# ODESSA

**VARIABLE SPECTRUM HARMONIC CLUSTER OSCILLATOR**

*Model of 1975*

**OPERATOR'S MANUAL** *rev. 1975/1.2*

## SALUT

*Thank you for purchasing this Xaoc Devices product. Odessa [ɔ'dɛssa] is an additive oscillator, which means the output signal is synthesized by adding a multitude of sinusoidal components (up to 2560 harmonic partials). By manipulating their parameters it is possible to obtain a broad range of unearthly sounds as well as classic saw, square, and pure sine. Odessa offers a set of controls for shaping harmonic spectra based on number of partials and their distribution in frequency and amplitude; all of which is illustrated by a spectrum analyzer comprising 12 multicolor LEDs. The series of harmonics can be squeezed or spread apart, tilted, or pruned by a comb-like frequency response, resulting in a huge variety of spectra. Animating the comb response yields radical effects similar to flanging and phasing. All partials are frequency-related to a common fundamental and controlled by a single volt/octave input. Additionally, the signal can be frequency modulated by exponential and linear (through-zero) means. Also, up to five detuned voices can be spread apart for a fat and dense cluster, or a powerful chord.*

## INSTALLATION & SETUP

*The module requires 24hp worth of free space in the eurorack cabinet. Always turn the power off before plugging the module into the bus board using the supplied ribbon cable. Pay close attention to power cable pinout and orientation. The red stripe indicates the negative rail and should match the dot or* **–12V** *mark on both the bus board and the unit. Odessa is internally secured against reversed power connection, however, rotating 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! Also, observe that there are several pin headers on the board.* **CONNECTING THE POWER CABLE TO AN INCORRECT HEADER WILL DESTROY YOUR ODESSA!** *The unit 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 use.*

## MODULE OVERVIEW

*The front panel of Odessa (fig. 1) offers direct access to all parameters in a one-knob-per-function arrangement. Observe that it also follows the traditional synthesis layout, wherein pitch and voicing are controlled on the left side, the main timbral features are centrally located, and additional effects are controlled at the right. Signal outputs are located in the bottom array of jacks. The arc of multicolor LEDs offers a rough overview of the spectrum of the signal, from very low to the highest audible frequencies.*

*Pitch frequency is controlled via the* **PITCH CV V/OCT** *input* ❶ *which accepts voltages in –5V...+10V range. The* **COARSE** ❷ *and* **FINE** ❸ *pair of potentiometers set the pitch throughout the entire audible range (16Hz to 20kHz) without the need for external voltage. Additionally, pitch can be modulated from the* **EXP FM** *input* ❹ *that accepts ±5V, with depth controlled by the dedicated attenuator above* ❺*. As with other Xaoc Devices products, the slider LED illuminates to show the absolute degree of modulation by lighting up for both negative and positive voltages. Bear in mind that while the pitch knobs alone cover the entire frequency range, at extreme knob positions modulation from the* **EXP FM** *input will* *not change the pitch any further. This limitation does not include the* **PITCH CV V/OCT** *input which is handled by a separate precision A/D converter.*

*The big, central* **PARTIALS** *knob* ❻ *limits the spectrum of the signal to a specific number of harmonic partials, from 1 to 512 per voice. This limit can also be controlled by CV using the jack below* ❼*. Note that the response appears to be stepped, especially at the beginning of the range, because it causes consecutive partials to be turned on and off. At the minimum position, only the fundamental frequency is audible. Also note that due to automatic volume compensation, lower frequencies become quieter as higher components are added to the spectrum.*

*The red* **SPECTRAL TILT** *knob* ❽ *controls how quickly the amplitudes of consecutive partials decrease with frequency. At the middle position, partials decrease slowly, similar to the spectrum of a saw wave. At the minimum position, the decrease is so rapid that mostly the fundamental is audible. At the maximum position, the amplitude spectrum is very flat (if no additional comb response is engaged), which results in a buzzy, narrow pulse waveform. This parameter can be also controlled by external CV (±5V) via the dedicated jack* ❾*.*

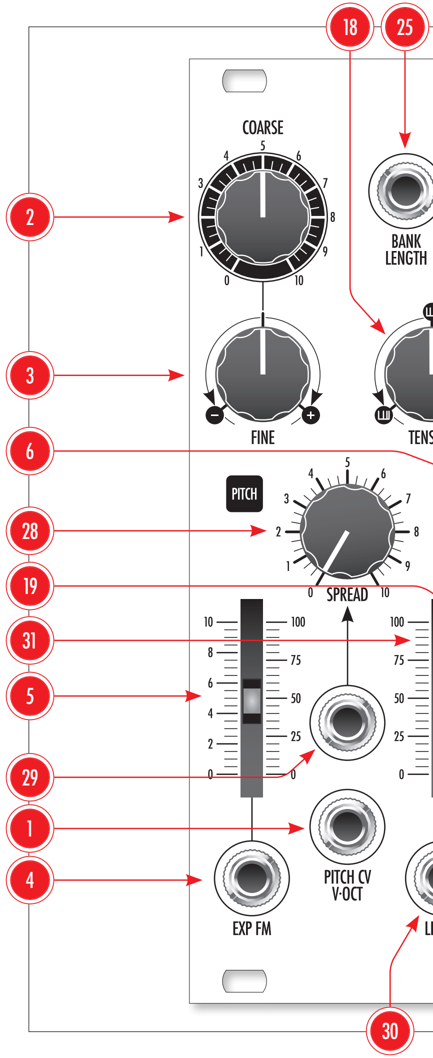
*The three knobs near the right edge of the panel control a comb-like frequency response that is imposed on the spectrum. Note there is no time-domain filtering applied to the signal (which would involve a significant delay for certain settings), instead, a frequency-domain shaping function is applied to the amplitude of each harmonic partial. The* **DENSITY** *knob* ❿ *controls how dense the notches of the comb are: from zero (no notches at all) through moderate (just a few notches) to a maximum density of 256, where each second partial is filtered out (assuming minimum warp setting). This parameter can be controlled by external CV via the dedicated jack* ⓫ *that accepts ±5V, and is scaled by the slider potentiometer above* ⓬*. The* **WARP** *knob* ⓭ *controls the uniformity of the comb response: from linear, where notches are equidistant in frequency (like in a classic flanger), up to a very nonlinear response, where notches are very dense at the bottom of the spectrum and become more distant for higher overtones (similar to a phaser effect). This parameter can also be controlled by CV via the dedicated jack* ⓮ *that accepts ±5V, and is scaled by the slider potentiometer above* ⓯*. The* **PEAKING** *knob* ⓰ *controls the shape of the comb response: from narrow notches (at the minimum position) through moderate up to wide notches with narrow peaks in the response (at the maximum position). This parameter can be controlled by a ±5V CV via the jack below* ⓱*.*

**TENSION** ⓲ *is a very important and sensitive parameter that determines whether the sinusoidal partials generated by Odessa adhere to a harmonic pattern wherein frequencies are strictly integer multiples of the fundamental frequency. There is a little dead zone in the central position of this knob that helps to set it to zero. With* **TENSION** *set to sharp (above the middle), partials are more spread apart so that their frequencies increase more quickly than with a linear law (e.g. the harmonic series) and the spectrum becomes sparse. With* **TENSION** *set to flat (below middle), partials are more condensed so that their frequencies increase slowly and create a dense non-harmonic cluster that may resemble noise. This parameter can be controlled by a ±5V CV via the jack below* ⓳*.*

*Odessa features two main outputs of the synthesized signal:* **ODD PARTIALS** ⑳ *and* **EVEN PARTIALS** ㉑*. It is possible to split the harmonic spectrum so that even and odd numbered partials are separately present at those outputs yet always mixed with the fundamental partial. An additional* **FUNDAMENTAL** *output* ㉒ *offers a simple signal of the fundamental frequency: either a sinusoid or a square wave that can be employed for syncing other oscillators. A jumper at the back (fig. 2) selects one of these two options.*

*The two knobs at the top (*㉓ *and* ㉔*) together with their associated CV inputs (*㉕ *and* ㉖ *) define banks of partials which address the distribution of spectral components between the* **ODD PARTIALS** *and* **EVEN PARTIALS** *outputs. When the* **BANK LENGTH** *parameter is set to 0, both outputs offer the same full signal. If set to +1, each output offers the same fundamental ($1^{st}$ partial) plus its even ($2^{nd}$, $4^{th}$, $6^{th}$, etc) and odd ($3^{rd}$, $5^{th}$, $7^{th}$, etc) overtones, respectively. With different lengths, odd and even sequences of partials are split between the two jacks. Additionally, all partials except the fundamental may be frequency-scaled by an integer factor: from simple fractions (1:2, 1:3 down to 1:8) to multiples (2, 3... up to 8), selected by* **HARMONIC FACTOR***. The direction of* **BANK LENGTH** *(either turned left or right) selects which of the two outputs will receive the modified frequencies, unless* **BANK LENGTH** *is 0, which means the* **HARMONIC FACTOR** *affects both outputs.*

*Odessa is capable of delivering 1, 3, or 5 stacked voices of its synthesized signal, selectable by the* **VOICES** *button* ㉗*. When a single voice is selected (button lit green), the* **SPREAD** *knob* ㉘ *and its corresponding CV jack below* ㉙ *have no effect. With 3 or 5 voices (button lit orange or*



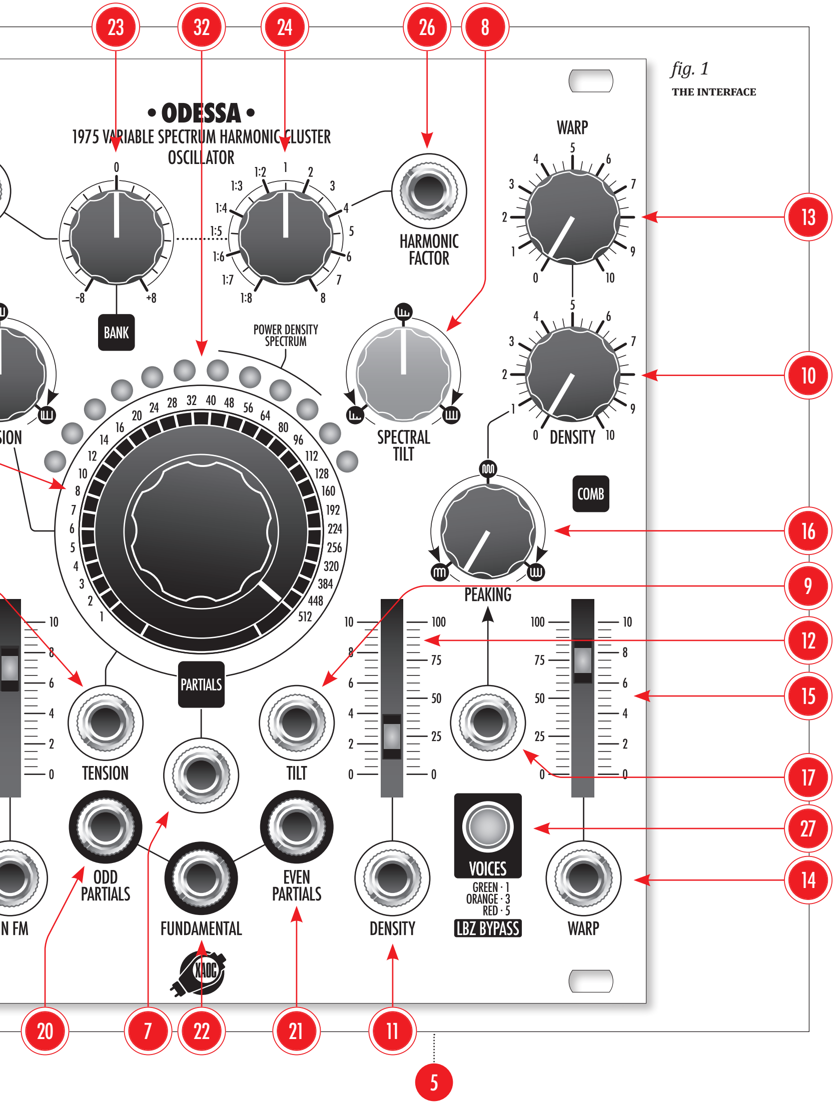
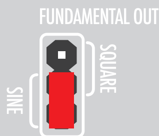



*fig. 1*

**THE INTERFACE**

*fig. 2*

**FUNDAMENTAL OUTPUT CONFIGURATION JUMPER**




*red), the* **SPREAD** *parameter controls the degree of symmetric detuning of the additional voices around the central voice.*

*The* **LIN FM** *input* 30 *together with the associated slider* 31 *offers a deep through-zero frequency modulation of the signal. The modulator input is AC coupled (cut below 20Hz) and accepts full-bandwidth signals up to 10Vpp. Bear in mind that while the fundamental frequency is modulated to the degree you set, the overtones are modulated much wider because the depth scales with their relative frequency. With a wideband carrier, the spectrum of an FM'd signal explodes into MHz range and most of it will be removed by the anti-aliasing protection. Classic clangorous FM sounds are obtained with just a few harmonic partials.* **NOTE:** *Place the slider at minimum when no modulation is applied in order to prevent amplification of random values read by the A/D converter which could impact pitch stability.*

## SPECTRUM ANALYZER

*The arc of 12 multicolor LEDs* 32 *shows the* **POWER DENSITY SPECTRUM** *which is the name of the power contribution of different frequency components of the signal in a number of disjoint bands. Here, the 12 bands cover the entire audible frequency range in exponentially spaced intervals (0.8 octave per band): below 35Hz, 35 to 63Hz, 63Hz to 113Hz, 113Hz to 204Hz, 204Hz to 367Hz, 367Hz to 661Hz, 661Hz to 1.19kHz, 1.19kHz to 2.14kHz, 2.14kHz to 3.85kHz, 3.85kHz to 6.94kHz, 6.94kHz to 12.5kHz, above 12.5kHz. Certainly, with only 12 bands it offers only a crude overview of what is going on.* **NOTE:** *the color temperature is mapped from dB scale. Although the LEDs turn off below a certain level, this does not mean there are no spectral components in a given band, but rather that they are too quiet to show.*

## THE MEANING OF SPECTRUM PARAMETERS

*The various parameters offered by Odessa have been selected by observing how spectra of different sounds vary, and how these differences could be generalized to a set of global features without losing the ability to synthesize a broad range of sounds. The default values of knobs shown in fig. 1 produce the most common waveform in synthesizers: the sawtooth wave. It became so popular because it is quite easy to generate in analog circuits, and also because it's a good starting point for many synthetic timbres.*

*The* **PARTIALS** *parameter controls the number of harmonic components in a signal, from 1 to 512. Turning it down limits the spectrum to the initial N partials, until the signal resembles a single sinusoid (fig. 4).* **NOTE:** *you can't turn off the fundamental. However, since it is separately available on a dedicated output, you can subtract it from your signal using a simple patch. So as to avoid aliasing, Odessa does not produce partials whose frequencies would exceed the maximum frequency of*

*The spectrum of a saw wave contains all overtones in a naturally decaying harmonic series: the amplitude of each harmonic partial is inversely proportional to its number: $A_n=A_1/n$ ($A_1$ is the amplitude of the first, fundamental partial). Other popular waveshapes, like a pulse wave, have certain harmonic partials missing because their spectra are shaped by a Sinc function which introduces a series of notches: $A_n=A_1\times\sin(2\pi n\beta)/(2\pi n\beta)$ ($\beta$ is the ratio of pulse width to length of period). For a square wave, $\beta=0.5$, which causes the Sinc function to cancel each second component so that only odd partials remain.*

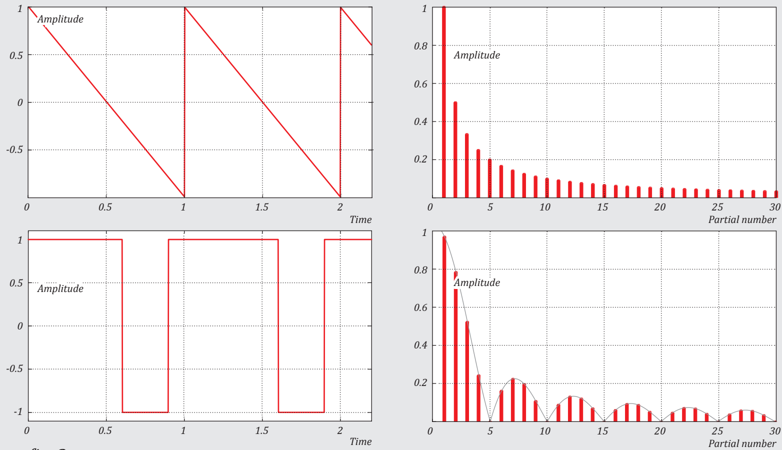



*fig. 3*

**SAWTOOTH AND PULSE WAVEFORMS AND THEIR RESPECTIVE HARMONIC SPECTRA (TRUNCATED FOR CLARITY).**

*21kHz. Therefore, the usable range of the big knob depends on pitch frequency. For high-pitched sounds, the frequency of most of the overtones would be too high, hence increasing this parameter above a certain number will not create any audible effect.*

*There is a fundamental problem with additive synthesis as it relates to dynamic range: a sum of many sinusoids may be much louder than just a single sinusoid (or a few). For example, with a flat spectrum, the difference can exceed 50dB. For practical reasons, Odessa applies a perceptually optimized volume compensation to the output signal. You may notice that the low-frequency partials become quieter when the energy of higher partials increases. The result is similar to what you hear when comparing the loudness of different waves from a traditional VCO.*

*The* **TILT** *parameter determines how quickly the spectrum decays (how quickly the amplitudes of partials decrease with frequency). This is achieved by changing the exponent $\gamma$ within the partial amplitude formula: $A_n=A_1/n^{\gamma}$.*

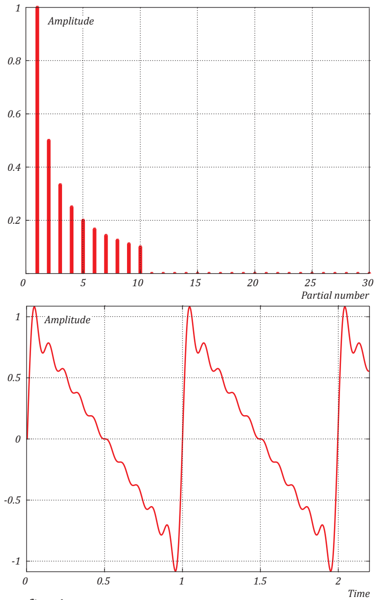



*fig. 4a*

**SAWTOOTH WAVE AFTER LIMITING THE SPECTRUM TO THE INITIAL 10 PARTIALS**

*This parameter can change from 3 (very quick decay, dull sound), through 1 (like in the sawtooth wave) down to nearly 0 (almost flat spectrum, very bright sound) — see fig. 5. Note that this parameter has a significant impact on the resulting energy of the signal.*

*Together, the* **DENSITY**, **WARP**, *and* **PEAKING** *parameters control the comb-like frequency response imposed on the spectrum. The notches of the comb are produced by a warped Sinc function in the frequency domain (fig. 6). Bear in mind the response refers to the relative frequencies of partials, so it scales with*

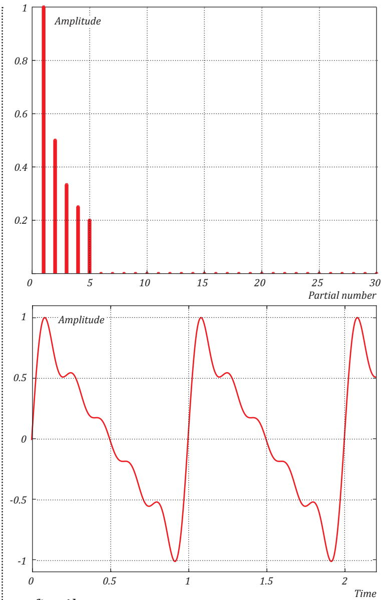



*fig. 4b*

**SAWTOOTH WAVE AFTER LIMITING THE SPECTRUM TO THE INITIAL 5 PARTIALS**

*pitch. Depending on the* **DENSITY** *parameter, there may be zero to 256 notches, hence at minimum, the spectrum is smooth, and at maximum, each second partial is filtered out (only odd-numbered partials remain), provided there is no warp. Thus, with all other parameters set to default, turning the* **DENSITY** *knob morphs the signal from a sawtooth to a square wave — but quite differently than a simple crossfade!*

*Warping the comb response results in a non-uniform distribution of the notches in frequency. As* **WARP** *increases from zero,*

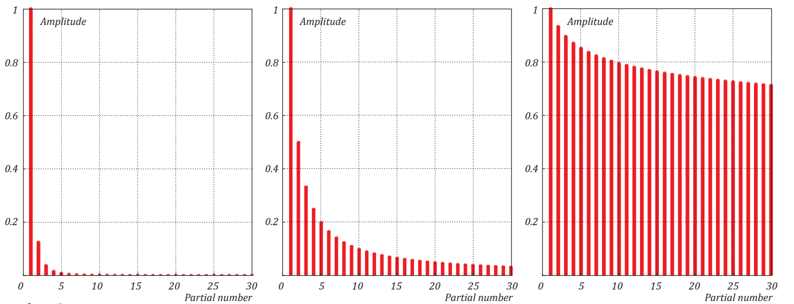



*fig. 5*

**COMPARISON OF TILTED SPECTRA IN EXTREME AND MIDDLE POSITIONS OF THE TILT KNOB**

*the notches become more concentrated in low frequencies.* **NOTE:** *at high density and warp values, notches may be so dense in low frequencies that they interfere with the harmonic pattern which may lead to unexpected holes in the spectrum. At low* **PEAKING** *values, notches of the comb response are very narrow. At high* **PEAKING** *values, the notches become wider and peaks become more narrow and resonant (fig. 7).*

*The* **TENSION** *parameter has a crucial impact on the harmonicity of the signal. At the neutral (middle) position, frequencies of all sinusoidal partials are integer multiples of the fundamental:* $F_n=n\times F_1$*, which is a necessary condition for obtaining a periodic waveform. This results in equidistant partials throughout the spectrum. With* **TENSION** *above 0, the upper partials are spread apart (the frequencies increase quicker than the partial numbers) which yields an inharmonic, metallic timbre with an often more sparse spectrum (fig. 8). With* **TENSION** *below 0, the distances between upper partials become smaller and smaller (the frequencies increase slower than the partial numbers) which yields a dense, rough, inharmonic cluster that resembles noise. Large negative values of* **TENSION** *may even result in the spectrum folding over itself to a degree where certain partials have lower frequencies than the fundamental.* **CAUTION:** *Pitch and intonation behaves paradoxically with these inharmonic sounds and they may be difficult to tune with other traditional sounds. Furthermore, these sounds can cause ear fatigue and are best used sparingly in musical contexts.*

*Bear in mind that inharmonic spectra yield aperiodic waves due to individual sinusoids being no longer synchronized in phase. When you turn the* **TENSION** *parameter off the central (zero) position, the relative phases of all signal components begin to drift away from each other. Thus the original waveform becomes more distorted and will remain as such, even after returning tension to zero. It is possible to re-synchronize the phase and restore the waveform, however, this produces an audible click in the signal due to discontinuity, therefore it is not done automatically. To do so, press the* **VOICES** *button. Besides selecting the number of unison voices, this re-syncs the individual voices and also restarts all sinusoids within each voice.*

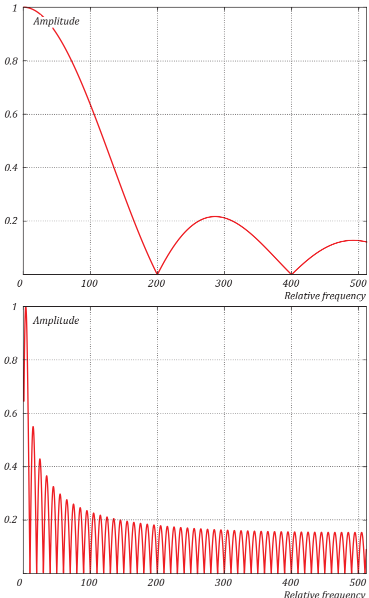



*fig. 6*

**TILT + COMB FREQUENCY RESPONSE FOR LOW (UPPER) AND HIGH (LOWER) DENSITY VALUES**

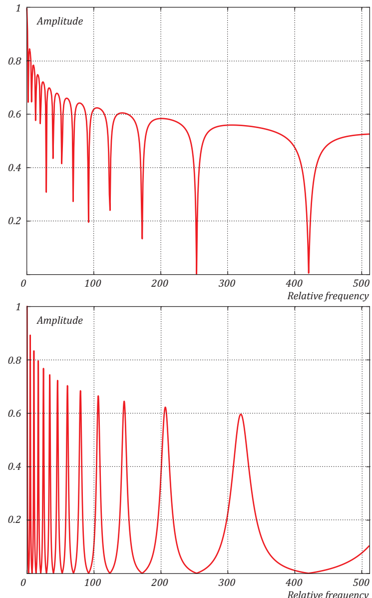



*fig. 7*

**WARPED COMB RESPONSE WITH MINIMUM PEAKING (UPPER) AND MAXIMUM PEAKING VALUES**

*Before they are summed in the final output signal, the sinusoidal partials generated by Odessa may be organized into harmonic banks and split between the* **ODD PARTIALS** *and* **EVEN PARTIALS** *outputs.* **BANK LENGTH** *defines the pattern of consecutive partials above the fundamental that belong to even and odd banks, respectively.* **HARMONIC FACTOR** *modifies the frequencies of partials within one of the banks.* **NOTE:** *the fundamental (1st partial) is excluded from the banks and is always present on both outputs with its original frequency unaffected. For example, with* **LENGTH** *set to 3, the* **ODD PARTIALS** *output contains the fundamental mixed with 5th, 6th, 7th, 11th, 12th, 13th ... etc, while the* **EVEN PARTIALS** *output contains the fundamental mixed with 2nd, 3rd, 4th, 8th, 9th, 10th... etc. Additionally, if* **FACTOR** *is set to 2, all partials (except the fundamental) on the* **EVEN PARTIALS** *output will have their frequencies doubled (fig.9).*

## EXPANDABILITY: HEL

*The shrouded header is dedicated to the universal Xaoc Hel module which offers paraphonic generation of 3-voice and 5-voice chords. Please refer to the manual of Hel for details.*

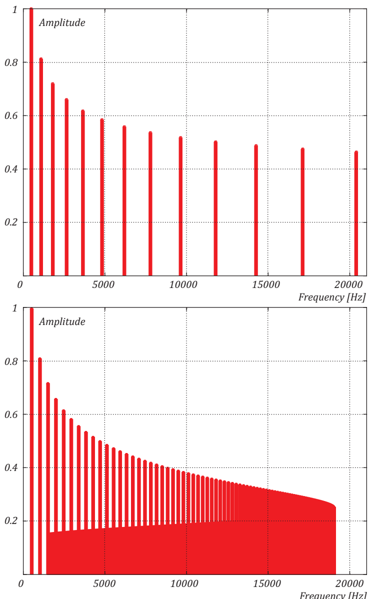



*fig. 8*

**INHARMONIC SPECTRA RESULTING FROM POSITIVE (UPPER) AND NEGATIVE (LOWER) VALUES OF TENSION**

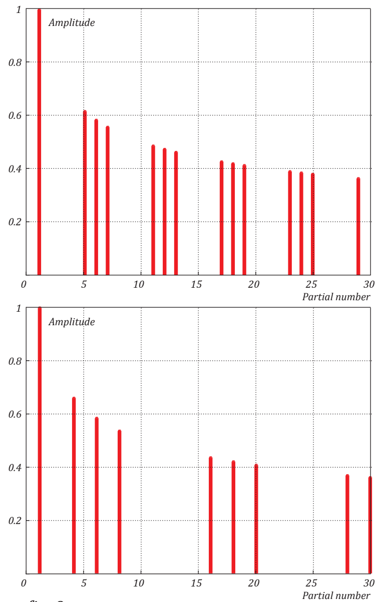



*fig. 9*

**SIGNAL SPECTRA AT THE ODD PARTIALS AND EVEN PARTIALS OUTPUTS FOR LENGTH=3 AND FACTOR=2**

## EXPANDABILITY: LEIBNIZ SUBSYSTEM

*Odessa also offers integration with the Leibniz Binary Subsystem via another expansion header at the back of the unit.*

*Connecting an expander like Xaoc Lipsk, allows one to enable and disable the individual groups of partials as defined by the* **BANK LENGTH** *parameter. To engage this control, press and hold the* **VOICES** *button for 1 second until it starts to blink. At this point, a high state of each binary line (for example, a button activated on Lipsk) turns one group on. The lowest bit ($B_0$) affects the first group (eg. 2nd, 3rd, and 4th), the next higher bit ($B_1$) affects the second group (5th, 6th, and 7th), and so on. The highest bit ($B_7$) affects all remaining partials (from 23rd up).* **NOTE:** *the result of switching individual partials may be subtle. For a more radical effect use longer bank lengths.*

## ACCESSORY

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

## WARRANTY TERMS

XAOC DEVICES WARRANTS THIS PRODUCT TO BE FREE OF DEFECTS IN MATERIALS OR WORKMANSHIP AND TO CONFORM WITH THE SPECIFICATIONS AT THE TIME OF SHIPMENT FOR ONE YEAR FROM THE DATE OF PURCHASE. DURING THAT PERIOD, ANY MALFUNCTIONING OR DAMAGED UNITS WILL BE REPAIRED, SERVICED, AND CALIBRATED ON A RETURN-TO-FACTORY BASIS. THIS WARRANTY DOES NOT COVER ANY PROBLEMS RESULTING FROM DAMAGES DURING SHIPPING, INCORRECT INSTALLATION OR POWER SUPPLY, IMPROPER WORKING ENVIRONMENT, ABUSIVE TREATMENT, OR ANY OTHER OBVIOUS USER-INFLICTED FAULT.

## LEGACY SUPPORT

IF SOMETHING GOES WRONG WITH A XAOC PRODUCT AFTER THE WARRANTY PERIOD IS OVER, THERE IS NO NEED TO WORRY, AS WE'RE STILL HAPPY TO HELP! THIS APPLIES TO ANY DEVICE, WHEREVER AND WHENEVER ORIGINALLY ACQUIRED. HOWEVER, IN SPECIFIC CASES, WE RESERVE THE RIGHT TO CHARGE FOR LABOR, PARTS, AND TRANSIT EXPENSES WHERE APPLICABLE.

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## MAIN FEATURES

*Powerful additive synthesis engine with up to 2560 sinusoidal partials*

*0.5Hz to 21kHz frequency range with resolution of 0.006Hz*

*Harmonic or inharmonic spectra shaped by tilt and warped comb response*

*Volt/octave pitch control*

*Through-zero linear FM input*

*Up to 5 unison and detuneable voices*

*Three signal outputs*

## TECHNICAL DETAILS

*Eurorack synth compatible*

*24hp, skiff friendly*

*Current draw: +110mA/ -80mA*

*Reverse power protection*