# User Manual for the ER-102: Sequencer Controller

January 14, 2015

## Contents

# 1 Introduction

## 1.1 What does it do?

The ER-102 Sequencer Controller is an expander for the ER-101. It's main purpose is to place various key aspects of the ER-101 under external voltage control. These key aspects are control of the play cursor, real-time modulation of step parameters, and the recording/alteration of sequences.

## 1.2 The Interface

## 1.3 The Math Transforms

Throughout this manual, you will encounter 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. |

The letter codes (aka variables) in the transform display are associated with the following (parameterized) operations:

| Code | Operation | Parameter Range | Default Value | Effect | Order |
|---|---|---|---|---|---|
| A | Addition | -99 to 99 | 0 | add A | 3 |
| G | Multiplication | 1/99 to 99 | 1 | multiply by G | 2 |
| Jt | Jitter | 0 to 99 | 0 | add a random integer between [-Jt, Jt] | 4 |
| Rd | Random | 0 to 99 | 0 | add a random integer between [0, Rd] | 1 |
| Qt | Quantize | 1 to 99 | 1 | round to the nearest multiple of Qt | 5 |

Currently, Jitter and Random are only available for destructive transforms.

[diagrams of the various operations]

Whenever you perform a transform, all of the operations are applied together in a specific order. This order of operations is shown in the table above. The result is the following formula:

$$New = QUANTIZE\big(G*\big(Old+RANDOM(Rd)\big)+JITTER(Jt)+A|Q\big) \quad (1)$$

where,

$New$ = the new value of the step parameter
$Old$ = the old value of the step paramter
$QUANTIZE(y|x)$ = round y to the nearest multiple of x
$RANDOM(x)$ = random integer between 0 and x (uniform distribution)
$JITTER(x)$ = random integer between -x and x (uniform distribution)

### 1.3.1 Identity Transform

A transform with all default values for each of its operations has no effect and is called the identity transform. You quickly reset any transform back to the identity transform by pressing the DELETE button while the desired transform is focused.

### 1.3.2 Assignment operation

To achieve the affect of an assignment operation, just set G = 0 and set A to the desired value.

# 2 Parts

The top section of the ER-102 is dedicated to the manipulation of parts. Using parts, you can divide your sequences 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.

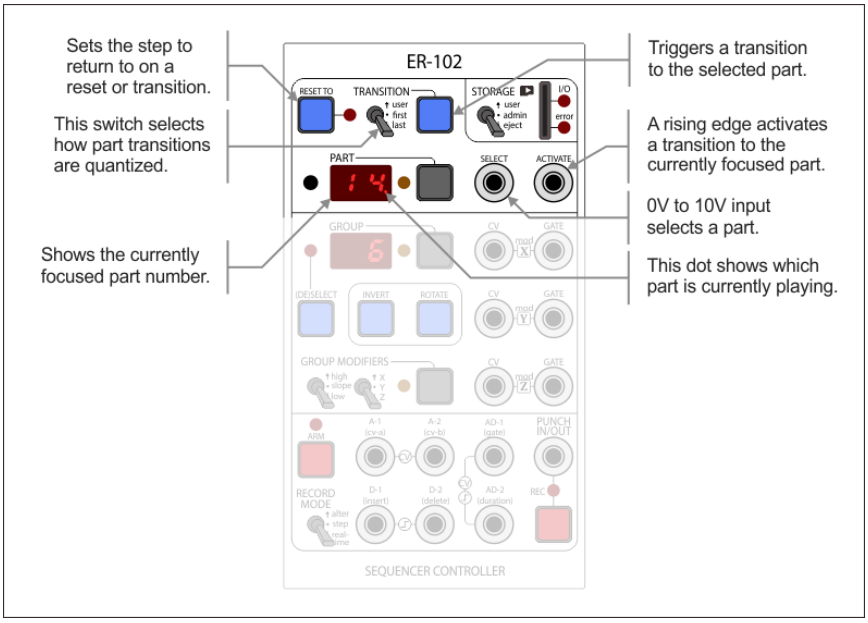


Figure 1: The PARTS section of the ER-102.

## 2.1 What are 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 the 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 part specifies a reset step and a looped section for each of the 4 tracks such that when a part is triggered, potentially all tracks have their reset steps and looped sections changed. A track's reset step can be set to any location in relation to its looped section. This allows for lots of flexibility in arranging what is played as a part starts and then enters its looped section. In fact, if the looped section is silent (e.g. Part 3 in the lower right figure) then the reset section describes a kind of one-shot trigger.

### 2.2 Reset-less parts

This is an important special case. When a part does not have a reset step specified 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. Both kinds of parts are of course musically useful.

### 2.3 The 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 specified with the RESET TO button on the ER-102.

### 2.4 The pending part

The pending part is the part that is scheduled to play next, 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 orange focus LED will flash when a part is pending but has not yet started playing yet.

### 2.5 The playing part

The currently playing part is indicated by the dot in the lower right of the PART display. Each track will perform according to the reset step and

looped section specified in the playing part.

## 2.6 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.

## 2.7 Transitions

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

### 2.7.1 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. 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 all tracks to finish a loop at least once before moving on to the pending part. In other words, the last track to finish its loop determines the transition to the pending part.

[diagram of first vs last transition modes]

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.

### 2.7.2 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.

Notice: Once configuration scripts are introduced in the next firmware, the behavior of the USER transition mode can be customized. More information on this feature will be made available at that time.

# 3 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/or CV/gate modulation. Each snapshot can contain up to 16 groups.

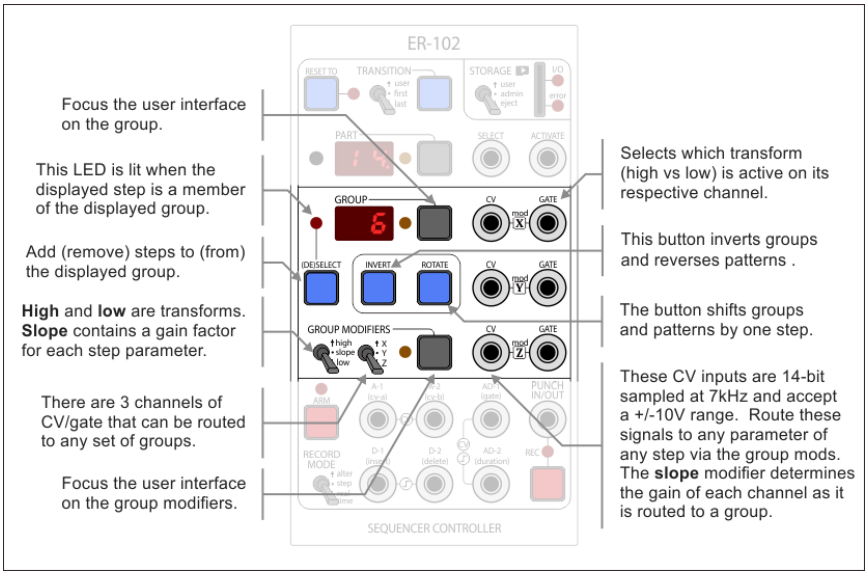


Figure 2: The GROUPS section of the ER-102.

## 3.1 Selections (or how to define groups of steps)

### 3.1.1 Select by Step (or Pattern or Track)

The most basic way to add steps to the current focused group, is to press the (DE)SELECT button while having the desired step 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 selection LED (next to the GROUP display) will light up when the focused step is in the focused group. Furthermore, the navigation focus of the ER-101 (i.e. STEP vs PATTERN vs TRACK) is used to determine whether a single step, or an

entire pattern, or the entire track should be added (or removed) from the group.

For example, to add all the steps of pattern #3 to group #1:

1. Navigate to group #1.
2. Navigate to any step in pattern #3 that is NOT a member of group #1.
3. Focus the PATTERN display.
4. Press the DE(SELECT) button.

And to remove all the steps of pattern #3 from group #1 just press the DE(SELECT) button again. Notice how the selection state of the focused step determines whether the whole pattern will be added or removed from the group. In other words, whatever happens to the focused step will also happen to all the other steps in the focused pattern. This same behavior applies to entire tracks when we have the TRACK display focused.

### 3.1.2 Copy a Selection

If you press the COPY button while the GROUP display is focused then the current group's selection (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 of steps will combine with the existing selection of steps in the target group, effectively creating the union of the two sets.

### 3.1.3 Delete a Selection

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

### 3.1.4 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 are selected. Holding the INVERT button while pressing the ROTATE button will shift the selection earlier by one step.

### 3.1.5 Invert a Selection

## 3.2 Peforming transforms on a group

Each group has its own destructive transform that is accessible via the MATH button and also 6 non-destructive transforms accessible via the high/low modifiers. Pressing the MATH button while the GROUP display is focused will show/apply 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 MATH button again to exit from the transform edit screen (without applying the transform).

## 3.3 Modifiers

The modifiers of a group specify 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 contain simplified (non-destructive) transforms which are activated according to the logic state of the 3 gate inputs.

### 3.3.1 The Slope Matrix

Each group is associated with a 4x3 matrix of slopes (or gain factors) that are in the range of -99 to 99. The 3 columns of this slope matrix correspond with the 3 channels of the modulation inputs: X, Y and Z. The 4 rows correspond with the 4 step parameters: CV-A, CV-B, DURATION, and GATE. The voltages, presented at each channel of the modulation bus, are multiplied by the group's slope matrix and then added to each parameter of the steps in a group:

{ $P_{mod[i]} = P_{orig[i]} + K[g] * V$ | for each step i in the group j }

$P_{mod[i]}$ = modified 4-vector of step i's parameters $P_{orig[i]}$ = original 4-vector of step i's parameters K[g] = 4x3 slope matrix of group j (element range: -99 to 99) V = 3-vector of the modulation CV inputs in Volts (element range: -10V to 10V)

In the case of CV-A and CV-B, this adjustment is added after the voltage table lookup (i.e. after converting the voltage index to an actual voltage).

To access the slope parameters for a particular modulation channel (i.e. a row of the matrix $K_g$):

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

[diagram: show SLOPE screen]

Now the GROUP display LED and the GROUP MODIFIER display LED will be lit. 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).

When altering the slope, please notice that 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.

### 3.3.2 The 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 is 6 transforms per group. 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. 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.

These 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).

# 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.

[diagram of the record section with callouts to each ui element.]

Common to all of the record modes, is the ARM button and the PUNCH IN/OUT section. 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.

## 4.1 Real-time mode

The real-time recording mode is used to record a live performance into a pattern of a track. Timing of CV and gate changes is measured against the clock (after per-track multiplication) and then re-interpreted as a sequence of steps with quantized voltages. 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 doing then you should put the ER-101 in FOLLOW mode.

[diagram of real-time record mode jack assignments]

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.

[diagram of how gate input determines timing values]

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.

[diagram of real-time recording configuration screen]

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

| Display | Purpose | Values | Default Value |
|---|---|---|---|
| CV-A | Trigger a new step when the CV-A changes? | tr,– | tr |
| CV-B | Trigger a new step when the CV-B changes? | tr,– | – |
| DURATION | Quantization grid size for step durations. | 1-99 | 1 |
| GATE | Quantization grid size 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 when a new step is started. Normally, during real-time recording a new step is only started when a rising edge is received from the gate input. However, there are cases when a new step should start without a new gate signal such as when the performance includes legato notes. Therefore, 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.

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 which means no rounding.

The D-1, D-2, and AD-2 jacks are not used in this mode.

### 4.1.1 Smooth in, Stepped out

The re-interpretation 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. Vibrato-types of modulation are best added later using the modulation bus of the GROUP section.

## 4.2 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 without regards to the timing in which you do it. The STEP recording 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. The STEP recording mode is 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.

[diagram of step record mode jack assignments]

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 Voltage | 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 according to the table above. The step parameters are locked and will no longer change when the D-1 (insert) gate goes low.

[diagram showing step mode example with CV/gate keyboard]

Since steps are added at the edit cursor, you can have the sequencer playing (and looping) the section as you add/remove steps.

### 4.3 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 steps are inserted in the armed tracks. Instead, step parameters are overwritten with new values (derived from the input voltages) just before the play cursor encounters the step and then plays it. Of course, 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:

[diagram of alter record mode jack assignments]

| Step Parameter | Input Voltage | 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. 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! However, now you have all the capabilities of the ER-101/102 added to your analog step sequencer.

[diagram of the knobby interface patch]

# 5 Memory Card

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 directory structure on the memory card:

```
ER-102/
  SNAPSHOT/
  FIRMWARE/
```

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

```
ER-102/
  METAINFO.BIN
  SNAPSHOT/
    A1.BIN
  FIRMWARE/
```

The METAINFO.BIN file contains various cached information such as the last snapshot saved and what version of the firmware was running on the ER-102 at the time. The snapshot in this example was saved as a binary dump to the file A1.BIN in the SNAPSHOT directory.

## 5.1 Snapshots

## 5.2 Updating the firmware

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. $f1_{02}$.bin) to the FIRMWARE directory on your microSD card. 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 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 then you can iterate through the available firmware files on your microSD card by repeatedly pressing the GROUP focus button.

# 6 Notes

### 6.0.1 need more examples throughout the manual