Dexter

User Manual

Valley

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Dexter is covered by BSD-3-Clause.

Contents

0. Background

FM synthesis is a technique that is often shied away from due to its apparent complex nature and unfamiliar parameters. This perception is usually caused by the bad interface design in the synthesiser that popularised the technique in the 1980s, the Yamaha DX7. With a huge number of parameters buried behind a small LCD screen, a single slider, and an array of buttons that served multiple functions, many people who sit down to program it quickly become lost. It was like trying to solve a Rubik's cube through a letter box. Whilst computers at the time aided programming, this still hampered down the potential of FM. However, some musicians and artists did unlock this potential, and produced sounds that were far beyond what FM synthesis was thought to be capable of.

Dexter approaches FM synthesis from a usability perspective, as in all the parameters are brought out and made accessible to the user. It employs the traditional 4 operator, algorithmic approach, however with some neat twists such as wavetables, phase distortion and sync in order to broaden the sonic pallet of FM synthesis. Sometimes it can be mellow, pristine and chilled, however with a simple knob twist it can becoming growling, snarling and noisy. Almost all of the parameters can be modulated by control voltages, allowing for easy exploration of FM, leading to new sounds and possibilities.

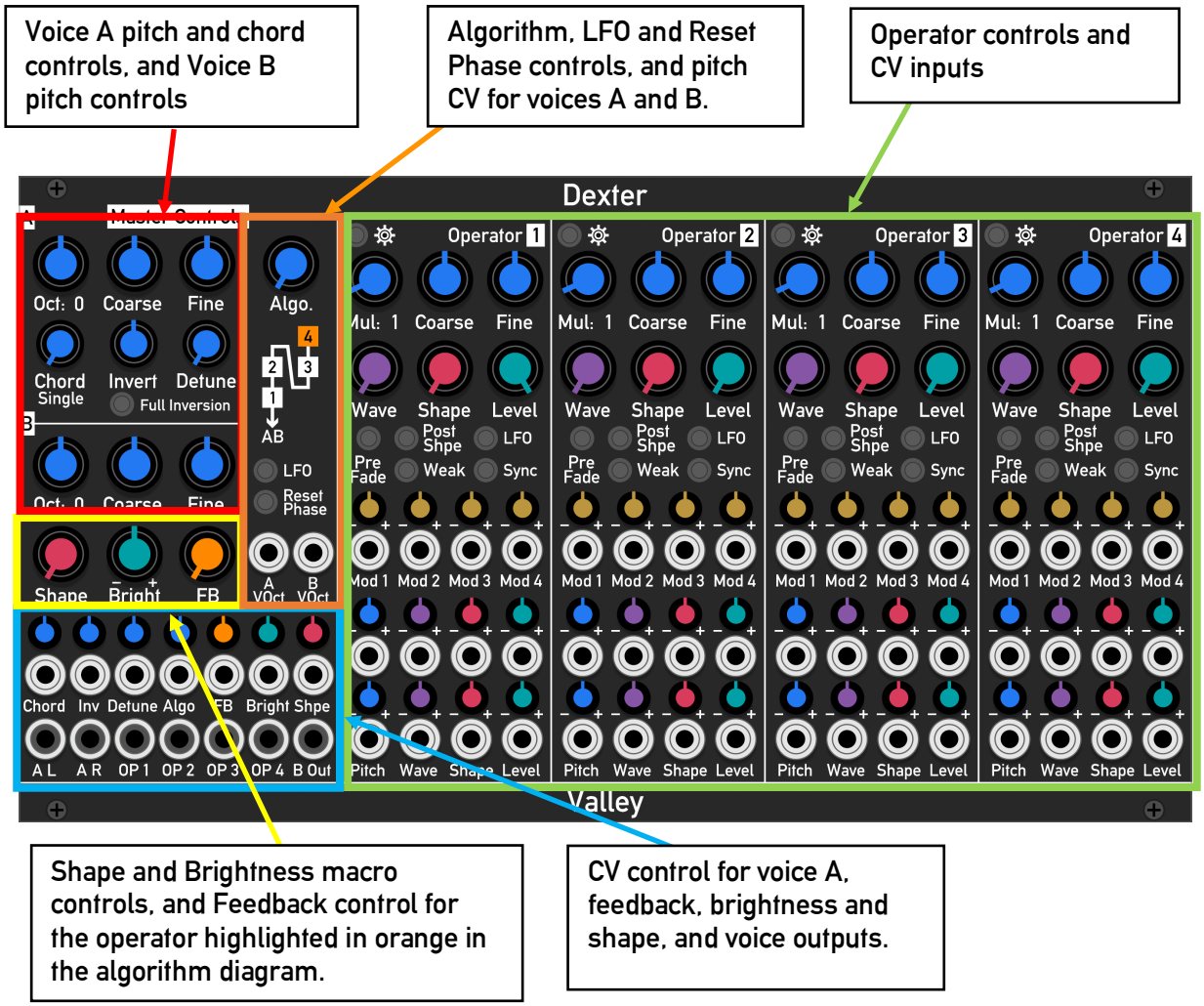
To use Dexter, download the Valley module set from the plugin manager at

https://vcvrack.com/plugins.html

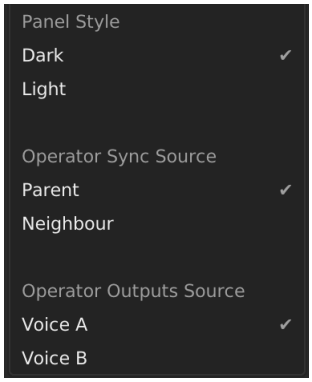
1. Overview

Dexter can be thought of as either an oscillator, a complex waveform generator, or even a “synth with no envelopes”. It is based off a combination of oscillator designs to create a highly usable and fun approach to FM synthesis. There is a lot of control available to the user, and I am sure that many of you will enjoy the results you will get from this module.

Below is an overview of the controls:

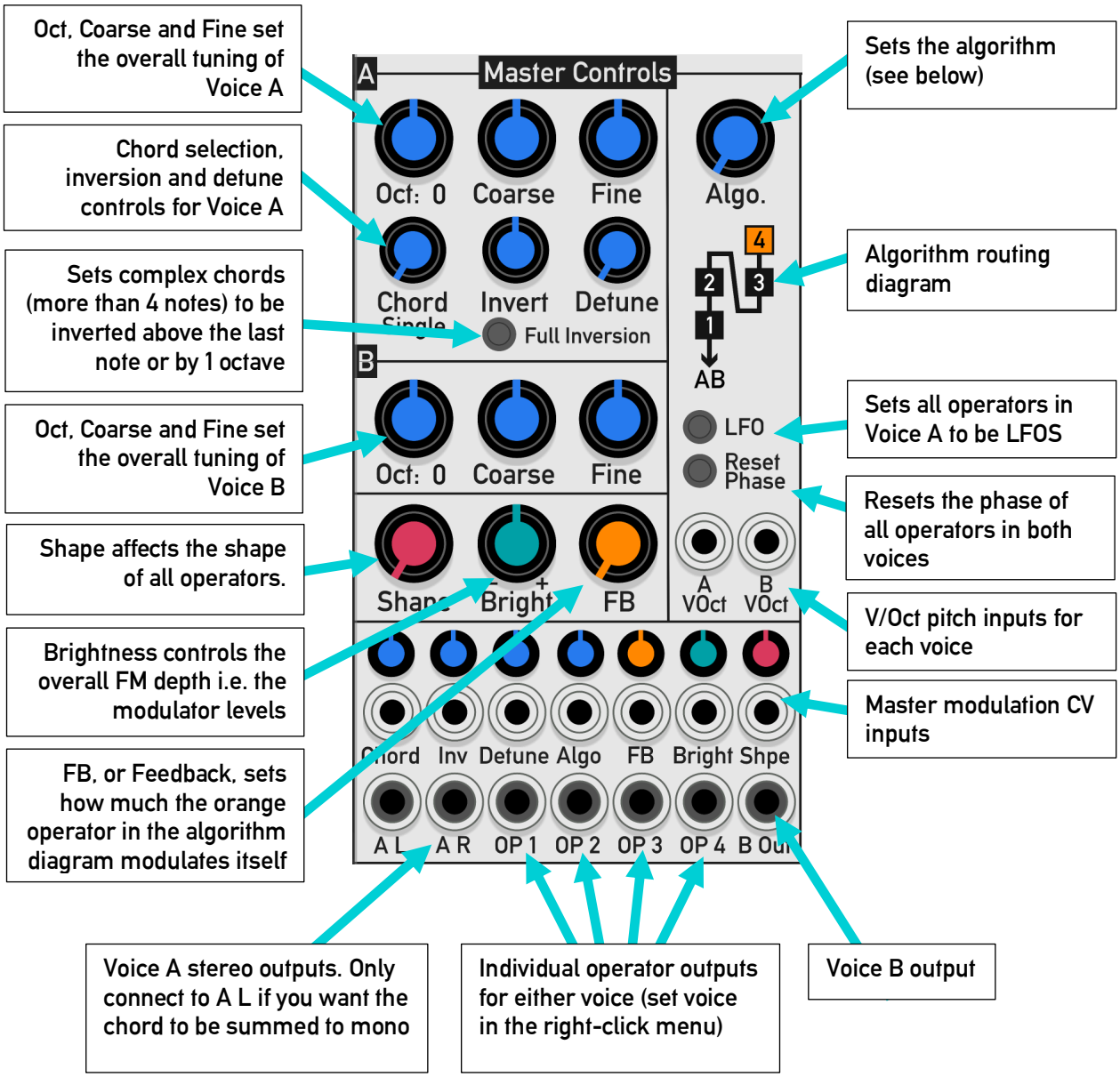


In the right click menu you may change the panel style, operator sync sources and individual output source.



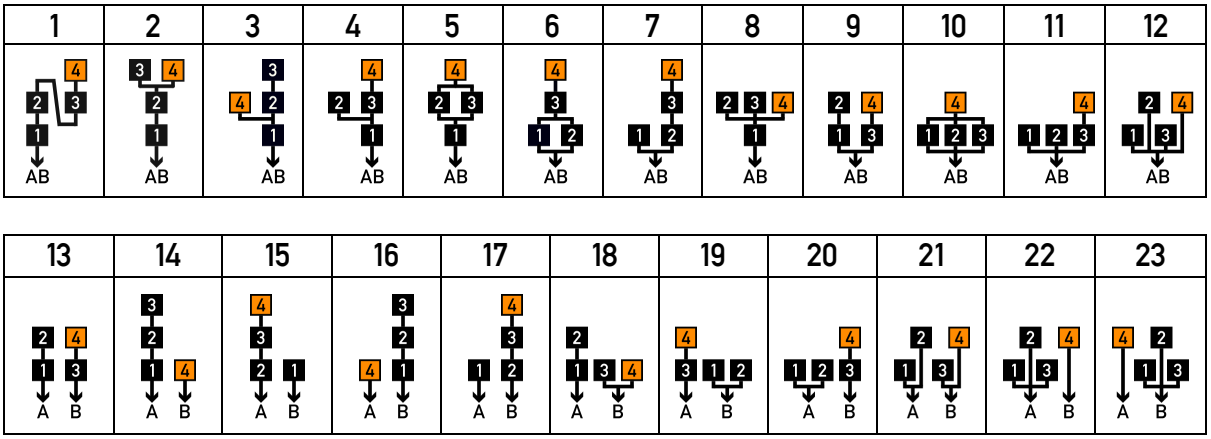
1.1 Master controls

The master controls are, as the name implies, are the main go-to controls in Dexter for basic things such as tuning, chords, algorithm selection and overall shape and brightness.



1.1.1 Algorithms

An algorithm describes how each operator modulates and synchronises another, and to which output they are directed to, via a routing matrix. It can be thought of as a recipe for a particular type of sound, as algorithms are often optimised for particular timbres e.g. metallic, brassy, smooth, vocal etc. Dexter offers 23 algorithms where 12 of these share operators for both voices A and B, and the remaining 11 dedicate operators to either A or B allowing for independent timbres from each voice. By default, the algorithms also determine the synchronisation source for each operator, where operators synchronise to their parent operator. This can be changed in the context menu to "neighbour" where an operator is syncs to the operator to its right on the panel i.e. 1 -> 2 , 2 -> 3 and 3 -> 4.



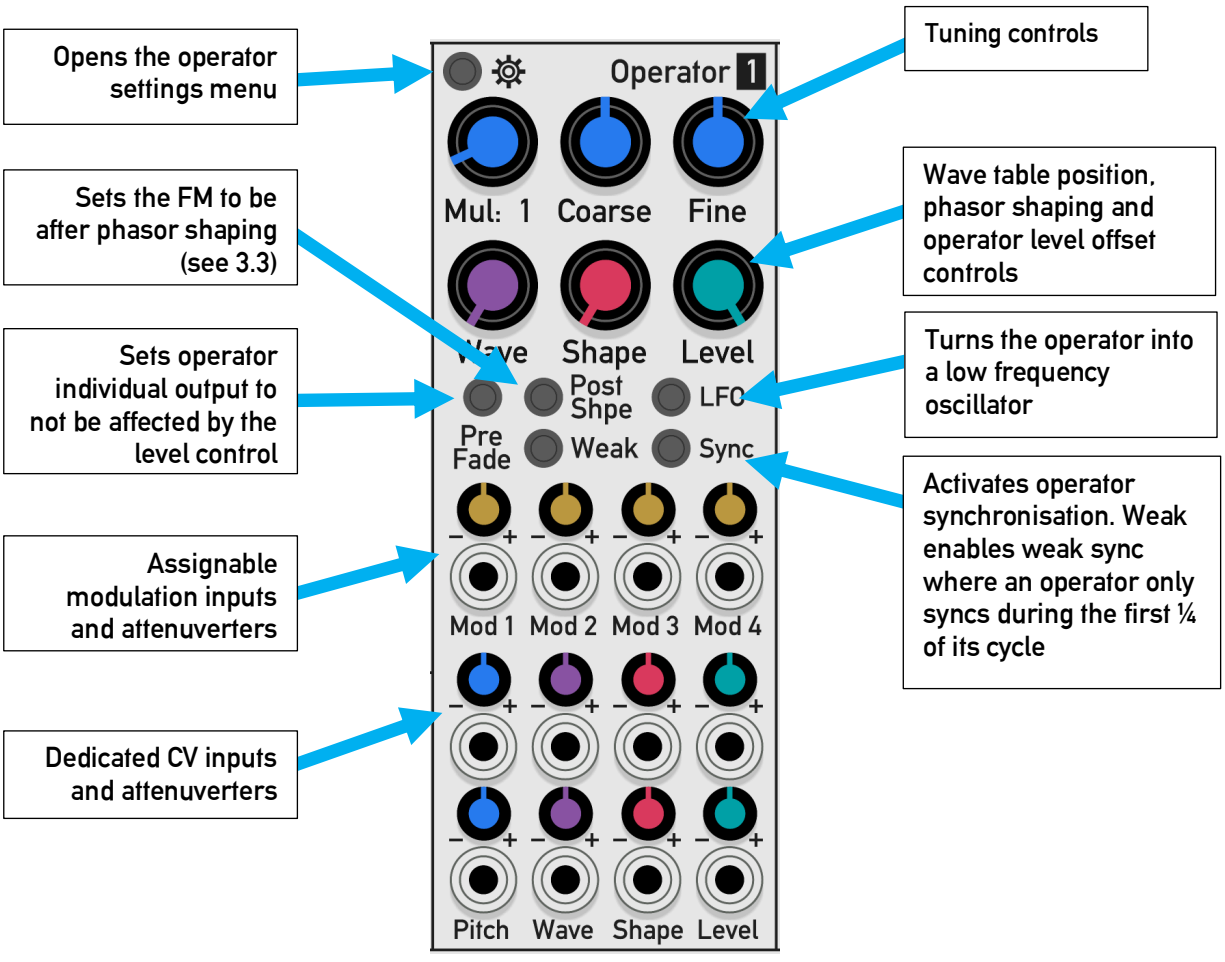
1.1.2 Chords

Voice A has the ability to play chords of 6 notes, plus two unison modes that use either 5 or 7 notes. Chords are selected using the 'Chord' knob in the Voice A section of Master Controls. The chord notes can be inverted several times using the 'Invert' knob. If the chords are more than 4 notes big, notes can be either inverted by one octave by default, or fully inverted so that they are placed after the last note of the chord. The notes in the chord can be detuned where some are tuned up (sharper) and others are tuned down (flatter). The detune is quite deep meaning some chords are totally transformed. If the Voice A output is patched in stereo i.e. both A L and A R, the notes are distributed between the two. The output level is adjusted as to prevent clipping i.e. the more notes, the quieter the output is made. The following table lists all available chords, their density, and note intervals:

Chord Name	Density	Intervals (semitones)
Single	1	0,
Minor 2nd	2	0, 1
Major 2nd	2	0, 2
Minor 3rd	2	0, 3
Major 3rd	2	0, 4
4th	2	0, 5
Tritone	2	0, 6
5th	2	0, 7
Augmented 5th	2	0, 8
6th	2	0, 9
Minor 7th	2	0, 10
Major 7th	2	0, 11
Octave	2	0, 12
Sub-octave	2	0, -12
Octave 2	3	0, 12, 24
Minor Triad	3	0, 3, 7
Major Triad	3	0, 4, 7
Sus Triad	3	0, 5, 7
Augmented Triad	3	0, 4, 8
Diminished Triad	3	0, 3, 6
Major 6th Triad	3	0, 4, 7, 9
Major 7th Triad	3	0, 4, 7, 11
Dominant 7th	4	0, 4, 7, 10
Minor 7th Triad	4	0, 3, 7, 10

Half-diminished 7th	4	0, 3, 6, 10
Diminished 7th	4	0, 3, 6, 9
Sus 7th	4	0, 5, 7, 10
Dominant 9th	5	0, 4, 7, 10, 14
Dominant minor 9th	5	0, 4, 7, 10, 13
Major 9th	5	0, 4, 7, 11, 14
Minor 9th	5	0, 3, 7, 10, 14
Major 6/9	5	0, 4, 7, 9, 14
Minor 6/9	5	0, 3, 7, 9, 14
9th Flat 5th	5	0, 4, 6, 10, 14
9th Sharp 5th	5	0, 4, 8, 10, 14
Dominant 11th	5	0, 7, 10, 14, 18
Minor 11th	6	0, 3, 7, 10, 14, 17
Unison 5	5	0, 0, 0, 0, 0
Unison 7	7	0, 0, 0, 0, 0, 0, 0

1.2 Operator controls



Notes:

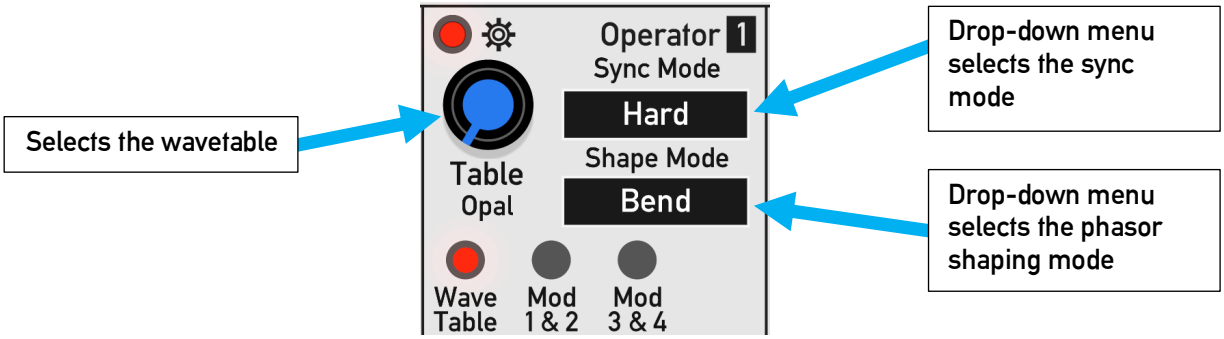
- All CV inputs operate between 0-10V and are scaled by the input attenuverters.
- All knobs act as an offset when combined with CV e.g. Operator Level = "Level Knob" + "Level CV1" + "Level CV2".

1.3 Operator settings menu

An operator's settings menu is accessed by clicking on the button next to the gear icon at the top left of the operator column. The menu is spread across 3 pages: Wavetable, Mod 1 & 2, and Mod 3 & 4.

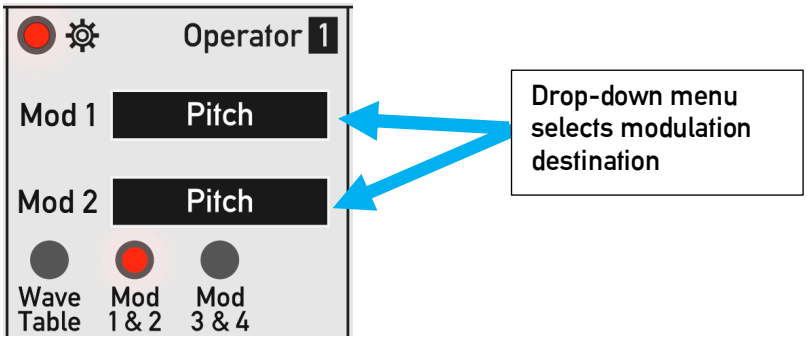
1.3.1 Wavetable Menu

This menu allows you change the operator's wavetable (or bank), and the sync and phasor shaping modes / methods (see sections 3.3 and 3.4 for more details).



1.3.2 Assignable modulation menus

Dexter features 4 assignable modulation inputs. These two menus allow you to route each modulation input to 13 different operator parameters.



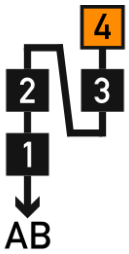
The following table gives all of the possible modulation destinations:

Destination	Description
Pitch	V/Oct modulation of the operator's pitch
Multiple	Operator's frequency multiplier
Wave Position	The position of the wave table the operator reads from
Wave Bank	Selects which wave bank the operator reads from
Shape	Operator's shape
Level	Operator's level
Ext FM	External FM input that is mixed with the operator's modulator's signal
Ext Sync	External synchronisation input. Syncs when a zero to positive transition is detected
Shape Mode	Selects the phasor shaping mode
Post Shape	Selects if the FM is performed before or after the phasor shaping
Sync Mode	Selects the operator's sync mode
Sync Enable	Activates the operator's synchronisation mode
Weak Sync	Enables weak synchronisation

2. Basic usage

Insert a copy of Dexter and connect the **A L** output to an **Audio Interface** output.

When the module is first inserted or re-initialised, the level of operator 1 is already at maximum and has a pitch multiplier of 1. You should be able to hear a pure tone. Changing the **Mult**, **Coarse** and **Fine** controls changes the pitch. It is best to leave **Coarse** and **Fine** in their default settings for now. Changing the wave and shape controls will change the timbre of the tone.



Looking at the algorithm diagram above, in its initial state you can see 1 goes to the AB output. The algorithm not only say what it sent to the output, but what operator is modulating another. In this algorithm 4 modulates 3, which modulates 2, which modulates 1. This is the key to FM synthesis:

- Complex sounds are generated by modulating operators with other operators, or carriers.

Also notice that operator 4 is highlighted orange. This means that it can self-modulate, and the depth for that is controlled by the orange FB knob in the Master Control section.

Now, turning up the level of operator 2 you'll hear the tone become richer as 2 increasingly modulates 1. This is much like controlling the cutoff frequency of a filter. Changing the multiplier of either operator will again result in different yet harmonious / pleasing timbres. The results are harmonious because the multiplier values between operators are related. These are also important aspects of FM synthesis:

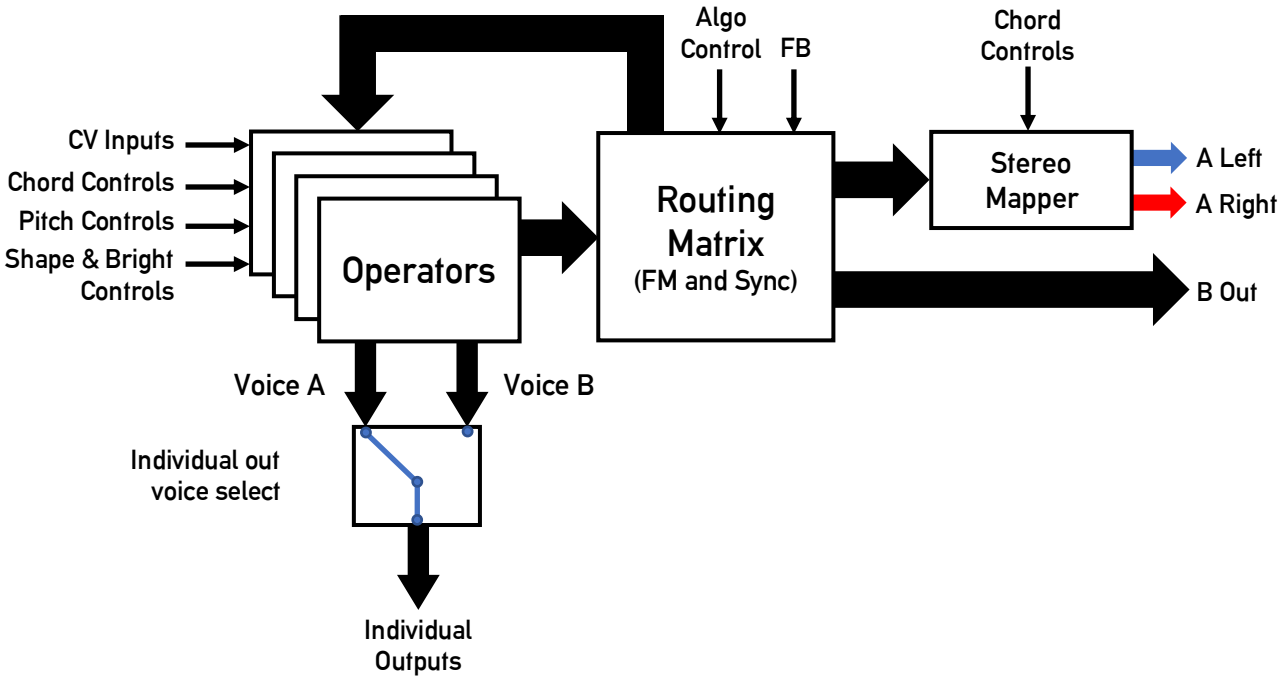
- Level controls the depth of the timbre.
- Multiplier controls the overall harmonic content and distribution in a pleasing manner.

If the multiplier values between operators are unrelated i.e. the **Coarse** and **Fine** controls are tweaked, the results become dissonant / clangourous / bell-like / metallic etc.

Inserting a jack into the **A VOct** input allows you to control the pitch of Voice A of Dexter, and the same goes for Voice B by inserting a jack into the **B VOct** input. Inserting jacks into the operator CV inputs allows you to modulate almost anything in the operator. The most common thing to do is to connect LFOs and envelopes into the level CV inputs as to modulate the level of each operator, controlling either the output volume if the operator is at the end of an algorithm and is connected to an output, or the depth of modulation if an operator is modulating another.

3. How it works

Dexter features 4 operators shared between two "Voices", A and B. Voice A is able to output chords of up to 7 notes spread across stereo outputs (A L and A R), whilst Voice B outputs a mono signal from "B Out". Both voices can be independently tuned allowing for multi-timbral patches. The individual operators outputs, OP 1 to 4, output a signal directly from an operator of either Voice A or B regardless of the chosen algorithm.



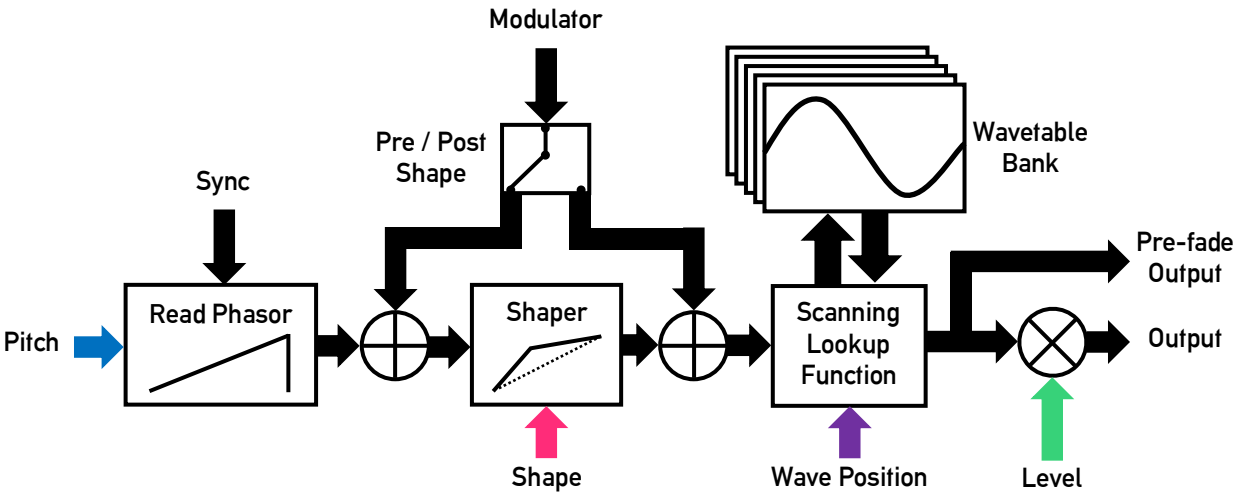
3.2 Operators

The operators generate a tone using lookup wavetable synthesis using a rising ramp, known as a read phasor, to read the contents of a table. Waves can be scanned through by cross fading between adjacent tables within the same bank of tables. FM synthesis is achieved by offsetting the read phasor's value with another signal, effectively speeding up / slowing down the read speed. Whilst this is technically known as phase-modulation (PM) and is not true FM, this still modulates the frequency and gives the same effect. If anything, PM is easier to implement, and it is the standard method in commercial hardware FM synthesizers such as the DX series. To expand the versatility of FM synthesis, the read phasor can be shaped in several ways that can distort and mangle the output waveform. Dexter offers 12 shaping modes. By default, the modulator signal is added to the read phasor before shaping, however it can be added post shaping by engaging the "Post Shpe" button. This allows for an alternative timbre and at times can make the shaping sound more pleasant.

Shape Mode	Description
Bend	The phasor is dragged to one side from the middle so that the 1st half of the table is read faster than the last half.
Tilt	The phasor reads the table faster and then waits at the end until a new cycle begins
Lean	The phasor follows a curve, so the table is initial read faster then gradually slower towards the end of the cycle.
Twist	Twists the middle third of the phasor around the centre, making it read the table forwards, backwards, then forwards again.
Wrap	The end of the phasor is wrapped back to the beginning several times between 0 and 1, creating a hard sync like effect
Mirror	Both the beginning and end of the phasor are mirrored when either reaches 0 or 1
Reflect	At a given point, the phasor is switched from an upward ramp to a downward ramp.
Pulse	The phasor is switched off and on at several positions, giving a type of PWM effect.
Step 4	Blends the phasor into a 4-step staircase, creating a very lo-fi sound
Step 8	Same as above but with an 8-step staircase
Step 16	Same as above but with a 16-step staircase
Var Step	Gradually makes the phasor increasingly stepped until it stops completely.

Finally, each operator can be synchronised in up to 15 different modes. The last two sync modes, are one-shot modes meaning an operator will only oscillate for one cycle when it detects a sync event. Sync events are triggered when a sync signal rises above 0V. Operators sync using a "beginning of cycle" pulse, however external sync relies on the zero-crossing of a raw waveform. By engaging the "Weak" button on the front panel, the synchronisation will only occur when the destination operator's phasor is in the first quarter of its cycle regardless of modulation or shaping.

Sync Mode	Description
Hard	Classic hard sync effect where the phasor restarts from the beginning
5th	Reads the table 1.5x fast until another sync event where it returns to 1x
+1 Oct	Reads the table 2x fast until another sync event where it returns to 1x
-1 Oct	Reads the table 0.5x fast until another sync event where it returns to 1x
Rise 1	0.5 is added to the read speed until it reaches 2x and then returns to 1x
Rise 2	0.5 is added to the read speed until it reaches 4x and then returns to 1x
Fall 1	Same as Rise 1 but in reverse
Fall 2	Same as Rise 2 but in reverse
Pull 1	Is pulled back 1/2 a cycle
Pull 2	Is pulled back 1/4 a cycle
Push 1	Is pushed forward 1/4 a cycle
Push 2	Is pushed forward 1/2 a cycle
Hold	Is held at its current value until the next sync signal
One Shot	Waits for sync signal before performing 1 cycle, however it is hard synchronised.
Lock Shot	Same as above but without hard sync, creating a harmonic locking effect.



3.3 Wavetables

Dexter features 35 different wavetables, providing a vast pallet of timbres and textures to work with. By default the "Opal" table is loaded, but this can be changed by going to the "Wavetable" page in the settings menu, and turning the blue wavetable knob to select another table. The following list gives a description about each table.

Table Name	Description
Opal	Based on the waves from a chip used in an early 90's PC soundcard
Basic	Sine, Triangle, Sawtooth and Pulse with PWM
TeeEks	Waves from a popular 1U rack unit FM synthesiser
SinHarm	Sine wave that increases in harmonic pitch
AddSin	Sine wave with harmonic overtones that increase with pitch
AMHarm	Sine wave that increases in harmonic pitch but also amplitude modulated with another sine wave
SwpHarm	Sine wave that increases in harmonic pitch but also amplitude modulated with a falling ramp wave. Mimics a resonant filter sweep.
AddSaw	Additive synthesis of a sawtooth wave using an increasing number of partials.
AddSqr	Additive synthesis of a square wave using an increasing number of partials.
AddBank	Waveforms generated from partials with random harmonics.
Oboe	Single cycle wave snippets of an oboe.
Sax	Single cycle wave snippets of a saxophone.
Cello1	Single cycle wave snippets of a cello.
Cello2	Single cycle wave snippets of a cello.
Violin	Single cycle wave snippets of a violin.
Piano	Single cycle wave snippets of a piano.
OvrTne1	Soft yet rich in harmonic overtones
OvrTne2	Soft yet rich in harmonic overtones
Sym	Symmetrical above and below the 0V line
Chip1	Lo-fi computer tones
Chip2	Lo-fi computer tones
BitCrush1	Bank of heavily bitcrushed waveforms
BitCrush2	Bank of heavily bitcrushed waveforms
Voice1	Softer, choir vocal tones
Voice2	Richer, choir vocal tones
Voice3	Vowel tones
Voice4	Vowel tones

Voice5	Nasal vocal tones
PWM	Pulse width modulated square wave
BiPls	Square wave that is gradually "pinched" to middle of the wave cycle
SawGap1	Saw wave with a gradually increasing gap in the middle of the wave cycle
SawGap2	Saw wave that is gradually "pinched" to middle of the wave cycle
VGame	Collection of lo-fi video game type waveforms.

4. Connectivity

Half of Dexter's front panel is covered in jacks, where most of these are in fact CV inputs. However, there is a lot a of repetition so try not to be intimidated. The following table describes the functionality of each jack:

Outputs

A L and A R	Stereo outputs of voice A. Chord notes are spread between the L and R outputs, or summed to the L output if only L is connected.
OP 1 to 4	These are the individual output taps from a voice's operators. Can be either post or pre-fade level.
B Out	Mono output of voice B.

Master Inputs

A and B VOct	Volts per octave pitch control of voices A and B
Chord	Chord CV
Inv	Chord inversion CV
Detune	Chord detune CV
Algo	Algorithm CV
FB (Feedback)	Feedback CV
Bright	Brightness CV
Shape	Shape CV

Operator Inputs

Pitch	Volts per octave pitch control. *Note: Multiple can be controlled via an assignable mod input.*
Wave	Wave CV
Shape	Shape CV
Level	Level CV
Mod 1 to 4	Assignable CV modulation inputs

Note: All inputs operate between 0 – 10V and feature an attenuverter.