LILLA 2023 user guide

R2 – 01/2024

Since firmware and functions can be updated/upgraded, the last version of this guide can be read and downloaded from www.lillasampler.it.

Summary

1. Overview

LILLA is polyphonic, multitimbral, and multi-midi audio sampler.

LILLA plays either imported audio files, or recorded audio, or live audio stream (when used as *Live Sampler*) applying various playing mode, adding ADSR envelope, changing length and pitch, and using digital effects.

1.1. Connections

- USB-B **POWER** input: power supply, firmware update
- 3.5mm jack **MIDI IN**
- 3.5mm jack **MIDI THRU**
- 3.5mm jack **LINE IN:** dynamic microphones/line 2 channels input with analog gain (level) control
- 3.5mm jack **LINE OUT**: 3.3Vpp 2 channels audio output
- 3.5mm jack **MONITOR** (output): 3.3Vpp 2 channels audio output (only for Sounds check)
- **MICRO SD** socket
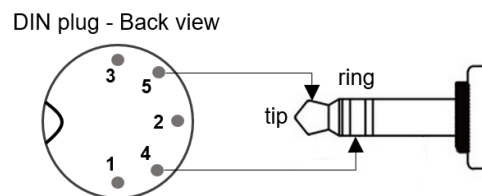
MIDI DIN to 3.5mm jack adapter schematics

1.2. Modes

Performance
Performance mode allows to play using Patches. A Patch is a group formed by 1 to 8 Sounds; each Sound is associated to an audio file, a MIDI channel, and includes all parameters that characterize the timbre.
Sampler
Sampler mode allows to record, save and export the incoming audio.
Live Sampler
LILLA can directly play the incoming audio stream, using a temporary/volatile memory as a virtual tape loop.

1.1. Line out and Monitor

The **LINE OUT** is the audio output.
The **MONITOR** output is intended as a help for Performance mode while playing; its purpose is checking a Sound before adding it to the Patch.

1.2. Audio files

LILLA supports CD audio quality (16bit/44.1Ksps) and uses .raw (headerless) mono audio files, that can be imported from micro SD card; imported audio files must have this format:
<0 → 255>.raw: **0.raw, 1.raw, …., 255.raw**.
Local recordings can also be exported to micro SD card with .raw format.

1.3. Micro SD card

Lilla uses a micro SD card FAT 32 formatted as a file source/repository (due to the relatively high latency of the access, there is no real time audio operation involving the micro SD card).

From **SD root**:
/LILLARAW is the folder containing .raw audio files to be imported in LILLA;
/LILLARAW_EXPORT is the folder containing .raw audio files exported from LILLA;
/LILLASET is the folder containing configuration files.

1.4.   Memory areas

LILLA stores digital audio in 3 memory areas: microcontroller RAM, 16MB PSRAM (volatile), and 64MB Flash memory (permanent):
.raw files (imported files, .raw-converted recordings) are stored in the Flash memory;
.rec files (Sampler recordings) are stored in the Flash memory;
live audio (Live Sampler stream) is temporary saved in PSRAM;
short audio snippets (used in Performance mode) are copied to and played from RAM.

1.5.   Polyphony

Playing audio from the Flash memory is much more time-consuming than playing from RAM or PSRAM, and high pitch-values require more data to be read than lower pitch-values: for these reasons, the number of the available voices depends on the type of memory read and the pitch required:
- playing from RAM and PSRAM, all 16 voices are available for any pitch value.
- playing from Flash memory, LILLA offers **4 optimization levels**:
    16 voices – max pitch 1.65
    12 voices – max pitch 3.0
    8 voices – max pitch 4.0
    4 voices – max pitch 10.0

1.6.   Voices assignment

When a NoteOn command is received, and also results associated to one or more Sounds, a process of voice/s assignment starts; this process takes into account the max polyphony allowed, the memory area involved, the state of all voices, the ageing of a "running" Sound, the "precedence" attribute of Sounds; that's why it can happened that a Sound is not played, or a Sound already running is replaced by a new one.

1.7.   Tuning tone

Click on **TUNING TONE** knob to switch on/off a sinus tuning-tone, activated by NoteOn commands (all MIDI channels are allowed); use the same knob to adjust the relative level.

1.8.   Display conventions

All adjustable (using knobs or pushbuttons) values are represented in YELLOW; fixed or not directly adjustable values are represented in WHITE; dimensions are represented in ORANGE. "S" is abbreviation for "samples".
Use **SELECT** knob for selecting items when a red or white frame is present, and click on **OK** to choose the item.

1.9.   Hardware

- Microcontroller: Teensy 4.1
- Audio A/D D/A interface: Teensy Audio Board 4.0 (16bit/44.1Ksps)
- Audio files memory: 64MB

1.10. Power Supply

5V DC 100mA

1.11. Dimensions

415 x 135 x 62 mm (LxPxH)

1.12. Contacts

LILLA Audio Sampler is designed and assembled in Italy by Sandro Grassia.

Website: www.lillasampler.it

Facebook: www.facebook.com/Lilla.audio.sampler

Email: info@lillasampler.it

2. Getting started
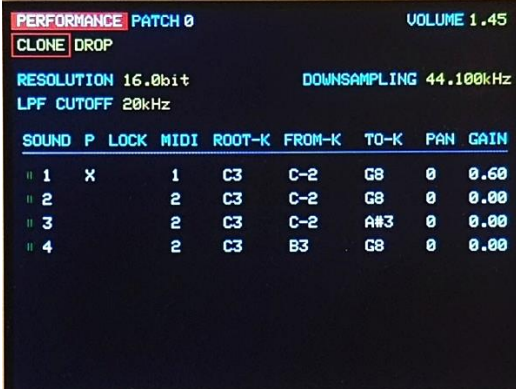
Connect LILLA to power supply, audio equipment and MIDI source:

1) connect **POWER** to your 5Vcc power supply unit;
2) connect stereo **LINE OUT** output to your audio mixer/amplifier input;
3) connect **MIDI IN** serial input to your MIDI source (a MIDI to jack adapter is included).

2.1. Getting started with Performance mode

At power on, LILLA starts in **Performance mode**.
The Performance page shows the first Patch available with its Sounds and their keyboard mapping (Root Key, From Key, To Key):

Performance page

To enter Performance mode, press **SHIFT** + **PERFORMANCE** buttons together.
Send NoteOn/NoteOff commands on MIDI channel associated to Sounds, and use **VOLUME** knob to adjust the volume.
Try **RESOLUTION**, **DOWNSAMPLING** and **LPF CUTOFF** knobs to introduce some distortion and filtering; click on the same knobs to reset the effect.

2.1.1. Sound editing - VCF

Press once **SOUND1** button; the display shows the Sound modeling page with Sound 1 characteristics:
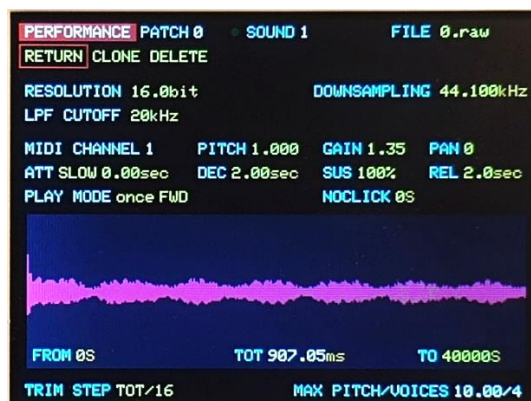
Sound modeling page

Use **GAIN** knob to adjust the Sound 1 level, **PITCH** knob to adjust the fine-pitch, **PAN** knob to change the stereo pan.

Use **FROM SAMPLE** and **TO SAMPLE** knobs for adjust the file segment played; use **TRIM STEP** knob to adjust the step length.

PLAY MODE knob allows to choose the reproduction mode among once forward, backward, loop forward, backward, and mixed loop forward/backward; for loop forward and loop backward Play modes, you can use **NO CLICK** knob to create a cross-mix area of first/last samples of the snippet.
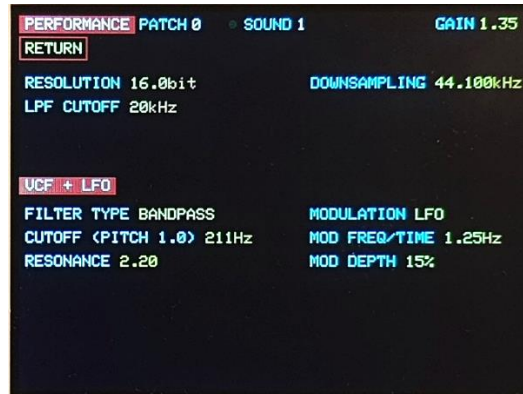
FILE knob is used to change the audio file.

Press a second time **SOUND1** button, or turn one of the encoders with `VCF` label; the display shows the VCF page associated to the Sound 1:

VCF page

Click on `VCF` **ON/OFF** to include/exclude VCF, use `VCF` **FILTER TYPE** knob to change type of filter, and `VCF` **CUTOFF FREQ** to adjust the filter cutoff frequency. Use `VCF` **MODULATION** knob to change the modulation source for the VCF cutoff frequency.

2.2. Getting started with Delay effect

LILLA has a stereo modulated Delay module; press together **SHIFT** + **DELAY** buttons together, the display shows the **Delay page**:
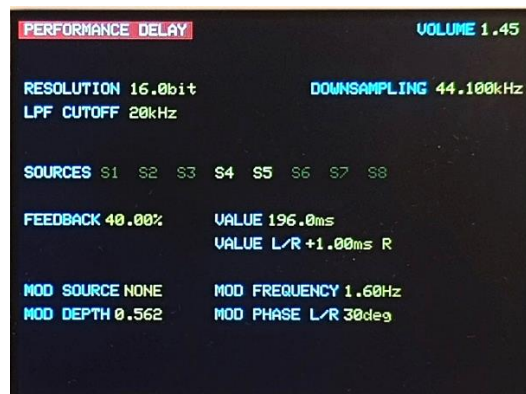
Delay page

By pressing **Sound 1-8** buttons the corresponding Sound is routed/not-routed to the Delay.

Use `DEL` **FEEDBACK** knob to adjust the Delay feedback, `DEL` **VALUE** knob to adjust the delay time, `DEL` **VALUE L/R** to introduce a differential (left/right channels) delay. Use `DEL` **MOD SOURCE** knob to change the modulation source for Delay value.

2.3.   Getting started with Sampler mode

LILLA can record, save and export analog audio from **AUDIO IN** stereo input.
Connect your audio source (line level/mic level) using a 3.5mm stereo jack, than press **SHIFT** + **SAMPLER** buttons together; the display shows the **Sampler page**:

Sampler page

Use the **level** knob (LINE IN area) to adjust the signal level; in this phase incoming audio is just metered.
If no recording is present, the 0.raw file is used just to test the MIDI source.

When you are ready to record, click **OK** and listen the incoming audio for a final check; again, click **OK** to choose MONO-REC: LILLA starts recording audio.
After some seconds, click **OK** to stop the recording: the display shows the MONO_FILE name (.rec extension) and duration.
Send NoteOn/NoteOff commands on <u>MIDI channel 1</u> to hear the recording.
Recordings are saved as .rec files, and can be included in a Patch (in Performance mode).

## 2.4.   Getting started with Live Sampler mode

LILLA can play the live stream from AUDIO IN stereo input using its volatile memory area as a virtual tape loop. Connect your stereo audio source (line level/mic level) using a 3.5mm stereo jack, then press **SHIFT** + <mark>LIVE SAMPLER</mark> buttons together; the display shows the **Live Sampler page**:
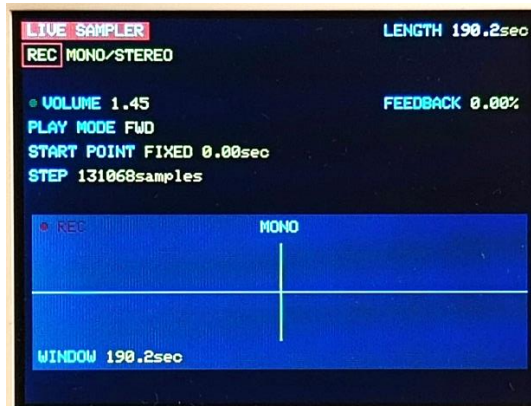
Live Sampler Page

The vertical green line is the **Play point** (starting point) when a NoteOn is received on <u>MIDI channel 1</u>; the Play point is always kept in the center of the screen.

When you are ready, press **OK**; audio stream is shown on the display; the waveform is written from left to right; fresh samples are yellow, older samples fade to red:
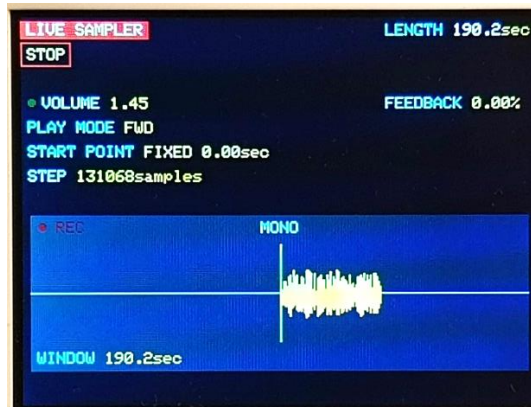
Live sampler page: locked to the virtual tape

Use the **level** knob (LINE IN area) to adjust the signal level.

Send NoteOn/NoteOff commands on <u>MIDI channel 1</u> and you will hear the recorded audio from the Play point. The page displays:
<mark>START POINT FIXED 0.00sec</mark>
It means that LILLA starts playing from the first (0.00sec) samples stored; use <mark>LIVE START POINT</mark> knob to adjust the Play point position.

If you click on **LIVE LOCK**, the Play point will follow the Record point; in this situation the recorded waveform slowly shifts on the left, and the last sample recorded is in the Play point:
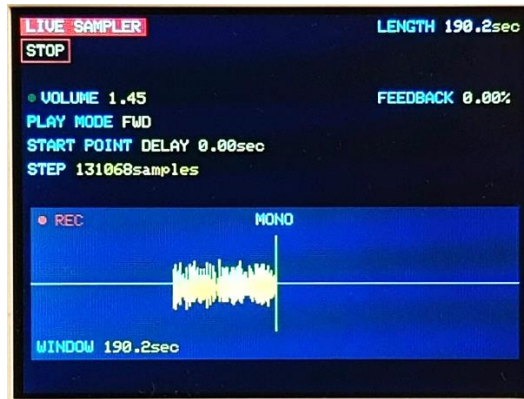
Live sampler page: locked to the Record point

The page displays:

START POINT DELAY 0.00sec

It means that the Play point and the Recording point are on the same sample; use **LIVE START POINT** knob to adjust this delay. Note that if delay is close to 0.00 sec, you cannot play NoteOn > 60 (pitch > 1.0).

Use **LIVE FEEDBACK** to adjust the feedback percentage to the Live sampler; try playing also sending MIDI PitchBend commands for creating a complex echo/pitch shift effect.

3. Performance mode

3.1. Performance page

Access to **Performance mode** by pressing **SHIFT** + **PERFORMANCE** buttons together.
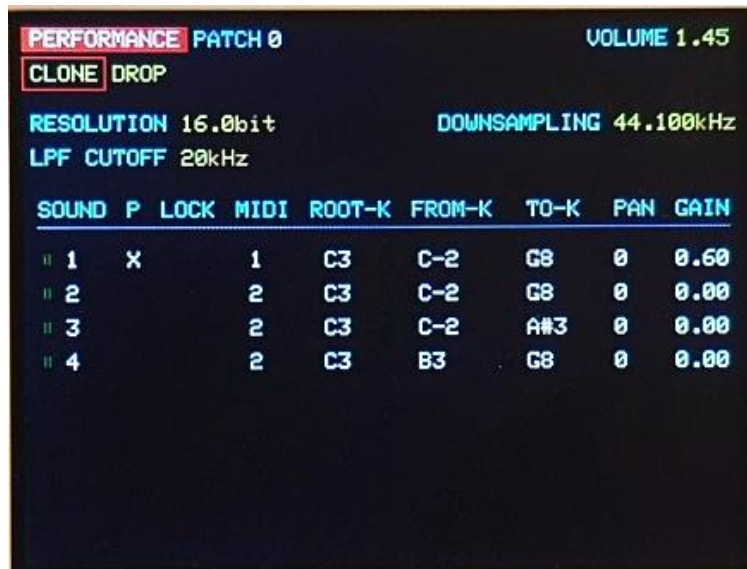
Performance page

Performance mode allows to play **Patches**, which are groups formed by **1 to 8 Sounds**. Each Sound contains an audio file name and all parameters that characterize the timbre and specify the keyboard range and midi channel assignment.
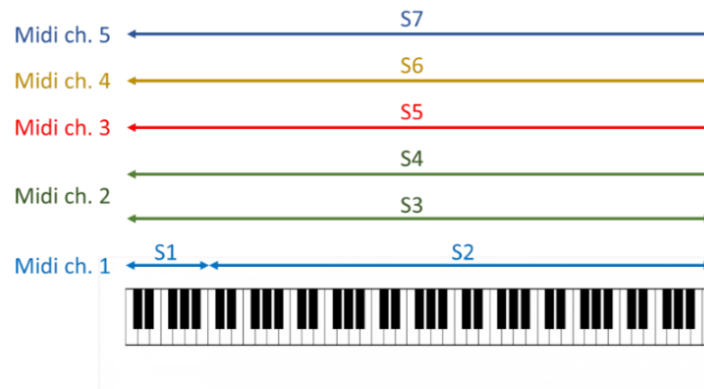
LILLA can save **25 Patches** and **90 Sounds**.

On top, the Performance page displays these elements:

Display	Knob/Button
PATCH: the Patch number (0→24)	PERF **PATCH**
VOLUME: the main volume	**VOLUME**
Menu items: **CLONE, DROP, SAVE, SAVE-AS-NEW**	**SELECT** + click **OK**

Notice that a new Patch can be created only by cloning, and later modifying, an existing Patch (that's why it is not possible to drop all Sessions).

Next lines show three general effects:

Display	Knob/Button

|	
RESOLUTION: reduces the resolution value below 16 bit	**RESOLUTION**
DOWNSAMPLING: reduces the sample rate below 44.1 Samples/second	**DOWNSAMPLING**
LPF CUTOFF: general low-pass filter 24dB/oct, cutoff frequency	**LPF CUTOFF**

Below, the display shows the Sounds included in the Patch; chose one of them using **SELECT** knob, then adjust the parameters:

Display	Knob/Button
P (Precedence): if selected, the Sound has precedence over other Sounds for the use of the voices	click **PRECEDENCE**
L (Lock): if selected the Sound is not affected by Resolution, Downsampling and PitchBend effects	click **LOCK**
MIDI (MIDI channel): the MIDI channel to use the Sound	**FILE/MIDI**
ROOT K (Root key): the note corresponding to pitch = 1.0	**ROOT KEY**
FROM-K (From key): the first note from which the Sound responds	**FROM KEY**
TO-K (To key): the last note the Sound respond	**TO KEY**
PAN: the stereo pan	**PAN**
GAIN: the relative volume of the Sound	**GAIN**

3.2. Sound modeling page

In Performance mode, Sound modeling page is shown by pushing once on the Sound 1-8 buttons:
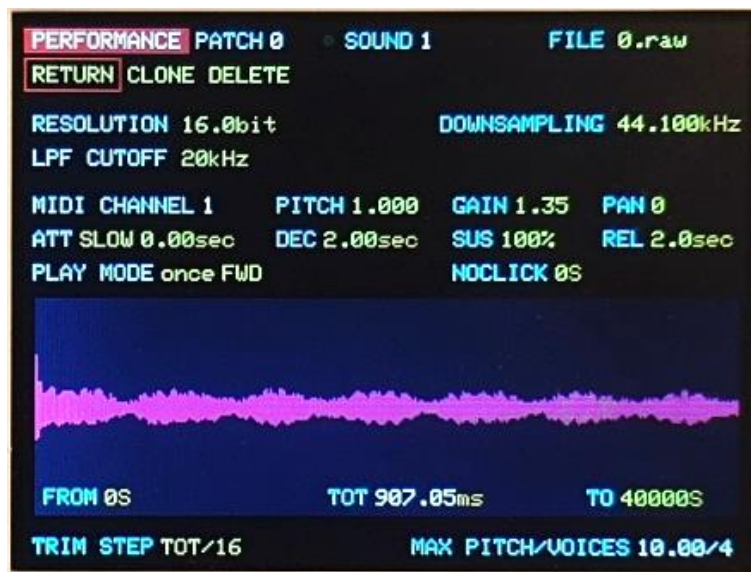
Sound modeling page

On top, the page displays these elements:

Display	Knob/Button
PATCH: the Patch number (0→24)	
SOUND: the Sound number (1→8)	
FILE: the file name associated to the Sound	**FILE/MIDI** + **toggle** (to activate FILE function)
Menu items: **RETURN**, **CLONE**, **DROP**	**SELECT** + click **OK**

Next 3 lines show general effects (as described in §3.1).

Next 3 lines below show these elements:

Display	Knob/Button
MIDI CHANNEL: the MIDI channel to use the Sound	**FILE/MIDI** + **toggle** (to activate MIDI channel function)
PITCH: fine-tuning of the Sound	**PITCH**
GAIN: the relative volume of the Sound	**GAIN**
PAN: the stereo pan	**PAN**
ATTACK: attack time; attack curve can be **FAST** or **SLOW**	**ATTACK** + click on **SLOW/FAST**
DECAY: decay time	**DECAY**
SUSTAIN: sustain level	**SUSTAIN**
RELEASE: release time	**RELEASE**
PLAY MODE: once FWD (forward), once REV (reverse) loop FWD, loop FWD/REV, loop REV/FWD, loop REV	**PLAY MODE**
NOCLICK: operates a cross fading which cancel any "click", in case of loop forward and loop reverse modes	**NOCLICK**

The page also shows the waveform played; parameters are:

Display	Knob/Button
FROM (sample): first sample played	**FROM SAMPLE**
TOT (total): the total number of samples played	
TO (sample): last sample played	**TO SAMPLE**

The bottom of the page shows:

Display	Knob/Button
TRIM STEP: samples for each step of FROM SAMPLE and TO SAMPLE knobs	**TRIM STEP**; click **DEFAULT** to set the default value (TOT/16)
MAX PITCH/VOICES: maximum number of voices/maximum pitch value; this value can be influenced by Optimization option in Setup (read Cap.8)	

3.3. VCF page

From Sound modeling page, push again on the same Sound button to access the VCF page:
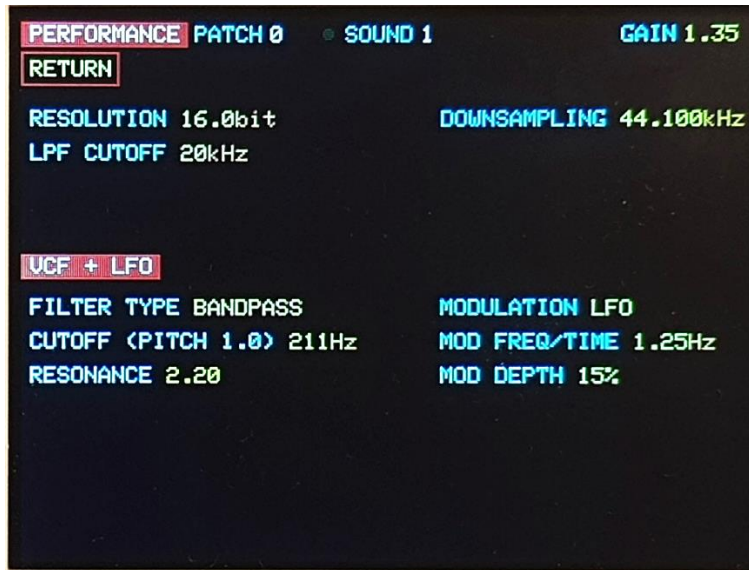
VCF page

The upper half of the page displays the same elements of the Sound modeling page (**PATCH**, **SOUND**, **GAIN**, **RESOLUTION**, **DOWNSAMPLING**, **LPF CUTOFF**) described in §3.1 and §3.2.

The lower part of the page displays the parameters of the VCF associated to the Sound:

Display	Knob/Button
FILTER TYPE: can be NONE (BYPASS), LOWPASS, HIGHPASS, BANDPASS, NOTCH.	VCF **FILTER TYPE**; click on VCF **ON/OFF** to bypass the VCF stage
MODULATION (modulation of the cutoff frequency): NONE, RISING, FALLING, LFO, LFO + CC7	VCF **MODULATION**; click on VCF **NONE** to cancel modulation
CUTOFF (PITCH = 1.0): cutoff/central frequency of the filter	VCF **CUTOFF FREQ**
MOD FREQ/TIME: shows time when modulation source is RISING or FALLING curves; shows a frequency in case of LFO or LFO+CC7	VCF **MOD F/T**
RESONANCE: the filter resonance	VCF **RESONANCE**
MOD DEPTH: the modulation depth	VCF **MOD DEPTH**

For a detailed description of the VCF read §10.4.

4. Sampler mode

Access to the **Sampler** by pressing **SHIFT** + **SAMPLER** buttons together.

Sampler page

Acting as a direct sampler, LILLA can act as a digital recorder of analog audio from AUDIO IN stereo input and save data as **.rec files**, stored in a dedicated portion of the Flash memory (permanent memory); .rec files can be converted into **.raw files**, stored in the Flash memory; .raw files can be exported to micro-SD card.

In the center, the page displays some information related to the storage space:

Display	Comments
STORAGE SPACE 64MB	Fixed value
FREE FOR RECORDING	Storage space free for .rec files (recordings)
FREE FOR RAW FILES	Storage space free for .raw-converted recordings

These repositories (for recordings, for raw files) are created when .raw file are imported from SD card; for a detailed description read §8.2.

4.1. Idle state

At first access, the Sampler is idle. If an audio source is connected, the bar-graph displays the audio level.
Incoming audio is NOT routed to both LINE OUT and MONITOR.
Incoming MIDI - Channel 1 only - is accepted.

- if there are no Recordings, the menu shows one only option:

Display	Knob/Button
PAUSE + REC	Click **OK** to start recording

And below:

Display	Knob/Button
RECORDING NONE	

Display	Knob/Button
TEST_FILE 0.RAW: test file is always 0.raw	
VOLUME	**VOLUME**

- if a Recording is present, the menu shows:

Display	Knob/Button
DELETE-RECORDING, PAUSE+REC, CONVERT-REC-TO-RAW (produces .raw files and delete the recording)**, EXPORT-TO-SD** (save files .raw in /LILLARAW_EXPORT folder)	**SELECT** + click **OK**

And below:

Display	Knob/Button
RECORDING	SAMP **RECORDING**
MONO_FILE or **STEREO_FILE**: shows the file name	
LENGTH: file length	
VOLUME	**VOLUME**

Incoming audio level can be reduced using **level** knob (analog command); input GAIN level can be adjusted using SAMP **LINE IN GAIN** knob (digital command).

4.2. Pause + Rec state

The Sampler is ready for recording.
Incoming audio is routed to both LINE OUT and MONITOR (if not, check the Mixer setting).
Incoming MIDI is NOT accepted.

The menu shows these options:

Display	Knob/Button
MONO-REC, STEREO-REC, **STOP**	**SELECT** + click **OK**

Incoming audio level can be reduced using **level** knob (analog command); input GAIN level can be adjusted using SAMP **LINE IN GAIN** knob (digital command).

4.3. Recording state

The Sampler is recording.

The menu shows one option:

Display	Knob/Button
STOP	**SELECT** + click **OK**

Below, **FREE FOR RECORDING** displays the time-space available.

The next rows display information about the recording:

Display	Knob/Button
RECORDING: recording number	
MONO_FILE or **LEFT_FILE** + **RIGHT_FILE**: recording file/s name/s	
LENGTH in seconds	

5. Live Sampler mode

Access to the **Live Sampler** by pressing **SHIFT +** <mark>**LIVE SAMPLER**</mark> buttons together.
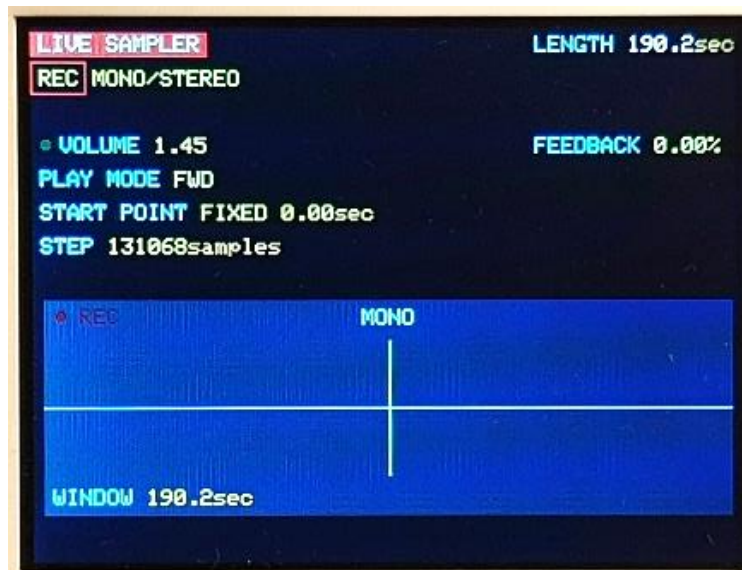
Live sampler page

Acting as a Live Sampler, LILLA can record analog audio from AUDIO IN stereo input and <u>temporary</u> save data in a volatile PSRAM repository. This memory area is configured as a **virtual tape loop** and it is overwritten when full.

Live Sampler use a temporary (unsaved) Patch, made of 1 Sound when recording MONO, 2 Sounds (left and right channel) when recording STEREO; for STEREO recording, both Sounds have the same VCF settings.

On top, **LENGTH** displays a 190.2sec if the Live sampler is set to MONO, 95.1sec if Live Sampler is set to STEREO.

The menu shows the following options:

Display	Knob/Button
REC, **STEREO/MONO**	**SELECT** + click **OK**

Mono
Choosing MONO, the waveform window displays a mono signal obtained as (left + right)/2.
Pushing on <mark>**LIVE L/MONO**</mark> the display shows the parameters of the VCF associated to the Sound; pushing again the displays returns to Live Sampler page.

Stereo
Choosing STEREO, the waveform window displays the left channel incoming audio; pushing on <mark>**LIVE L/MONO**</mark> the display shows the parameters of the VCF associated to the Sounds; pushing again on the same button the display returns to Live Sampler page.
Pushing on <mark>**LIVE R**</mark> the display shows the right channel incoming audio; pushing again on the same button the parameters of the VCF associated to the Sounds.

Below, the page shows these elements:

Display	Knob/Button
VOLUME	**VOLUME**
FEEDBACK: feed the Live Sampler with a percentage of the LINE OUT signal	LIVE **FEEDBACK**
PLAY MODE: FWD (forward), REV (reverse), loop FWD, loop FWD/REV	LIVE **PLAY MODE**; for loop modes use LIVE **LOOP WIDTH** for adjusting the loop time.
START POINT: position of the start-playing point; can be either FIXED to the virtual tape loop; or mobile with a certain DELAY from the recording point	LIVE **START-POINT**; toggle between FIXED and DELAY by clicking on LIVE **LOCK**
STEP: samples for each step of LIVE **START-POINT** and LIVE **LOOP WIDTH** knobs	LIVE **STEP**

The waveform window shows the real-time memory content; fresh data is yellow, older data is red. Use LIVE WINDOW to adjust the width of the window; click on LIVE FULL VIEW for a complete view of the virtual tape loop.
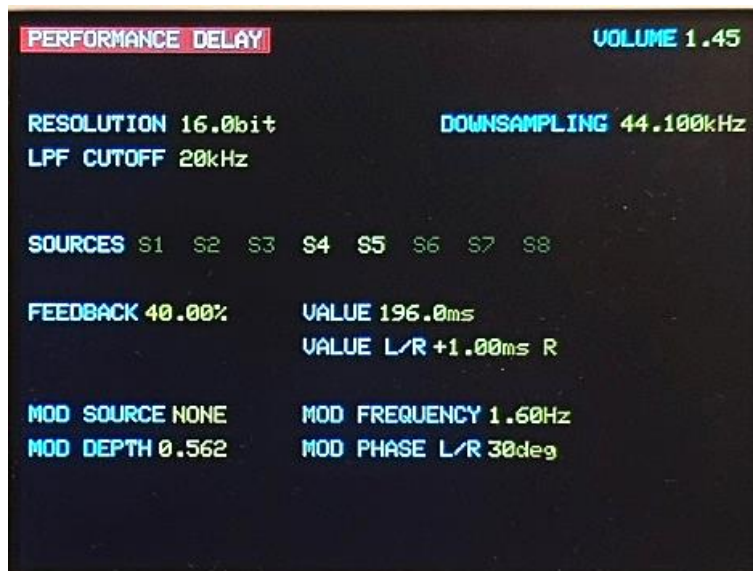
6. Delay

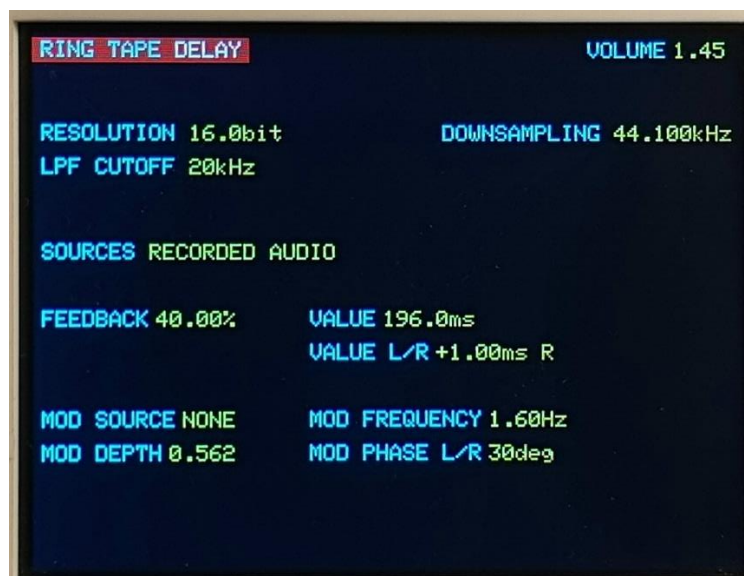Access to **Delay** settings by pressing **SHIFT +** `DELAY` buttons together.
The Delay effect is enabled in Performance mode and Live Sampler mode (not available in Sampler mode, which is intended for offline activity).

Delay for Performance mode
In Performance mode, this is the Delay page displayed:

Delay for Performance page

Delay for Live Sampler page

The first (upper) half of the page displays the same elements of the Performance page (**RESOLUTION, DOWNSAMPLING, LPF -CUTOFF**) described in §3.1.

SOURCES shows the Sounds routed (yellow color) or NOT routed (dark color) to the Delay effect; coming from Performance mode, Sounds are S1 (Sound1), S2 (Sound2), ..., S8 (Sound 8), and can be individually routed/not-

routed by pushing on the relative button; coming from Live Sampler mode, SOURCES is the recorded audio only and can be routed/not-routed by pushing on **LIVE L/MONO** or **LIVE R**.

The following parameters refer to Delay parameters:

Display	Knob/Button
FEEDBACK	**DEL FEEDBACK**
VALUE: delay value (0.2ms → 5sec)	**DEL VALUE**
VALUE L/R: delay difference between L channel Delay and R channel Delay (1ms → 10ms)	**DEL VALUE L/R**
MOD SOURCE: modulation of delay value (NONE, LFO, SOURCE signal)	**DEL MOD SOURCE**; click **DEL NONE** for canceling delay value modulation
MOD FREQUENCY: LFO frequency	**DEL MOD FREQ**
MOD DEPTH	**DEL MOD DEPTH**
MOD PHASE L/R: phase difference between left LFO and right LFO	**DEL MOD PHASE L/R**

All Delay parameters are saved after exit.

7. Mixer

Access to **Mixer** settings by pressing **SHIFT +** **MIXER** buttons together.
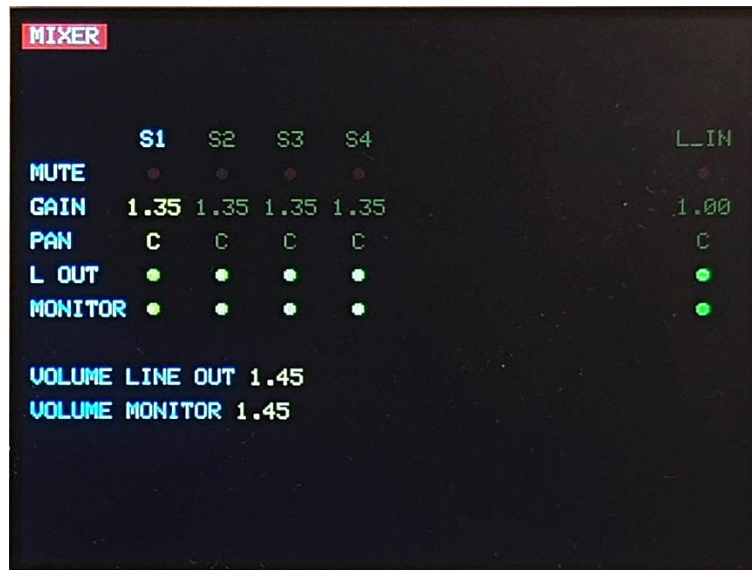

Mixer page

For each Sound plus Audio In, the Mixer offers the possibility of adjusting parameters and routing the source to the outputs:

Display	Knob/Button
S1, S2, S3, S4, S5, S6, S7, S8, L IN (line IN): select the sound source	buttons S1 to S8 and MIX LINE IN
MUTE	MIX MUTE
GAIN	MIX SOURCE GAIN
PAN	MIX PAN
L OUT (LINE OUT): route the source to LINE OUT	MIX → MAIN
MONITOR: route the source to MONITOR	MIX → MONITOR
VOLUME LINE OUT	MIX VOLUME MAIN
VOLUME MONITOR	MIX VOLUME MONITOR

Mixer setup is volatile; at startup all sources are routed to LINE OUT and MONITOR outputs, none of the sources are muted.

8. Setup

Access to **Setup** by pressing **SHIFT + SETUP** buttons together.
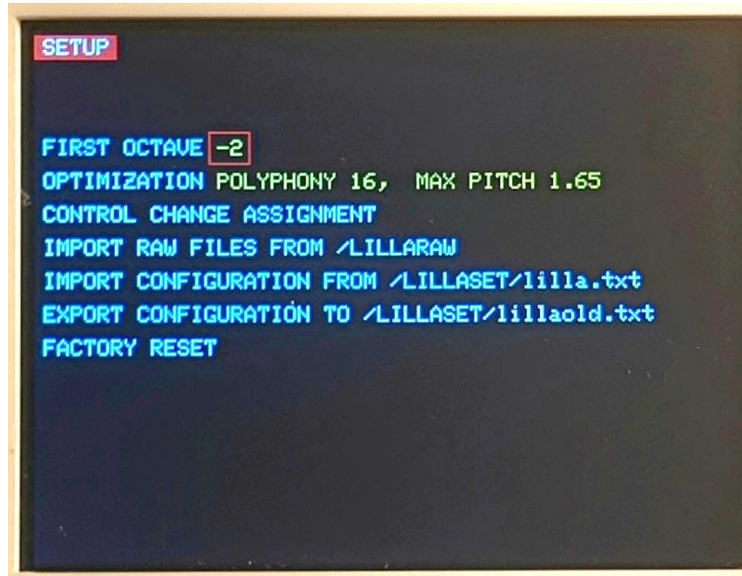
Setup page

The Setup page displays the following elements; use **SELECT** knob for choosing the item, and **OK** to select:

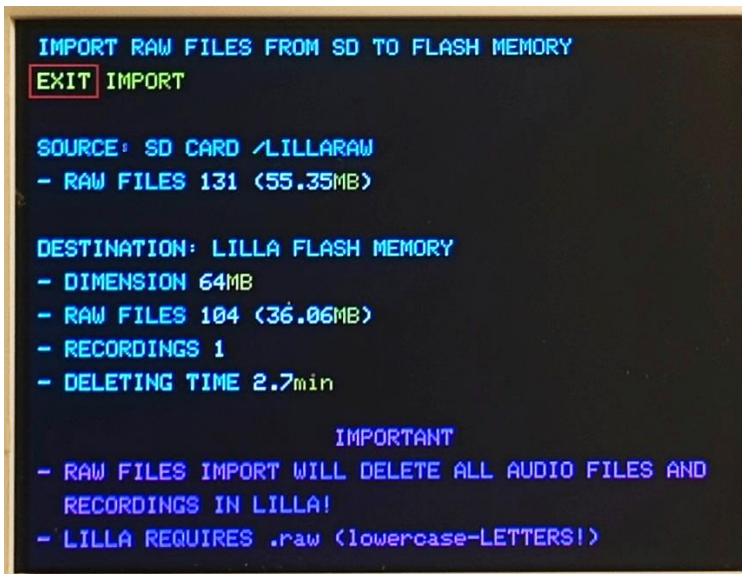| Display	Knob/Button
FIRST OCTAVE: assign the preferred number from -2 to 0	**VALUE**
OPTIMIZATION: description at §1.5	**VALUE**
CONTROL CHANGE ASSIGNMENT	**OK** → dedicated page
IMPORT RAW FILES FROM /LILLARAW	**OK** → dedicate page
IMPORT CONFIGURATION FROM /LILLASET/lilla.txt	**OK**
EXPORT CONFIGURATION TO /LILLASET/lillaold.txt: if lillaold.txt is present in SD, it will be substituted by a new file	**OK**
FACTORY RESET: all setup, audio files and recordings are deleted	**OK**

For importing the configuration, use your computer to rename a previously exported file **lillaold.txt** to **lilla.txt**.

8.1. Control Change assignment
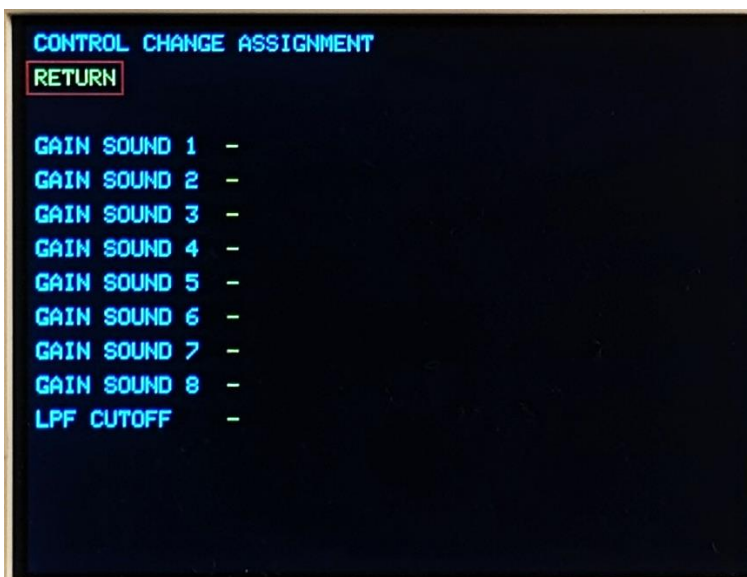
Control Change assignment page allows to set Control Change commands to adjust Sounds gain and Lowpass filter cutoff frequency; use **SELECT** and **VALUE** knobs for setting the Control Change commands; when finished, select RETURN and click **OK** to return to Setup page.

8.2. Import .raw files from micro SD card

This page allows to import **.raw** files from micro-SD card, directory **/LILLARAW**. Notice that audio files import requires the flash memory to be formatted: all audio files and recordings in LILLA are erased!

9. MIDI Monitor
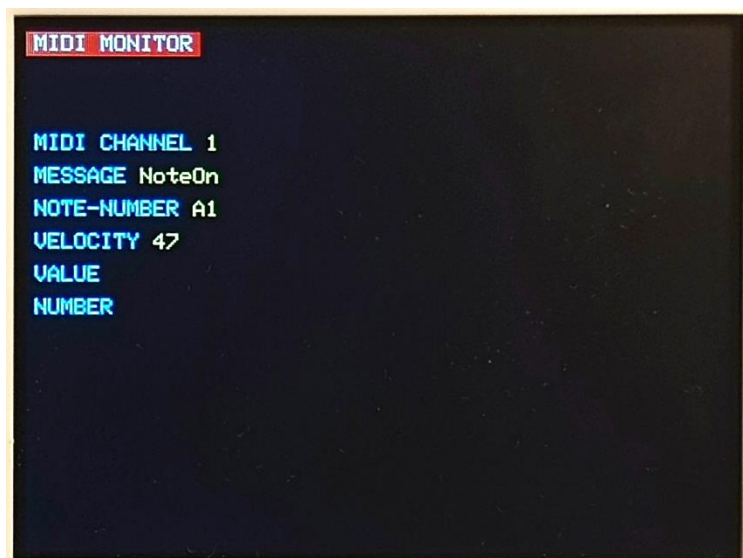
The MIDI Monitor simply displays the last MIDI message received.

10. Effects description

10.1. Lowpass Filter

This is a 12dB/oct digital Low-pass filter, placed close to the end of the audio signal path;

10.2. Resolution

This filter affects the bits resolution internally used, and simulates a low-quality audio; the filter is embedded in each voice, and disabled if the Sound is "LOCK".

10.3. Downsampling

This filter affects the sampling rate of the signal, and simulates a low-quality audio; the filter is embedded in each voice, and disabled if the Sound is "LOCK".

10.4. Multimodal VCF

This filter is embedded in each of the 16 voices; all VCF parameters are set up when the NoteOn command is received ad a Sound is played. The following diagram shows the signal path and the available controls:
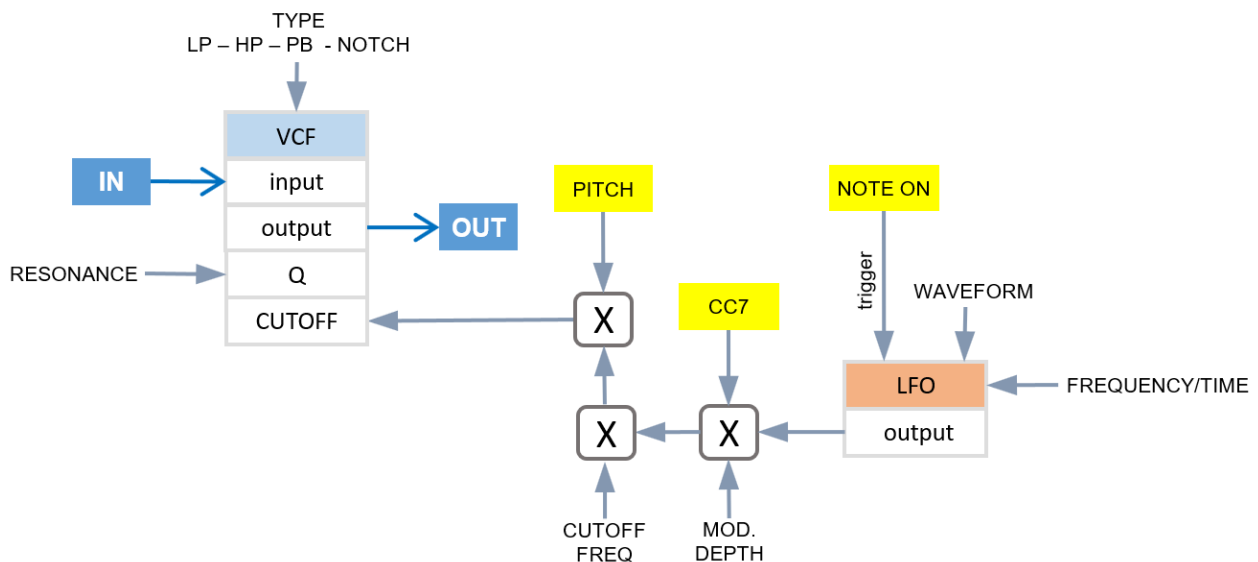
The virtual (digital) VCF filter is a multimodal (lowpass, highpass, bandpass, notch) 12dB/oct filter; the cutoff frequency displayed is relative to the root key, and varies depending on the pitch:

*Cutoff frequency = Cutoff frequency displayed x pitch.*

LFO waveform can be periodic (sinus) or aperiodic (rising curve, falling curve) triggered by the NoteOn command.

10.5. Delay

The (stereo) Delay effect is placed close to the end of the audio-signal path; the configuration is a simple Schroeder allpass filter.
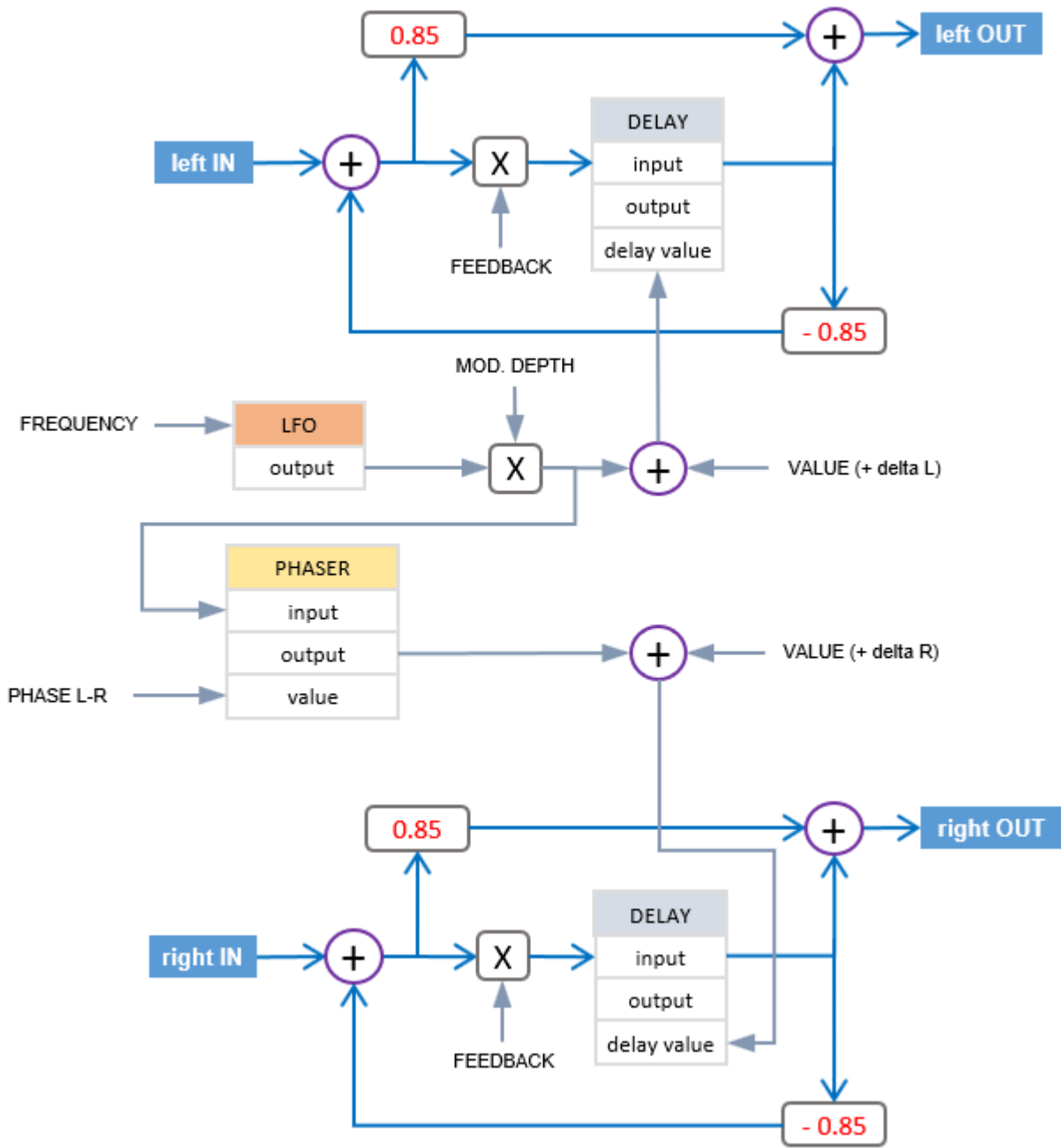
Delay value can be set with different values for left and right channels; this value can also be modulated by an LFO or the same incoming audio signal.
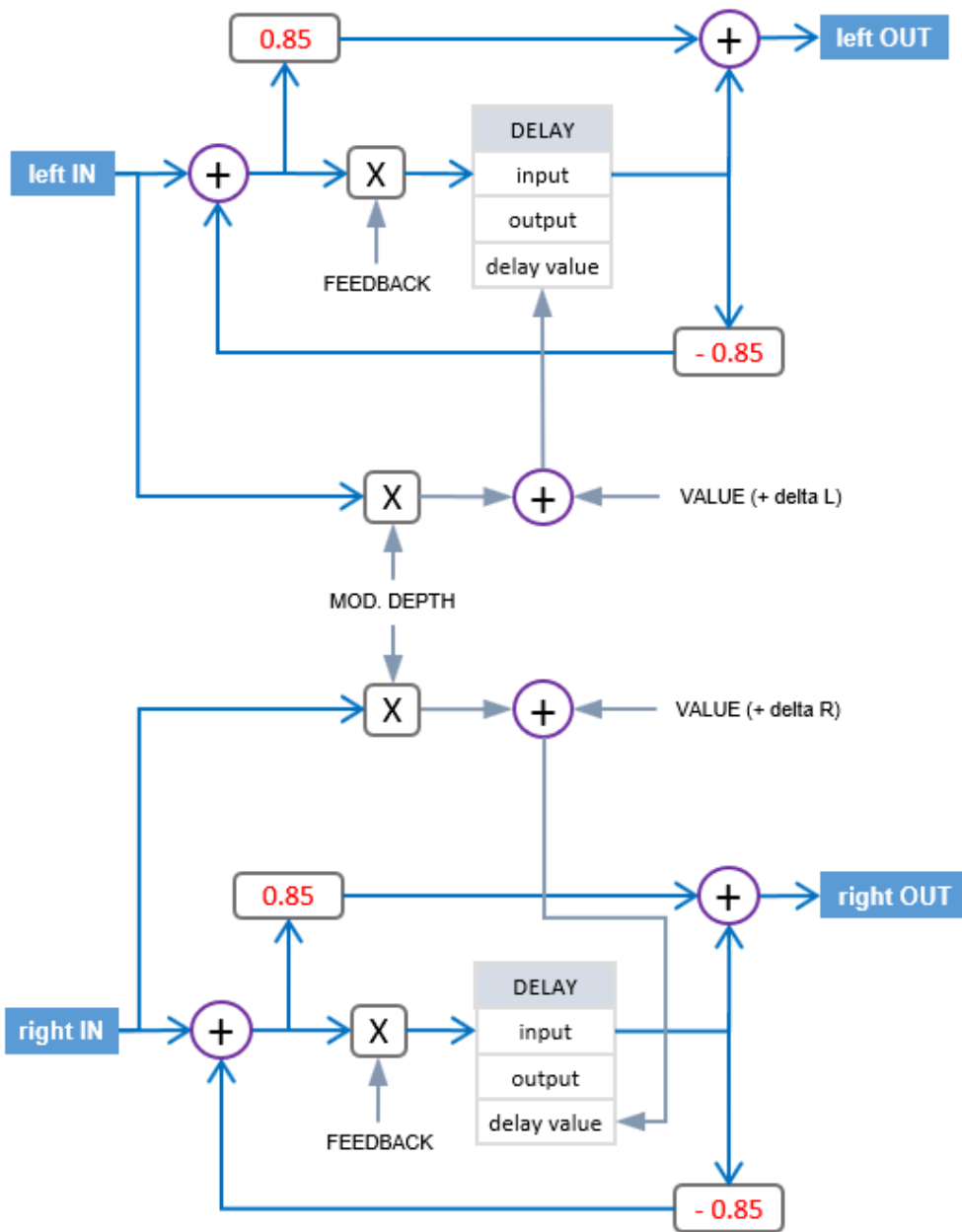
10.5.1. Not modulated Delay
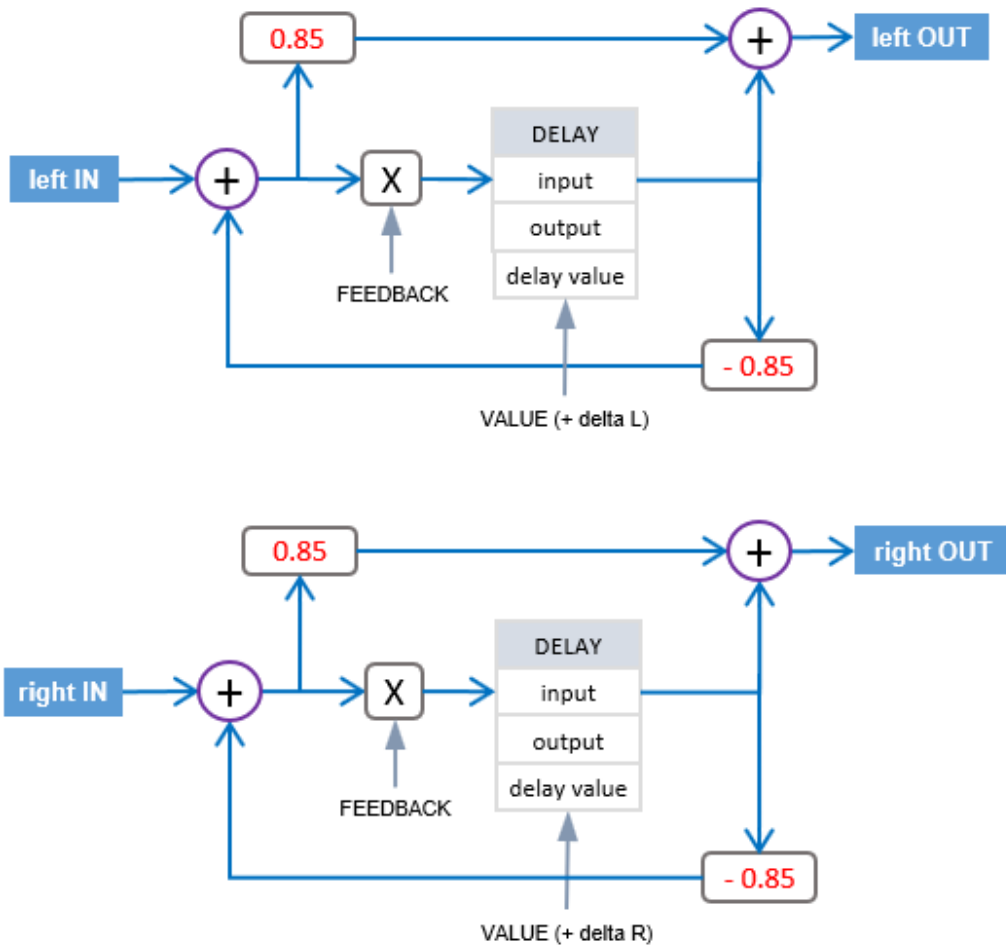
10.5.2.   LFO modulated Delay

In this case there is a unique LFO (sinus waveform) coupled with a phaser.
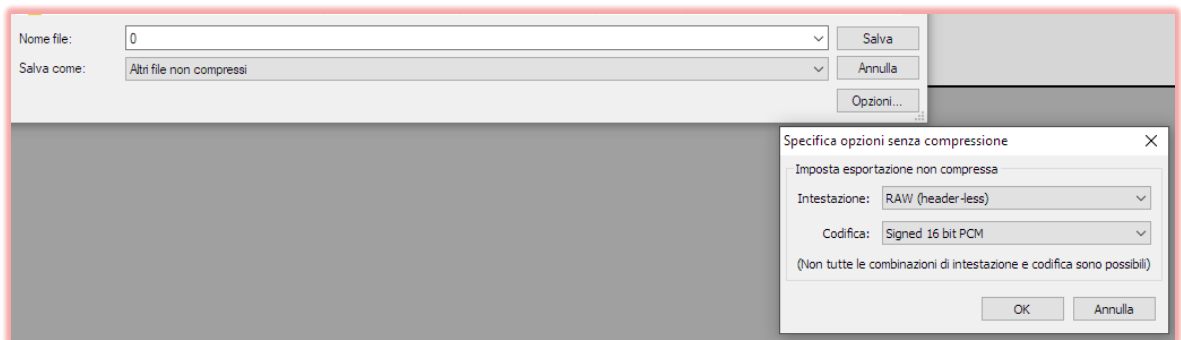
10.5.3. Incoming signal modulated Delay

11. How to make .raw files using Audacity

Using Audacity, a 16bit/44.1Ksps mono file can easily be exported into .raw format.
From "**File**", choose "**Audio Export…**" then **"Other uncompressed files**" and in "**Options**" choose **Header: "RAW (header-less)**" and **Coding: "Signed 16 bit PCM"**.

For naming, use the filename convention required <number>.raw (lowercase).

12. How to update LILLA firmware

Firmware update requires a computer with the Teensy Loader application installed:

1. go to the Teensy Loader download page (https://www.pjrc.com/teensy/loader.html) and choose the right version for your operating system;
2. download the last version of LILLA firmware (.zip compressed file) from https://www.lillasampler.it/firmware-lilla-2022/;
3. uncompress the Lilla_Rxxxx.bin file;
4. run the Teensy Loader application;
5. check that Operation/ Automatic mode is flegged/selected;
6. click File/Open HEX File and select the Lilla_Rxxxx.bin;
7. connect LILLA to one of your computer USB plug; switch on LILLA and, using a thin stick, click the PRGM inner button: the new firmware will be uploaded and LILLA will restart.