User Manual

ER-102:
Sequencer Controller

with Firmware v2.04

Last revised on December 13, 2016

If you find any typos, errors, or poor wording in this manual please let me know.
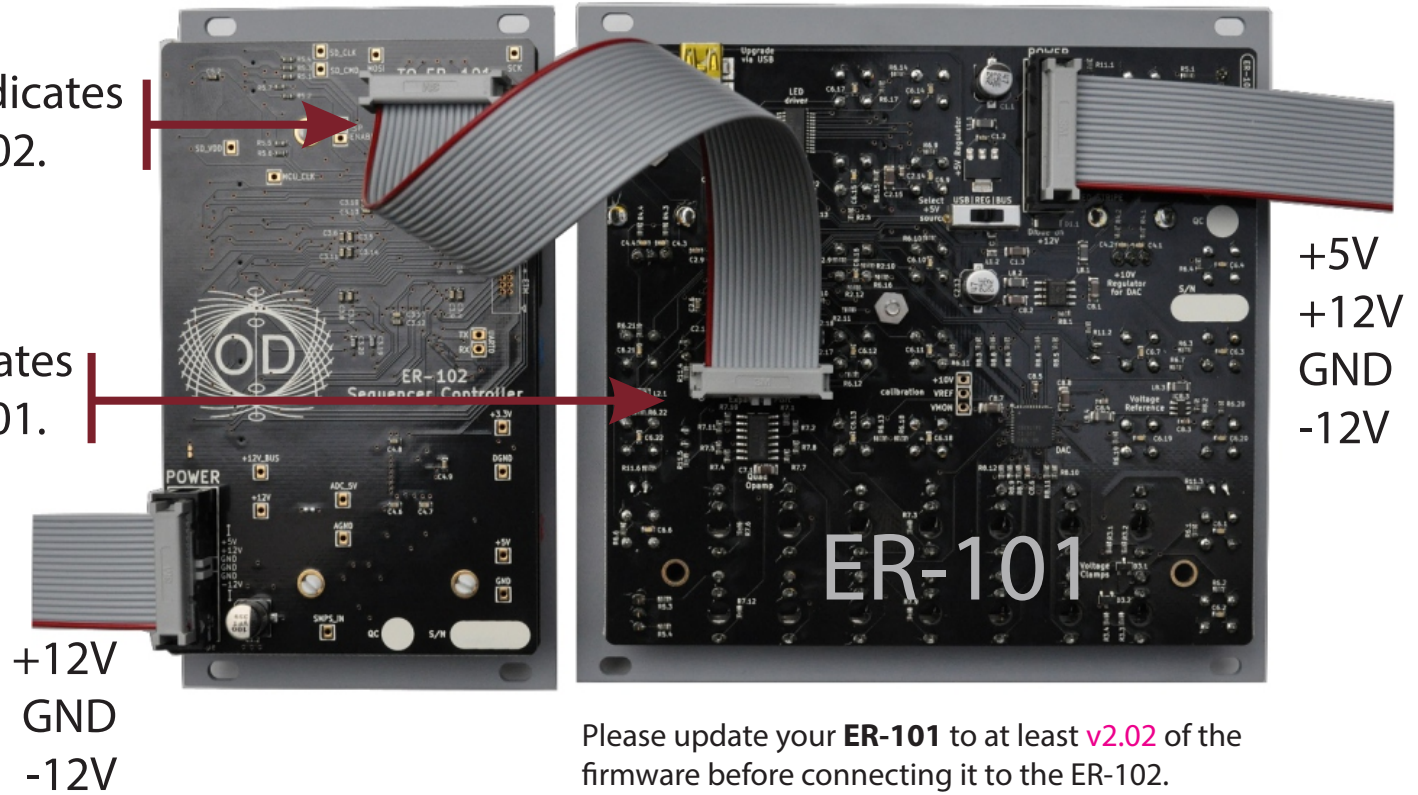http://www.orthogonaldevices.com/contact

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How to connect the ER-102 to the ER-101

△ A small triangle indicates pin #1 on the ER-102.

○ A small circle indicates pin #1 on the ER-101.

+12V
GND
-12V

+5V
+12V
GND
-12V

Please update your **ER-101** to at least v2.02 of the firmware before connecting it to the ER-102.

INTRODUCTION

What does it do?

The ER-102 Sequencer Controller is an expander for the ER-101. The design and feature set implemented by the ER-102 is the result of the critical distillation of the many overlapping feature requests that were made by users during the first year of the ER-101's release.

> TIP: Throughout this manual, I will assume that you are already familiar with the ER-101's interface. If that is not the case then please first read the ER-101 User Manual.

The interface

The ER-102 interface is divided into 4 sections:

- **STORAGE**: a memory card for holding snapshots and loading firmware.
- **PARTS**: adds up to 99 CV-controllable loops (each with their own reset step) to each snapshot.
- **GROUP**: adds up to 16 arbitrary selections of steps each with their own transforms and routing matrix that is connected to a 3 channel modulation bus.
- **RECORDING**: adds a comprehensive and reconfigurable set of inputs that can record new sequences, alter existing ones, or place the ER-101 under remote editing control.

The ER-102 was designed to be place to the right of the ER-101. This layout was chosen to minimize the impact on your hand motions when including the ER-102 in your workflow. For example, the LEFT knob on the ER-101 is used whenever changing any values on displays with focus buttons on their right (INDEX, TRACK, PATTERN, STEP, SNAPSHOT, PART and GROUP). The RIGHT knob on the ER-101 is used whenever changing any values on displays with focus buttons on their left (VOLTAGE, CV-A, CV-B, DURATION, and GATE). The result is that your hands never obstruct the displays that you need to see while you are manipulating the interface.

> TIP: Throughout this manual, a "focused press" means to press the focus button of a display that is already focused. If the display is not focused, then you will need to focus it first and then press it again to get the desired effect.
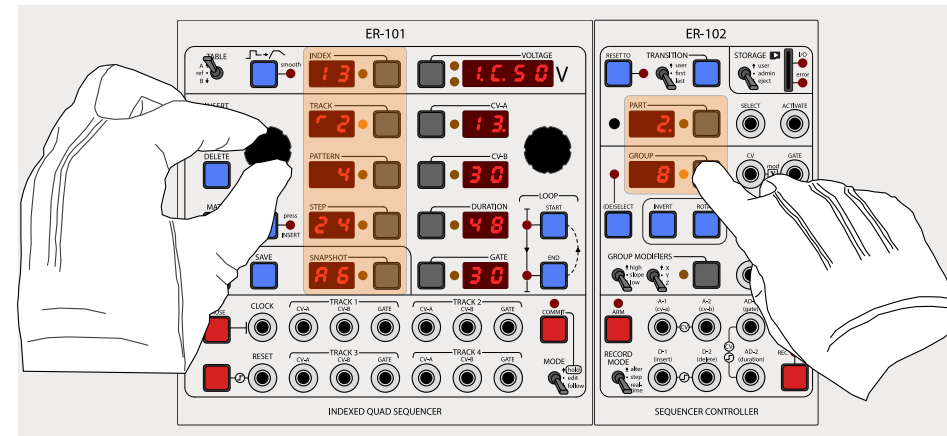
The possible targets for the LEFT knob are highlighted.
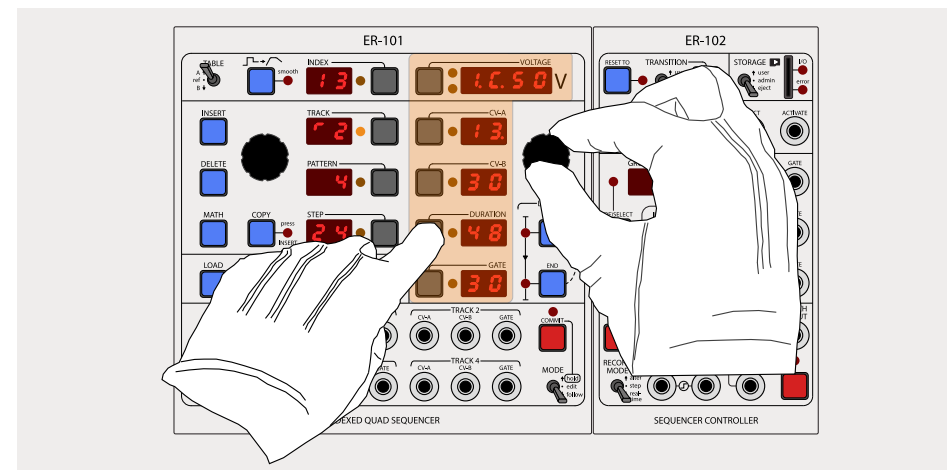
The possible targets for the RIGHT knob are highlighted.

MATH TRANSFORMS

Under the ER-101/102 paradigm, whenever you want to operate mathematically on the parameters of a single step or multiple steps, you use a MATH transform. Examples of such operations are transposing pitch values, randomizing gate lengths, doubling or halving step durations, and quantizing random note durations or pitches to a fixed grid.

There are two types of transforms, destructive and non-destructive. A destructive transform permanently alters the stored parameters of the target steps. These destructive transforms are always accessed via the MATH button. A non-destructive transform alters step parameters as they are being interpreted during playback but without changing their stored values. You will find non-destructive transforms in the GROUP MODIFIER section of the ER-102's interface.

All transforms share the following interface:

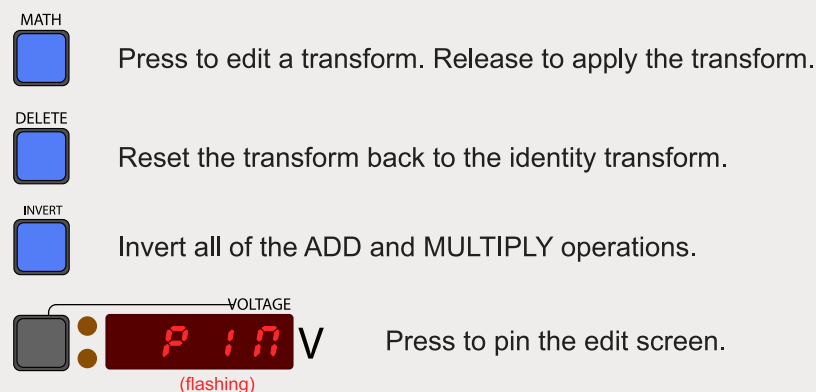| UI Element	Function
LEFT knob	Selects an operation (i.e. add, multiply, randomize, etc.).
RIGHT knob	Changes the focused operator's parameter.
FOCUS buttons	Focuses the interface on a particular step parameter.
DELETE button	Clears all operations so that the transform has no effect.

Edit screen

Pressing and holding the MATH button will activate the TRANSFORM EDIT screen for any of the desctructive transforms associated with tracks and groups.

> TIP: When you first enter the TRANSFORM EDIT screen, the word "PIN" will be flashing in the VOLTAGE display. Press the VOLTAGE focus button to pin the TRANSFORM EDIT screen so that you do not have to hold the MATH button while making long edits to the transform. Pressing the MATH button while pinned in the edit screen will apply the current MATH transform.

The TRANSFORM EDIT screen for the non-destructive group transforms is automatically activated when editing the GROUP MODIFIERS (refer to the chapter on groups).
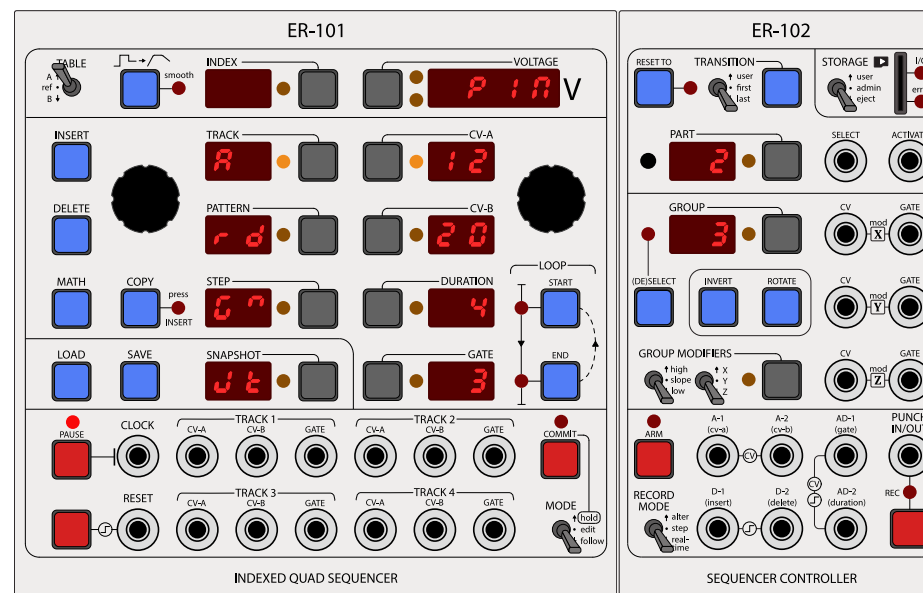
The TRANSFORM EDIT screen: Turning the LEFT knob will change the focused operation for the focused parameter (in this case CV-A). Turning the RIGHT knob will change the focused operation's paramter value.

Press to edit a transform. Release to apply the transform.

Reset the transform back to the identity transform.

Invert all of the ADD and MULTIPLY operations.

Press to pin the edit screen.

4

Operations

Whenever you apply a transform, all of the operations that it contains are applied sequentially in the following order to each step parameter:

Step	Destructive	Non-destructive
1	if Rd > 0 then replace with RANDOM(Rd)	Add RANDOM(Rd)
2	Multiply by G	Multiply by G
3	Add JITTER(Jt)	Add JITTER(Jt)
4	Add A	Add A
5	Quantize to Qt	Quantize to Qt

The result is the following formula for the destructive case:

$$P_{after} = \text{QUANTIZE}(G*\text{IF}(Rd=0,P_{before},\text{RANDOM}(Rd)) + \text{JITTER}(Jt) + A,Qt)$$

and this formula for the non-destructive case:

$$P_{after} = \text{QUANTIZE}(G*(P_{before} + \text{RANDOM}(Rd)) + \text{JITTER}(Jt) + A,Qt)$$

where,

P_{after}: The new value of the step parameter
P_{before}: The old value of the step parameter
$\text{QUANTIZE}(x,y)$: Round x to the nearest multiple of y
$\text{RANDOM}(x)$: Random integer between 0 and x (uniform distribution)
$\text{JITTER}(x)$: Random integer between -x and x (uniform distribution)

If for a particular step and parameter, the transform results in a P_{after} that is outside the valid range of the step parameter then the transform will have no effect on that parameter. For example, trying to subtracting 50 from CV-A = 12 will have no effect.

TIP: In the case of non-destructive transforms, the Jitter and Random operations are re-evaluated (i.e. a new random value is generated) every time a target step is played.

Identity

A transform with all default values for each of its operations has no effect and is called the identity transform. You can quickly reset any transform back to its identity

Code	Operation	Range	Effect
A or S	Addition or Set	-99 to 99	add A (when G≠0) or set S (when G=0)
G	Multiplication	1/99 to 99	multipy by G
Jt	Jitter	0 to 99	add random integer between [-Jt, Jt]
Rd	Random	0 to 99	add random integer between [0, Rd][†]
Qt	Quantize	1 to 99	round to the nearest multiple of Qt

The letter codes (aka variables) used in the TRANSFORM EDIT screen to represent each operation. [†] If destructive and Rd > 0 then set instead of add.

Configurable Option: You can edit the configuration file to have only a single operation active at a time instead of all operations.

Add 12.

Subtract 12.

Multiply by 2.

Divide by 2.

Add a random number between 0 and 10.

Add a random number between -3 and 3.

Round to the nearest multiple of 8.

by pressing the DELETE button while in the TRANSFORM EDIT screen.

Inversion

You can invert a transform that you are editing by pressing the INVERT button. Also, you can apply the inverted version of a transform by holding the INVERT button while pressing and releasing the MATH button. Transform inversion only applies to the Add (A) and Multiply (G) operators.

Examples

Set parameters to a specific value:
To achieve the affect of an assignment operation, just set G = 0 and set A to the desired value. Typically you would do this when you want to simultaneously set a particular parameter of many steps to a desired value (e.g. set the DURATION of all steps in a pattern to 16 clock pulses). Additionally, you can use the JITTER(Jt) parameter to add a bit of zero-centered random noise to the parameter. This is especially useful for velocity CVs and gate lengths.

Generate random parameter values in a given range:
The RANDOM operation produces random integers between 0 and Rd. If you want random numbers between L and H, then just set A = L and Rd = H-L. For example, to get random values between 12 and 19, set A = 12 and Rd = 7. This is often done when producing random pitch values that are within a restricted range.

Generate random pitches separated by a given fixed interval:
To generate random multiples of a given number just set Rd and A as you would for producing random numbers in a range but also set G to the desired interval size. For example, to produce random pitch values from one octave of the whole tone series then set G=2, Rd=6, and set A to the root pitch. Alternatively, you can use RANDOM with the QUANTIZE operation: Rd=12 and Qt=2.

Generate random rhythms with customized probabilities:
Start with a simple sequence of steps with all the GATE parameters set to zero. If you apply a MATH transform of [GATE+RANDOM(4)]/3 to the entire track then you will get random sample of steps with a GATE parameter of 1 and the rest will be zero. Furthermore, if you start with a sequence of steps where some of the steps have a GATE parameter of 1, 2 or 3 (rather than just zero) then these steps will have a progressively higher probability of being assigned a non-zero GATE after you apply the MATH transform. This way you can sculpt the resulting random rhythm lightly by biasing the randomization. For example, this is great for producing random rhythms that have a higher probability of triggering on the strong beats then on the weak beats.

This example works especially well with the HIGH/LOW transforms (see Groups) because the initial probability contour is not overwritten by the application of these non-destructive transform, and, the HIGH/LOW transforms get re-evaluated everytime a step is played, thus producing a continually evolving rhythm that nevertheless adheres to the user's specified probability contour.
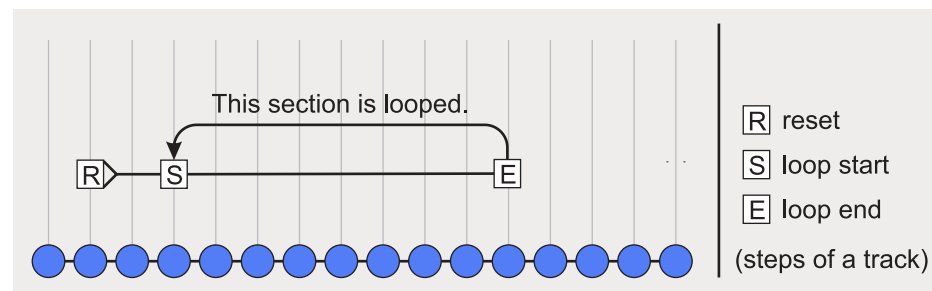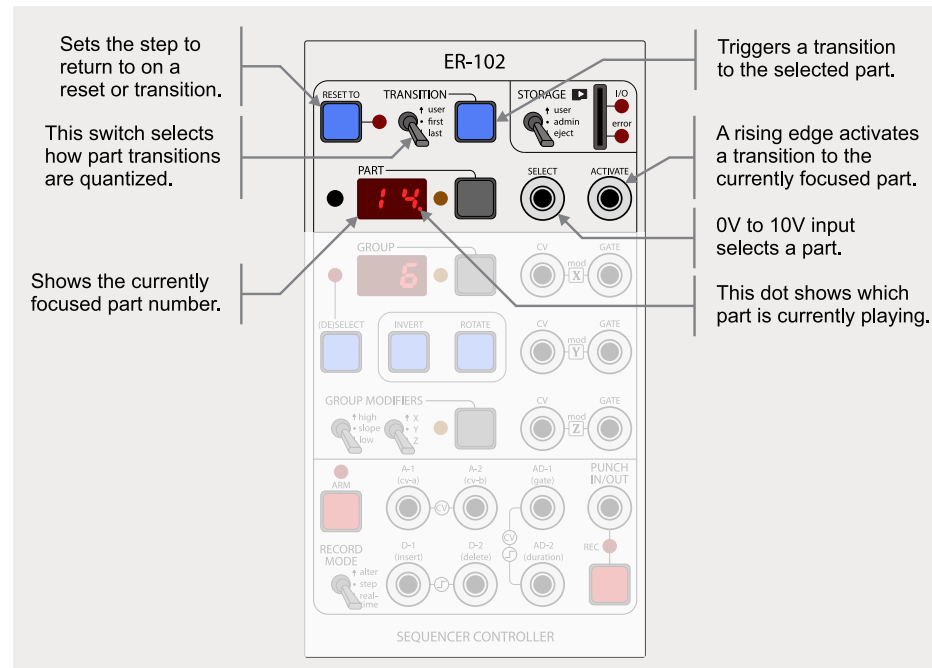
PARTS

What are parts?

The top section of the ER-102 is dedicated to the manipulation of parts. Using parts, you can divide tracks into smaller sub-sequences (called parts) and then activate these parts during playback using the manual interface or using voltage control. A single snapshot can contain up to 99 parts.

Looping different sections of a track on just the ER-101 is a very effective way of introducing variations in real-time. However, there are some limitations with a standalone ER-101:

- You cannot save and recall multiple loops.
- You cannot activate different loops simultaneously across all or some tracks.
- You cannot change the step that the ER-101 rewinds to on a reset signal.
- There is no external voltage control of the play cursor.

The ER-102 removes each of these limitations by introducing the concept of a part. A single part assigns a reset step and a looped section **for each** of the 4 tracks such that when a part is triggered, potentially all tracks will have their reset steps and looped sections changed.

> TIP: Parts are great for turning the ER-101/102 into a very powerful arpeggiator. Just enter the arpeggios that you wish to use as separate patterns on a single track (for a single voice arpeggio) or on multiple tracks (for multiple voice arpeggios). Then (using pattern looping) set up a part for each of these patterns. Last, assign all of these patterns to a group and set the slope of one of the CV mod channels to 1.0. Now you can use the PART SELECT/ACTIVATE inputs to select the arpeggio and the CV mod input to set the root pitch (in 1V/oct). Don't forget to save your work as a snapshot for easy recall later.

Sets the step to return to on a reset or transition.

This switch selects how part transitions are quantized.

Shows the currently focused part number.

Triggers a transition to the selected part.

A rising edge activates a transition to the currently focused part.

0V to 10V input selects a part.

This dot shows which part is currently playing.

This section is looped.

R	reset
S	loop start
E	loop end

(steps of a track)

Interface

At any time there will always be a part that is focused and a part that is playing. Sometimes, there will also be part that is pending. When the PART display is focused, you can change the part by turning the LEFT knob. Also, the INDEX and VOLTAGE display are commandeered to show information relevant to the focused part and the next pending part, if any.

Focused Part
The focused part is the part whose number is showing in the PART display. When you are changing the reset step or the loop section for the current track, then your changes are always applied to the focused part. The looped section of the focused part is set with the LOOP START and LOOP END buttons on the ER-101, while the reset step is assigned with the RESET TO button on the ER-102.

Pending Part
The pending part is the part that is scheduled to play next (i.e. after the current part finishes). When the PART display is focused then the pending part will be shown in the INDEX display on the ER-101. Also, the PART display's orange LED will flash when a part is pending.

Playing Part
The currently playing part is indicated by the dot in the lower right of the PART display. All tracks will adhere to the reset step and looped section assigned in the playing part.

Part Overview *(experimental)*
When the PART display is focused a rough overview of the focused part is shown in the VOLTAGE display. The display is divided horizontally into 4 sections, one for each track. Each section holds 3 horizontal bars that indicate (from top to bottom) whether the RESET TO, LOOP START, and LOOP END steps have been set in their respective tracks.

Quick Navigation
If you hold down the PART focus button and turn the LEFT knob then the cursor will skip in order through the steps in the following list:

First step - RESET TO step - LOOP START step - LOOP END step - Last step
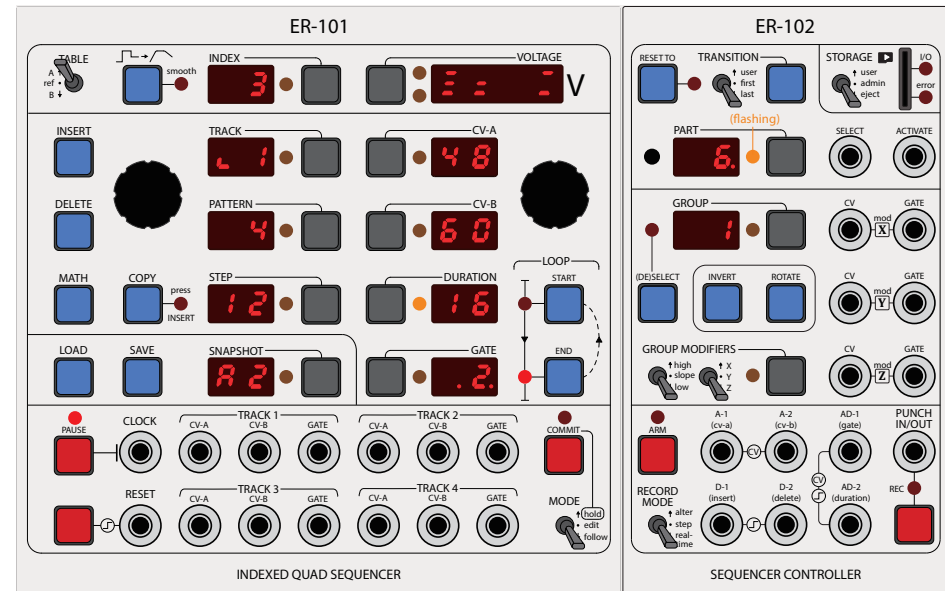

In this example, the PART display is focused and part 6 is showing. The VOLTAGE display shows an overview of the part and we can see that track 1 has a RESET TO, LOOP START and LOOP END all set, while track 2 only has the LOOP START and LOOP STOP set. Track 3 has none of them set and track 4 has RESET TO and LOOP END set. Additionally, we can see that part 3 is pending to be played after part 6.
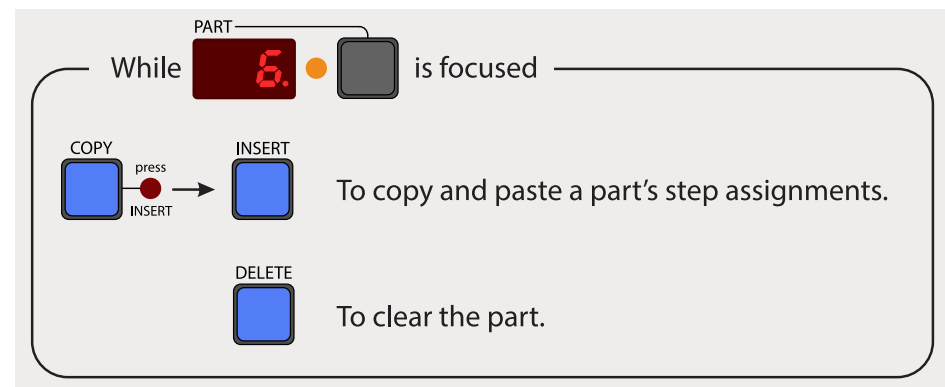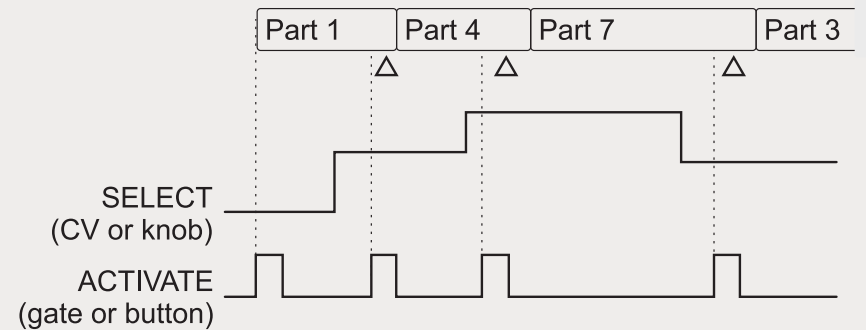
Voltage control

Parts can be focused and activated using external voltage control just by patching a suitable CV/gate source into the SELECT and ACTIVATE jacks on the ER-102. The SELECT voltage is converted to a PART number according to the chart on the right.

TIP: As soon as you insert a cable into the SELECT jack, part selection is placed under external voltage control. This means that the LEFT KNOB can no longer be used to alter the focused part. If you try to change the focused part with the LEFT knob while a cable is patched into the SELECT jack, the word "PLUG" will flash in the VOLTAGE display to remind you that part selection is under external voltage control. Remove the cable to once again be able to select parts via the LEFT KNOB.
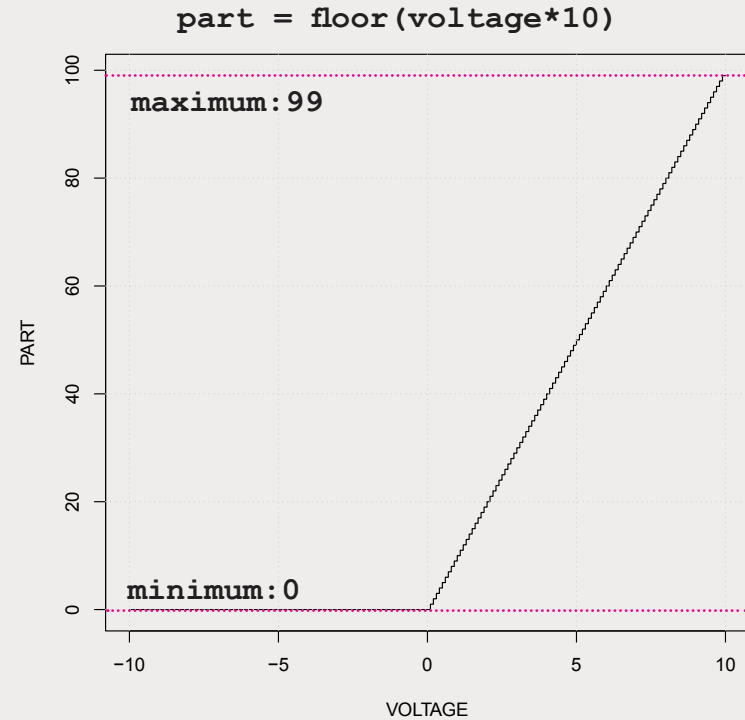
Once a part is selected (or focused), then this part can be activated with gate signal to the ACTIVATE jack. In fact, as long as the ACTIVATE input is held high the pending part (or next part cued to play) will track the voltage selection. This allows you to effectively "play" parts in real-time.

TIP: The actual timing of when the newly activated part starts playing depends on the position of the TRANSITION switch (see the section on Transitions).

$$part = floor(voltage*10)$$

maximum: 99

minimum: 0

Part 1   Part 4   Part 7   Part 3

SELECT
(CV or knob)

ACTIVATE
(gate or button)

△ The TRANSITION switch chooses quantization behavior for the start of the next part.

Various types of parts

There is no restriction on how you assign the RESET TO, LOOP START and LOOP END steps in a part. In the following, I will borrow terminology used to describe the structure of popular songs because it is familiar and easy to understand. Suppose the material for a song was laid out over a track or tracks in the following manner:

Intro-Verse-Chorus-Bridge-Outro

Material that is laid out this way is not meant to be played from start to finish but to be sliced up and reordered.

Intro-[Verse-Chorus]
The most common kind of part assigns a RESET TO step to the beginning of a passage and then LOOP START and END to loop some portion of the latter half of the passage. For example, in a ...ABCBCBC... song arrangement where A is the intro, B is a verse and C is the chorus then you could easily arrange a part to play an intro seamlessly segue into the refrain (i.e. repeating verse-chorus: BCBC...). See Part 1 in the figure.

Chorus-[Verse-Chorus]
Sometimes you want to trigger a chorus and then return to the refrain. In this case you would put the RESET TO step inside the looped section as in Part 4 of the figure.

Outro (or One-Shot)
If you want a section to play once and then play nothing afterwards then just set the RESET TO step to the beginning of the section and then loop a single rest step (i.e. step with GATE=0 or DURATION=0). See Part 3 in the figure.

The builtin STOP part
Finally, there is builtin part (always assigned to Part 0) that plays absolutely nothing on all tracks when it is active. You can use this part to end all playing material.

Naked Loops
This is an important special case which is often used for bridges. See Part 5 in the figure. When a part does not have a RESET TO step assigned then this part begins playing from where the previous part left off. This means that the rhythmic relationship (e.g. sync) of such "resetless" parts with other tracks can change depending on what part is playing when they are triggered. On the other hand, parts with reset steps will always start from the same place.

Various types of parts

R reset
S loop start
E loop end

(steps of a track)
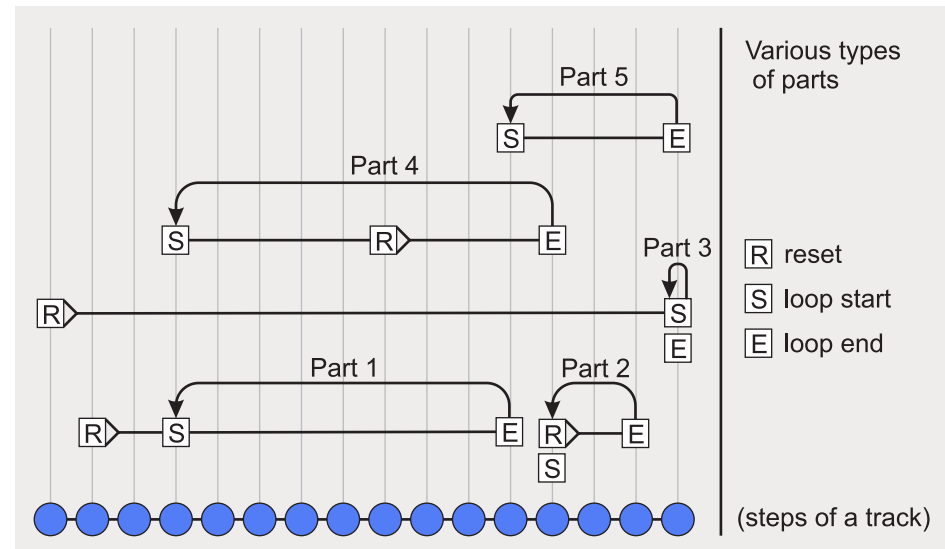
Transitions

Once a part is triggered, the exact time it will start playing depends on the setting of the TRANSITION switch.

Triggering a part

Parts are activated or triggered in two ways - manually via the TRANSITION button or remotely via a rising edge on the ACTIVATE input. As soon as the focused part is activated then it also becomes the pending part and its number will be flashing in the INDEX display when the PART display is also focused. When you trigger a part, you are actually triggering parts across all of the tracks.

FIRST vs LAST Transitions

When transitioning from one part to the next, it is musically useful to wait for the current part to finish playing before starting the next pending part. However, since a single part potentially contains a loop for each track, there is an ambiguity about when a part exactly finishes. In other words, which track gets to decide for the other tracks that the current playing part has finished? The FIRST and LAST transition modes solve this ambiguity. The FIRST transition mode means that the transition to the pending part will occur as soon as any track completes its loop. In other words, the first track to complete its loop is used to finish the current part and transition to the pending part. The LAST transition mode waits for all tracks to finish at least one loop before moving on to the pending part. In other words, the last track to finish a loop determines the transition to the pending part.

When the current playing part ends (as defined by the TRANSITION mode), then all tracks with a RESET TO step defined are reset and the pending part becomes the current playing part.

The USER Transition

The USER transition mode is by default configured to transition immediately without a reset (even if there is a RESET TO step defined). However, a reset on the ER-101 will behave as normal.

> Configurable Option: The USER transition can have its behavior changed via the configuration file. Please refer to the configuration file on your SD card for more details.
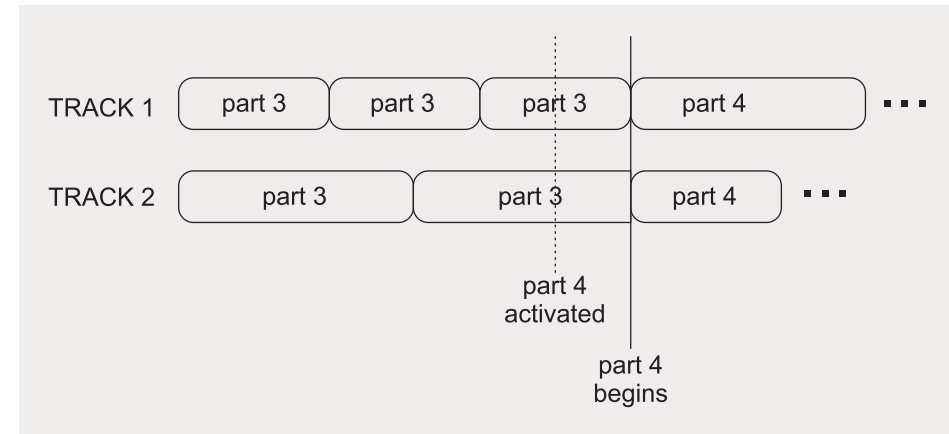
In this example, parts have been defined for only 2 tracks and the TRANSITION switch is set to FIRST. The dotted line indicates when the next part is triggered. Track 1 finishes first, so track 1 determines the beginning of the next part.
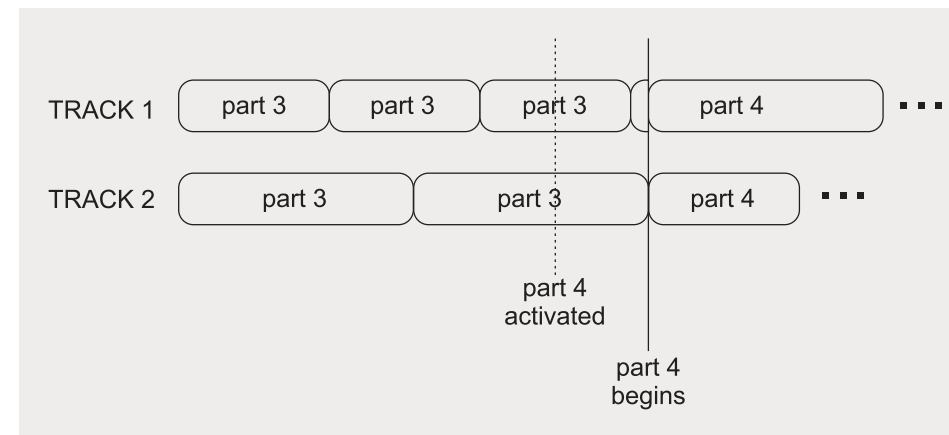
This is the same scenario as above except the TRANSITION switch is set to LAST. Track 2 finishes last, therefore track 2 determines the beginning of the next part.

GROUPS

What are groups?

The middle section of the ER-102 is dedicated to groups. Groups are arbitrary selections of steps that can be the target of transforms and CV/gate modulation. Each snapshot can contain up to 16 groups. There are 3 independent channels of CV/gate moduation called the MOD bus that can be routed and thus affect each of the groups and their assigned steps.

Selecting steps

Select a single step at a time

The most basic way to add steps to the current focused group, is to press the (DE)SELECT button while the desired step is focused. Pressing the (DE)SELECT button adds the step if it is not part of the group already, and removes the step if it is already part of the group. The red selection LED (to the left of the GROUP display) will light up when the focused step is in the focused group.
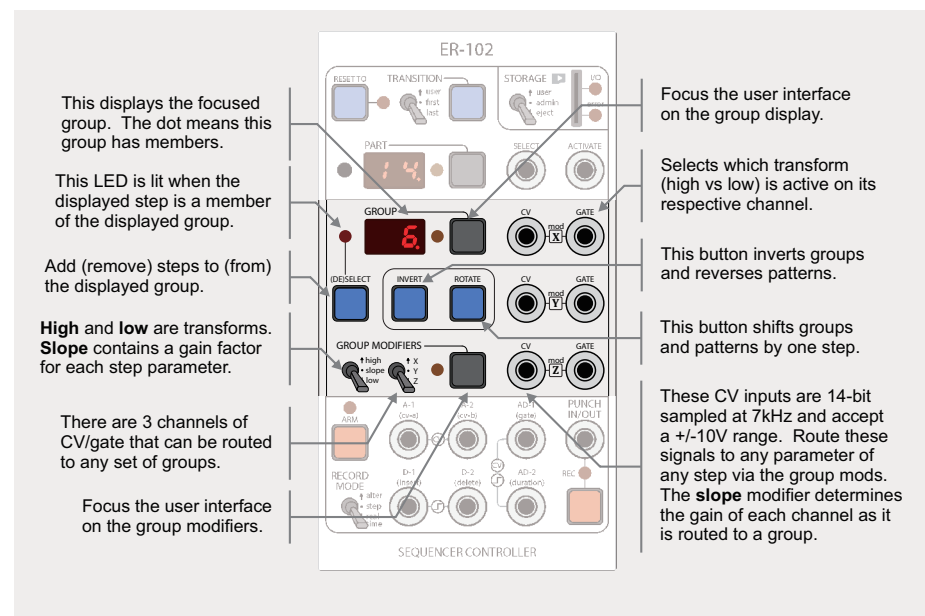
Copy a selection

If you press the COPY button while the GROUP display is focused then the current group's selection (but not the steps themselves) is copied to the clipboard. At this point the GROUP display LED will start flashing. You can now navigate to another group and paste the copied selection with the INSERT button. The pasted selection will combine with the existing selection in the target group, creating the union of the two selections.

Delete a selection

If you press the DELETE button while the GROUP display is focused then all steps are removed from the focused group.

Rotate a selection

The ROTATE button will shift a group's selection later in the sequence by one step. So if step #4 and step #12 are selected then after pressing the ROTATE button, step #5 and step #13 will be selected. Holding the INVERT button while pressing the ROTATE button will shift the selection earlier by one step.

This displays the focused group. The dot means this group has members.

This LED is lit when the displayed step is a member of the displayed group.

Add (remove) steps to (from) the displayed group.

High and **low** are transforms. **Slope** contains a gain factor for each step parameter.

There are 3 channels of CV/gate that can be routed to any set of groups.

Focus the user interface on the group modifiers.

Focus the user interface on the group display.

Selects which transform (high vs low) is active on its respective channel.

This button inverts groups and reverses patterns.

This button shifts groups and patterns by one step.

These CV inputs are 14-bit sampled at 7kHz and accept a +/-10V range. Route these signals to any parameter of any step via the group mods. The **slope** modifier determines the gain of each channel as it is routed to a group.

TIP: Selection operations are track-specific! Operations that change what steps are selected (i.e. COPY, DELETE, INVERT, ROTATE) in a particular GROUP, will only affect the steps of the current focused TRACK.

TIP: When the GROUP display is focused, the number of steps in the group (for the current track) is shown in the VOLTAGE display. The prefix 'nS' will be shown in the INDEX display to remind you. In the example below, the current group contains 64 steps from the current track.
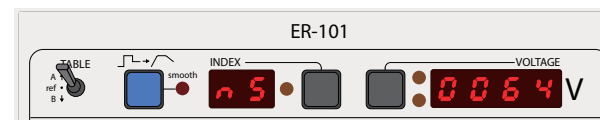
Invert a selection

Group membership can be inverted by focusing a group and pressing the INVERT button. All steps that were in the group are taken out of the group and all steps that were not in the group are placed in the group. This applies only to steps in the focused track.

Select multiple steps via Euclidean masks

When the navigation focus of the ER-101/102 is PATTERN or TRACK, then pressing the (DE)SELECT button enters you into a special selection mode where you can specify a Euclidean pattern that wil be used as a 'selection mask' to select (and dese-lect) steps from the focused pattern or track.

Let's start with a quick example to illustrate the concept. Suppose you want to add every 3rd step of PATTERN #2 (which has 8 steps total) to GROUP #1:

1. Navigate to GROUP #1 and PATTERN #2 but leave the PATTERN display focused.
2. Press the DE(SELECT) button. The LED will start flashing and the INDEX/VOLT-AGE displays will show something like '8Eu.8' in the case the focused PATTERN has 8 steps. '8Eu.8' = E(8,8) = [11111111] or all 8 steps are in the selection mask.
3. Use the LEFT encoder to change the Euclidean mask to '3Eu.8' which specifies the selection mask E(3,8) = [10010010] or in other words 3 steps out of 8, spaced out as evenly as possible.
4. Press (DE)SELECT again to select steps from PATTERN #3 into GROUP #1 accord-ing to the Euclidean mask (3Eu.8 = [10010010]). In this case, steps that corre-spond to a '1' will be selected into the GROUP and the rest will be taken out of the GROUP.

The point of all this is that now you can apply GROUP transforms and modifiers to steps that are arranged according to a Euclidean pattern of your choice. For ex-ample, you can create drum hits or accents on just the 1's (or the 0's) in a Euclidean pattern with a quick GROUP transform. The power of arbitrary transforms through the lens of Euclidean masks is a wonderful tool for rhythmic composition.

Let's tie up some loose ends with respect to selecting steps via the Euclidean algo-rithm:

- When in Euclidean selection mode, use the RIGHT encoder to change the length of the generated Euclidean pattern, M.
- If there are more steps in the focused PATTERN (or TRACK) than in the generated Euclidean mask (i.e. number of steps > M) then the Euclidean mask just gets

= E(6,16)
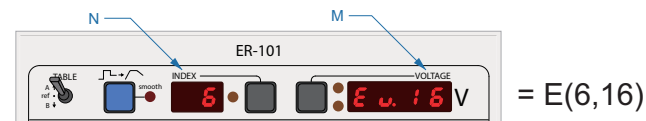
What is a Euclidean pattern? Suppose you have N paid holidays that you have to use before the end of the year which is M days away. Furthermore, you would like to spread the paid holidays out as much as possible because that's the way you like it. How do you figure out the optimal schedule? If M is evenly divisible by N (e.g. M = 100 and N = 10) then the answer is obvious, take a day off every M÷N days. However, if M is not evenly divisible by N than the answer is not so obvious and in fact there are possibly many answers all related by a shift (or rotation).

As it turns out, the most evenly spaced mapping of N objects onto M positions on a line (usually the time line in practice) can be calculated by the Euclidean algorithm. The Euclidean algorithm was first developed by Bjorklund (1) to optimize the timing of neutron firing patterns in an accelerator and later found by Toussaint (2) to have musical utility because it generates many of the world's common rhythms. The algorithm takes two parameters, N for the number of objects and M for the number of positions and yields a binary sequence (or mask) as its output. For example, E(N,M) = E(2,4) = [1010] or [0101] and shows how 2 objects may be distributed in the most even manner amongst 4 positions. Some other examples are:

```
E(3,8)    = [10010010]
E(5,12)   = [100101001010]
E(7,12)   = [101101011010]
E(8,12)   = [101101101101]
E(5,16)   = [1000100100100100]
E(16,40)  = [1001010010010010100101001010010100101010010010]
E(7,17)   = [10010101001010010]
E(6,16)   = [1001010010010100]
```

Keep in mind that a Euclidean mask may still need to be shifted/rotated to taste because shifting/rotating the mask does not alter its properties from the point of view of the Euclidean algorithm.

A Python implementation of Bjorklund's algorithm for generating Euclidean patterns can be downloaded from:

http://www.orthogonaldevices.com/files/euclid.py?attredirects=0&d=1

References
(1) E. Bjorklund. The theory of rep-rate pattern generation in the SNS timing system. SNS ASD Technical Note SNS-NOTE-CNTRL-99, Los Alamos National Laboratory. 2003.

(2) G. Toussaint. The Euclidean Algorithm Generates Traditional Musical Rhythms. Proceed-ings of BRIDGES: Mathematical Connections in Art, Music, and Science. 2005.
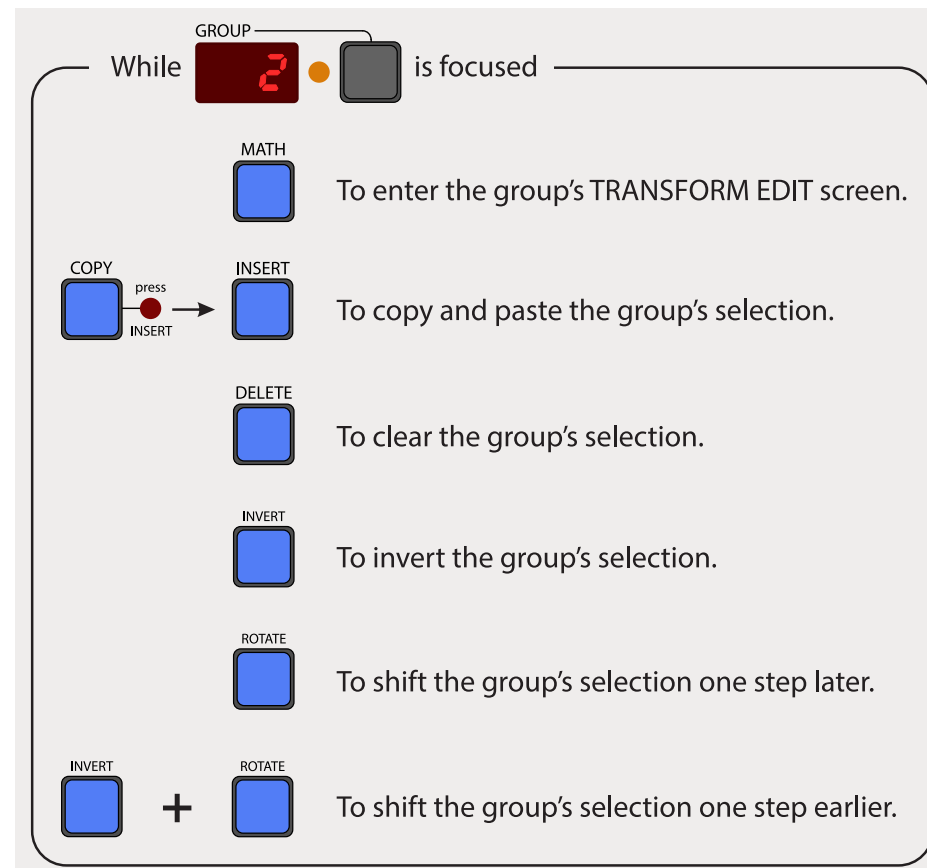
repeated over and over again until it covers the entire PATTERN (or TRACK). For example, suppose we are selecting steps from a PATTERN with 10 steps with the Euclidean mask, E(1,4)=[1000]. This mask will be extended to [1000100010] and then used to select those steps that correspond to the 1's.

- When you enter Euclidean selection mode, the parameters are always set to E(L,L) where L is the number of steps in the focused PATTERN. You can press the DELETE button to quickly set the N parameter to zero, thus giving E(0,L). Pressing the INDEX focus button will toggle between E(0,L) and E(L,L), or, in effect 'deselect all' and 'select all', respectively.
- If the TRACK is focused when entering the Euclidean selection mode then the generated Euclidean mask is repeated over the **entire track**, selecting steps into the focused GROUP as it goes.
- The longest Euclidean mask that can be generated is 99 steps.
- After applying the Euclidean mask, use the INVERT and ROTATE buttons with the GROUP focused to further adjust the selection.
- Select steps from the same PATTERN or TRACK into one or more GROUPS using different Euclidean masks for an endless variety of phasing patterns.

Applying transforms

Each group has its own destructive transform that is accessible via the MATH button and also non-destructive transforms that are accessible as the high/low modifiers. Pressing the MATH button while the GROUP display is focused will show the destructive transform just like accessing the track transforms. When you apply a group transform by pressing and releasing the MATH button, the transform will only alter the parameters of those steps that are in the group.

You can edit the transform while holding down the MATH button and then apply it by releasing the MATH button. Also, you can "pin" the transform edit screen by pressing the VOLTAGE display button so that the screen stays when you release the MATH button. In this case, press the VOLTAGE focus button (now displaying 'dONE') again to exit from the transform edit screen. Apply the transform at any time by pressing the MATH button. See the section on Math Transforms for a detailed description.

While [GROUP 2] is focused

MATH — To enter the group's TRANSFORM EDIT screen.

COPY press→ INSERT — To copy and paste the group's selection.

DELETE — To clear the group's selection.

INVERT — To invert the group's selection.

ROTATE — To shift the group's selection one step later.

INVERT + ROTATE — To shift the group's selection one step earlier.

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Modifiers

The modifiers of a group dictate how the 3 channels of CV/gate modulation (X, Y, and Z) affect the steps within the group. The SLOPE modifier holds the gain matrix that routes the 3 CV inputs to each parameter of each step in a group. The HIGH and LOW modifiers are non-destructive transforms which are activated according to the logic state of the 3 gate inputs (X, Y, and Z).

The Slope Matrix

This is one of those things that is actually very easy to understand when you are using it but requires a lot of words to explain.

Each group has 3 slopes (X, Y, and Z) for each of the 4 step parameters (CV-A, CV-B, DURATION, and GATE). The voltages present at each channel of the modulation bus are multiplied by each group's slope matrix and then added to each step parameter:

$$\mathbf{P}_{after} = \mathbf{P}_{before} + \mathbf{K}_X\mathbf{V}_X + \mathbf{K}_Y\mathbf{V}_Y + \mathbf{K}_Z\mathbf{V}_Z$$

where,

$\mathbf{P}_{after}$: step parameter after modification
$\mathbf{P}_{before}$: step parameter before modification
$\mathbf{K}_X$, $\mathbf{K}_Y$, $\mathbf{K}_Z$: The 3 slopes (or gains) associated with a given group
$\mathbf{V}_X$, $\mathbf{V}_Y$, $\mathbf{V}_Z$: the voltages from the 3 modulation channels

In the case of CV-A and CV-B, this adjustment is added after the voltage table lookup (i.e. after converting the CV index to an actual voltage). To access the slope parameters for a particular modulation channel:

1. Toggle the GROUP MODIFIER HIGH/SLOPE/LOW switch to SLOPE.
1. Toggle the GROUP MODIFIER XYZ switch to the desired channel.
2. Press the GROUP MODIFIER focus button.

Now the GROUP display LED and the GROUP MODIFIER display LED will be flashing. This means that the LEFT knob on the ER-101 will alter the focused group and the RIGHT knob will alter the slope value associated with the focused step parameter (i.e. CV-A, CV-B, DURATION and GATE).

Configurable Option: You can configure the voltage that is used when there is no jack plugged into the CV mod jacks. The default is zero volts.

	X	Y	Z
CV-A	1.0	0.05	0.0
CV-B	0.0	0.25	0.0
DURATION	0.0	0.0	0.0
GATE	-4.0	0.0	2.5

This table shows an example slope matrix that results in the following modifications to each step parameter:

$$\mathbf{CV\text{-}A}_{after} = \mathbf{CV\text{-}A}_{before} + 1.0\mathbf{V}_X + 0.05\mathbf{V}_Y$$
$$\mathbf{CV\text{-}B}_{after} = \mathbf{CV\text{-}B}_{before} + 0.25\mathbf{V}_Y$$
$$\mathbf{DURATION}_{after} = \mathbf{DURATION}_{before}$$
$$\mathbf{GATE}_{after} = \mathbf{GATE}_{before} - 4.0\mathbf{V}_X + 2.5\mathbf{V}_Z$$
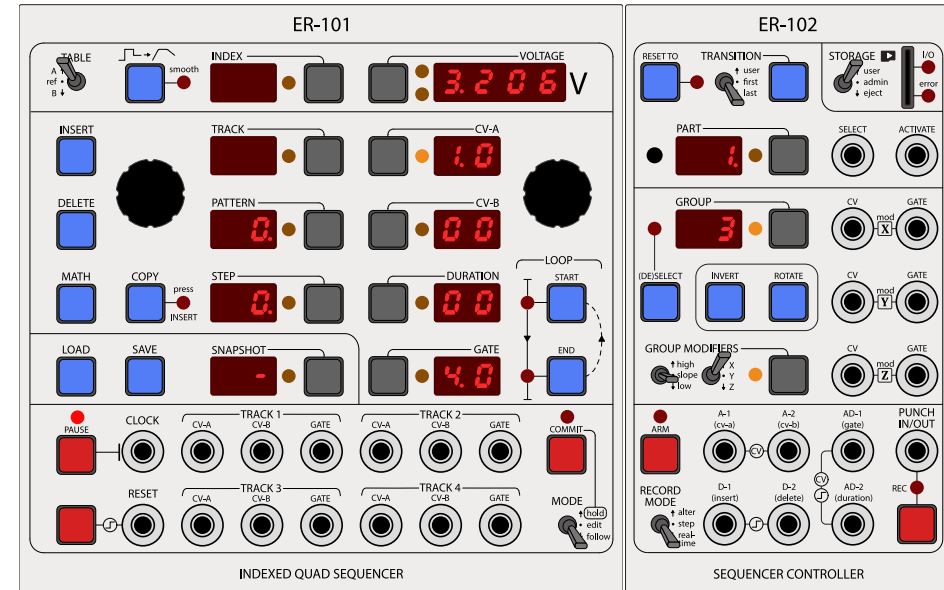
This is how the ER-101/102 appears when you are viewing/editing the **X** column (1.0, 0.0, 0.0 -4.0) of the example slope matrix shown above. Notice the positions of the GROUP MODIFIER switches. Since CV-A is focused, the value shown in the VOLTAGE display is $\mathbf{K}_X\mathbf{V}_X = (1.0)\mathbf{V}_X$ or just the voltage present at the CV input for channel X.

When altering the slope, the size of the encoder increments depends on the slope's magnitude:

Min	Max	Increment
-99	-10	1
-9.9	-1.0	0.1
-0.99	0.99	0.01
1.0	9.9	0.1
10	99	1

This logarithmic scheme allows for fine control when dialing in small gains while also making very large gains easy to reach.

High vs Low transforms

The GATE inputs on the 3 modulation channels (X, Y, and Z) control which of each group's (non-destructive) transforms are active. Each group has 6 of these transforms because there are high and low transforms for each of the 3 channels which comes out to 6 transforms per group. For example, a high voltage (>1.5V) on the X channel GATE input will activate all of the X-high transforms, while a low voltage (<1.5V) will activate all of the X-low transforms and so on.

> TIP: If there is no plug in the GATE input jack then the low transforms are active by default.

The usual interface for transforms is used to edit a group's high/low transforms. See the section on Math Transforms. However, there is no need to apply the high/low transforms because they are applied automatically everytime a step plays.

The high/low transforms have many uses:

- Provide programmable offsets for the CV modulation bus.
- Mute steps in a group by having the high transform multiply the GATE parameter by zero.
- Skip steps in a group by having the high transform multiply the DURATION parameter by zero.
- Momentarily double or half the step durations of a group for rhythmic effect. This works especially well when you partition your sequence into two groups each with opposite transforms (i.e. one group doubles in duration while the other group halves the duration).
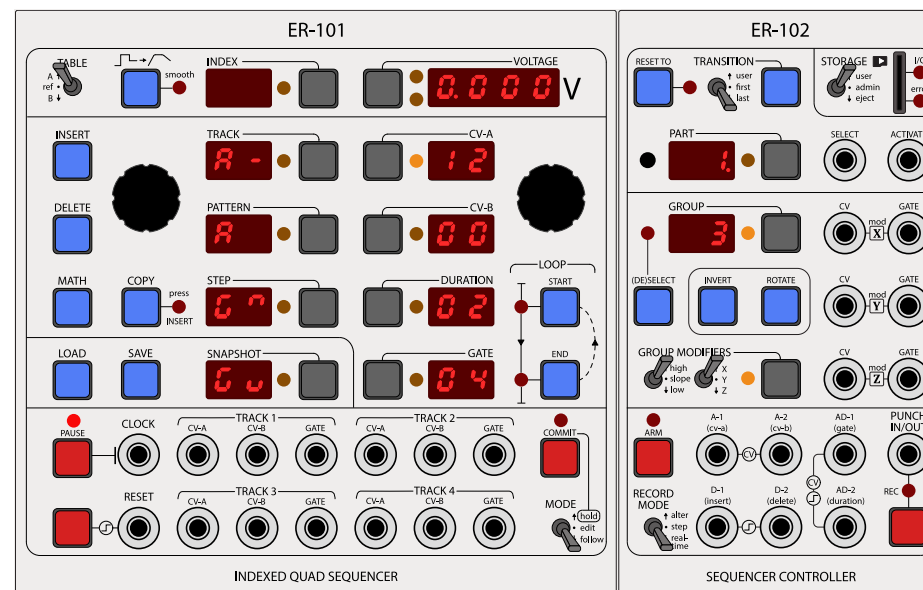
Here the GROUP MODIFIER switches are set so the X channel's HIGH transform is displayed for the steps in group 3. In this case, assuming the other operations are set to their default values, the transform will decrease CV-A by an octave (subtract 12), leave CV-B untouched, double the DURATION and divide the GATE length by 4.

RECORDING

The lower section of the ER-102 is dedicated to recording and remote control of the ER-102 editing functions. In addition to the PUNCH IN/OUT gate input, there are 6 multi-purpose inputs:
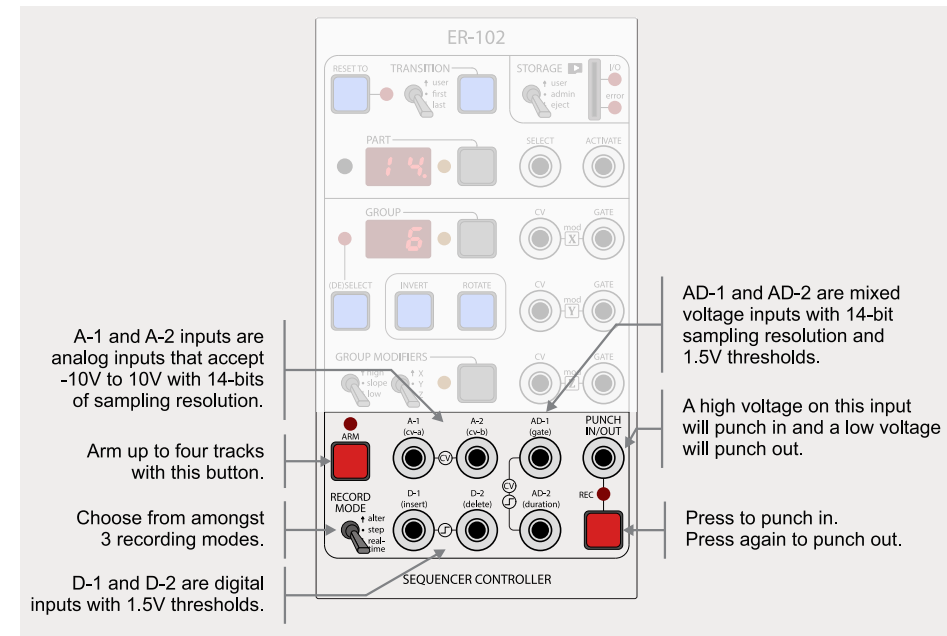
A-1 and A-2: analog inputs that accept -10V to 10V
D-1 and D-2: digital inputs with a trigger threshold of 1.5V.
AD-1 and AD-2: can be used either as analog or digital inputs.

The role of each of these inputs depends on the record mode.

The ARM button and the PUNCH IN/OUT section are common to all of the recording modes. Recording is enabled for one or more tracks by toggling the ARM button while the desired track is focused. A track is armed when the ARM LED is lit. Assuming the ER-101 is not paused, actual recording begins when you punch in via the PUNCH IN/OUT button, or, via a high gate signal on the PUNCH IN/OUT gate input. Recording stops again when you press the PUNCH IN/OUT button again, or, when the PUNCH IN/OUT gate goes low. The ER-102 is actively recording when the REC LED is lit.

A-1 and A-2 inputs are analog inputs that accept -10V to 10V with 14-bits of sampling resolution.

Arm up to four tracks with this button.

Choose from amongst 3 recording modes.

D-1 and D-2 are digital inputs with 1.5V thresholds.

AD-1 and AD-2 are mixed voltage inputs with 14-bit sampling resolution and 1.5V thresholds.

A high voltage on this input will punch in and a low voltage will punch out.

Press to punch in.
Press again to punch out.

Real-time mode

The real-time recording mode is used to capture a live performance as a step sequence. Timing of CV and gate changes are measured against the clock (after per-track multiplication) and then re-interpreted as a sequence of steps with quantized voltages and timing. Real-time recording starts on all armed tracks when the PUNCH LED is lit and the ER-101 is not paused. The newly recorded steps are inserted at the current location of the play cursor. In fact, in real-time mode the play cursor and the record cursor are the same. So if you want to see what you are recording then put the ER-101 in FOLLOW mode.

The A-1 and A-2 analog inputs are routed to CV-A and CV-B, respectively. The AD-1 input is placed in digital mode and expects a gate signal that goes high for a "note on" event and goes low for a "note off" event. In other words, the time between two consecutive rising edges on this gate input determines the duration of the recorded step, while the time between a rising edge and a falling edge determines the recorded step's gate length.

> Configurable Option: The unused D-1, D-2 and AD-2 inputs can be configured to control other aspects while in this mode. See the configuration file on your SD card for more details.

The CV index that is assigned to the current recording step is determined in the following manner. Once a new step has started, the ER-102 then waits for approximately half a clock pulse before sampling the A-1 and/or A-2 inputs. This helps insure that the voltage on these inputs has settled to an accurate value. The value that is sampled (with 14-bits of resolution) is truncated to the output range of the ER-101 (0V to 8.192V) and then quantized to the nearest entry in the track's voltage table.

The re-interpretation of your performance as a step sequence means that glides, vibrato, or any continuous CV movements will not retain their smooth nature. However, you can regain some of these smooth movements later by manually enabling smoothing on the necessary steps. Continuous modulations are best added later using the modulation bus of the GROUP section.

> TIP: While recording, the live inputs (A-1, A-2 and AD-1) are passed unchanged to the outputs (CV-A, CV-B, and GATE) of the ER-101 so that you can monitor your performance in real-time. This is called **record pass-thru**. There is more information on record pass-thru later on in this chapter.
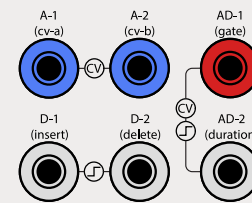
These CV inputs are sampled half a clock pulse after inserting a new step.

Two consecutive rising edges determines the duration of a step. A rising edge followed by a falling edge determines the step's gate duration.
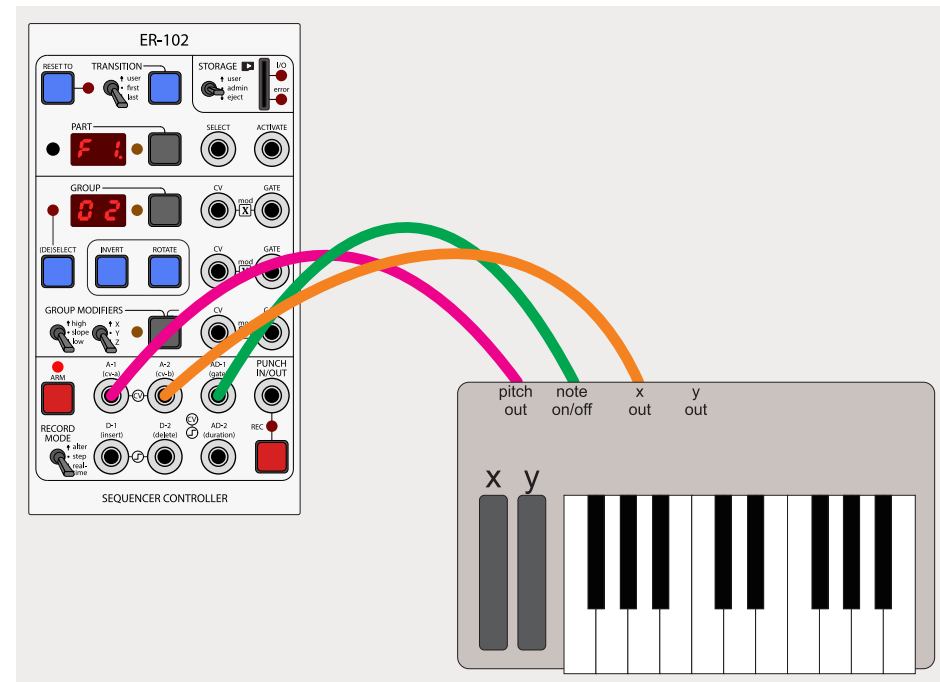
CV/Gate trigger vs Gate-only trigger

A configuration screen is shown whenever you arm a track for real-time recording. This screen has the following options:

Display	Purpose	Range	Default
CV-A	Trigger a new step when CV-A changes?	tr, --	tr
CV-B	Trigger a new step when CV-B changes?	tr, --	--
DURATION	Quantization grid for step durations.	1-99	1
GATE	Quantization grid for gate lengths.	1-99	1

This screen disappears when you press the (flashing) ARM button once more. The CV-A and CV-B options affect how a new step is created and are set by pressing the FOCUS buttons next to the CV-A and CV-B displays.

Normally, during real-time recording a new step is only started when a rising edge is received from the gate input, AD-1. However, there are cases when a new step should start without a new gate signal such as when the performance includes legato notes. Setting the real-time configuration for CV-A or CV-B to "tr" will cause new steps to be created whenever the pitch CV changes (post quantization). The default setting is to enable this option for CV-A but disable it for CV-B because it is assumed that CV-A will usually be controlling pitch and CV-B will usually be controlling some other non-pitch parameter such as velocity. If this is not the case then you can change the behavior in this screen.

Duration and Gate Quantization

The next two options allow the user to specify the granularity of the quantization grid. Steps that are recorded will have their DURATION and GATE parameters rounded to the nearest multiple of these quantization settings. The default setting is 1, the minimum amount of quantization. Set the desired quantization by focusing the DURATION or GATE display and turning the RIGHT knob.

Recording Focus

The flashing LED in the configuration screen indicates the current recording focus:

Focus	Behavior
TRACK	New material is inserted at the end of the track in a new pattern.
PATTERN	New material is inserted after the current track in a new pattern.
STEP	New material is inserted after the current step in the existing pattern.
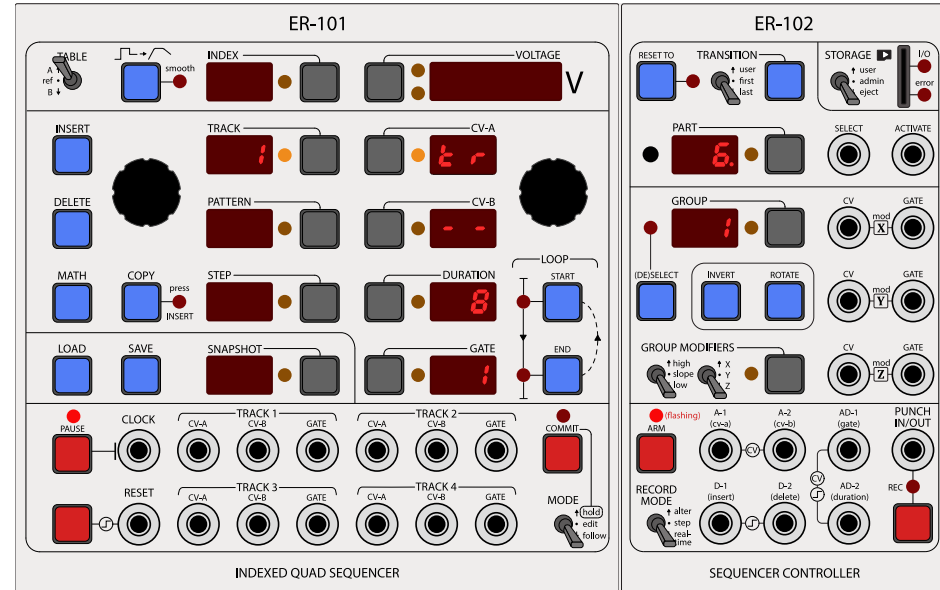
This figure shows the configuration screen for real-time recording. In this case, new steps would be generated only when a new gate is received or CV-A changes. The step durations are quantized to multiples of 8. The recording focus is set to TRACK.
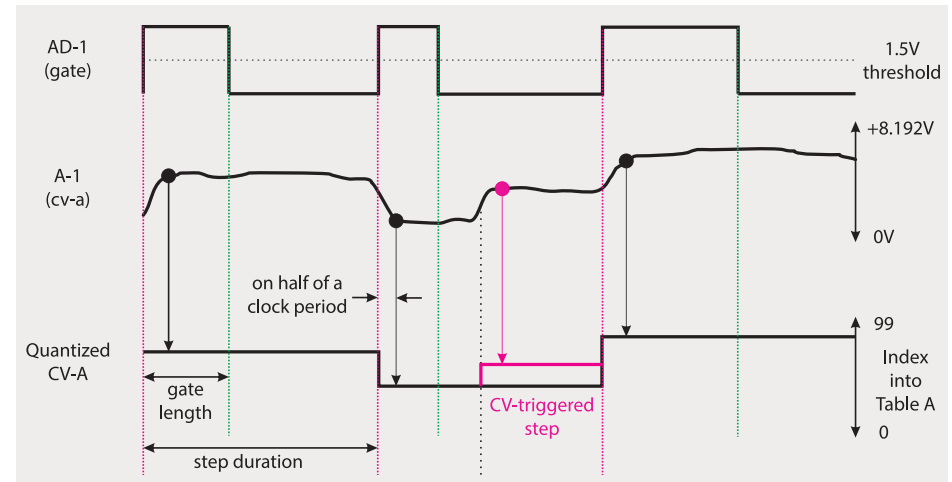
This figure portrays how a raw CV and gate pair are converted to a sequence of steps. The pink overlay shows the extra step that would be generated if a change in CV-A was configured to trigger new steps.

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Pass-Thru for Real-time Recording

It is essential to be able to hear what you are recording as you are recording it. It is also likely that you will want to rehearse (possibly along with existing material) before actually recording. Both of these cases are handled via **record pass-thru**. When record pass-thru is activated, any of the real-time record inputs (A-1, A-2, and AD-1) that have jacks plugged into them will also pass their signals unprocessed directly to the ER-101 outputs of all armed tracks.

Record pass-thru is **activated** in the following cases:
- *Monitor while recording*: the ER-101 is unpaused, at least one track is armed and you are punched in.
- *Rehearse before recording*: the ER-101 is unpaused, at least one track is armed and you are not punched in but a note event has been detected on the record inputs.

Record pass-thru is **deactivated** by the same events that end a recording:
- RESET (button or gate signal)
- PAUSE button pushed
- PUNCH OUT (button or gate signal)

Also, unarming a track will stop pass-thru on that track but pass-thru will continue on any other armed tracks.

Given the above description, a typical recording session would unfold as follows:

1. Track 1 contains a lead sequence and you would like to record a supporting bass sequence into track 2.
2. Attach your CV keyboard or similar to the record inputs (pitch CV to A-1, velocity to A-2, and gate to AD-1)
3. Place the RECORD MODE switch in the 'real-time' position and make sure you are punched out.
4. Unpause the ER-101, so that the lead sequence on track 1 is playing.
5. Arm track 2 for recording, setting any desired CV-trigger and quantization options.
6. Rehearse a few times by playing on your CV keyboard. You will hear what you are playing in real-time on the output of track 2, along with track 1 that is playing the lead sequence.
7. When you are ready, punch in and record a take.
8. When you are done, either punch out manually or perhaps arrange to be automatically punch out via an external gate signal.

Configurable Option: By default, actual recording doesn't start as soon as you punch in. Instead, the ER-102 waits for a note to be played on the record inputs and then starts recording. Punching in just tells the ER-102 to be ready and waiting for this first note. This way you don't need to worry about punching in and beginning to play at the same time. However, if you would prefer that recording starts as soon as you punch in then you can change the 'wait-for-first-note' configuration option in the CONFIG.INI to false. This will cause a recording to start immediately with a rest step (i.e. GATE=0) the moment you punch in.

Step mode

The purpose of step recording is to use an external CV/gate source (such as a CV/gate keyboard) to insert and delete steps but ignore the timing with which you do it. The STEP record mode essentially places the ER-101 under remote editing control. Unlike the other two recording modes, this mode inserts/deletes steps at the edit cursor, not the play cursor. It helps to think of the STEP recording mode as really just another editing mode. So if you want to see what you are doing you should put the ER-101 in EDIT mode. Also, while recording in STEP mode, you can seamlessly use the controls on the ER-101 to make additional edits or move the edit cursor to another location.

The A-1 and A-2 analog inputs are as always routed to the CV-A and CV-B step parameters, respectively. The AD-1 input is placed in analog mode and is routed to the GATE parameter. The AD-2 input is also placed in analog mode and is routed to the DURATION parameter. D-1 takes a gate signal from your controller that triggers step insertion and D-2 takes a gate signal that triggers step deletion.

Once you punch in, all armed tracks will be under remote control. A rising edge on D-1 (insert) will cause a new step to be inserted at the edit cursor of all armed tracks. So before you start recording, make sure you move the edit cursors of all armed tracks to where you want new steps to be added. The step parameters of a newly inserted step are set according to the voltage levels present at A-1 (cv-a), A-2 (cv-b), AD-1 (gate), and AD-2 (duration):

| Step Parameter	Input	Relationship
CV-A	A-1	Quantize voltage with table A
CV-B	A-2	Quantize voltage with table B
DURATION	AD-2	(voltage)*20 (max 99 at 5V and over)
GATE	AD-1	(voltage)*20 (max 99 at 5V and over)

As long as the D-1 (insert) gate is held high, the step parameters of the just inserted step will follow any voltage changes as dictated by the table above. The step parameters are locked and will no longer change when the D-1 (insert) gate goes low.

Since steps are added at the edit cursor, you can have the sequencer playing (and looping) the same section as you add/remove steps.
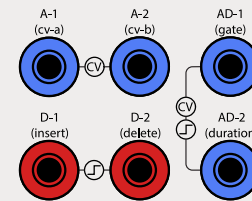
While the (insert) gate is high, continuously sample the inputs and update the last inserted step.

Trigger a step to be inserted/deleted at the edit cursor.
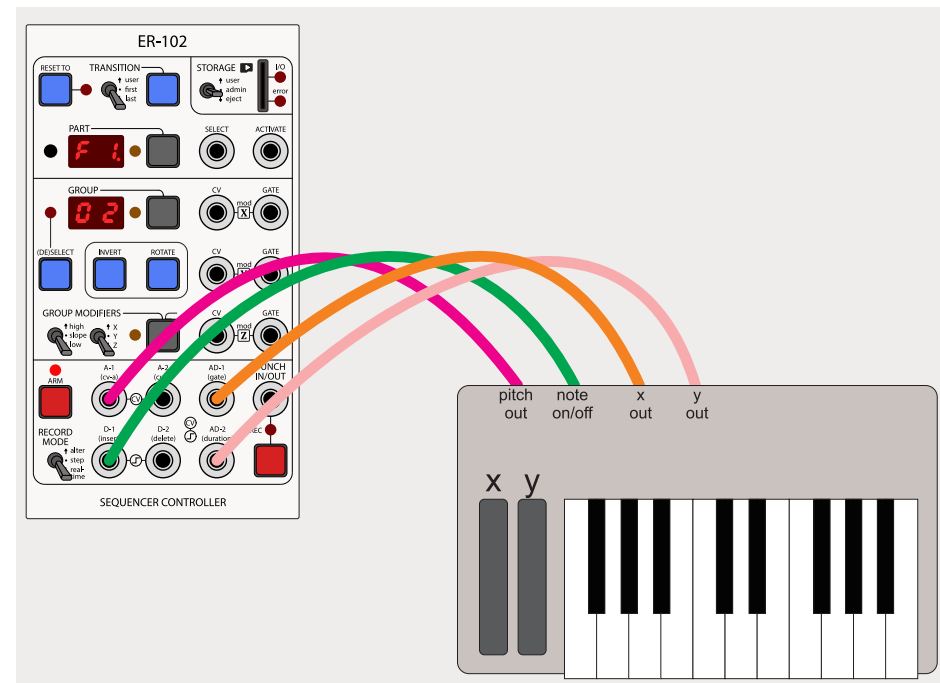
Alter mode

This mode is similar to the REAL-TIME mode in that steps under the play cursor are affected and recording happens in real-time. However, no new steps are inserted in the armed tracks. Instead, step parameters are overwritten with new values that are derived from the input voltages. The step parameters are rewritten **just before** the play cursor encounters the step and then plays it. If you are looping a single step then the currently playing step and the next step about to be played are the same step. In this case, voltage changes are reflected immediately.

Except for the D-1/D-2 inputs which are not used, the jack mapping and relationship between voltages and step parameters is the same as in the STEP recording mode:

| Step Parameter	Input	Relationship
CV-A	A-1	Quantize voltage with table A
CV-B	A-2	Quantize voltage with table B
DURATION	AD-2	(voltage)*20 (max 99 at 5V and over)
GATE	AD-1	(voltage)*20 (max 99 at 5V and over)

The typical useage scenario for the ALTER record mode is to lay down new automation or melody on an existing sequence of steps. However, there are many unusual and interesting possibilities that can lead to complex results when using non-synced LFOs or even feedback from the ER-101 itself.

> Configurable Option: The unused D-1 and D-2 inputs can be configured to control other aspects while in this mode. See the configuration file on your SD card for more details.

> TIP: The knobby interface. A particularly useful setup is to synchronize a traditional analog step sequencer with the ER-101 but have all of the analog step sequencer's outputs go through the ER-102 in ALTER record mode. If the ER-101 is looping a section that is the same length as the sequence of steps on the analog step sequencer then you get a real-time knobby interface for the loop playing on the ER-101 with pitch quantization!
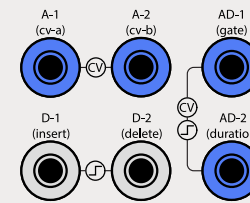
Any of the 4 step parameters of the step that is currently being played are overwritten with the sampled values present at these inputs.
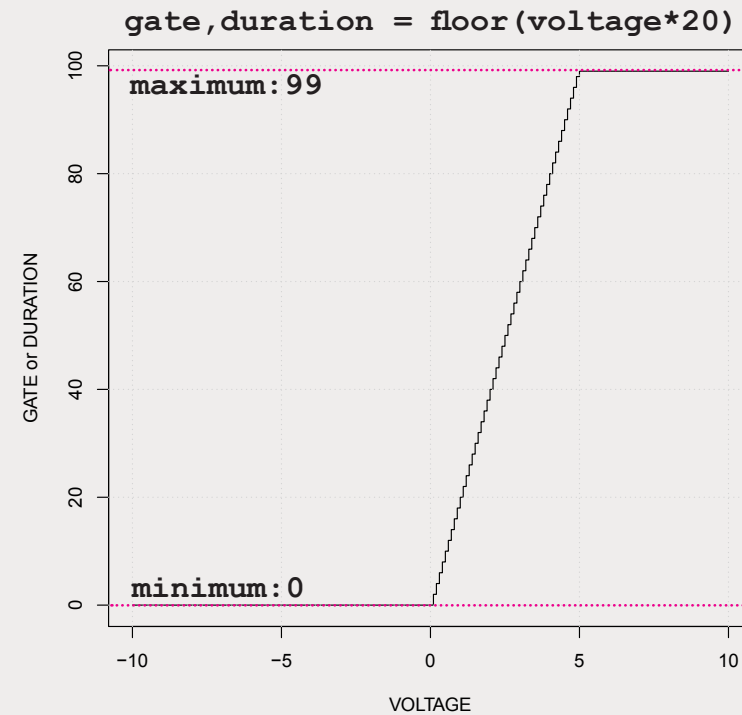
Rotoinversion

The ER-101 provides the COPY operation and the MATH transforms as its main tools for generating new material from existing material. However, permutations of a given sequence were not easily accessible except via manual step-by-step editing. Hence, I included the inversion and rotation operations (i.e. rotoinversion) on the ER-102. Using just basic inversion and rotation operations any permutation of a given sequence can be generated quickly and intuitively.

The behavior of the INVERT and ROTATE buttons depends on what is focused when they are pressed:

Focus	Target
PATTERN	The focused parameter of the steps in the focused pattern are affected.
TRACK	The focused parameter of all steps in the focused track are affected.
PART	The focused parameter of all steps between the start step and end step of the focused part are affected.
GROUP	The membership of the focused group is affected.

Focus	INVERT	INVERT+ROTATE	ROTATE
PATTERN	Reverse	Shift Backward	Shift Forward
TRACK	Reverse	Shift Backward	Shift Forward
PART	Reverse	Shift Backward	Shift Forward
GROUP	Invert	Shift Backward	Shift Forward

Notice that when PATTERN, TRACK, or PART are focused, it is the focused step parameter that is shifted or reversed, but, when the GROUP is focused then it is the group membership that is shifted or inverted. INVERT+ROTATE means that you press the ROTATE the button while holding the INVERT button.

The figure to the right depicts these shifting and reversing operations in the case that a pattern is focused. Notice how it is only the focused parameter (DURATION in this case) that is affected, thus allowing you to alter rhythm and voicing separately from pitch and so on.


23
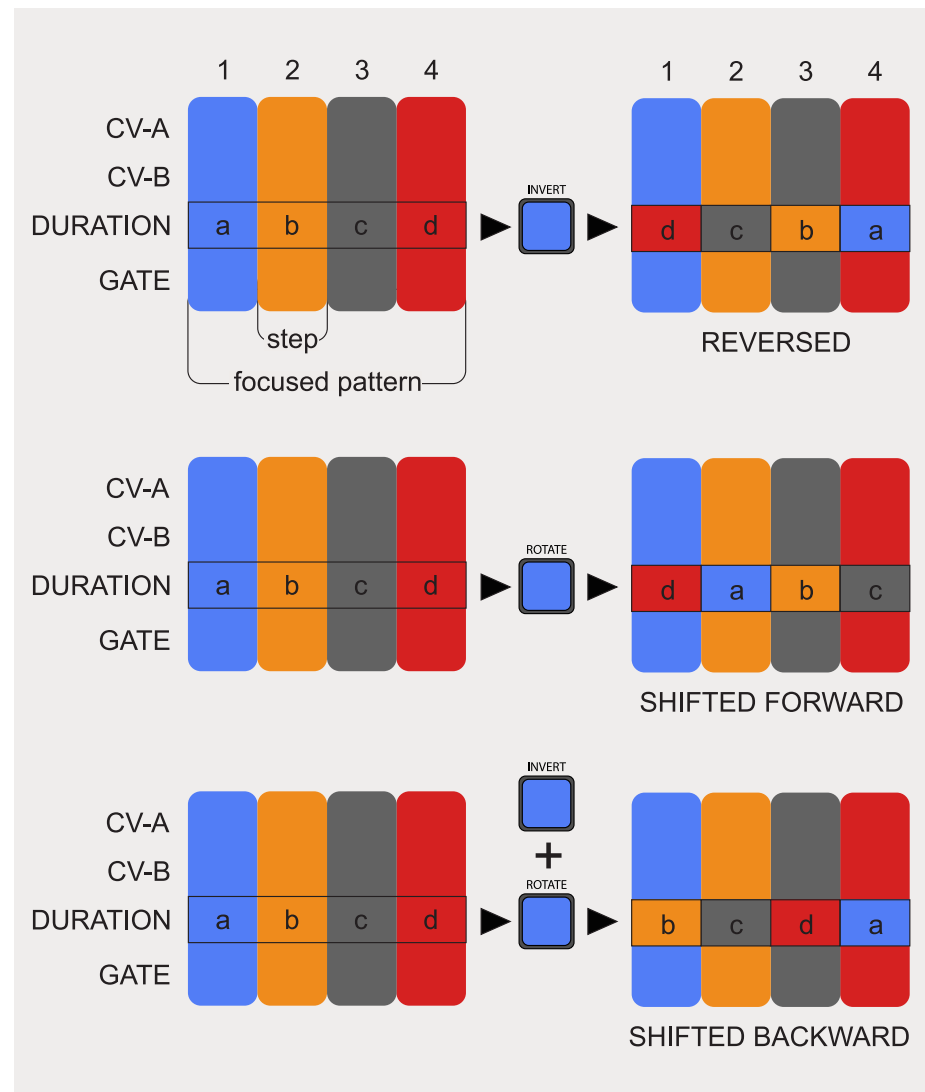
STORAGE

The ER-102 stores snapshots and loads firmware upgrades via its microSD card slot. If it doesn't already exist, the ER-102 will create the following files and directory structure on your memory card:

```
ER-102/
    FIRMWARE/
    SNAPSHOT/
    TABLES/
    CONFIG.INI
    METAINFO.BIN
```

The FIRMWARE directory is where the ER-102 will look for firmware binaries. The SNAPSHOT directory is where the ER-102 saves snapshots (and their revisions). The ER-102 loads the user voltage tables from the TABLES directory. The CONFIG.INI file is the global configuration file (see the section on Configuration Files). Lastly, the METAINFO.BIN file is used by the ER-102 to keep track of some internal state like the last snapshot loaded and what version of the ER-102 firmware last accessed this SD card.

> Tip: Loading and saving snapshots will only work while the STORAGE switch is set to USER. ADMIN is used only for firmware updates at the moment.

> Warning: Since the ER-102 does not have the battery-backup necessary for keeping track of the date and time when powered off, timestamps of those files written or modified by the ER-102 are not going to be very meaningful.
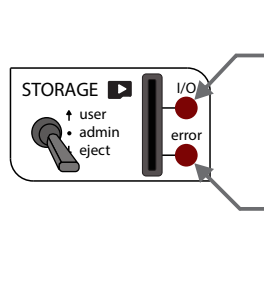
Flashes when accessing the microSD card.

Lit when the microSD card is no longer mounted because either the card was ejected, or because there was an error.

error occurred

accessing card   card mounted   card ejected (safe to remove)
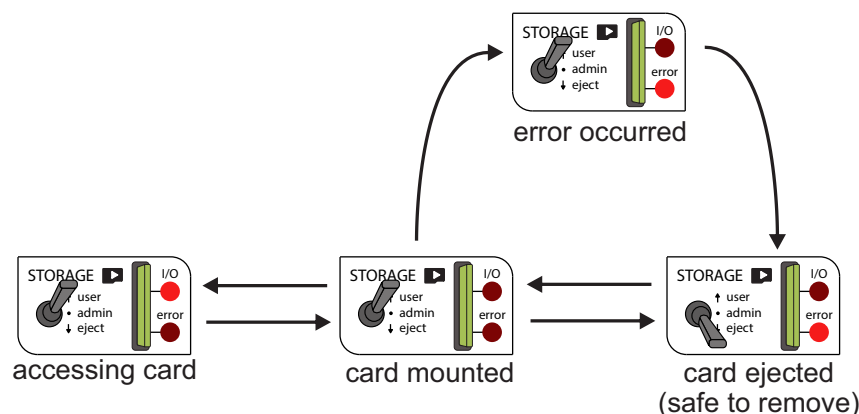
The SD card ejection process
1. I want to take the SD card out of my ER-102 safely without powering down.
2. Place the STORAGE switch in the EJECT position.
3. Wait for the ERROR LED to light. This means that the ER-102 no longer has access to the SD card and all pending data has been flushed.
4. Remove the SD card.

The SD card insertion process
1. I want to insert an SD card in to my ER-102 while powered up.
2. Place the STORAGE switch in the EJECT position (if it isn't already).
3. Insert the SD card.
4. Place the STORAGE switch in the USER position.
5. If the ERROR LED turns off then the ER-102 has successfully mounted your SD card.

Remounting the SD card after an error
1. There was an error (for whatever reason) when accessing the card and now the ERROR LED is lit.
2. Place the STORAGE switch in the EJECT position.
3. Place the STORAGE switch in the USER position.
4. If the ERROR LED turns off then you are ready to go again.

Snapshots

Snapshots can be saved to and loaded from any of 127 slots: A1 to U7 (for regular snapshots) and t1 to t9 (for templates). There is a permanent blank snapshot [--] before A1 and some template snapshots (t1 to t9) before the blank snapshot. Load the blank snapshot to start with a fresh empty snapshot. Prepare and save template snapshots for quick startup later on.

After you save a snapshot (such as to the A1 slot in this example) then the file structure will look like this:

```
ER-102/
   SNAPSHOT/
      A1/
         LATEST.BIN
         R0001.BIN
         R0002.BIN
            .
            .
```

Each slot has its own subdirectory (named after the slot, A1 through L9) that contains the latest snapshot revision (LATEST.BIN) and all previously saved versions of the snapshot, numbered according to their revision count (i.e. R0001.BIN, R0002.BIN, and so on). Everytime you save a snapshot, the slot's revision number is incremented and a new file is created, thus leaving a trail of revisions that can be recalled later.

To help you remember what your snapshots contain, you can also include a rough description of your snapshot when saving. To access the snapshot description screen just "focus press" the SNAPSHOT display. Doing this on an empty slot will show a screen that looks like the figure in the upper right where the revision number is zero and the description area is filled with hyphens. You can edit the description area (marked in blue in the figure) by pressing any of the display's corresponding focus buttons (multiple presses toggle between the left and right character) and then using the appropriate knob to scroll through the available characters (0-9, A-Z). Some characters (like K and X) are not available. In the example on the lower right, the user has named this snapshot "London Bridge" and indicated that it has 7 parts.

Pressing the SAVE button will save this description along with the snapshot. Scrolling through the slots and revisions while in the snapshot description screen, will successively show the descriptions that were saved with each snapshot and its revisions.
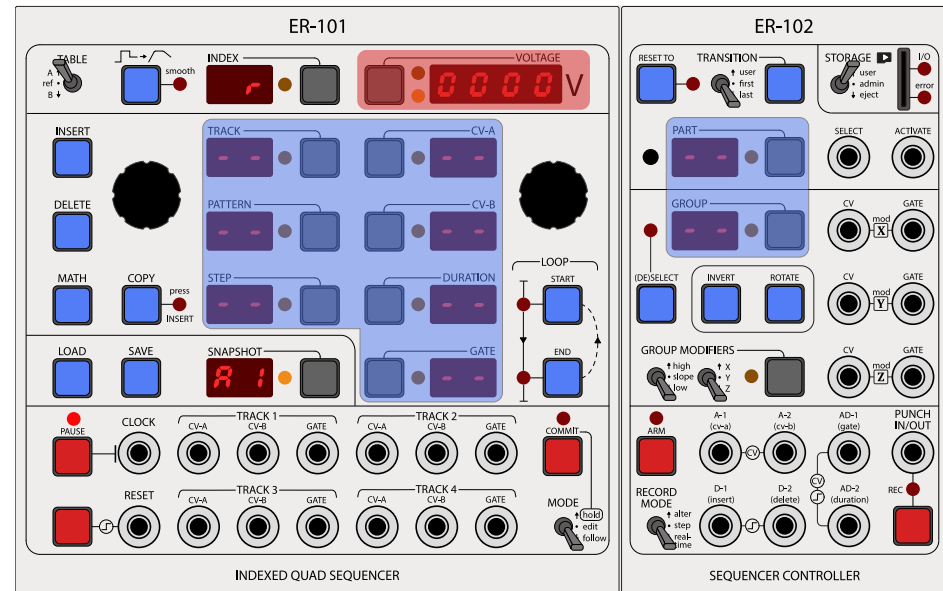
This is how an empty snapshot description looks at first. The red area shows the current revision number and all of the displays in the blue area can edited at will by the user to describe the snapshot that is about to be saved in the focused slot.
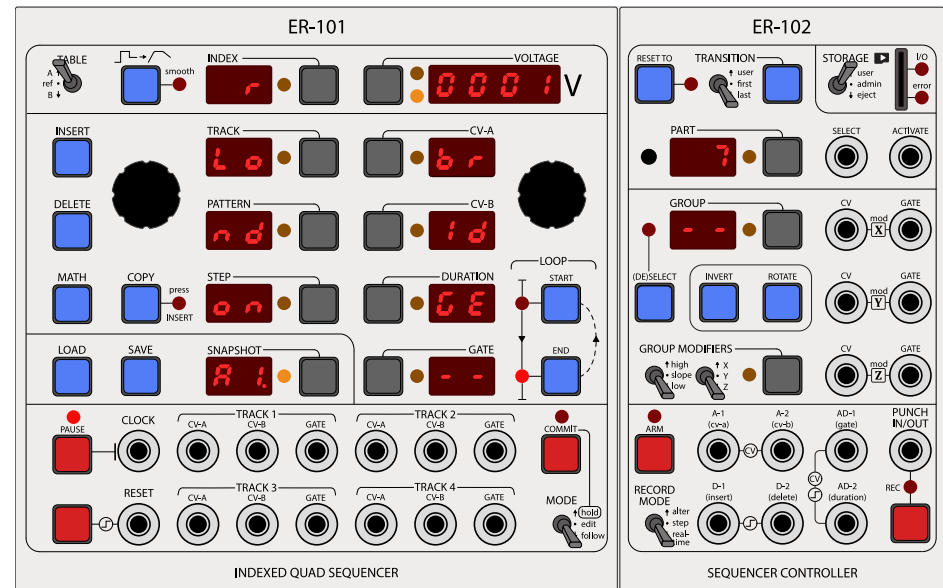
Loading MIDI files

The ER-102 can load SMF0 (single track) and SMF1 (multiple track) type MIDI files but not SMF2 (song files). There are two methods available. If you have a MIDI file with events on MIDI channels 1-4 that you just want to load quickly then use the **simple method**. If you have multiple MIDI files that you want to load into a single snapshot, or you want to control the MIDI channel to ER-101/102 track mapping, then you would use the **advanced method**.

The simple method for loading MIDI files

On your computer:
1. Choose a snapshot slot (such as C4).
2. If the slot directory (e.g. ER-101/SNAPSHOT/C4/) doesn't exist on your SD card already then create it. This directory must have no *.BIN files in it!
3. Copy the MIDI file to the slot directory and make sure it has a .MID extension.

Back at your ER-102,
1. Insert the SD card and move the STORAGE switch to the USER position.
2. FOCUS the SNAPSHOT display and navigate to the slot containing the MIDI file (e.g. C4 in our example).
3. Press the LOAD button twice.

When LOAD the MIDI file, MIDI channel 1 is loaded into TRACK 1, channel 2 into TRACK 2, and so on. MIDI channels greater than 4 are ignored. The snapshot description is initialized with the first 8 letters of the MIDI filename.

How the import deals with polyphony
If a Note On message occurs while another note is playing, then the previously playing note is turned off and a new note starts.

> Configurable Options: There are options in the configuration file that relate to the MIDI import algorithm. Please see the comments in the [MIDI] section of the CONFIG.INI file on your SD card for more details.

```
ER-102/
    SNAPSHOT/
        C4/
            MINUET.MID
```

The directory structure to the left would produce the snapshot description below.
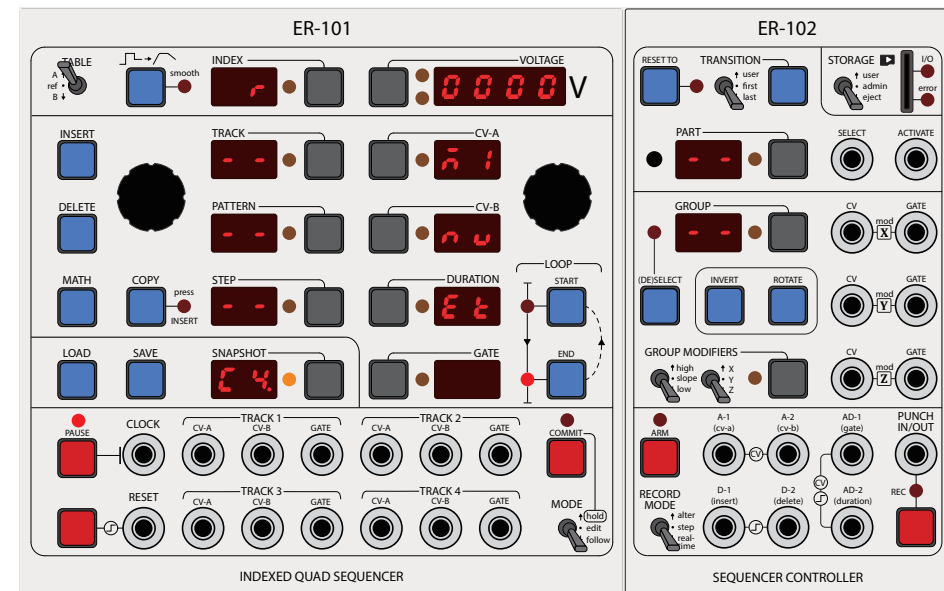
The advanced method for loading MIDI files

Using this method you can load up to 4 different MIDI files into one snapshot and have complete control over what MIDI channel gets assigned to what track on the ER-101/102. This information is placed in an INI file (that you create in a text editor). This INI file and the required MIDI files are then copied to an empty snapshot slot directory.

The MIDI import INI file can contain up to 4 sections, one for each of the 4 tracks on the ER-101/102. A complete INI file (called MYSONG.INI) that loads data into all 4 tracks is shown to the right. It is not required to specify all the tracks. At the minimum you need to specify at least one track section (i.e. [Track 1] or [Track 2] and so on) and in that section you must specify at least the filename and channel. The rest is optional and if not specified then the values from the ER-102/CONFIG.INI file are used by default.

Notice that the same MIDI file can be referenced more than once and any MIDI channel (1-16) can be mapped to any track (1-4). Also, each track can use different transposition, divider and quantization settings when peforming the MIDI import. See the CONFIG.INI file's [MIDI] section for more information on these parameters and their effect on the MIDI import process.

The snapshot description is initialized with the first 8 letters of the INI filename.

```
ER-102/
   SNAPSHOT/
      C4/
         MYSONG.INI
         MELODY.MID
         HARMONY.MID
         DRUMS.MID
```

```
MYSONG.INI

[Track 1]
filename = melody.mid
channel = 1
quantize = none
divider = auto
transpose = -24

[Track 2]
filename = harmony.mid
channel = 10
quantize = 4
divider = auto
transpose = -12

[Track 3]
filename = drums.mid
channel = 1
quantize = none
divider = auto
transpose = -24

[Track 4]
filename = drums.mid
channel = 2
quantize = none
divider = auto
transpose = -24
```

A MIDI import INI file

User Voltage Tables

When using the ER-102 with your ER-101, the user reference voltage tables are saved to and loaded from the SD card:

```
ER-102/
  TABLES/
    JUI7.BIN
    USR1.BIN
    USR2.BIN
    USR3.BIN
    USR4.BIN
    USR5.BIN
    USR6.BIN
    USR7.BIN
    USR8.BIN
```

The USR(1-8).BIN files contain the 8 original user voltage tables from the ER-101 and are initialized with the 12ET chromatic table. You can place any number of additional files in this directory to add more voltage tables. The format of these files is an array of 100 16-bit unsigned integers in little endian order where 1.000V is represented as 8000, 2.000V is 16000 and so on. The following snippet of Python code would create the 12ET voltage table:

```python
# create a list of codes for each semitone
codes = [int(round(x*8000/12.0)) for x in range(100)]
# do not exceed the max for unsigned shorts
codes = [x if x<(1<<16)-1 else (1<<16)-1 for x in codes]
# convert the python list to a binary array
import ctypes
data = (ctypes.c_uint16 * len(codes))(*codes)
# write the binary array out to a file
with open("12ET-P.BIN","wb") as f:
    f.write(data)
    f.close()
```

Only the first 4 letters of the filename will be shown in the ER-101's VOLTAGE display when browsing the user reference tables. So make sure at least this part of the filename is unique amongst all the files in the TABLES directory.

TIP: There are over 40 scales (voltage tables) available for download from my website:

http://www.orthogonaldevices.com/files/scales.zip?attredirects=0&d=1

Just download and extract its contents in to the ER-102/TABLES directory of your uSD card. This zip archive also includes the Python script that was used to generate the voltage tables and is useful as a reference in case you want to create some of your own scales or voltage tables.

TIP: If a voltage table represents pitches and you wish the 'pitch' display to be enabled by default when using it, then just append '-P' or '-p' to the voltage table's filename. See the next tip for how to change the units of the 'pitch' display.

TIP: There is a setting in the CONFIG.INI that lets use choose the units of 'pitch' display as chromatic or cents.

The Configuration File

Composing music is an extremely complex and personal endeavor. In designing, the ER-101/102 modules, I have tried to make design decisions that prioritize the needs of the experienced user over the beginner, thus hopefully creating a system that you can grow into rather than outgrow over time. However, it is impossible to anticipate all needs and even if I try, sooner or later the interface will collapse under the weight of the mountain of features and options.

Therefore, I have introduced a configuration file that lives on the SD card to take care of all of those esoteric options and "if only I could do X" type of feature requests. The configuration file relieves the default interface from having to support all the various feature requests that users have made and will continue to make over the years to come.

TIP: You can view the current default CONFIG.INI file (the one that gets created for you on an empty uSD card) by accessing the following URL:

   http://www.orthogonaldevices.com/er-102/default-config-ini

Most users can blissfully ignore the configuration file. However, if at any point you find that you wish that the ER-101/102 could behave just slightly different then please take a look in the configuration file and see if there is an option that does what you need. If it doesn't exist, then let me know and I will see what I can do.

The configuration file (aka CONFIG.INI) lives in the ER-102 directory of your SD card. The configuration file is re-read by the ER-102 whenever you:

• Power up the ER-102
• Toggle the STORAGE switch from EJECT to USER or ADMIN.

Therefore, to change a configuration setting it is not necessary to power down your ER-102:

1. Eject the SD card from the ER-102.
2. Load the CONFIG.INI file in a text editor on your computer.
3. Make the desired changes to the CONFIG.INI file and save it.
4. Eject the SD card from your computer.
5. Insert the SD card into the ER-102.
6. Toggle the STORAGE switch from EJECT to USER.

   TIP: The CONFIG.INI file uses the UNIX convention for line endings (i.e. LF or '\n'). This
   means that when you open the file on a Windows computer, depending on the sophisti-
   cation of your text editor, all the text might appear on one line. The fix is to use a better
   text editor such as Emacs (complex alternative) or Notepad2 (simple alternative).

Updating the firmware

The ER-101 and the ER-102 have separate firmware. Changing the firmware on one device does not change the firmware on the other. It is recommended that you use the most up-to-date firmware for both your ER-101 and ER-102. This chapter describes how to update the ER-102 firmware only.

To update the firmware on the ER-102, download the newest firmware binary from:

> http://www.orthogonaldevices.com/er-102

and copy the file (e.g. f2_00.bin) to the FIRMWARE directory on your microSD card. Do not rename the file! The ER-102 requires the firmware files to be named in a specific format:
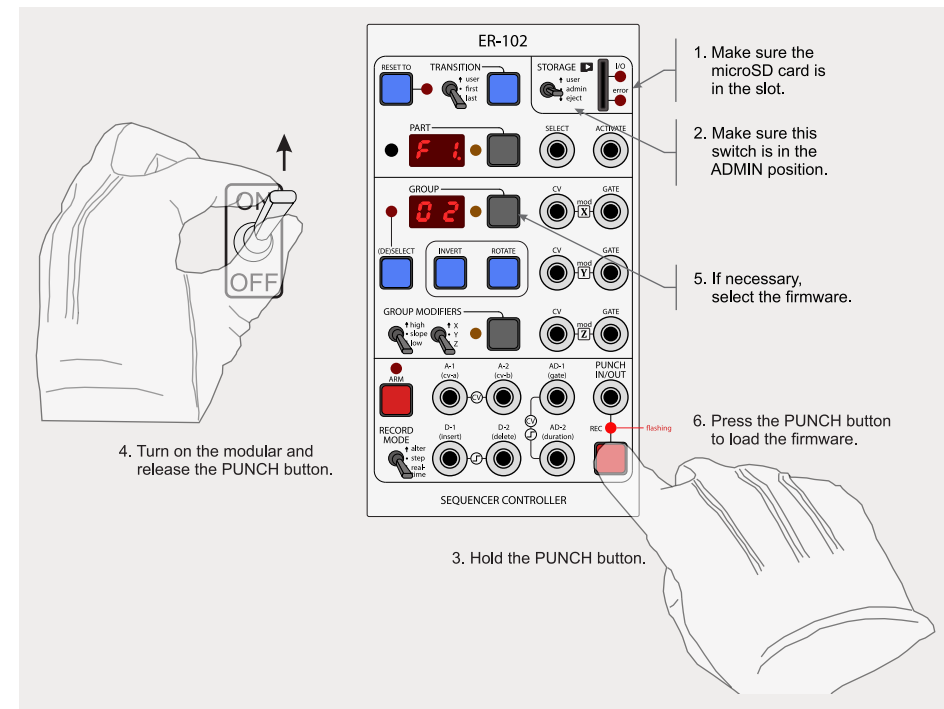
> **f<major version>_<minor version>.bin**

Next, place the microSD card back into the ER-102's card slot and switch the STORAGE mode to ADMIN. Turn off the power to your modular if it is not already off. Now while pressing the PUNCH button, turn your modular back on. The REC LED will start to flash and the rest of the LEDs display a vertical pendulum. The PART/ GROUP segmented displays will show the firmware with the highest version number in the FIRMWARE directory. Usually this is the last firmware that you copied over and exactly the firmware that you want to load onto the ER-102. Pressing the PUNCH button again will begin the upload process (which should finish in about 3-5 seconds) and flash "Good" in the display when done. That's it.

If you ever want to upload a firmware file other than the most recent version, you can iterate through the available firmware files on your microSD card by repeatedly pressing the GROUP focus button.

> TIP: You can perform a software reset on your ER-102 without cycling the power of your modular. Here is how:
>
> 1. Place the STORAGE switch in the ADMIN position. (Display will show SUDO.)
> 2. Press the RESET button on the ER-101 to reboot the ER-102.
> 3. If you hold down the PUNCH button while doing step 2 then the ER-102 will boot into the firmware update mode.
> 4. Remember to put the STORAGE switch back to the USER position when you are done.

1. Make sure the microSD card is in the slot.
2. Make sure this switch is in the ADMIN position.
5. If necessary, select the firmware.
6. Press the PUNCH button to load the firmware.
4. Turn on the modular and release the PUNCH button.
3. Hold the PUNCH button.

Warning! It is highly recommended that you backup the entire ER-102 directory to your computer before doing a firmware update.