KOSZALIN

STEREO VC FREQUENCY SHIFTOR

Model of 1964

OPERATOR'S MANUAL *rev. 1964/1.1ę*

SALUT

Thank you for purchasing this Xaoc Devices product. Koszalin [kɔ'ʃalin] is a stereo frequency shifter (2 ins/4 outs) offering both quasi-exponential and linear frequency modulation as well as full stereo feedback under voltage control. Frequency shifting results in a linear translation of the signal spectrum, which produces a variety of atonal sounds. It should not be confused with frequency scaling, also known as pitch shifting. Complex phase cancellation patterns occurring with frequency shifting and deep feedback produce spectacular barber-pole effects.

Koszalin offers direct controls over feedback amount, feedback routing, and feedback response. It also facilitates frequency modulation of any stereo audio signal, thanks to the linear TZFM input. Koszalin is a digital module with a DSP behind an analog interface.

INSTALLATION

The module requires 10hp worth of free space in the Eurorack cabinet. Always turn the power off before plugging the module into the bus board using the supplied 16-pin/16-pin ribbon cable, paying close attention to power cable pinout and orientation. The red stripe indicates the negative rail and should match the **–12v** *mark on the bus board and the unit. Koszalin is internally secured against reversed power connection; however, flipping the 16-pin header* **MAY CAUSE SERIOUS DAMAGE** *to other components of your system because it will short circuit the +12V and +5V power lines. Always pay particularly close attention to the proper orientation of your ribbon cable on both sides!*

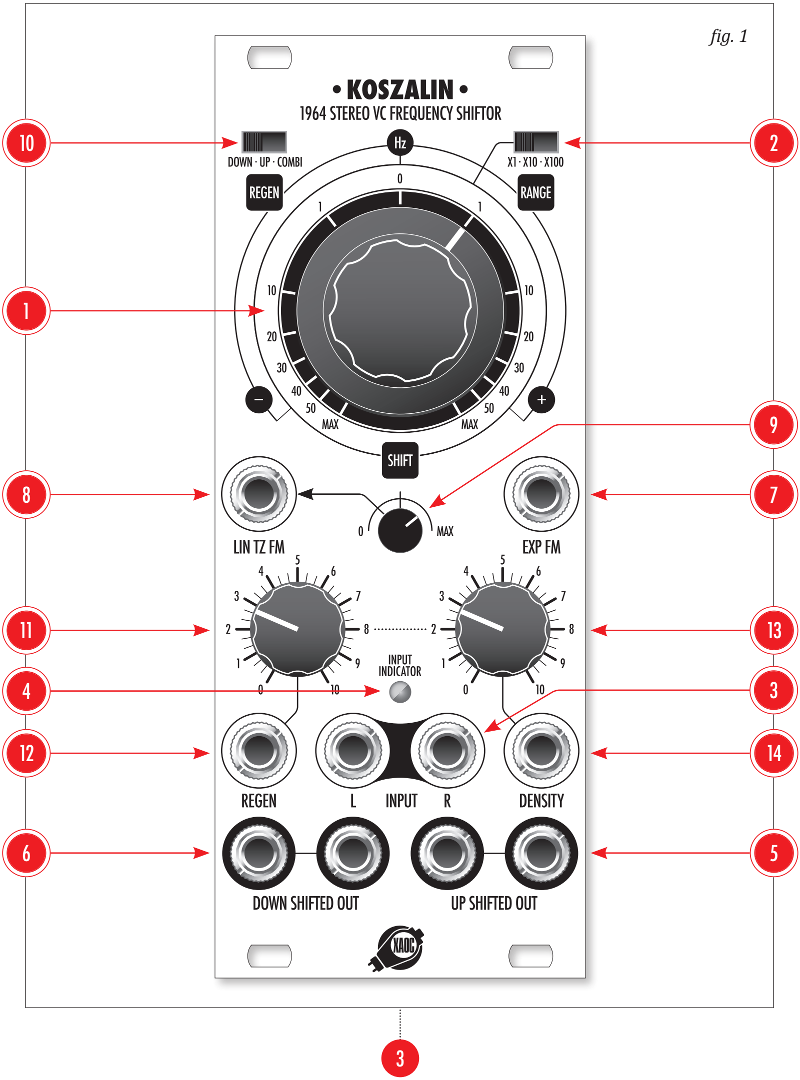
The module should be fastened by mounting the supplied screws before powering up. To better understand the device and avoid common pitfalls, we strongly advise the user to read through the entire manual before use.

MODULE OVERVIEW

The front panel of Koszalin (fig. 1) features a **SHIFT** *knob* ❶ *used for setting the amount of frequency shifting applied to the input signal (in Hz). The response of this knob is bent exponentially in both directions from the center of the scale (which indicates 0Hz). In other words, the scale is stretched proportionally around zero, which facilitates greater precision in setting a low shift amount. Three ranges are set with the* **RANGE** *switch* ❷*: X1 (-50Hz to +50Hz), X10 (-500Hz to +500Hz), and X100 (-5kHz to +5kHz). Stereo input signals should be patched into the pair of* **INPUT** *jacks* ❸*. The* **INPUT INDICATOR** ❹ *shows the volume of the input using light intensity and color, gradually changing from green to yellow and red when the sum exceeds 16Vpp.*

Two pairs of stereo outputs are available for independent access to the signal being shifted up ❺ *(towards higher frequencies), as well as shifted down* ❻ *(towards lower frequencies, including and beyond 0Hz; more on that be-*

FRONT PANEL OVERVIEW



havior in the "Negative Frequencies?" section). The functions of these two pairs effectively swap when the **SHIFT** *knob is turned to the left of 0Hz, or a negative control voltage is applied.*

Two ±5V range CV inputs are available for modulating the amount of frequency shift: **EXP FM** ❼ *for exponential control and* **LIN TZ FM** ❽ *for linear control. The sensitivity of the exponential input is switched together with the* **RANGE** *switch, while the sensitivity of the linear input is controlled by the attenuator* ❾ *and doesn't change with range.*

Koszalin provides several internal feedback options. The **REGEN** *switch* ❿ *determines internal feedback routing: from downshifted signals, upshifted signals, or both combined (combo feedback explained below). The feedback amount is controlled with the* **REGEN** *knob* ⓫*, and CV plugged into the corresponding jack* ⓬*. The temporal character of the feedback effect depends on the* **DENSITY** *parameter, controlled by knob* ⓭ *and/or CV via the corresponding input below* ⓮*.*

WHAT IS FREQUENCY SHIFTING?

Frequency shifting is a process that affects all spectral components of a signal by changing their frequencies by an equal number of Hz. For example: if the input is a periodic waveform with a 1kHz frequency, it usually contains the 1kHz component plus the harmonic overtones: 2kHz, 3kHz, 4kHz, etc. When this signal is shifted by 200Hz the result contains 1.2kHz, 2.2kHz, 3.2kHz, 4.2kHz, etc. (fig. 2). That means the new components are no longer multiples of the first frequency; hence the signal is inharmonic and non-periodic.

Bear in mind that this is a very different effect to pitch shifting, which results in scaling the frequencies by the same factor. So, for example, applying a factor of 1.2 would result in a signal that contains 1.2kHz, 2.4kHz, 3.6kHz, 4.8kHz, etc.—still a harmonic signal, just with a different pitch.

Technically, shifting of the spectrum is achieved through Single Side Band (SSB) modulation that is much more complex than a simple multiplication, which is sometimes inappropriately called ring modulation.

A common fallacy says modulation is the same as adding and subtracting signals, which is nonsense since multiplying is not adding and subtracting. Instead, this type of modulation (specifically, four quadrant amplitude modulation) affects individual harmonic components in such a way that their frequencies are added and subtracted.

The SSB separates these modulation products and offers two new signals: one with frequencies shifted up and one with frequencies shifted down. This is obtained by complex filtering, phase rotation, and quadrature modulations, which are difficult to achieve with analog technology but relatively easy with DSP. **NOTE:** *summing both down- and upshifted signals reduces the effect to a mere multiplication (balanced modulation, aka "ring mod").*

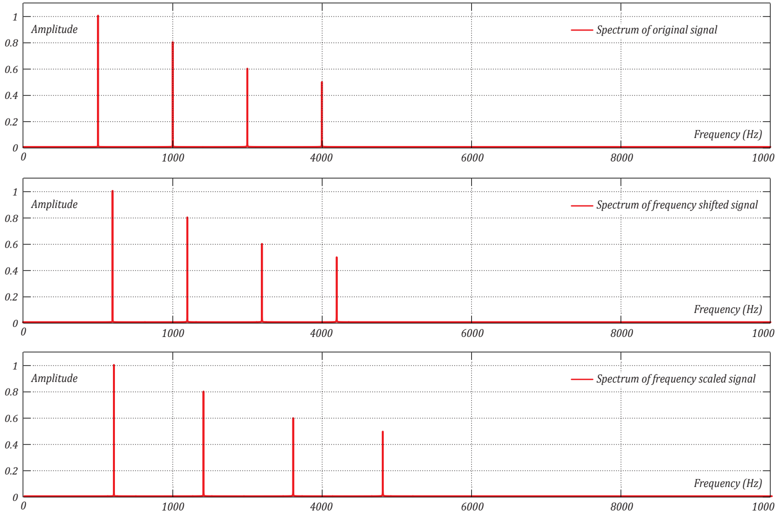


fig. 2: FREQUENCY SHIFTING VS. FREQUENCY SCALING

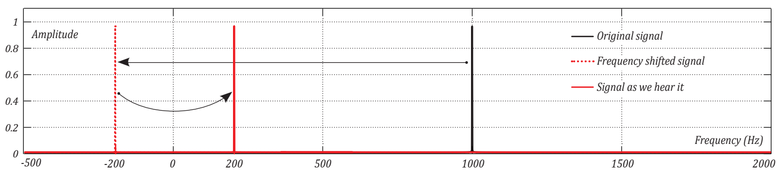


fig. 3: REFLECTING NEGATIVE FREQUENCY BACK TO POSITIVE

NEGATIVE FREQUENCIES?

Consider a point rotating on a circle at X rpm. When observed along one dimension, it would oscillate sinusoidally with a frequency of X/60 Hz (because there are 60 seconds in a minute). If we slow down the circle, the frequency decreases towards 0Hz, but when we stop the circle and change the direction, the frequency starts rising again—towards the negative frequency values.

Sinusoids with negative frequencies are indistinguishable from those with positive frequencies, except when crossing zero. This zero-crossing is why through-zero frequency

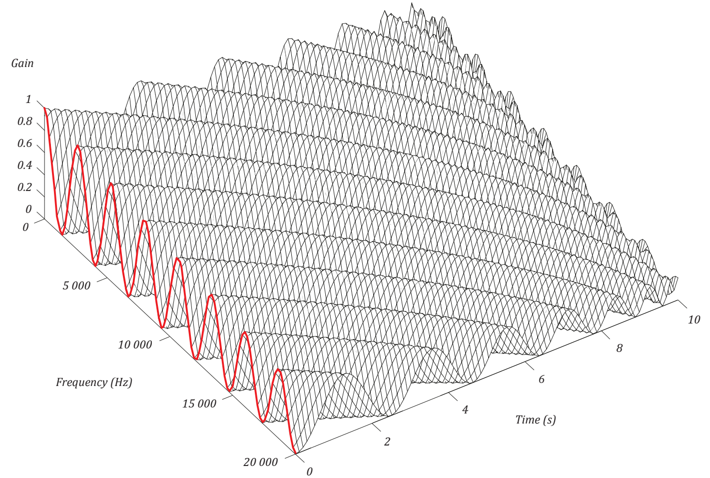


fig. 4: TIME-FREQUENCY RESPONSE OF FREQUENCY SHIFTING WITH FEEDBACK

modulation sounds different than positive-only FM. Frequency shifting by increasing negative amounts has a distinctive effect that at some point, the original frequencies approach zero, cross it, and then start to increase again (see fig. 3). For example, with the incoming signal frequency being 300Hz, turning the **SHIFT** *knob counterclockwise to the -300Hz position, i.e., 30 with the* **x10** *switch engaged (while listening to the* **UP SHIFTED OUTS***), compensates the original frequency, so the result reaches 0Hz (300-300=0). Beyond this point, as we hear it, the frequency appears to be increasing, even though it actually moves towards -inf.*

Interestingly, shifting a harmonic signal down moves its fundamental to an inaudible DC. At the same time, all the overtones move down by one position, thus producing a harmonic signal again. Further shifting, however, causes its fundamental to appear in increasing (negative) frequency, as opposed to its other components, which still decrease toward zero; thus, the signal becomes increasingly inharmonic.

THE EFFECTS OF FEEDBACK

Feeding a frequency-shifted signal back to the input of the shifter creates a cascade of shifts because part of the signal is shifted multiple *times. If the shift is slight, a comb response is created resembling a very deep, resonant flanger. Phase cancellation creates ripples that move in time and frequency (fig. 4), yielding a spectacular barber-pole effect. Koszalin offers two controls of this behavior through its* **REGEN** *and* **DENSITY** *knobs and CV inputs.*

Additionally, three feedback configurations are available via the **REGEN** *switch. The left and middle positions select feedback created from the downshifted and upshifted stereo pair of outputs, respectively. Finally, the rightmost position selects* **COMBI** *with the left channel from the* **DOWN SHIFTED OUT** *and the right channel from the* **UP SHIFTED OUT***. The combined feedback position is useful when patching both stereo channels in series (see: "Patch ideas").*

SOUND QUALITY CONSIDERATIONS

Koszalin is designed to operate on audio signals with Eurorack levels; therefore, a ±5V input is recommended. For best audio quality, avoid using very quiet signals and amplifying the output to compensate. Conversely, avoid overdriving the input with very hot signals—use the color input indicator LED as a general guide for optimal signal level. Due to internal gain staging, there is a chance of amplifying noise from the bus board; hence, the quality of power supply and distribution impact the output signal. We recommend using linear, and to a lesser extent, hybrid (switching converters followed by linear regulators) power solutions since they are quieter than switching-type power regulators. Additionally, we suggest avoiding "flying bus" cables as they increase coupling between modules which can cause interference and instability.

PATCH IDEAS

• *Feed a sinusoidal signal from your oscillator to the left or right input of Koszalin. Set the* **SHIFT** *knob to zero and set regen to zero. Patch another audio rate signal to the* **LIN TZ FM** *input (directly or through a VCA) and set the small attenuator to taste—now you have an FM operator. You can replace the input sinusoid with any other signal, e.g., from a sampler, to get a different flavor of FM.* **NOTE:** *the result of modulation will smear and diminish when you add feedback.*

• *Take any plain signal to Koszalin's right* **INPUT***, take the right* **UP SHIFTED OUT** *and patch to the left* **INPUT,** *then listen from the left* **DOWN SHIFTED OUT***. These two shifts will cancel, but the interesting part is what happens in-between. Set the* **REGEN** *switch to* **COMBI** *and turn the regen knob up. Manipulate the amount of* **SHIFT** *and* **DENSITY** *for different effects. This creates a kind of filter with an extraordinary response. Try pinging it. You can also flip the shift direction for a different effect.*

ACCESSORY

Our Coal Mine black panels are available for all of Xaoc Devices modules. Sold separately. Ask your favorite retailer. •

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MADE IN THE EUROPEAN UNION

MAIN FEATURES

Full stereo frequency shifting with 2 inputs and 4 outputs

3 ranges of shift: 50Hz, 500Hz, and 5kHz

Independent exponential and linear thru-zero control inputs

Internal feedback under voltage control

TECHNICAL DETAILS

Eurorack synth compatible

10hp, skiff friendly

Current draw: +140mA/-30mA

Reverse power protection