen that the program is blocked by your virus scanner at the first call, then you have to authorize it as trustworthy.

6.2 OPERATION OF THE APP

6.2.1 Tab Player

The program is started by double-clicking onto the file symbol RFCorder_2_0.exe. After some startup time the tab 'player' is displayed.

With this tab, you can play back recordings the same way as with the old RFCorder (v1.1, v1.2), but recording is currently not possible (will be available in a future release). The controls in the recorder field are self-explanatory (see fig. 6-1). New compared to RFCorder v1.2 are:

- (1) You can now play wav-files as well
- (2) You can now jump back and forth in the file with a scroll bar, so you can easily find different places in the recording.
- (3) The running time is displayed correctly, according to the original time during recording (UTC). Of course this only works with wav files, not with *.dat, as the corresponding information is stored in the wav-header of the files.
- (4) There is a logarithmic signal strength indicator, which should optimally stay somewhat below 0 dB. If the signal is too weak (bar turns yellow), you can amplify it within limits (logarithmically) with the 'Gain' control. If you turn up the gain too much, clipping and intermodulation distortion will occur during playback and the bar will turn red.
- (5) The play button is now a 'play/pause' button, like on SDRUno. (see fig. Fig. 6-2)
- (6) There is an endless play button (see fig. Fig. 6-2).

The controls for configuring the IP address of the STEMLAB are the same as for RFCorder.v1. At the beginning, the IP address of the STEMLAB must be entered at least once by clicking on 'Set STEMLAB IP Address', after which it remains stored until changed again.

Either by clicking on 'File open' or by pressing the 'Play' button you will be asked to select a file. At the same time, the file name is displayed below the scroll bar.

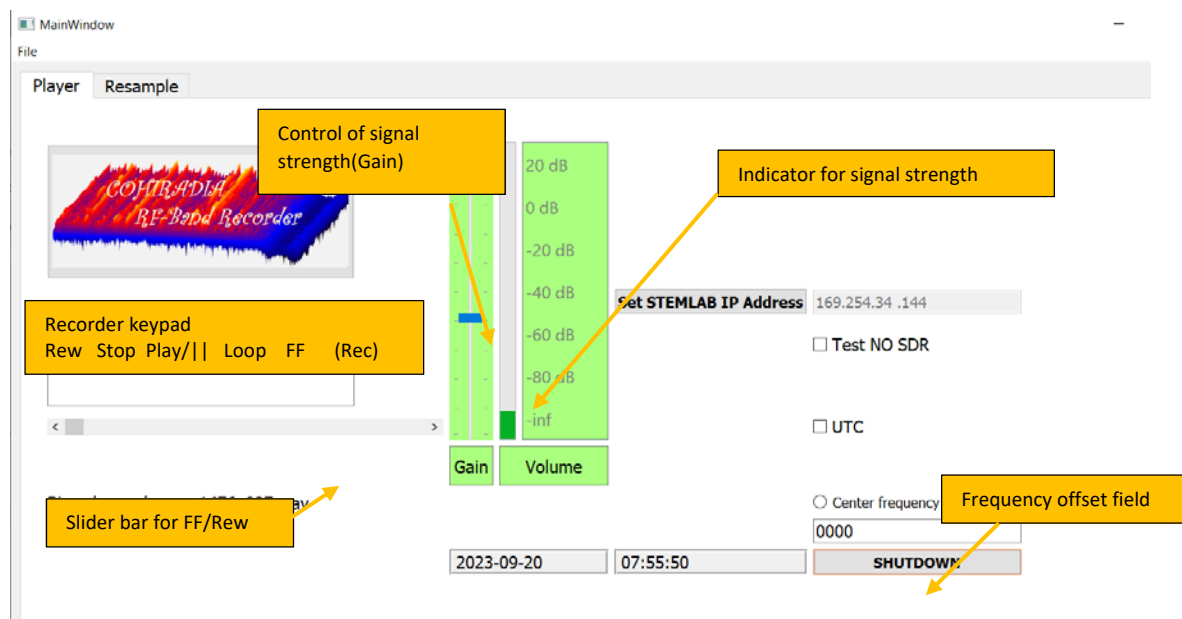


Fig. 6-1: Player: New Features vs RFCorder 1.2b

The Play button is now a 'Play/Pause' button. Each time it is pressed, it changes state between 'Play' and 'Pause' (see Fig. 6-3). The 'Play' key starts playback at the very beginning of the recording and the key turns to a 'Pause' key. At the same time, the playback time is displayed in the time display window located below the keypad. Now the radio signal is transmitted and the stations can be tuned through and listened to on the radio. Playback continues until the 'Stop' key is pressed. It can be paused at any time by pressing 'Pause' and resumed by pressing 'Play' again.

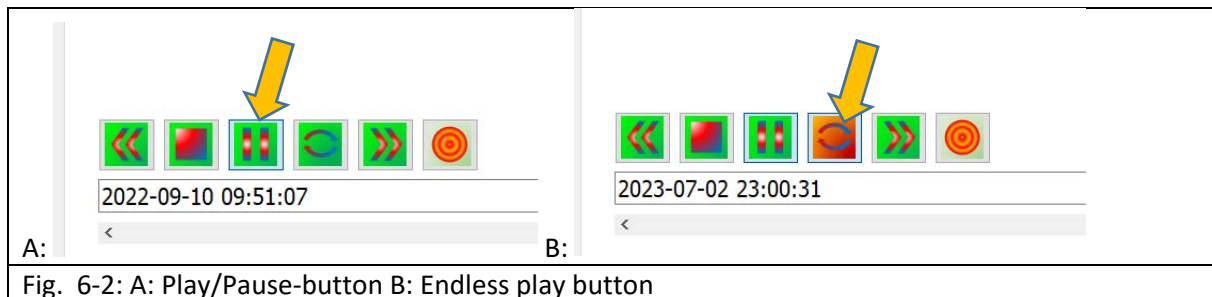


Fig. 6-2: A: Play/Pause-button B: Endless play button

The '>>' and '<<' buttons can be used to fast forward and rewind. For single clicks this is stepwise (currently 5s steps). If you hold down these keys **after double-clicking**, it will automatically fast-forward/fast-rewind as long as the key is held down. If you want to jump to a certain position in the recording, you can use the FF/Rew slider under the recorder keypad. To do this, keep the slider button pressed while advancing or rewinding.

If a recording in wav format was either originally made with SDRUno (SDRPlay) or the option with multiple wav files ('Download for SDRUno/SDR#' , see Fig. 6 3) was selected when downloading from the radio museum, these files are automatically played one after the other starting from the file selected during file-open. The playback stops after the last file. At the same time, the correct time at which the recording was running is displayed.

These options are not available when using the originally used dat format. It is therefore recommended to select the download option with multiple wav files under 'Download for SDRUno/SDR#' (fig. 6-3).

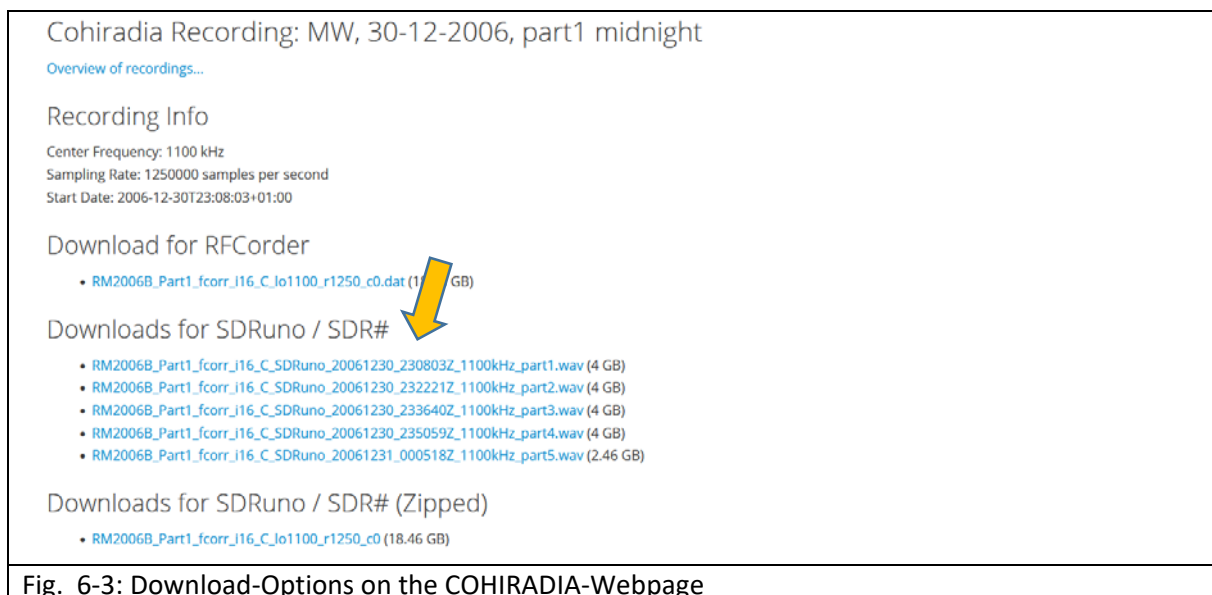


Fig. 6-3: Download-Options on the COHIRADIA-Webpage

For special purposes there are 3 more options in the right part of the app:

- (1) checkbox with 'UTC'. With this option you can change the timer and the displayed time to UTC, by default local time is used.
- (2) checkbox TEST NO SDR: If you activate this option, the software runs in a test mode, in which no STEMLAB must be connected. This mode is only for testing if the app runs on the PC and if the basic functions run properly. In this mode, there is no sound playback because no STEMLAB is connected.
- (3) radio button 'Center frequency offset': If you activate this button, you can set how much the playback center frequency is offset from the recording center frequency. This makes it possible to play a longwave recording in the center frequency band. Example: You have a LW recording with center frequency 180 kHz and set an offset of 1000kHz, then the band will be shifted up by 1000kHz, what was before e.g. on 153 kHz will now be played on 1153 kHz. This may be useful in special cases, e.g. a LW recording with center frequency 180 kHz could be played in the medium wave range of a radio. Compared to the old RFCorder, erroneous inputs are now intercepted. Activation of the offset is indicated by the input field under the radio button 'center frequency offset (kHz)' being highlighted in yellow.

If you want to end the program, it is recommended to perform a shutdown of the STEMLAB beforehand. Since the STEMLAB125-14 runs a LINUX operating system, the device should not be shut down simply by disconnecting the power supply, but should be shut down in a controlled manner. According to many Internet reports, the file system of Pavel Demin is write-protected, however, under unfavorable conditions, damage to the file system can allegedly occur. Such are observed very rarely (has not happened to the author yet), but better safe than sorry. Therefore the author recommends to always shutdown the LINUX by pressing the button 'SHUTDOWN' and to wait until the red 'Heartbeat'-LED on the STEMLAB stops blinking or the message about the successful logout is displayed as a popup message. After that you can exit the program via the closebox and disconnect the power supply plug of the STEMLAB.

6.2.2 Tab Resample

This tab is in an experimental stage and should still be used with caution. It has not yet been extensively tested and some planned features are not yet enabled.

IMPORTANT ! Absolute requirement: The freely available command line program 'sox' must also be installed on the PC. Sox can be downloaded for free at:

<https://sourceforge.net/projects/sox/files/sox/14.4.2/>. It is best to install sox in the installation directory of COHIWizard. Alternatively, the system path must be set to the installation directory of sox.

Fig. 6-4 shows the interface of the resampler after loading a file with 'open File'.

First the spectrum is displayed in the plot window, the current center frequency and the bandwidth are marked by the orange thread and the red rectangle. Outlined in blue you can see the fields for setting the new sampling rate.



Fig. 6-4: Surface of the Resampler

Standard application:

The most common application is probably to recode a recording if its sampling rate does not correspond to one of the values allowed for STEMLAB (e.g. RSP1a, long wave: SR = 150kHz). The default setting in the control panel 'target sampling rate' is then typically already correct by default. The center frequency is left as it is, and the sampling rate is set to the next higher rate. This increases the size of the file, but is necessary to be able to play the whole tape. If you then press Resample, the conversion procedure starts and creates the new file, which gets a new name containing the string 'resamp'. This file is also loaded automatically after the conversion and can be played immediately. The conversion takes some time, but of course it has to be done only once. Instead of the original file the new file has to be loaded in the future.

During the conversion, the file is automatically converted to 32bit COMPLEX, i.e. 16bit per sample. This means that originals with 24bit (e.g. Perseus) or 32bit can also be converted to COHIRADIA format. However, 24bit only works in the current version if the center frequency (target LO) is NOT changed