X



I. Features



 Amplitude (ring) modulation Voltage controlled amplification Wave shaping Working both with audio or CV signals Exponential conversion Simple to use Available with minijack or banana sockets 	 Eurorack module Width: 6 HP Dimensions:128,5 mm x 30,3 mm Depth: 35 mm Supply voltage: ±12V Current consumption: +12V: ≤10mA; -12V: ≤10mA
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2. Description

X is a 4-quadrant multiplier for universal use. Two input voltages "Y in" and "X in" are be multiplied, resulting in the *product* voltage "W out". In comparison to a VCA (2-quadrant operation multiplier), the 'control voltage' of X can also be negative, resulting in an inversion of the multiplied signal. The X is working as a ring modulator, but fully DC-coupled, which means that also control voltages can be processed.

The X-Input is equipped with manual input level adjustment and an \pm offset voltage knob. This offset voltage can be added to the X input signal. Also it may be used to provide an amount of the pure or inverted Y-input signal on the output. In addition, the X-Input signal is invertable and/or convertable from linear to exponential voltage (useful for VCA-like applications etc). The Y-input is a pure input without any additional features to avoid unnecessary complexity.





Drawing

3. Functions



1 X input offset control adjusts a voltage between $\approx -5V - +5V$, which is added to the multiplier's X input; the numbers on the scale (-5 to +5) may be used for orientation. This knob can be used e.g. to provide the Y signal at the output W out ⑦ without any modulations. By turning the knob CCW of '0' on the scale the offset voltage becomes negative resulting in an inversion of the voltage applied on Y in ⑥ (condition: switch ③ in "lin" mode). In exponential mode (switch ③ lower position), the offset control can be used to determine the multiplier's X in operating point (See chapter 4: "Principle of Operation).

2 X input level The knob allows attenuation or amplification of the input signal applied on X in (5). With the knob set to \approx '1' on the scale the amplification for the X input is *1. Maximum amplification of the input is \approx *3. The numbers on the scale (0 – 3,0) may be used for orientation. Please note that the internal X input amp will be overdriven when the amplification level is set to high for high range input signals. Also the added offset signal may shift the X input signal to its limit, which is $\approx \pm 11$ V. This will result in a distorted X input signal for the multiplier. The Y input signal will be multiplied with the overdriven X signal. Even if the output level at **W out** seems to be low (with a low-level signal applied at **Y in** (6)), this may cause a distorted multiplication signal with less dynamics too.

This point when it gets overdriven is indicated by the red LED 'Limit' B (from Rev.4!).



3 X input linear/exponential mode switch In linear mode (switch in upper position), the 'normal' (*linear*) multiplying operation is provided. The sum of the offset voltage adjusted by knob ① and the X input signal ⑤ (level adjustable by knob 'Level' ② and invertable by switch 'inv.' ④) will be multiplied with the Y input signal ⑥ . This mode may be used for example for ring modulation. In exponential mode (switch in lower position) the applied X signal will be converted into an *exponential* voltage. Due to its rectifying properties the exponential converter only will amplify positive signals. An added offset voltage may define the 0-point (See chapter *4.Principle of Operation*). This mode is useful for VCA-like applications or volume control, e.g. in combination with an envelope generator (which is not exponentially shaped) or waveshaping applications.

- (4) X input inversion switch With switch "inv." (4) in lower position, the X input signal polarity will be inverted, this means a positive voltage will be turned into a negative one, and vice versa. Note that in exponential mode (switch 'lin/exp' (3) in lower position) a pure negative X voltage will not be amplified. It can be shifted to positive range by adding a positive offset voltage by knob 'Offset' (1). The switch only affects the input signal and not the addable offset voltage.
- S input: This input can be attenuated/amplified with the 'Level' knob ②. The switch 'inv' ④ allows an invertion of the applied signal. With the 'Offset' knob ① an offset voltage can be added to the input signal. With the 'lin./exp.' switch ③ an exponential conversion of the sum of X in (adjusted with 'X Level' knob ②) and 'X Offset ' (adjusted with ①) signals is possible.
- 6 Y input 2nd multiplier input with no additional features. Input amplification is *1 at W out ⑦ with knob 'Offset' ① fully turned cw and no modulation signal applied at 'X in' ⑤.
- **Woutput** The multiplied signal, which is the product of (**X** in*Level adjust+X Offset) and **Y** in, is provided on this socket. To make sure that the multiplied signal is almost in the range between the system limits of $\pm 11V$, the product of X*Y is attenuated by default to *0,2.The attenuation level (scaling factor) can be adjusted by trimmer ④ (See chapter 6: "Adjustments") *Example*: X Offset knob ① = 0 on scale; X Level knob ② = 1 on scale (\triangleq Xin amplification *1); ③ linear mode; ④ not inversed;

X in = +5V; Y in = +5V; <u>W out = 5V</u>.

Please note: For high input signal levels of **X in** (and/or highly turned up knob 'Level' ⁽²⁾), the multiplication product may be distorted; observe Led 'Limit' ⁽³⁾ for better control.

8 **LED Limit** for indication of X input overdrive (from Rev. 4!)

The red LED when lights signalizes that input X (Sum of offset and input) is overdriven. The overdrive of the X-input results not in an directly 'distorted' output signal, but in less dynamic: The modulating X-input comes to its limit and from this certain level, the multiplied Y in signal will remain at the same peak level on output **W out** – even with higher input signals at Xin – no further dynamic will be provided. Please read also about X in 'Level' ⁽²⁾ and see the shown diagram.

4. Principle of Operation

The two input voltages X and Y are multiplied together. The resulting product voltage is *W*. To ensure that the product voltage is almost in the range of the supply voltage, W is by default scaled to \approx *0,2 (The scale factor can be changed, see chapter *6*. *Adjustments*)

While the Y input has no external adjustment features, the X input can be attenuated or amplified (max. *3 of the input voltage). An offset voltage, adjustable from -5V to +5V is addable. The X input polarity (without the added offset voltage) is also invertable by switching.

There is an internal linear-to-expontial converter which can be switched to the X input. Because in exponential mode the X signal is rectified, no negative voltages become amplified for the X input and the polarity (minus or plus) of the resulting voltage **W out** will always have the same polarity as **Y in**.

For linear operation the equation is:



Block Diagram



Examples (linear mode)

Linear mode: switch ③ in upper position

X in or Y in = $0 \Rightarrow W$ out = 0		X in polarity ≠ Y in polarity ⇒ W out = negative				
X in	0	±	+	+	_	_
Y in	±	0	+	-	+	_
W out	0	0	+	-	_	+

X Offset	X in	Y in	W out
0			
+2			
+4			

Examples (exponential mode)

1. X Level: \approx 3 (\triangleq X in amplification \approx 1); exponential mode switch ③ in lower position

X Offset	X in	Y in	W out
+3,5			willion

2. Due to the exponential mode's rectifying characteristic, with different settings of the X input level ② and X offset ①, several modulation shapes can be achieved for Y in (Y in: +10V DC voltage)

X Offset	X in Level	X in (ca. 8V pp)	W out
+3,5	1		
+2,5	2		
0	4		
-4	7		

5. Adjustments

The X is already carefully adjusted, but it may be necassary to readjust again. Also some settings can be changed, if required.

Note: This is for Revision 4 or higher; previous versions (*without LED*) can be seen here: <u>http://www.cg-products.de/X_documentation_Rev.3.6.pdf</u>



Apply an audio signal (e.g. VCO or noise generator) to the X-input X in S . The X control knob Offset 1 should be placed in middle

position and the X **Level** control ⁽²⁾ almost turned all the way up. Switch '**lin**./**exp**.' ⁽³⁾ is in upper position and Y-Input Y in ⁽⁶⁾ left open. Connect W Out ⁽⁷⁾ to an audio system and adjust Trimmer ⁽¹⁾ by listening for minimal feedthrough of the X input signal.

2. X offset adjustment

Apply an audio signal on input **Y** in **(6)**. **X** in **(5)** may be left open. Knob Offset **(1)** is turned fully ccw and the Level knob **(2)** muted (fully ccw). Switch **exp./lin. (3)** must be in lower '**exp.'** position. Calibrate Trimmer **(5)** by listening for minimal feedthrough of the Y input signal.

3. Potentiometer 'Offset' 0 0-point adjustment

With the audio signal applied on input Y in (6), turn knob Offset (1) in middle position '0' (denter locked) and knob Level (2) muted (fully ccw). Switch exp./lin. (3) must be in upper 'lin.' position. Calibrate Trimmer (2) (on lower board, near knob 'Offset' (1)) for minimal feedthrough of the Y input signal.

4. 0-point in exponential mode

With the same settings as described unter '3.' (audio signal applied on input Y in (6), knob Offset ① in middle position '0', knob Level ② muted), shift switch 'exp./lin.' ③ in lower position 'exp.'. Calibrate Trimmer ③ until the Y input signal is even no more audible on output W out ⑦.

5. Exponential gain

Turn knob **Offset** ① fully clockwise. By switching '**lin**./**exp**.' ③ between its two positions '**lin**.' and '**exp**.', compare the output volume levels and adjust trimmer ⑥ until the signal level in the '**exp**.' mode is the same as in '**lin**.' mode.

If necessary, repeat steps '4.' and '5.' for proper operation.

6. Output Gain

With knob 'Offset' ① fully turned up (fully cw) and knob Level ② muted, compare the output level on **W out** ⑦ with the original signal applied on **Y in** ⑥. Adjust trimmer ④ until the volume level on output **W out** is the same as on the Y input.



6. Contact & Support

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This is the documentation for revision 4.3 (+)

Revision 3.6 and previous (without LED!): http://www.cg-products.de/X_documentation_Rev.3.6.pdf

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