



# BELGRAD

DUAL PEAK  
MULTIMODE  
STATE VARIABLE  
FILTER

Model of 1976

OPERATOR'S MANUAL rev. 1976/1.0

## SALUT

Thank you for purchasing this Xaoc Devices product. Belgrad is our first all-analog voltage controlled filter module which—on par with our other modules—brings something new to the table. While it can be used as a traditional VCF for “academic” subtractive synthesis, we guarantee countless hours of exciting timbral explorations thanks to its unique character, flexibility, and features. The most prominent feature is that it offers a multitude of frequency responses with two resonant peaks.

## INSTALLATION

The module requires 14hp 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 is supposed to 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.

## CONTROLS AND OPERATION

Belgrad features a pair of state variable filter cores whose inputs and outputs can be combined in various serial and parallel configurations. The **MODE** rotary switch ①

selects one of ten unique filter responses. Turning the knob from its leftmost position to its rightmost position consecutively selects modes that gradually change from lowpass to high-pass with several more exotic responses in the intermediate positions.

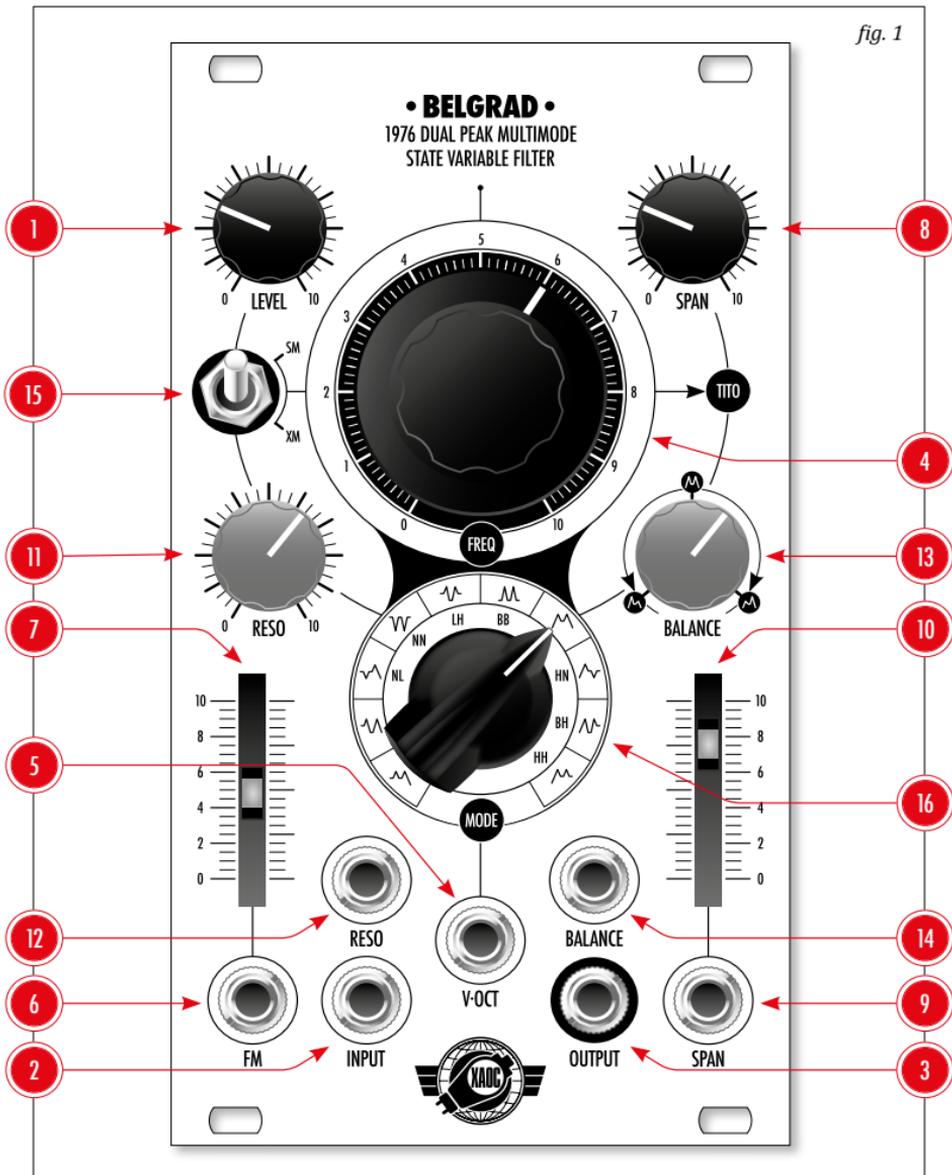
Different filter responses vary in overall amplitude gain and resonance behaviour. Therefore, you should not be surprised by varying volume levels after changing modes, especially when switching from a narrow bandpass to a narrow notch response. Detailed mode descriptions can be found on pages 5 to 7.

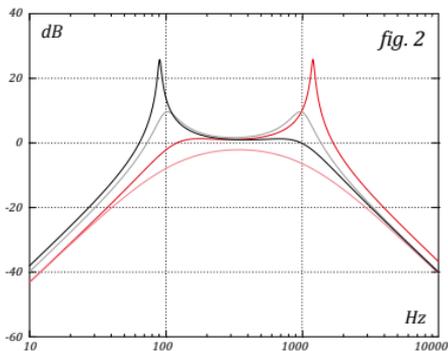
The **LEVEL** knob ② (fig. 1) controls the amplitude of the signal fed into the filter from the main **INPUT** ③ up to some degree of input overdrive. The processed signal is available at the main **OUTPUT** socket ④.

The big **FREQ** knob ⑤ sets the center frequency of both filter cores in the approximate range of 4Hz to 28kHz. This frequency can be voltage controlled through the **V-OCT** input ⑥ and modulated by the **FM** input ⑦ (attenuated by the illuminated slider ⑧).

Furthermore, both filter cores may be symmetrically detuned with respect to the center cutoff frequency, resulting in a range of interesting responses, including vocal formants. The detuning is controlled by the deliberately non-linear **SPAN** knob ⑨ as well as the corresponding bipolar (-5V to +5V) **SPAN** control voltage input ⑩, additionally scaled by the illuminated attenuator ⑪.

fig. 1

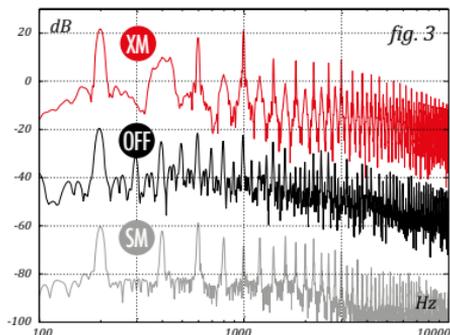




### DUAL PEAK CONTROL

Unlike most traditional synthesizer filters that offer just a single resonance (emphasis, or *Q*) control, Belgrad is equipped with a number of advanced resonance controls.

The overall degree of resonance is set by the **RESO** knob 11 as well as a control voltage (0 to 8V) supplied to the **RESO** input 12. The two resonant peaks of the filter may have different emphasis — set by the **BALANCE** knob 13 — from domination of the lower peak, through full symmetry, up to domina-



tion of the higher peak (fig. 2). The degree of symmetry may also be voltage controlled by a bipolar (-5V to +5V) CV at the **BALANCE** input 14. Finally, the distance between the two peaks is set by the **SPAN** knob and CV from zero up to nearly eight octaves.

### SELF OSCILLATION & NON LINEAR BEHAVIOUR

With the **RESO** knob set around 8 (depending on the mode and other settings), Belgrad starts to self-oscillate. In such state, it behaves like one or two sine wave VCOs musically controlled by the **V-OCT** input. When tuned right, it is expected to track about five octaves and be reasonably stable with temperature variations.

Driving the resonance further reveals the nonlinearities inherent in the feedback paths of the filter cores, making the waveform more saturated and distorted. Experimenting with the **BALANCE** and **SPAN** controls can yield interesting wave shapes.

Another unique feature that can produce unusual sonic effects is the internal coupling topology which applies double non-linear audio-rate modulation to the filter cores. It is controlled by the **TITO** switch 15 and may be toggled from the neutral position either up for self-modulation or down for cross-modulation (fig. 3). The **SM** mode gives the resonance a radical and textured sound, while **XM** mode adds a warbly and chirpy character in different scenarios such as processing drums or bass.

**SOME USAGE TIPS**

Vocal-like timbres are easily obtainable via **LL**, **LB**, or **BB** mode, with **RESO** at 6–7 (just below the oscillation threshold), and **SPAN** set between 2 and 4.

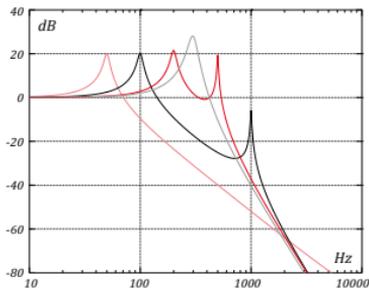
Notch modes are surprisingly most prominent at the lowest positions of the **RESO** knob, because high resonance narrows the notches making them barely audible. An asymmetric **BALANCE** setting is particularly helpful in **NL** and **HN** modes.

The **TITO** switch has the most radical effect at high positions of the **RESO** knob. Very in-

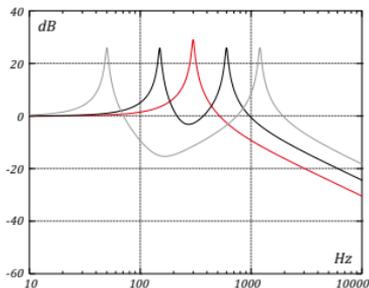
teresting chaotic behaviour may be observed in **BH** and **HH** modes, with **TITO** switched to **XM**, and **RESO** is set to self-oscillation while limiting the **SPAN** knob to moderate settings.

Most of the settings are highly dependent on each other, so we encourage wild exploration to discover a plethora of sweet spots and ranges between the filter modes and resonance configurations. As you will quickly discover, even the least interesting signal can be brought to life, fattened up, processed elegantly, or severely mangled beyond expectation! Have fun with Belgrad, just as we do. •

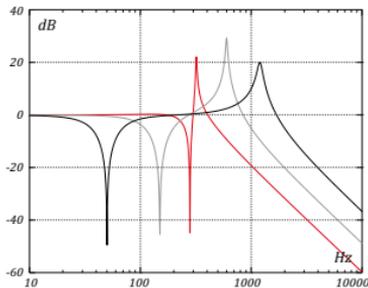
**FILTER MODES DETAILED DESCRIPTION: CHARACTERISTICS, POLES AND RESPONSES**



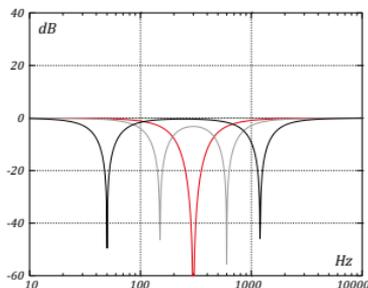
1. **DOUBLE SLOPE LOWPASS MODE.** The frequency response is near-flat for low frequencies. It offers a -12dB/oct slope in the frequency range between peaks and a more radical -24dB/oct slope for frequencies above the second peak. With **SPAN** turned to zero it behaves like a classic 4-pole lowpass filter, and with **SPAN** turned to the max it behaves like a 2-pole lowpass filter.



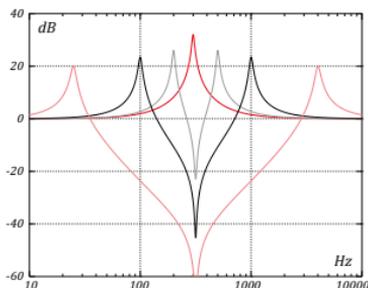
2. **LOWPASS + BANDPASS MODE.** The characteristic is of a 2-pole lowpass, but the second core is operating in bandpass mode thus offering an additional formant bump in higher frequencies. Thanks to phase cancellation when mixing the cores, there is an audible gap in the frequency range between lower and higher peaks. For frequencies above the higher peak, the response is -6dB/oct.



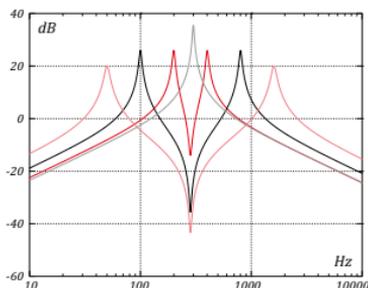
**3. LOWPASS MODE WITH ADDITIONAL NOTCH IN THE PASSBAND.** The characteristic is of a -12dB lowpass. However, one core is employed to create a notch in the range below the corner frequency of the lowpass section.



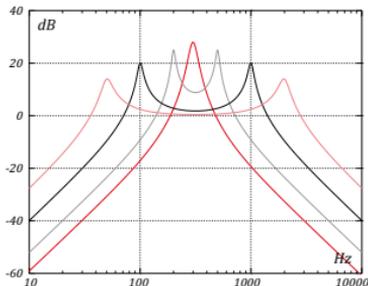
**4. DOUBLE NOTCH MODE.** Obtained through the cascaded connection of two 2-pole notch filters. With resonance down, it is equivalent to a short phaser effect, except that it offers a variable frequency distance between the notches set by the **SPAN** controls.



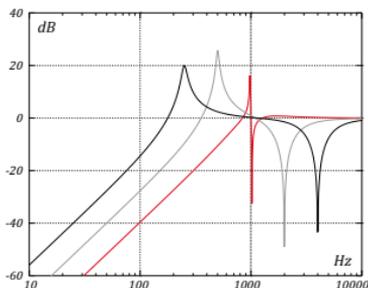
**5. LOWPASS + HIGHPASS MODE.** Offers variable width (depending on the **SPAN** controls) band-rejection filtering with two resonant peaks at both corners of the stop-band. Mostly the bottom end + the top end frequencies will be audible at the output.



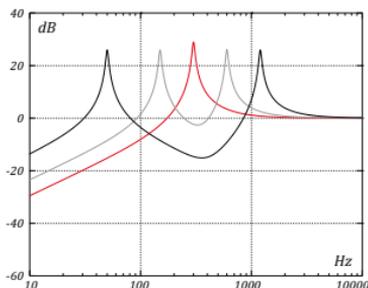
**6. DOUBLE BANDPASS MODE.** Two narrowband or wideband (depending on the **RESO** and **BALANCE** controls) peaks are mixed, offering a typical two-formant response, particularly suitable for synthesizing vocal or bowed string timbres.



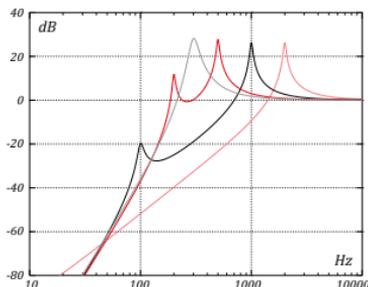
7. **BANDPASS MODE.** Obtained by cascading a 12dB/oct highpass and a -12dB/oct lowpass filter with two resonant peaks at both ends of the passband. At higher **SPAN** settings the response is near-flat in the frequency range between the resonant peaks.



8. **HIGHPASS MODE WITH ADDITIONAL NOTCH IN THE PASSBAND.** The characteristic is of a 12dB highpass. However, one core is employed to create a notch in the range above the corner frequency of the highpass section.



9. **BANDPASS + HIGHPASS MODE.** The characteristic is of a 2-pole highpass, but the first core is operating in bandpass mode, thus offering an additional formant bump in lower frequencies. Thanks to phase cancellation when mixing the cores, there is an audible gap in the frequency range between lower and higher peaks. For frequencies below the lower peak, the response is +6dB/oct.



10. **DOUBLE SLOPE HIGHPASS MODE.** The frequency response is near-flat for high frequencies. It offers a +12dB/oct slope in the frequency range between peaks and a stronger +24dB/oct slope for frequencies below the first peak. With **SPAN** turned to zero it behaves like a classic 4-pole highpass filter, whereas with **SPAN** turned to the max it behaves like a 2-pole highpass filter.

## WARRANTY TERMS

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# WORKING CLASS ELECTRONICS®

EASTERN BLOC TECHNOLOGIES



MADE IN THE EUROPEAN UNION

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## MAIN FEATURES

*All analog, dual core filter design*

*10 distinct frequency responses*

*Wide tuning range, approx. 4hz to 28kHz*

*Low noise audio path*

*Voltage control over the resonance and peaks balance*

*Nonlinear feedback and cross-modulation*

*V/octave input*

*Adjustable input overdrive*

## TECHNICAL DETAILS

*Eurorack synth compatible*

*14hp, skiff friendly*

*Current draw: +45mA / -42mA*

*Reverse power protection*