TRIDENT

Multi-Synchronic Oscillator Ensemble

Operation Manual

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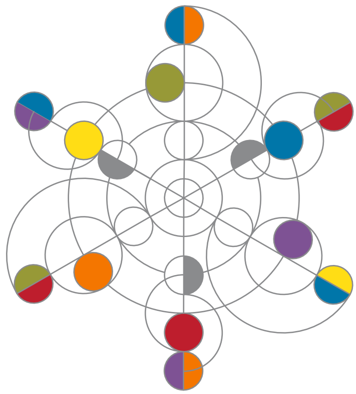
www.rossum-electro.com

Contents

1. Introduction



Thanks for purchasing (or otherwise acquiring) the Rossum Electro-Music Trident Multi-Synchronic Oscillator Ensemble. This manual will give you the information you need to get the most out of Trident. The manual assumes you already have a basic understanding of synthesis and synthesizers. If you're just starting out, there are a number of good reference and tutorial resources available to get you up to speed. One that we highly recommend is:

Power Tools for Synthesizer Programming
(2nd Edition)
By Jim Aikin
Published by Hal Leonard
HL00131064

Support

In the unlikely event that you have a problem with your Trident, tell us about it here:

http://www.rossum-electro.com/support/support-request-form/

...and we'll get you sorted out.

If you have any questions, comments, or just want to say "Hi!," you can always get in touch here:

http://www.rossum-electro.com/about-2/contact-us/

...and we'll get back to you.

Happy music making!

2. Module Installation

As you will have no doubt noticed, the rear of Trident is a circuit board with exposed parts and connections. When handling Trident, it's best that you hold it by the edges of the front panel or circuit board. It's not particularly easy to blow up, but why take chances?

More specifically, the biggest risk (to the extent that there's a risk), is damage by static electricity. Particularly on dry, cold days (or if you've just shuffled across your shag carpet in fuzzy slippers), make a point of touching the metal panel first, before touching any other part of the module.

While all Rossum Electro-Music modules are protected against reverse polarity damage, both to your module and your system, care should still be taken to connect the power cable correctly. (For more detail on our unique protection method, check out Dave's discussion of Circuit Protection in Chapter 9.)

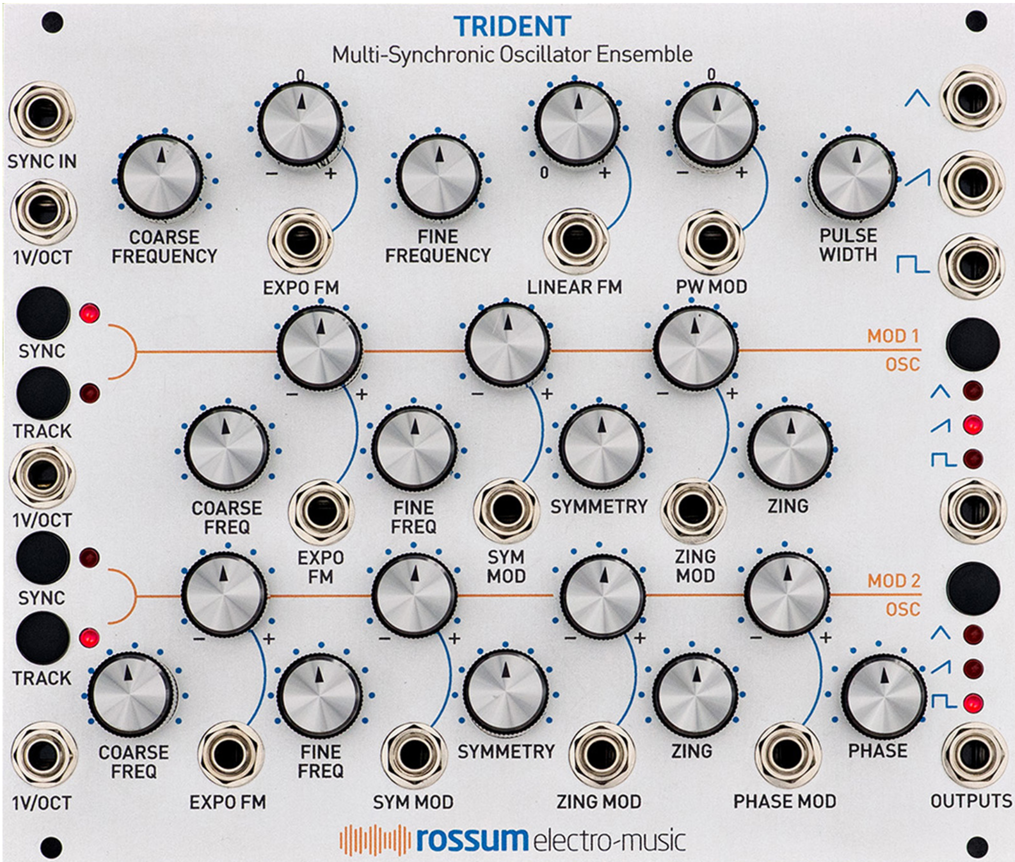
Plug the included 16-pin connector into the header on the rear of the module such that the red stripe on the cable (the -12V side) is on the same end of the header as the "Red Stripe" text on the PCB.

Trident requires, at most, 290mA of +12V and 270mA of -12V.

We have included both M3 and M2.5 (for vector rails) mounting screws. Use what fits your system.

If rack rash is of concern to you, use the included nylon washers when mounting Trident in your case.

3. Overview



What is Trident?

The latest brainchild of synth pioneer Dave Rossum, Trident is a 100% analog, triple oscillator module that opens up a universe of dynamic timbral textures.

At its most basic level, Trident is three precision audio VCOs, each sporting a unique variety of control voltage inputs.

The main or **"Carrier"** oscillator provides its three waveforms simultaneously. The two **Modulation Oscillators** each have a single output and a waveform selector. The Modulation Oscillators also have a voltage controlled **Symmetry** parameter which varies the duty cycle of the triangle wave output from sawtooth to triangle back to time reversed sawtooth, and also varies the sawtooth output to have an upward or downward kink in the middle, as well as controlling pulse width when the pulse waveform is selected.

And while each oscillator can be used independently if desired, it's when they're combined into a synchronous ensemble that the real sonic magic happens.

That magic is what we call **"Zing"** modulation. Each of the Modulation Oscillators can modulate each of the Carrier outputs in an amount controlled by the Zing parameter. Zing modulation is mathematically akin to ring modulation, but due to the synchronization of the oscillators (when an oscillator's **Sync** button on), the aharmonic sum and difference sidetones of ring modulation transform into complex but purely harmonic overtone spectra, which vary dynamically and dramatically with the frequency and waveshape modulations of the modulation oscillators. Each change in the Modulation Oscillator parameters — **Frequency, Symmetry, Waveshape, Zing,** and (in the case of Modulation Oscillator 2) **Phase** — will have a different effect on the timbre of each of the three Carrier waveshape outputs.

When the modulation oscillators are set to track the carrier oscillator, the waveshape will remain constant as the carrier frequency changes. In this case the overtone structure is determined by the settings and CV modulations of the modulation oscillators. If instead the modulation oscillators do not track the carrier, some of the overtone structure will vary relative to the carrier frequency.

What all this means is that whether you take advantage of Trident's unique synchronous modulation capabilities (which you, of course, should), or just treat it as three superb, wide-range analog oscillators, Trident offers a vast variety of dramatic sonic textures.

Trident features include:

- Three **precision analog oscillators** with dedicated 1V/Octave inputs and coarse control ranges of 20Hz to 20kHz and modulated ranges of 0.01Hz to 25 kHz.
- **Main Carrier Oscillator** with simultaneous triangle, sawtooth and pulse waveforms, with exponential and linear frequency modulation and pulse width modulation.
- Main Carrier Oscillator **hard sync** input.
- **Modulation Oscillator 1** with selectable triangle, sawtooth and pulse waveforms with exponential frequency modulation, variable symmetry and symmetry modulation, and variable Zing level and Zing level modulation.
- **Modulation Oscillator 2** with selectable triangle, sawtooth and pulse waveforms with exponential frequency modulation, variable symmetry and symmetry modulation, variable Zing level and Zing level modulation, and variable phase and phase modulation.
- Both Modulation Oscillators with independently selectable options to **sync to the main oscillator** and **track the main oscillator.**
- Trident, like all Rossum Electro-Music modules, features solid construction, with thick aluminum panels, solid aluminum knobs, and quality components throughout.

For a substantially more in-depth exploration of Trident's technology, be sure to check out "From Dave's Lab" in Chapter 9.

4. Basic Functionality

Before we jump into individual functions in detail, let's take a quick look at Trident's controls.

Coarse and Fine Frequency

Controls an oscillator's initial frequency over a range of 20Hz to 20kHz. Modulated ranges are from 0.01Hz to 25kHz.

1V/Oct Input

Calibrated 1 volt per octave Frequency CV inputs (accurate over 10 octaves).

Exponential and Linear (Carrier Oscillator only) Frequency Modulation

CV inputs into attenuverters (exponential) or an attenuator (linear).

Pulse Width and PW Modulation

Sets the Carrier Oscillator's initial pulse width from 0% to 100% and modulates it via the CV input through an attenuverter. Note that at audio rates, 0% or 100% pulse width results in no audio, just a static DC level.

Symmetry and Sym Modulation (Mod Oscillators)

Varies the duty cycle of the triangle wave output from sawtooth to triangle back to time reversed sawtooth, and also varies the sawtooth output to have an upward or downward kink in the middle. Sets the pulse width when the pulse waveform is selected. Symmetry can be modulated via the CV input through an attenuverter.

Zing Level and Zing Modulation (Mod Oscillators)

Sets the amount of a Mod Oscillator's Zing modulation of the Carrier Oscillator. Modulates the Zing amount via the CV input through an attenuverter.

Phase and Phase Modulation (Mod 2 Oscillator only)

Varies the phase of the Mod 2 Oscillator compared to the Carrier when Mod 2 Sync is enabled. Modulates it via the CV input through an attenuverter.

Sync Buttons (Mod Oscillators)

When engaged (with the LED lit), a Mod Oscillator is hard synced to the Carrier Oscillator's frequency.

Track Buttons (Mod Oscillators)

When engaged (with the LED lit), causes the Mod Oscillator to track precisely the Carrier Oscillator's frequency.

Carrier Oscillator Sync In

Hard syncs the Carrier Oscillator to the rising edge of an external source or to either of the Mod Oscillators (by patching their output to this input).

Outputs

The Carrier Oscillator provides simultaneous triangle, sawtooth, and pulse outputs. The Mod Oscillators each have a single output with selectable waveforms.

5. Make Some Noise!

If you've already followed along with the Make Some Noise! section of the printed Trident Quick Start Guide included with your module, you can skip this chapter and go directly to the next. However, if you haven't, spending a few minutes here will give you a quick introduction to the function and effects of the basic controls.

Given Trident's plethora of knobs and mod inputs, experimentation is the order of the day. To get you started:

> Monitor the triangle output of the Carrier Oscillator.

> Turn up the Zing level of Mod 1 and turn down the Zing level of Mod 2. Ensure that Mod 1's Sync and Track are enabled.

> Vary Mod 1's Frequency, Symmetry, Zing settings, and waveform and listen to their effect. Try modulating the parameters with external signals (or with the output of Mod 2).

> For dual Zing Modulation, turn up the Zing on Mod 2 and vary its parameters and waveform.

> Try disengaging Sync and/or Tracking on each Mod Oscillator and listen to their effects.

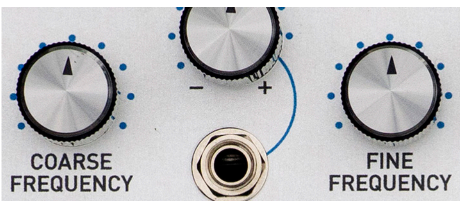
> Zing!

6. The Carrier Oscillator in Detail

Trident's Carrier Oscillator is a precision voltage controlled oscillator in the tradition of the legendary oscillators Dave designed for the original E-mu Modular System. It can, of course, stand alone as a superb VCO, but it truly comes alive as the target of Zing Modulation by one or both of Trident's Modulation Oscillators.

Here's what it offers:

COARSE and FINE FREQUENCY



Using the COARSE FREQUENCY and FINE FREQUENCY controls, the Carrier Oscillator's initial frequency can be set between 20Hz and 20kHz.

With the addition of the frequency modulation CVs described below, the available range is between 0.01Hz and 25kHz.

1V/OCT Input

The 1V/OCT CV Input is a calibrated full level control voltage input that is summed with the values of the Coarse and Fine Frequency controls and the Expo FM input.

Trident's 1V/Octave tracking is accurate over a 10 octave range.

EXPO FM

The EXPO FM Input is a control voltage input that is modified by its associated attenuverter and then summed with the value of the Coarse and Fine Frequency controls and the 1V/OCT input.

When the attenuverter knob is set to its "0" position, no control voltage is passed to Trident. As the knob is turned clockwise from 0, the amplitude of the control voltage increases until, at maximum clockwise rotation, the full amplitude of the signal at the EXPO FM Input is passed through and results in a nominal 1V/Oct response.

As the knob is turned counterclockwise from 0, the signal at the EXPO FM input is inverted (e.g., a CV of +2.5V becomes -2.5V). The farther counterclockwise the knob is turned, the less the attenuation of the inverted signal, until, at maximum counterclockwise rotation, the full amplitude of the inverse of the signal at the EXPO FM input is passed through, also at a nominal 1V/Oct response.

A TIP: *You can use the Carrier Oscillator (or, in fact, any of the three oscillators) as precision LFOs by setting the Coarse and Fine Frequency controls to their minimum (fully CCW) positions and patching 5V (or more) into the Exponential FM input. Adjust the input's attenuverter in the negative range to set the LFO's frequency.*

LINEAR FM

The LINEAR FM Input is an AC coupled control voltage input that is modified by its associated attenuator to allow Linear Frequency Modulation of Trident's output frequency.

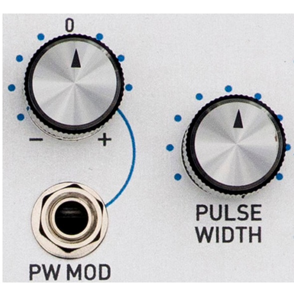
When the input's associated attenuator knob is set to its maximum counterclockwise position, no control voltage is passed to Trident. As the knob is turned clockwise, the amplitude of the control voltage increases until, at maximum clockwise rotation, the full amplitude of the signal at the LIN FM Input is passed through.

NOTE: *It's beyond the scope of this manual to provide an in-depth discussion of Linear versus Exponential FM, but for those interested, Chris Meyer (as part of his Learning Modular series) offers clear explanations, along with audio examples, here:*

https://learningmodular.com/understanding-the-differences-between-exponential-linear-and-through-zero-fm/

For those not-so-interested, the tl;dr version is that unlike exponential FM, linear FM does not typically result in shifting the pitch of the target oscillator with changes in modulation depth (as long as the modulation depth does not result in driving the pitch of the target oscillator below 0Hz).

PULSE WIDTH and PW MOD



The PULSE WIDTH control lets you set the initial pulse width of the Carrier Oscillator's pulse wave output from 0% to 100%.

IMPORTANT NOTE: *At audio rates, when the pulse width is set to 0% or 100%, there will be no audio output, just a static DC level. At 0%, the output will be a continuous -5V and at 100%, it will be a continuous +5V.*

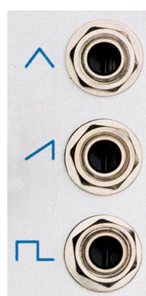
A TIP: *If you aren't using the Carrier Oscillator Pulse output for audio, you can turn the Pulse Width to 0% and use it as a source of -5V to bias one of the Mod Oscillators to the LFO range.*

The PW MOD input is a control voltage input that is modified by its associated attenuverter to allow CV control of the pulse wave's pulse width. The attenuverter functions as described in the EXPO FM section above.

SYNC IN

Hard syncs the Carrier Oscillator to the rising edge of a signal patched into this input when the signal exceeds a threshold of 3.5V. The signal can be from an external source or from either of the Mod Oscillators (by patching their output to this input).

AUDIO OUTPUTS



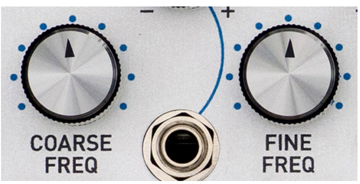
The Carrier Oscillator provides simultaneous triangle, sawtooth and pulse outputs.

7. The Modulation Oscillators in Detail

Like the Carrier Oscillator, Trident's two modulation oscillators can serve as full-function, stand-alone oscillators with independent frequency control and unique CV-controlled waveform symmetry. But it's their roles as Zing Modulation sources that open up a virtually unlimited variety of unique timbral textures.

MODULATION OSCILLATOR 1

COARSE and FINE FREQUENCY



Using the COARSE FREQ and FINE FREQ controls, the Mod 1 Oscillator's initial frequency can be set between 20Hz and 20kHz.

With the addition of the frequency modulation CVs described below, the available range is between 0.01Hz and 25kHz.

NOTE: *When using Mod 1 as a stand-alone oscillator, the frequency controls (and the frequency CVs described below) function as you'd expect to change the frequency of the oscillator. However, when using Mod 1 as a modulation source for Zing Modulation with the Sync function activated, the frequency controls and CVs serve to define and modulate the timbre of the Carrier Oscillator. For that reason, using the EXPO FM input described below to modulate frequency is one of the keys to dynamic Zing Modulation textures.*

With that being said, if you monitor the output of Mod 1 while it is serving as a Zing Modulation source, you will still hear the expected frequency modifications that result from adjustments of its frequency controls and CVs.

1V/OCT CV

The 1V/OCT CV Input is a calibrated full level control voltage input that is summed with the values of the COARSE and FINE FREQ controls and the EXPO FM input.

NOTE: *In terms of the Track function's effect on Zing Modulation:*

With TRACK on, the Carrier Oscillator's waveshape will remain constant as the Carrier's frequency changes.

With TRACK off, the Carrier Oscillator's waveshape will vary with changes in the Carrier frequency.

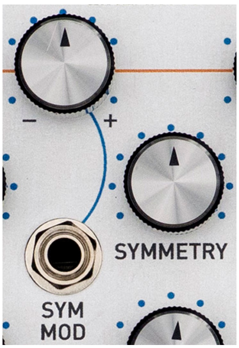
EXPO FM

The EXPO FM Input is a control voltage input that is modified by its associated attenuverter and then summed with the value of the Coarse and Fine Frequency controls and the 1V/OCT input. As above, when the Track function is active, it is also summed with the Carrier Oscillator's COARSE and FINE FREQUENCY controls, 1V/ OCT input, and EXPO FM input.

The Attenuverter functions exactly as described in the Carrier Oscillator's EXPO FM section in the previous chapter.

A TIP: *As also described in the previous chapter, You can use the Mod Oscillators as precision LFOs by setting the Coarse and Fine Frequency controls to their minimum (fully counterclockwise) positions and patching 5V (or more) into the Exponential FM input. Adjust the input's attenuverter in the negative range to set the LFO's frequency.*

SYMMETRY and SYM MOD



The SYMMETRY control lets you smoothly and continuously vary the shapes of the Mod Oscillator's waveforms. The effect on the various waveforms are as follows:

Triangle: Varies the waveform from a sawtooth (at the fully counterclockwise position) to a pure triangle (at the 12:00 o'clock position) to a time reversed sawtooth (at the fully CW position).

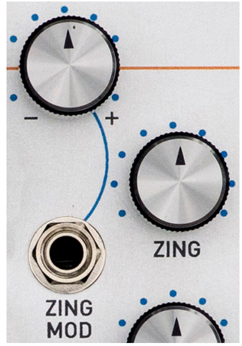
Sawtooth: Varies the waveform from a sawtooth with a downward kink in the middle (at the fully counterclockwise position) to a pure sawtooth (at the 12:00 o'clock position) to a sawtooth with an upward kink in the middle (at the fully CW position).

Pulse: Varies the pulse width from 0% to 100%. Like the Carrier Oscillator's Pulse Width control, when the pulse width is set to 0% or 100%, there will be no audio output. At 0%, the output will be a continuous 0V and at 100%, it will be a continuous 5V.

The SYM MOD input is a control voltage input that is modified by its associated attenuverter to allow CV control of the Mod Oscillator's waveform shapes.

A TIP: *Symmetry, like the Mod Oscillator's other continuous controls, can have a dramatic effect on the Carrier Oscillator's sound, particularly when modulated by a CV.*

ZING LEVEL and ZING MOD



The ZING control is the key that opens the door to Trident's universe of sounds.

The ZING control lets you set the initial amount of the Mod Oscillator's modulation of the Carrier Oscillator. At its fully counterclockwise position, Mod 1 Oscillator's Zing modulation is disabled. As it is rotated clockwise, the amount of Zing Modulation increases.

The ZING MOD input is a control voltage input that is modified by its associated attenuverter to allow CV control of the Mod Oscillator's Zing Modulation amount. By this point, you're probably pretty clear on how the attenuverter works.

A TIP: *Like the Frequency and Symmetry controls described above (and the Phase control described below), Trident really comes alive with dynamic timbres. The Modulation Oscillators' CV inputs are the primary tools for building dramatic, evolving sounds.*

SYNC

Pressing the SYNC button will toggle the Sync function on and off, as indicated by the associated LED. When turned on, the Mod Oscillator will be hard synced to the output of the Carrier Oscillator.

The Sync function is the key to Zing Modulation's unique ability to create rich, dynamic timbres with complex but purely harmonic overtone spectra. You can check out Chapter 3 for a brief discussion of how this works, or Chapter 9 for Dave's more in-depth explanation. But honestly, it's not necessary to understand it to create amazing sounds with it.

NOTE: *You can, of course, turn SYNC off and use the Mod Oscillators' controls to create dense, clangorous timbres bristling with aharmonic spectra.*

A TIP: *While Zing modulation works best when Sync is engaged, if you engage Track, but not Sync, don't use any FM, and tune the Mod Oscillator carefully, you can get Zing-like effects with some extra timbral motion in the sound.*

ANOTHER NOTE: *Since Trident is 100% analog, your Sync setting is not remembered when the module is turned off. Sync is always set to "on" when the module is powered on.*

TRACK

Pressing the TRACK button will toggle the Track function on and off, as indicated by the associated LED.

When the Track function is engaged, the Carrier Oscillator's COARSE and FINE FREQUENCY controls, 1V/OCT input, and EXPO FM input are all summed with the Mod Oscillator's frequency controls and CV inputs. As a result, the Mod Oscillator will track the frequency of the Carrier Oscillator (with the addition of any of the Mod Oscillator's own frequency controls and CV inputs).

NOTE: *In terms of the Track function's effect on Zing Modulation:*

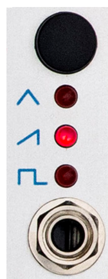
With Track on, the Carrier Oscillator's waveshape will remain constant as the Carrier's frequency changes.

With Track off, the Carrier Oscillator's waveshape will vary with changes in the Carrier frequency.

ANOTHER NOTE: *As mentioned above for Sync, your Track setting is not remembered when the module is turned off. Track is always set to "on" when the module is powered on.*

A TIP: *While the main intent of the Track Function is its use with Zing Modulation, it also makes it easy to create stacked oscillator sounds by patching your frequency control CV(s) into the Carrier Oscillator, turning on Track for the two Mod Oscillators, and tuning (or detuning) the three oscillators as desired.*

AUDIO OUTPUT



Each Modulation Oscillator lets you select a triangle, sawtooth or pulse output. Press the waveform selection button to sequentially cycle between the three options. The waveform's associated LED will light to indicate the current choice.

A TIP: *When using a Mod Oscillator for Zing Modulation, the selected waveform can have a dramatic effect on the resulting sound. Once you have a patch set up, be sure to audition the effects of the three choices.*

MODULATION OSCILLATOR 2

Modulation Oscillator 2 is identical to Modulation Oscillator 1, with the exception that it provides an additional CV controlled parameter: Modulation Phase.

PHASE and PHASE MOD

The PHASE control lets you vary the phase of the Mod 2 Oscillator relative to the Carrier Oscillator when Mod 2 Sync is enabled.

NOTE: *This control has no audio effect when simply listening to MOD 2. It is solely for affecting the timbre of the Zing modulation of the Carrier Oscillator.*

The PHASE MOD input is a control voltage input that is modified by its associated attenuverter to allow CV control of the phase of MOD 2's Zing Modulation. The attenuverter, not surprisingly, is just like all the other attenuverters.

A TIP: *While Phase adjustments can result in interesting static timbres, the really cool stuff happens when you use a CV to dynamically vary the phase.*

8. Specifications

CARRIER OSCILLATOR

CONTROLS
Coarse Frequency
Fine Frequency
Pulse Width

SYNC IN
1x 3.5mm mono socket
100kΩ Input Impedance
3.5V Rising Edge Threshold

1 V/OCT CV
1x 3.5mm mono socket
100kΩ Input Impedance

ATTENUVERTED EXPONENTIAL FM CV
1x 3.5mm mono socket
100kΩ Input Impedance

ATTENUATED LINEAR FM CV
1x 3.5mm mono socket
Min 80kΩ Input Impedance

ATTENUVERTED PULSE WIDTH MODULATION CV
1x 3.5mm mono socket
100kΩ Input Impedance

AUDIO OUTPUTS
3x 3.5mm mono socket
1kΩ Impedance

MODULATION OSCILLATOR 1

CONTROLS
Coarse Frequency
Fine Frequency
Symmetry
Zing Level
Sync On/Off
Track On/Off
Output Waveform

1 V/OCT CV
1x 3.5mm mono socket
100kΩ Input Impedance

ATTENUVERTED EXPONENTIAL FM CV
1x 3.5mm mono socket
100kΩ Input Impedance

ATTENUVERTED SYMMETRY MODULATION CV
1x 3.5mm mono socket
100kΩ Input Impedance

ATTENUVERTED ZING LEVEL CV
1x 3.5mm mono socket
100kΩ Input Impedance

AUDIO OUTPUT
1x 3.5mm mono socket
1kΩ Impedance

MODULATION OSCILLATOR 2

CONTROLS
Coarse Frequency
Fine Frequency
Symmetry
Zing Level
Phase
Sync On/Off
Track On/Off
Output Waveform

1 V/OCT CV
1x 3.5mm mono socket
100kΩ Input Impedance

ATTENUVERTED EXPONENTIAL FM CV
1x 3.5mm mono socket
100kΩ Input Impedance

ATTENUVERTED SYMMETRY MODULATION CV
1x 3.5mm mono socket
100kΩ Input Impedance

ATTENUVERTED ZING LEVEL CV
1x 3.5mm mono socket
100kΩ Input Impedance

ATTENUVERTED PHASE MODULATION CV
1x 3.5mm mono socket
100kΩ Input Impedance

AUDIO OUTPUT
1x 3.5mm mono socket
1kΩ Impedance

POWER REQUIREMENTS
+/-12V (+/- 2.5%) via 16-pin, Doepfer-style connector

CURRENT DRAW
290mA +12V, 270mA -12V (maximum)

DIMENSIONS
30HP (W); Panel to power connector (with connector plugged in) 25mm (D)

SUPPLIED ACCESSORIES
1x 16-pin, Doepfer-style cable
4x M3 screws
4x M2.5 screws
4x Nylon washers
1x Quickstart Guide

9. From Dave's Lab

Circuit Protection

Eurorack suffers from the problem of power connector reversal. When 10 pin connectors are used, mis-insertion results in a swap of +12V and -12 V, and protection is easily accomplished using various techniques such as series diodes.

But more systems are providing the +5V supply and thus use the full 16 pin connector. When this is reversed, a diode-protected module is still safe, but the six connected ground pins in the module will short together the system's +5V and +12V supplies, potentially damaging the power supply and any modules that use +5V.

To prevent this, Rossum Electro-Music modules deviate from the standard Eurorack power connector by leaving power connector pins 9 and 10 open, rather than connecting them to ground. When plugged in backwards, this leaves the system +12V supply disconnected. Since ground is still supplied by four pins as well the chassis and any patch cords connected to the module, the dropping of these two pins has no measurable effect on circuit performance, but it means that if a Rossum Electro module is accidentally plugged in backwards, no stress is placed on the +5V supply or modules that use it.

Trident Technology in Depth

Since we launched Rossum Electro and produced our first module (Evolution), folks have been bugging me to build an analog VCO. In their day, the E-mu Modular VCOs were the most stable and had widest range of any of that era. But I waited for inspiration to strike, and it did, twice!

So what is "Zing Modulation" anyway? In thinking about what makes an interesting timbre, I have always felt ring modulation (actually, "four quadrant multiplication") held a prime spot, but it's limited in usefulness because it produces frequencies that are not harmonically related to its inputs. This is due to the trigonometric identity

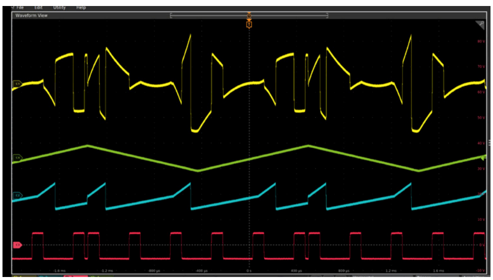
$$2 \times \sin(A) \times \cos(B) = \sin(A + B) + \sin(A - B)$$

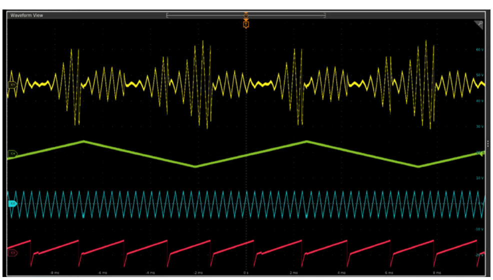
where A and B are frequency components of the ring modulator inputs.

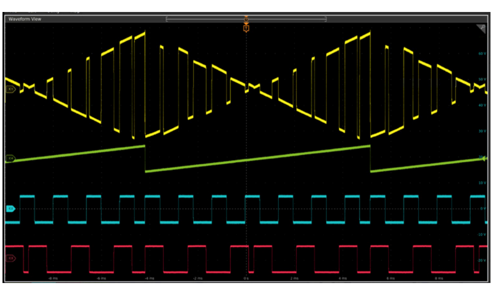
But I realized that if the two inputs could be forced to be periodic with the same frequency, this limitation would disappear. To understand why, just realize that there is no "memory" in a ring modulator — if you start over from the same spot and give it the same waveforms, it will produce the same output every time. So the output of two inputs that have the same period must itself be periodic at that same frequency, which means all its frequency components must be harmonics of that frequency. And it's fairly easy to arrange two oscillators to be precisely periodic — it's called hard sync[1]. Bingo!

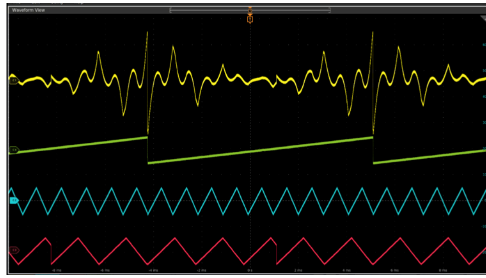
[1] I'm pretty sure I was the person who first coined the term "hard sync." I didn't invent hard sync; I think that honor goes to Serge Tcherepnin. When I heard about it and how great it sounded, I immediately implemented it. But E-mu modular VCOs already had one form of sync, so we needed another name to distinguish the two. Hence "hard sync" and "soft sync".

But because of that crazy trigonometric identity, there are going to be zillions of harmonic components, all adding together in weird combinations of phases, and these will vary in interesting ways depending on the exact details of the incoming waveshapes. Here are some examples of the bizarre waveshapes coming out of Trident. The yellow waveshape is the carrier oscillator with Zing modulation; the green is the original carrier waveshape. The blue and red traces are the modulation oscillators.

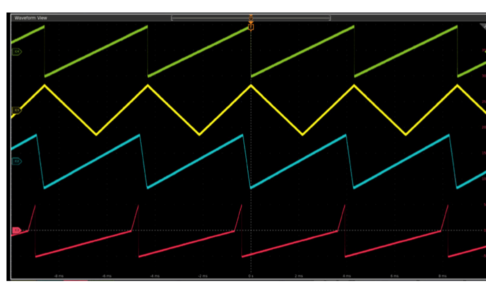


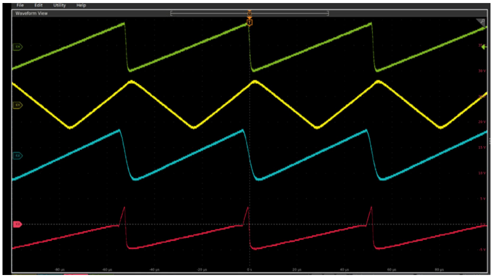




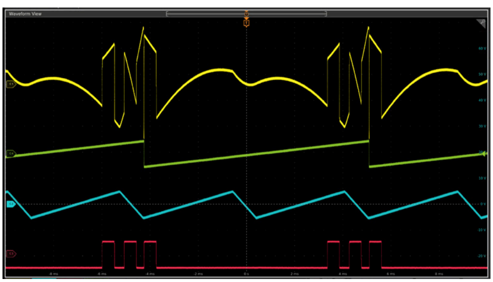


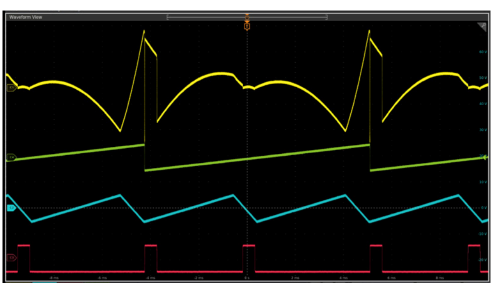
The second inspiration was to build a VCO that would provide interesting yet precise control of the waveshapes. The circuitry underlying Trident's symmetry control was remarkably challenging. Varying the symmetry of a triangle wave from sawtooth, through triangle, to inverted sawtooth has been done many times before, but doing so in a fully analog, voltage controlled manner that has absolutely no effect on the underlying frequency is extremely challenging. Add to that challenge the requirement for the waveforms to be visually perfect up to 20kHz — now that would be fun (i.e. really hard)! I had to throw away an entire prototyped design because it wasn't quite accurate enough at the highest frequencies. The final circuit is the only time I've ever had to specify a capacitor as small as 0.5pF to get the precise results I wanted. Here are some of the pure waveshape 'scope photos. The first picture below shows the shapes at about 250 Hz, the picture after it shows the shapes at about 20kHz!





Finally, I realized that I've never seen anybody play with the phase relationship between hard synced oscillators. Combining that with Zing modulation gives even more voltage controlled timbral variation. These waveforms differ only by the phase of the MOD 2 oscillator!





10. Acknowledgements

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