

# User Manual

## Table Of Contents

- Introduction
  - Features
- Concepts
  - Project
  - Track
  - Note Track
  - Curve Track
  - MIDI/CV Track
  - Pattern
  - Snapshot
  - Fills
  - Song
  - Scale
  - Clock
  - Routing
  - Controller
  - File Management
- User Interface
  - Overview
  - Navigation
  - Page Layout
  - List Pages
  - Copy/Paste
- Pages
  - Project
  - Layout
  - Track
  - Sequence
  - Steps
  - Song
  - Tempo
  - Pattern
  - Performer
  - Routing
  - Midi Output
  - User Scale
  - Overview
  - Monitor
  - Clock
  - System
- Appendix
  - Recording
  - Divisors
  - Run Modes
  - Play Modes
  - Rotation
  - Step Conditions
  - Scales
  - Shapes
  - Arpeggiator Modes
  - Launchpad
  - Calibration Procedure
  - Firmware Update

## Introduction

**PER|FORMER** is an open source and open hardware eurorack sequencer module. It packs a lot of functionality into a small form factor and was designed both as a versatile sequencer in the studio as well as for live performance. To fully take advantage of all the features available in this module, it is highly recommended to study this document carefully.

The Concepts chapter introduces the overall architecture and functionality of the sequencer. The User Interface chapter gives an overview of the user interface and introduces key concepts of how to use the sequencer. The Pages chapter goes into more detail in terms of functionality and user interface of the various modes and contexts in the sequencer and introduces common workflows.

## Features

The following list describes the key features of the **PER|FORMER** sequencer:

- 8 track sequencer
- 16 sequences per track
- 64 steps per sequence
- Multiple track and sequence modes
- Note and modulation sequencing
- Arpeggiator
- Snapshot system
- Sequence generators
- Advanced clock system
- 8 CV Outputs (-5V to 5V)
- 8 Gate Outputs (5V)
- 4 CV Inputs (-5V to 5V)
- Clock input/output
- MIDI input/output
- USB host port with support for USB MIDI controllers
- 256x64 pixel OLED display
- Encoder with push button
- 32 buttons with bi-color LEDs
- 5 function buttons with labels on display
- Micro SD card slot

## Concepts

This chapter introduces the basic concepts of the sequencer and should familiarize readers with the overall functionality of the sequencer. More in-depth information about specific features are provided in the following chapters.

### Project

A project represents the complete state of the sequencer, with the exception of calibration data. Only one project can be loaded at any given time and all data is volatile, meaning that all changes are lost when the unit is powered off. To persist a project it needs to be stored to the SD card (see Project page).

Projects are split into two data regions. The first region contains all the global data such as project settings, layout settings, MIDI output settings, routing settings, song data and play state. The second region contains the data for the 8 tracks, where each track contains the track settings and 16 sequences. Each sequence in turn contains the sequence settings and up to 64 steps.

Note: Calibration data is stored in the flash memory of the micro controller and can be backed up and restored from the SD card. This allows exchanging the SD card while running the sequencer or run the sequencer without an SD card at all and still have it properly calibrated.

### Track

A track is responsible for generating note or modulation signals used to control other modules in the eurorack system using the CV/gate outputs. The **PER|FORMER** sequencer can run up to 8 tracks, that primarily use step sequencing to generate these signals, where each track can run independent of the other tracks. This means that every sequence in a track can have a different time division, run mode, duration or scale among other properties.

#### Track Mode

Each of the 8 tracks can be configured to one of the following modes:

- Note
- Curve
- MIDI/CV

In *Note* mode, the default mode, a track uses advanced step sequencing to generate rhythms and melodies. *Curve* mode also uses step sequencing, but each step is defined as a curve shape, making this mode very versatile for generating modulation signals. In MIDI/CV mode, a track acts as a MIDI to CV converter, which can be useful when attaching a MIDI keyboard to play some voices live or sequence them from an external MIDI sequencer.

#### Track Routing

In the default configuration, each track controls one of the CV/gate output pairs of the sequencer to control a single voice. However, this configuration can be changed to allow for more flexible routing of the virtual track outputs to the physical CV/gate outputs. For example, a MIDI/CV track can control more than one physical CV/gate output to allow polyphonic operation or output a velocity signal in addition to the pitch signal.

#### Track Linking

In *Note* or *Curve* mode, a track generates a single CV signal, typically a pitch or modulation signal. To control a voice with multiple signals, for example a pitch and velocity signal, two tracks have to be used in combination. The first track is used to generate the pitch signal while the second track generates the velocity signal. Using two tracks allows to use different sequence lengths, time division and other properties that affect playback. If that is not desired, the second track can be linked to the first track, essentially doubling the playback behavior.

Track modes, the physical routing to CV/gate outputs and track linking can be configured on the Layout page.

#### Note Track

By default, all tracks are configured as note tracks. In this mode, the track uses step sequencing to generate gate and CV signals. A sequence consists of a maximum of 64 steps and there is a total of 16 sequences per track.

Each step is defined through a number of properties, also called layers, to control the generated gate and CV signals.

The *Gate* layer defines what steps of the sequence create a gate signal. To introduce some random variation, the *Gate Probability* layer is used to control how often an active gate is actually generated.

The *Gate Offset* layer is used to offset gate signals into the future, adding a delay before triggering a note.

The *Length* layer controls the duration of the gate signal and allows to tie notes together if set to the maximum. Again, to introduce some random variation, the *Length Variation Range* and *Length Variation Probability* layers control a maximum random deviation of the gate length and the probability of actually randomizing the gate length.

The *Retrigger* layer allows each gate signal to be retriggered multiple times within the duration of the step, allowing for faster gates and ratcheting effects. Retriggering can also be randomized using the *Retrigger Probability* layer.

The generated CV signal is controlled by the *Note* layer, which basically defines the voltage to be output for each step. Each note is stored as an index to an entry in a Scale, allowing the generated CV signals to be used both for controlling note pitch as well as other arbitrary modulation signals. Using the *Note Variation Range* and *Note Variation Probability* layers some random variation can be applied to the CV signal. The *Slide* layer controls if the generated CV signal is changed immediately on the start of a gate or smoothly slides to the new voltage.

Finally, the *Condition* layer is used to conditionally trigger steps based on certain rules. This allows to create relatively short sequences that feel more complex, for example by only playing steps every few iterations. See Step Conditions for additional information.

The playback of the sequence is controlled by additional parameters:

- *Divisor* controls the rate at which steps are played back
- *Run Mode* controls the order in which steps are played back
- *First Step* and *Last Step* control what range of the sequence is played back

Sequences are edited on the Steps page and sequence parameters can be edited on the Sequence page.

## Curve Track

In *Curve* mode, a track also uses step sequencing with similar playback features to the note track. However, in this track mode the CV signal is defined by a series of curve shapes, making this mode useful to generate modulation signals. This mode also allows to output gate patterns, but it is different from how the *Note* mode works.

The generated CV signal is controlled by the *Shape* layer, which defines a curve shape to be output over the duration of one step. The *Minimum* and *Maximum* layers define the lower and upper voltage that is output for each step. To introduce some random variation, the *Shape Variation* and *Shape Variation Probability* layers can be used to define altered shapes that are used instead of the primary shape with some probability.

The generated gate signal is controlled by the *Gate* layer. It allows to define a pattern of up to 4 gate triggers per step. To introduce some random variation, the *Gate Probability* layer is used to control how often a gate is actually played.

The playback of the sequence is controlled by the same set of parameters as in the note track.

## MIDI/CV Track

In MIDI/CV mode, a track acts as a MIDI to CV converter, taking MIDI note data from either the MIDI or USBMIDI input and converting it to voltages at the CV/gate outputs. This allows for playing voices live from a keyboard or use an external MIDI sequencer to control them. MIDI/CV mode also provides a powerful arpeggiator to further help playing live.

Note: MIDI/CV mode allows for using the **PER|FORMER** module as a pure MIDI/CV converter with up to 8 CV/Gate outputs.

## Pattern

In *Note* and *Curve* mode, each of the 8 tracks contains up to 16 sequences, also referred to as patterns. During playback, each track is playing one of its 16 patterns. When switching patterns, all tracks can be switched to the same pattern number or specific patterns can be selected for individual tracks. Patterns are controlled from the Pattern page.

## Snapshot

In addition to the 16 patterns per track, there is an additional snapshot pattern which can temporarily be used to edit sequences without affecting the original. When taking a snapshot, all patterns that are currently playing in each track are copied to the snapshot. Snapshots come in handy during live performance for quickly changing sequences on the fly. The changes can later be committed or reverted. Snapshots are controlled from the Pattern page.

## Fills

Fills can be used as an effective tool during live performance. They allow to temporarily change the playback of a sequence to add some variation or tension. Each track can be configured with a specific fill mode. The default mode will simply trigger every step of a sequence no matter if the gate is enabled or disabled. Other fill modes allow to temporarily play steps from the next sequence or trigger steps that have the *Fill* condition set. To make things more interesting, each track also has a *Fill Amount* associated which is a probability value that controls how often a step is affected by the selected fill mode. This for example allows to morph between two patterns by selectively playing a given amount of steps from either pattern. Fills can then be controlled from the Performer page.

## Song

Songs are used to chain together a sequence of patterns for each track. This can either be used to quickly chain together patterns during a live performance to get more variation or to create an entire arrangement of a song.

A song consists of up to 64 slots, each holding a set of patterns to be played on the 8 tracks in addition to specifying for how many bars/measures the slot is played for. Songs are controlled from the Song page.

## Scale

In contrast to many other sequencers that directly operate on chromatic note values, the **PER|FORMER** sequencer is using the concept of voltage tables. Each note is stored as an index into a voltage table that does not necessarily have a specific musical meaning. While offering many of the more commonly used scales in form of presets, the sequencer also provides some scales beyond the typical western chromatic variants, for example a 24 tone equal temperament scale. The additional 4 user scales allow for even more experimentation as well as setting up voltage tables to specifically address discrete values of a CV input on another module. This allows for example to select a specific sample slot, choose a wavetable or similar applications.

A global default scale and root note can be specified on the Project page which can be overridden for individual sequences in the Sequence page. The user scales can be edited on the User Scale page. See Scales appendix for a list of all preset scales.

## Clock

The sequencer is driven by a flexible clock system. In master mode, the clock is generated internally and can be sent to external gear and modules using MIDI clock and analog clock signals. In slave mode, the clock is received from an external source via MIDI or analog clock signals. For convenience, the clock is set to an auto mode by default that automatically switches to master mode when the sequencer is started manually or switches to the slave mode when an external clock signal is detected.

To allow for accurate timing, the internal clock is running at a resolution of 192 parts per quarter note (PPQN). In master mode, a hardware timer is used to generate a low-jitter clock signal. To drive external clock signals, the internal clock is divided down to the required PPQN of the external clock signals. In slave mode, the external clock signal is multiplied internally to generate the 192 PPQN internal clock resolution, which in turn is used to clock the sequencer as well as the external clock signals.

The clock system is configured on the Clock page.

## Routing

Many of the parameters in the sequencer can be controlled from external signals. This is useful for both experimentation and for controlling the sequencer with additional controllers in a live performance. The following sources can be used in the routing system:

- 4 CV inputs
- 8 CV outputs (allows for cross modulation without patching)
- MIDI controllers (pitch bend, controller change, individual notes)

Each *route* is a mapping from a source signal to a parameter, including a mapping of the source range to a parameter range. For example, an external CV signal can be mapped to the master clock tempo such that -5V – +5V maps to 100 – 140 BPM.

The routing system also implements a MIDI learn function, which allows to easily map MIDI controllers to specific parameters. Routes can be created and edited on the Routing page.

## Controller

In addition to the routing system, specific MIDI controllers such as the Novation Launchpad can be used to control many aspects of the sequencer. This includes editing sequences, controlling mutes, launching patterns among other things.

Note: Launchpad is currently the only supported controller but others may follow.

See Launchpad for more details.

## File Management

The SD card can be used to store various resources such as projects, user scales and system settings. Resources are stored into slots, with each type having a total of 128 slots available. The actual content on the SD card looks as follows:

- **PROJECTS/**
  - **001.PRO**
  - **002.PRO**
  - ...
- **SCALES/**
  - **001.SCA**
  - **002.SCA**
  - ...
- **SETTINGS.DAT**

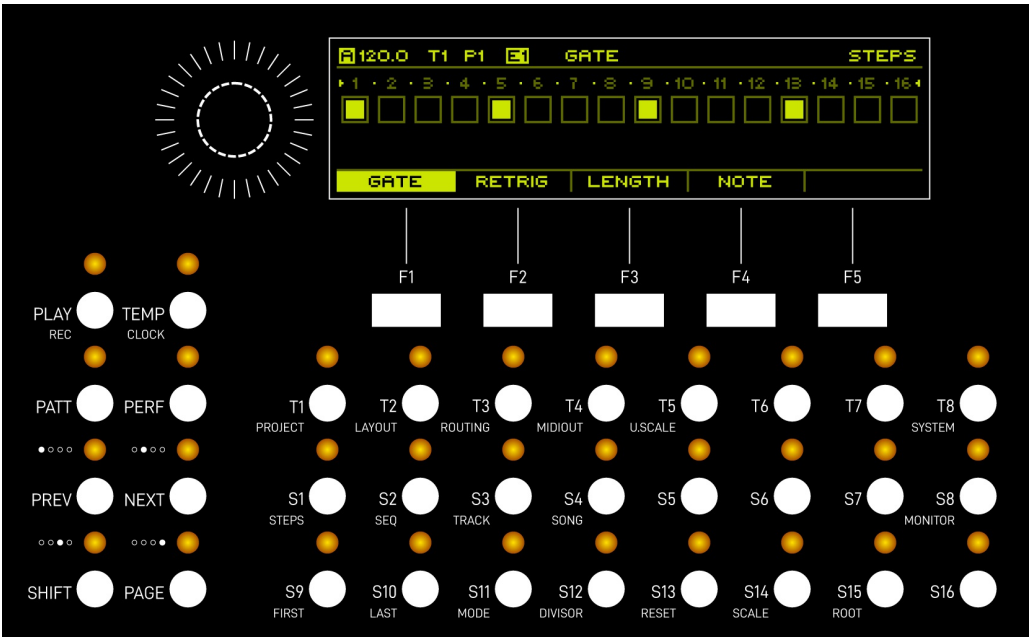
where **001.PRO** is the first project slot, **002.SCA** is the second user scale slot and **SETTINGS.DAT** is the backup of the system settings (also stored in on-chip flash memory).

The reason for using a slot system rather than traditional filenames is in order to allow for a smooth user experience while preserving the limited resources on the system.

Note: The SD card can easily be backed up to a computer by just copying the files. Slots can freely be rearranged by just renaming the files.

# User Interface

## Overview



The user interface of the **PER|FORMER** sequencer is made up from the following components:

- OLED display
- Rotary encoder with button
- 5 function buttons
- 32 buttons with bi-color LEDs

The rotary encoder will furthermore be denoted as **ENCODER**. The buttons are split into 4 groups:

### Function Buttons

There are 5 function buttons below the display: **F1**, **F2**, **F3**, **F4** and **F5**. The function associated with each button depends on the currently selected page and context. However, due to each function button being dynamically labeled on the display, its always easy to see what the associated functions are.

### Global Buttons

There are 8 global buttons: **PLAY**, **TEMP**, **PATT**, **PERF**, **PREV**, **NEXT**, **SHIFT** and **PAGE**.

All global buttons have fixed functions associated to them:

Button	Function
<b>PLAY</b>	Starts/stops the master clock.
<b>SHIFT</b> + <b>PLAY</b>	Pause/continue or restart master clock depending on the configured <i>Shift Mode</i> on the Clock page.
<b>PAGE</b> + <b>PLAY</b>	Enable/disable recording mode.
<b>TEMP</b>	Shows the Tempo page while being hold.
<b>PATT</b>	Shows the Pattern page while being hold.
<b>PERF</b>	Shows the Performer page while being hold.
<b>PREV</b> , <b>NEXT</b>	Navigate on a page, depends on current context.
<b>SHIFT</b>	Enable alternate function, depends on current context.
<b>PAGE</b>	Switch between pages.
<b>SHIFT</b> + <b>PAGE</b>	Show context menu for the active page.

### Track Buttons

There are 8 track buttons: **T1** to **T8**. These buttons are generally used to select the active track, but also to select pages in combination with the **PAGE** button and some other functions depending on the active page.

### Step Buttons

There are 16 step buttons: **S1** to **S16**. These buttons are generally used to select steps in a sequence, but also to select pages in combination with the **PAGE** button and some other functions depending on the active page.

### Navigation

The user interface is organized in multiple pages, each page giving access to a different part of the sequencer such as:

- Editing configuration options
- Editing sequences and steps
- Performance related functions such as tempo, muting or pattern selection
- Displaying various other information

The active page is selected by holding the **PAGE** button and pressing the corresponding page button:

Button	Page
<b>PAGE</b> + <b>CLOCK</b> ( <b>TEMP</b> )	Clock
<b>PAGE</b> + <b>PATT</b>	Pattern
<b>PAGE</b> + <b>PERF</b>	Performer
<b>PAGE</b> + <b>PROJECT</b> ( <b>T1</b> )	Project
<b>PAGE</b> + <b>LAYOUT</b> ( <b>T2</b> )	Layout
<b>PAGE</b> + <b>ROUTING</b> ( <b>T3</b> )	Routing
<b>PAGE</b> + <b>MIDIOUT</b> ( <b>T4</b> )	Midi Output
<b>PAGE</b> + <b>U. SCALE</b> ( <b>T5</b> )	User Scale
<b>PAGE</b> + <b>STEPS</b> ( <b>S1</b> )	Steps
<b>PAGE</b> + <b>SEQ</b> ( <b>S2</b> )	Sequence
<b>PAGE</b> + <b>TRACK</b> ( <b>S3</b> )	Track
<b>PAGE</b> + <b>SONG</b> ( <b>S4</b> )	Song
<b>PAGE</b> + <b>MONITOR</b> ( <b>S8</b> )	Monitor
<b>PAGE</b> + <b>SYSTEM</b> ( <b>T8</b> )	System
<b>PAGE</b> + <b>PREV</b>	Overview

There are 3 special pages which can be entered temporarily by just holding a single button, namely the Tempo, Pattern and Performer pages. These pages give access to performance related features which need to be quickly accessible at any time.

Note: While holding **PAGE**, the LEDs are used to indicate the currently selected page as well as marking the buttons associated with a page.

### Page Layout

Pages are divided into three sections.

#### Header

The *header* is used to display the global state of the sequencer and information about the active page and context.





The current clock mode and tempo are shown in the top-left corner. The clock mode can be any of the following:

- **A** Auto
- **M** Master
- **S** Slave

Instead of showing the clock mode, **R** is displayed when recording is enabled.

The currently selected track is shown as **T1** – **T8**. The currently playing pattern on the selected track is shown as **P1** – **P16**. If a song is currently playing, the playing pattern is highlighted. The currently edited pattern is shown as **E1** – **E16** and is highlighted if it matches the pattern that is currently playing. If a snapshot is currently active, the pattern info is replaced with a single item **SNAP**.

The currently active page is shown in the top-right corner and optionally a sub-page or mode is shown to its left.

### Body

The *body* is used to display the main content for the active page.



### Footer

The *footer* is used to display the labels of the function buttons for the current page.



On pages such as the Layout page, the function buttons are used to switch between different sub-pages. In that case, the currently active sub-page is highlighted in the footer.

On pages that provide a context menu, the labels dynamically change to the context menu actions when **SHIFT** + **PAGE** is hold.

### List Pages

Pages that expose configuration options are typically presented as a list of items, each having the name shown on the left and the value on the right side.

Rotate the **ENCODER** or use **PREV**, **NEXT** to navigate up and down the list. Press **ENCODER** to enter and leave edit mode which is indicated by moving the highlight from the item name to the item value and back. While in edit mode, rotate the **ENCODER** or use **PREV**, **NEXT** to adjust the value. Hold **SHIFT** to change the value in larger or smaller steps depending on the item being edited.

## Copy/Paste

To allow moving and copying data, a copy/paste system is implemented that allows acting on the following types of objects:

- Track (see Track page)
- Sequence (see Sequence page)
- Steps (see Steps page)
- Pattern (see Pattern page)
- User Scale (see User Scale page)

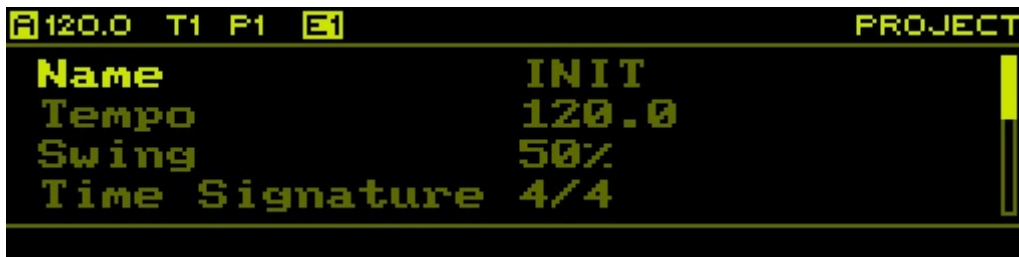
Copy/paste actions are provided in the context menu when holding **SHIFT** + **PAGE**.

Note: Due to memory limitations, the clipboard can only hold one object at a time and shares memory across all different types. This means that copying an object always results in the previously copied object being cleared from the clipboard.

## Pages

### Project

The *Project* page is entered using **PAGE** + **PROJECT**.



This page allows to change project wide parameters as well loading and saving projects from/to the SD card.

### Parameters

The following parameters are available:

Parameter	Range	Description
Name	–	Press <b>ENCODER</b> to enter text editor for changing the project name.
Tempo	1.0 – 1000.0 BPM	Tempo of the master clock.
Swing	50% – 75%	Global swing amount.
Time Signature	Beats/Note	Time signature defining the musical measure/bar length for <i>Sync Measure</i> and <i>Reset Measure</i> on sequences. The time signature is also used to define the length of a bar in song mode.
Sync Measure	1 – 128 bars	Multiple of measures/bars at which to execute <i>syncing</i> (see Pattern and Performer pages).
Scale	Scales	Default scale. Can be overwritten per sequence on the Sequence page.
Root Note	C, C#, D, D#, E, F, F#, G, G#, A, B	Default root note. Can be overwritten per sequence on the Sequence page.
Record Mode	Overdub, Overwrite, Step Record	Recording mode (see Recording).
CV/Gate Input	Off, CV1/CV2, CV3/CV4	Enable CV/Gate input on CV inputs for monitoring and recording (equivalent to a MIDI keyboard).
Curve CV Input	Off, CV1, CV2, CV3, CV4	Select CV input for curve recording.

Note: *Tempo* and *Swing* are routable parameters.

### Context Menu

Hold **SHIFT** + **PAGE** to open the context menu and access the following functions:

Button	Function	Description
<b>F1</b>	Init	Initialize the project to its default state. This will revert all unsaved changes.
<b>F2</b>	Load	Load a project from the SD card.
<b>F3</b>	Save	Save the project to the SD card and automatically overwrite the previous slot.

<b>F4</b>	Save As	Save the project to a new slot on the SD card.
<b>F5</b>	Route	Show existing or create a new route for the currently selected parameter (only active if selected parameter is routable).

Note: Should you ever get bored sequencing, take a break and hit **PAGE** + **S16**.

## Layout

The *Layout* page is entered using **PAGE** + **LAYOUT**. This page has 4 tabs accessed through **F1**, **F2**, **F3** and **F4**.

### Track Mode

The first tab is used to configure the track mode of each track.

<b>120.0</b>	<b>T1</b>	<b>P1</b>	<b>31</b>	<b>TRACK MODE</b>	<b>LAYOUT</b>
<b>Track1</b>				<b>Note</b>	
<b>Track2</b>				<b>Note</b>	
<b>Track3</b>				<b>Note</b>	
<b>Track4</b>				<b>Note</b>	
<b>MODE</b>	<b>LINK</b>	<b>GATE</b>	<b>CV</b>		

Changing track mode results in all data associated with a given track to be erased. Because of this, when setting a new track mode, it only takes effect after manually committing the change by pressing **F5**.

<b>120.0</b>	<b>T1</b>	<b>P1</b>	<b>31</b>	<b>TRACK MODE</b>	<b>LAYOUT</b>
<b>Track1</b>				<b>Curve</b>	
<b>Track2</b>				<b>Note</b>	
<b>Track3</b>				<b>Note</b>	
<b>Track4</b>				<b>Note</b>	
<b>MODE</b>	<b>LINK</b>	<b>GATE</b>	<b>CV</b>	<b>COMMIT</b>	

### Link Track

The second tab is used to setup track linking. Each of the 8 tracks can be linked to any of the preceding tracks, taking over its playback behavior.

<b>120.0</b>	<b>T1</b>	<b>P1</b>	<b>31</b>	<b>LINK TRACK</b>	<b>LAYOUT</b>
<b>Track1</b>				<b>None</b>	
<b>Track2</b>				<b>None</b>	
<b>Track3</b>				<b>None</b>	
<b>Track4</b>				<b>None</b>	
<b>MODE</b>	<b>LINK</b>	<b>GATE</b>	<b>CV</b>		

Note: A track can only be linked to a preceding track due to the internal architecture of the sequencer. This means that track 1 cannot use track linking, while track 2 can only be linked to track 1. Track 8 on the other hand can be linked to any of the tracks 1–7.

## Gate Output

The third tab is used to setup the mapping of virtual track gate outputs to the physical gate outputs. In default state, each track is linked to the corresponding gate output with the same number.

120.0	T1	P1	31	GATE OUTPUT		LAYOUT
Gate1		Track1:Gate				
Gate2		Track2:Gate				
Gate3		Track3:Gate				
Gate4		Track4:Gate				
MODE		LINK		GATE		CV

## CV Output

The fourth tab is used to setup the mapping of virtual track CV outputs to the physical CV outputs. In default state, each track is linked to the corresponding CV output with the same number.

120.0	T1	P1	31	CV OUTPUT		LAYOUT
CV1		Track1:CV				
CV2		Track2:CV				
CV3		Track3:CV				
CV4		Track4:CV				
MODE		LINK		GATE		CV

If using a MIDI/CV track, it can be useful to map multiple virtual outputs of the track to physical outputs to allow for polyphonic signals or add modulation signals such as velocity or aftertouch. The following shows a configuration with two note polyphony and pitch/velocity signals.

120.0	T1	P1	31	CV OUTPUT		LAYOUT
CV1		Track1:V/Oct1				
CV2		Track1:V/Oct2				
CV3		Track1:Vel1				
CV4		Track1:Vel2				
MODE		LINK		GATE		CV

## Track

The *Track* page is entered using **PAGE** + **TRACK**.

120.0	T1	P1	31	NOTE		TRACK
Play Mode		Aligned				
Fill Mode		Gates				
CV Update Mode		Gate				
Slide Time		50%				

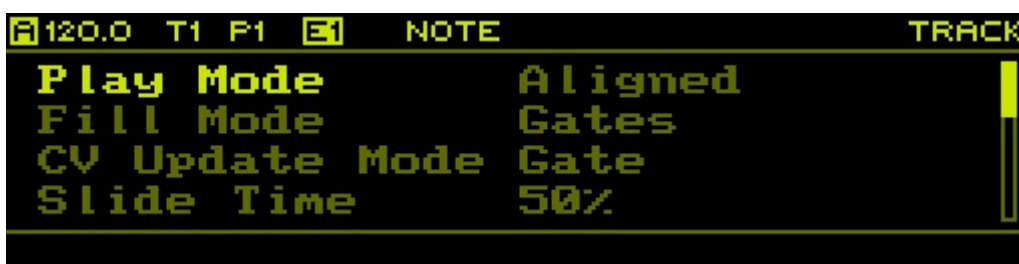
This page allows to change track wide settings. Note that the shown parameters depend on the configured *Track Mode* of the selected track. Press **T[1-8]** to change the selected track.

## Context Menu

Hold **SHIFT** + **PAGE** to open the context menu and access the following functions:

Button	Function	Description
<b>F1</b>	Init	Initialize the selected track and all its content to the default state.
<b>F2</b>	Copy	Copy the selected track and all its content to the clipboard.
<b>F3</b>	Paste	Paste the clipboard to the selected track.
<b>F4</b>	Route	Show existing or create a new route for the currently selected parameter (only active if selected parameter is routable).

## Note Track

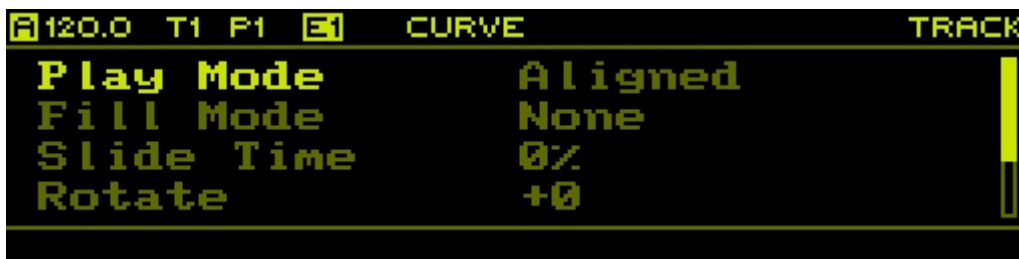


If a track is in *Note* mode, the following parameters are available:

Parameter	Range	Description
Play Mode	Play Modes	Mode used for playing sequences in this track.
Fill Mode	None, Gates, Next Pattern, Condition	Mode used when fill is activated for the track. <i>None</i> does nothing. <i>Gates</i> plays each step of the sequence independent of whether the step gate is active or not. <i>Next Pattern</i> uses the step data of the next pattern on the same track. <i>Condition</i> plays steps that have the <i>Fill</i> condition set, and does not play steps that have the <i>!Fill</i> condition set.
CV Update Mode	Gate, Always	Mode used for updating the CV output of this track. <i>Gate</i> only updates the CV output if the step gate is active, <i>Always</i> always updates the CV output independent of the step gate.
Slide Time	0% – 100%	Duration of voltage slides for steps that have <i>Slide</i> enabled.
Octave	-10 – +10	Number of octaves to transpose the sequence up or down.
Transpose	-100 – +100	Number of notes to transpose the sequence up or down. Note that this depends on the current Scale of the sequence.
Rotate	Rotation	Amount of rotation applied to the sequence.
Gate P. Bias	-100% – +100%	Gate probability bias that is added to the sequence.
Retrig P. Bias	-100% – +100%	Retrigger probability bias that is added to the sequence.
Length Bias	-100% – +100%	Length bias bias that is added to the sequence.
Note P. Bias	-100% – +100%	Note variation probability bias that is added to the sequence.

Note: *Slide Time*, *Octave*, *Transpose*, *Rotate*, *Gate P. Bias*, *Retrig P. Bias*, *Length Bias* and *Note P. Bias* are routable parameters. These parameters are great for live performance, as they allow to change how the sequence is played back without actually changing the sequence itself.

## Curve Track



If a track is in *Curve*, the following parameters are available:

Parameter	Range	Description
Play Mode	Play Modes	Mode used for playing sequences in this track.
Fill Mode	None, Variation, Next Pattern, Invert	Mode used when fill is activated for the track. <i>None</i> does nothing. <i>Variation</i> plays the curve shapes defined in the <i>Shape Variation</i> layer independent of their probability. <i>Next Pattern</i> uses the step data of the next pattern on the same track. <i>Invert</i> plays the curve shapes inverted.
Slide Time	0% – 100%	Global slide time (slew limiter) applied to curve.
Rotate	Rotation	Amount of rotation applied to the sequence.
Shape P. Bias	-100% – +100%	Shape probability bias that is added to the sequence.
Gate P. Bias	-100% – +100%	Gate probability bias that is added to the sequence.

Note: *Slide Time*, *Rotate*, *Shape P. Bias* and *Gate P. Bias* are routable parameters.

## MIDI/CV Track



If a track is in MIDI/CV mode, the following parameters are available:

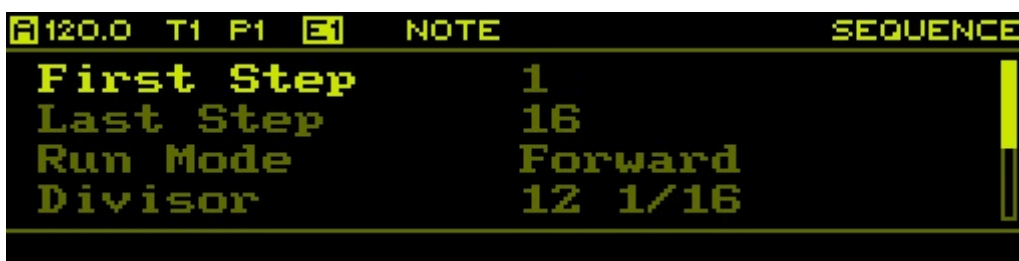
Parameter	Range	Description
Source	MIDI, USB	MIDI source port (hold <b>SHIFT</b> and rotate <b>ENCODER</b> to select MIDI channel).
Voices	1 – 8	Number of voices.
Voice	Pitch, Pitch+Vel,	CV signals to generate for each voice.

Config	Pitch+Vel+Press	
Note Priority	Last Note, First Note, Lowest Note, Highest Note	Determines which active notes have the highest priority to be output.
Low Note	C-1 – G9	Low MIDI note of the key range this track listens to.
High Note	C-1 – G9	High MIDI note of the key range this track listens to.
Pitch Bend	off, 1 – 48 semitones	Pitch bend range.
Mod Range	1-5V Unipolar, 1-5V Bipolar	CV output voltage range for modulation signals (velocity and pressure).
Retrigger	no, yes	Retrigger voices on each received <i>Note On</i> MIDI message.
Arpeggiator	no, yes	Enable arpeggiator mode.
Hold	no, yes	Hold chords in arpeggiator after keys are released.
Mode	Arpeggiator Modes	Arpeggiator mode (sequence).
Divisor	Divisors	Divisor for arpeggiator sequence.
Gate Length	1-100%	Gate length generated notes.
Octaves	Off, Up 1-5, Up Down 1-5, Down 1-5, Down Up 1-5	Order and number of octaves to play the arpeggiator sequence over. The note order is reverse when playing <i>down</i> the octaves.

Note: *Low Note* and *High Note* can be used to setup key ranges such that multiple MIDI/CV tracks can be played in split keyboard mode.

## Sequence

The *Sequence* page is entered using **PAGE** + **SEQ**.



This page allows to change the sequence settings of the currently selected sequence on the selected track. Note that the shown parameters depend on the configured *Track Mode* of the selected track. Press **T[1-8]** to change the selected track. Hold **PATT** and rotate the **ENCODER** to change the selected sequence.

For quick access to most of the sequence parameters, there is also a quick edit mode on the Steps page, introduced in the next section.

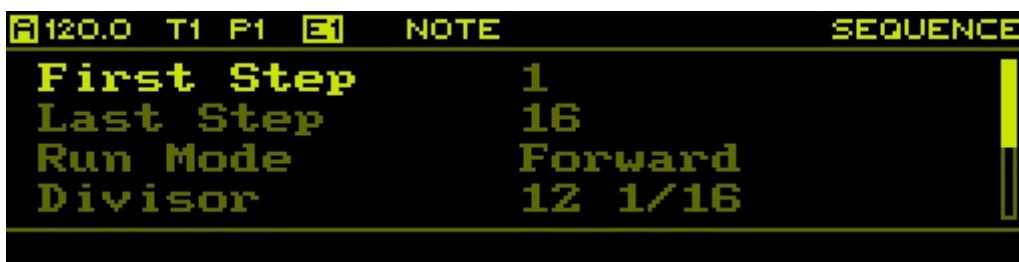
## Context Menu

Hold **SHIFT** + **PAGE** to open the context menu and access the following functions:

Button	Function	Description
<b>F1</b>	Init	Initialize the selected sequence and all its content to the default state.
<b>F2</b>	Copy	Copy the selected sequence and all its content to the clipboard.
<b>F3</b>	Paste	Paste the clipboard to the selected sequence.
<b>F4</b>	Duplicate	Copy the selected sequence to the next sequence on the selected track. For example copy of the first sequence to the second sequence.

## Note Track

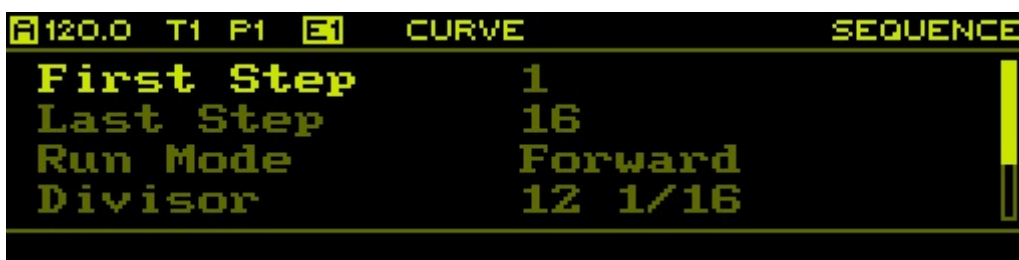




If a track is in *Note* mode, the following parameters are available:

Parameter	Range	Description
First Step	1 – 64	First step to play. Hold <b>SHIFT</b> to edit both first and last step together.
Last Step	1 – 64	Last step to play. Hold <b>SHIFT</b> to edit both first and last step together.
Run Mode	Run Modes	Mode in which to play the sequence.
Divisor	Divisors	Time divisor for this sequence.
Reset Measure	off, 1 – 128 bars	Number of measures/bars at which to reset the sequence.
Scale	Scales	Scale to use for this sequence. If set to <i>Default</i> , uses the default scale set on the Project page.
Root Note	C, C#, D, D#, E, F, F#, G, G#, A, B	Root note to use for this sequence. If set to <i>Default</i> , uses the default root note set on the Project page.

## Curve Track

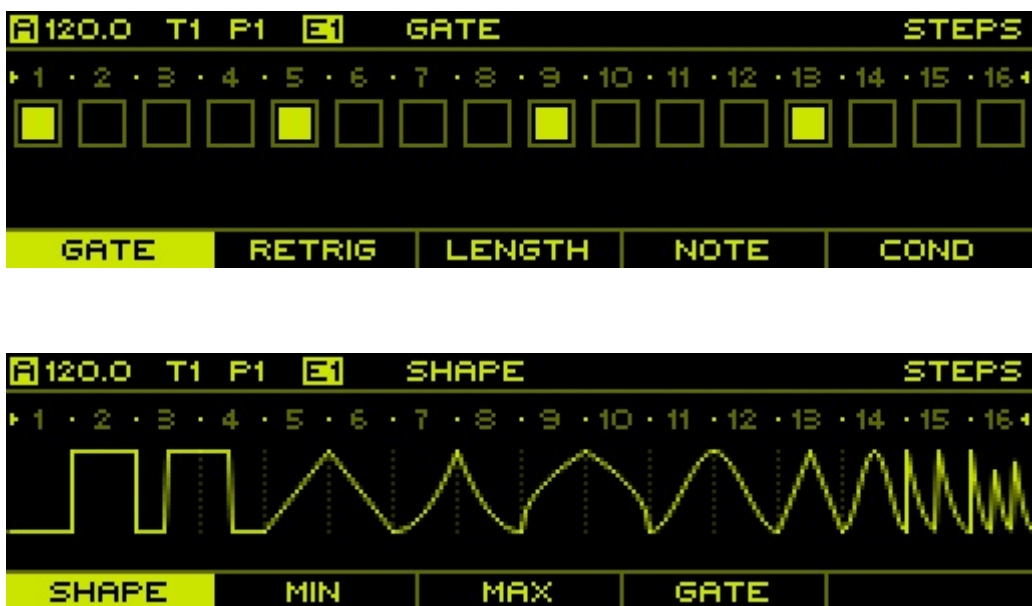


If a track is in *Curve* mode, the following parameters are available:

Parameter	Range	Description
First Step	1 – 64	First step to play. Hold <b>SHIFT</b> to edit both first and last step together.
Last Step	1 – 64	Last step to play. Hold <b>SHIFT</b> to edit both first and last step together.
Run Mode	Run Modes	Mode in which to play the sequence.
Divisor	Divisors	Time divisor for this sequence.
Reset Measure	off, 1 – 128 bars	Number of measures/bars at which to reset the sequence.
Range	1V – 5V Unipolar, 1V – 5V Bipolar	Voltage range to use for this sequence.

## Steps

The *Steps* page is entered using **PAGE** + **STEPS**.



This page allows editing the currently selected sequence on the currently selected track. Depending on the track mode of the selected track, this page shows a different graphical representation of the sequence. If track mode is set to *MIDI/CV*, the page is not available and selecting it will jump to the Track page.

**Layer Selection**

Sequence data is organized in layers (see Note Track and Curve Track). Press **F1**, **F2**, **F3**, **F4** or **F5** to select different layers. The currently selected layer is shown in the header and the graphical representation of the sequence will change accordingly. Note that each function button can represent a group of layers, in which case pressing the same function button repeatedly will cycle through the layers contained in the group. Press **SHIFT** + **F[1-5]** to quickly switch to the first layer of a group.

The following layers are available in *Note* mode:

Button	Layers
<b>F1</b>	Gate, Gate Probability, Gate Offset, Slide
<b>F2</b>	Retrigger, Retrigger Probability
<b>F3</b>	Length, Length Variation Range, Length Variation Probability
<b>F4</b>	Note, Note Variation Range, Note Variation Probability
<b>F5</b>	Condition

Note: See Step Conditions for a description of the different step conditions.

The following layers are available in *Curve* mode:

Button	Layers
<b>F1</b>	Shape, Shape Variation, Shape Variation Probability
<b>F2</b>	Minimum
<b>F3</b>	Maximum
<b>F4</b>	Gate, Gate Probability

**Section Selection**

Sequences contain up to 64 steps, of which only 16 are shown on the page. Press **PREV** and **NEXT** to select one of the 4 available sections (1–16, 17–32, 33–48, 49–64). The currently selected section is indicated by the 4 LEDs in the bottom left corner as well as with the step indices above each step on the page.

## Editing Steps

To adjust the values of the currently selected layer, hold **S[1-16]** and rotate the **ENCODER**. To adjust multiple steps at the same time, hold multiple step buttons and rotate the **ENCODER**. The currently selected steps are visualized both on the page by highlighting the step indices as well as on the step LEDs which turn orange. When adjusting multiple steps, the values are adjusted relative to their current value. Depending on the track mode and the selected layer, there is some additional functionality available:

- When editing the *Gate* layer on a sequence of a *Note* track, pressing **S[1-16]** enables/disables the gate values.
- When editing any other layer on a sequence of a *Note* track, holding one or multiple step buttons and pressing the **ENCODER** enables/disables the gate values. This comes in handy for example when editing note values, as gates can easily be enabled/disabled without switching layers.
- When editing the *Note* layer, notes can be entered by holding **S[1-16]** and pressing keys on an external MIDI keyboard.
- When editing the *Note* or *Note Range* layer on a sequence with a chromatic scale, holding **SHIFT** and rotating the **ENCODER** will move notes up and down by octaves.
- When editing layers on a sequence of a *Curve* track, pressing and rotating the **ENCODER** adjusts the values in smaller steps.
- When editing the *Min* or *Max* layer on a sequence of a *Curve* track, pressing **SHIFT** or **ENCODER** and rotating the **ENCODER** will adjust the value in smaller steps.
- When editing the *Min* or *Max* layer on a sequence of a *Curve* track while holding **F2** or **F3**, the curve shape is offset up and down (adjusting min/max at the same time).

## Advanced Step Selection

When holding **SHIFT** and pressing any of the step buttons, steps are selected in a *persistent* mode. This means that steps are kept selected even when the step buttons are released. This allows to select multiple steps across different sections. Steps can also be removed from the selection by holding **SHIFT** and pressing step buttons corresponding to selected steps again. To clear the entire selection, simply press any step button without holding **SHIFT** or quickly press **SHIFT** twice (double tap). When the selection is empty, double tap **SHIFT** to select all 64 steps.

There are two additional functions for selecting groups of steps. To select a series of steps, for example steps 1, 5, 9, 13 and so forth, hold **SHIFT** and **S1** and then double tap **S5** while holding the other two buttons. With this function, any series of steps with a common interval can be selected quickly, great to build rhythms. To select all steps that have the same value on the currently selected layer, hold **SHIFT** and double tap one of the step keys.

Note: When selecting groups of steps they are added to the current selection. This allows to quickly combine multiple groups of steps into a single selection.

## Shifting Steps

Press **SHIFT** + **PREV** or **SHIFT** + **NEXT** to shift all steps in the sequence to the left or right. This has the same effect as Rotation, but instead of changing the playback position, shifting actually moves the steps in the sequence itself.

## Context Menu

Hold **SHIFT** + **PAGE** to open the context menu and access the following functions:

Button	Function	Description
<b>F1</b>	Init	Initialize all steps of the current sequence to the default state.
<b>F2</b>	Copy	Copy the selected steps to the clipboard.
<b>F3</b>	Paste	Paste steps in the clipboard to the selected steps.
<b>F4</b>	Duplicate	Doubles the length of the sequence between <i>First Step</i> and <i>Last Step</i> and copies the first half to the second half.

Copy/Paste only works with steps selected in *persistent* mode. When more steps are pasted than copied to the clipboard, the steps will be repeated multiple times. This means that for example one can copy 2 steps and then paste them to 8 steps, creating a repetition of the two copied steps.

## Quick Access

The *Steps* page is one of the most frequently used pages when operating the sequencer. To change sequence parameters such as the *Run Mode*, *First Step*, *Last Step* and others, one needs to temporarily switch to the Sequence page. This breaks the workflow, especially when in a live situation, where immediate access to the most important features and parameters is paramount. To help improve the workflow, most of the sequence parameters can be accessed through a quick access function. To access a parameter, hold **PAGE** and press **S[9-16]**, similarly to switching between pages, but keep holding the **PAGE** button. The page is now overlaid with the selected parameter.



Depending on the *Track Mode*, the following parameters are available through quick access:

Button	Note Track	Curve Track
S9	First Step	First Step
S10	Last Step	Last Step
S11	Run Mode	Run Mode
S12	Divisor	Divisor
S13	Reset Measure	Reset Measure
S14	Scale	Range
S15	Root Note	-
S16	-	-

While holding the **PAGE** button, the selected sequence parameter can be adjusted by rotating the **ENCODER** or by pressing **S[1-16]** to select the most common values. Releasing the **PAGE** button will return to the normal state of the steps page.

Note: When quick access is active, the step LEDs will indicate the range of values that can be selected in green as well as the current selection in red.

Note: Pressing the **ENCODER** while rotating it has the same effect as pressing **SHIFT** when editing the same parameter through the menu.

### Song

The *Song* page is entered using **PAGE** + **SONG**.



A song consists of up to 64 slots, each referencing a set of 8 patterns to be played on the 8 tracks. Each slot is played for a number of bars/measures which duration is defined by the *Time Signature* on the Project page.

### Context Menu

Hold **SHIFT** + **PAGE** to open the context menu and access the following functions:

Button	Function	Description
<b>F1</b>	Init	Initialize the song.

### Pattern Chaining

A quick way to create songs on the fly is pattern chaining. This function is specifically made for live performance to quickly create more interesting structures by chaining multiple patterns together.

To create a pattern chain, hold **F1** and press **S[1-16]** to select the pattern to be played for the newly created slot. If the same pattern is added multiple times by pressing **S[1-16]** again, the bar/measure count of the last added slot is incremented. For example, holding **F1** and pressing the sequence **S1**, **S1**, **S1**, **S2**, **S1**, **S1**, **S1**, **S3** will create the following slot list:

SONG										
#	N	T1	T2	T3	T4	T5	T6	T7	T8	
1	3	P1	P1	P1	P1	P1	P1	P1	P1	
2	1	P2	P2	P2	P2	P2	P2	P2	P2	
3	3	P1	P1	P1	P1	P1	P1	P1	P1	
4	1	P3	P3	P3	P3	P3	P3	P3	P3	
CHAIN		ADD		REMOVE		DUPL		PLAY		

Note: When creating a pattern chain, the song is immediately activated for playback and the sequencer clock is started if not already running.

### Editing Slots

- Rotate the **ENCODER** or use **PREV** and **NEXT** to select a slot in the list.
- Press **F2** to add a slot at the end of the list.
- Press **SHIFT** + **F2** to insert a slot at the current cursor position.
- Press **F3** to remove the selected slot.
- Press **F4** to duplicate the selected slot.
- Hold **SHIFT** and press **PREV** or **NEXT** to move the selected slot backward and forward in the list.
- Hold **SHIFT** and rotate the **ENCODER** to adjust the number of bars/measures a slot is played for.
- Hold **SHIFT** and press **S[1-16]** to selected the number of bars/measures (1-16).
- Press **S[1-16]** to assign a pattern to all tracks of the selected slot.
- Hold any combination of **T[1-8]** and rotate the **ENCODER** to adjust the patterns of a group of tracks of the selected slot.
- Hold any combination of **T[1-8]** and press **S[1-16]** to assign a pattern to a group of tracks of the selected slot.

### Playback

Song playback can be started and stopped independently of the sequencer actually running. This allows to engage song playback while the sequencer is already running, or stop song playback without stopping the sequencer. When song playback is activated, the sequencer simply changes the playing patterns automatically and in sync.

Press **F5** to start playback of the song from the currently selected slot. This will also start the sequencer if it is not already running. Playback will be immediate, meaning that the currently playing pattern is switched instantaneously. To start playback on the next *Sync Measure*, use **SHIFT** + **F5**. A progress bar will appear at the top of the page, indicating the time until playback is started. To stop playback, simply press **F5** again. Playback can also be started by selecting a slot and pressing the **ENCODER**. This is also useful quickly switch to a different slot while playback is active. Again, to switch slot on the next *Sync Measure*, hold **SHIFT** and press the **ENCODER**.

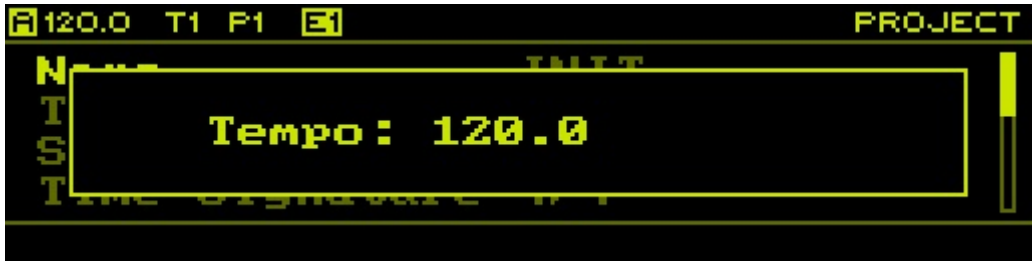
During playback, the current slot is indicated with a small arrow and also shown on the left side together with a progress bar, indicating the duration for which the slot is played for. In the top left corner, the current bar and note is also displayed.

120.0	T1	P1	S1	SONG							
1.4	#	N	T1	T2	T3	T4	T5	T6	T7	T8	
S1	1	3	P1	P1	P1	P1	P1	P1	P1	P1	
	2	1	P2	P2	P2	P2	P2	P2	P2	P2	
	3	3	P1	P1	P1	P1	P1	P1	P1	P1	
	4	1	P3	P3	P3	P3	P3	P3	P3	P3	
CHAIN	ADD	REMOVE	DUPL	STOP							

Note: Song mode can also be used to toggle between different sets of patterns. Simply use slots to define the pattern sets and then select a slot and press **F5** twice to quickly start/stop song playback to switch to a new set of patterns.

### Tempo

The *Tempo* page is temporarily shown while holding **TEMP**.



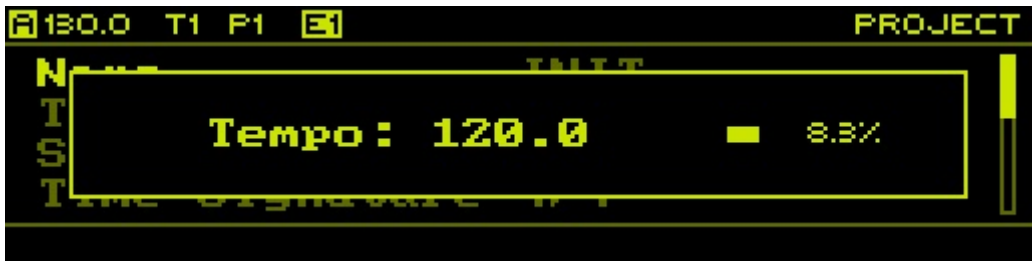
On this page the tempo of the master clock is adjusted. Simply rotate the **ENCODER** to adjust the tempo. Press and rotate the **ENCODER** to adjust the tempo in smaller steps. Hold **SHIFT** and rotate the **ENCODER** to adjust in larger steps.

#### Tap Tempo

In addition to manually adjusting the tempo, it can also be set using tap tempo by pressing **PLAY** in a regular interval while holding **TEMP**.

#### Nudging

To sync the master clock by ear to some other source, for example a turntable, tempo nudging is a useful feature. This allows the tempo to be temporarily increased/decreased within a 10% range. Nudging is activated by holding **TEMP** and holding **NEXT** or **PREV** to increase/decrease the tempo. The amount of tempo change due to nudging is visualized on the tempo page.



Note: The tempo is incrementally increased/decreased up to 10%, so one needs to hold both **TEMP** and **NEXT** or **PREV** for a small amount of time to get an effect.

### Pattern

The *Pattern* page can either be permanently entered using **PAGE** + **PATT** or just temporarily while holding **PATT**.



On this page you can handle pattern changes as well as selecting the currently edited pattern. Pattern changes can be scheduled by using *latching* or *syncing*. In addition, this page gives access to the snapshot system and allows for copy/pasting patterns.

Note: The currently playing *Pattern* can be selected as a routing target on the Routing page.

### Editing Pattern

To change the pattern for editing which is indicated in the header as **E[1-16]** simple rotate the **ENCODER** or press **PREV** and **NEXT**. Alternatively you can use **SHIFT** + **S[1-16]** to select the editing pattern.

Note: The editing pattern indicated in the header is highlighted if the selected pattern for editing is the same as the currently playing pattern.

### Pattern Changes

To change to any of the 16 patterns press **S[1-16]**. This will switch all tracks to play the selected pattern immediately. To only switch patterns for certain tracks, hold any combination of **T[1-8]** and then select the pattern using **S[1-16]**.

### Latching Pattern Changes

To perform multiple pattern changes at the same time, hold **F1** while performing pattern changes. All changes are scheduled and executed together when **F1** is let go. While **F1** is hold and some changes have been scheduled, you can press **F5** to cancel them.

Note: When using the temporary mode of the performer page by holding **PATT**, you can let go of **PATT** while holding **F1** and keep the page open.

### Synced Pattern Changes

To execute pattern changes on a musical beat, hold **F2** while performing pattern changes. A progress bar will appear at the top of the page, indicating the time until the changes are executed. Again, while holding **F2** you can press **F5** to cancel any scheduled changes.

Note: When using the temporary mode of the performer page by holding **PATT**, you can let go of **PATT** while holding **F2** and keep the page open.

Note: Synced actions are triggered on the beginning of a musical measure, configured on the Project page using the *Sync Measure* parameter.

### Snapshots

Snapshots are a useful tool to quickly make a temporary copy of all patterns currently playing and later take over the changes or throw them away.

Press **F3** create a snapshot of the patterns currently being played.

Note that the pattern indicators at the top-left of the screen change to **SNAP**, indicating that snapshot mode is active. While in snapshot mode, all functions of the sequencer remain working as expected, with the only exception that patterns cannot be changed on the Pattern page.

After editing the snapshot, press **F4** to commit the changes back to the original patterns. To commit the changes to a new set of patterns, press **S[1-16]** + **F4**. This will automatically change all tracks to play the selected pattern after the snapshot is committed.

Press **F3** to revert the edits done on the snapshot and go back to playing the set of patterns that have been playing before taking the snapshot. Press **S[1-16]** + **F3** to revert the snapshot but continue playing a new set of patterns.

## Performer

The *Performer* page can either be permanently entered using **PAGE** + **PERF** or just temporarily while holding **PERF**.



On this page you can handle mutes/solos as well as fills. Similar as with pattern changes you can also schedule mute, unmute or solo actions either by using *latching* or *syncing*.

The temporary mode is very handy to quickly trigger performance actions while working on another page.

The page visualizes the current mute state for every track. In addition, the currently playing step of a sequence is visualized right below. Finally, a percentage bar is used to visualize the current *Fill* state and the selected *Fill Amount*.

Note: *Mute*, *Fill* and *Fill Amount* can be selected as routing targets on the Routing page to be controlled from external sources or even internal sequences.

## Mutes/Solos

Press **T[1-8]** to mute and unmute tracks or **SHIFT** + **T[1-8]** to solo a track. Press **F3** to unmute all tracks at once.

## Latching Mutes/Solos

To perform multiple actions at the same time, hold **F1** while executing mute, unmute or solo actions. All actions are scheduled and executed together when **F1** is let go. While **F1** is hold and some actions have been scheduled, you can press **F5** to cancel them.

Note: When using the temporary mode of the performer page by holding **PERF**, you can let go of **PERF** while holding **F1** and keep the page open.

## Synced Mutes/Solos

To execute actions on a musical beat, hold **F2** while executing mute, unmute or solo actions. A progress bar will appear at the top of the page, indicating the time until the actions are executed. Again, while holding **F2** you can press **F5** to cancel any scheduled action.

Note: When using the temporary mode of the performer page by holding **PERF**, you can let go of **PERF** while holding **F2** and keep the page open.

Note: Synced actions are triggered on the beginning of a musical measure, configured on the Project page using the *Sync Measure* parameter.



## Fills

Hold **S[9-16]** to temporarily enable fills on individual tracks. Press **SHIFT** + **S[9-16]** to permanently enable fill on a track and disable fill by simply pressing **S[9-16]** again later on. Hold **F4** to temporarily fill all tracks at once. Press **SHIFT** + **F4** to permanently enable fill on all tracks.

To control the *Fill Amount* of a track, hold **S[1-8]** and rotate the **ENCODER**.

Note: There are different fill modes that can be configured per track on the Track page using the *Fill Mode* parameter.

## Routing

The *Routing* page is entered using **PAGE** + **ROUTING**.



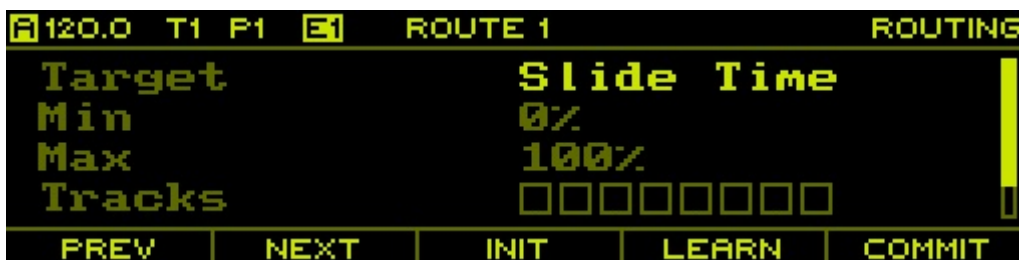
There is a maximum of 16 routes that can be set up. Press **F1** and **F2** or hold **SHIFT** and rotate the **ENCODER** to select the route to edit.

To create a new route, select one of the empty routes that has *Target* value set to *None*. Then press the encoder to select a routing target by rotating the **ENCODER**.

Note: Most routable parameters can alternatively be set up from the page where the parameter is exposed (Project and Track pages) by using the context menu and selecting *Route*. This automatically switches to the *Routing* page and sets up the next available route for the chosen parameter, or selects the previously created route.

Once the routing target is selected, the following parameters are available for configuration:

Parameter	Range	Description
Target	Routable Parameters	Target parameter to affect by this route.
Min	–	Value to set the target parameter to when source is at the minimum value.
Max	–	Value to set the target parameter to when source is at the maximum value.
Tracks	–	Target tracks to affect by this route. Only available if selected target parameter is a track parameter. Press <b>ENCODER</b> to edit the value and press <b>T[1-8]</b> to select which tracks are affected.
Source	None, CV In 1-4, CV Out 1-8, MIDI	Source signal to use. <i>CV In 1-4</i> correspond to the physical CV inputs. <i>CV Out 1-8</i> correspond to the CV output signals generated by the sequencer. <i>MIDI</i> uses events from either MIDI or USB.
Range	1V – 5V Unipolar, 1V – 5V Bipolar	Voltage range to use for the CV source. Only available if source is set to a <i>CV In 1-4</i> or <i>CV Out 1-8</i> .
MIDI Source	MIDI, USB	MIDI port and channel used for the source. Only available when source is set to <i>MIDI</i> .
MIDI Event	CC Absolute, CC Relative, Pitch Bend, Note Momentary, Note Toggle, Note Velocity, Note Range	MIDI event to use as the source signal. Only available when source is set to <i>MIDI</i> .
CC Number	0 – 127	MIDI CC number to use as the source signal. Only available if MIDI Event is set to <i>CC Absolute</i> or <i>CC Relative</i> .



When changing the route parameters, they will not immediately be active. Press **F5** to commit the changes and make the new configuration active. An existing route can be reset to its default state by pressing **F3**. Again, the change has no effect before being committed using **F5**.

In order to simplify assigning MIDI controllers to target parameters, press **F4** to enter MIDI learn mode. Simply rotate an encoder or press a key/button on the connected MIDI controller to assign it to the target parameter. MIDI learn mode is active when the *Learn* button is highlighted. Press **F4** again to exit MIDI learn mode without assigning a MIDI controller.

Note: Routed parameters are marked with an arrow when displayed on other pages.

## Midi Output

The *Midi Output* page is entered using **PAGE** + **MIDIOUT**.



There is a maximum of 8 MIDI outputs that can be set up. Press **F1** and **F2** or hold **SHIFT** and rotate the **ENCODER** to select the MIDI output to edit.

Each of the MIDI outputs can be configured to either output note or control change messages derived from any of the 8 tracks of the sequencer.

To make things interesting, note data can be generated by using multiple sequencer tracks, e.g. different tracks can be used as the gate, note and velocity source. The generated note messages are still monophonic, but by combining multiple tracks of potentially different lengths, divisors and play modes, interesting MIDI sequences can be generated.

The following parameters are available for configuration:

Parameter	Range	Description
Target	MIDI, USB	MIDI port and channel used for sending MIDI data.
Event	None, Note, CC	MIDI event to generate. <i>None</i> generates no events, <i>Note</i> generates MIDI note on/off events, <i>CC</i> generates MIDI control change events.

When configured to *Note* event, the following additional parameters are available for configuration:

Parameter	Range	Description
Gate Source	Track 1–8	Sequencer track to use as the note gate source.

Note Source	Track 1–8, C–1 – G9	Sequencer track to use as the note source or a constant MIDI note.
Vel. Source	Track 1–8, 0–127	Sequencer track to use as the velocity source or a constant velocity value.

The *Gate Source* controls the generation of MIDI note on/off events. Notes span multiple steps (legato) if step length is set to maximum. The *Note Source* controls the MIDI note and is derived from a V/Oct CV signal with 0V being a C4. The *Vel. Source* controls the note velocity and is derived from a unipolar 5V signal which is mapped to 0–127. If the *Gate Source* contains a slide layer, slides are output as MIDI CC 65 events (portamento on/off). When the sequencer is reset, a MIDI CC 120 event (all notes off) is sent.

When configured to *CC* event, the following additional parameters are available for configuration:

Parameter	Range	Description
Control Number	0 – 127	Control number to use for the event.
Control Source	Track 1–8	Sequencer track to use as the control value source.

The *Control Source* controls the MIDI CC values and is derived from a unipolar 5V signal which is mapped to 0–127.

When changing the MIDI output parameters, they will not immediately be active. Press **F5** to commit the changes and make the new configuration active. An existing MIDI output configuration can be reset to its default state by pressing **F3**. Again, the change has no effect before being committed using **F5**.

## User Scale

The *User Scale* page is entered using **PAGE** + **U.SCALE**.



On this page you can edit the 4 user scales stored in the project. Switch between the 4 scales using **F1**, **F2**, **F3** and **F4**.

As with the preset scales, user scales can either be in *Chromatic* or *Voltage* mode. The former is used to create scales from the 12 semitones of the equal tempered chromatic scale. The latter can be used to make arbitrary scales.

The number of items in the scale is set with the *Size* parameter and can be up to 32 items.

When in *Chromatic* mode, each item can be assigned a semitone: **C**, **C#**, **D**, **D#**, **E**, **F**, **F#**, **G**, **G#**, **A**, **A#** or **B**.

When in *Voltage* mode, each item can be assigned a voltage between –5V and +5V with millivolts accuracy.

Note: The items defined in the user scale represent a single octave of the scale, which is equal to 12 semitones (1V) in *Chromatic* mode and the interval between the first and last item in *Voltage* mode. The other octaves are automatically inferred by repetition.

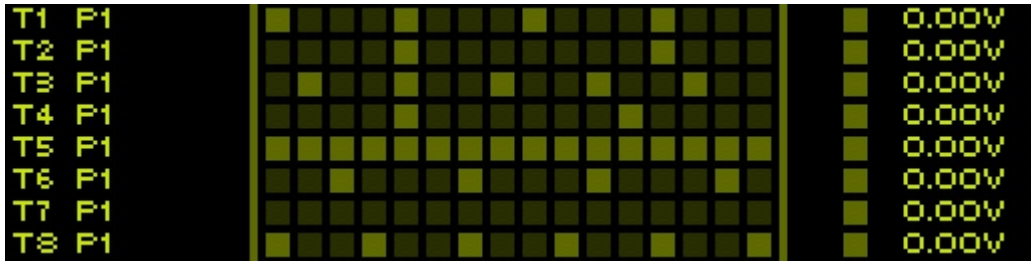
## Context Menu

Hold **SHIFT** + **PAGE** to open the context menu and access the following functions:

Button	Function	Description
<b>F1</b>	Init	Initialize the selected user scale to the default state.
<b>F2</b>	Copy	Copy the selected user scale to the clipboard.
<b>F3</b>	Paste	Paste the clipboard to the selected user scale.
<b>F4</b>	Load	Load a user scale from the SD card into the selected user scale.
<b>F5</b>	Save	Save the selected user scale to the SD card.

### Overview

The *Overview* page is entered using **PAGE** + **PREV**.



On this page you can see an overall representation of all currently running sequences. This page is a bit like a screensaver, as it has no controls attached to it and purely serves as a neat visualization. In the left section, the currently playing pattern for each track is indicated. In the middle section, a dense representation of the sequence is shown (steps or curves). In the right section, the current state of the gate and CV outputs is visualized.

### Monitor

The *Monitor* page is entered using **PAGE** + **MONITOR**. This page has 4 tabs accessed using **F1**, **F2**, **F3** and **F4**.

#### CV Inputs

The first tab shows the current voltages of the CV inputs.



#### CV Outputs

The second tab shows the current voltages of the CV outputs.



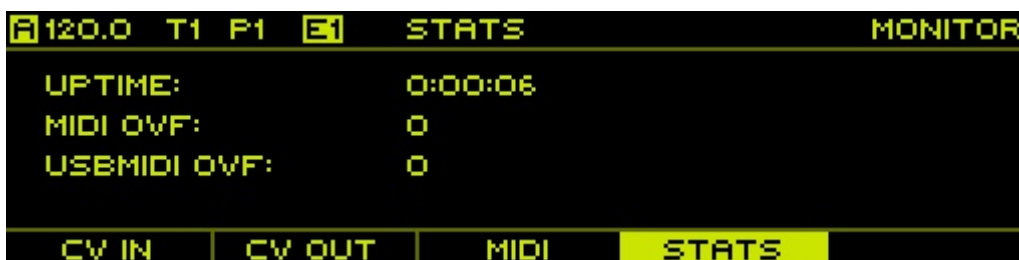
### MIDI

The third tab shows incoming MIDI messages.



## Stats

The fourth tab shows general stats of the sequencer such as the total uptime and overflows of the MIDI message queues.



## Clock

The *Clock* page is entered using **PAGE** + **CLOCK**.



This page is used to setup the clock system of the sequencer using the following parameters:

Parameter	Range	Description
Mode	Auto, Master, Slave	Clock mode
Shift Mode	Restart, Pause	Action to perform when <b>SHIFT</b> + <b>PLAY</b> is pressed: In <i>Restart</i> mode, the master clock is restarted. In <i>Pause</i> mode, the master clock is stopped/resumed.
Input Divisor	Divisors	Musical note duration at which to interpret incoming clock pulses. The divisor is actually used as a clock multiplier to generate the internal 192 PPQN clock resolution.
Input Mode	Reset, Run, Start/Stop	Mode in which to handle the incoming clock control signal. In <i>Reset</i> mode, the clock is kept in reset state while a high signal is read. In <i>Run</i> mode, the clock is only run when the signal is high. In <i>Start/Stop</i> mode, the clock is started when a high signal is read and stopped/paused when a low signal is read.
Output Divisor	Divisors	Musical note duration at which to generate outgoing clock pulses. The divisor is used to divide the internal 192 PPQN clock resolution to generate the outgoing clock pulses.
Output Swing	yes, no	Enable clock output with swing amount set on Project page.

Output Pulse	1 – 20 ms	Duration of the outgoing clock pulses.
Output Mode	Reset, Run	Mode for generating the outgoing clock control signal. In <i>Reset</i> mode, the signal is high when the clock is stopped and in reset state. In <i>Run</i> mode, the signal is high when the clock is currently running.
MIDI RX	yes, no	Receive MIDI clock from MIDI.
MIDI TX	yes, no	Transmit MIDI clock to MIDI.
USB RX	yes, no	Receive MIDI clock from USB.
USB TX	yes, no	Transmit MIDI clock to USB.

Note: To set up a 24 PPQN input or output clock resolution, the divisor needs to be set to 2. This is because the divisor is applied to a 48 PPQN resolution instead of the internal 192 PPQN resolution.

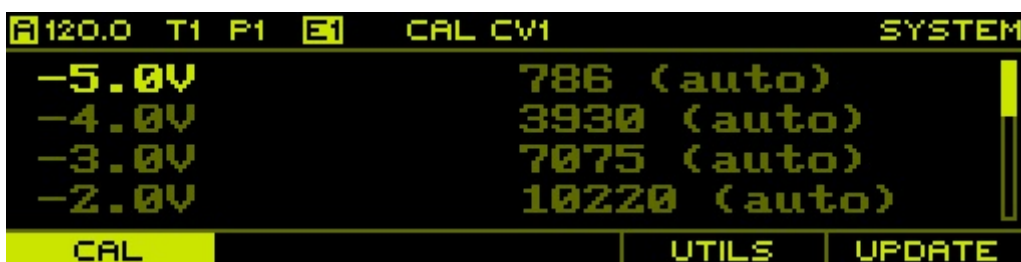
## System

The *System* page is entered using **PAGE** + **SYSTEM** and needs confirmation to prevent accidental entering.



## Calibration

Press **F1** to show the calibration tab.



On this tab you can calibrate the 8 physical CV outputs of the sequencer to millivolts accuracy, given that you have access to a volt meter with high accuracy. Proper calibration is important to get accurate pitch signals (1V/Oct) to control the pitch of oscillators.

Each channel is calibrated using a list of calibration entries for all voltages from -5V to +5V at 1V increments. Each entry stores the decimal value that is sent to the digital-to-analog converter for the given voltage. By default, entries are set to *auto* which automatically determines the best guess for the calibration value. This value is either determined by a reference table or by interpolating other manually set calibration entries.

Press **T[1-8]** to select the channel for calibration. The voltage present at the CV outputs directly depends on the entry selected in the list. This allows to scroll through the list and adjust the calibration values until the CV output generates the correct voltage. To edit a calibration entry, simply press the **ENCODER**. Rotate the encoder to set the calibration value or press **F1** to revert back to the *auto* value.



See Calibration Procedure for more information on how to efficiently calibrate the CV outputs.

**Context Menu**

Hold **SHIFT** + **PAGE** to open the context menu and access the following functions:

Button	Function	Description
<b>F1</b>	Init	Initialize the settings to the default state.
<b>F2</b>	Save	Save the settings to flash memory.
<b>F3</b>	Backup	Backup the settings to the SD card.
<b>F4</b>	Restore	Restore the settings from the SD card.

**Utilities**

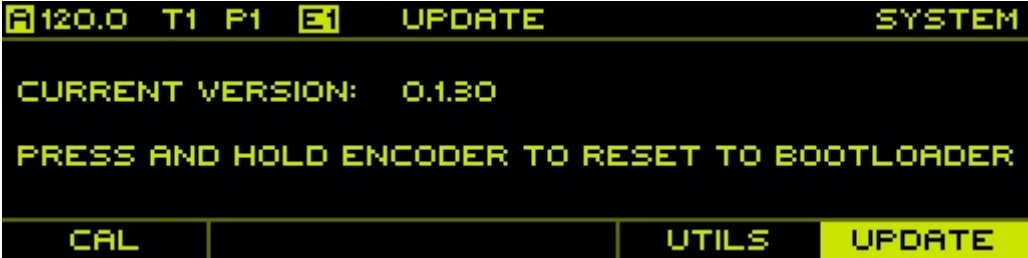
Press **F4** to show the utilities tab.



Currently there is only one utility to allow formatting the SD card.

**Update**

Press **F5** to show the update tab.



This tab shows the current version of the firmware and allows to reset to the bootloader to easily initiate the firmware update procedure. See Firmware Update for more information.

## Appendix

### Recording

Instead of entering note sequences one step at a time, an external MIDI keyboard can be used to speed up the process. There are two ways for recording sequences. First, sequences can be recorded live by just playing the keyboard while the sequencer is running. Secondly, step recording allows to quickly enter one note after the other using a keyboard, either when the sequencer is running or stopped. The recording mode is selected on the Project page. Recording is armed and disarmed using **PAGE** + **PLAY**.

#### Live Recording

The first two record modes, *Overdub* and *Overwrite* enable live recording. While recording is armed and the sequencer is running, notes played on a keyboard are immediately written into the active sequence. In *Overdub* mode, steps are added to the existing sequence, potentially replacing existing steps. In *Overwrite* mode, existing steps are cleared as the play head moves through the sequence, adding new steps when the keyboard is played. The length of the sequence is not changed and has to be set in advance. While *Overdub* mode is intended to gradually build up or evolve a sequence, *Overwrite* mode can be used to quickly replace a sequence with a new one. Arming and disarming recording while playing the keyboard can be challenging. Therefore, recording can also be controlled via a route. This allows for example to use a foot pedal to punch in and out of recording while keeping the hands free for playing.

Note: Incoming notes from the keyboard have to be translated into the fixed grid of a sequence. Best results are obtained by playing in a way that maps well to a note sequence, e.g. monophonic and as quantized as possible.

#### Step Recording

The *Step Record* mode is used to enter notes one step at a time. When recording is armed, playing notes on a keyboard simply sets one step after the other in the active note sequence. Recording starts at the first step and wraps around at the last step. Again, the length of the sequence has to be set in advance. While on the Steps page and the *Note* layer, **S[1-16]** can be used to select the current step to record from. The next step to be recorded into is marked with a circle.

#### Divisors

Divisors are used to divide clock ticks with a resolution of 48 PPQN into periods corresponding to musical notes. The divisor is applied to a 48 PPQN resolution instead of the internal 192 PPQN resolution, as this results in a more meaningful musical range of musical notes. While any integer number between 1 and 192 can be used as a divisor, the following known divisor values are used to generate the commonly used musical notes:

Divisor	Note	Name
2	1/64T	Triplet sixty-fourth note
3	1/64	Sixty-fourth note
4	1/32T	Triplet thirty-second note
6	1/32	Thirty-second note
8	1/16T	Triplet sixteenth note
9	1/32.	Dotted thirty-second note
12	1/16	Sixteenth note
16	1/8T	Triplet eighth note
18	1/16.	Dotted sixteenth note
24	1/8	Eighth note
32	1/4T	Triplet quarter note
36	1/8.	Dotted eighth note
48	1/4	Quarter note
64	1/2T	Triplet half note
72	1/4.	Dotted quarter note
96	1/2	Half note
128	1T	Triplet whole note
144	1/2.	Dotted half note



192	1	Whole note
256	2T	Triplet double note
288	1.	Dotted whole note
384	2	Double note
512	4T	Triplet quadruple note
576	2.	Dotted double note
768	4	Quadruple note

## Run Modes

Step sequences can be run in various run modes, which describe the order in which the steps of the sequence are played. To illustrate the different run modes, assume a sequence with  $N = 8$  steps, indexed from 1 to 8:

1 2 3 4 5 6 7 8

### Forward

In *Forward* mode, the sequence is played from the first to the last step and then repeated. Each iteration is exactly  $N$  steps:

1 2 3 4 5 6 7 8 | 1 2 3 4 5 6 7 8 | 1 ...

### Backward

In *Backward* mode, the sequence is played from the last to the first step and then repeated. Each iteration is exactly  $N$  steps:

8 7 6 5 4 3 2 1 | 8 7 6 5 4 3 2 1 | 8 ...

### Pendulum

In *Pendulum* mode, the sequence is alternately played in forward and backward mode. Each iteration is exactly  $2 * N$  steps:

1 2 3 4 5 6 7 8 8 7 6 5 4 3 2 1 | 1 ...

### Ping Pong

In *Ping Pong* mode, the sequence is played similarly to the pendulum mode, but when changing direction, the first/last step is not played twice. This essentially shortens the iteration by two steps to  $2 * N - 2$  steps:

1 2 3 4 5 6 7 8 7 6 5 4 3 2 | 1 ...

### Random

In *Random* mode, the sequence starts with a random step and each time the sequence advances, a new random step is picked:

4 7 5 3 5 7 5 3 5 6 8 6 4 2 4 1 3 6 ...

### Random Walk

In *Random Walk* mode, the sequence starts with a random step and each time the sequence advances, a random coin toss is used to either pick the step to the left or to the right of the last played step. This also works across the boundary from the first to the last step of the sequence:

7 8 7 8 1 2 1 2 3 2 3 4 5 4 3 4 3 2 ...

## Play Modes

Step sequences can be played in two different modes. In *Aligned* mode, the default mode, the current step position is computed in a deterministic way, whereas in *Free* mode, the current step position is always determined based on the previous step position.

The following example illustrates the difference between the two modes: Let's assume a sequence with a length of 16 steps and the step length set to quarter notes, running in *Forward* mode. When the sequencer is reset and started, the sequence will be played the same in both *Aligned* and *Free* mode, advancing to the next step at each quarter note division. Let's assume that the step length is changed to half notes while the sequencer is running and the step sequence is currently at the 9th step. In *Free* mode, the sequence will continue from the 9th step, but advancing to the next step at each half note division. This means that the step position is not the same as if the sequencer would have been started with the step length set to half notes. This is exactly what *Aligned* mode does, it always computes the current position based on the time that has passed since the sequencer was last reset and started. So in this example, the sequence would jump to the 5th or 13th step instead and continue playing from there.

In summary, *Free* mode behaves more like an analog sequencer, which simply advances to the next step when the current step length has passed. This may lead to sequences being played in weird ways, depending on how parameters like *Divisor*, *First Step* and *Last Step* are changed while the sequencer is running. While these side effects may allow for some nice happy accidents, *Aligned* mode is generally the safer bet for most purposes.

## Rotation

Rotation enables to play back the sequence at different start points. A typical 8 step sequence in *Forward* mode is played back as follows:

```
1 2 3 4 5 6 7 8 1 2 3 4 5 6 7 8 ...
```

With a rotation of +1 the sequence is rotated 1 step to the right and played back as follows:

```
2 3 4 5 6 7 8 1 2 3 4 5 6 7 8 1 ...
```

With a rotation of -3 the sequence is rotated 3 steps to the left and played back as follows:

```
6 7 8 1 2 3 4 5 6 7 8 1 2 3 4 5 ...
```

## Step Conditions

Step conditions allow individual steps to only be played if a certain condition is met. In addition to the various probabilistic variations of a step, this allows for even more dynamic sequences. The following conditions are available:

Condition	Description
Fill	Step is only played if <i>Fill</i> is enabled (and the track has <i>Fill Mode</i> set to <i>Condition</i> mode).
!Fill	Step is only played if <i>Fill</i> is disabled (and the track has <i>Fill Mode</i> set to <i>Condition</i> mode).
Pre	Step is only played if the most recently evaluated step condition was true.
!Pre	Step is only played if the most recently evaluated step condition was false.
First	Step is only played on the very first iteration of the playback.
!First	Step is played on every but the very first iteration of the playback.
N:M	Step is played on the Nth iteration every M iterations. So for example, 2:4 plays the step on iteration 2, 6, 10 etc.

Note: Step conditions are only evaluated if the step is actually triggered. That means that if a step is not triggered due to *Gate Probability* the assigned step condition will not be evaluated and has no effect.

## Scales

### Semitones

---

Index	1	2	3	4	5	6	7	8	9	10	11	12
Volts	0.000	0.083	0.167	0.250	0.333	0.417	0.500	0.583	0.667	0.750	0.833	0.917

#### Major

Index	1	2	3	4	5	6	7
Volts	0.000	0.167	0.333	0.417	0.583	0.750	0.917

#### Minor

Index	1	2	3	4	5	6	7
Volts	0.000	0.167	0.250	0.417	0.583	0.667	0.833

#### Major Blues

Index	1	2	3	4	5	6
Volts	0.000	0.250	0.333	0.583	0.750	0.833

#### Minor Blues

Index	1	2	3	4	5	6
Volts	0.000	0.250	0.417	0.500	0.583	0.833

#### Major Pent.

Index	1	2	3	4	5
Volts	0.000	0.167	0.333	0.583	0.750

#### Minor Pent.

Index	1	2	3	4	5
Volts	0.000	0.250	0.417	0.583	0.833

#### Folk

Index	1	2	3	4	5	6	7	8
Volts	0.000	0.083	0.250	0.333	0.417	0.583	0.667	0.833

#### Japanese

Index	1	2	3	4	5
Volts	0.000	0.083	0.417	0.583	0.667

#### Gamelan

Index	1	2	3	4	5
Volts	0.000	0.083	0.250	0.583	0.667

#### Gypsy

Index	1	2	3	4	5	6	7	8	9	10	11	12
-------	---	---	---	---	---	---	---	---	---	----	----	----

Index	1	2	3	4	5	6	7
Volts	0.000	0.167	0.250	0.500	0.583	0.667	0.917

Arabian

Index	1	2	3	4	5	6	7
Volts	0.000	0.083	0.333	0.417	0.583	0.667	0.917

Flamenco

Index	1	2	3	4	5	6	7
Volts	0.000	0.083	0.333	0.417	0.583	0.667	0.833

Whole Tone

Index	1	2	3	4	5	6
Volts	0.000	0.167	0.333	0.500	0.667	0.833

5-tet

Index	1	2	3	4	5
Volts	0.000	0.200	0.400	0.600	0.800

7-tet

Index	1	2	3	4	5	6	7
Volts	0.000	0.143	0.286	0.428	0.572	0.714	0.857

19-tet

Index	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Volts	0.000	0.053	0.105	0.158	0.210	0.263	0.316	0.368	0.421	0.474	0.526	0.579	0.632	0.684

22-tet

Index	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Volts	0.000	0.046	0.091	0.136	0.182	0.227	0.273	0.318	0.364	0.409	0.454	0.500	0.546	0.591

24-tet



















Index	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Volts	0.000	0.042	0.083	0.125	0.167	0.208	0.250	0.292	0.333	0.375	0.417	0.458	0.500	0.542

Voltage

Index	1	2	3	4	5	6	7	8	9	10
Volts	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900

Shapes

--

Index	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
Shapes																		

## Arpeggiator Modes

The following arpeggiator modes are available. The example note order is based on a chord with 5 notes:

Mode	Sequence
Play Order	Played back in the order the notes were entered.
Up	` 1 2 3 4 5                      1 2 3 4 5                      ... `
Down	` 5 4 3 2 1                      5 4 3 2 1                      ... `
Up Down	` 1 2 3 4 5 4 3 2                      1 2 3 4 5 4 3 2                      ... `
Down Up	` 5 4 3 2 1 2 3 4                      5 4 3 2 1 2 3 4                      ... `
Up & Down	` 1 2 3 4 5 5 4 3 2 1                      1 2 3 4 5 5 4 3 2 1                      ... `
Down & Up	` 5 4 3 2 1 1 2 3 4 5                      5 4 3 2 1 1 2 3 4 5                      ... `
Converge	` 1 5 2 4 3                      1 5 2 4 3                      ... `
Diverge	` 3 2 4 1 5                      3 2 4 1 5                      ... `
Random	Played back in random order.

## Launchpad

The Novation Launchpad can be used as an advanced control surface for the sequencer, allowing for editing sequences and launching patterns via the 8x8 button matrix. When a Launchpad is connected to the USB port, the sequencer automatically detects the device and immediately starts using it as a control surface.

The following Lauchpad controllers have been tested and are working:

- Launchpad Mini MK1
- Launchpad Mini MK2
- Launchpad S
- Launchpad Mk2
- Launchpad Pro

Note: Support for the very first version of Launchpad will never happen, as it is not a USB MIDI class compliant device.

Launchpad controllers are exclusively used as control surfaces and cannot be used as a standard MIDI device for the routing system or live recording.

When using a Launchpad Mini or Launchpad S, it should preferably be configured to operate in the *Low Power* mode. This is important in order to not draw too much current which can lead to the Launchpad spuriously disconnect. In addition, make sure that the Launchpad is configured to use ID 1, otherwise it will be detected as a general MIDI controller by the sequencer. The procedure to switch between *Low Power* and *Full Power* mode and setting the ID can be looked up here ([https://customer.novationmusic.com/sites/customer/files/novation/downloads/6961/launchpad-s-and-mini-advanced-features-guide\\_0.pdf](https://customer.novationmusic.com/sites/customer/files/novation/downloads/6961/launchpad-s-and-mini-advanced-features-guide_0.pdf)).

## Global Functions

The **8** button acts as a *shift* button and can be pressed in combination with other buttons to access secondary functions. The following functions are always available:

Buttons	Description
---------	-------------

<b>8</b> + <b>7</b>	Start and stop the sequencer
<b>8</b> + <b>1</b>	Switch to sequence mode
<b>8</b> + <b>2</b>	Switch to pattern mode

Because the 8x8 grid of the Launchpad can only represent part of the data to be edited, the grid only acts as a window into a larger virtual 64x64 grid. Hold **1** to enter navigation mode, where the position of the window can be selected:

Buttons	Description
<b>1</b> + <b>2</b>	Move window left
<b>1</b> + <b>3</b>	Move window right
<b>1</b> + <b>4</b>	Move window up
<b>1</b> + <b>5</b>	Move window down
<b>1</b> + <b>GRID</b>	Move window to specific position

Note: Navigation is available in both sequence and pattern mode.

## Sequence Mode

Sequence mode allows for comprehensive editing of the patterns on all tracks. The grid allows for editing individual step values on the active track and layer. The following functions are available:

Buttons	Description
<b>A</b> – <b>H</b>	Select active track
<b>2</b> + <b>GRID</b>	Select active layer
<b>3</b> + <b>GRID</b>	Select first step
<b>4</b> + <b>GRID</b>	Select last step
<b>5</b> + <b>GRID</b>	Select run mode
<b>7</b> + <b>A</b> – <b>H</b>	Fill track
<b>8</b> + <b>A</b> – <b>H</b>	Mute/unmute track

The visualization on the grid depends on the selected layer. Binary layers (e.g. *Gate* and *Slide*) can be visualized directly on the 8x8 grid without the need for navigation. This is useful for programming drum sequences for example. Other layers use navigation to various degree in order to allow programming the steps. When editing the *Note* layer, the base note (first note per octave) is visualized to help orientation.

## Pattern Mode

Pattern mode allows selecting the currently playing pattern on all the tracks. Each column on the **GRID** represents one track, allowing to launch individual patterns per track. The **A** – **H** buttons represent scenes, allowing to launch the same pattern number on all the tracks simultaneously. This is very similar to how Ableton Live allows launching clips and scenes on a Launchpad. Active patterns are shown as bright green, non-empty patterns are shown in dim colors, yellow for note tracks, red for curve tracks.

In addition, holding **2** while selecting patterns and scenes, allows to use latching mode. This means that the patterns are switched at the moment when **2** is released. Holding **3** while selecting patterns and scenes allows to launch them synchronized to the global *Sync Measure*.

Requested patterns due to latching or syncing are shown in dim green.

## Calibration Procedure

The following method allows you to quickly calibrate the 8 CV outputs of the sequencer to millivolts accuracy. In order to achieve good results you have to use a volt meter capable of measuring within millivolts accuracy.

**The calibration will only be as good as the volt meter to measure the voltages!**

Enter the System page using **PAGE** + **SYSTEM**.

For each of the 8 channels, perform the following steps:

- Select the channel by pressing **T[1-8]**.
- Connect the volt meter to the given CV output.
- Select the -5.0V entry and adjust the calibration value such that the volt meter measures as close to -5.000V as possible.
- Repeat the the previous step for the +5.0V entry then for the +0.0V entry.
- At this point, calibration should be good enough with all other entries set to *auto*.
- Check each entry in-between the calibrated ones and adjust them if the measured voltage deviates too much from the expected value. In general it is a good idea to do this recursively by always selecting the voltage in the middle of two calibrated entries. For example, with +0.0V and +5.0V calibrated, continue with either +2.0V or +3.0V.

With all channels calibrated you should save the data to flash memory by holding **SHIFT** + **PAGE** and pressing **F2**. You can also save the calibration data as a backup to the SD card by holding **SHIFT** + **PAGE** and pressing **F3**.

## Firmware Update

Use the following steps to upgrade the sequencer:

- Download the latest **UPDATE.DAT** file from <https://github.com/westlicht/performer/releases> (<https://github.com/westlicht/performer/releases>).
- Copy the **UPDATE.DAT** file to the root directory of the SD card.
- Insert the SD card into the sequencer's SD card slot.

The update procedure is performed by the bootloader on the sequencer. There are two possible ways to enter the bootloader:

1. Power up the sequencer while pressing down the **ENCODER**.
2. Enter the System page and go to the update tab, then press and hold the **ENCODER** which will initiate a reset and jump to the bootloader.

The bootloader will verify the integrity of the **UPDATE.DAT** file using an MD5 hash. Once verified, a confirmation is requested to actually initiate the update process. Simply rotate the **ENCODER** to change to **YES** and press the **ENCODER** to start the update.

After the firmware is written to the flash memory, it is verified again to ensure it was written properly. In case the verification fails, the firmware is erased from flash memory. At this point the sequencer will always enter the bootloader when powering up, allowing to load a different firmware.