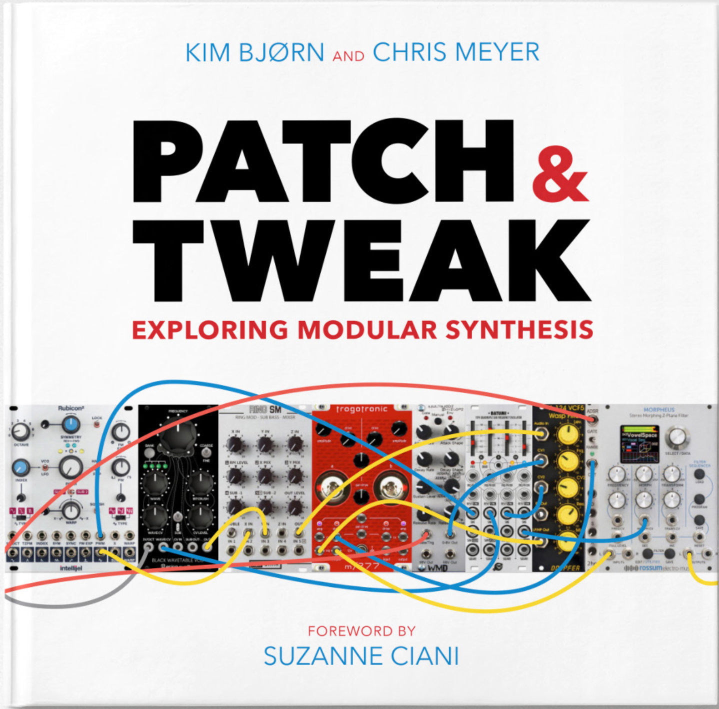

PUSH TURN MOVE and **PATCH & TWEAK**

Books on electronic music instruments,
their artists and makers.

Free sample pages

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PREFACE BY THE AUTHOR

The why

This may very well be the first book not focusing on the sounds of the instruments it's about. However, it was the fascinating and mysterious sounds that made me study the first music videos on MTV and the inner sleeves of vinyl albums, to find out what instruments were used to make them. That's when I discovered my first synthesizer, the Casio CZ-5000, which was used by Jean-Michel Jarre on 'Fifth Rendez-Vous' along with classics such as the ARP 2600, the Emulator II, the Fairlight, Prophet-5 and Roland JX-8P in 1986. I wanted to get them all (I still do) but the CZ-5000 was available and what I could afford as a teenager.

Since then, I journeyed through various kinds of electronic gear, always with the curiosity of 'what can this thing do?' The pure joy of pushing a button, turning a knob, or moving a fader and listening to how it affects the sound, is unique. As curiosity combines easily with creation, my interest in how things sound connected naturally with my interest in how things look. To me, the word 'composition' has always been interesting and essential to everything we do, whether design, music, cooking or living.

Many people have asked me about my reasons for this book. The first and most important reason is that I was looking for it, but it wasn't there. There are plenty of books and videos about vintage synthesizers or YouTube reviews of the latest gear. But none of these combined my two interests: electronic instruments and design. A second reason was simply so I could 'collect' and study all these devices, and get to hear why they look the way they do – from legendary or upcoming makers and brands themselves. Having been lecturing for more than two decades, and with an interest to share and spark curiosity, it was only natural to try and make sense of this world. Providing it as a book was just as natural, as it's one of the formats we can sit comfortably and study, sift through and explore, or share with others.

The scope

This book is by no means a history of electronic music instruments or a complete overview of all instruments and controllers. Thankfully, this is hardly possible and would serve little purpose. Neither is it a catalog of vintage hardware synthesizers, and you may even not find your favorite among the examples. Because that's precisely what they are: examples of concepts and principles, not chosen because of their sound, mechanical stability or popularity, but chosen because they are good examples of the topic discussed at that particular place in the book. Furthermore, I have chosen (and always will choose) a positive attitude towards all examples. It's much too easy (and unfortunately common) to criticize and focus on what doesn't work. But it would not be pleasant reading, respectful or useful in any way.

One of the things that struck me during interviews has been how many times the word 'conversation' comes up. The dialogue, exchange of ideas, and co-operation happening between designers, engineers, users, and across brands, is a unique element of the generous family I have come to see the electronic music world as. My concern is that we keep it that way, with opportunity and respect for everyone.

The book is an attempt to celebrate and honor the artistic creativity, technical skills and undeniable devotion of all the people and companies inventing, designing and developing electronic instruments, whether hardware, software, analog or digital, that have brought so many great experiences to us all.

The omission of any instrument, artist, designer, inventor or brand from this book is not intended as a reflection on their influence or contribution. But it is simply not possible to cover everything in a single book. Hopefully, though, this book will serve as an addition to the conversation, and in some way offer incentive to build more weird and wonderful electronic music instruments.

The structure

The underlying structure of the book is aimed at providing a framework and an overview regarding the different elements of interface design of electronic instruments. It ranges from how the user approaches an instrument, and how we are used to seeing sound visualized, to technical and functional control elements arranged according to design principles into concepts – all enclosed by technological, financial, aesthetic, and cultural possibilities.

The interviews are mixed in where appropriate to provide a diverse reading experience.

While software has become the primary tool for many artists, analog as well as digital hardware has gained ground previously lost in studios of all sizes. Add to this the difference in price ranges, instrument types, technological advancements, cultural influences and various philosophies, and you have a great mix of opportunities for electronic music making. This mix requires a lot from practicing musicians and instrument creators, and the interviews in this book serve as perspectives on these topics. Through many of the interviews, I found the desire to make electronic instruments more accessible and affordable was widespread among companies and makers. This admirable intention of sharing tools and experience will foster new generations of makers and musicians, starting with the novice getting their first synthesizer, drum machine, or music app.

With this book, I hope to pass on that same excitement, fascination, and curiosity for the world of electronic music instruments that I first discovered in the sound and liner notes of countless albums. This book is dedicated to the incredible artists that have generously shared their explorations with us – whether they call themselves makers, musicians, designers, engineers, or visionaries.

Kim Bjørn, Copenhagen, 2017

TOUCHSTRIPS

Used in everything from analog synthesizers to DJ controllers and Eurorack modules, the touchstrip can take on a variety of functions, from modulation and note generation to volume control, CV control, crossfading or pitch bend. It is a space-saving interface element with no movable parts, which also allows instant parameter jumps. That's in contrast to a physical fader, which has to be moved from one position to another (and thus will run through all of the values in between).

The principle of the touchstrip is often used on XY pads (p. 102) or even expanded to complete interface concepts like multitouch (p. 250).

On smaller units, the touchstrip comes in handy as a multifunctional value-tweaking interface element. On the Pioneer DJ Toraiz AS-1 synthesizer, up to seven parameters can be modified at the same time by the touchstrip. Note that the keys are a touchpad, too.

Touchstrips placed as on the Native Instruments Maschine Jam allow the user to use four fingers on each hand to adjust up to eight parameters simultaneously, which is a lot more than is possible with knobs. The sliders are configurable and even work as level meters, indicating the volume of each track.

On the first version of the Komplete Kontrol keyboards from Native Instrumens, the touchstrips can function as pitch bend and modulation wheels. Here, the left touchstrip has a zero value in the middle; pitch goes up when the user slides upwards and down when sliding downwards. This principle of placing the zero-value at either the center or at the bottom allows for many modulation types.

Intellijel brings pressure-sensitive touchstrips to the Eurorack world with the Tetrapad. As the name indicates, four strips are able to output smooth modulation values, notes, and a variety of other data, depending on the mode setting of each touchstrip. On each touchstrip, 12 LEDs give convenient feedback.

The touchstrips on these Roland Boutique products have a color indication to their right, offering positional feedback to the user. Though these units can be attached to a keyboard, the touchstrips can be convenient for note input.

The Dave Smith Tempest analog drum machine (also a very capable synthesizer) features two touchstrips for realtime control of up to four parameters. The values of the parameters are momentary by default, but it's also possible to latch them at the touch of a button.

On the Pro2 synthesizer, Dave Smith Instruments adds pressure sensitivity as yet another modulation source on the two configurable touchstrips, which provides for even more expression and playability.

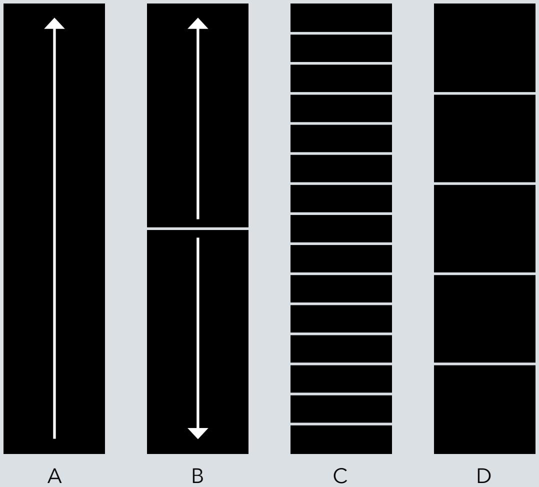
Four basic functionalities in touchstrips:

Unipolar – top-to-bottom smooth values where the base value resides on either end (A).

Bipolar – center-based smooth values, with the base value in the middle of the strip (often with a central dead zone so that a zero amount is easily obtained with a variety of finger widths) (B).

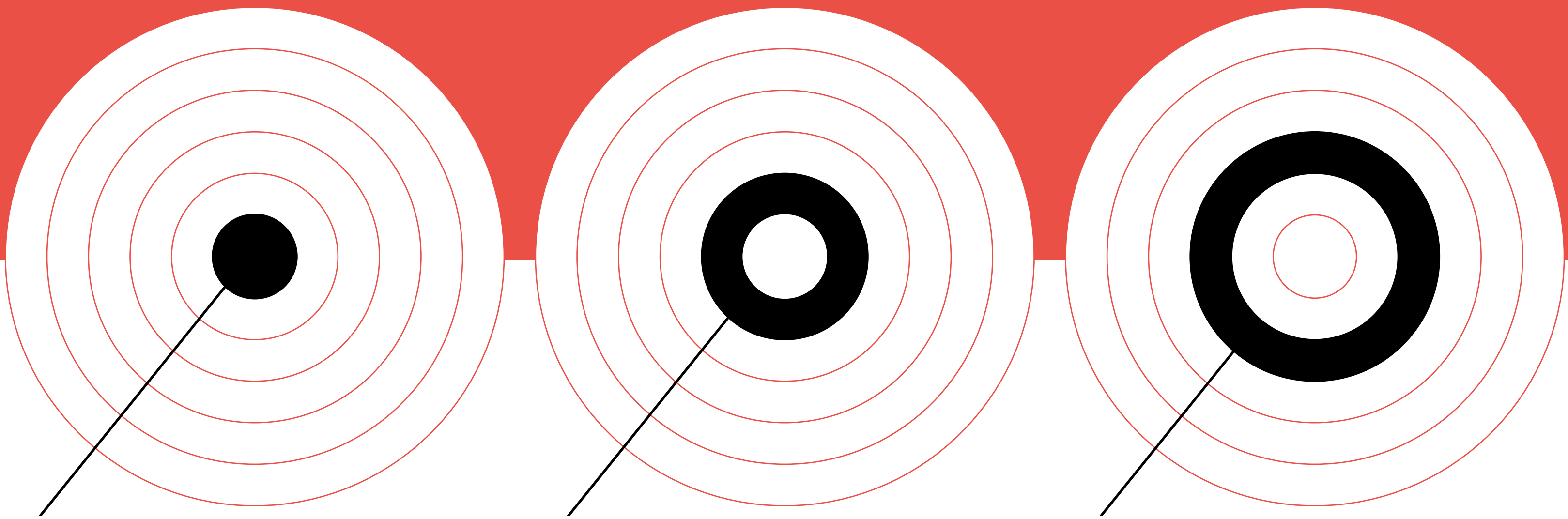
Stepped – divided into any number of areas with fixed values like notes (C), or larger areas functioning as buttons with specific functionalities (D).

Pressure sensitivity – providing an extra dimension of parameter modulation.



FRAMEWORK

Electronic instruments emerge in the mysterious space between innovators and musicians, driven by the ongoing march of technology and the visions of those at its leading edge. The designs are based on core principles, evolving technological possibilities, cultural trends, traditions, desires and imagination. The following model sets out the framework for this book and for exploring, understanding and studying the world of electronic instruments and their many forms.



USER

Electronic instruments seldom make sound without a human initiating an action or a process somewhere. As users, we tap on pads, press buttons or tweak knobs to generate, route or modify the sound. While doing this, we are engaged in a focused or explorative workflow, whether playing on stage or in the studio, in a collaborative situation or alone, and we react to feedback from our actions – whether visual or audible. We do, see, hear – and do again.

This human-machine interaction can be quantifiably successful, annoyingly stressful, or qualitatively joyful. It depends on our experience, efforts and results with a given device. User experiences are thus also dependent on a range of factors such as situation, skill level, and understanding.

SOUND

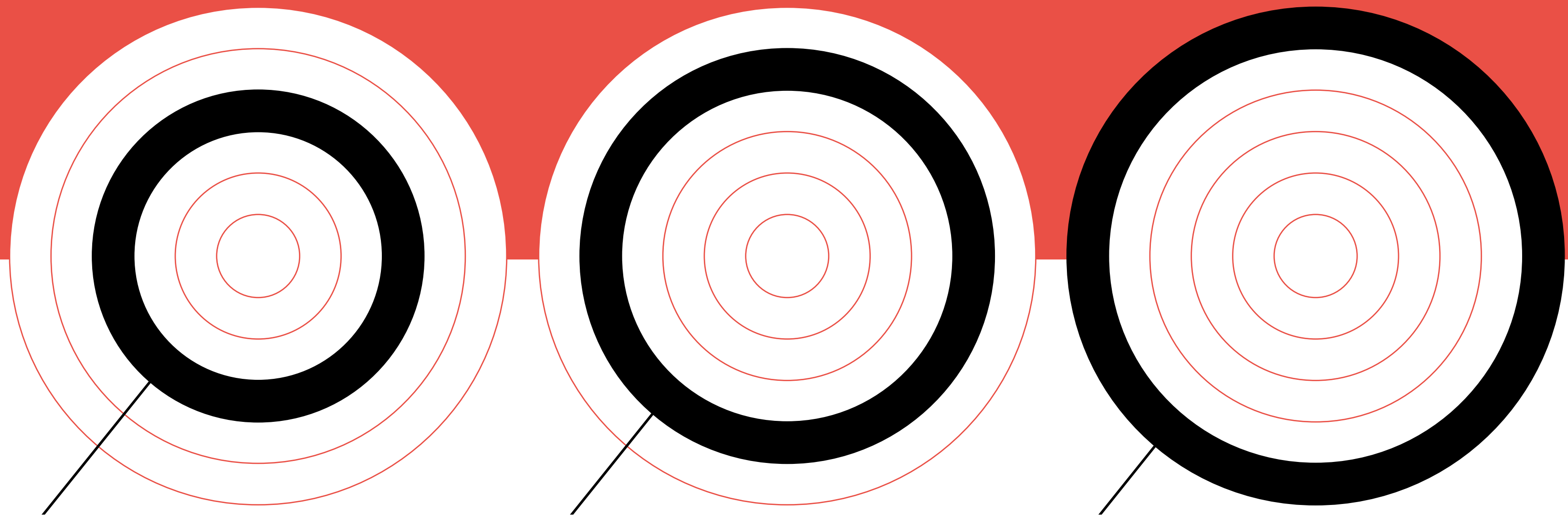
Electronic music starts with sound. Listening to sound is important when working with it, but visualization of sound adds a new dimension and supports further understanding. This can aid the generation, routing or modification of the sound while interacting with an electronic instrument.

Visualizing sound on an instrument, in a software interface or in an app, can be accomplished in countless ways. However, there are some commonly-used methods to help the user perform tasks across a variety of products and/or interfaces. These can include everything from reaching out for the sustain knob on a synthesizer to filtering out certain frequencies in a mix, adjusting the velocity or scale of notes on a sequencer, or beat-matching songs in a live DJ performance.

CONTROL

Sound is controlled by either being set or generated, routed/patched somewhere, or modified. Whether it's a full track played, mixed and effected by a DJ, or a waveform being modulated, filtered and routed in a modular synthesis system, the three main functions of controlling sound are: Generation, Routing, and Modifying.

To control sound we need to interact with it. Traditional techniques like adding vibrato to a string on an electric guitar or playing with a soft attack are commonly applied to synthesis, which employs knobs, faders, modulation wheels, buttons and many other types of control. This section examines the many control elements that directly connect the user to the sounds being made.



LAYOUT
The controls available on an electronic music device are laid out according to certain design principles that have evolved over many decades. These principles guide the user with respect to the function and relevance of the controls.

Whether on a hardware synthesizer, DJ mixer, Eurorack module or a music app, these principles derive from the way we perceive elements and objects in our environment. We ask: What is nearby? What should be grouped together? What is important?

Applying these ideas requires a mix of gestalt rules, ergonomic considerations, design traditions, and a wide variety of interface factors: visual and tactile feedback, legibility, familiarity, color, consistency, grouping, and more.

CONCEPT
Historically, electronic instruments have inspired a diverse spread of interface concepts. This chapter explores how these are realized in different software and hardware platforms.

Here we look beyond traditional categories such as drum machines, synthesizers, sequencers, etc. Instead, we'll consider the ideas that drive contemporary electronic music making, drawing attention to commonly-shared principles and interesting approaches.

TIME
Our experience as either maker or user is widely colored by the time we live in and therefore the technology that is currently available – and already established. How we use instruments and devices changes over time, as does technology, production methods, availability, aesthetics and style. The swipe on an iPad is today as natural an interaction for most musicians as sliding a fader or pressing a key. To put things into perspective, we look at some significant devices that defined or challenged previous and contemporary ways of interacting with electronic music – or managed to do both at once.

KNOBS & ENCODERS

Encoders and knobs are perhaps the most used interface elements in electronic music – and with good reason. Using knobs in an interface opens up many possibilities for the designer – it saves space in the interface, and can even look good with the right DJesque movements.

The physical form and size of knobs should always be implemented with these things in mind: frequency of use, impact on sound, grip/handling, proximity, and feedback.

Endless encoder
The endless encoder can be turned in either direction endlessly. The feedback from an endless encoder often comes from a screen or LEDs around the encoder. In this way, the endless encoder can control multiple parameters and contain multiple ranges of values. On the Moog Slim Phatty, just four endless encoders control all parameters.

270° unipolar knob
This type of knob has a defined start and end position which is usually very visible and tangible for the user. The leftmost position is usually the minimum value of the parameter and the rightmost position usually the maximum value.

Rotary switch
Detented knobs can be used for switching between defined parameters, like presets, sounds, waveforms or the like. On the vintage Roland Rhythm Arranger, the rhythms are chosen via a rotary switch and three green buttons.

On the Novation Circuit Mono Station, and on many other synthesizers, the filter knob is bigger as it usually has the biggest impact on the sound; open the filter for instant EDM buildup. The backlit transparent knobs in the mixer section provide feedback by becoming more intense in color the higher the value.

Detented encoders and knobs

Encoders and knobs can have stepped detents as opposed to a smooth transition from one value to the next. The stepped resolution from detents allows for more precise increments in values.

On the Tetra (below), the most frequently used knobs are present: Filter Cutoff, Resonance, Attack and Decay/Release. The Cutoff and Resonance knobs are potentiometers, which allow for smooth filter changes. Four additional and assignable detented encoders allow for precise value changes of the assigned parameters which, when turned, update the display above.

Bipolar 270˚ encoders

If an encoder controls two parameters or two versions of a parameter, it may have a centered zero-position (often visually marked and tangible, felt by a 'snap' to that position).

On the Roland AIRA System-1, the LFO amounts for Pitch, Filter and Amp are adjusted with bipolar encoders.

Besides being obviously usable in situations with centered functionality, e.g. panning left to right, a popular version of this bipolar encoder is the 'DJ filter knob'. It functions as a lowpass filter when turned to the left, and as a highpass filter if turned from center to the right. In the center position, all frequencies pass through.

The dial

The larger dial (frequently called a jog wheel) often turns with very little resistance with just one finger placed in the indentation. Stepped detents allow for precise control of values and selections. On the System-1, the dial is used to select the type of scatter effect, and the surrounding bi-polar ring with spring-back function (also called a shuttle wheel) is used to dial in the amount (which can be held by pressing a nearby button) or used as a pitch bender.

Push-encoders

Push-encoders allow extra or refined functionality when pushed or held down. The push of the encoder can access other menu levels, trigger a function, confirm a value change or, for example, speed up the value change if held while turning. This saves space in the interface and multiplies the functionality of the encoder.

On the Novation Ultranova, holding the push-encoder down while turning allows switching between banks, patches, presets or speeding through value changes. The endless control encoders are touch-sensitive, allowing the user to touch an encoder to see its value on the display – without turning it. The touch functionality also lets the user trigger effects, envelopes, etc.

The Source of the Little Phatty

The Little Phatty synthesizer owes some of its inspiration to the Moog Source, although none of the current team were around when that esteemed synth was created. Steve explains:

"From the standpoint of design economy, potentiometers cost a lot of money, and back when the Source was introduced, multiplexing and scanning a load of pots for storing presets was expensive and didn't have great performance. So, an advantage of this type of interface is that you are scanning a bank of switches, which is easy and not so expensive, and you are only scanning one rotary control, which can be done with greater precision if you can spend a few more resources on it."

"Another advantage is that there is not as much of a disconnect with the physical location of a rotary pot and the value for that pot that is stored in a preset. Some means of reconciling that disconnect should exist in an instrument with many pots and presets. The main disadvantage of the membrane approach is that sound design can be a bit less immediate; if playing the knobs is an important part of a musical exploration, then this design is a liability."

"The Source was an inspiration for our Little Phatty synth, but by having one knob per functional section, and selector switches, sound design was a bit more immediate and we allowed for more live tweaking than the Source. I consider the Little Phatty interface to be quite a good design for its time."

Over time, the Source's membrane switches wore out or contacts got dirty. According to Amos, the Moog Little Phatty used a variation on the theme involving a silicone-rubber switch mat instead of a panel membrane, and an assignable (analog) knob per UI section in place of the single encoder.

"The goal with the Moog Little Phatty was to obtain the advantages of the Source panel, with improved reliability and faster mapping of the knobs to individual parameters. The approach of one knob with multiple buttons to assign the knob to parameters is very fast and convenient to use if the parameter assignments are well-chosen and well laid out. Having good visual feedback is important, which is why we chose to use LED rings around the knobs to show the value of the parameter currently assigned to the knob."

> "I think it improves my playing to see a beautiful instrument under my fingers.
>
> *Jeff Snyder, Snyderphonics*

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INSTANT FUN WITH LIMITATIONS

Interview with Jesper Kouthoofd, CEO at Teenage Engineering

"To be honest, we are not interested in design at all. It just needs to work."

It's an unusual introduction, especially from a Head of Design and CEO, but Jesper Kouthoofd points to the Pocket Operators as examples:

"They are a bit ugly, funky and raw. If we had a design perspective on things, we would never release a product like that. The problem about the design community as a whole is that it's so much about styling and not solving problems. When people solve problems, it can lead to iconic products because you start with how it should work."

Having become well-known for their gadget-like approach to design, one could claim that the success of Teenage Instruments' small instruments derives from a nostalgia effect. But according to Jesper, that's the easy answer.

"I think that a guy like Jean-Michel Jarre, for example, sees a machine with limitations as familiar because it's how he started. He gets creative because there aren't a thousand knobs. It's like he's going back to his roots – and I think that's the secret: people love to be creative. And to be creative, you often need many limitations. Suppose you have an endless canvas to work on – the result is that you can't even start. If your choices include everything, you're not hungry anymore; you lose your appetite. Limitation is everything."

The story of the beginning

Jesper approached Elektron after they released the SidStation and got involved with some design work.

"At the time, they were just 4 engineers from the university at Gothenburg. I started to help them with the Machinedrum – not from an industrial design perspective, but more like cleaning it up, using a nicer typeface, doing some color indications, etc."

Soon, Jesper and Elektron co-founder Daniel Hansson became best friends. "He was like a genius, and we talked a lot about synths and stuff. I suggested we should do portable synths, so I did some sketches for that around 1999-2000. Then we worked on the Monomachine and the Machinedrum UW." But everything changed when Daniel died tragically in a car crash.

"Then I was in a new situation with two of my friends. We felt it was more or less a sign, and though I didn't want to start a company, we shared some office space and started work on prototypes, more or less based on the original sketch I showed Daniel a couple of years earlier. I did 3-4 mockups and we took it from there. So the OP-1 started almost ten years before it actually came out."

When Teenage Engineering was founded in 2007 they were building internet-connected installations for advertising companies, but the urge to build their own hardware from scratch had deeper connections.

The portable aspect

Having a brother who worked in a music store was handy, and as a teenager, Jesper managed to borrow a lot of the gear that was current at the time (circa 1982-1985) and explore it on weekends.

"If you think about what type of gear you typically used back then, when you didn't have any money, it was things like a TASCAM 4-track Portastudio, some BOSS pedals and some cheap Korg or Roland synths. We couldn't afford the TR-808 or TB-303, but had the SH-101 and also some Casio stuff like the VL-Tone. Imagine all that gear – but the dream was to put it all into one portable machine – not because of the sound but because of the workflow. The OP-1 is all about the workflow. It has similar limitations to that kind of gear – only four tracks, not many knobs (four), small modules that can be combined, etc."

"The hard thing was to figure out how to make it portable and still be able to play on it. I'm not a musician, so when I used the old stuff, I always used a sequencer rather than doing it live, overdubbing track after track, bouncing and adding a lot of effects. Our goal with the OP-1 was never to create a live performance instrument in that sense. But I think a lot of factors combined to make it look how it does at this particular time."

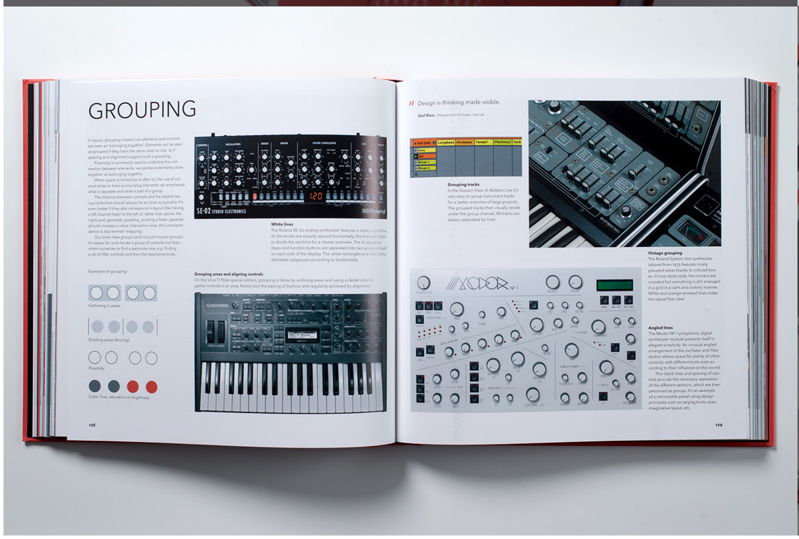
PUSH TURN MOVE

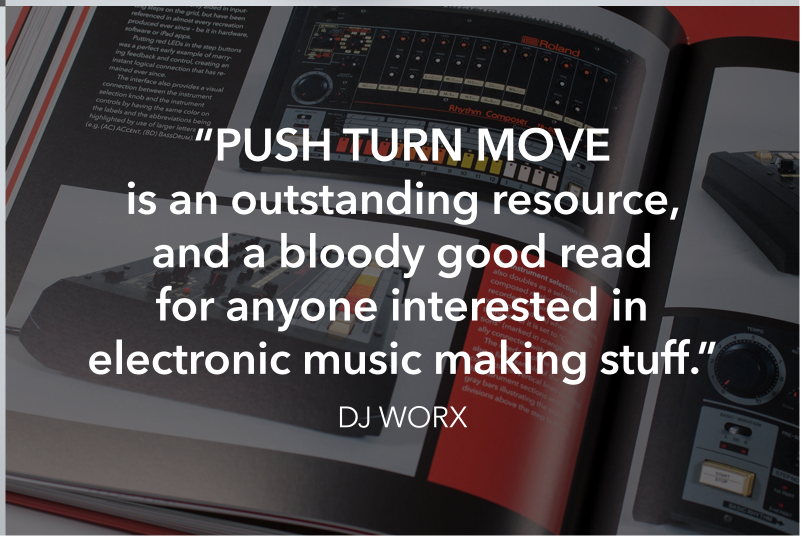
The book about electronic music instruments

A must-have for every synth and design nerd.
PUSH TURN MOVE was funded on Kickstarter within an hour in April 2017 by more than 1.430 backers in 55 countries. Packed with interviews, and information, PUSH TURN MOVE is a fascinating coffee table book, richly illustrated with a unique collection of designs, photos, and graphics.

"It's a fascinating insight into the design of music technology over the years."

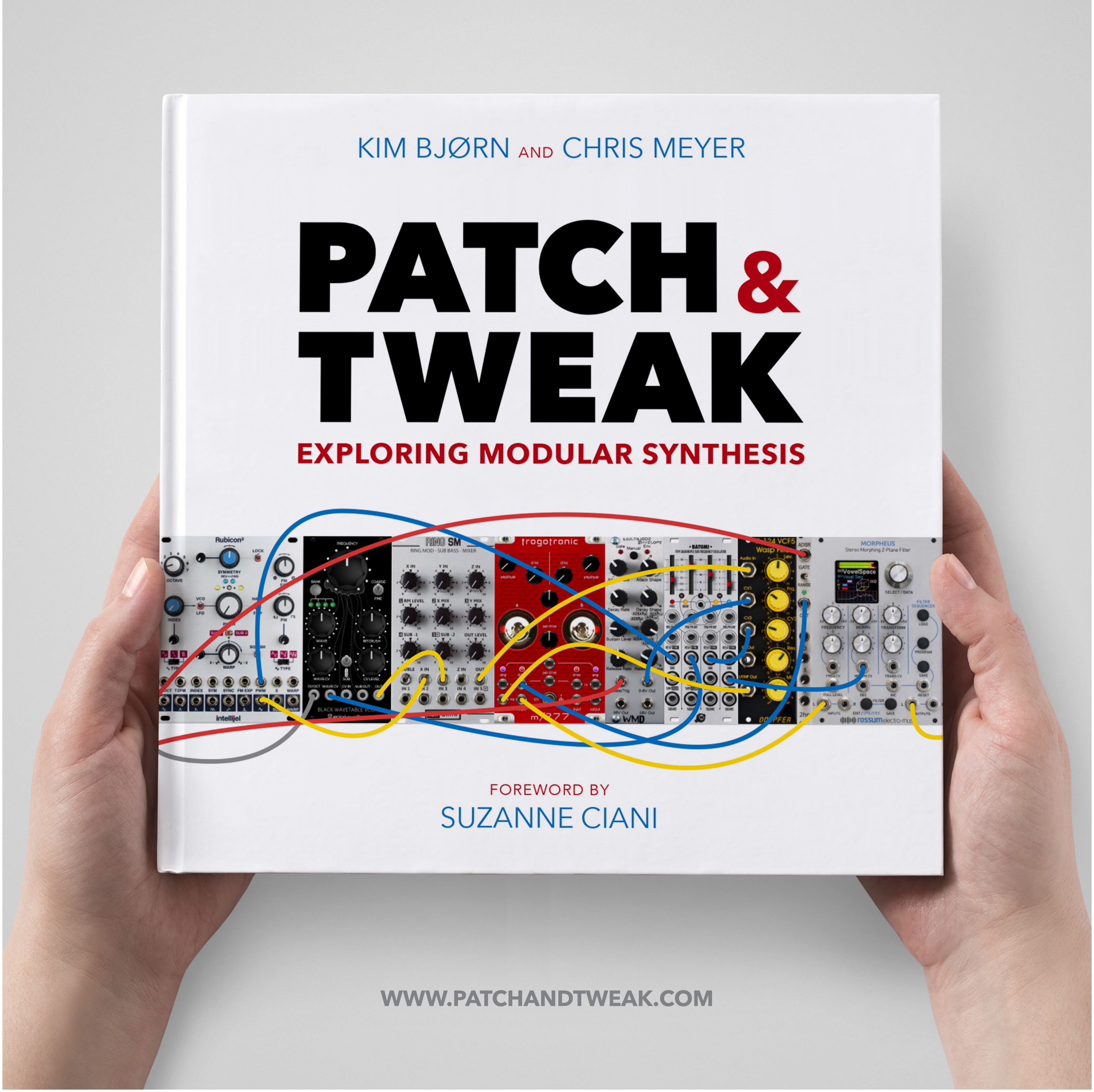
ASK AUDIO





"PUSH TURN MOVE is an outstanding resource, and a bloody good read for anyone interested in electronic music making stuff."

DJ WORX

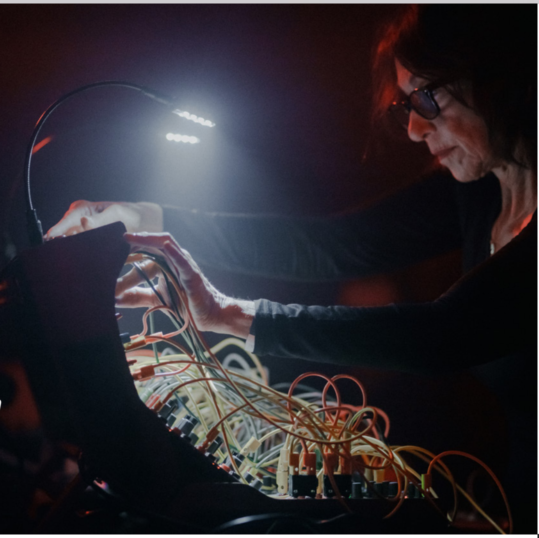

KIM BJØRN AND CHRIS MEYER
PATCH & TWEAK
EXPLORING MODULAR SYNTHESIS
FOREWORD BY
SUZANNE CIANI
WWW.PATCHANDTWEAK.COM

PATCH & TWEAK

The new book about modular synths, their makers, and masters

PATCH & TWEAK provides an opportunity for new and experienced users to become true masters of their modular systems. It contains inspirational interviews with significant creators and major artists who share their passion for modular. Explore their systems, philosophies, patching secrets, and performance tips. Written by Kim Bjørn & Chris Meyer, with a foreword by Suzanne Ciani.

" When I started out doing this, I felt a sense of responsibility to educate the world about what this stuff was ... Now, I'm coming back to it, and there's a very receptive area with a lot of young people engaged in modular synthesis.
– Suzanne Ciani

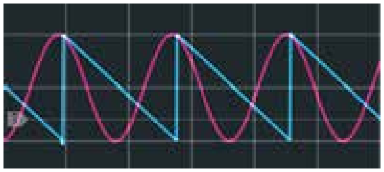


Interviews with artists and makers: Junkie XL, Robert Rich, Bana Haffar, Caterina Barbieri, NODE, Hans Zimmer, Lady Starlight, Russell E. L. Butler, Robin Rimbaud / Scanner, Ian Boddy, Hataken, Andrew Huang, Richard Devine, Verbos Electronics, Fraptools, Mutable Instruments, WMD, Make Noise, Intellijel, Endorphin.es, 4ms Company, Noise Engineering, Rossum Electro-Music, Erica Synths, and Music Thing Modular. Synthesizers.com, Doepfer, Buchla, Serge, Moog, and others will also be featured.

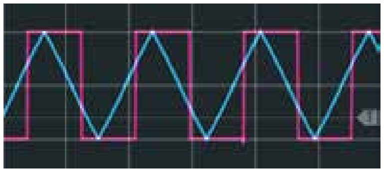
VCOs Voltage Controlled Oscillators

The analog VCO

Many oscillator modules today can produce a wide variety of waveforms, each with its own unique set of harmonics and therefore tone or 'timbre.' However, in the early days most oscillators only produced two to four basic waveforms: sawtooth, square, triangle, and sine.



Sine wave and sawtooth wave



Square wave and triangle wave

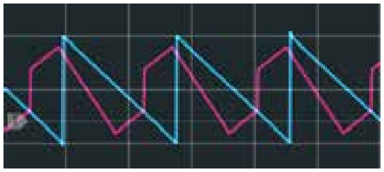
Although each of these has a unique sound, in reality most were chosen because they were easy to produce with analog circuitry. Since some modules use different circuits to produce the "same" waveforms, there may be slight imperfections, resulting in subtle tonal differences between them: That's why some users will claim that a particular VCO has a "better" sawtooth or square wave than another.

However, the real fun starts when you start creating variations on those basic shapes, or completely new waveshapes. Let's start by discussing common variations that analog VCOs can create and what they sound like, then branch out to alternate ways to create and process sound from the oscillator waveform.

Variable waveshapes

Analog VCOs are often based around a 'core' that creates one specific waveform such as the triangle or saw. The other waveforms are created by using internal 'waveshapers' that bend or otherwise re-arrange one waveshape into another. Many oscillators hide this from you, carefully calibrating the resulting waveshape at the factory. But wouldn't it be fun if you could bend these waveshapes yourself?

A number of VCOs have front panel controls that allow you to do this. For example, the *Catalyst Audio Model 158 Dual Sine-Sawtooth Generator* is based on the *Buchla 158* – one of the first VCO modules created – and allows you to crossfade from its internal sawtooth core to the sine wave created from that core. Many other oscillators also allow you to vary the final waveshape; other examples include the *TipTop Z3000, Analogue Systems 95e, Make Noise STO,* and *Erica Synths Fusion VCO.*



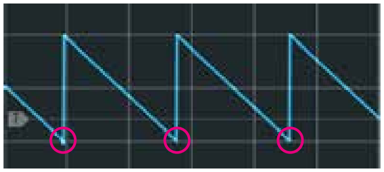
Morphed waveshape as a result of morphing between a sawtooth and triangle wave.

Also interesting are VCOs that offer alternate waveform outputs that are more harmonically rich 'mash-ups' of existing waves. A popular example is the Blade waveshape on many Pittsburgh Modular VCOs; their *Primary Oscillator* has this feature as well as an optional dirty 'harmonic' sine wave, plus a circuit to impose digital-like 'stair stepping' onto analog waveforms.

Most desirable are VCOs that allow you to alter their waveshapes or mixtures under voltage control, allowing you to add more harmonic variety and motion to your sound.

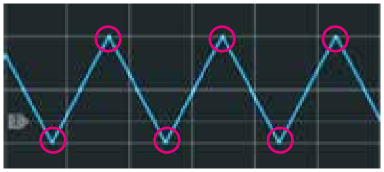
Newer analog oscillator designs are offering far more flexibility as well as voltage control over the resulting waveshape. In addition to the *Pittsburgh Primary Oscillator*, excellent examples include the waveshape crossfade and morph capabilities of the *Steady State Fate Zero Point Oscillator*, the internal VCAs for each wave in the *Future Sound Systems OSC1*, and the Shape section of the *Abstract Data ADE-40 Shaping VCO*.

Oscillator cores
You will sometimes hear the terms 'sawtooth core' or 'triangle core.' This refers to the basic design of the oscillating circuit. Different core designs also have different strengths and weaknesses.

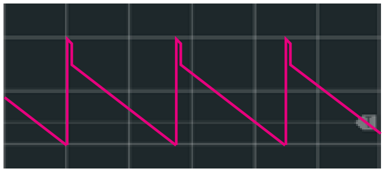


Reset points
The sawtooth core circuit starts at a particular voltage level such as +5v, falls to a target such as -5v, and then resets as fast as it can to its starting level. The slope of how fast or slow the voltage falls determines the frequency of the oscillation. Some designs do this in reverse; rising instead of falling. Obviously, creating a sawtooth wave is this design's strength; it also creates a great square wave, and creates a nice 'hard sync' sound (p xx). It is harder to create a perfect triangle or sine from a sawtooth wave; the result may have some extra harmonics in it.

The *AJH Mini Mod* (left) is a recreation of the classic triangle core oscillator in the Minimoog.



Reverse points
The triangle core circuit is similar but different: Instead of resetting to its starting point once it has reached its target, it turns around and starts going in the other direction, such as rising instead of falling. It takes a bit of adjustment to get it to rise and fall at the same rate, but the result is usually a cleaner triangle and sine wave, with the tradeoff of possibly a less-perfect sawtooth. This design makes it easier to produce 'reversing' or 'flip' sync (p. xx).



Unique glitches
Analog circuits are rarely perfect; these imperfections – and how designers deal with them – can create unique sounds. For example, Yamaha apparently was unhappy with how slow the sawtooth wave in their CS-80 oscillator reset, so they added a small pulse to the very start of the waveform to cover for this. Some digital VCOs such as the *Mutable Instruments Braids* (p. xx) even recreate this in software.

A few oscillators use alternate core designs. The *Doepfer A-110-6* is an analog implementation of Don Tillmann's original design, yielding a sound between a triangle and square: the trapezoid.

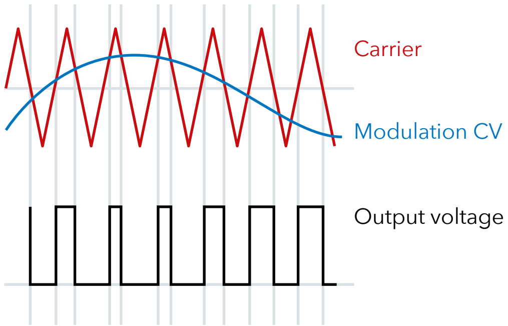
Sub-octaves
Some VCOs offer an additional 'sub-octave' output. This is usually a square wave that is at half the pitch of the other waveform outputs, helping create a bass-heavy sound. Some oscillators offer even more divisions: For example, the *Erica Synths Fusion VCO* offers divisions one and two octaves below; the *Analogue Solutions VCO-Sub* also offers three octaves below its main pitch. The result is often below audibility, resulting in a clicking sound.

It's not unusual for a VCO to offer more than one of the features we've mentioned so far. The *Sputnik Modular Oscillator*, for example, has both a sub-octave output and a Waveshape section where you can crossfade from a sine wave to either a square or a sawtooth wave. Other oscillators like the Make Noise STO (p. xx) also offer similar features.

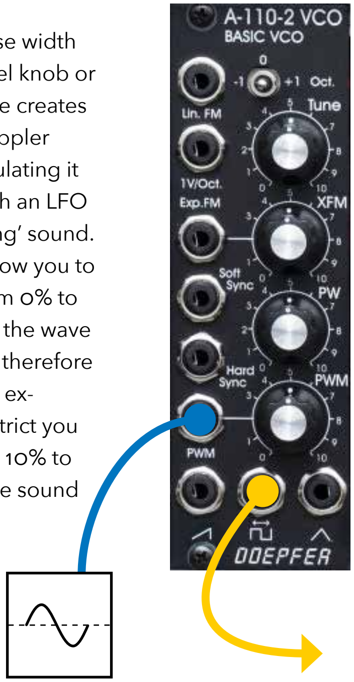
A few oscillators are also starting to offer alternate waveshapes for their sub-octaves, which widens the sonic potential. For example, the *ACL Variable Frequency Discrete VCO* duplicates all of its main waveforms an octave down.

Pulse width modulation (PWM)

The most common variable waveshape is the square, often referred to as a 'pulse' wave. It is usually created by looking at the voltage level of the sawtooth's waveform, and comparing it to a voltage set by the 'pulse width' knob or a control voltage input. When the voltage is above this reference, a positive voltage is sent to the pulse wave's output; when the sawtooth falls below this reference, either 0 volts or a negative voltage is sent to the pulse output.

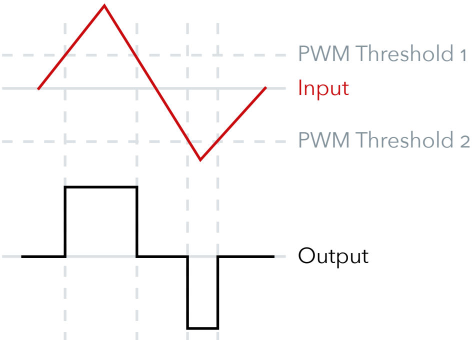


Changing the pulse width with the front panel knob or a voltage envelope creates an interesting 'Doppler shift' sound; modulating it back and forth with an LFO creates a 'chorusing' sound. Some modules allow you to vary this width from 0% to 100%, resulting in the wave disappearing and therefore going silent at the extremes; others restrict you to a range such as 10% to 90% to prevent the sound from 'cutting out.'



This 'pulse width modulation' (PWM) trick has such an interesting sound that some VCOs provide even more control over the resulting wave. For example, the classic *Livewire Audio Frequency Generator* (AFG) allows you to modulate both the leading and trailing edge of the pulse. The newer *ACL Multi Function Discrete VCO* includes a switch decides shows whether a rising ramp, falling sawtooth, or a triangle wave is compared to the pulse width reference to create the final wave.

A further evolution of this approach can be found in VCOs such as the *Cwejman VCO-6* and *Intellijel Rubicon II*. They can create variations with separate ascending and descending pulses. The *VCO-6* contains a second PWM input so the lower pulse can be modulated separately from the upper pulse. This approach can produce an even richer, more animated sound.

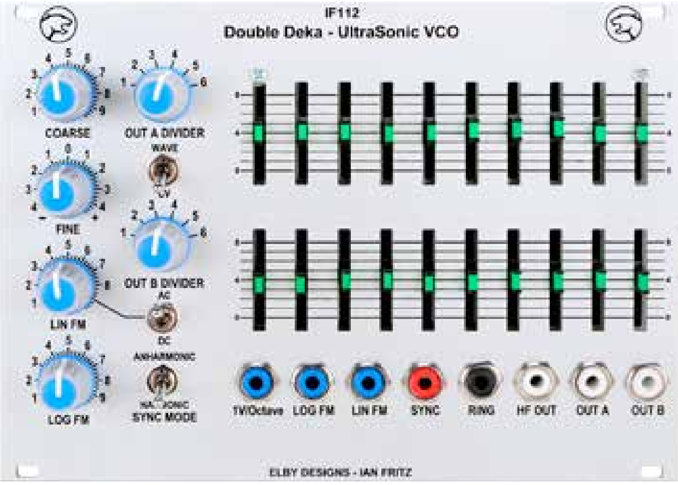


Filters as Oscillators

Many voltage-controlled filters (p xx) can have their internal feedback ('resonance' or 'Q') turned up so high that they start to oscillate, like the feedback howl caused when a microphone is aimed at a speaker. The resulting waveform is usually a sine wave, which can be hard for a normal oscillator to produce accurately. However, most filters use less-precise components than VCOs, meaning they may not track a keyboard or sequencer very accurately. Look for ones that label their cutoff frequency inputs as '1v/oct' instead of just 'freq' – this indicates they are designed to track a pitch CV accurately. An excellent example is the *Joranalogue Filter 8*, as it also contains both exponential and linear frequency modulation inputs (p xx).

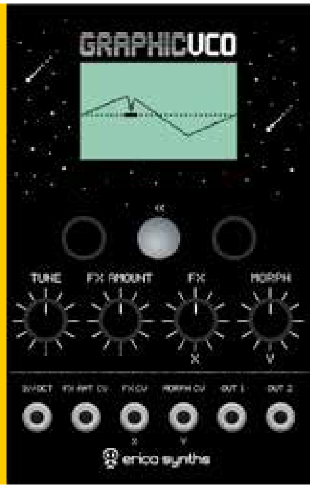
VCOs as LFOs

Many VCOs have a switch that slows them down to the sub-audio range, making them useful as low frequency oscillators for modulation (pg xx).



Draw your own waveshapes

Some VCOs allow you to 'draw' your own waveshapes. For example, the *Elby Designs IF112 Double Deka* contains rows of sliders or potentiometers to outline the desired waveform. Some users have tried to create this themselves, using a very high frequency VCO (such as the *Doepfer A-196 PLL*) to clock a sequencer and adjusting its voltage stage levels to draw a wave. The results are very jagged, resulting in a lot of high harmonics; consider patching a low-pass filter after these. The more recent digital *Erica Synths Graphic VCO* provides an LCD and simplified cursor interface – as well as a few global tools – to make this task easier.



Additive synthesis with harmonics

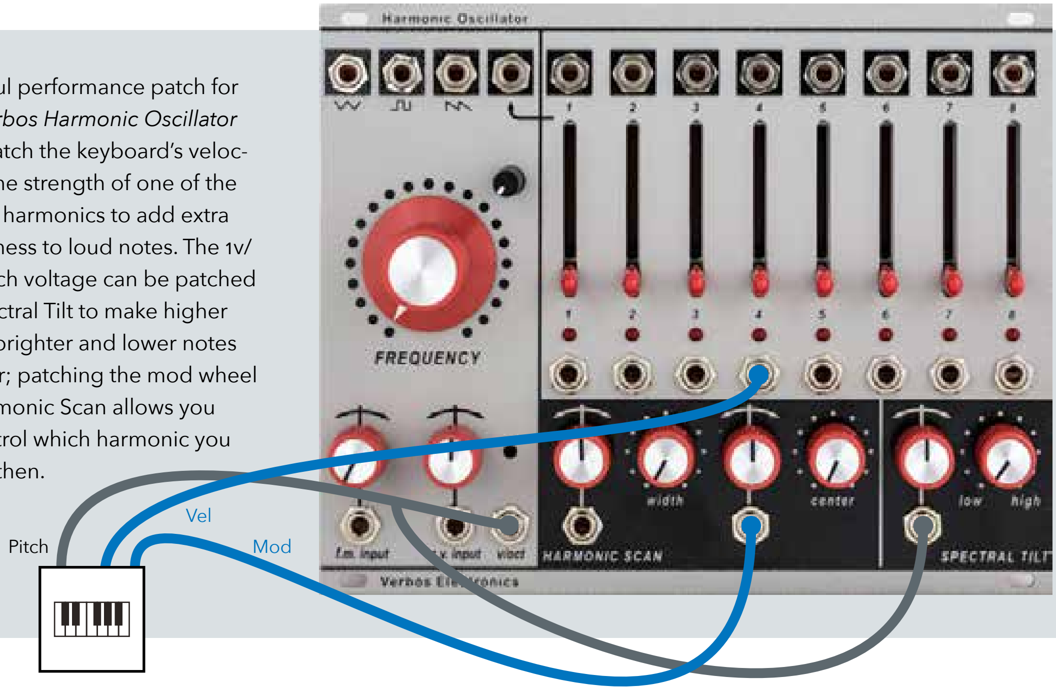
Creating a sound means sculpting its harmonic content. Therefore, an oscillator that gives you direct control over the harmonic mix is a powerful tool. This approach is referred to as 'Additive Synthesis' as you are adding individual harmonics together to create a sound.

There are several different approaches to additive synthesis. A couple of VCOs use sliders to set the relative strength of their harmonics – such as the *Verbos Harmonic Oscillator* or the *Audiospektri HG-30* – and they also offer voltage control over these levels. The *Expert Sleepers General CV* also provides menu access to the strength of individual harmonics. The *Harmonic Oscillator* and *General CV* don't use pure sine waves for their partials, resulting in a more harmonically rich sound than textbook additive synthesis.

As controlling the strength of each individual harmonic can be tedious, many additive VCOs provide a more general control over the harmonic mix, such as choosing the center and width of harmonics that are emphasized. This is related to the way a parametric equalizer works. Examples of this include also the 'H' mode of the *Make Noise tELHARMONIC*, and modes in the *Klavis Twin Waves*, and *Mutable Instruments Braids* and *Plaits*.

The *Xaoc Devices Odessa Variable Spectrum Harmonic Cluster Oscillator*, provides a set of carefully tailored macro parameters to customize the harmonic mix rather than direct control over the individual harmonics itself. Note that the *Odessa* and several of these other additive VCOs are digital rather than analog, which is often a better way to create complex modules like these.

A useful performance patch for the *Verbos Harmonic Oscillator* is to patch the keyboard's velocity to the strength of one of the higher harmonics to add extra brightness to loud notes. The 1v/oct pitch voltage can be patched to Spectral Tilt to make higher notes brighter and lower notes deeper; patching the mod wheel to Harmonic Scan allows you to control which harmonic you strengthen.



Patch Tip

Just setting and forgetting the harmonic mix often results in a sterile sound; modulate the mixture or individual strength of the harmonics to create a far more