Oakley Sound Systems

Eurorack Modular Series

Human Voice Module

PCB Issue 1

Builder's Guide

V1.5

Tony Allgood
Oakley Sound Systems
CARLISLE
United Kingdom

Introduction

This is the Project Builder's Guide for the issue 1 Human Voice Module (HVM) Eurorack module from Oakley Sound. This document contains a basic introduction to the board set, a full parts list for the components needed to populate the boards and some hints on how to build the unit.

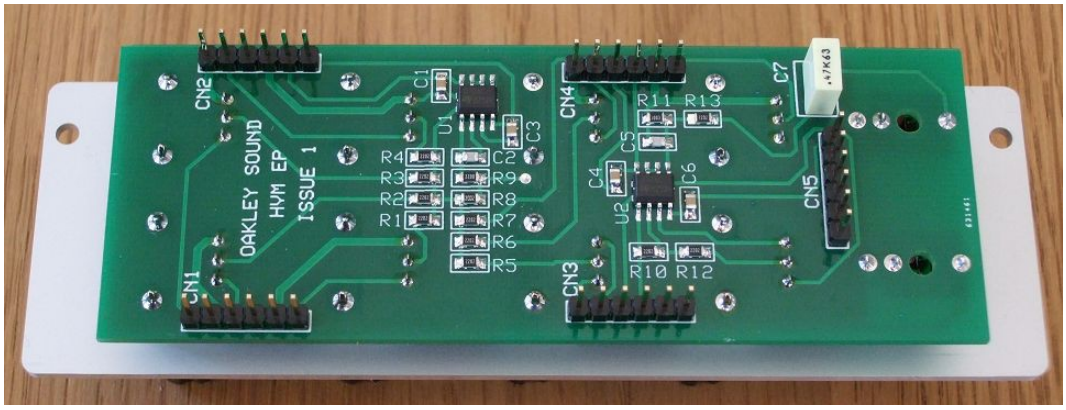
The prototype panel design – note the small typographic error in the labelling of the 220Hz pot as 230Hz.

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

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

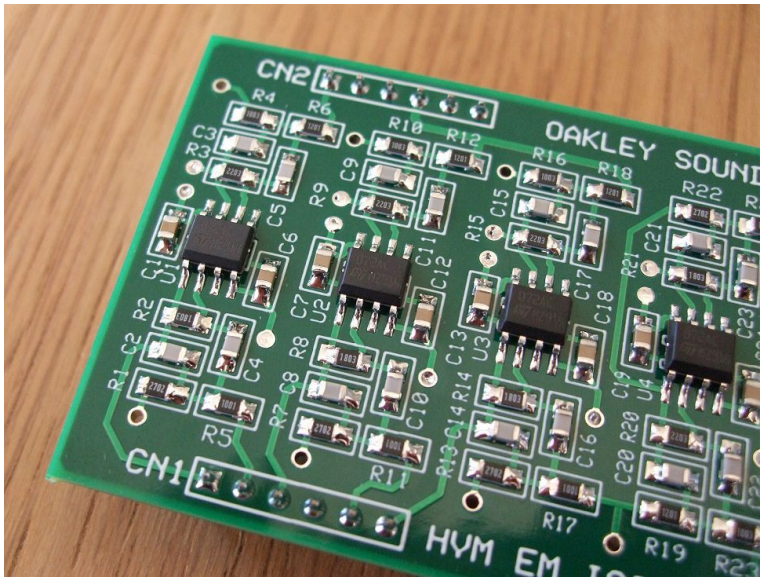
The HVM PCB set

The electronics of the Oakley HVM is built on two printed circuit boards (PCBs). The Pot board holds the eight pots, input and output sockets, and the audio input and output circuitry. All the front panel components are directly soldered to the Pot board. The board is a double sided design meaning that there are electrically conductive copper tracks on the top and bottom surfaces of the board. The surface mount components are all soldered to the top side of the board while the pots and sockets are soldered to the underside which faces the inside surface of the front panel.



The top side of the pot board. The board is already fitted to the front panel. Note that all the surface mount components are fitted to this side. The pots and sockets cannot be seen as they are fitted to the underside of the board.

The second board is called the main board. This holds the seven pairs of band pass filters, the power supply conditioning, and power inlet. The main board is a four layer design. This means that the board has layers of copper on top and bottom sides, as well as two internal copper layers. The top internal layer is solely reserved for the 0V connections – sometimes called module ground – used for the main and top board's electronics.



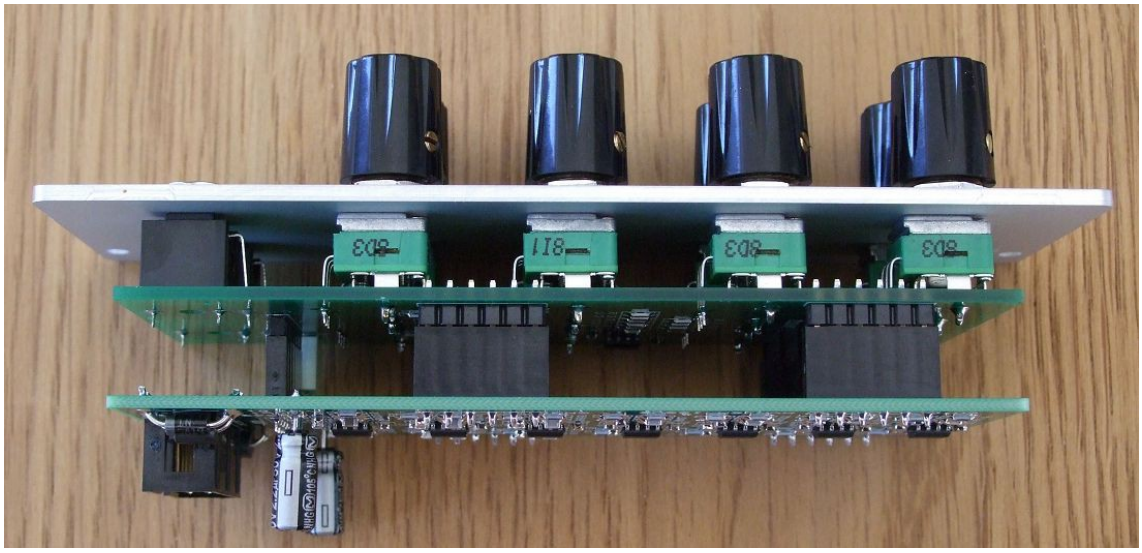
A close up of the main board showing four of the band pass filters used in the module.

The components, again a mixture of through hole and surface mount devices, are soldered to the top

of the board. The main board's components are all accessible from the rear of the module. Although this means that you need to be a little careful when handling the module, it does mean that fault finding is much easier than it would be if the main board was facing the other way and no components would be visible.

The surface mount components are of relatively large geometries to make the build suitable even for beginners in surface mount soldering. The resistors and capacitors are all 0805 and the ICs are narrow body SOIC. The larger capacitors, diodes and all the interconnects are through hole parts.

Both circuit boards are the same size, that is, 40 mm (wide) x 107 mm (high). The boards are designed to go behind a panel that is 8HP wide.



The module comprises of two circuit boards connected together with five six way 0.1" SIL headers and sockets.

The grip of the multiple SIL interconnects are strong enough to hold the boards together for most uses. Should you require more rigidity then a **small** blob of silicone sealant or heat melt glue across the join between the plastic housings of CN1, CN2, CN3 and CN4 would hold everything together tightly. However, it is best not to do this until your unit has been thoroughly tested.

The design requires plus and minus 12V supplies, although it will work on +/-15V too with no modifications. The power supply should be adequately regulated. The current consumption is around +40mA and -40mA at +/-12V.

HVM Parts Lists

The components are grouped into values, the order of the component names is of no particular consequence.

Many of the parts for this circuit board are surface mount devices but not all of them. Take special care when ordering your parts that you order the correct type of part. This parts list shows the type of part needed whereas the circuit diagram does not.

A quick note on European part descriptions. R is shorthand for ohm. K is shorthand for kilo-ohm. R is shorthand for ohm. So 22R is 22 ohm, 1K5 is 1,500 ohms or 1.5 kilohms. For capacitors: 1uF = one microfarad = 1000nF = one thousand nanofarad. For electrolytic capacitors the maximum working voltage is normally given with the value, eg. 1uF/63V is a one microfarad capacitor with a working DC voltage of 63V.

To prevent loss of the small '.' as the decimal point, a convention of inserting the unit in its place is used. eg. 4R7 is a 4.7 ohm, 4K7 is a 4700 ohm resistor, 3n9 is a 3.9 nF capacitor.

HVM Main Board issue 1 Parts List

Resistors

All resistors except are surface mount, size 0805 (or metric 2012) 1% 125mW metal film.

1K	R5, R29, R11, R34, R41, R17, R24
1K2	R28, R19, R12, R18, R35, R6, R38
27K	R25, R22, R36, R1, R42, R7, R13
100K	R23, R16, R10, R4, R31, R30, R37
180K	R40, R33, R14, R8, R21, R26, R2
220K	R20, R15, R9, R32, R27, R3, R39

Capacitors

The following capacitors are surface mount, size 0805 (or metric 2012) multilayer ceramic, dielectric C0G (or NP0), working voltage 50V (25V for the 47nF), tolerance +/-5%.

3n3	C8, C9, C10, C11
3n9	C2, C3, C4, C5
8n2	C14, C15, C16, C17
12nF	C20, C21, C22, C23
18nF	C26, C27, C28, C29
33nF	C32, C33, C34, C35
47nF	C38, C39, C40, C41

The following capacitors are surface mount, size 0805 (or metric 2012) multilayer ceramic, dielectric X7R, working voltage 50V, tolerance +/-5%.

100nF	C7, C30, C6, C24, C42, C36, C25, C31, C37, C19, C13, C1, C18, C12

The following capacitors are standard through hole electrolytic capacitors with 0.1” (2.5mm) or 0.2” (5mm) radial leads.

2u2/50V electrolytic	C43, C44

Discrete Semiconductors

The following devices are standard through hole parts.

1N5819 Schottky diode	D1, D2

Integrated Circuits

The following parts are surface mount devices. All are small outline (SOIC) narrow body packages.

TL072ACD dual op-amp	U1, U2, U3, U4, U5, U6, U7

Miscellaneous

Leaded axial ferrite bead	L1, L2
2 x 5 0.1” boxed header	STRIPE
6-way 0.1” SIL socket	CN1, CN2, CN3, CN4, CN5

CN1 to CN5 are mounted on the underside of the board, facing down, and soldered from the top. Special care must to be taken to ensure that these connectors are mounted perpendicular to the board surface.

HVM Pot Board issue 1 Parts List

Resistors

All resistors except are surface mount, size 0805 (or metric 2012) 1% 125mW metal film.

220R	R9
22K	R1, R2, R3, R4, R5, R6, R7, R8, R10, R12, R13
100K	R11

Capacitors

The following capacitors are surface mount, size 0805 (or metric 2012) multilayer ceramic, dielectric C0G (or NP0), working voltage 50V, tolerance +/-5%.

100pF	C2, C5

The following capacitors are surface mount, size 0805 (or metric 2012) multilayer ceramic, dielectric X7R, working voltage 50V, tolerance +/-5%.

100nF	C1, C3, C4, C6

The following capacitor is a through hole component.

470nF, 63V polyester film	C7

Potentiometers

All pots are Alpha 9mm vertical pots with 6.35mm round shafts.

50K linear	LEVEL, 220Hz, 330Hz, 600Hz, 910Hz, 1300Hz, 2800Hz, 3300Hz

The pots are to be fitted to the underside of the board and their pins soldered from the topside.

Integrated Circuits

The following parts are surface mount devices. They are small outline (SOIC) narrow body packages.

TL072ACD dual op-amp	U1, U2

Miscellaneous

6-way SIL header	CN1, CN2, CN3, CN4, CN5

Special care must to be taken to ensure that these connectors are mounted perpendicular to the board surface.

Thonkiconn 3.5mm socket	IN, OUT

The two 3.5mm sockets are to be fitted to the underside of the board and their pins soldered from the topside.

8 knobs to suit. Davies 1900H or clones thereof are to be recommended.

Alternative Build with Vintage Frequency Spacings

The original keyboard that inspired this module used seven band pass filters with operating frequencies of 185Hz, 220Hz, 600Hz, 910Hz, 1300Hz, 2800Hz, and 3300Hz. The suggested build of the HVM uses a slightly different set of frequencies with its lowest two bands at working at 220Hz and 330Hz. This was done as the original 185Hz and 220Hz filters were quite closely spaced and for many input signals the sonic differences between the two were minimal. The addition of the new 330Hz band, which very nicely fills the large gap between 220Hz and 600Hz, can give interesting textures that the original arrangement could not. However, with notes of less than 110Hz the difference between the original 185Hz and 220Hz bands is more significant. For example, if you wish to copy the sound of the vintage keyboard's Male 8' Lower preset it is not possible to do so exactly on the Oakley HVM when built as suggested.

To recreate the original frequency bands, that is gain the 185Hz band, but lose the 330Hz band, you should make the following changes to the parts list:

The following capacitors are surface mount, size 0805 (or metric 2012) multilayer ceramic, dielectric C0G (or NP0), working voltage 25V, tolerance +/-5%.

47nF C32, C33, C34, C35

The following capacitors are surface mount, size 0805 (or metric 2012) multilayer ceramic, dielectric U2J, working voltage 25V, tolerance +/-5%.

56nF C38, C39, C40, C41

Note the different dielectric used in these two capacitors. 56nF is not currently available as a C0G/NP0 device in 0805 size – it's simply too large a capacitance to fit into that small space. However, Kemet make an 0805 56nF capacitor in their excellent U2J dielectric. This is their part number C0805C563J3JACTU and is normally available from Farnell and Mouser.

56nF is also, and easily, available in the X7R dielectric. For example, Kemet part number C0805C563K5RACTU. This is not such a good performing dielectric but may, I have not tried it, work perfectly well in this application.

Part Sourcing

For general information regarding where to get parts and suggested part numbers for Oakley projects please see my Parts Guide at the project webpage or www.oakleysound.com/parts.pdf.

The front panel is obtained either from Schaeffer in Germany, or Front Panel Express (FPE) in the US. The database for the panel is provided on the project webpage and this file can be opened, edited and ordered using the Frontplatten Designer program available free from Schaeffer or FPE. The cost of the 8HP wide panel was around 27 Euros at the time of writing. The panel is 2.5mm thick and has a natural silvery finish. The black text is printed, although it is possible to edit the database to have the text engraved.

The pots are Alpha 9mm vertical pots as sold by Thonk and others. I use Thonk's standard ones with 6.35mm (0.25”) round shafts. Other shaft types are available, like splined or D-type, and you should purchase those that are compatible with your choice of control knob. I prefer the round shafts as they require control knobs that have a fixing screw. Although these knobs take more time to place and secure, the height at which the knob sits on the pot shaft is under your control. Push fit knobs can sometimes not sit at the right height which is unsightly if they are too high, or graunch against the pot's securing nut and washer if they are too low.

For control knobs I use Davies 1900H clones available from Thonk and others.

The two 3.5mm sockets are the same type and are available from Thonk known either by their Thonkiconn moniker or as part number PJ398SM.

The fixed 2.54mm (0.1”) interconnects are in two parts, the male header, and the female socket or receptacle. I use six way single in line (SIL) connectors in the HVM. The ones I use are made by Multicomp, although more expensive types are available which may offer increased longevity. These are the Multicomp part numbers for the parts I used:

6 way socket	2212S-06SG-85
6 way header	2211S-06G

All the dual op-amps are recommended to be TL072ACD. Note the A in the part number suffix, this is the improved specification version of the standard TL072 which has lower offset voltages. Offset voltage is an unwanted voltage on the inputs of an op-amp which then manifests itself as an error voltage on the output of the op-amp. Other dual op-amps may be used such as the LF412CD and TLE2072CD.

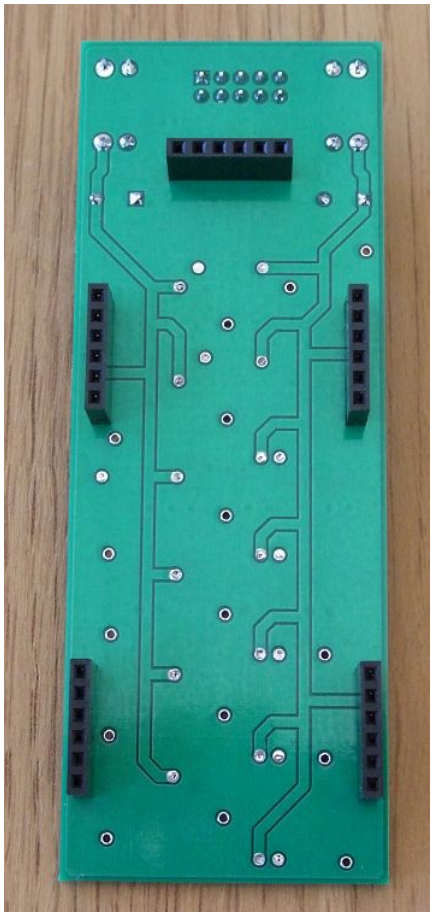
Populating the Circuit Boards

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

Main Board Construction

All the surface mount components should be soldered first. Take care to treat all ICs as static sensitive devices. I usually solder the resistors first, then the capacitors, and then the ICs.

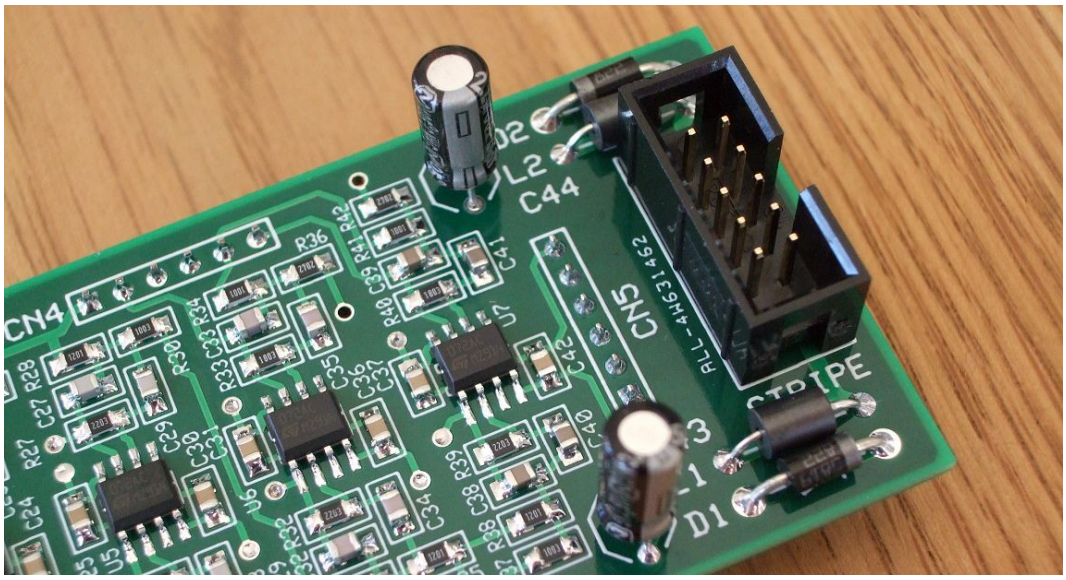
The next items to be soldered are the single in line (SIL) sockets. These are to be fitted to the underside of the board and soldered from the top side.



Special care should be taken to ensure that each SIL socket sits at right angles to the board surface. One way to do this is to temporarily fit the SIL headers into the SIL sockets and fit the Main board and Pot board together with the headers and sockets in between. Then solder the headers to the main board. Pulling the two boards apart should reveal all the sockets neatly in place and at the correct angle.

The next items to be soldered will be the through hole components. Remember that diodes and electrolytic capacitors are polarised so they need to be fitted the right way around. You also should especially make sure that the boxed header is correctly orientated. Pin 1 is normally designated with a little arrow shape on the plastic housing of the header and this should align with the square pad on

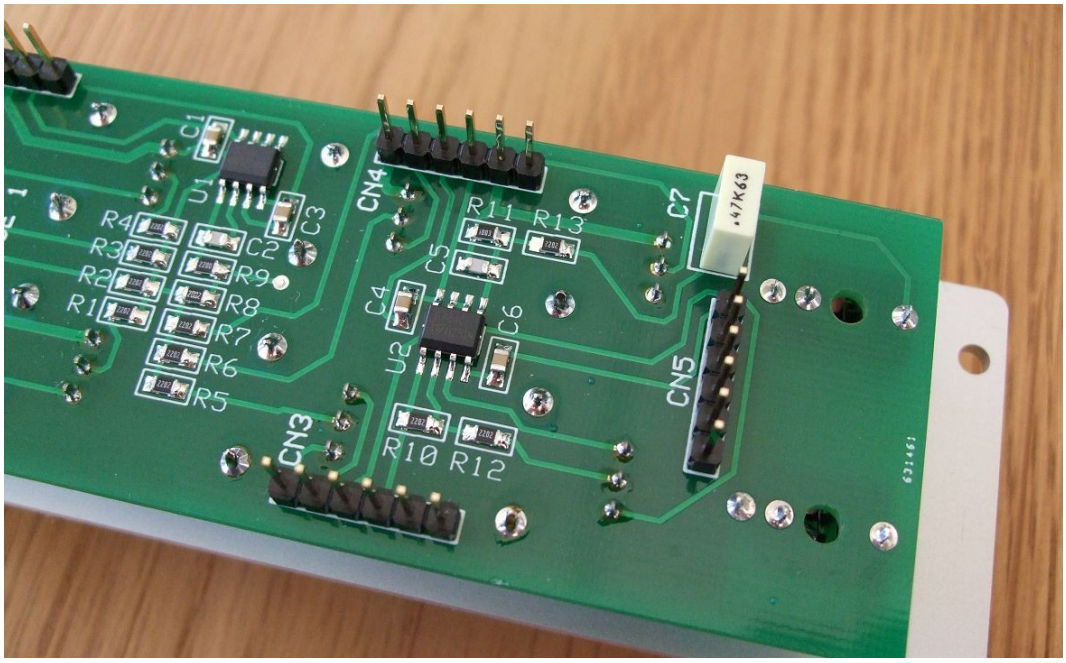
the board. Also, the hole in the housing should correspond to the little box shape on the board's printed legend.



The power supply inlet is a 10 way (2 x 5) IDC boxed header. Note the orientation of the notch in the side of the plastic housing.

Pot Board Construction

Except for the pots and sockets all the parts are to be fitted to the topside of the board. The surface mount parts should again be soldered first. Then fit the single 470nF polyester film capacitor to the board which needs to be soldered from the underside of the board.



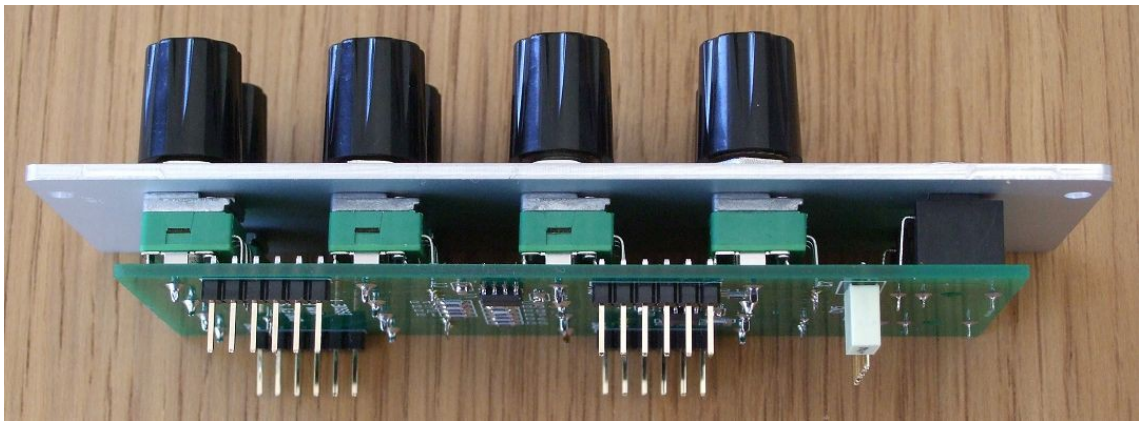
Now fit the SIL headers into place and solder from the underside of the board. It may be worth temporarily fitting the Pot board to the Main Board so as to hold the headers exactly at right angles while you solder.

The remaining parts are the front panel components and these will be fitted to the underside of the board and soldered from the top of the board. There are no legends on the underside of the board to indicate where the parts will go but it should be obvious where they need to be fitted. To ensure the correct alignment of these parts before soldering you should have your front panel ready. The panel will be used as a jig to hold the parts in the correct place while you solder. Failure to use the panel as a jig for these components could mean that the panel will not slide onto the components.

The first parts to place, but not solder, will be the pots. The pots should be fitted so that the three pot pins go into the board first, then ease in the two lugs into their holes and push in firmly so that the pot clicks into place. The pot will sit securely in the board even without soldering.

Fit the two sockets into the board but again do not solder yet.

Now ease the panel down onto the pots and sockets making sure that all their threads are sitting snugly in their holes. Place a washer and a nut on each of the pots and sockets. Tighten the nuts but not too tightly. Turn the module over to reveal the topside of the circuit board. Now solder all the pots and sockets.



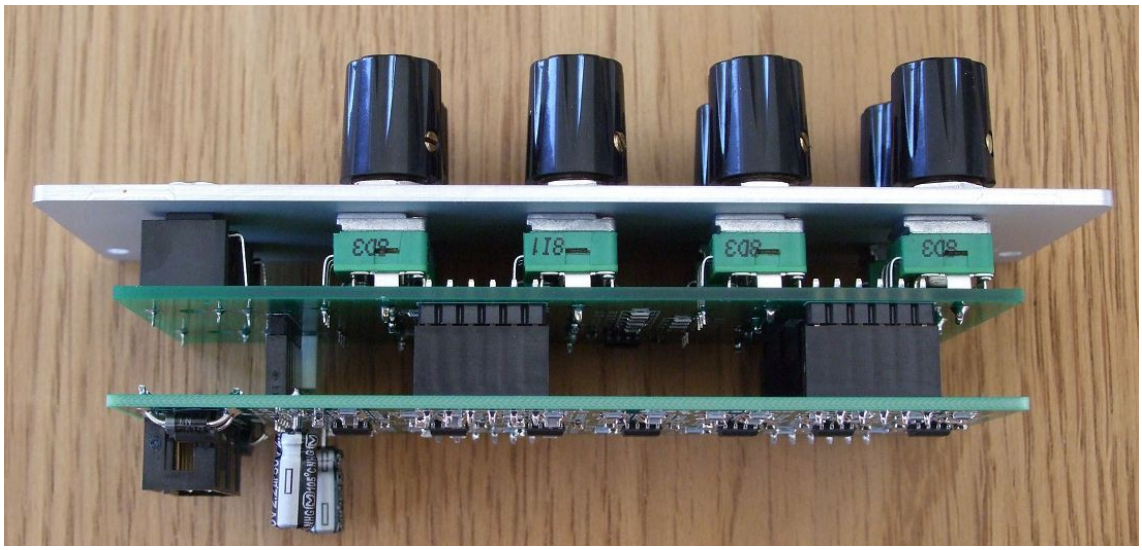
The completed pot board attached to the front panel.

Testing

It is prudent to test the main board on its own before fitting it to the pot board and panel. If you have a bench power supply that allows you to select the current limit then set both the +12V and -12V supplies to a current limit of 50mA. This should prevent any serious meltdowns if there is a problem with the build.

Power up the main board on its own. If you can measure power supply current then it should be around -35mA and +35mA. Anything significantly more than this will indicate a problem. If you can't measure current then check that no devices are getting warm.

It may be worthwhile checking the output voltage of each op-amp. Measure the voltages at pin 1 and at pin 7 with respect to 0V (module ground). 0V may be most easily available from any of the solder pads of CN5. Each op-amp output should have a voltage of no more than +/-10mV, that is, very close to 0V. If any of them are not this then that particular circuit has a problem.



If all is well, then the main board can be powered down. Wait a couple of minutes and then attach the main board to the pot board. Be very careful to ensure all the SIL connections are correctly in place.

Power the module up again and, if you can, check the current draw of the module. It should be around +/-40mA. Anything significantly different to this, say over 50mA, will indicate a problem.

Insert a 110Hz sawtooth signal from a VCO into the input socket. Turn the level pot up and then by rotating each filter band's pot one at a time, check that each filter section is working. Each filter should sound very different the others, from the smooth sounds from the lower frequency bands, to the boxy and then nasal sounding ones in the middle, to the fizzy ones at the top.

Final Comments

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

If you can't get your project to work and you are in the EU, then Oakley Sound Systems are able to offer a 'get you working' service. If you wish to take up this service please e-mail me, Tony Allgood, at my contact e-mail address found on the website. I can service either fully populated PCBs or whole modules. You will be charged for all postage costs, any parts used and my time at 25GBP per hour. Most faults can be found and fixed within one hour, and I normally return modules within a week. The minimum charge is 25GBP plus return postage costs.

If you have a comment about this builder's guide, or have a found a mistake in it, then please do let me know. But please do not contact me directly with questions about sourcing components or general fault finding. Honestly, I would love to help but I do not have the time to help everyone individually by e-mail.

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

Tony Allgood at Oakley Sound

Cumbria, UK