Mantis

WORKSHOP MANUAL

A user's guide...



Chris Huggett 1949 – 2020

Chris Huggett, now sadly no longer with us, designed most of the Mantis: the underlying hybrid principle, the original design of the digital oscillators and the analogue signal processing. He also designed the control panel layout and functionality in collaboration with Paul Whittington.

Chris is an important and innovative figure in the history of synthesiser development, going back to the early '80s analogue EDP Wasp*, the OSC Oscar* – renowned for its filter implementation – and later, numerous synths and other devices under the Novation label.

Chris and Paul collaborated closely on the Mantis concept and after his cancer became terminal, Chris expressed a wish that Paul should complete the project. Paul thus saw that he had a mission to honour Chris's lifetime of work by completing the design and putting Mantis into full production.

*The Electronic Dream Plant Wasp and Oxford Synthesiser Company OSCar are two well-known synths designed by Chris Huggett.

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Introduction

Welcome to the PWM Mantis, we just know you're going to have a lot of fun with it. We set out to design an instrument that's different from most others, yet easy to get grips with, and above all, is capable of generating some absolutely great and unique sounds... and we're really proud of what we've come up with!

Do register for the PWM User Group at www.1pwm.com: we'll help you stay current with firmware updates and hints and tips from other owners.

This User Guide will help you understand the thinking behind Mantis's design and to discover some of its less obvious features. But most fundamentally, what you should know is that it's a *hybrid* synth. This means that the sound generation sections are *digital* – giving you a great deal of control flexibility plus the power of wavetables – while the primary sound processing sections use traditional *analogue* filter and VCA designs, with the distinctive sound character we associate with many classic synths. Finally, there's a *digital* effects section, letting you treat your sounds with reverb and chorus.

Mantis can be played in monophonic, duophonic, or four-voice polyphonic modes, though it's important to note that each voice can be sourced from up to four oscillators, so you can create some really thick and heavy sounds.

Mantis has two LFOs, two envelope generators (with more than the usual ADSR), numerous filter options, a comprehensive but simple-to-use arpeggiator section, and a logically presented set of modulation options. It comes with 200 patch slots, 100 of which are preloaded with great sounds designed by some top sound designers.

Mantis has full MIDI implementation, so it's easy to integrate into your existing set-up or to use it as a keyboard controller for other software or hardware synths.

Apart from this User Guide, you'll find additional hints and tips in our videos at youtube.com/@1pwm. Do contact us at support@1pwm.com with any issues you may have. Plus - comments and suggestions are always welcome, we're very approachable! You can find everything at www.1pwm.com/mantis.

Thanks again for investing in Mantis.

Legal bits.....

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Mantis – what it is and what it does

- Four-voice polyphonic hybrid-analogue synthesiser
- Chris Huggett-designed digital oscillators generating sine, sawtooth, triangle and pulse waveforms
- Additional Pipe Organ and wavetable oscillator waveforms, plus nine original OSCar™ wavetables
- Chris Huggett-designed analogue signal path
- 37-note keyboard with aftertouch and velocity sensing
- Octave shift: -4 to +3 octaves

Patches:

- 200 patch memories – 100 preloaded with factory patches, 100 User
- Compare and Initialise functions, plus ten levels of Undo

Oscillators:

- Two primary oscillators, each with six mathematically generated waveshapes, plus nine original OSCar™ wavetables
- Eight octave range
- Shape control
- Shape and pitch modulation
- Separate Sub oscillator follows OSC 1 one octave lower
- OSC 2 has drift and density parameters
- Noise source
- Ring modulator

LFOs:

- Two LFOs, each with six waveshapes
- Fade in/out
- Rate control or locks to external sync
- One-shot mode

Filter section:

- Two analogue filters, one per signal path
- Configurable as lo-pass, hi-pass or band-pass, with 12 dB/oct or 24 dB/oct slopes
- Additional Wide Band and Notch filter modes
- Frequency and width modulation
- Key track and Resonance controls

Envelopes:

- Two independent envelopes: ENV 1 controls amplitude by default
- ADSR controls, plus control of additional Velocity and Sustain Fall parameters
- Repeat mode retriggers envelope to create looping effect

Arp:

- Six arp modes
- One- to six-octave range
- Adjustable positive or negative swing
- Syncs to internal or external clock
- 13 arp rates available as ratios of base clock rate, including dotted notes and triplets
- Tap tempo button

Modulation:

- Six mod sources
- Six mod destinations
- Six scaling factors including aftertouch, velocity and joystick controller

Digital Effects:

- Reverb with decay and level controls, plus HP and LP filters
- Four Chorus modes with level control

Other features:

- Variable Glide with Auto mode
- Legato mode selectable for each envelope
- X-Y joystick controller defaults as mod and pitch bend performance controls
- Master tune and master volume controls
- Powered by external DC PSU (9 V) or via USB connection

What's In The Box

Please check that everything listed is present and correct. If anything is missing or damaged, please let the dealer who supplied your Mantis know immediately.

In the box, you should find:

- PWM Mantis synthesiser
- 2 x detachable end cheeks
- Getting Started Guide
- List of factory patches, with sound designer credits
- 1.75 m USB cable, Type 'A' to Type 'C'
- Mains power supply with interchangeable plug heads to suit various territories

Fitting the end cheeks

You don't have to fit them – it's up to you. We think they look nice and we like the green colour. If you disagree strongly about the colour (maybe they clash with the rest of your stage rig!), let us know, as the 3D printing files are freely available to let your imagination run riot.

The cheeks attach magnetically; there are ten small round magnets on each end of Mantis and the end cheeks have a steel insert. Just offer them up to the synth and ensure the lip of the cheek engages with the rebate on the end of the synth all the way round. Easy!

Powering Mantis

There are two ways of powering Mantis: with the supplied mains power supply unit (PSU), or via USB.

Via the mains:

The plug-top PSU has interchangeable plug heads: it should come with the correct head for the country where you live (or at least, where you bought your Mantis!) A selection of alternative plug heads is supplied.

The PSU's DC cable is fitted with a standard 5 mm coaxial connector: plug this into the socket marked 9V DC on the synth's rear panel.

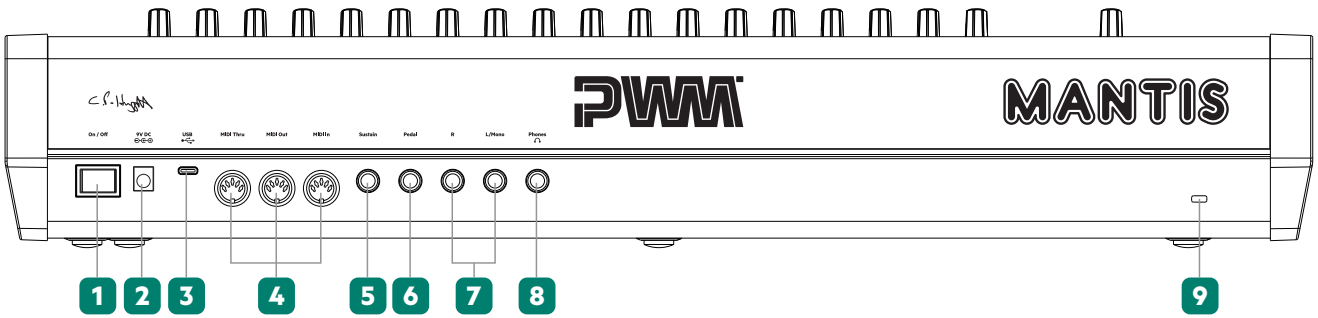
The PSU is rated at 9 V DC, 600 mA; it will operate on mains voltages between 100 V and 240 V AC, 50/60 Hz. The coaxial connector is "centre-positive". If it is necessary to operate Mantis from an alternative PSU, ensure that that it meets these specifications.

Via USB:

Mantis has a USB Type 'C' socket on the rear connector panel: you can connect this to a USB Type 'A' port on a computer or other device using the cable supplied, and it will draw its power from the device. Note that if the device is a laptop, we recommend that you power it from the mains, as the additional DC load of the Mantis will drain the laptop battery more quickly than you might expect.

NOTE: Mantis will not object if you use the mains PSU at the same time as the USB connection. It's been designed with this in mind.

Rear Panel - connections



1. ON/OFF - guess what this does?

2. 9V DC - coaxial socket for connecting mains PSU.

3. USB - Type 'C' USB port; connect to computer or other external device. Mantis can be powered via this connection; it is also used for passing MIDI data (bidirectionally), and for firmware updates.

4. MIDI Thru, MIDI Out and MIDI In - standard set of 3 x 5-pin DIN sockets allows Mantis to be interfaced to similar MIDI-compatible equipment.

5. Sustain - 1/4" TS jack socket for connection of a sustain pedal. Mantis auto-detects whether the pedal is an NO or NC type.

6. Pedal - 1/4" TRS jack socket for connection of an expression pedal*.

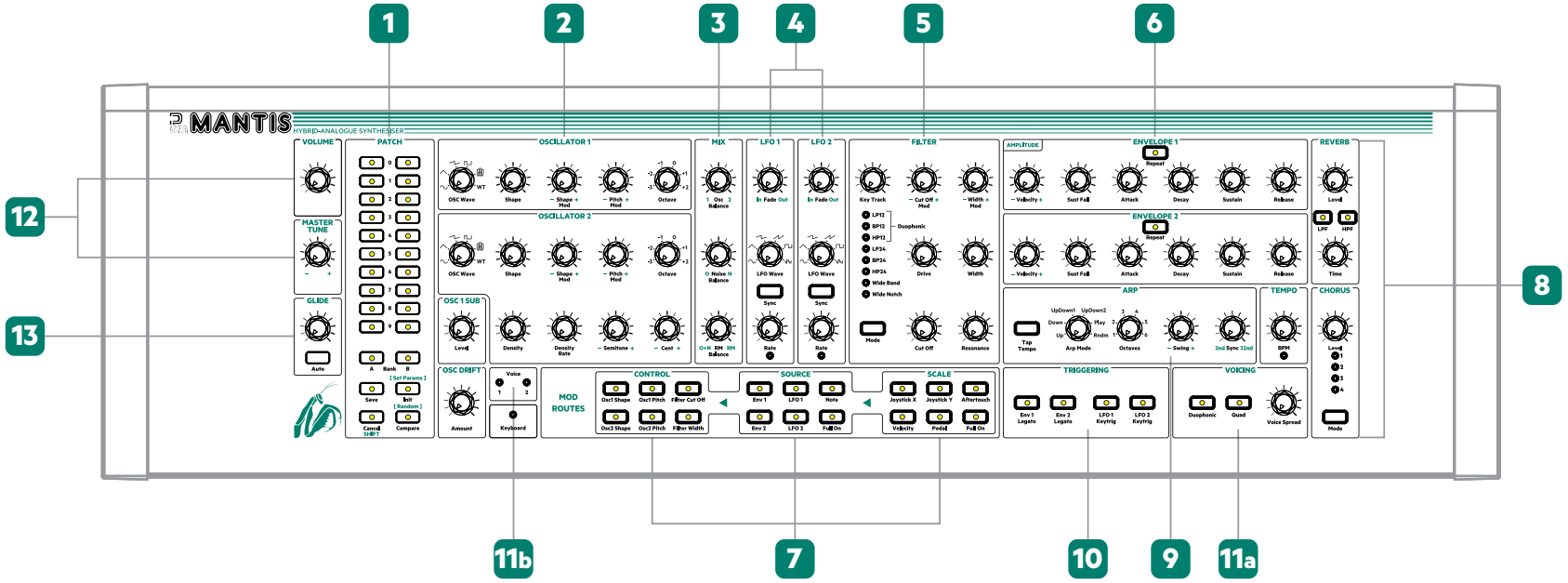
7. R and **L/Mono** - main outputs. The outputs use ¼" TS jacks, are unbalanced and have a maximum level of approx. +9 dBu (3 V peak-to-peak). Use both sockets if working in stereo; inserting a jack into L/Mono only will cause the synth's stereo signal to be summed to mono.

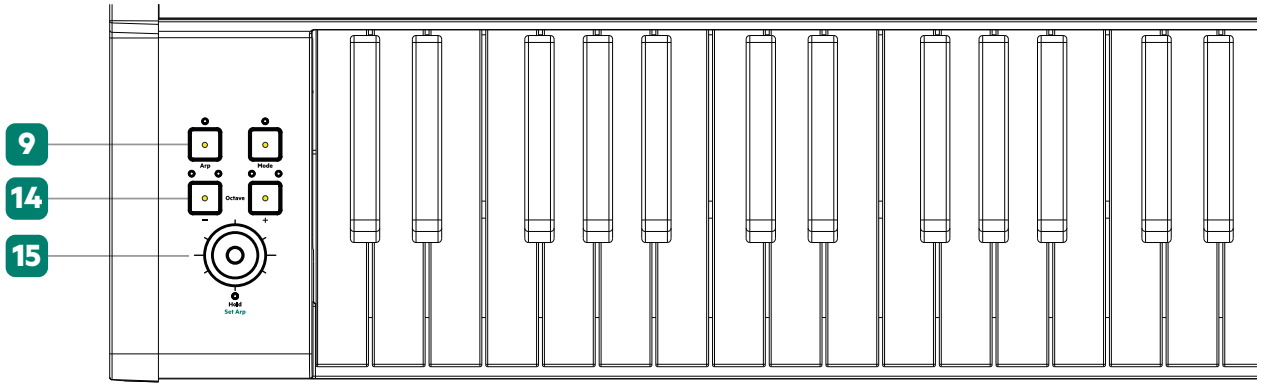
8. Phones - if working on headphones, connect them here. Mantis has been designed to work with headphone impedances of between 32 to 250 ohms. You can use headphones at the same time as the main outputs.

9. Security lock aperture - you can use this to physically secure your Mantis to a keyboard stand, shelf or whatever.

*Various standards exist for the wiring of expression pedals. Mantis's TRS jack is wired thus: T (tip - sensed voltage from pedal; R (ring) - reference voltage for pedal; S (screen) - 0 V. PWM can confirm that pedals from M-Audio and Roland work correctly with Mantis. The user should check the wiring of other pedals.

Top Panel - Overview





Mantis's controls are laid out on the control panel in a logical order, broadly following the signal flow from left to right (though there are one or two exceptions!)

Each control panel section is described in detail further on in the User Guide, but here is a summary:

1. PATCH – Mantis comes with 100 factory patches and there's space for another 100 of your own.

2. OSCILLATORS – it looks like Mantis only has two oscillators per voice (see #11 below), but there are actually four: OSC 1 has a separate sub oscillator and OSC 2 has two oscillators, one of which can be detuned against the other.

3. MIX – lets you mix the oscillator outputs together, add noise and route the mix through a ring modulator as well.

4. LFOs – Mantis has two Low Frequency Oscillators (LFOs): you can set up control routings for the LFOs to modulate various oscillator and filter parameters.

5. FILTER – the analogue filter section tailors the tonal properties of the waveform. It has a range of filter types: hi-pass, lo-pass and band-pass, plus drive, width and resonance controls.

6. ENVELOPES – the envelopes define how the sound changes over time after you've played a note. Mantis has two analogue envelope generators: ENV 1 will always control the amplitude – or "volume" of the note, but both can be used to vary other parameters as well.

7. MOD ROUTES – Mantis allows for up to six simultaneous modulation routings; the controls are divided into three sections: **CONTROL** (what gets altered), **SOURCE** (what Mantis part does the altering) and **SCALE** (the manner and range of alteration available to the player).

8. REVERB & CHORUS – these are digital effects which can be added to the final sound.

9. ARP – the arp ("Arpeggiator") section will automatically play a set of notes in sequence, in various ways. You can set the arp tempo manually, or sync it to other instruments. Note there are further arp controls to the left of the keyboard.

10. TRIGGERING – these controls determine what the envelope generators and LFOs do when you play in legato style (playing a second note while a first is still held).

11. VOICING – Mantis has four levels of polyphony – mono, duophonic and quad, plus a fourth mode which combines aspects of duophonic and quad. At the simplest level, the polyphony mode defines how many notes can sound simultaneously.

12. The **VOLUME** and **MASTER TUNE** controls are master controls that are always operational. The first should be self-explanatory, **MASTER TUNE** lets you tweak the synth's overall tuning. Note that the settings of these two controls are not save with a patch.

13. GLIDE does just that – it adds a glissando between consecutive notes. However, note that the precise way Glide works depends on which voice mode is selected.

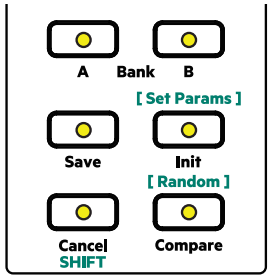
14. Octave – these buttons shift the entire keyboard up or down in pitch by one or more octaves.

15. Joystick – by default, this replaces the pitch and mod wheels found on other synths, but its use can be reassigned by altering the modulation routing. It also has a push function which switches Mantis's Hold mode between momentary and latching.

The Controls in detail

Some general points:

SHIFT functions:



Some Mantis controls – both push-buttons and knobs – have “second functions”, which are selected when you hold down the **SHIFT** button in the **PATCH** section while pressing the button or turning the knob in question. The most commonly needed shift functions have green text in green square brackets adjacent to the relevant button or knob, indicating the shifted function.

A full list of all Mantis’s shift functions is included in the Appendix at the end of this User Guide.

Rotary controls:

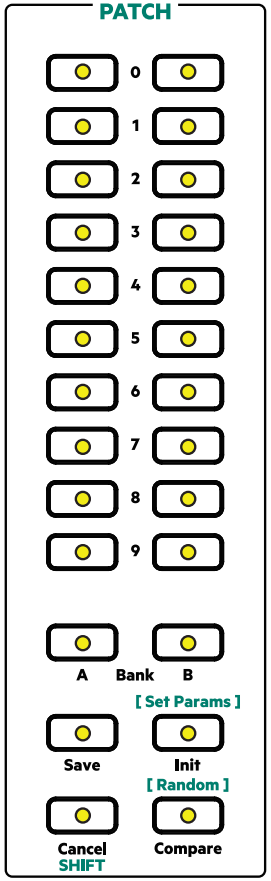
You’ll note that Mantis has two types of continuous rotary controls (i.e., not the rotary switches). Some turn smoothly over their whole range, others have a detent (or “notch”) at their 12 o’clock position. The synth functions with notched type controls are in some sense “bipolar”, that is, they can alter a sound in a positive (clockwise) or negative (anticlockwise) sense. A simple example of this is OSC 2’s **Semitone** control: in the 12 o’clock position the oscillator has standard tuning, but you can alter the pitch up or down by turning it right or left respectively.

Immediate control response

When a patch is loaded, it is likely that many of the controls will be in a different position to where they were when the patch was saved. You will find that Mantis will respond to a new control setting immediately the control is adjusted. This means, for example, that if the patch has a particular parameter set to zero and the corresponding control is “fully up” when the patch is loaded, adjusting that control will immediately set the parameter to its maximum value.

You may not be familiar with this principle: some synths use a “nulling” technique whereby the parameter is not altered until the knob position corresponds to the stored parameter value. We think an immediate control response is more suited to the overall Mantis design.

Patches



The current settings of every Mantis control collectively define every detail of the sound you hear when you play a note. If the settings are stored in memory, the sound is then referred to as a "patch". Mantis lets you store your settings – with the exception of **VOLUME** and **MASTER TUNE** – so that you can recall favourite patches simply and quickly any time you need them.

Patch memories

Mantis has a total of 200 patch memories, arranged in two banks of 100. The banks are called A and B, and the patches within each are numbered 00-99.

You will find 100 factory patches pre-loaded into Bank A's memories. We got some well-known synth wizards to design the sounds, and you will find a list showing the patch names, their memory location and the sound designer at the end of this User Guide. The range of sounds in the factory patches is extremely wide, and you should spend some time listening to them and tinkering to gain an insight into just how powerful Mantis is.

Patch memory protection

Out of the box, Bank A is memory-protected to prevent you from inadvertently overwriting any of the factory patches, while Bank B is empty and available for you to save patches you create yourself – either by modifying factory patches, or building them up from scratch. Bank protection can be overridden if required: hold **SHIFT** and press the **Bank A** or **Bank B** button as required. You can check bank protection at any time by pressing and holding **SHIFT**: If the LED in a Bank button is illuminated, the protection for the Bank is active.

Selecting a patch

A maximum of three button presses is required to load a patch, by entering its location in the form: <bank> <digit 1> <digit 2>. The left-hand column of number buttons are the "tens" of the patch number, the right-hand are the "units".

For example, to recall patch A25, press the **Bank A** button, then **2** in the left-hand column, then **5** in the right-hand column. To change to patch B73, press the **Bank B** button, then **7** in the left-hand column, then **3** in the right-hand column. However, if you're changing to a different patch in the same bank, just enter its two-digit number; you only need to press a **Bank** button when switching between banks. And if you're changing to a different patch in the same "decade" in the same bank (e.g., from B35 to B37) you can just press the button for the second digit. This principle also holds if you're changing patches between decades with the same "second digit" (e.g., from B46 to B66); in this case just press the button for the first digit.

Saving a patch

To save a patch – in other words, to store the current settings of every* Mantis control, press **Save**; LEDs will blink in the **Save** button, and also in the **Bank** and number buttons for the

last selected patch location. Select a different destination location if you don't want to overwrite what's in the currently selected one - you can double-check that the location doesn't contain a patch you want to keep by auditioning with the keyboard at this point. If you're happy you've got the right location, press **Save** again; the LEDs stop blinking after a second or so.

If you think you've selected the wrong patch number before pressing **Save** a second time, you can exit the save procedure by pressing **Cancel**.

If you try to store a patch in a bank which is memory-protected, you'll find the **Bank** button is disabled once you've pressed **Save**, to prevent you from doing so. The **Save** button will have no effect at all if the memory protection in both banks has been enabled.

Initialising parameters

If you intend to create your own sound from scratch, it's often useful to start from a known set of synth parameters. The **Init** button is there for this purpose. (Out of the box, you'll find that the Init patch is pre-loaded into all 100 memory locations of Bank B.) The Init patch gives you a basic sawtooth waveform from each oscillator, but **Osc Balance** is set to OSC 1, so you will initially only hear the OSC 1 tone. All other synth parameters set either off or "neutral": for example, the ENV 1 parameters are set to values that cause a note to sound at full level immediately a key is pressed and stop immediately it's released.

Comparing patches

Holding down the **Compare** button lets you immediately hear the last-loaded patch. This is a very useful feature during sound creation: as you make modifications to a known patch (including the Init patch), pressing **Compare** will let you hear what the original patch sounded like before you made the modifications. When you're happy with the changes you've made, you can re-save the patch to the same location, or to another location if you want to retain your starting point.

You may also listen to other saved patches without destroying the sound you're working on, by choosing them with the patch buttons while keeping **Compare** held down.

Randomising parameters

Parameter randomisation is an unusual and creative feature of Mantis, and is an interesting method of initialisation when setting out to create a completely new sound. **[Random]** is the shifted function of the **Compare** button (hold down **SHIFT** and press **Compare**). It forces every* parameter throughout the synth to adopt a randomly-selected value. You'll lose anything you haven't saved, of course, though you can "back out" by using the Undo function (press **Shift** + **PATCH Tens** – see Appendix 1 on page 52 for full details)

The whole purpose of the Random function is that you'll never know what you're going to get! You'll probably have to select Random several times in succession before you hear something that gives you an idea. But we're sure you'll come across some fascinating and unusual sounds on the way.

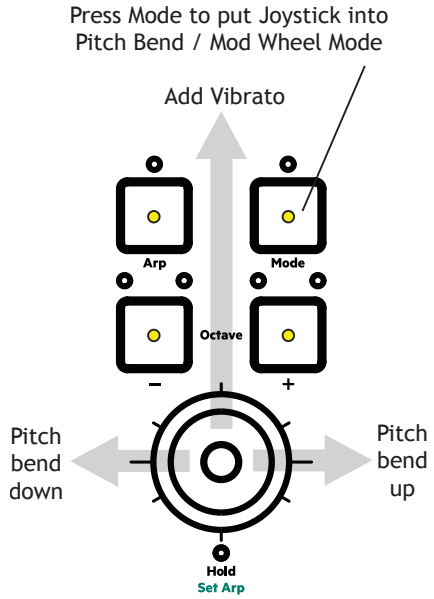
The Set Parameters button

[Set Params] is the shifted function of the **Init** button (hold down **SHIFT** and press **Init**). This creates a patch using the current setting of every rotary control and button. This may make either a minor or a drastic alteration to the sound, depending on how many controls happen to be set in the same positions they were in when the current patch was loaded or created.

*excluding Master **Volume** and **Master Tune**

Pitch and Modulation controls

If you're already familiar with synthesisers, you've probably noticed straightaway that Mantis doesn't have the "standard" Pitch and Mod wheels. Ah! – we've done something slightly different. The joystick to the left of the keyboard performs both of these functions, so really it's just like other synths, only slightly different. We think you'll find quite easy to get used to.



To make the joystick to do what Pitch and Mod wheels do on other synths, press the Mode button above it if it is not already selected: the LED lights when Mode is selected. (Note that most of the factory patches in Bank A, and the Init patch will activate Mode in any case.)

Pitch Bend

Moving the joystick left or right from its centre position will bend the note(s) being played either up (joystick right) or down (joystick left) with a default pitch shift of two semitones with the joystick at its maximum position.

The range of pitch bend can be increased by pressing the **Octave +** button while holding down **Mode**. Each press increases the pitch bend range by one semitone up to a maximum of one octave. Pressing **Octave –** while holding **Mode** down has the opposite effect, and because the default pitch bend range is two semitones, two presses of this (from the default setting) disables the pitch bend function. Use repeated presses of **Mode** + **Octave -** to reduce the pitch bend range if it's been increased by **Mode** + **Octave +**. The LEDs above the **Octave** buttons indicate the number of semitones of pitch bend currently set in binary number format, with the LSB at the right, while **Mode** is pressed.

In case you're not familiar with binary number formats, the table below summarises the pitch bend range indications.

Octave - LEDs		Octave + LEDs		Semitones
○	○	○	○	0 (pitch bend off)
○	○	○	●	1
○	○	●	○	2 (default)
○	○	●	●	3
○	●	○	○	4
○	●	○	●	5
○	●	●	○	6
○	●	●	●	7
●	○	○	○	8
●	○	○	●	9
●	○	●	○	10
●	○	●	●	11
●	●	○	○	12

LED Indications for Joystick Pitch Bend Range
(Hold Mode button while pressing Octave +/-)

Modulation

Moving the joystick forward from its centre position will add vibrato to the note(s) played. This vibrato is generated by a dedicated LFO, and is quite independent of Mantis's two LFO sections. The LFO frequency is fixed, and the shape is a sine wave. The joystick controls its amplitude, so the degree of vibrato increases as you push the stick forward.

You can move the joystick forward at an angle (e.g., 45°) if you want to bend the note and add vibrato at the same time.

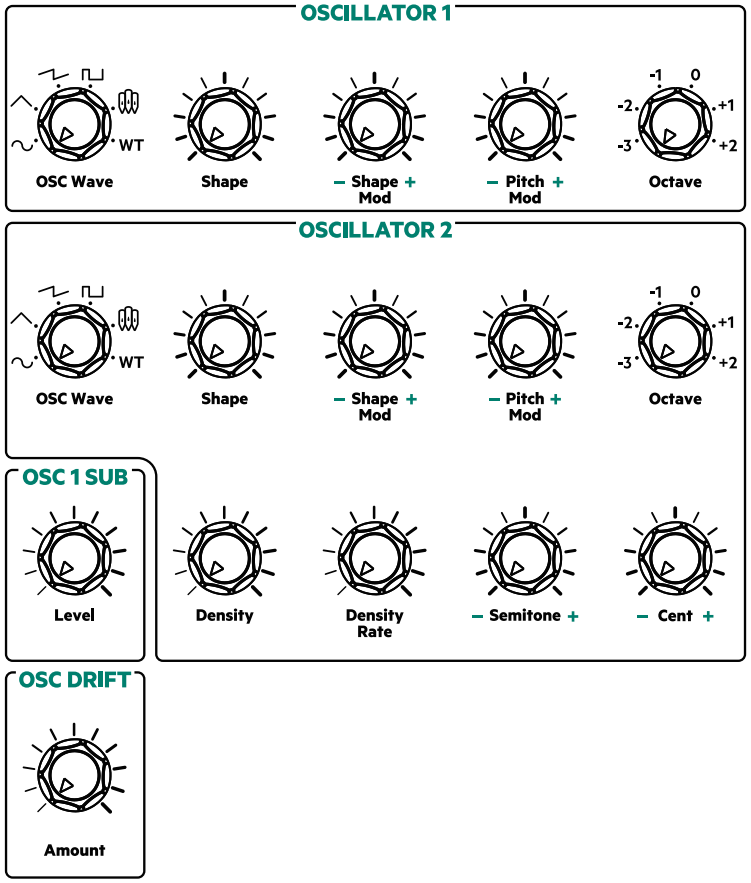
The joystick controls other Mantis functions as well, specifically the Arpeggiator, but these are described in a later section of the Guide. Note that when **Mode** is off, Pitch Bend and Modulation joystick functionality are turned off, but the additional features remain available.

Note Hold

Mantis has a Note Hold function, which allows a note to sound continuously once a key has been pressed. The joystick has a push-switch function to allow Note Hold to be activated. To use Note Hold, first press the joystick down while in its centre position. Then flick the joystick backwards (i.e., towards you): the **Hold** LED will illuminate, and the note held will now continue to sound without the key be pressed.

To stop Note Hold, flick the joystick back again, the note will stop and the **Hold** LED will go out. However, the Note Hold function is still enabled; it will remain so until you press the joystick's push-switch function again. Thus you can simply flick the joystick back while playing any other note, which will then sound continuously instead.

The Oscillator section



Mantis has two main oscillator sections with identical primary controls. However, each oscillator section also has a second "supplementary" oscillator: these differ in function and use for Oscillators 1 and 2.

Controls duplicated for OSC 1 and OSC2:

Oscillator 1's set of five primary controls is duplicated in Oscillator 2, so looking at these first, from left to right:

- **OSC Wave** – sets the oscillator to generate one of six waveforms. Note that the triangle wave is derived from a wavetable, while sine, sawtooth, pulse and organ waves are mathematically generated.
  - ∿ – sine wave
  - ∧ – triangle wave
  - ⟋ – sawtooth wave
  - ⊓ – square/pulse wave
  -  – a custom combination of waveforms which emulates a pipe organ
  - **WT** – a waveform derived mathematically from a wave table. The wave table has seven segments: you can select which segment is used by adjusting the Shape control. As you rotate Shape, the waveform actually morphs between segments, so you'll find that intermediate settings between adjacent segments produce a waveform which is a hybrid of the two either side.

In addition to the six waveforms above, Mantis comes with a set of nine OSCar wavetables, an emulation of the original 1980s Oxford Synthesiser Company's OSCar analogue synth. Both oscillators are able to use these. They are described in detail at the end of this section, see page 53.

- **Shape** – modifies the waveform's shape, and consequently alters its harmonic content. The different methods of waveform generation used

in Mantis (wavetables and mathematically-derived ones) means that the **Shape** control works in a different way with each.

Note that **Shape** is a centre-detented control, with a different effect on some wave shapes depending which way it's turned. **Shape**'s exact effect varies with the setting of **OSC Wave**, but generally lets you add upper harmonics to the basic waveform. With sine, sawtooth and pulse waveforms, the wave shape has no extra harmonic content when **Shape** is in its centre position; with a triangle waveform the most basic waveshape is produced with the control fully anti-clockwise. Other settings alter the wave shape giving you different sets of odd or even harmonics: e.g., with a sawtooth wave, the pitch is effectively an octave higher with **Shape** at maximum (either way); with a square wave, the 1:1 mark-space ratio is reduced dramatically to a thin pulse shape.

Triangle waveforms are derived from a wavetable, and the **Shape** control applies a hard distortion function in this mode. Increasing the setting of **Shape** adds more intense harmonics.

With OSC Wave set to , **Shape** changes the mix of harmonics in a manner that is intended to emulate the action of traditional organ drawbars. With **Shape** in its centre position, the waveform emulates a so-called Shepard tone*, with 1st, 2nd, 4th, 8th, 16th, etc. harmonics. Anticlockwise settings replace the 2nd and 4th harmonics with the 3rd and 5th , giving it a squarish quality. Clockwise rotation removes the fundamental and provides an even harmonic sequence of the 2nd, 4th, 6th, 8th, 16th etc.

- **Shape Mod** – modifies the waveform shape in the same way as the **Shape** control, but does so under the control of another part of the synth, as set up in **MOD ROUTES**. For example, if an LFO (a mod **SOURCE**) is set to vary **Osc1 Shape** (a mod **CONTROL**), the amount of wave shape modification will be varied cyclically by the LFO. The effects of **Shape** and **Shape Mod** are "summed" together, so you can alter the basic waveform with **Shape**, and then dynamically vary the resulting sound with **Shape Mod**. **Shape Mod** is a centre-detented control, and thus has zero effect when set centrally, and a subtly different effect when turned left or right.

- **Pitch Mod** – the pitch of the oscillator can be varied by another synth section using **MOD ROUTES**. **Pitch Mod** controls the "amount" of pitch variation. It's centre-detented, so in its central position the oscillator produces notes at a steady pitch. If, for example, you program **MOD ROUTES** to make an LFO to vary **Osc1 Pitch**, the pitch of the oscillator will wobble above and below the note played, producing a vibrato effect. The degree of pitch variation is determined by **Pitch Mod**: a clockwise setting will produce a rising pitch from a positive-going mod source, e.g., a rising LFO sawtooth, and an anticlockwise setting will have the opposite effect.

- **Octave** – lets you alter the pitch of the oscillator in one octave increments. With **Octave** set at **0**, the oscillator is at standard pitch. You can shift the pitch of the whole oscillator up by one or two octaves, or down by one, two or three octaves, with the **Octave** control.

*A Shepard tone is basically a superposition of sine waves an octave apart. They can be a very interesting auditory phenomenon, see https://en.wikipedia.org/wiki/Shepard_tone for more information!

One other common control:

There is only a single **OSC DRIFT** control, and it affects both Oscillators.

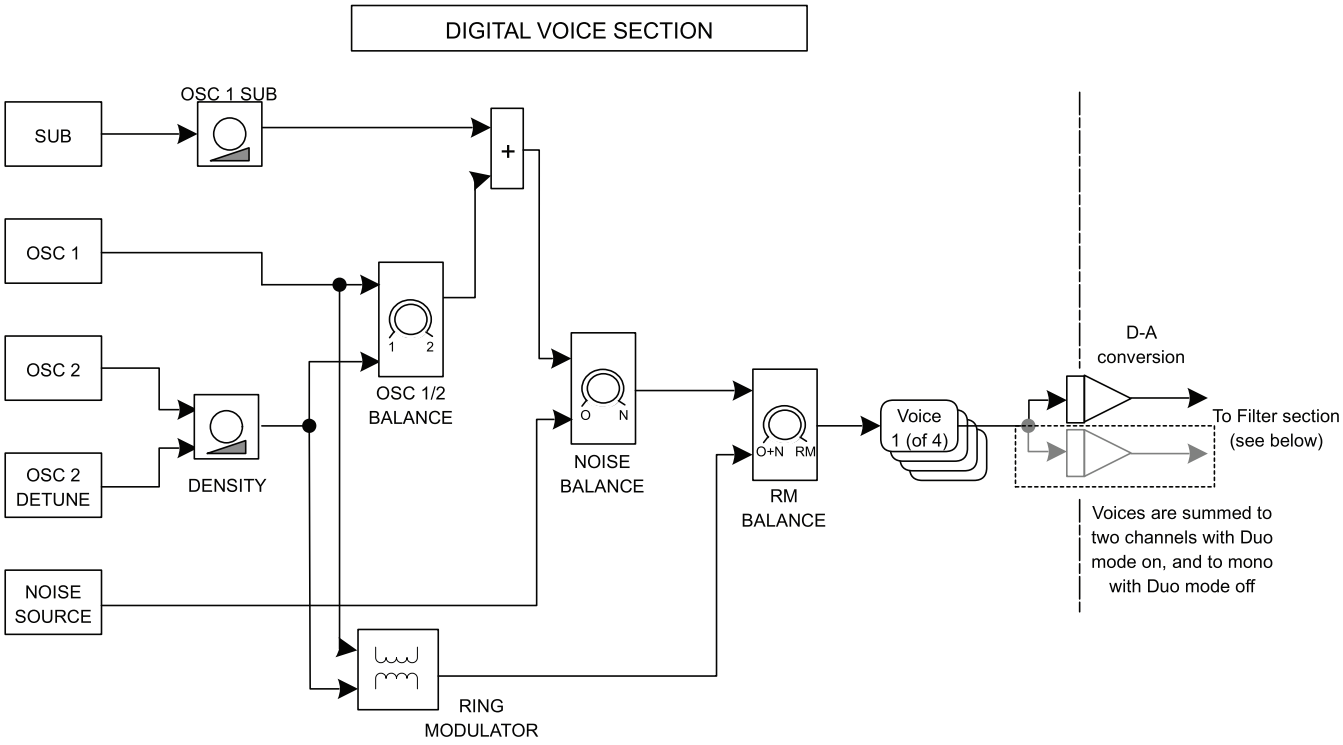
- **OSC DRIFT** – This applies a very slight wandering pitch detune to both Oscillators: the control sets the "amount" of drift that occurs. The effect is subtle, but is intended to emulate the inevitable pitch errors that early analogue synthesisers exhibited, and which is now seen as a recognisable element of their characteristic sound.

Control specific to OSC 1:

- **OSC 1 SUB** – Oscillator 1 has a second, supplementary oscillator, which always generates a sine waveform one octave below the main oscillator. This can add extra depth to whatever other waveforms are in use, and the **OSC 1 SUB** control is essentially its volume control. The sub oscillator output is mixed with the sum of OSC 1 and OSC 2.

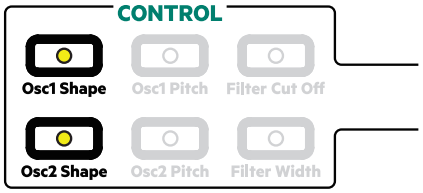
Additional OSC 2 controls:

- **Density** - Oscillator 2 also has a second "hidden" oscillator which runs at a fractionally different frequency to the main oscillator. The purpose of this Density Oscillator is to add a slightly off-pitch component to "thicken up" the sound: the **Density** control sets how much of this is added.
- **Density Rate** – when two similar waveforms at slightly different frequencies are combined, they produce an audible "beat". The frequency of this beat is the difference of the frequencies of the two original waveforms. For example, if we mix two waveforms with fundamental frequencies of 1,000 Hz and 1,002 Hz, we'll hear a slow "pulsing" effect at a rate of 2 Hz. **Density Rate** sets the pitch of the Density Oscillator, so as its setting is increased, the difference between the Density Oscillator's pitch and OSC 2's main pitch will increase. At low settings, you'll hear the slow beat between the oscillators. As the rate is increased, the beat will become faster until it is eventually perceived as two separate pitches.
- **Semitone** – think of this as a "coarse" pitch control for OSC2. It has a range of ±1 octave: at its centre-detent position, the oscillator will sound at keyboard pitch. Its main function is to allow you to add a second tone to the note generated by OSC 1. The control's range is "quantised" – if you turn it slowly, you will hear that it alters OSC 2's pitch in semitone increments, making it easy to set OSC 2 in a correct musical relation to OSC 1.
- **Cent** – as **Semitone** is OSC 2's coarse pitch control, Cent is its fine control, with a range of ±1 semitone. You can use Cent as an additional way of imparting slight variations to the sound. Also, setting **Cent** to its central position ensures that the oscillator is exactly in tune with Oscillator 1.


DIGITAL VOICE SECTION
SUB
OSC 1 SUB
OSC 1
OSC 2
OSC 2 DETUNE
DENSITY
NOISE SOURCE
+
1
2
OSC 1/2 BALANCE
RING MODULATOR
O
N
NOISE BALANCE
O+N
RM
RM BALANCE
Voice 1 (of 4)
D-A conversion
To Filter section (see below)
Voices are summed to two channels with Duo mode on, and to mono with Duo mode off

The OSCar wavetables

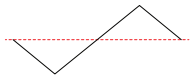
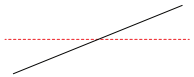
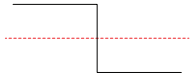
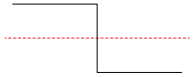
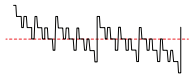
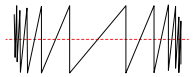
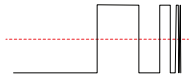
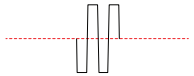
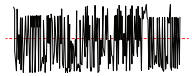
The OSCar waveforms are accessed with a shifted function of the two **OSC Shape** buttons in the **CONTROL** group of the **MOD ROUTES** section of the control panel.



To select an OSCar waveform:

- Select **WT** on the **OSC Wave** control for the oscillator in use
- Hold down **SHIFT** and press **Osc1 Shape** (or **Osc2 Shape**); its LED will blink
- You can now select one of nine OSCar waveforms by pressing the Units buttons **1** to **9** in the **PATCH** section
- Press **Osc1 Shape** or **Osc2 Shape** to exit the shifted function with the new waveform in place, or press **Cancel** to exit and revert to the previous selection. Patch selection will revert to normal.

The nine waveforms available are:

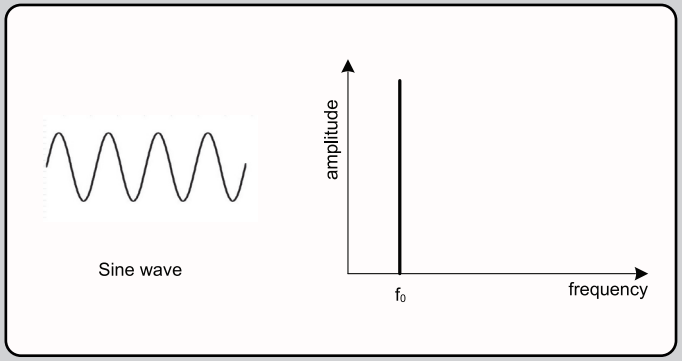
Select by Units Patch button	Name	Waveform
1	Triangle	
2	Sawtooth	
3	Pulse	
4	Pulse (modulated)	
5	Organ	
6	Harpsichord	
7	Strong Lead	
8	Double Pulse	
9	High-Density	

SYNTH TUTORIAL 1 - SOUND BASICS

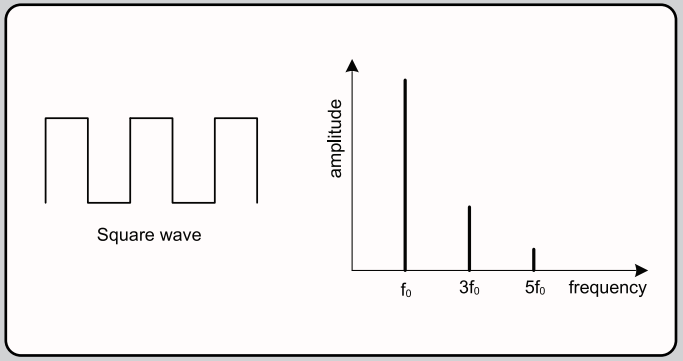
Why do a piano, a trumpet and a church bell sound completely different even when they play exactly the same note? The answer is actually quite simple, but we need to understand why each - or indeed, any sound - sounds the way it does.

There are two fundamental processes at work here, which together, give a musical instrument the characteristic sound that enables us to immediately recognise what the instrument is. The first is harmonic content: different instruments naturally produce different combinations of harmonic frequencies, and each harmonic will differ in amplitude.

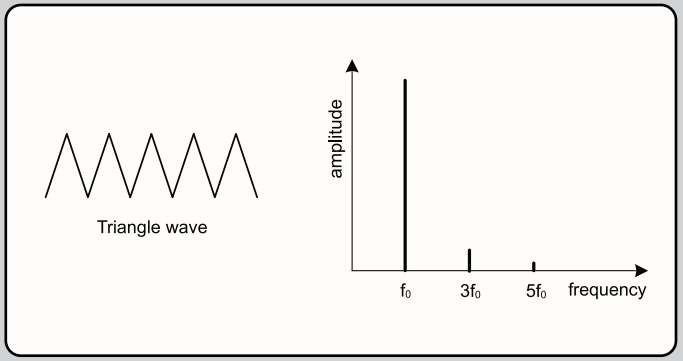
The most basic sound of all is a simple sine wave. A sine wave has no harmonics present, we just hear a single tone, though it will still have the properties of pitch and volume. Mathematically, if we plot amplitude against frequency, the "spectrum" of a sine wave looks like this:



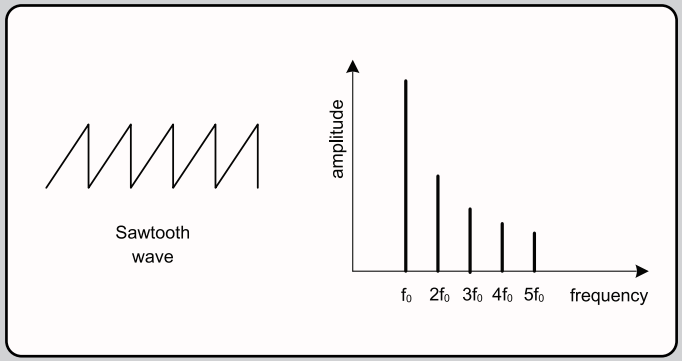
Other waveforms have additional harmonics. A square wave has higher harmonics at odd-numbered multiples of the fundamental frequency, and at reducing amplitudes:



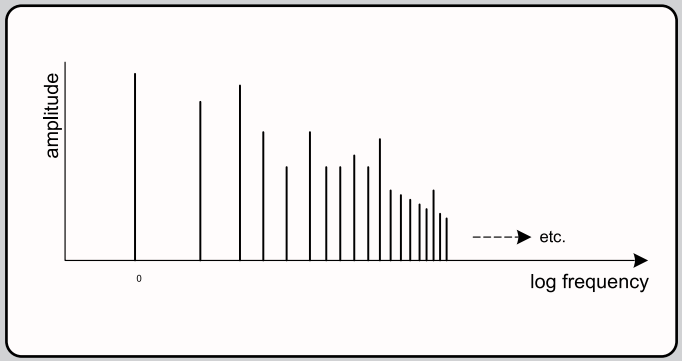
A triangular wave has upper harmonics similar to those in a square wave, but their amplitudes fall off more rapidly with increasing frequency:



A sawtooth wave has even harmonics as well as odd:



These are all very simple waveforms which rarely occur in nature. Real-world musical instruments have far more complex harmonic structures, For example, a bowed violin produces a very rich set of strong harmonics extending far above the fundamental:



(Note that the frequency axis in this spectrum is logarithmic, emphasising how far above the fundamental notes the harmonics extend.)

The second factor distinguishing one instrument from another is how the amplitude (volume) of each harmonic - including the fundamental - varies over time. A plucked string, such as on a guitar, will have a very short burst of upper harmonics, which will be considerably louder compared to the rest of the note as it dies away. The vibrating string, once plucked, will have a lower harmonic content as well. By contrast, woodwind instruments tend to lack this initial “attack” and emit something closer to an unchanging note at a continuous level and with a constant harmonic content.

The pattern of how each harmonic present in the instrument’s sound initially rises and then falls (“decays”) over time after the note is played can be extremely complex.

Synthesisers give you the ability to create sounds by combining simple waveforms in a variety of ways, and then controlling how their amplitude and harmonic content vary with time. But with the addition of noise sources, low-frequency oscillators and various ways of modulating the sound, they can create completely original sounds unachievable with conventional instrumentation.

The Mixer section



The controls in the mixer section let you mix the outputs of OSC 1 and OSC 2 together, adjust their levels, add noise, and also add the output of a ring modulator whose inputs are OSC 1 and OSC 2.

Unlike other mixers, the controls in this section are by default all centre-detented balance controls rather than level controls. We're saying "by default" here because if you hold the **Shift** button down while turning the controls, two of them do something slightly different; the details are below.

Each control lets you make a mix of two sound sources, and this approach means that you will always hear something, even when all three are turned fully anticlockwise. The signal flow through the mixer section is effectively from top to bottom.

- **Osc Balance** – this allows the outputs of OSC 1 and OSC 2 to be mixed together in any proportion. With the control fully anticlockwise you will only hear OSC1, with it fully clockwise you will only hear OSC 2 (and its associated Density oscillator); in its centre position you get a 50/50 mix of the two. Note that if OSC 1 SUB is in use, it will always be present at a fixed level regardless of the **Osc Balance** setting.
- **Shift + Osc Balance** – this controls overall Patch Level. It lets you adjust the absolute oscillator levels while retaining the balance between OSC 1 and OSC 2 you've set with the "non-Shift" function. So, if you've set **Osc Balance** centrally so that the two oscillators are of equal level, hold down **Shift**, and the **Osc Balance** control will now let you turn both oscillators up or down by an equal amount. And if the balance between the two oscillators has been set with one oscillator louder than the other, using the Shift function will still adjust the absolute level of both oscillators, but retain the relative proportion previously defined.
- **Noise Balance** – works in a similar way to **Osc Balance**. It lets you add white noise to the mix of OSC 1 and OSC 2 created by **Osc Balance**. With the control fully anticlockwise you will hear the OSC1/2 mix; with it fully clockwise you will hear pure noise. In its centre position you get the oscillators with added noise.
- **Shift + Noise Balance** – adjusts "Noise Sparseness". The shifted function adjusts a parameter called *Noise Density* rather than absolute noise level: you'll notice that as the control is turned down, the noise changes in character from a smooth hiss via something rather harsher-sounding in the middle of the range, to a sparse cracking sound with the control fully anti-clockwise.

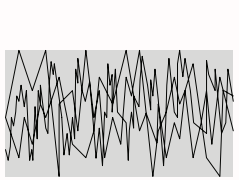
- **RM Balance** – the outputs of OSC 1 (minus its SUB oscillator) and OSC 2 are always applied to the inputs of Mantis's ring modulator. This primarily generates sum and difference frequencies, but also many additional harmonics, depending on the waveshapes in use. The **RM Balance** control lets you add the modulator output to the OSC1/2+Noise mix defined by the **Noise Balance** control. With the control fully anticlockwise **(O+N)** you will hear the OSC1/2+Noise mix; with it fully clockwise **(RM)** you will hear the ring modulator plus any noise. In its centre position you will hear a mix of OSC1/2 and the ring modulated result of OSC 1 and OSC 2, plus any noise.

SYNTH TUTORIAL 2 – NOISE AND RING MODULATION

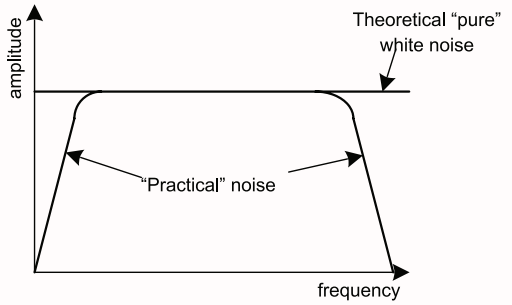
We've looked at how the various common waveforms have different harmonics. Noise can also contribute effectively to a sound and it differs from all other waveforms in that it has no fundamental frequency: it is a mixture of randomly-generated frequencies, and the sound is a characteristic hiss. Technically, we distinguish between "white noise", which contains all frequencies (or at least all those available to the system's bandwidth), and "pink noise", which is deliberately restricted in bandwidth in some way, often by a linear reduction in amplitude of higher frequencies. Both types of noise are very useful in sound system calibration and measurement.

If you look at noise (using an oscilloscope), you don't see any recognisable waveform at all, just a wobbling blur, the consequence of a chaotic mix of all frequencies. The harmonic spectrum of noise can be depicted graphically as shown.

Mantis includes a noise source, the output of which may be added to the oscillator waveforms. Noise can be a useful component of percussive sounds and distinctive sound effects such as explosions.



Noise

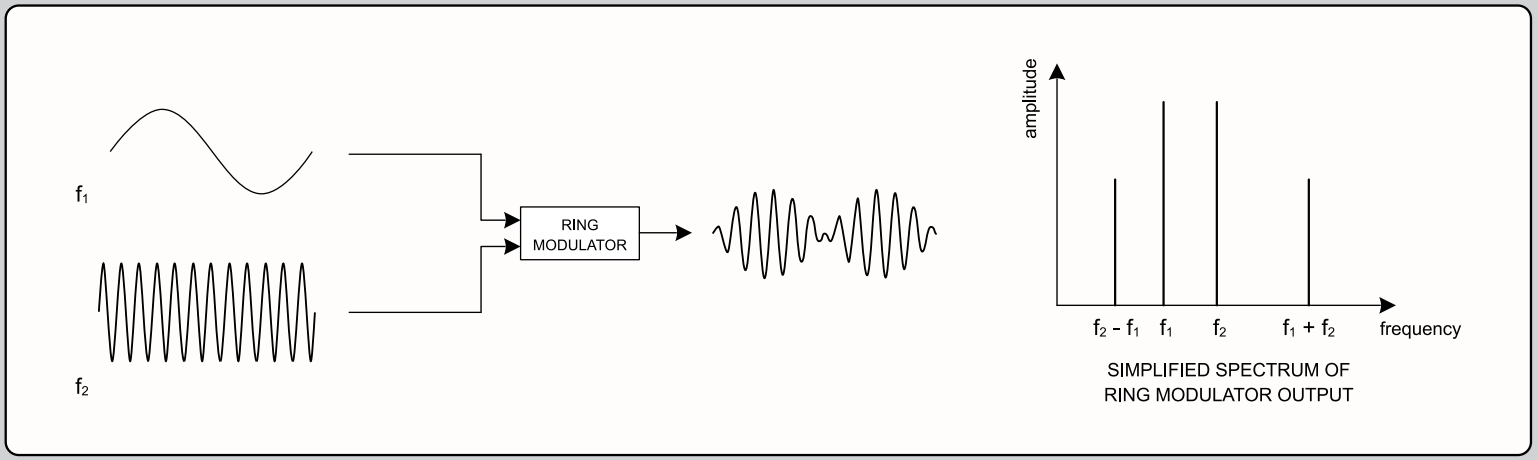


Ring modulation is another technique that can be used to produce some dramatic sonic effects. In its earliest form, a ring modulator was a simple electronic circuit based on a transformer, with two inputs and one output. The ring modulator combines waveforms applied to the inputs in a more complex manner than simple summation: it effectively “multiplies” the waveforms together. Typically, the envelope of the waveform with the higher frequency adopts the shape of the waveform with the lower frequency, a process engineers term amplitude modulation.

The harmonic content of the resulting output is highly dependent on the types of waveforms at the inputs, and in particular, their relative fundamental frequencies. Ring modulation produces components that are the sums and differences of all the frequencies present in each of the two input waveforms. If the two sounds are harmonically rich and mutually slightly detuned, the result is harmonically complex and musically hard to predict.

If the input waveforms are complex, containing many harmonics, every harmonic present in one waveform will combine with every harmonic present in the other. This means the harmonic content of the output will be very rich indeed, with an extended range of sum and difference components.

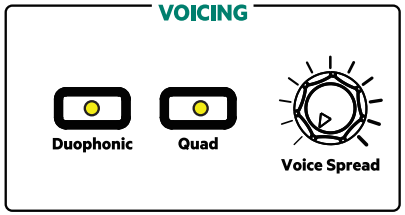
In modern synths (Mantis included!), the properties of the original electronic modulator are emulated in software.

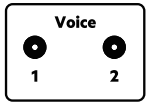


Mantis Voice Modes

Mantis is a four-voice synth, where each voice (Voice 1, Voice 2, Voice 3 and Voice 4) can consist of waveforms from up to four oscillators - OSC1, OSC2, OSC1 SUB and OSC2 Density. So in reality, you have 16 oscillators in total, i.e., four for each voice. The single set of oscillator controls on the panel control the respective oscillators across all four voices.

This multiplicity of oscillators allows Mantis to have four "operational modes", which differ in the way the voices are routed through the filter section, and also determine the level of polyphony available to the player. The modes are selected by the two buttons in the **VOICING** area of the panel:





- Mono – this mode is active when neither the Duophonic nor Quad buttons are pressed. The synth is mono, and only one note (a single voice) will sound at a time: playing a second note will cancel the first, and trigger a new envelope (unless Legato mode is active).

  As only Voice 1 is in use, the signal passed on to the filter section is mono, where the two filter paths may be configured in series or parallel. The output of the filter section is stereo in the case of the parallel filter modes (LP12, BP12 and HP12), allowing a degree of stereo "image width" to be adjusted with the Voice Spread control

- **Duophonic** – provides two-note polyphony, with Voice 1 and Voice 2 both active. Two notes may be played simultaneously, the first will use Voice 1, the second Voice 2. Each triggers its own envelope. Playing a third note while the first two are held will cancel one of the notes already sounding (this is called "note stealing").

  The two voices pass via independent signal paths to the filter section. The two filter paths remain separate, one per path. Turning **Voice Spread** clockwise will pan Voice 1 to the left of the stereo image and Voice 2 to the right. Note that in Duophonic mode, only the 12 dB/oct filter options are available (LP12, BP12, HP12): these filter sections are dual, and each voice path has its own filter.

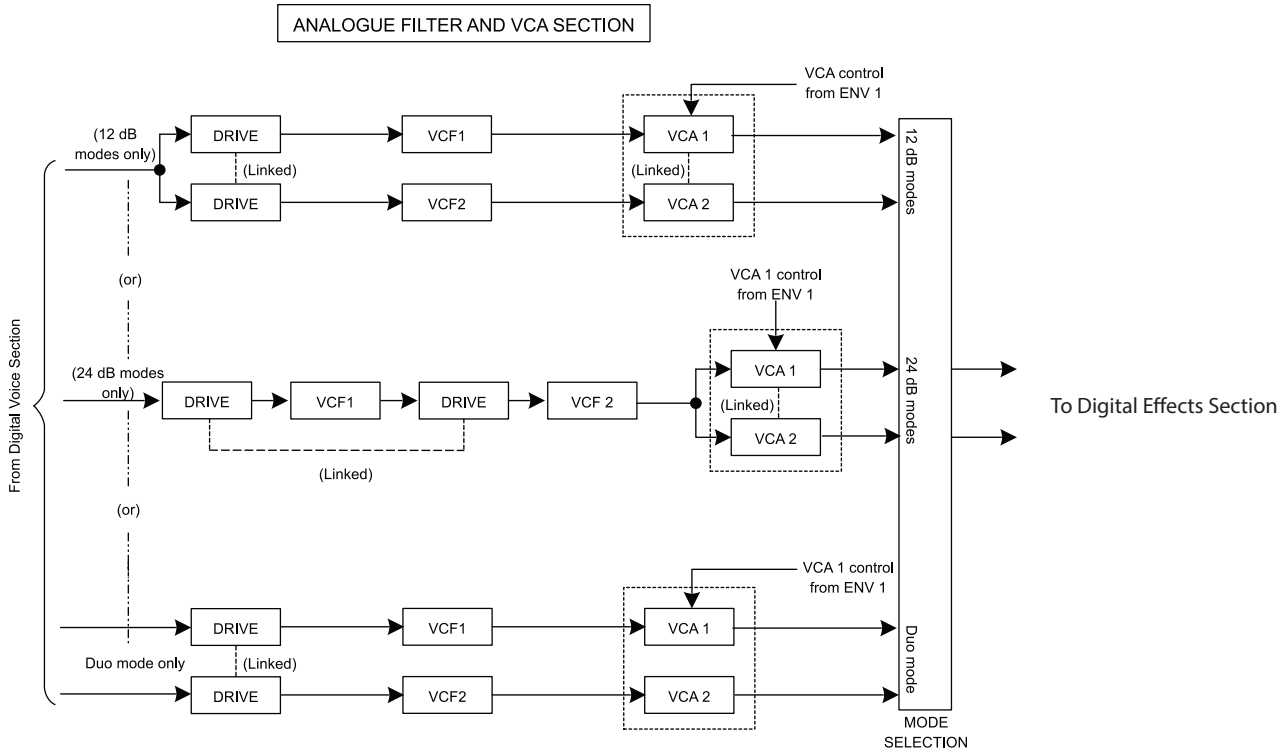
- **Quad** – uses all four voices, so we can have four-note polyphony. Playing a fifth note while four are already held will result in one of the four being cancelled ("stolen"). Mantis uses an algorithm to intelligently determine which voice should be stolen: this will generally result in the least significant note currently sounding being replaced by the new one.

  The signal routing is as per Mono mode, but with one voice per note. The voices are summed to mono and routed to the filter section where the filters may be configured in series or parallel, as with Mono Mode.

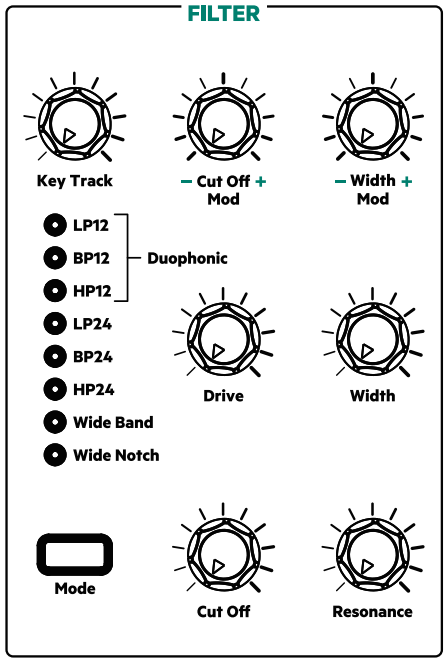
  Mantis uses digitally-controlled analogue VCAs in the Envelope section, so the gains of the analogue VCAs are set by digital data corresponding to the

envelope parameter settings. In Quad mode the VCA shapes the overall signal (so it's driven by the loudest voice at any given time) and the differences are worked out digitally. Thus each of the 4 voices in quad mode uses a “digital” VCA, with a true analogue “supervisory” VCA controlling them all. This makes Mantis truly polyphonic (not paraphonic), but the VCAs are a combination of digital and analogue in this mode.

- Dual-path Quad – this mode is a combination of Duophonic and Quad modes, and is selected by pressing both buttons. Four-note polyphony is available as with Quad mode, but the oscillator voices are summed to two separate signal paths, as in Duophonic mode. In the filter section, two independent filter paths are used, one per signal path. In this mode, turning **Voice Spread** clockwise pans Voices 1 and 3 to the left of the stereo image and Voices 2 and 4 to the right. Note that in this mode – as with Duophonic mode - the filter section is limited to the three 12 dB curves (LP12, BP12, HP12).



The Filter section



Mantis features a powerful and flexible filter section. In fact, it has two voltage-controlled analogue filter sections (VCFs), which are configured either in series or parallel, depending on the voice mode in use: a single set of controls adjusts the parameters of both sections. The filter signal paths are analogue, to retain the classic sonic qualities of early synths. Voltage control is used as this approach provides a great deal more flexibility and range of control.

The filter section may be configured as high-pass, low-pass or band-pass, with roll-offs of either 12 dB/octave or 24 dB/octave. There are also two further modes using a combination of hi-pass and low-pass elements which can be used to create notch and peak filters.

The filter section lets you boost or cut a range of frequencies in the audio spectrum, thus letting you suppress or enhance various harmonics of the waveform in use. A most effective use of filtering is to dynamically alter filter parameters – particularly cut-off frequency – within the duration of the note's envelope. Mantis allows modulation of filter frequency and filter width to be part of patch design. In live performance, manually adjusting filter frequency to slowly "open" the filter is possibly one of *the* definitive synthesiser effects.

Mode – pressing this button selects one of the eight available filter configurations; the currently selected one is indicated by the LED column above.

- Note that only the first three filter configurations are available when Mantis is in Duophonic mode: in this mode the two VCFs are driven independently by the two sets of summed voices from the Digital Voice section, and the signal paths remain separate through the subsequent Mantis processing sections.
  - **LP12** – a low-pass filter with a 12 dB/octave slope.
  - **BP12** – a band-pass filter with 12 dB/octave HF and LF slopes.
  - **HP12** – a high-pass filter with a 12 dB/octave slope.
  - **LP24** – a low-pass filter with a 24 dB/octave slope.
  - **BP24** – a band-pass filter with 24 dB/octave HF and LF slopes.
  - **HP24** – a high-pass filter with a 24 dB/octave slope.
  - **Wide Band** – a band-pass filter configured by a high-pass and a low-pass filter in series, with adjustable bandwidth.
  - **Wide Notch** – a notch filter configured by a high pass and a low-pass filter in parallel, with adjustable bandwidth.
- **Cut Off** – the primary frequency adjustment of the filter sections. Turning the control clockwise increases the frequency, which means that the "sense" of the control depends on the selected filter type. With a low-pass filter, clockwise rotation allows more upper harmonics to be audible, with a high-pass filter, clockwise rotation removes lower

harmonics so that only the upper ones are audible. With a band-pass filter, **Cut Off** sets the centre frequency of the band of harmonics being allowed through.

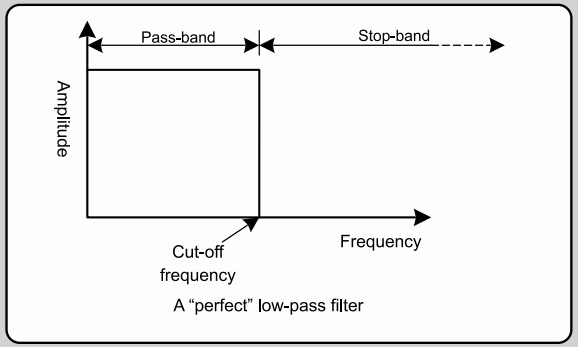
- **Resonance** – emphasises the frequencies around the filter cut-off point. Adding resonance makes the sonic effect of opening or closing the filter with the **Cut Off** control more dramatic. High settings can cause the filter section to self-oscillate at the cut-off frequency, which can be used to great effect.
- **Width** – moves the cut-off frequencies of the two filters apart. For low- or high-pass filters, this changes the shape of the slope. For band-pass filters, it increases the bandwidth. In duophonic mode, which has only one filter per voice, this control has no effect.
- **Cut Off Mod** – the filter's cut-off frequency can be dynamically altered by other synth parameters; you can set this up in the Modulation section. The centre-detented **Cut Off Mod** control determines by how much the cut-off frequency varies for the assigned control input. In the centre position, there is no external control; rotating the control allows increasing degrees of cut-off frequency variation. Some controlling sources will produce a different effect depending on which way the control is turned.
- **Width Mod** – Width is the other filter parameter which can be controlled by other parts of Mantis. The Width Mod control works in exactly the same way as **Cut Off Mod**, except it affects the Width parameter.
- **Key Track** – Mantis can automatically adjust the filter cut-off frequency according to the note being played. With **Key Track** fully anticlockwise, the cut-off frequency is constant (apart from any modulation applied via **Cut Off Mod**.) With **Key Track** set fully clockwise, the cut-off frequency tracks the keyboard effectively note-for-note, altering by one semitone for each successive key.
- **Drive** – each VCF is preceded in the signal path by a pre-amplifier stage, whose gain is adjustable with the **Drive** control. This allows you to increase the signal level into the filter section itself to (and past!) the point where analogue overload and distortion start to kick in. This can be used to create some of the really nasty, biting sounds that Mantis is capable of.

SYNTH TUTORIAL 3 - FILTERS

We've seen how the waveforms produced by the oscillators and other sound sources generally have a fundamental frequency and a range of upper harmonics. Filters are signal processing blocks that can suppress or enhance some of the harmonics in the waveform, making significant alterations to the sound. The ability to vary filter parameters throughout the duration of a note is something that can be used very expressively.

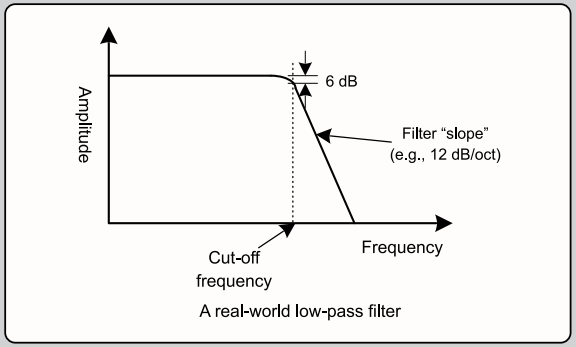
Filters can be thought of as sophisticated "tone controls", but with a far greater range of control than the treble and bass controls on a simple audio amplifier. Nowadays, complex filters are often realised in software, which can have a considerable processing overhead. However, Mantis uses traditional analogue technology which avoids this problem, and you get classic sound quality thrown in.

Filter responses can be easily visualised as an amplitude/frequency plot. A "perfect" filter - in this example, a low-pass filter - would pass all frequencies below the cut-off frequency without attenuation and reject all frequencies above. Such a filter is often referred to as a "brick-wall filter", and would exhibit a response like this:



A "perfect" low-pass filter

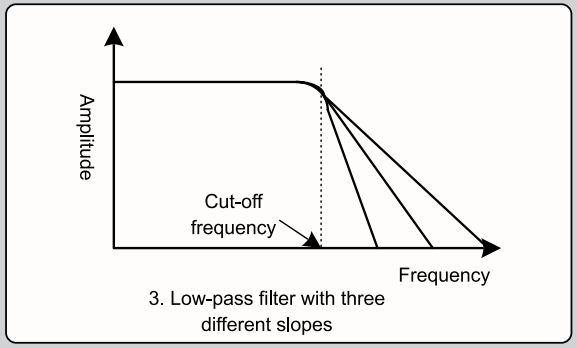
We refer to the range of frequencies passed by the filter as the "pass-band", and those that are rejected as the "stop-band". Perfect filters such as this can be realised in software, and indeed do have specialised applications in digital systems. Analogue versions do not exist: the filters found in synthesisers will always be "less than perfect", in that they only partially reject frequencies in the stop-band, the degree of rejection being greater at frequencies more distantly removed from the cut-off. Thus a "real-world" low-pass filter has a response like this:



A real-world low-pass filter

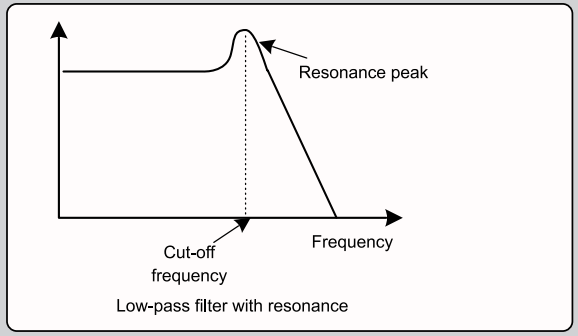
The filter response begins to fall away slightly below the cut-off, and from slightly above the cut-off it continues linearly, increasingly rejecting higher frequencies. The linear fall-off of the response is termed the filter slope. The "steepness" of the slope is expressed in units of dBs per octave, and a slope of 6 dB/octave means that at twice the cut-off frequency (i.e., an octave higher), a signal's amplitude will be half that of the signals in the pass-band.

Mantis offers filter slopes of 12 dB/octave or 24 dB/octave, which give greater degrees of stop-band attenuation.



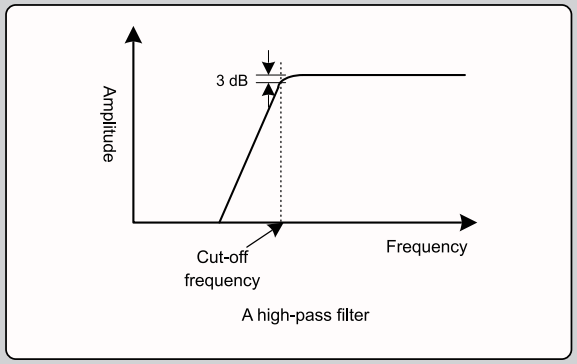
3. Low-pass filter with three different slopes

When a filter has resonance applied, frequencies around the cut-off frequency are boosted, so the response curve is typically like that shown here (a low-pass filter in this example):



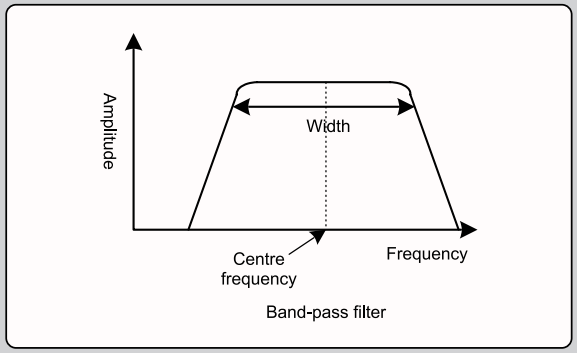
Low-pass filter with resonance

All these principles apply equally to a high-pass filter, only “in reverse”:

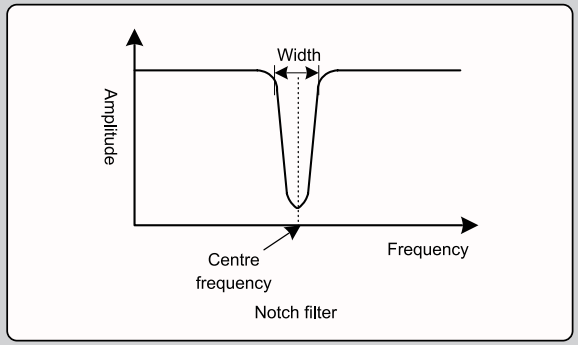


A high-pass filter

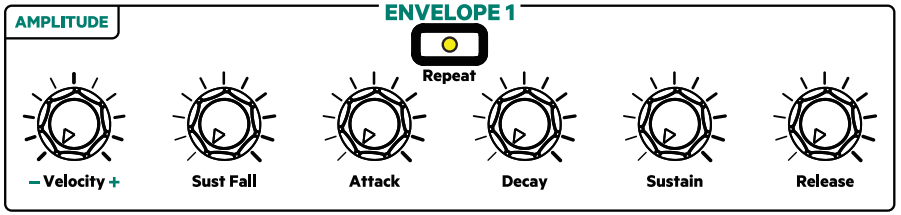
A band-pass filter is typically created by combining a low-pass filter with a high-pass filter, where the low-pass filter has a higher cut-off frequency than the high-pass. Only a certain range of frequencies is passed, any others, above or below the range are rejected. We usually describe a band-pass filter by its “centre frequency” and its “width”. Mantis’s band-pass filters use the Cut Off control to set the centre frequency while the Width control does what it says.

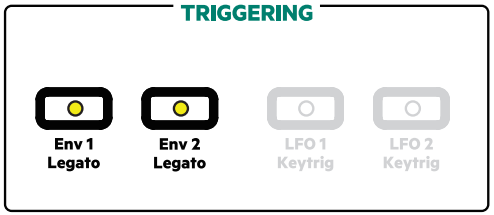


The “inverse” of a band-pass filter is technically known as a band-stop filter, but in synths, we generally call it a notch filter, as its most useful implementation is with the width set narrow. Notch filters are usually designed with steep slopes, so they only reject a narrow range of frequencies.



The Envelopes Section





Mantis has two independent envelope generators: they have identical facilities.

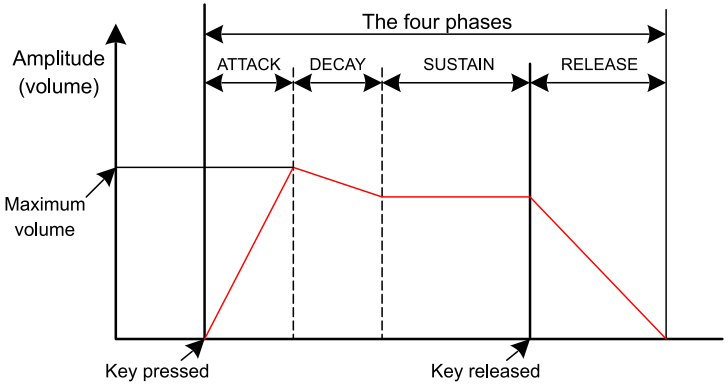
Both envelopes are triggered each time a key is pressed. Unless an envelope is in 'Legato' mode (by selecting **Env1 Legato** or **Env2 Legato**), it will be triggered each time a key is pressed. In Dual and Quad modes, the envelope will be triggered anyway unless a voice has been stolen from a playing note.

Both envelopes are freely available to control other synth parameters - e.g., pitch or filter cut-off - when patched to do so in the **MOD ROUTES** section. However, **ENVELOPE 1** is always applied to the dual VCAs immediately following the filter section, and thus always affects the amplitude (or volume) of the output, regardless of any other envelope patching.

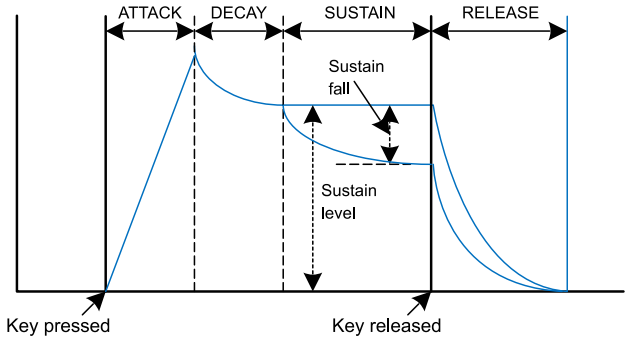
Mantis's envelope controls follow the familiar ADSR system (Attack, Decay, Sustain, Release), with a couple of interesting additions: we've added **Sustain Fall** and **Velocity** functions, which give you more scope in tailoring the envelope shape.

The envelopes can also be made to automatically re-trigger with the **Repeat** button.

The diagram below illustrates the phases of Mantis's envelopes:



Typical "classic" ADSR envelope



Mantis ADSFR envelope

Most of the controls do what you would expect: we've described their action in terms of Envelope 1's control of amplitude (as it always does this), but as mentioned above, either envelope may be used to vary other synth parameters.

- **Attack** – sets how long a note takes to reach its maximum volume after you press a key. The range is 2 ms to 15 s.
- **Decay** – the note's volume then reduces over a period set by the **Decay** control. The range is 0.2 ms/dB to 600 ms/dB. How much the volume drops by is determined by the setting of the **Sustain** control.....
- **Sustain** – at the end of the decay phase the note stays at a constant volume, which is determined by the **Sustain** control. Unlike the other three primary envelope controls (Attack, Decay, Release), **Sustain** is an amplitude parameter. However, the note will only stay at a constant volume if **Sustain Fall** is at its minimum setting..... **Sustain Fall** – this parameter is not found on most synths: it allows a further reduction in volume to be factored in at the and of the Decay phase. The control's range is 0.2 ms/dB to 600 ms/dB. If **Sustain Fall** is set fully anticlockwise, the note's volume remains virtually constant during the Sustain phase. With any other setting, its volume decreases during the Sustain phase. Note that the initial volume in the Sustain phase will always be set by the **Sustain** control, regardless of **Sustain Fall**'s setting.
- **Release** – the Release phase starts when you let go of the key. With **Release** fully anticlockwise, the note stops sounding immediately. With higher settings, the note dies away (from its volume at the end of the Sustain phase) either quickly or slowly. The range of **Release** is 0.2 ms/dB to 600 ms/dB.
- **Velocity** – links the note velocity – i.e., how hard a key is struck – to Sustain level, and as Sustain level will generally define how loud the note is for much of its duration, **Velocity** effectively links the note's volume to how hard you play. The **Velocity** control is centre-detented: when set centrally, varying your playing style will have no effect on note volume. Turn it clockwise to make the volume proportional to how hard you hit the keys. Turn it anticlockwise to get the (unusual!) opposite effect; now, the harder you hit the keys, the softer the volume. This can be useful when creating abstract sounds or to control a modulation effect which is scaled to velocity.
- **Repeat** – with **Repeat** off, one envelope is generated (by both Env 1 and Env 2) each time a note is played. With **Repeat** on, a new envelope will be retriggered automatically as it enters its Sustain phase.

The **Attack**, **Decay** and **Sustain** controls change the shape of the repeating envelope, essentially turning it into an additional low-frequency oscillator. Note that reducing the Sustain level shortens the retriggering rate as it causes the Decay phase to end earlier.

SYNTH TUTORIAL 4 - ENVELOPES

In Tutorial 1, we explained that the manner in which the volume and harmonic content of a note "evolves" over its duration is a defining characteristic that distinguishes one musical instrument from another. In a synthesiser, we can precisely define this evolution ourselves, and we call it an envelope. Inside a synth, an envelope is a control voltage that varies with time, starting each time you play a note. This control voltage can be applied to different sections of the synth to alter exactly what that section does to the sound in the time period following a keypress.

Synths can have multiple envelopes, each doing something different, but all synths use one envelope to control the amplitude (or volume) of the note at various stages of its evolution by controlling the gain of one or more Voltage Control Amplifiers (VCAs). Another envelope might be used to affect the filter section, thereby changing the harmonics in the note's waveform during its duration. We can also use an envelope to change the oscillator frequency over time, so we might want to make each note start with a rapid upward pitch bend, or finish with a slow drop in pitch as it dies away.

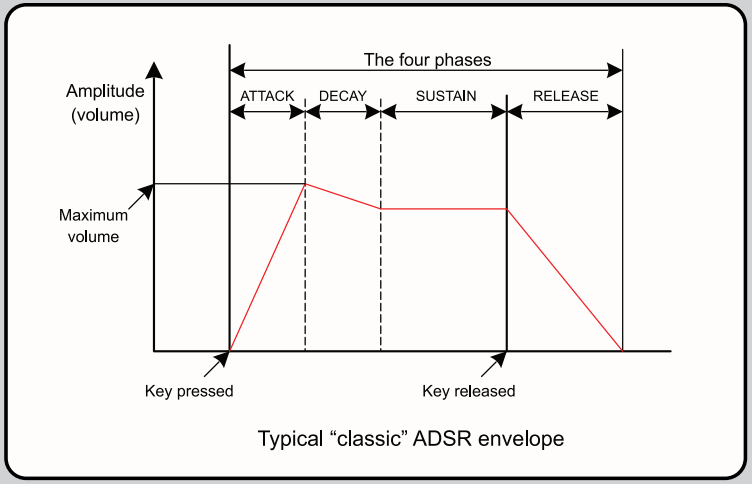
Mantis has two envelopes, one of which always controls the note's amplitude, and is (inevitably) called the Amplitude Envelope. We'll use this to discuss envelopes further, as control of amplitude is easy to visualise.

THE ADSR PHASES OF AN AMPLITUDE ENVELOPE

Many synths provide a standard set of controls for the four primary phases of an envelope. These are called Attack, Decay, Sustain and Release, commonly referred to simply as ADSR. Attack, Decay and Release are defined in terms of time, while Sustain is normally defined as a level (or volume).

Some synths add additional envelope phases or controls: Mantis has one called Sustain Fall.

A "standard" ADSR envelope can be represented like this:



Typical "classic" ADSR envelope

The ADSR envelope is initiated when you press a key. During the Attack phase the note initially increases in volume to its maximum. With a short attack, the note will be at its maximum volume almost immediately; with a long attack, it ramps up in volume slowly.

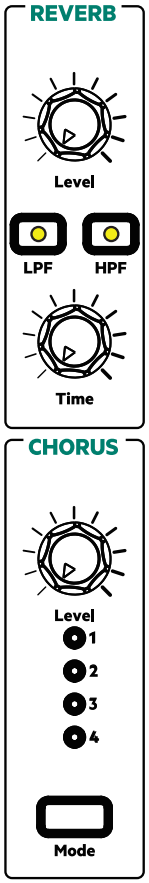
Having reached its maximum volume, the note then typically reduces in volume somewhat during the Decay phase.

At the end of the Decay phase, the note then stays at a constant volume while the key is held: this is the Sustain phase. Note that the duration of the Sustain phase is not determined by a

time value: Sustain lasts until the key is released. Sustain is an amplitude parameter; a high setting means the note will be near (or even the same as) its maximum value for as long as you hold the key down. With a low setting, the note will sound more percussive, as the attack/decay phases will be the most evident.

When you let go of the key, the Release phase starts. With a low setting of Release, the note will stop sounding almost immediately. With higher settings, it dies away more slowly (from its volume at the end of the Sustain phase), adding a bell-like quality to many types of sounds.

On Mantis, there is an additional envelope parameter called Sustain Fall. This allows the note's volume to gradually reduce during the Sustain phase, instead of staying at a constant level. This produces more naturalistic sounds, as few acoustic instruments have constant sustain (though a violin note being continuously bowed is an often-heard exception!)



Digital Effects (Reverb and Chorus)

Following the VCAs which apply the amplitude envelope to the summed and filtered waveforms, Mantis routes the signals through two digital effects sections, **CHORUS** and **REVERB**. Either may be bypassed by leaving the relevant **Level** control turned right down: their use isn't mandatory.

Chorus and reverb settings are saved with Patches. In fact, you'll find that many of the factory patches use one or both as part of their sound.

The Chorus section

The Chorus processor has two separate signal paths, so the stereo imagery derived from the filter/VCA section is retained. Chorus is great for adding a "shimmering" quality to many different types of sounds, particularly those using Mantis's polyphonic modes.

The **CHORUS** section only has two controls, **Mode** and **Level**:

- **Mode** – the button steps through four different chorus rates (or speeds), the LED ladder (**1** to **4**) indicating that selected. **1** is the slowest, **4** the fastest.
- **Level** – adjusts the depth (or "amount") of chorus effect. Fully-anticlockwise is "off": turn the control right down if you don't want to add any chorus. As you turn **Level** up, the depth of the phase effect increases, and this produces an impressive stereo enhancement.

The Reverb section

Mantis's **REVERB** processor is mono, so the reverberation is essentially placed in the centre of the stereo image.

The controls in the **REVERB** section are:

- **Time** – adjusts the reverb time: how long the reverberation persists before dying away. A longer **Time** setting creates the impression of a larger physical space.
- **Level** – basically, this controls the volume of the multiple echoes which constitute the reverberation. The physical analogue of a higher setting would be a space with more reflective surfaces.
- **LPF** and **HPF** – these are low-pass and high-pass filters which may be applied solely to the reverberation itself.
    - The low-pass filter has two settings: a single press introduces a reduction of the upper frequencies in the reverb envelope (the LED in the button is bright), a second press (LED is dim) lessens the filtering effect by changing the filter to higher cut-off frequency. Use of the filter mimics the way different surfaces in a "real" space have different absorbance characteristics
    - The high-pass filter has only one setting, and is most useful for controlling low-frequency instability or overloading.

SYNTH TUTORIAL 5 - CHORUS AND REVERB

CHORUS:

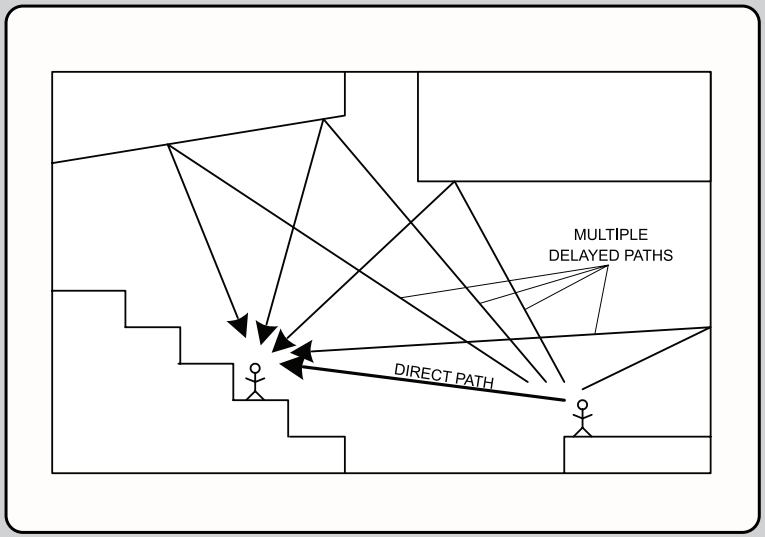
The Chorus effect is so-called because of the slight variations in pitch and timing that inevitably arise when a large choir sings. The effect is pleasing, and adds audio "colour" and character to the performance.

Electronically, the Chorus effect is simulated ("approximated" might be a better term!) by passing the audio signal through multiple delay circuits, and then mixing the delayed versions back in with the original untreated signal. This, on its own, would produce a multitrack effect (as in "ADT" - automatic double tracking). But the characteristic sound of electronic chorusing is to cyclically vary the delay time of each delay element: this is done by using a low-frequency oscillator (LFO) to modulate the delay times. The overall effect is typically one of "shimmering", with constantly-changing phase relationships between the original signal and its delayed versions, which the ear interprets as small pitch variations.

Chorus processors may be mono or stereo: Mantis's is stereo. Stereo Chorus produces a fuller and more convincing experience than the mono version. Stereo Chorus processors work on the same principle as described above, except that the LFO delay modulation is applied to the two channels with slightly different delays or phase-shifts.

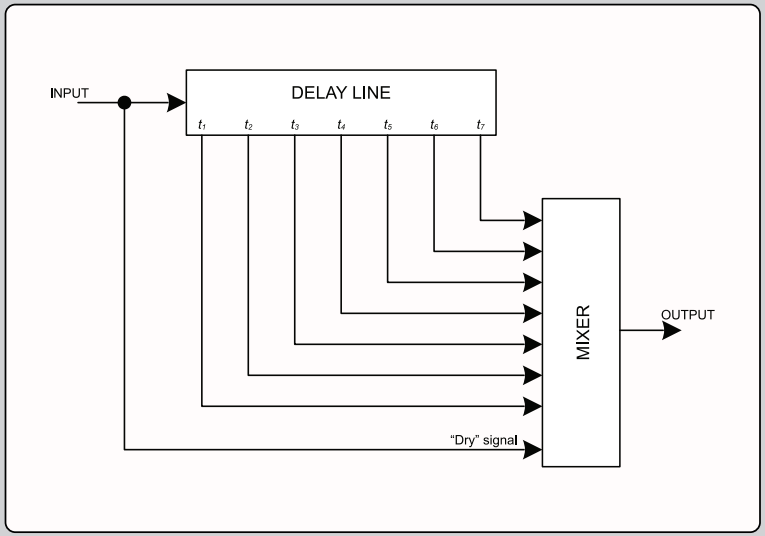
REVERB:

Otherwise dry-sounding sounds can be brought to life by adding a touch of reverberation. Reverb is not the same thing as "delay" or "echo". Delay produces one or more individually distinguishable repetitions, and is particularly effective on short, percussive sounds. Reverb recreates the ambience of a real-world space by generating a large number of echoes with short, random delay times. This is what actually happens in a real space, where different surfaces reflect sound back to the listener over paths of different lengths, and where different surfaces absorb and reflect different ranges of frequencies.



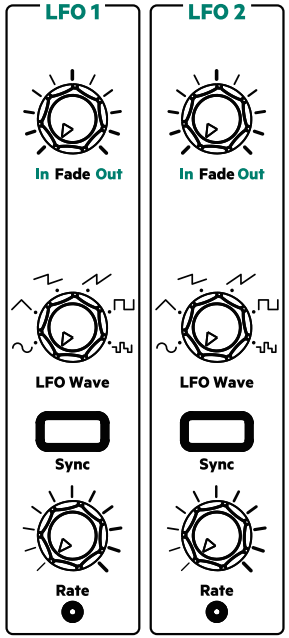
For many years, artificial reverb was created mechanically, using metal springs or plates with transducers fitted to produce delays. Purpose-built rooms (“echo chambers”), containing loudspeakers and microphones were also used.

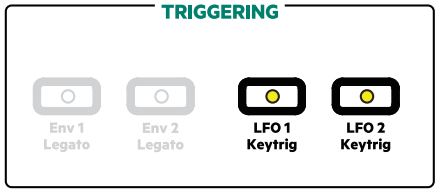
Reverb is created electronically by combining many delayed versions of the original signal together, and (usually) adding the result to the “dry” original. The diagram below shows the basic principle (greatly simplified).



In reverb processors the range of delay times will be extensive, up to several seconds. The more dense the delays, the more accurate the modelling of a real acoustic space. Simulation of different types of spaces is achieved by adding some of the delayed signals at different levels, and also by applying selective filtering to some of them.

The LFOs





Mantis has two independent, identical Low Frequency Oscillators (LFOs). The waveforms from either - or both - may be patched via the **MOD ROUTES** section to control other Mantis elements, e.g., oscillator pitch, to create a vibrato effect.

Each LFO may be set to generate one of six different waveshapes over a wide range of frequencies. Many LFO-based effects will use a fairly slow LFO rate. It is also possible to lock the LFO rate to an incoming MIDI clock so that the cyclic sonic variation produced by the LFO modulation is synchronised to other sound sources. The LFOs may also be programmed to ramp the level of the waveform up or down from the start of each note, so that the effect increases or decreases (respectively) over the note's duration.

LFO 1 and **LFO 2** have identical sets of controls.

• **LFO Wave** - sets the oscillator to generate one of six waveforms. We've use the term "zero" in the following to indicate the point on the LFO waveform that would have no effect on the parameter being modulated, e.g., if we are modulating Oscillator 1 pitch, when the LFO waveform is "zero", the overall pitch of the resulting sound will remain at that of the note played.

- ∿ - a sine wave, symmetrical about "zero"
- ∧ - a triangle wave which ramps linearly up and down, and is symmetrical around "zero"
- ◿ - type 1 sawtooth wave: this commences at "zero" when a note is pressed, ramps up to a maximum positive value, then immediately drops to an equal negative value and recommences the ramp
- ◿ - type 2 sawtooth wave: this is similar to Sawtooth 1, but always commences at the minimum negative value to begin its ramp.
- ⊓ - a square wave: switches rapidly between maximum high and low levels of equal duration
- ⊓ - a series of randomly generated levels of equal duration

- **Rate** - sets the LFO's frequency. With the control fully anticlockwise, the LFO is effectively "off". The frequency range goes up to 54.5 Hz. The LED below the **Rate** control shows the current LFO frequency, with its brightness indicating the instantaneous output level. Note that if **Rate** is turned right down, the LFO retains the waveform's last value. Using this control in live performance, you can

temporarily stop the LFO effect, and when you restart it, the mod effect will continue from its last state.

- **Sync** - pressing **Sync** locks the LFO frequency to the current Mantis clock BPM rate. This may be the synth's internal clock, or an external MIDI clock. Note that the **Rate** control is still operational, but now acts as a BPM divider, to make it easy to lock the LFO rate to a multiple (up to 16 x) or a subdivision (down to 1/32) of the clock rate. With **Rate** in its centre position, the LFO rate is one complete waveform cycle per beat. When Mantis is running on its internal clock, this is will be one cycle per beat at 120 bpm.

  In Sync mode, the full range of **Rate** allows for 28 different multiples/subdivisions of the clock rate (includes dotted notes and triplets), and the control's range is tailored so that larger areas of its rotation will be found either side of the centre position, as the rates selected there will be those most commonly used. Note that the rate of the internal clock is adjusted with the **TEMPO BPM** control to the right of the **ARP** section.

SHIFT + Sync puts the LFO into one-shot mode. When a key is struck, the LFO will complete only one cycle of its waveform, so this can be very useful in adding an effect to the start of a note. An interesting one-shot effect results when modulating pitch with **LFO Wave** set to random, which by definition, doesn't have a cyclic waveform. Striking any key will generate an unpredictable note, and striking the same key repeatedly will produce a different note every time.

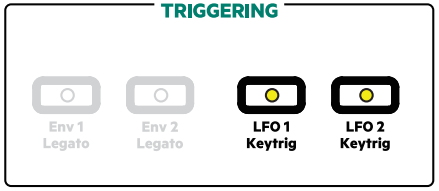
The LED in the **Sync** button illuminates while **SHIFT** is pressed, but doesn't remain lit once it is released. However, One-Shot mode can be confirmed at any time by pressing **SHIFT** again, when the LED will light.

Equivalent musical note		Ratio
European notation	US notation	
Longa		16.00
Dotted Breve		12.00
Triplet Longa		10.67
Breve	Double	8.000
Dotted Semibreve	Dotted Whole	6.000
Triplet Breve	Triplet Double	5.333
Semibreve	Whole	4.000
Dotted Minim	Dotted Half	3.000
Triplet Semibreve	Triplet Whole	2.667
Minim	Half	2.000
Dotted Crotchet	Dotted 1/4	1.500
Triplet Minim	Triplet 1/2	1.333
Crotchet	1/4	1.000
Dotted Quaver	Dotted 1/8	0.750
Triplet Crotchet	Triplet 1/4	0.667
Quaver	1/8	0.500
Dotted Semiquaver	Dotted 1/16	0.375
Triplet Quaver	Triplet 1/8	0.333
Semiquaver	1/16	0.250
Dotted Demisemiquaver	Dotted 1/32	0.187
Triplet Semiquaver	Triplet 1/16	0.167
Demisemiquaver	1/32	0.125
Dotted Hemidemisemiquaver	Dotted 1/64	0.093
Triplet Demisemiquaver	Triplet 1/32	0.083
Hemidemisemiquaver	1/64	0.062
Dotted Semidemihemisemiquaver	Dotted 1/128	0.0465
Triplet Hemidemisemiquaver	Triplet 1/64	0.041
Semihemidemisemiquaver	1/128	0.031

- **Fade** – some interesting effects can be created by allowing the LFO's output waveform to ramp up (**Fade In**) or down (**Fade Out**) in amplitude when a note is played. When Fade In is active, the LFO's action will not be apparent as soon as a note is played, but will gradually increase in effect over the duration of the note. With Fade Out, the opposite happens: the LFO modulation will be evident as soon as a note is played, but its effect will gradually diminish. With **Fade** in its centre position, the LFO waveform is of constant amplitude, and its effect is unchanging. Turn **Fade** anticlockwise to create a Fade In effect, and clockwise for a Fade Out. The degree of rotation determines how rapidly LFO modulation is increased (Fade In) or reduced (Fade Out); higher settings in either sense increases the delay.

LFO Triggering

There are two further LFO controls in the **TRIGGERING** area of the control panel:

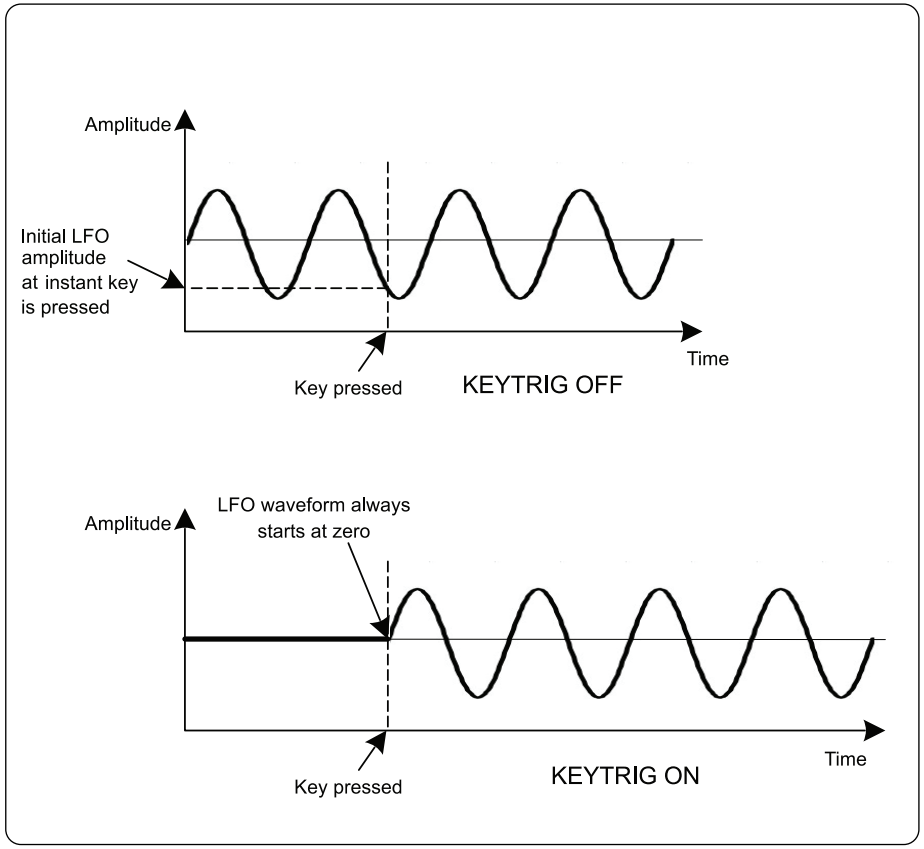


The two buttons **LFO1 Keytrig** and **LFO2 Keytrig** determine the point on the waveform at which an LFO starts when a key is pressed. The two buttons perform the same function in their respective LFOs.

With **Keytrig** off, the LFOs are free-running; that is, they are always active. When a note is pressed, the LFO waveform will be applied (via **MOD ROUTING**) at whatever value it currently is at that instant, and will just continue as normal from that point.

With **Keytrig** on, pressing a key resets the LFO so that the waveform will start from zero. This will ensure that the modulation effect being created will always be predictable.

The diagrams below illustrate the difference between the two options. We have used a sine LFO waveform in the example.

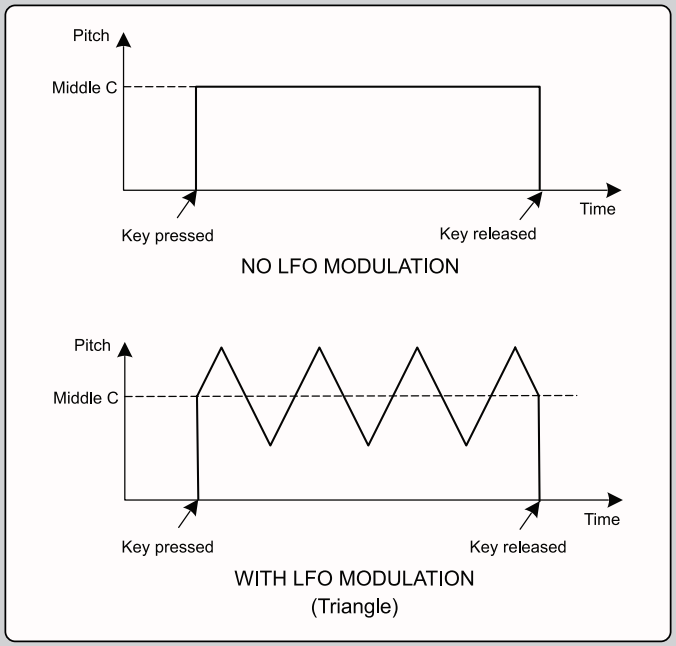


SYNTH TUTORIAL 6 - LFOs

Many synthesisers come with at least one Low Frequency Oscillator (LFO): Mantis has two. LFOs generate a range of waveforms in a similar manner to the primary oscillators, but do so over a much smaller range of frequencies, a range that will extend to very low subsonic frequencies, typically less than 1 Hz, or one cycle per second. LFO waveforms do not contribute to the synth sounds directly: instead, they are used to modify - or modulate - the synth sounds in a variety of ways. You will find the two LFOs are available in Mantis's **MOD ROUTING** section, where they may be used to modify synth parameters such as oscillator pitch and filter cutoff frequency.

In this way, LFOs perform a similar function to the envelopes, in that they may be used to alter the character of a note during the note's duration. The main difference is that modulation by an envelope produces a transient effect, e.g., altering the filter during the initial attack and decay phases of the envelope for each note, while modulation by an LFO is more likely to be a continuous effect. (However, the Fade In/Out functions of the LFOs allow us to make the LFO's effect transient as well.)

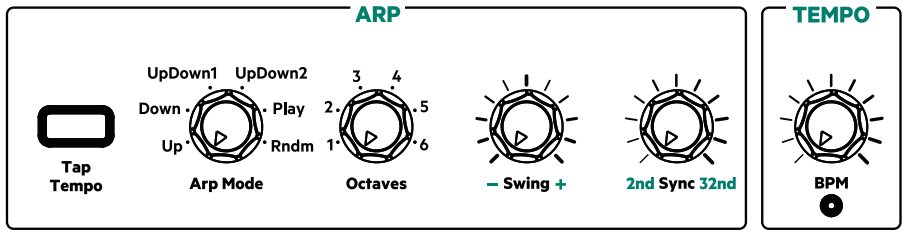
LFO modulation of oscillator pitch is probably the easiest to visualise. If we modulate oscillator pitch with an LFO waveform, the pitch of a note played will vary at a rate determined by the LFO frequency, and in a manner determined by the LFO wave shape. This is illustrated in simplified form below: note that the vertical axis of these graphs is pitch, not amplitude.

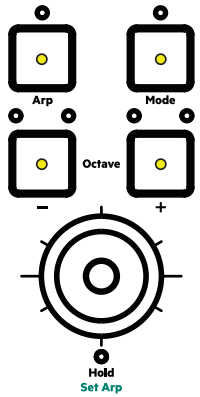


In the example above, we are using a single oscillator to generate a single tone. If we play middle C, we will hear that note at constant pitch. If we now modulate the oscillator pitch with an LFO waveform - we've used a sawtooth in the example - the pitch of the note played will not be constant; it will vary above and below middle C in a cyclic manner for its whole duration. The "wobbling" effect produced is called vibrato. The rate at which the pitch wobbles is set by the LFO frequency (the LFO **Rate** control on Mantis) and how much it wobbles - how much the note's pitch deviates from the nominal pitch - is set with the oscillator's **Pitch Mod** Control.

The manner in which a note's pitch varies will also depend on the LFO waveform employed. A sawtooth LFO wave will cause the pitch to only rise (or fall) repeatedly as opposed to both rising and falling alternately. If we use a pulse wave, the pitch will switch between two notes above and below the nominal note, reminiscent of a police car siren at some settings of **Pitch Mod**.

The Arpeggiator (Arp)





(We'll refer to the Arpeggiator as the Arp from hereon, because we know you will.)

The Arp lets Mantis play a series of notes as a repeating pattern. When Arp is enabled, each note is retriggered at a rate determined by the Arp's tempo setting, so holding a key down will play that key's note over and over again. More usefully, a set of keys held down at the same time will generate a sequence consisting of those notes, in a manner and at a rate which you can control. As a simple example, if you hold down a C major triad, the Arp will play the notes comprising that triad – C, E and G – in sequence.

The controls for the Arp are in two places: the sequence controls are on the main control panel, and the start/stop controls that you will need in performance are at the left-hand end of the keyboard.

The Arp's sequence controls are these:

- **Tempo BPM** – this control sets Mantis's internal clock rate. With the control at 12 o'clock, the BPM is approximately 120. The Arp runs at two notes per clock pulse. Note that the **Tempo BPM** control also determines the frequency of an LFO when the **Sync** button in the LFO section is pressed (LED on).
- **Arp Mode** – this is a six-position rotary switch which determines the type of pattern that will be played for the selected set of notes. We've used the simple example of the C major triad again for the first four modes as illustration.
  - **Up** – the selected notes are played in sequence from the lowest to the highest: C, E, G, C, E, G....
  - **Down** - the selected notes are played in sequence from the highest to the lowest: G, E, C, G, E, C....
  - **UpDown1** – the selected notes are played in ascending order and then in descending order. This means that musically, the sequence will be longer than in **Up** or **Down** modes. The lowest and highest notes are not repeated: C, E, G, E, C, E, G.....
  - **UpDown2** – this is similar to **UpDown1** mode, except that the lowest and highest notes are repeated, making the pattern longer again: C, E, G, G, E, C, C, E, G, G, E....
  - **Play** – the Arp plays the notes in the order in which their keys are pressed.
  - **Rndm** – as the name implies, the Arp sequence will consist of the notes being played, but they will be in a random order, which will continue to change for as long as the pattern is active.

- **Octaves** – the description of the Arp sequences above are correct when the **Octaves** control is set to **1**. Setting it to **2** doubles the length of the sequence by adding an entire second note pattern, but one octave higher, to the sequence. Correspondingly, setting **Octaves** to any of the higher values (**3** to **6**) will increase the length of the sequence further by adding extra, higher octaves.

  Note that the two keyboard **Octave** buttons are completely independent of the Arp's octave setting.

- **Swing** – a centre-detented control that alters the duration of successive notes in the Arp sequence. It allows an Arp pattern to have a more interesting character suggesting swung triplets or a dotted rhythm. With **Swing** in its centre position, the notes are at regular intervals and of equal duration; as **Swing** is adjusted clockwise, the odd-numbered notes in the sequence are extended in duration and the even-numbered notes are accordingly shortened to maintain the tempo. Anticlockwise adjustment has the opposite effect, with the even-numbered notes being lengthened and the odd-numbered shortened.

- **Sync** – acts as a multiplier or divider of the Arp's base clock rate, and works in a very similar way to the **LFO Sync** control. You may want to generate an Arp sequence which runs faster or slower than the BPM set by the **TEMPO BPM** control, but which is still in time. With **Sync** at 12 o'clock, the Arp runs at the base BPM. Clockwise rotation increases the Arp rate in increments: as well as simple multiples of the base tempo, x2, x4, x8, etc., ratios corresponding to dotted notes and triplets are included. Anticlockwise rotation has the opposite effect, reducing the base tempo by similar ratios. 13 different ratios are available*; the control is scaled so that the "simple" ratios occupy a larger arc portion of the control's rotation.

The available sync rates are detailed in the table below:

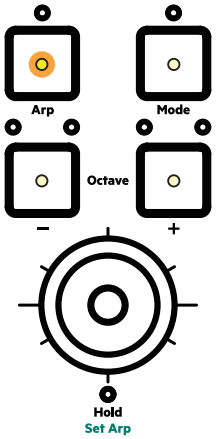
Equivalent musical note		Ratio
European notation	US notation	
Minim	Half	2.000
Dotted Crotchet	Dotted 1/4	1.500
Triplet Minim	Triplet 1/2	1.333
Crotchet	1/4	1.000
Dotted Quaver	Dotted 1/8	0.750
Triplet Crotchet	Triplet 1/4	0.667
Quaver	1/8	0.500
Dotted Semiquaver	Dotted 1/16	0.375
Triplet Quaver	Triplet 1/8	0.333
Semiquaver	1/16	0.250
Dotted Demisemiquaver	Dotted 1/32	0.187
Triplet Semiquaver	Triplet 1/16	0.167
Demisemiquaver	1/32	0.125

* 3 additional slower ratios (Triplet Semibreve, Dotted Minim and Semibreve) are available if the Arp sync is set by a MIDI NRPN message.

- **Tap Tempo** – allows you to "physically define" the Arp tempo. Tap the **Tap Tempo** button, and the Arp will measure the interval and base the tempo on it. This feature is very useful if you are working on a track but don't know its BPM: you can simply tap along in time while listening to it.

Using the Arp

The joystick and associated buttons (and LEDs) to the left of the keyboard are used to activate the Arp.



The Arp button must be on (LED lit) in order to enable the arpeggiator. Adjust the Arp section controls to generate the sequence you're after by holding the notes making up the sequence. Note that in any of the voice modes, the notes in the sequence will always be played by Voice 1 alone.

Mantis's Arp has an Arp Hold function, which allows it to continuously loop the Arp sequence without any need to press the keys down (until you tell it to stop!) In order to use Arp Hold, you first need to enable it by pressing the joystick's push-switch function, in exactly the same manner as for Note Hold (see page 14).

How Arp Hold is activated depends on the Voice Mode currently selected.

- Mono mode – pull the joystick towards you: the **Hold** LED will illuminate brightly. You can do this either before you play the notes of the sequence, or after you've started the Arp sequence, by playing the notes first. You can take your fingers off the keys, and the Arp sequence will continue playing. To stop the sequence, pull the joystick towards you again: the **Hold** LED goes off.
- Duophonic mode – Arp Hold operation differs from Mono mode in that the joystick must be held in the **Hold** position (LED illuminates brightly), and while holding it, play the notes comprising the sequence. The Arp pattern will start; release the joystick. The **Hold** LED will now indicate at "half-brightness".

  In Duo mode you now have a powerful, Chris Hugget-designed feature. Because the Arp sequence only needs one voice (Voice 1), Voice 2 is available for you to add additional non-Arped notes, as a melody, or whatever.

  To stop the sequence, pull the joystick towards you again, as in Mono mode.
- Quad mode – this is operated in the same manner as Duophonic mode, but you now have three additional voices available, allowing you to play polyphonically (3-voices) over the Arp sequence.
- Dual-path Quad mode – this is operated in the same manner as Quad mode.

Modulation Routes

A great many interesting sounds can be created by arranging for one section of the synth to affect another. Mantis gives you the ability to simultaneously vary – or "modulate" - up to six synth parameters by assigning any of six control sources to each one. The modulation itself is in the form of a control voltage, derived from the source, and the signal path element that is to be modulated are all "voltage-controllable".

You can also assign one of six "scaling factors" as part of the setup, that is, which action will determine the magnitude of the modulation.

Each of the these setups is termed a Modulation Route, and is programmed using Mantis's **MOD ROUTES** section.

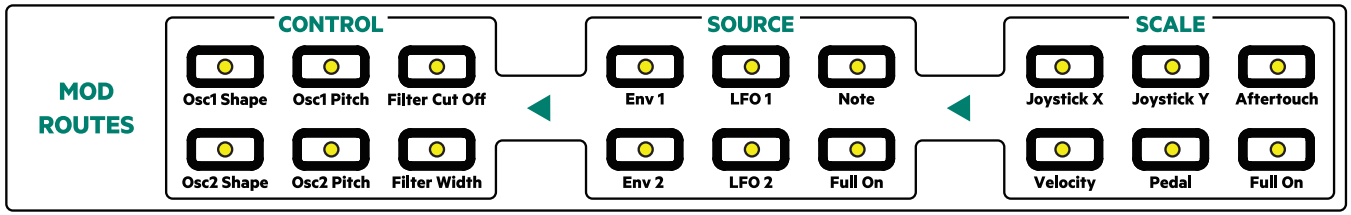
The **MOD ROUTES** controls are divided in three groups: **CONTROL**, **SOURCE** and **SCALE**:

- The six **CONTROL** buttons are the control "destinations". This is where you choose which synth parameter you want to modulate. Each of the six parameters has an associated **Mod** control in the relevant control panel section; this lets you adjust the "amount" of parameter variation that the modulation creates. The **Mod** controls are all "bipolar", which means that the modulation can be made to affect the parameter in either a positive or negative sense. They are centre-detented: in the centre position, the parameter will not respond to any applied modulation.

The six parameters that can be modulated are:

- **Osc1 Shape** – allows the Shape of Oscillator 1's waveform to be modulated. This is equivalent to manually adjusting the Shape control in the **OSCILLATOR 1** control section. The degree of the modulation effect is set by the adjacent **Shape** Mod control.
- **Osc2 Shape** – performs the same function as above for **OSCILLATOR 2**.
- **Osc1 Pitch** – allows Oscillator 1's pitch to be modulated. Use the **Pitch Mod** control to set the degree of modulation.
- **Osc2 Pitch** – performs the same function as above for **OSCILLATOR 2**.
- **Filter Cut Off** – allows the filter cut-off frequency to be modulated. This is equivalent to manually adjusting the **FILTER** section's **Cut Off** control. The **Cut Off Mod** control in the **FILTER** section determines the amount of modulation.
- **Filter Width** – allows the filter's Width parameter to be modulated. This is equivalent to manually adjusting the **Width** control. The **Width Mod** control in the **FILTER** section determines the amount of modulation.

- The **SOURCE** buttons determine which synth control voltage will provide the modulation. The options are:
  - **Env 1** – the modulating control voltage effectively follows Envelope 1's shape, and its timings are defined



by the settings of Envelope 1's controls.

- **Env 2** – performs the same function as above for Envelope 2.
- **LFO 1** – The modulating control voltage is LFO 1's waveform. Use the controls in the **LFO 1** section to determine the rate, wave shape and fade in/out values.
- **LFO 2** – performs the same function as above for LFO 2.
- **Note** – The control voltage is derived from the note's position on the keyboard, relative to middle C. Playing middle C itself causes zero modulation, and the magnitude of the modulation increases with higher and lower notes. The polarity of the control voltage changes at middle C, and is positive for notes above, and negative for notes below. By applying the modulation to oscillator frequency, you can use this option to generate microtone scales.
- **Full On** – this causes maximum positive modulation to be applied to the parameter being controlled. The **SCALE** setting (described below) still allows dynamic control.
- The **SCALE** buttons give you further control of the modulation's magnitude, and lets you choose a dynamic controller to use during live performance. The options are:
  - **Joystick X** – lets you use the left-right action of the joystick to control the modulation that's been configured in the **CONTROL** and **SOURCE** blocks. If the **Mod** control for the destination parameter is set to a positive value, moving the joystick to the right produces a positive modulation effect; moving it to the right produces a negative effect. If the **Mod** control is set to a negative value, the sense of the modulation is reversed.
  - **Joystick Y** – as above, but applies to the up-down action of the joystick. However, note that the joystick only has a "forward" direction available, applying the modulation in a positive sense. (The "reverse" joystick action is reserved for activating the Hold function.)
  - **Aftertouch** – Mantis's keys have aftertouch; this means the keys may be depressed slightly further than is needed in normal playing. By setting up a Mod route to apply an LFO sinewave to oscillator pitch, aftertouch is often used very effectively to add vibrato to the end of a long note. Another interesting effect is to use aftertouch to change filter width to produce a "talky" sound – you can hear this in factory Patch A00.
  - **Velocity** – Mantis measures how hard you hit the keys by measuring the speed at which they are depressed. It generates a control signal called Velocity which is proportional to a key's downward speed. You can apply Velocity as the scaling factor to a Mod Route: thus the harder you hit the keys, the greater the modulation effect. With an Envelope as a source and filter cut-off as the controlled parameter, you can create an expressive effect by scaling the mod route with Velocity: the harder you play, the more pronounced the effect of the filter during the attack phase of the Envelope.

- **Pedal** – the control signal will be derived from an expression foot-pedal connected to the rear panel Pedal socket.
- **Full On** – select this option if you don't want to add a dynamic aspect to the modulation. In this case, the modulation will be constant, its magnitude defined only by the setting of the relevant **Mod** control.

Setting up a Mod Route

The **MOD ROUTES** buttons are laid out in the three groups to make it logical and simple to configure a modulation set-up. The procedure is to work from left to right:

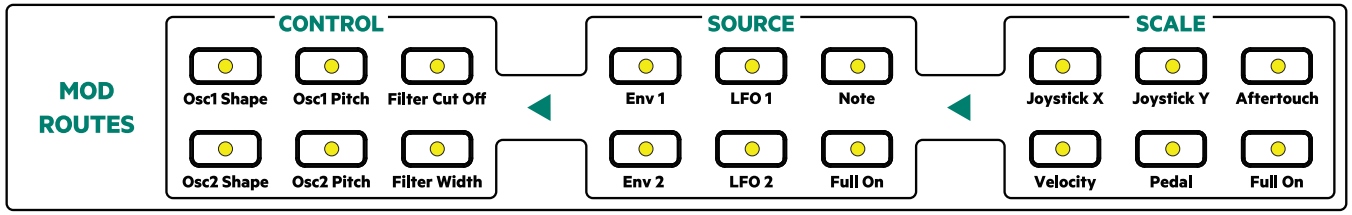
1. Select the synth parameter you want to the modulation to vary by pressing one of the buttons in the **CONTROL** group;
2. Select the source you want to use to vary the parameter by pressing one of the buttons in the **SOURCE** group. If you just want to be able to vary the parameter manually, using one of the dynamic playing options in the **SCALE** group, select **Full On** in the **SOURCE** group.
3. You can now assign one of the dynamic playing controls in the **SCALE** group. This will cause the modulation to only be applied when you e.g., move the joystick, use aftertouch, etc. If you don't want to use any of the dynamic control options, select **Full On** in the **SCALE** group.
4. You won't hear the effect of the Mod Route you've just defined unless you adjust the relevant **Mod** rotary control. For example, if you've chosen **Filter Cut Off** in the **CONTROL** group as the parameter to be modulated, you need to tweak **Cut Off Mod** in the **FILTER** section to get the modulation to work. Remember that all Mantis's modulation is bipolar – that is, it can be applied to the parameter being controlled in a positive or negative sense, depending whether the **Mod** control is to the left or right of its centre detented position.

First – select the parameter you want to control.....

Next – decide what you want to do the controlling.....

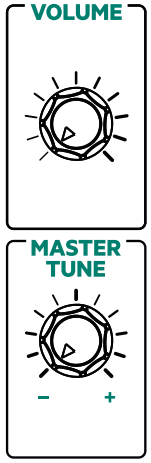
Then – add a dynamic controller, if you want one.....

Finally – adjust the Mod knob for the parameter you selected





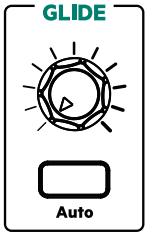
The Master Controls



Mantis has two additional controls not directly concerned with sound generation, but which do affect the overall operation of the synth. The settings of these two controls are NOT saved within a Patch.

- **VOLUME** – this is the master volume control for the synth's audio output. It affects both the main outputs and the headphone output.
- **MASTER TUNE** – as the name implies, this adjusts the frequency of all the sound generating oscillators (i.e., not the LFOs) in tandem. Use it if you're playing with some other instrument that's not tuned precisely to concert pitch. The range is one semitone sharp or flat. the control is centre-detented: in the centre position, Mantis's oscillators will be tuned to standard concert pitch: A above middle C = 440 Hz. (As long as no pitch modulation is applied, and OSC2's **Semitone** and **Cent** adjustments are set centrally.)

The Glide Controls

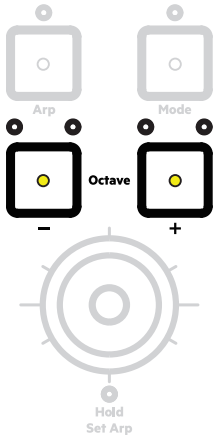


- **GLIDE** – applies "portamento" - a smooth, gliding pitch transition between consecutive notes. The setting of **GLIDE** determines the duration of the portamento before the new note sounds at its normal pitch, but the duration is also determined by how far apart the two consecutive notes are: the further apart, the longer the glide.

  When active, Glide is applied to all notes in mono mode, and when a note is "stolen" in Duo and Quad modes.

Pressing the **Auto** button below the **GLIDE** control turns off the portamento when notes are played "detached" from one another; that is, when one note is released before another is pressed. Portamento will now be added to the start of a new note only when playing Legato style (playing a second note while holding down the first, so that the notes "overlap").

Octave Shift



- **Octave Shift** – the two buttons immediately above the joystick (**Octave +** and **Octave -**) shift the entire keyboard up or down one octave at a time for each press. The default setting (on power-up) is zero octave shift. The range is +3 octaves up and -4 octaves down. The LEDs above the buttons confirm the octave shift currently active: the table below shows the indications. Octave shift is simply cancelled by pressing i) both buttons together, or ii) the “opposite” Octave button. Both LEDs will be off when standard tuning is active. Any active octave shift is saved to the patch.

Octave - LEDs		Octave + LEDs		Octave Shift
○	○	○	○	Standard keyboard (default)
○	○	◉	○	+1 octave
○	○	○	◉	+2 octaves
○	○	◉	◉	+3 octaves
○	◉		○	-1 octave
◉	○	○	○	-2 octaves
◉	◉	◉	○	-3 octaves
◉	◉	◉	○	-4 octaves

LED indications for keyboard Octave Shift

APPENDICES

1. Mantis Shift Functions

The table below summarises the various actions of the **SHIFT** button used in conjunction with various other controls. The table is arranged in sections, according to the type (button or knob) and location of the control with a shifted function.

Note that the fourth table below (Joystick buttons) describes the action of the **Mode** button rather than the **SHIFT** button.

PATCH SECTION BUTTONS		
Shift +	**Action**	**Description**
PATCH Tens (LH 0-9 column)	**UNDO**	Undo allows you retrieve unsaved work if you wrongly press a **PATCH** button. An Undo point is created if an unsaved patch is overwritten by one of the following operations: • Recalling a patch from memory • Overwriting the current patch by sending Mantis a SysEx dump • Using the panel pickup or random functions You can also create an Undo point with **SHIFT** + **Save**. Ten levels of Undo are available; 0 is the most recent. When an Undo point has been defined, the relevant LEDs in the Tens column light when **SHIFT** is held down. Note that Undo points are not saved when Mantis is powered down.
Bank A and **Bank B**	**BANK WRITE PROTECT**	Disables the Save function for the whole Bank (A or B). SysEx dumps into the memory will still work. If both Banks are protected, the **Save** button is inoperative. When a Bank is write-protected, the **Bank** button LED lights when **Shift** is pressed.
Compare	**RANDOMISE**	Creates an unpredictable patch by applying random parameter values to every control.
Init	**PANEL PICKUP**	Applies the current "setting" of every rotary control to the current patch. Button functions adopt the setting they have in the Init patch. (See Appendix 4)

Save	**SYSEX DUMP**	Writes the current patch out as a MIDI System Exclusive message (SysEx dump). You can replay this back into Mantis to recreate the current patch. This action also creates an Undo point, so it can be used as a “quick save” while tweaking a patch.

SYNTH SECTION BUTTONS		
Shift +	**Action**	**Description**
LFO Sync	**ONE SHOT**	When active, the LFO will only generate a single waveform cycle. If **LFO Wave** is set to Random, an unpredictable modulation value is generated for every key press. When one-shot mode is active, the **Sync** button LED will light when **SHIFT** is pressed.
Osc1 Shape and **Osc 2 Shape** (in **MOD ROUTES**/**CONTROL**)	**OSCar Wavetables**	**PATCH** Units buttons **0-9** now select an original OSCar waveform. The **Osc Shape** button LED flashes: press **Osc Shape** again to commit the selection. Press **SHIFT** again to cancel. See page 53 for full details of the nine waveforms available.

SYNTH SECTION ROTARY CONTROLS		
Shift +	**Action**	**Description**
Osc Balance	**PATCH LEVEL**	This shifted function makes the Osc Balance control into an extra volume control. It is useful with particularly loud patches, to reduce the mixer’s output level by up to 15 dB, preventing clipping in the filter section.
Noise Balance	**NOISE SPARSENESS**	Changes the character of the noise source by passing only the higher amplitude components of the noise. It allows for a range of noise “colours” from normal white noise to a very crackly sound.

JOYSTICK BUTTONS		
Mode +	**Action**	**Description**
Octave + and **Octave -**	**PITCH BEND RANGE**	**Mode** acts as a Shift button in this case. The two **Octave** buttons normally shift the keyboard up or down in octave increments. With **Mode** pressed, they adjust the range of pitch bend actioned by horizontal movements of the joystick, in semitone increments. With **Mode** pressed, the Octave LEDs illuminate in a pattern which denotes the number of semitones in binary form: see page 13 for full details.

2. Midi Implementation and Init Patch Parameters

This table lists the MIDI messages corresponding to all Mantis controls, and also the value of each parameter used by the Init patch.

Parameter	CC/NRPN	Control Number	Range	Init patch parameter value
General (Page I)				
Keyboard Octave	NRPN	0:5		+0
Glide Time	CC	5	0-127	0
Glide Auto	CC	35	0/1	Off
Drift	NRPN	0:10	0-127	0
Bend Range	NRPN	0:20		+2
Oscillator 1				
O1 Octave	NRPN	0:24	0-3-5	3
O1 Wave	NRPN	0:14	0-5	Saw/Mantis
O1 Shape	CC	12/24	0-255	+0
O1 Shape Mod	NRPN	0:21	0-64-127	
O1 Pitch Mod	NRPN	0:22	0-64-127	

Oscillator 2				
O2 Octave	NRPN	0:32	0-3-5	3
O2 Wave	NRPN	0:23	0-5	Saw/Mantis
O2 Shape	CC	19/51	0-255	+0
O2 Shape Mod	NRPN	0:30	0-64-127	
O2 Pitch Mod	NRPN	0:31	0-64-127	
O2 Coarse	NRPN	0:28	52-64-76	+0
O2 Fine	NRPN	0:29	0-127	+0
O2 Density	NRPN	0:26	0-127	0
O2 Density Rate	NRPN	0:27	0-127	0
Sub Oscillator				
Osc Sub Level	CC	24	0-127	0
Mixer				
Osc Balance	CC	23	0-127	-64
RM Balance	CC	26	0-127	-64
Noise Balance	CC	27	0-127	-64
Filters				
Filter Drive	CC	80	0-127	0
Filter Shape	NRPN	0:46	0-7	LP_12
Filter Key Track	NRPN	0:48	0-127	+0
Filter Resonance	CC	71	0-127	0
Filter Width	CC	75	0-127	0
Filter Frequency	CC	29/61	0-255	255
Filter Frequency Mod	NRPN	0:49	0-64-127	
Filter Width Mod	NRPN	0:50	0-64-127	

Envelope 1				
E1 Velocity	NRPN	0:55	0-64-127	+0
E1 Sustain Fall	NRPN	0:57	0-127	0
E1 Attack	CC	82	0-127	2
E1 Decay	CC	83	0-127	90
E1 Sustain	CC	84	0-127	127
E1 Release	CC	85	0-127	0
E1 Legato	NRPN	0:56	0/1	On
E1 Repeat	NRPN	0:25	0/1	Off
Envelope 2				
E2 Velocity	NRPN	0:60	0-64-127	+0
E2 Sustain Fall	NRPN	0:62	0-127	0
E2 Attack	CC	86	0-127	2
E2 Decay	CC	87	0-127	56
E2 Sustain	CC	88	0-127	0
E2 Release	CC	89	0-127	0
E2 Legato	NRPN	0:61	0/1	On
E2 Repeat	NRPN	0:33	0/1	Off
LFOs				
L1 Sync	NRPN	0:68	0/1	Off
L1 Rate	NRPN	0:70	0-127	64
L1 Synced Rate	NRPN	0:71	0-127	3:8
L1 Wave	NRPN	0:69	0-5	Triangle
L1 Fade Time	NRPN	0:67	0-64-127	+0
L1 Key Trigger	NRPN	0:74	0/1	Off
L1 One Shot	NRPN	0:68	0/2	

L2 Sync	NRPN	0:77	0/1	Off
L2 Rate	NRPN	0:79	0-127	64
L2 Synced Rate	NRPN	0:80	0-127	3:8
L2 Wave	NRPN	0:78	0-5	Triangle
L2 Fade Time	NRPN	0:76	0-64-127	+0
L2 Key Trigger	NRPN	0:83	0/1	Off
L2 One Shot	NRPN	0:77	0/2	
Voices				
Voice Mode	NRPN	0:66	0/1/2	Mono
Voice Spread	NRPN	0:51	0-127	0
Reverb				
Rev Level	CC	91	0-127	0
Rev Time	NRPN	0:113	0-127	64
Rev Filters	NRPN	0:102	0-7	None
Chorus				
Chor Level	CC	93	0-127	0
Chor Type	NRPN	0:111	0-3	0
Arp				
Arp Sync	NRPN	0:116	0-15	1:2
Arp Pattern	NRPN	0:117	0-5	Up
Arp Octaves	NRPN	0:119	0-5	0
Arp Swing	NRPN	0:120	0-64-127	+0
Arp On	NRPN	0:121	0/1	Off
General (Page II)				
Joystick PB Mod	No MIDI control			On
Level Trim	CC	7	0-127	+0

Noise Density	NRPN	0:123	0-127	127
Tempo	No MIDI control		0-127	100
Modulation Routes				
O1 Shape Source	NRPN	1:0	0-5	LFO 2
O1 Shape Scale	NRPN	1:1	0-5	Full On
O1 Shape Amount				+0
O2 Shape Source	NRPN	2:0	0-5	LFO 2
O2 Shape Scale	NRPN	2:1	0-5	Full On
O2 Shape Amount				+0
O1 Pitch Source	NRPN	3:0	0-5	LFO 1
O1 Pitch Scale	NRPN	3:1	0-5	Full On
O1 Pitch Amount				+0
O2 Pitch Source	NRPN	4:0	0-5	LFO 1
O2 Pitch Scale	NRPN	4:1	0-5	Full On
O2 Pitch Amount				+0
Filter Freq Source	NRPN	5:0	0-5	Env 2
Filter Freq Scale	NRPN	5:1	0-5	Full On
Filter Freq Amount				+0
Filter Width Source	NRPN	6:0	0-5	LFO 1
Filter Width Scale	NRPN	6:1	0-5	Aftertouch
Filter Width Amount				+0

3. Firmware Update Procedure

Current Mantis firmware is available at https://www.1pwm.com/support. Scroll down to MANTIS DOWNLOADS and select the Firmware Upgrade. Download the firmware upgrader (zip file), then extract the contents of the zip. Run the upgrader (.EXE for Windows, .APP for Mac), following all on-screen instructions.

4. List Of Bank A Factory Patches

Here's a list of the default factory patches A00 to A99: many thanks to the following who lovingly created them for us.

BR – Blush Response

DF – Daniel Fisher

KK – Kyle Kilpatrick

MP – Mark Palmer (Tangerine Dream)

PH – Paul Hartnoll (Orbital)

PW – Paul Whittington

TQ – Thorsten Quaeschning

TW – Tom Wolfe

VT – Venus Theory

A00	Talky AT	PW	A11	Instability	DF
A01	3 Oh 3	KK	A12	A Calm Respite	BR
A02	Wasp King	DF	A13	Talking Growler	KK
A04	Crystal Organ	DF	A14	HighpassRipper	KK
A05	Razor Pad	DF	A15	Anomaly	VT
A06	Two Forty Two	BR	A16	Le Violon	PW
A06	Gravitas Lead	DF	A17	Poor Mouse	PW
A07	Stereo Sheen	DF	A18	Reflecting Pools	PW
A08	Space Roulette	DF	A19	Trippy Arpy	PW
A09	Beach Dazed	KK	A20	Hollow Knocker Bass	KK
A10	HAL8999	PW	A21	BandpassOD	KK

A22	Proggy Lead	KK	A48	Jedi Gnat	DF
A23	Moog Over	KK	A49	Lacking Patience	BR
A24	Filter to X+	KK	A50	TrentSetTable	TQ
A25	Noisy Stabber	KK	A51	Adjusting Pieces	TQ
A26	Aftertouch Filter	KK	A52	Gogh on a bike	TQ
A27	All ur Saws	KK	A53	Morph	TQ
A28	Hooverish	KK	A54	Strangest Thing	TQ
A29	Repeater	KK	A55	Portisneck	TQ
A30	Kairos	VT	A56	CitrusNightMare	TQ
A31	Ananke	VT	A57	ONE	PH
A32	Iterations	VT	A58	TWO	PH
A33	Flicker	VT	A59	THREE	PH
A34	Kinetics	VT	A60	Big Rez	TW
A35	Carbon	VT	A61	S&H Shredder	TW
A36	Antimatter	VT	A62	Punchy Bass	TW
A37	Mobius	VT	A63	BandpassArpeg	TW
A38	Reckoning	VT	A64	Stereo Bounce	TW
A39	Hawkins	VT	A65	Ear Bleed Lead	TW
A40	Just Foolin’	DF	A66	Notch lead	TW
A41	Boomer Bass	DF	A67	Not For Use	TW
A42	Crazy Touch	DF	A68	Wakeman	MP
A43	Pressure Scream	DF	A69	WT	MP
A44	Sweeping Legend	DF	A70	BIG LEAD	DM
A45	Funky Mantis	DF	A71	FLUTE	DM
A46	Metallic Perc	DF	A72	6TH POLY	DM
A47	Dirty Polly	DF	A73	POLYSYNTH	DM

A74	FAT BASS	DM	A87	Large Organ	PW
A75	SQUARE LEAD	DM	A88	Rave Fifths	PW
A76	SYNTH BASS	DM	A89	Metal	MP
A77	Vangelis	MP	A90	Random	MP
A78	Pulse	MP	A91	Spaceship	MP
A79	VocalDingAT	MP	A92	Underwater Love	PW
A80	Arping Madness	PW	A93	Yoi Yoi	PW
A81	Big Sympth	PW	A94	Twin Filter OSC	PW
A82	Saw Me In Half	PW	A95	COPTER	DM
A83	Bass In Time	PW	A96	BROKEN ROBOT	DM
A84	Big Slide	PW	A97	Fractalized	BR
A85	Saw Ring	PW	A98	Further Fractals	BR
A86	Glassy Lead	PW	A99	Empty Machinery	BR

5. Special Power-On Functions

Mantis has a number of global functions, which in most cases, will only ever be needed for basic set-up configuration, or if a problem arises.

We recommend that you don't use any of the "factory" functions without first contacting PWM for advice.

All the functions below are actioned by holding down certain buttons or keys during power-up.

SPECIAL POWER-ON FUNCTIONS		
Hold down while powering up...	**Action**	**Description**
Arp	**LOCAL OFF**	Decouples the keyboard from the synthesiser so they can be used as separate MIDI devices. The keyboard will transmit standard Note On/Note Off messages, while the synth engine will respond to incoming messages. Mantis will respond to a MIDI Local On/Off message. Mantis auto-reverts to Local On at power-up.
Arp + Mode	**FACTORY TEST**	Enters factory test mode. For factory use only.
One of the lowest 16 white notes	**SET MIDI CHANNEL**	Sets the MIDI channel Mantis will use. 16 MIDI channels are available. The lowest note (bottom C) will set Channel 1, D two octaves above will set Channel 16.
Highest white note	**GENTLE FACTORY RESET**	Performs a non-destructive reset back to factory settings. After this reset, • The power-on default patch will be A00 • MIDI Channel 1 will be set • Patch bank A will be locked and Bank B unlocked • The joysticks "sticky hold" mode (activated by pressing down on the joystick) will be off
Env 1 Legato + **Env 2 Legato +** **LFO Keyrig +** **LFO2 Keytrig**	**FULL FACTORY RESET**	**Use this "four-finger shuffle" with extreme care!** Performs a full, irrevocable, destructive reset back to original factory settings. In addition to the result of the Gentle Factory Reset above, it also: • Reinstates the original default patches into Bank A • Loads the Init Patch into all Bank B patch memories

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