Oakley Sound Systems

5U Oakley Modular Series

COTA
Four stage cascaded multimode filter

User Manual

V3.0

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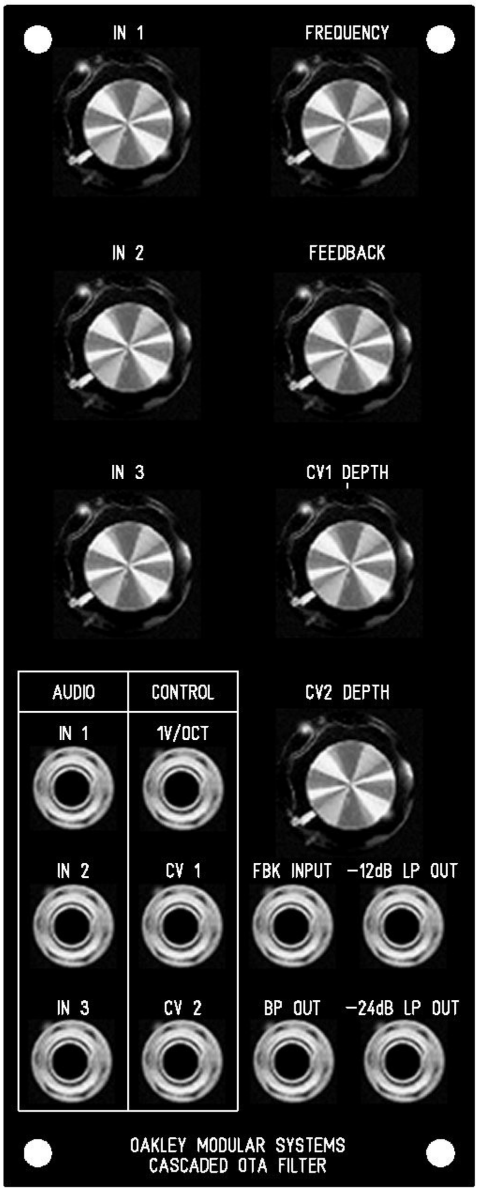
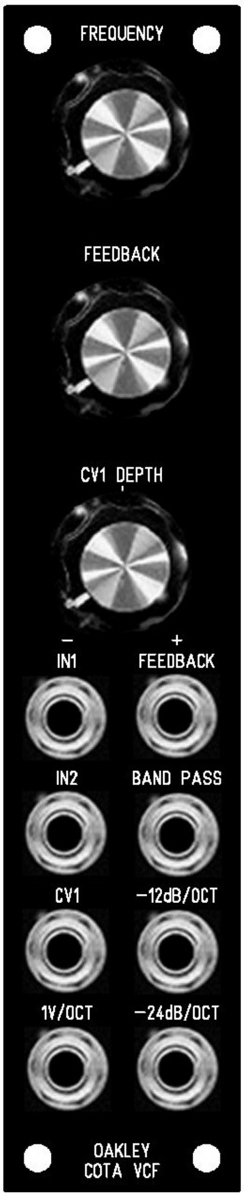


The 2U wide full module in standard MOTM compatible format.



The 1U Filter Core Module in standard MOTM compatible format.

Introduction

This is the User Manual for the COTA module from Oakley Sound.

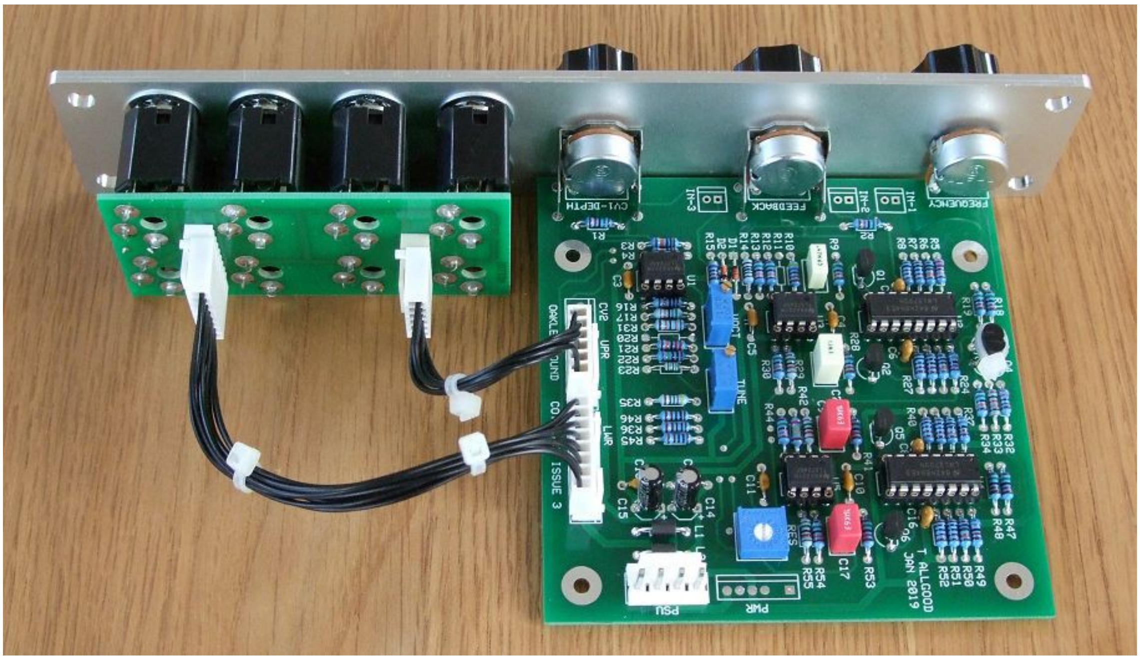
This document contains an overview of the operation of the unit and the simple calibration procedures.

For the Builder's Guide which contains information on how to construct the module from our PCB and parts kits please visit the main project webpage at:

http://www.oakleysound.com/cota.htm

For general information regarding where to get parts and suggested part numbers please see our useful Parts Guide at the project webpage or http://www.oakleysound.com/parts.pdf.

For general information on how to build our modules, including circuit board population, mounting front panel components and making up board interconnects please see our generic Construction Guide at the project webpage or http://www.oakleysound.com/construct.pdf.



The issue 3 COTA behind a 1U wide MOTM format natural finish Schaeffer panel.

Oakley COTA Voltage Controlled Filter Module

This is a four pole multimode filter capable of -24dB/octave low pass, -12dB/octave low pass and +/-6dB/octave bandpass outputs simultaneously. The filter core is based on four identical cascaded current controlled integrators. This is similar to the topology found on the filters in the SH series of monosynths as well as the CEM3320, IR3109 and SSM2040 filters of the classic polyphonic synthesisers.

COTA is an acronym for 'cascaded operational transconductance amplifier'.

At high resonance, I call it 'feedback' in this module, the COTA VCF will oscillate well over the whole of the audio band with a clean sine wave. It is temperature compensated too so you can use it as a reasonably accurate tracking oscillator. The module also features a feedback input. This is similar to the one I introduced in the ground breaking Multiladder module. In conjunction with the 24dB/octave output this input allows the resonance signal path to be split. This means that additional modules can process the resonance loop independently. This allows a large variety of new timbres to be created. And it also allows for voltage controlled resonance with the use of an extra single VCA module.

The design is intended to fit into a 1U wide 'filter-core' module or a more fully featured 2U wide panel with seven control pots.

The 1U 'Filter Core' format is my way of handling filter modules. Although the 1U module can be used as a filter module on its own, it is expected that users will make use of external mixers to control CV and audio levels going into the filter. In this way, one is able to have a collection of space saving 1U filter cores that can be used with any generic mixer module. The Oakley Multimix and Fourmix are ideal choices for a handy mixer module.

The 1U model features two CV inputs, one is fixed at a sensitivity of 1V/octave, while the other is controlled by a reversible attenuator. Two audio inputs are provided which are summed equally into the filter.

For the 2U design three audio inputs are provided each with its own attenuator. Three CVs can control the cut-off of the filter. One is fixed at approximately 1V/octave, the other two have input attenuators. CV1 features a reversible type attenuator with inverting/non-inverting properties.

As already mentioned voltage controlled resonance can be simply attained with one channel of an external VCA module. Set the feedback to maximum, patch the -24dB/octave output to the input of the VCA and then take the output from the VCA to the 'feedback' input on the COTA. Now the VCA is controlling the resonance of the COTA. The higher the gain of the VCA, that is the higher the VCA control voltage or VCA's gain setting pot, the greater the resonance.

Power requirement: +/-15V via MOTM/Oakley or MU power headers. Current consumption is approximately 20mA.

The Filter Core Idea

As you have read this module can be made into either a standard 2U wide module, or as a compact 1U filter core module.

The Filter Core idea has come from the fact that many of our customers were buying different filter types, eg. they may have an MS-20 clone, a Moog ladder filter and an SVF. Each filter type gives a different sound so its worthwhile having a few in your modular set up. However, each filter module also has its own input mixer for audio and an input mixer for CVs. This adds to panel real estate and soon your modular is filling up very quickly. While this does look very impressive, it does mean that, in many patches, you have a lot of redundant electronics in your modular.

Step forward the 'filter core'. This is quite simply a 1U module that contains only the filter and a few important front panel pots. All the audio and CV mixing is done externally with a dedicated mixer module, like the Multimix or Fourmix. The good thing about this is that any unused filter module is only 'wasting' 1U of panel space. So you can afford to have many different flavours of filter without the additional cost and panel space of mixers.

However, as with all things, there are disadvantages too. The lack of inbuilt mixers mean that you will need to get more dedicated mixer modules. But remember that these relatively cheap mixer modules can be used for **any** mixing or level controlling within your modular. Thus, you have more flexibility, at the expense of a little more patching.

The great thing about the Oakley Filter Core modules is that they will all be designed so that they can still be used in the full format design. All the Filter Core modules will have input summing amplifiers built onto the PCB. You won't be using these circuits in the 1U format, but they are there if you want to go for the larger 2U or 3U designs.

What is a Multimode filter?

An electronic filter is a device that lets you separate out some of the elements that make up the whole input. With a filter we can remove parts of the audio signal to give us something that sounds different to the original. Let us take a look at the two basic filter responses of the Oakley COTA:

Low pass: This type of filter will pass all frequencies below the cut-off frequency, *fc*. Above this frequency, the output amplitude or level of the filter will drop as the frequency is increased. The rate at which this output drops is normally determined by the number of active poles in the design. For example a two pole filter will loose output amplitude by 12dB per octave, a four pole filter by 24dB/octave.

The COTA has four identical single pole filters cascaded together. Therefore a maximum attenuation of 24dB/octave is possible with the COTA. In theory, by taking the outputs from each stage you could obtain outputs of -6dB/octave, -12dB/octave and -18dB/octave too. Indeed, the COTA has an additional tap half way along so making the -12dB/octave output available.

By increasing the **resonance** (or **feedback** in the COTA) a band of frequencies around *fc* will be emphasised. This creates a more artificial or electronic sound.

Low pass filtering is the most common form of active filtering in most analogue synthesisers, and generally the most useful.

Band pass: This will pass a band of frequencies centred around *fc*. All other frequencies are attenuated. The roll-off on either side of the centre frequency will normally be determined by the number of active elements in the filter. For example, the roll off in a two stage state variable filter like the Oakley SVF, it is -6dB/octave either side of the centre frequency.

The COTA provides a bandpass output by combining the output from the first stage and fourth stage of the cascaded filter elements. At first glance, this may seem an unexpected result getting a bandpass response from two low pass outputs. However, one should remember that a filter also affects the phase of the audio signal. The two outputs, when mixed in the right amounts, cancel themselves out at lower frequencies and reinforce each other at higher frequencies. This produces a classic -6dB/octave band pass response.

Turning up the resonance control will effectively narrow the band of frequencies passed, making the filter more selective.

This is a very useful response and results in powerful filtering effects. Its more drastic than the low pass filter since it effects the audio on either side of the cut-off frequency. Several band pass filters may be used in parallel to achieve natural resonant or vocal effects.

The bit about gain staging...

Say what?

The COTA is made from four identical low pass filter stages constructed from an electronic circuit called an OTA. Each stage passes low frequencies and attenuates higher ones. The actual frequency of cut-off is controlled by an external CV or the frequency pot on the front panel.

Unlike many cascaded OTA designs, in the COTA the gain of each filter stage is not set to one. That is, even below the cut-off frequency, there is change in the signal level in each stage.

For the first low pass stage there is an gain of approximately one half. This is to reduce the relatively large signal levels coming out of the input mixer circuit. Then the other three following stages have a gain of just below one and a half.

This means that when the filter is put into self-oscillation the magnitude of the resultant sine wave output is the same from all four filter stages.

However, it also means that the audio level gets hotter as it works its way through the filter. This means that any non-linearities or distortions in the circuits are going to be exacerbated as even a small input signal gets progressively closer to overdriving the sensitive OTA input circuitry in each filter stage.

You'll notice that the ordinary signal output from the -24dB/octave socket is twice that as from the -12dB/octave socket.

So why have I done this because surely this is a problem?

Over the years I have heard many different synthesisers and some I like a lot, and some not so much. I analysed the circuits of one of my favourite synths and wondered why this 1978 synth sounded better than those that followed it. One of the differences was the filter gain structure. Later synth designs made by that same company, and others, were designed so that the signal level through the stages was maintained. Not so this one, this synth's filter had been made for constant oscillation levels and not a constant signal level. And it just sounded better to my ears.

So the COTA is inspired by the unusual gain structure from that wonderful 1978 synthesiser.

So which synth is it? You'll have to guess.

Power Supply Connections

MOTM and Oakley

The PSU power socket is 0.156” Molex/MTA 4-way header. Friction lock types are recommended. This system is compatible with MOTM systems.

Power	***Pin number***
+15V	1
Module ground (0V)	2
Socket ground	3
-15V	4

Pin 2 on the LWR header is connected to pin 3 of the PSU header and has been provided to allow the ground tags of the jack sockets to be connected to the power supply ground without using the module’s 0V supply. Earth loops cannot occur through patch leads this way, although screening is maintained.

MU and Synthesizers.com

The PWR power socket is to be fitted if you are using the module with a Synthesizers.com system. In this case you should not fit the PSU header. The PWR header is a six way 0.1” MTA, but the pin in location 2 is removed. In this way location 3 is actually pin 2 on my schematic, location 4 is actually pin 5 and so on.

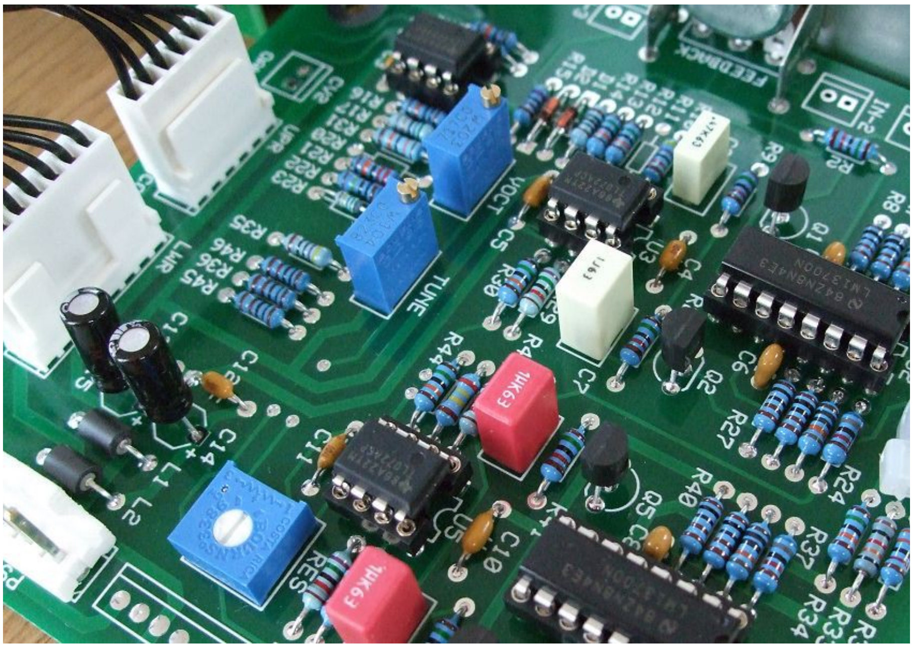
Power	***Location number***	***Schematic Pin number***
+15V	1	1
Missing Pin	2	
+5V	3	2
Module ground (0V)	4	3
-15V	5	4
Socket Ground *	6	5

+5V is not used on this module, so location 3 (pin 2) is not actually connected to anything on the PCB.

If fitting the PWR header and using it with a standard MU power distribution system, you will also need to connect together the middle two pads of the PSU header on the main board. This link connects the socket and panel ground with the module ground. Simply solder a solid wire hoop made from a resistor lead clipping, or bit of solid core wire, to join to the two middle pads of PSU.

* Issue 3 COTA main boards now connect the unused pin 6 of the MU connector to socket ground. With the link on PSU not fitted, and using an Oakley MU Dizzy distribution board with a five way power cable, will allow the socket ground to be kept separate from module ground to prevent ground loops.

Trimmers



There are three trimmers on the PCB. Two multiturn, for VOCT and TUNE, and one single turn, for RES.

V/OCT: This adjusts the scaling of the exponential inputs. Adjust this so that there is an octave jump in cut-off frequency when the 1V/OCT input is raised by one volt.

Plug a 1V/octave source into the 1V/OCT socket. This may be your keyboard's pitch CV output, or from the CV output of a midi-CV convertor. Set the Feedback pot fully clockwise to get the filter oscillating. Now listen to the output coming from the low pass output. I found it is best to use the Frequency pot on the front panel to set the filter oscillating at quite a high frequency tone. Somewhere around 880Hz (two As above middle C) will do. Now play a note on your keyboard and then the same note an octave above. Repeat this again and again and adjust the V/OCT trimmer to get the filter's oscillations to jump an octave too. Don't worry about the actual pitch the VCF is producing. Just concentrate on getting roughly one octave difference between the low note and the high note.

It is a fiddly adjustment and it takes a while to get it right. But remember that this is filter and not a VCO, so you don't have to be too accurate.

TUNE: This adjusts the filter's cut-off frequency. Set this so that the filter's FREQ pot covers your chosen range. In a polyphonic modular, this is needed to make each voice's VCF behave identically.

RES: This allows you to set where you want the resonance to occur as you turn up the Feedback pot. I normally make resonance start at around three quarters of the pot's turn, ie. between 2 and 3 o'clock.

Final Comments

I hope you enjoy using the Oakley COTA module.

If you have any problems with the module, an excellent source of support is the Oakley Sound Forum at Muffwiggler.com. Paul Darlow and I are on this group, as well as many other users and builders of Oakley modules.

If you have a comment about this user manual, or have a found a mistake in it, then please do let me know.

Last but not least, can I say a big thank you to all of you who helped and inspired me. Thanks especially to all those nice people on the Synth-diy and Analogue Heaven mailing lists and those at Muffwiggler.com.

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