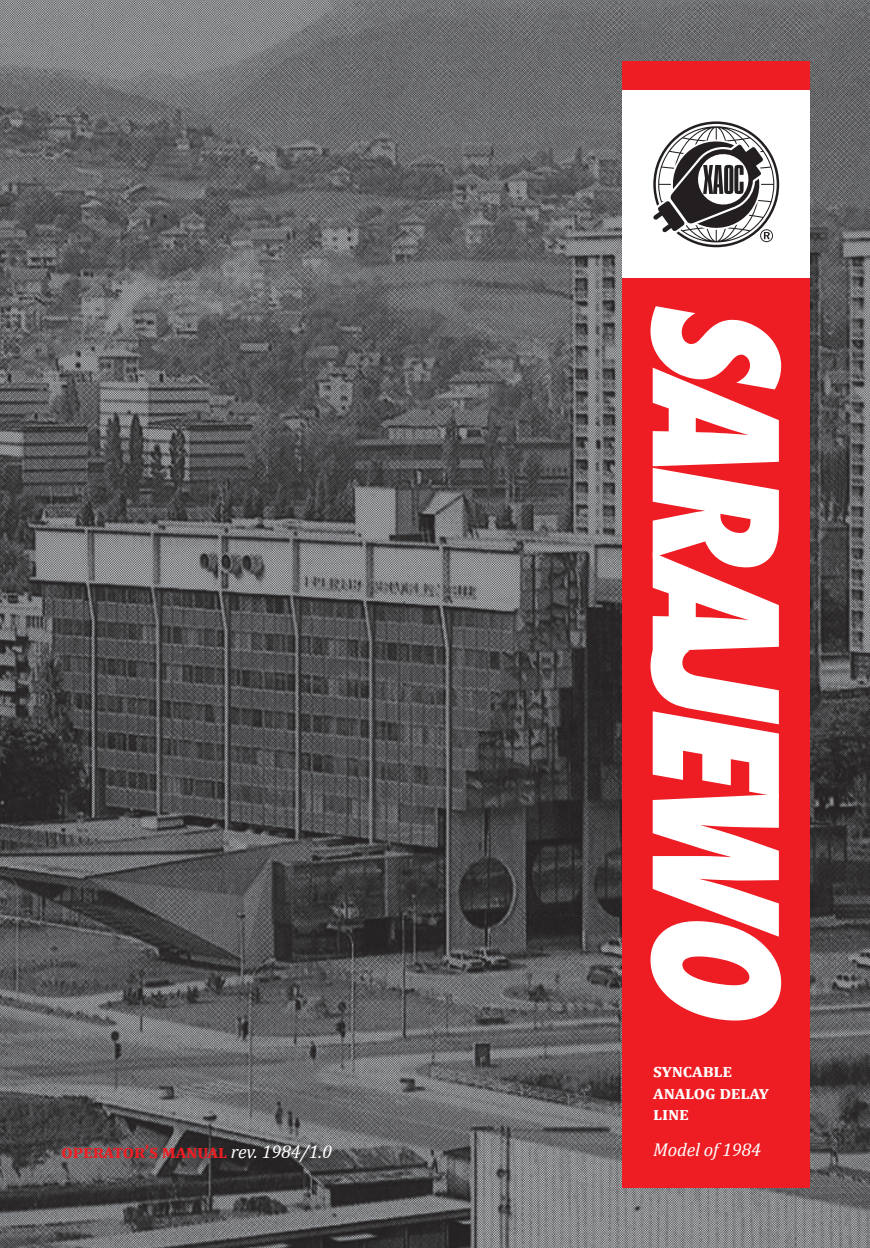

SARAJEVO

SYNCABLE ANALOG DELAY LINE

Model of 1984

OPERATOR'S MANUAL *rev. 1984/1.0*

SALUT

Thank you for purchasing this Xaoc Devices product. Sarajewo is an analog delay module based on old school (but newly manufactured) BBD (Bucket Brigade Delay) chips. It features three delay taps, an external clock input with various tempo sync factors, and a wide range of settings controllable via CV. It is based on high quality components with maximum effort put towards the highest sound quality possible, while still preserving the charm of the BBD technology. The module offers a clean and warm analog sound with tons of character and a comfortable user interface with a tap tempo button, signal level indicators, sync and CV inputs, four signal outputs, and an adjustable feedback filter.

INSTALLATION

The module requires 12hp worth of free space in the Eurorack cabinet. The ribbon-type power cable must be plugged into the bus board, paying close attention to polarity orientation. The red stripe indicates the negative **–12v** *rail and should point in the same direction on both the bus board and the unit. The module itself is secured against reversed power connection, however, reversing the 16-pin header* **MAY CAUSE SERIOUS DAMAGE** *to other components of your system because it will short-circuit the +12V and +5V power rails. The module should be fastened by mounting the supplied screws before powering up. To better understand the device, we strongly advise the user to read through the entire manual before using the module.*

MODULE OVERVIEW

Sarajewo features an audio delay line consisting of three BBD chips of 4096 stages each (see fig. 1). All three chips are driven by the same clock, and are connected in series so that the

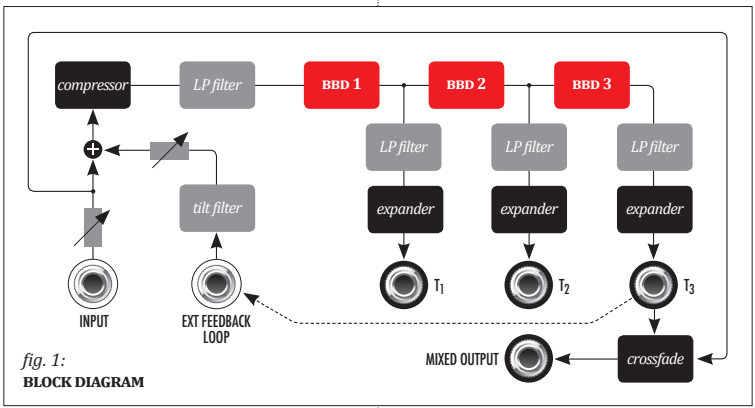

fig. 1:
BLOCK DIAGRAM

delayed signal is available after each chip. A high signal–to–noise ratio is achieved thanks to signal companding (dynamic compression at the input matched with dynamic expansion on each of the outputs). An anti-aliasing filter at the input and anti-imaging filters on each of the outputs ensure optimal conditions for the BBD chips to process the signal.

In general, the incoming signal must be band–limited in order to prevent high frequency components from interfering with the clock. Similarly, lowpass filtering applied after the signal is processed helps to eliminate high frequency artifacts introduced by the BBD chips. In Sarajewo, all of these filters are tunable and follow the current clock frequency, thus offering maximum bandwidth with minimal artifacts.

An internal feedback loop taken from the last tap allows for the classic echo effect with additional coloration offered by an adjustable tilt filter. The feedback loop can also be processed externally while a crossfading circuit offers a continuous mix of the input and the signal from the last tap.

The front panel of Sarajewo is shown in fig. 2. The signal you wish to process should be patched to the **INPUT** *jack* ❶*. The* **LEVEL** *knob* ❷ *above controls the amplitude with the* **INPUT INDICATION** *multicolor LED* ❸ *providing visual feedback. The outputs from individual taps are labeled* **T1**, **T2**, *and* **T3**, *respectively:* ❹,❺,❻*. The central large* **T3 TIME** *dial* ❼ *allows for precise setting of the overall delay time of the three stages, from about 20ms to over 1.5s. The delay time can be modulated via CV patched into the corresponding jack below* ❽ *or synchronized to an external clock source via the* **SYNC** *input* ❾*. Since all three BBD chips share a common clock, using the* **T1** *and* **T2** *outputs will provide signals delayed by 1/3 and 2/3 of the* **T3 TIME**, *respectively. The* **MIXED** *output* ❿ *delivers a continuous mix of your input signal and the* **T3** *tap. The balance is controlled both by the* **EFFECT** *knob* ⓫ *and the CV patched into the* **MIX CV** *jack* ⓬*. The signal from the* **EXT FEEDBACK LOOP** *input* ⓭ *is mixed with the input of the delay line. This jack is normalized to the* **T3** *output, however, the connection can be broken by sending one of the tap outputs to an external processor (such as the Xaoc Belgrad filter), and back to Sarajewo via the* **EXT FEEDBACK LOOP** *input. Regardless of the actual feedback signal path (internal or external), the signal always passes through an internal tilt-type filter, adjustable with the* **TONE** *slider* ⓮*. The amount of feedback is controlled by the* **FBCK** *slider* ⓯*. The* **BBD OFF-RANGE LED** ⓰ *indicates that the delay time set by the combination of the* **T3 TIME** *dial and the incoming CV signal exceeds the time range of the module. When the CV inputs are in use, the corresponding knobs act as offsets.*

INPUT SIGNAL

Sarajewo is AC coupled and accepts modular level audio signals (10Vpp and higher). The **LEVEL** *knob attenuates the input to prevent distortion (indicated by the color of the* **INPUT INDICATION** *LED). When it turns from green to yellow and then to red, it means the signal is too hot and the BBD chips may introduce audible distortion.*

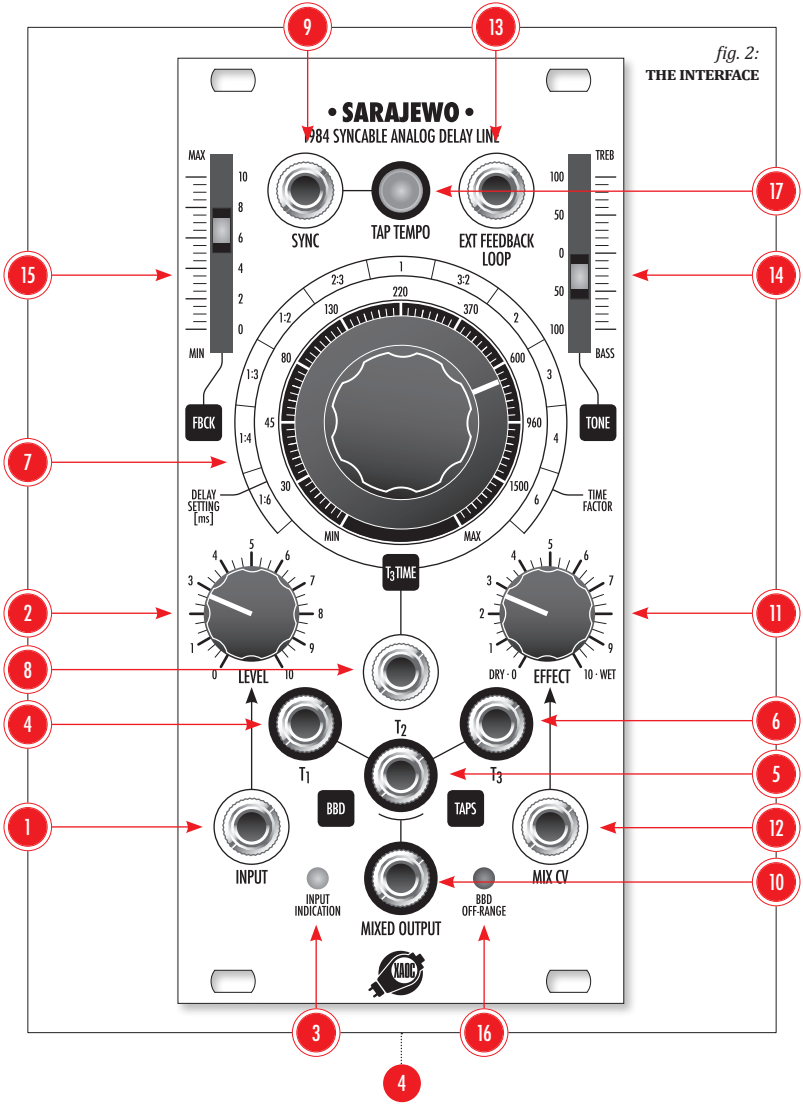

fig. 2:
THE INTERFACE

CONTINUOUS AND TAP-TEMPO DELAY CONTROL

Sarajewo can operate as a continuously variable delay or in one of two synced modes in which the delay follows a given time base. The illuminated **TAP TEMPO** *button* ⓱ *always blinks with a period equal to the current delay time, while its color indicates the current mode. Please note that unlike digital delay effects which vary the length of their memory buffer, each change of the delay time in Sarajewo is reflected by a change in speed of signal propagation in a fixed delay line, hence it will inevitably cause pitch variation similar to the sound of a tape-based machine.*

FREE MODE

When Sarajewo operates in FREE MODE*, the* **TAP TEMPO** *button blinks green and delay time is continuously adjustable from 20 to 1560ms via with the central dial.*

The external CV input adds an offset to the current value, extending the delay time up to 4x (with negative CV) as well as shortening down to ¼ (with positive CV). Keep in mind that you cannot exceed the limits mentioned above. Values beyond the range will be clamped and the **BBD OFF-RANGE** *LED will appear red.*

TAP-TEMPO MODE

Pressing the **TAP TEMPO** *button at least two times switches Sarajewo to* TAP-TEMPO MODE*, indicated by a yellow* **TAP TEMPO** *button backlight. The period of your recent taps is measured and used as the current time base (unless it is slower than the longest delay setting, i.e.*

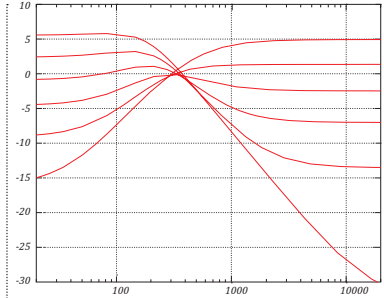

fig. 3: **TILT FILTER RESPONSE**

1560ms). In this mode, both the **T_3 TIME** *knob and the corresponding CV input are still active, but their function changes so that the* **T_3 TIME** *knob allows for multiplication or division of the time base. The delay time is modified by one of the factors from the scale: 1:6, 1:4, 1:3 1:2, 2:3, 1:1, 3:2, 2, 3, 4, 6. Turning the dial will switch these factors in discrete steps. Turning the dial left will shorten the delay time (from 1:1 ratio to 1:6 ratio). Turning the dial right will lengthen the delay time (from 1:1 ratio to 6:1).*

A long press of the **TAP TEMPO** *button brings you back to* FREE MODE*.*

SYNC MODE

Patching an external clock source to the **SYNC** *input switches Sarajewo to external* SYNC MODE*, indicated by a red tap tempo button backlight. The delay now follows the tempo of the external clock while applying the same modifications (and automatic adjustments) of the factor as in* TAP-TEMPO MODE*. Please note that you cannot exit this mode as long*

as a cable is patched and new impulses arrive. When you unplug the cable, the module returns to the FREE MODE*, with the delay time reflecting the current position of the* **T_3 TIME** *knob.*

Again, you cannot exceed the BBD clocking limits by turning the knob to the extremes and/or applying a high amplitude CV signal. However, instead of clamping the delay time at the upper or lower limit, the time factor is automatically reduced to the nearest synced value, so that your echoes remain in sync.

TAP-TEMPO & SYNC MODE TIME CV INPUT BEHAVIOR

The **TIME** *CV input acts as an offset, and provides two user-selectable options. The default behavior is that CV is added to knob position which yields quantized switching between time factors. The alternative option is that the CV value is unquantized which allows for subtle modulation of the delay time. In order to activate the second option, power up your system while holding the* **TAP TEMPO** *button.*

OPERATING THE FEEDBACK

The **FBCK** *slider potentiometer determines how much of the delayed signal is returned to the input of the BBD line and mixed with the input signal. Obviously, the stronger the feedback, the more the echoes repeat, thus sustaining the sound to the point where self-oscillation builds up a wall of saturated sound and noise. Please note that the buildup or decay rate depends very much on the current delay time—the key is the number of audible repetitions. The illuminated* **FBCK** *slider shows the amplitude of the feedback signal by blinking green and turning to red to warn that the signal is too hot and close to the clipping level of the BBD chip.*

Besides the depth of feedback, you can also shape the frequency content of your signal by adjusting the **TONE** *slider (fig. 3). Keep in mind that with a deep feedback your sound will pass through this filter multiple times and the effect will be more and more pronounced. In the middle position of the slider, it introduces very little coloration. At the lower position of the slider, the filter amplifies lower frequencies while attenuating higher frequencies. Please note that amplifying low frequencies may accelerate the self-oscillation effect and increase distortion. At the higher position of the slider, the filter will attenuate low frequencies and amplify middle and higher frequencies, hence the echoes will sound brighter. Again, note that exaggerating this effect may affect feedback depth. The illuminated* **TONE** *slider blinks in color, showing which frequencies are dominating in your feedback signal with red indicating highs and green indicating lows.*

EFFECT MIXING

The **EFFECT** *knob in Sarajewo controls the wet/dry balance in a distinct manner. In the middle position, both the original and delayed sounds are delivered to the* **MIXED OUTPUT** *at their original amplitudes. Unlike a traditional crossfader, turning this control left and right attenuates one of the signals without amplifying the other. This balance can also be*

BBD TECHNOLOGY

Bucket Brigade Delay is an analog technology used in vintage integrated circuits that were popular in the 1970s, long before digital signal converters and digital memory were affordable. Each BBD chip contains thousands of small capacitors and pMOS or nMOS transistors that act as analog switches. The signal is transferred as an electric charge that is passed from one stage to the next, like a fire brigade passing buckets of water (hence the name). A clock signal governs the speed of charge transmission, and directly controls the delay time: the faster the clock, the shorter the delay (and vice versa). Due to the limitations of vintage technology, signal degradation occurs—some noise and analog distortion results from the nonlinearities of MOS transistors. Even though contemporary digital delay effects offer a much cleaner signal, BBD delays are still sought after due to their desirable sonic characteristics. Furthermore, the range of delay time offered by just a single BBD chip is limited to 20–300 ms, which is much less than what is commonly expected from modern delay effects. In order to achieve more attractive delay times, several chips must be used and the clock partially operates outside of the factory specifications. This yields additional signal degradation at extreme delay time settings due to the accumulation of noise and distortion from multiple stages.

voltage–controlled by a bipolar (±5V) signal patched into the **MIX CV** *input.*

DELAY TIME VS BANDWIDTH

Just like any other BBD-based effect, Sarajewo achieves long delays by reducing the clock rate, which inevitably limits the usable bandwidth. At the end of the scale, the (normally ultrasonic) clock is slowed enough to become an audible whine. Also, it produces some aliasing and imaging artifacts, as well as increased background noise. Sarajewo handles this problem by automatically adjusting its four internal filters that attenuate unwanted components just before they become audible. That is why the signal becomes dark when the delay is set beyond 500ms, and even darker the further the scale. Each unit comes factory calibrated to achieve the optimal balance between the bandwidth and artifacts.

USAGE TIPS

Sarajewo is intended as a long delay effect unit, and as such, it excels at longer delay settings. For best results at the shortest delay settings you are advised to use the **T_1** *output and combine it with moderate, but not minimum delay time settings of the* **T_3 TIME** *dial. To make Sarajewo work as expected in that configuration—and depending on the intended sonic result—you may wish to patch the* **T_1** *output to the* **EXT FEEDBACK LOOP** *input. To mix the dry signal with the wet signal from the* **T_1** *output, an external mixer is needed, as the internal* **EFFECT** *mixer always crossfades between the dry and the* **T_3** *signal.* •

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EASTERN BLOC TECHNOLOGIES

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MADE IN THE EUROPEAN UNION

MAIN FEATURES

BBD-based analog delay unit

Up to 1560ms of analog delay times

Three delay taps with individual outputs

External clock synchronization

Manual tap tempo function

Variable tempo divisions and multiplications

Automatic bandwidth control

Tilt filter in feedback loop

External feedback loop input

TECHNICAL DETAILS

Eurorack synth compatible

12hp, skiff friendly

Current draw: +180mA/-120mA

Reverse power protection