

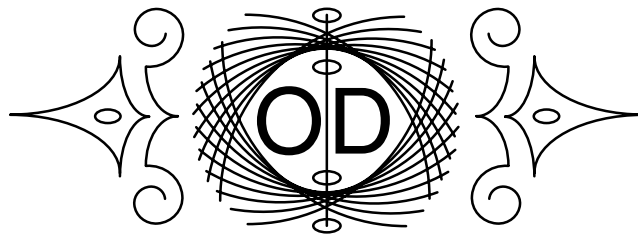
(Draft Version)

User Manual

ER-101 Indexed Quad Sequencer

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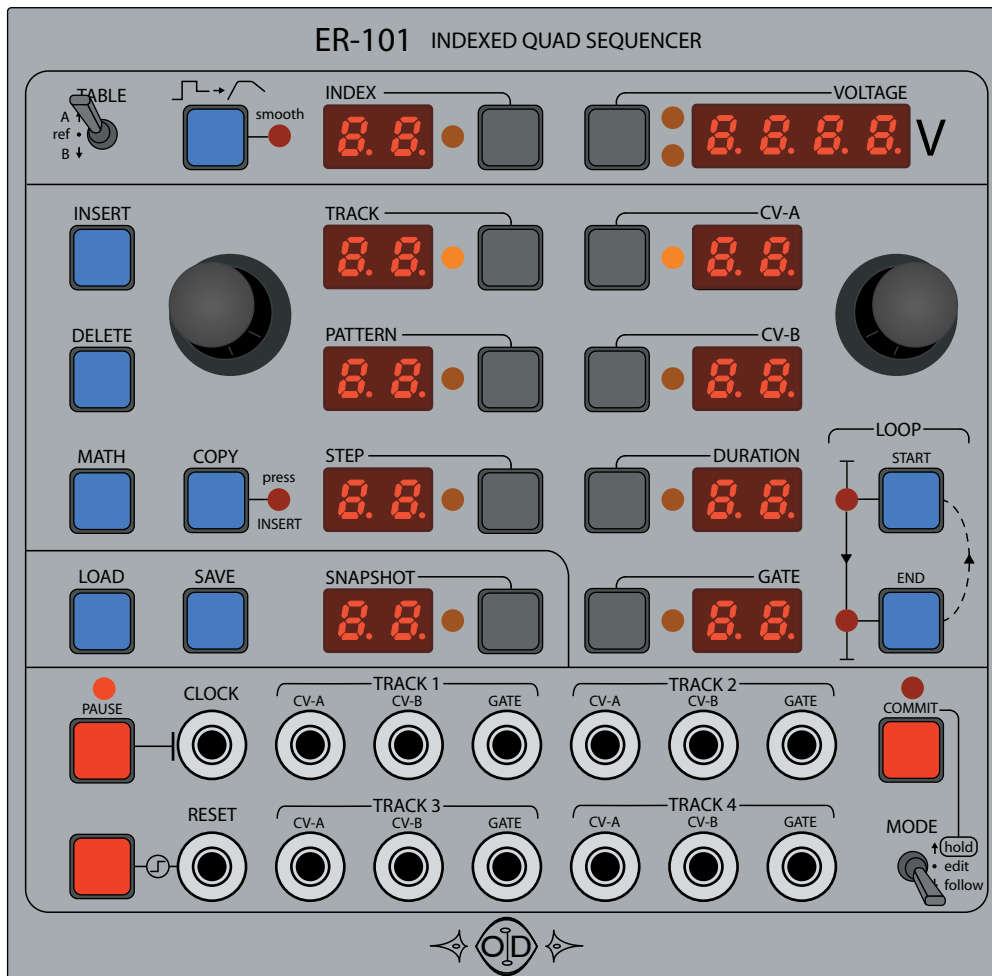
Firmware v1.04



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What does it do?

The ER-101 Indexed Quad Sequencer is an externally clocked and resettable 4-track sequencer for the Eurorack modular format. Each track consists of 2 analog control voltage outputs referred to as CV-A and CV-B, and, one digital output referred to as GATE. The ER-101's purpose is to provide the musician with a tool for creating and manipulating clock-synced control voltage contours of great length and complexity. Probably the most typical usage for each track's output is:

Pitch Control:	CV-A to the 1V/octave input of a VCO (voltage-controlled oscillator)
Velocity Control:	CV-B to the level input of an EG (envelope generator)
Note On/Off:	GATE to the gate input of the same EG

Patched this way, the ER-101 gives you the ability to create almost any 4-part harmony with arbitrary dynamics and rhythm. However, as many modular enthusiasts will already know, this is really only like dipping your toes in the tops of Jupiter's clouds because the full brutal and subtle strength of your modular lies deep within a storm of complex and many times chaotic intermodulations. The ER-101 will hopefully be that tool that enables you to inject just the right of amount of structure, repeatability, and control into your stormy creations. This is also as good a time as any to tell you that this manual will not spend any space telling you *how* to use your ER-101. This manual will concentrate its energies and use of your time (!) on simply what will happen when its various buttons, knobs, and switches are manipulated in certain specific (and hopefully obvious) ways.

User Interface Basics

The ER-101's panel is roughly divided into two halves as shown in Figure 1. The left portion contains navigation elements such as INDEX, TRACK, PATTERN, STEP, and SNAPSHOT. The right portion contains parameters such as VOLTAGE, CV-A, CV-B, DURATION, and GATE. You select what you want to adjust by pressing the appropriate focus button and then adjusting the value with the knob for that half.

For example in Figure 2 we are navigating to a specific STEP and then selecting the CV-A parameter and adjusting it. Notice that the ER-101 is designed to be used efficiently with two hands. The essential idea to remember is that the numeric display that currently has your attention should be between your left and right hand. Particularly the bottom frame of Figure 2 shows how you can rapidly change the CV-A parameter for many steps in succession by having STEP and CV-A focused while keeping your hands on the left and right knobs.

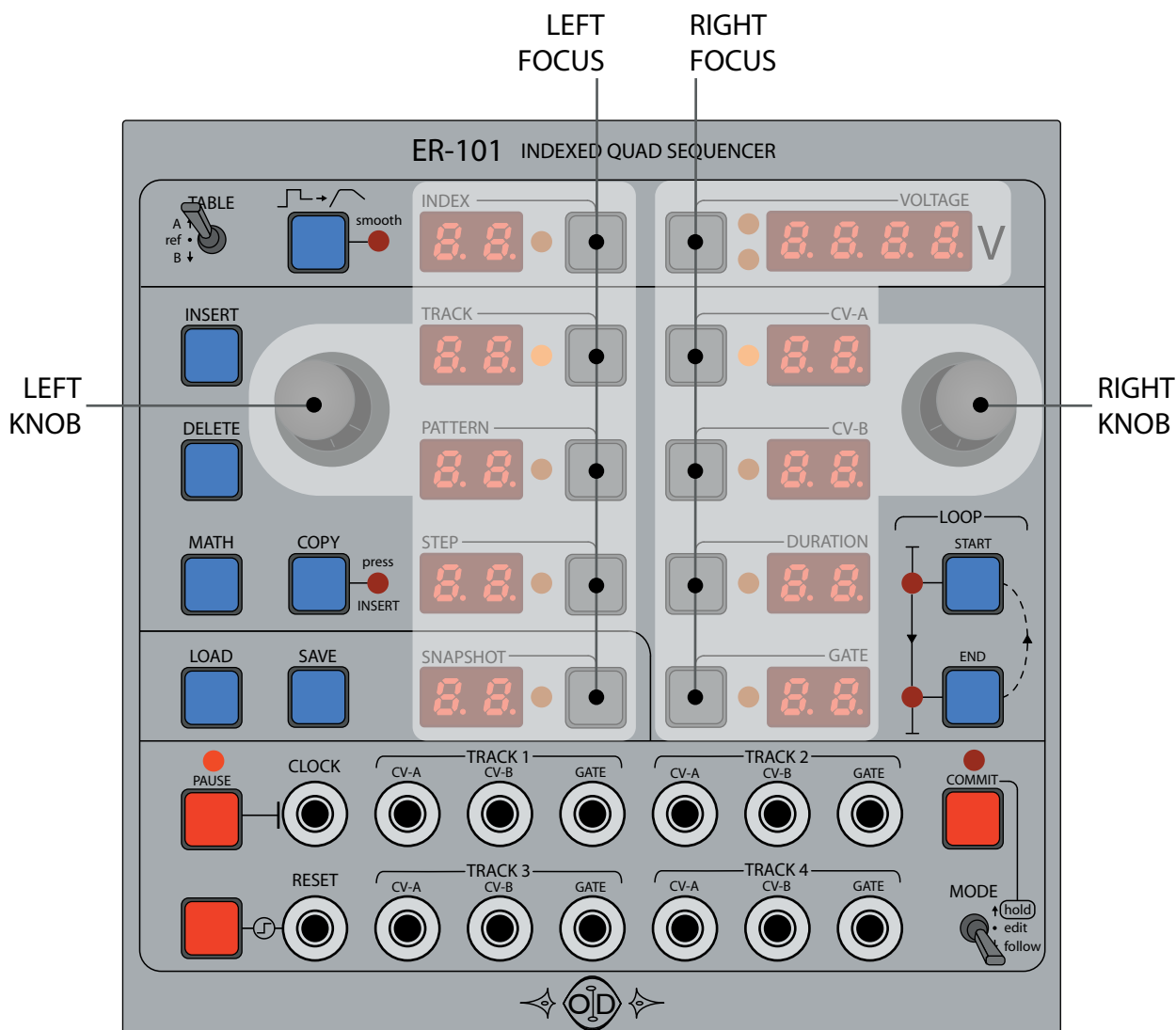


Figure 1

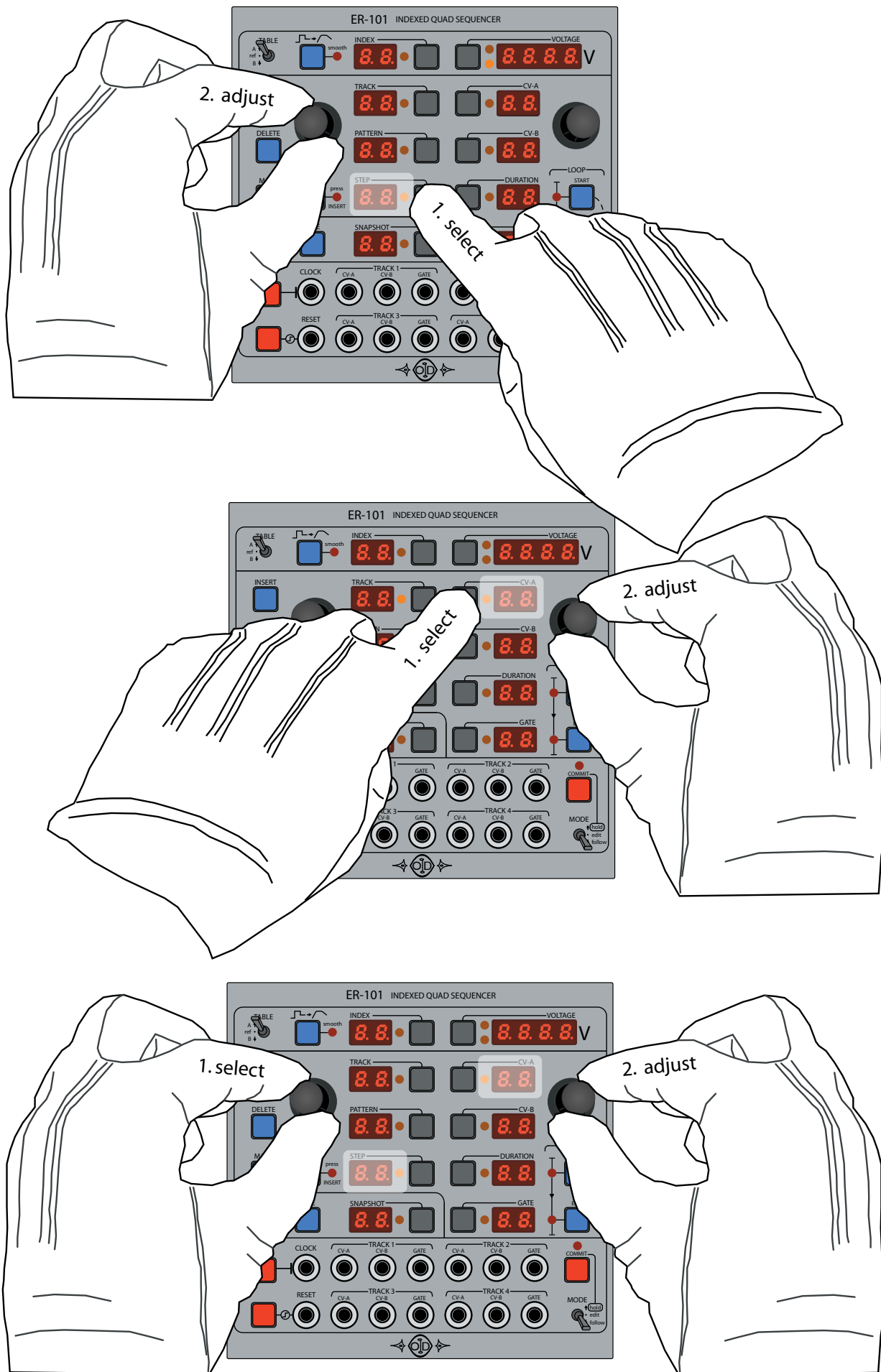


Figure 2

Anatomy of a Sequence

Each of the ER-101's four tracks can contain up to 100 patterns. Each pattern can contain up to 100 steps. The signal patched into the CLOCK input controls the timing of all four tracks simultaneously. The RESET signal will also reset all four tracks simultaneously to the 1st step of the 1st pattern.

Each step has 4 basic parameters that range from 0-99:

CV-A:	index into the track's voltage table A
CV-B:	index into the track's voltage table B
DURATION:	length of the step in clock cycles
GATE:	length of the logic high portion of the gate in clock cycles

When a particular step is in focus (see Sequence Navigation) then you can edit any of these parameters with the following procedure:

To adjust a step parameter

1. Press the focus button for the desired parameter, if necessary.
2. Use the RIGHT knob to adjust the parameter to the desired value.

In addition to the above parameters, each step also has two boolean flags:

SMOOTH-A:	CV-A voltage transition to the next step is linear (set) or abrupt (not set)
SMOOTH-B:	CV-B voltage transition to the next step is linear (set) or abrupt (not set)

Note: Tracks and patterns also have their own SMOOTH-A and SMOOTH-B flags. A particular step has smoothing enable if any of the track or pattern or step smooth flags are enabled. This arrangement means that you can turn smoothing on at the pattern or track granularity without overwriting the particular smoothing pattern that you created at the step granularity.

Figure 3 shows how each of these parameters affects the playback using a two step sequence as an example. In this sequence, both steps have DURATION=3 clock cycles, GATE=2 clock cycles, SMOOTH-A=true, and SMOOTH-B=false. Smoothed voltage transitions start when the gate goes low and proceeds until the next step. In other words, the length of a smoothed transition is DURATION minus GATE.

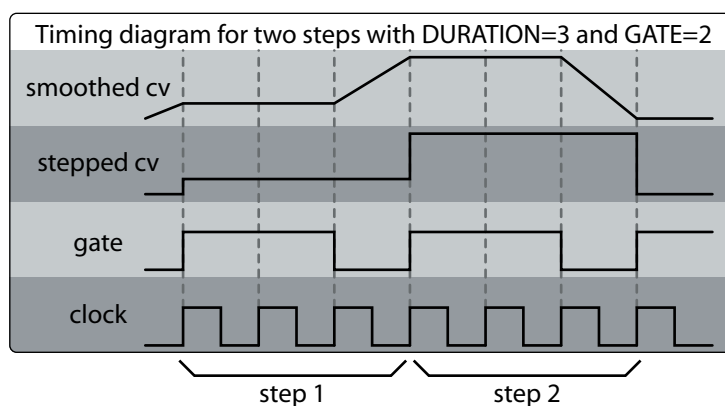


Figure 3

Sequence Navigation

The basic procedure for navigating to any specific step within a track is

1. Focus the TRACK display.
2. Select the TRACK with the LEFT knob.
3. Focus the STEP display.
4. Select the STEP with the LEFT knob.

As you scroll through the steps in a track, the PATTERN display will also update to reflect which pattern contains the current step. Once a track gets very long, it is quicker to navigate around the track by PATTERN. The procedure is similar:

1. Focus the TRACK display.
2. Select the TRACK with the LEFT knob.
3. Focus the PATTERN display.
4. Select the PATTERN with the LEFT knob.
5. Focus the STEP display.
6. Select the STEP with the LEFT knob.

However, there is one subtle difference when navigating by PATTERN. As you scroll forward through the patterns, notice that the STEP display will show the first and then the last step of the current pattern and vice versa when scrolling backwards. This gives you a quick way to jump to the beginning or end of a pattern. This convenience of navigating a long track quickly via patterns is one of the reasons why it is good to break a track up into smaller patterns.

Sequence Editing

For the following we will assume that the ER-101 mode switch is set to EDIT or HOLD. These instructions can also apply to the case when the mode switch is set to FOLLOW but only when the ER-101 is PAUSED.

Creating and editing a sequence relies on two basic operations: INSERT and DELETE. You can insert a step or a pattern as well delete them. When the COPY indicator is not lit then the INSERT button will insert either a new step or an new empty pattern depending on whether the STEP or PATTERN display is focused.

To insert a new step (or pattern) after the current step (or pattern)

1. FOCUS the STEP (or PATTERN) display, if necessary.
2. Press and release the INSERT button.

To insert a new step (or pattern) before the current step (or pattern)

1. FOCUS the STEP (or PATTERN) display, if necessary.
2. Press and hold the INSERT button.
3. Turn the RIGHT knob counter-clockwise.
4. Release the INSERT button.

Notice that when the INSERT button is held the VOLTAGE display changes to show the current step (or pattern) number and the new step (or pattern) number which is flashing. The parameters of a new step are initialized in the following manner:

CV-A:	defaults to the index which yields the closest voltage to 1.0V in table A.
CV-B:	defaults to the index which yields the closest voltage to 1.0V in table B.
DURATION:	defaults to zero, so that initially this step is skipped.
GATE:	defaults to zero.

To delete the current step (or pattern)

1. FOCUS the STEP (or PATTERN) display, if necessary.
2. Press and release the DELETE button.

To clear the entire track

1. FOCUS the TRACK display, if necessary.
2. Press the DELETE button.
3. To confirm, press the DELETE button again.
4. To abort, press any other button.

To copy the current step (or pattern) to the clipboard

1. FOCUS the STEP (or PATTERN) display, if necessary.
2. Press the COPY button

At this point the COPY indicator will light up and depending on whether you copied a step or a pattern the STEP or PATTERN indicator will be flashing.

To paste the step (or pattern) on the clipboard after the current step (or pattern)

1. FOCUS the STEP (or PATTERN) display, if necessary.
2. Press and release the INSERT button.

To paste the step (or pattern) on the clipboard before the current step (or pattern)

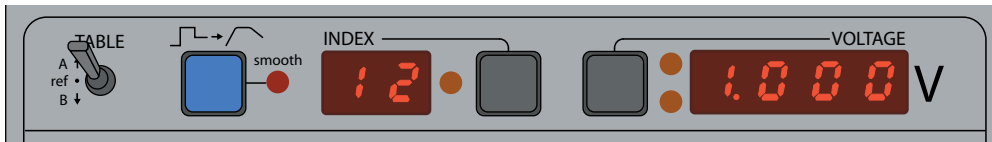
1. FOCUS the STEP (or PATTERN) display, if necessary.
2. Press and hold the INSERT button.
3. Turn the RIGHT knob counter-clockwise.
4. Release the INSERT button and repeat as many times as desired.
5. To clear the clipboard, press the COPY button again.

Notice that if you have a step copied to the clipboard (therefore the STEP indicator is flashing) but then press the INSERT button while the PATTERN display is focused, then a new pattern will be inserted. Similarly, if you have a pattern copied to the clipboard (therefore the PATTERN indicator is flashing) but then press the INSERT button while the STEP display is focused, then a new step will be inserted.

To copy one track onto another track

1. FOCUS the TRACK display, if necessary.
2. Select the track to copy with the LEFT knob and press the COPY button.
3. Select the destination track and press the INSERT button.
4. Repeat 3 as many times as desired.
5. To clear the clipboard, press the COPY button again.

User Voltage Tables



The ER-101 is an *indexed* sequencer because rather than having each step separately store its own voltage, each step just stores an index into a larger voltage table (two tables in fact, CV-A and CV-B). This is beneficial for the following reasons:

1. It would get very tedious to have to dial in a specific voltage for each step every time when using a rotary encoder with only 24ppr (pulses per revolution).
2. By indexing into a table of voltages, you can specify at the beginning what voltages are important for your current task. If you are using the output voltages to control pitch then you can think of the voltage tables as scales. Of course, the ER-101 will use all possible voltages when smoothly transitioning between two specific voltage levels.
3. Later you can alter the specific voltage levels independent of the CV-A and CV-B indices saved in your sequences. You want to flatten all of those B-flat's a little more? Just adjust the appropriate entry in the voltage table and all of the step's using that index will be affected.

Each track has two user voltage tables, one for CV-A and one for CV-B. Each voltage table contains 100 entries indexed over 0-99.

To browse the voltages in table A (or B):

1. Set the TABLE switch to A (or B).
2. Press the INDEX button.
3. Turn the LEFT knob to adjust the index of the voltage shown in the VOLTAGE display.

To edit the voltages in table A (or B):

1. Press the VOLTAGE button.
2. Turn the RIGHT knob to adjust the voltage in 2mV increments.

Reference Voltage Tables

These are built-in voltage tables that are meant to be used as starting points for building your own tables. The following reference voltage tables are currently provided:

12ET	12-tone equally tempered (i.e. semitones)
24ET	24-tone equally tempered (i.e. quatertones)
22JT	22-tone just intonation (in fact these are the 22 shrutis of India)
BLUE	diatonic scale plus flattened 3rd, 5th and 7th degrees
L-8	rising linear ramp, 0 to 8.0V in increments of 80mV
E-8	rising exponential curve, 0 to 8.0V
LE-8	linear ramp, 0 to 0.1V (2mV increments) and exponential curve, 0.1 to 0.8V

To use a reference table just copy it to one of your track's voltage tables and then edit to fit your needs.

To copy a reference table:

1. Focus the desired the track.
2. Set the TABLE switch to the REF position.
3. Select the specific table with the RIGHT knob.
4. Press the COPY button.
5. Set the TABLE switch to the A position or B position to copy, or, press the COPY button again to cancel.

To browse the voltages in a reference table:

1. Set the TABLE switch to the REF position.
2. Select the specific table with the RIGHT knob.
3. Use the LEFT knob to scroll through the index values.

Loop Points

When a track reaches the LOOP END step, the sequence starts again from the LOOP START step. If there is no LOOP START step then the sequence starts playing again from the first step. If there is no LOOP END step then the sequence plays until the end before looping back to the LOOP START step.

To set the loop start (or end):

1. Navigate to the desired step.
2. Press the LOOP START (or END) button.

To unset the loop start (or end):

1. Navigate to the loop start step (the LOOP START or END indicator should light up).
2. Press the LOOP START (or END) button.

To unset the loop start (or end) without navigating to a loop point:

2. Press the LOOP START (or END) button twice.

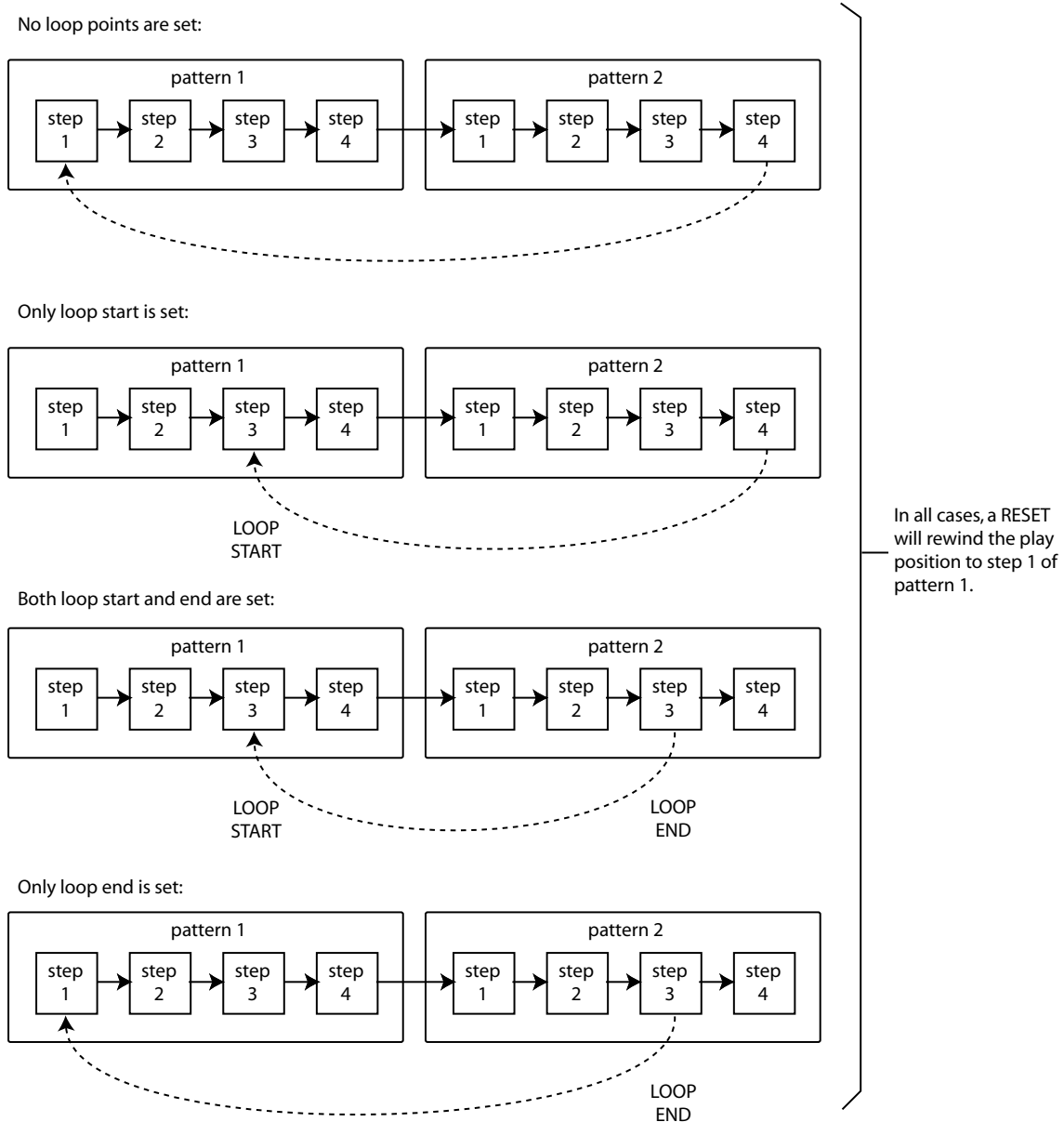
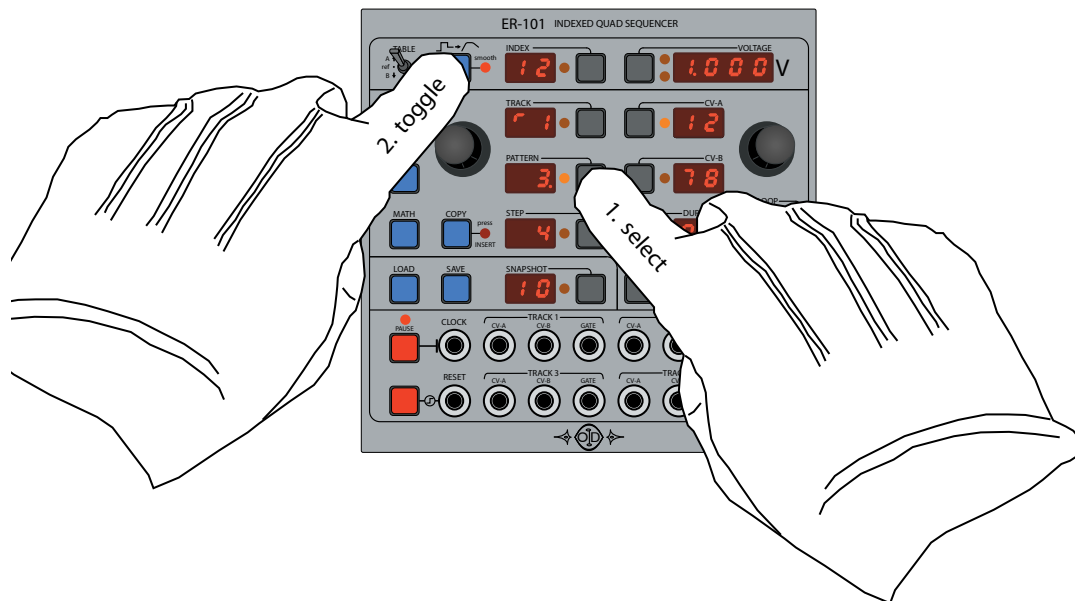


Figure 4



Smoothing Transitions

By default the transitions from one CV to the next is stepped. However, with the SMOOTH button you can enable smoothing on individual steps, on individual patterns, for an entire track, or any combination of the three.

To toggle the smoothed transition from the end of the current step to the next step:

1. Set the TABLE switch to A or B, if necessary.
2. Press the STEP button to focus the current step.
3. Press the SMOOTH button.

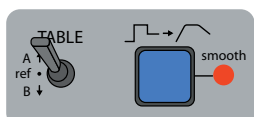
To toggle smoothed transitions for all steps in the current pattern:

1. Set the TABLE switch to A or B, if necessary.
2. Press the PATTERN button to focus the current pattern.
3. Press the SMOOTH button.

To toggle smoothed transitions for all steps in the current track:

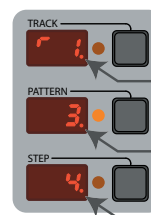
1. Set the TABLE switch to A or B, if necessary
2. Press the TRACK button to focus the current track.
3. Press the SMOOTH button.

Smoothing is enabled or disabled separately for the CV-A and CV-B outputs. When toggling the smoothing behavior use the TABLE switch to focus the A or B outputs. The indicator light next to the SMOOTH button will light up if the current step is being smoothed because at least one of the following is true:



The smooth indicator is lit when...

smoothing is enabled for the current track,
or
smoothing is enabled for the current pattern,
or
smoothing is enabled for the current step.



indicator for track
indicator for pattern
indicator for step

Please refer to **Anatomy of a Sequence** for how smoothing actually affects the CV outputs.

The Modes

Understanding the different modes and their effect on the ER-101's behavior is very important for a smooth workflow experience. To understand the difference between the EDIT and FOLLOW modes, you just have to remember that every track has two cursors, a play cursor and an edit cursor, which are independent of each other. The actual CV outputs always reflect the step indicated by the play cursor and never the edit cursor. The primary purpose of the edit cursor is to allow you to edit a sequence while it is playing. The HOLD mode is the most complicated and will be described last.

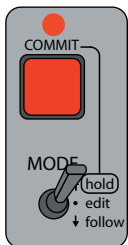
Edit Mode

All of the other sections in this manual, assume by default that the ER-101 is in the EDIT mode. In this mode, display always shows the edit cursor. The edit cursor will only move if the user moves it using the LEFT knob. Changes made to tracks while in EDIT mode are reflected immediately and can be heard the next time the play cursor hits whatever it is you changed.

Follow Mode

In FOLLOW mode the display always shows the play cursor. The play cursor will move on its own to reflect the currently playing step and pattern. The user can also "scrub" the play cursor by focusing the PATTERN display or STEP display and turning the LEFT knob while in FOLLOW mode.

Certain operations are not allowed while in FOLLOW mode. If you attempt them then the VOLTAGE display briefly flashes TILT and your action is ignored. For example, INSERT, DELETE and changing step parameters such as CV-A, CV-B, DURATION and GATE are not allowed in FOLLOW mode **unless** the ER-101 is paused. However, setting loop points or enabling/disabling smoothing is allowed because doing these operations even on a moving target are still useful.



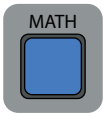
Hold Mode

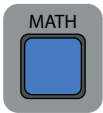
This mode is extremely useful for when you want to make many changes to a number of tracks and then have your changes reflected in the playing sequence all at once rather than as you make the edits. The easiest way to describe the HOLD mode is that it is exactly like the EDIT mode in that you are manipulating the edit cursor. However, you are editing a completely new copy of all the tracks. In other words, as soon as you enter the HOLD mode the entire contents of the ER-101 are copied (or shadowed) and all of your subsequent edits are made on this copy and therefore do not affect the material that is currently being played.

This edited copy can be immediately written onto the original at any time by pressing the COMMIT button twice. If you press the COMMIT button once, then the COMMIT indicator starts to flash and the actual overwriting will occur the next time the current track loops back to its beginning. You can select any of the four tracks to be used for timing this synchronized commit by just focusing the desired track. This synchronized commit mechanism allows you to introduce a whole batch of changes in time with currently playing material. You can even load an entire new snapshot and seamlessly cue it using the COMMIT button.

You can throw away any changes without committing them by simply leaving the HOLD mode without pressing the COMMIT button.

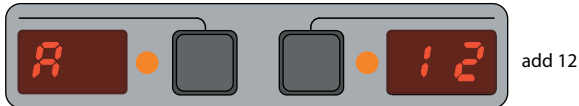
Math Operations



The  button is a valuable tool for performing various operations on steps, patterns or entire tracks. The operations available in this version of the firmware are:

Arithmetic

Add or subtract a constant



Geometric

Multiply or divide by a constant



Assignment

Set to a constant



The letter (A, G, or S) on the left indicates the type of operation and the number on the right indicates the operand. Each step parameter has its own operation.

To apply the current math operation to the current step, pattern, or track:

1. Press the STEP or PATTERN or TRACK button.
2. Navigate to the desired step or pattern or track using the LEFT knob.
3. Press and release the MATH button.

To edit the current math operation:

1. Press and hold the MATH button. (The word EDIT will flash in the VOLTAGE display.)
2. Press the VOLTAGE button to enter MATH's edit mode.
3. Press one of the left focus buttons to cycle through operations (A->G->S->A...)
4. Edit the operands for CV-A, CV-B, DURATION and GATE by using the RIGHT knob.
5. Press the MATH button again to leave the math edit mode.

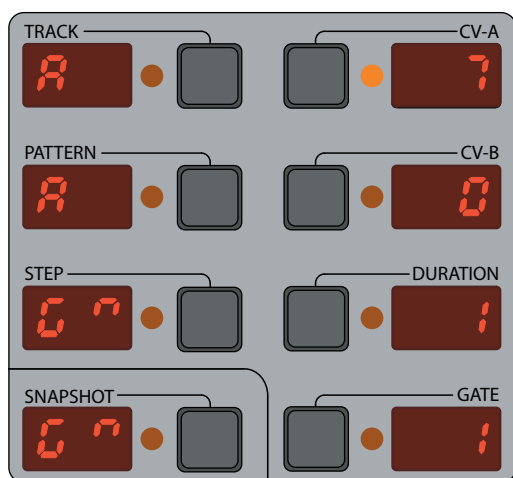
To just look at the current math operation without applying:

1. Press and hold the MATH button. (The word EDIT will flash in the VOLTAGE display.)
2. Press the VOLTAGE button to enter MATH's edit mode.
3. Press the MATH button again to leave the math edit mode.

The idea is that you will prepare a math operation and then apply it multiple times to various parts of your sequence. Math operations are especially fun when applied in real-time to a playing sequence.

For example, here is how to quickly create a rising sequence of control voltages of any length.

1. First prepare the following MATH operation:



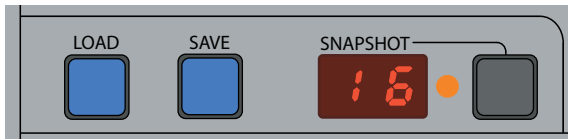
2. Press the PATTERN button.
3. Press the INSERT button to insert a new pattern.
4. Press the STEP button.
5. Press the INSERT button 4 times to insert 4 new steps.
6. Set CV-A for step 1 to 0, step 2 to 4, step 3 to 7 and step 4 to 4, and set the DURATION to 4 and the GATE to 2 for all steps. (You could use any desired values of course.)
7. Press the PATTERN button to focus the 4-step pattern that you just made.
8. Press the COPY button to copy the current pattern to the clipboard.
9. Press the INSERT button to paste the pattern after the current pattern.
10. Press the MATH button to add 7 to CV-A of all the steps in the pattern you just pasted.
11. Press the COPY button to clear the clipboard.
12. repeat (8)-(11) until you have the desired sequence length.

The result will be a sequence of patterns where each pattern is transposed upwards by 7 indices from the previous pattern. In fact, if table A was set to 12ET (which it is by default) then each pattern would be transposed up 7 semitones or a major 5th. And the sequence we just created is actually an arpeggiation of a major I chord successively transposed upwards by 5ths. Also, notice how the MATH operation left CV-B, DURATION and GATE unchanged because we had those parameter operations set to one of the null operations: Add zero, Multiply by one, Divide by one.

Other uses for math operations are:

- Doubling or halving DURATION and/or GATE times.
- Silencing a pattern by setting the GATE value of all its steps to zero.
- Causing a pattern to be skipped by setting the DURATION value of all its steps to zero.
- Increasing or decreasing loudness in the case where CV-A or CV-B are controlling dynamics.
- Creating variations on a theme is easy when you combine the MATH and COPY operations.

Loading and Saving Snapshots



All state information contained in the four tracks can be saved as a snapshot at any time and loaded back later. Up to 16 snapshots can be saved in the ER-101's non-volatile flash memory.

To save the current state to a snapshot:

1. Press the SNAPSHOT button.
2. Use the LEFT knob to dial in the desired snapshot.
3. Press the SAVE button.

If the desired destination snapshot is already showing, then just pressing the SAVE button is enough.

To load a snapshot:

1. Press the SNAPSHOT button.
2. Use the LEFT knob to dial in the desired snapshot.
3. Press the LOAD button.

If the desired snapshot is already showing, then just pressing the LOAD button is enough. The ER-101's flash memory is spec'ed out to be good for at least 100,000 writes with 15-year retention of data.

Warning for live performance situations! Saving a snapshot will cause the ER-101 to be unresponsive for about 0.75 seconds. Therefore, it is not recommended to save a snapshot while the sequencer is playing because it will ignore all CLOCK and RESET signals during this time. However, loading a snapshot is very fast (less than 1ms) and probably not a problem even in a live setting.

Technical Matters

The two control voltage outputs (CV-A and CV-B) have a resolution of 12-bits and a range of 0-8.192V. In other words, you can specify voltages with a precision of 2mV and an accuracy of $\pm 2\text{mV}$.

The GATE outputs are 0V when low and 9.9V when high.

All outputs are updated at a rate of approximately 3kHz, or in other words, with a maximum 0.333ms latency.

A low-level logic reading on the CLOCK or RESET input is guaranteed for any voltage less than 1.5V and a high-level logic reading is guaranteed for any voltage greater than 3.5V. In practice, this means the threshold for a valid trigger on the CLOCK or RESET inputs is around 2.5V.