Oakley Sound Systems

Discontinuity Module

PCB Issue 1

User and Builder's Guide

V1.0.1

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A render of the suggested front panel design. The format is our standard 5U high 2U wide module that is compatible with MOTM.

Introduction

The Discontinuity is an updated version of an older Oakley module called the Wavefolder. Both devices are voltage controlled waveshaper modules designed primarily for use in modular analogue music synthesisers. The module comes in our standard 5U high 2U wide format which is directly compatible with Synthtech's MOTM series.

The Discontinuity module, although using the same core technology as the old Oakley Wavefolder, is different enough in circuitry, usage and front panel design to be worthy of a new name. And it is the new discontinuity and offset controls and CV inputs that make this module very unique.

Waveshaper modules work very differently to, and perhaps less intuitively than, other sound shaping modules such as filters, ring modulators and amplifiers. As such the Discontinuity will take some time to get used to. However, when used to process simple VCO waveforms it is capable of creating some very beautiful tones, all of which can be varied dynamically in musically interesting ways. Input waveform type, whether triangle, sawtooth or sine, can have profound tonal differences in the Discontinuity's output. And varying the input level can also have some amazing affects.

Internally the module is arranged as five sections connected in series.

1. The Soft Clipper. This circuit gently restricts all input signals to around +/- 5.5 volts peak. Its essentially mimics an overdriven valve or tube amplifier. The output of this circuit passes directly to the next stage which is...

2. The Clamper. This prevents the output from going above or below a preset limit. Unlike the soft clipper circuit the clamping is hard and abrupt. And unlike the soft clipper the limit is completely voltage controllable. We call it the Threshold and it can be controlled with a front panel pot or input CV. Any input can be altered dramatically with this function. As well as being passed on to the next stage of the module, the output of clamper is available at its own output.

A three way toggle switch, called 'polarity' although not marked as such on the front panel, offers three modes of clamping:

> a) POS – the input signal is clamped when it exceeds the threshold voltage. ie. if the threshold voltage is 2V, then all parts of the input signal that go above 2V will be clamped.
>
> b) NEG – the input signal is clipped when it falls below the inverse of the threshold voltage. ie. if the threshold voltage is 2V, then all parts of the input signal below -2V will be clamped.
>
> c) BOTH – the switch is in its middle position. Both negative and positive clipping takes place. ie. if the threshold voltage is 2V, then all parts of the input signal above 2V are clamped, and all parts of the input signal below -2V are clamped.

In the old Wavefolder when the signal was clamped the output signal was simply held at the threshold voltage. In the Oakley Discontinuity the output level during clamping can now be varied dynamically. This can be done either as a function of the threshold voltage, via the module's Discontinuity control and its CV input, or as a fixed offset with the Offset control and its CV input. Furthermore, the offset can either be applied symmetrically or asymmetrically depending on the Track/Oppose switch. What this means is that we can actually remove any proportion of the original signal at that point where it exceeds the threshold voltages and replace it with another input. In other words we can splice one waveform in place of another. This has the potential to make some very new and wonderful timbres.

The track/oppose switch controls whether the offset voltage is added to the output waveform in a symmetrical or asymmetrical way. The switch's position only affects the negative part of the input waveform. If in track then the offset voltage is applied equally to both the negative and positive parts of the input waveform. ie. a 1V offset CV, with Discon set to 0%, will make the part of the waveform that is replaced when the threshold is exceeded be both be 1V. In Oppose mode, you have a 1V section in the positive part and -1V in the negative part of the input waveform.

3. The Clipper. What the Clamper bites off, the clipper returns. The Clip output is the part of the original input signal that gets chopped off by the clamper circuit. So if you put a 5V peak triangle waveform into the Clamper, set the threshold to be 2.5V and set the mode switch to BOTH, the Clamp output will give you the neatly clipped almost square wave output, while the clipper will give you the tips of the pointed bits of the original triangle waveform.

4. The Folder. The Discontinuity's fourth section is based around a four quadrant multiplier. Here the Clip out and Clamp out are mixed together. However, the clip output may be added or subtracted from the clamped signal. A pot and an external CV sets the mix ratio and polarity. Again, consider the 5V triangle waveform with the polarity switch set to either POS or NEG. With the Fold pot set to 0, you get the plain Clamped signal at the main output. Turn the Fold pot clockwise and the clipped signal will return to create the original signal once more. But keep turning it, and the clipped signal is now bigger then the original. Now turn the pot the other way. The clipped signal gets subtracted from the clamped signal. You can get full wave rectification, thus your triangle becomes another triangle at twice the frequency. Multiplication. Turn it up further and more harmonics come in.

5. The Amp. The last stage is a simple x10 amplifier. The Discontinuity can clip accurately down to small levels if you want, so you need a good amplifier to bring it up to a decent level again.

And don't forget the Discontinuity will work with any signal, audio and CV. You can mangle EG outputs, LFOs and, of course, your VCO.

The Issue 1 PCB set

The main printed circuit board (PCB) is 113 mm (depth) x 143 mm (height) in size. All three boards use double sided copper traces and have through plated holes. The solder pads are large and are easy to solder and de-solder if necessary. They have a high quality solder mask on both sides for easier soldering, and have clear legending on the component side for easier building.

If you are building the standard design there are no components mounted off the boards except for the switches. All other components including LED, sockets and pots are soldered directly to the boards.

Previously, many Oakley modules have had the sockets, switches and extra pots wired to the board by individual wires. This module allows all the socket wiring to be done via the socket PCB and three MTA solderless or Molex connections. If you are building this module in the standard Oakley format this new system will reduce assembly time and possible wiring errors.

Some people will wish to use this Oakley design in a non standard format, such as fitting it to another manufacturer's rack or one of their own invention. This is perfectly easy to do. Simply do not use the socket board and wire the main board to the sockets as per usual. I have laid the board out to accept 0.1" headers for each additional pot and switch.

I have provided space for four of the control pots on the main PCB, whilst the other four pots are fitted to their own board. If you use the specified pots and brackets, the PCBs can be held firmly to the panel without any additional mounting procedures. The pot spacing is 1.625" and is the same as vertical spacing of the MOTM modular synthesiser.

There are detailed instructions later in the document about how to build the boards. The whole project takes around 3 hours to build and test.

Power Supplies

The design requires plus and minus 15V supplies. These should be adequately regulated. Although quite large perturbations in the supply will not cause any pitch changes, waveform linearity and DC offset will be affected by an unregulated supply. The current consumption is a maximum of 60mA for the +15V rail and slightly less for the -15V.

Power is routed onto the PCB by either four way 0.156" MTA/Molex type connector or 0.1" Synthesizer.com compatible header. You could, of course, wire up the board by soldering on wires directly. The four pins on the MTA/Molex connector are +15V, ground, panel, -15V. The panel connection allows you to connect the metal front panel to the power supply's ground without it sharing the modules' ground line. There is an optional wire link provided on the board to join ground and panel connections together should you wish. More about this later.

How to Use this Module

As I have already mentioned waveshapers can be less intuitive than other synth modules. This is especially true of the Discontinuity since it has several shaping functions available. In the introduction I went through the various internal modules of the Discontinuity module, here I will try to explain what each front panel control does in more detail.

The **Polarity** switch determines what part of the waveform is to be affected by the module. In the POS position the module affects the positive parts of the input signal. That is all the parts of the input signal that are above zero volts. Note that the module is completely DC coupled this means that it will process slowly moving or even static control voltages as well as audio signals. Figure 1 shows a triangular input waveform being clipped by the module.

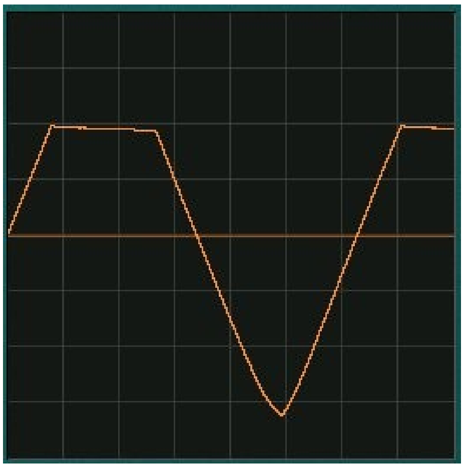


Figure 1- Polarity set to POS showing basic clipping with threshold set to around 2V with no folding. The slightly sloped flat part of the clipping is caused by the AC coupled input of the digital scope I have used to make this picture and not the module itself

When the Polarity switch is put in the NEG position then the module will only affect the negative portions of the input waveform. With the switch set to BOTH, its middle position, both negative and positive parts of the waveform are affected.

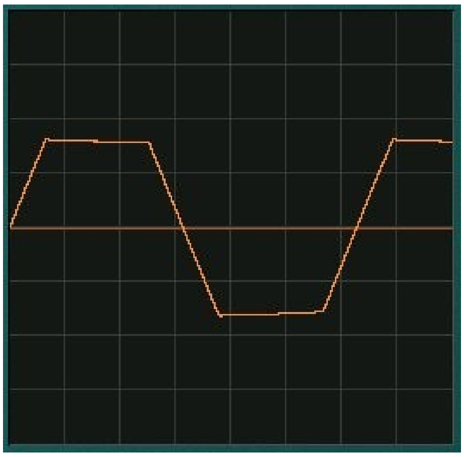


Figure 2 – Polarity switch set to BOTH. Note both negative and positive parts of the input triangle wave input have been clipped to produce a symmetrically clipped output waveform.

The **Threshold** pot is a manual control that sets the point when the input signal is to be affected by the module. In figures 1 and 2 it is Threshold that sets the point at which the clipping starts, ie. the point at which the input waveform starts to become deformed. The Threshold value can be changed from around -7V to +7V with 0V being at the mid point. The pot features a dead zone near the middle. This means that it is very easy to set the pot to exactly 0V just by putting somewhere near the middle.

When the threshold voltage is set to say +2V, ie. slightly right of its centre point, the input signal will be affected when it exceeds +2V if the Polarity switch is in either POS or BOTH, and when it falls below -2V when the Polarity switch is in either NEG or BOTH. This part is important to understand – the threshold pot will control both the negative and positive threshold voltages simultaneously but its position shows the positive threshold voltage only. The negative threshold voltage is always the inverse of the positive threshold voltage. For example, if the positive threshold is 3V the negative will be -3V and so on.

Note: Setting the Polarity switch to BOTH and moving the threshold pot to 0V doesn't make much sense since all signals above and below 0V will be clipped. ie. you'll get nothing. However, this null result should also happen with any value of Threshold below 0V since how can you have a signal that is both below -1V and above 1V? But Discontinuity does not obey the laws of mathematics due to a quirk in the circuit topology. The output in this 'illegal' state becomes a pulse wave whose height and width are determined by the Threshold pot. With a triangle wave input and threshold values of just slightly negative the output will be a low amplitude square wave. As you decrease the threshold value further the square wave will narrow producing pulse wave of increasing amplitude. This behaviour was not originally intended but its quite a useful feature to have.

The **Thresh CV** pot controls the depth of the Thresh CV input. CV stands for control voltage and this can come from any voltage source such as an LFO, VCO or ADSR. In this way the threshold parameter can be varied automatically as if you were turning the Threshold pot manually and proportionally to the input control voltage. With the Thresh CV pot at its maximum value the threshold voltage will be equal to the input CV voltage.

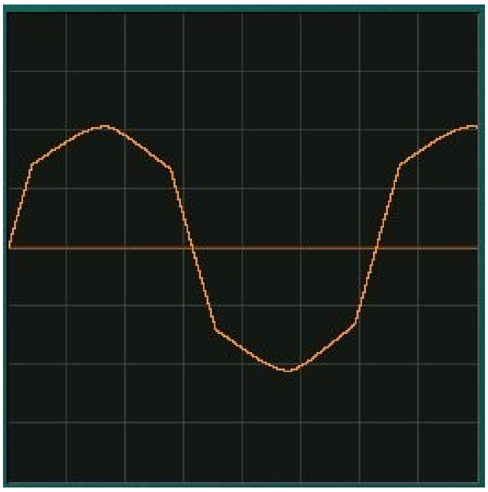


Figure 3. Slight positive folding causing a soft clipping type of effect. Note the slightly rounded tips of the triangle wave caused by the actions of the input soft clipping circuit.

With the **Fold** pot set to its middle dead band position the output is clipped at the level determined by the Threshold pot and its input CV. The Fold pot however lets you control the amount of the input signal that is allowed to return. At positions right of centre the input signal is allowed to return with the same phase. This means that positive going parts of the waveform are returned still going positive. The gain can be controlled by the Fold pot, with zero in the middle, unity or 100% around two o'clock, and 200% at its maximum. Figure 3 shows this happening where we can see the top and bottom parts of the waveform having a different gain to the middle parts. Look how the slope of the triangle wave is less at the points compared to the bits crossing the middle horizontal 0V line.

It should be noted that when the fold pot is set the unity position, at around two o'clock, then the Threshold and Discontinuity parts of the circuit are effectively switched off and the unit is in a type of bypass mode. The output signal is more or less the same as the input signal.

With the Fold pot turned left of centre the phase of the returned input signal is switched. This means positively going parts of the waveform are now negatively going. This means the output waveform appears to fold back on itself. This can create frequency doubling effects as the waveform now can cross the horizontal 0V line more often. Figure 4 shows the folding action showing the tips of the input triangle wave being bent in opposite directions.

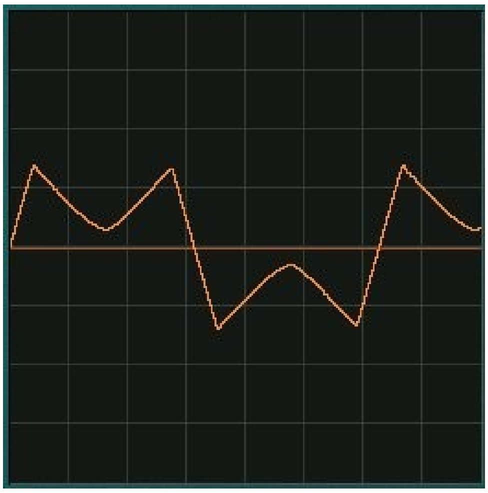


Figure 4. Folding with the Fold pot set to around -25% which is slightly left of its central position.

The **Fold CV** pot controls the depth of the Fold CV input signal. Like the Thresh CV, the Fold CV input allows remote control over the fold parameter. Later on we will see that we can use the Fold CV as the modulator input of a ring modulator.

The **Discontinuity** pot is probably unique in the world of modular synthesisers. Wave folding modules of various sorts have been around for sometime. Indeed, our own Wavefolder successfully introduced the technique to many people. The discontinuity mode is something else though and comes in part from the actual way that the original Wavefolder did its wave folding. When an input signal rises above the positive threshold voltage and/or below the negative threshold voltage, the input signal is actually removed and the threshold voltages put in its place. Now as we have seen the input signal, or a multiple of it, may then be returned by the action of the Fold pot, but let us for the moment assume that the Fold pot is set centrally.

The Discontinuity pot controls that proportion of the threshold voltages that are replacing the input signal. It can be varied from zero, ie. the replacement voltage is zero volts, to around two, which is double that of the threshold voltage. The middle position of the Discontinuity pot is calibrated to give unity. This means that at the middle position the replacement voltages are exactly the same as the Threshold voltages, in other words, the traditional Oakley Wavefolder action. As with the Fold and Threshold pots there is a dead zone built into the pot's movement so it is easy to locate the unity position.

Figure 5 shows applying Discontinuity on a triangle wave. You can see the clipped sections are no longer flat sections at the threshold voltage, but at lower voltages. In this case the Discontinuity parameter is set to around 40%, that is around 9 o'clock on the front panel.

You should remember that the Discontinuity pot sets the multiple of the threshold voltage and not the actual voltage itself. This means varying the Threshold pot will also vary the level of the replacement voltages. When the Threshold voltage is set to 0V, ie. its middle position, then varying Discontinuity will have no effect on the output signal. This is because 0V times any number is still 0V.

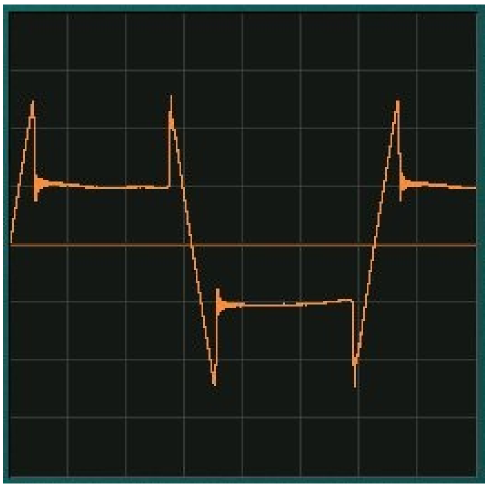


Figure 5. Discontinuity on both negative and positive parts of the input waveform. Discontinuity is set at around 40% of the threshold voltage.

The action of discontinuities in the waveform generate lots of high harmonics. These can be seen in figure 5 as orange blurs on the leading edge of the discontinuity. These blurs are actually reactions to the high frequencies inside the digital scope I have used to take these pictures. They could have been easily removed with a little low pass filtering after the output of the Discontinuity module. Its probably worth adding at this point that connecting any filter post-waveshaping will give you an even greater range of sounds.

As with the other two front panel waveshaping pots the Discontinuity parameter can also be varied with an external control voltage. The **Discon CV** pot controls the modulation depth of a connected CV.

As we have seen the Discontinuity pot allows us to control the voltage that replaces the input signal at that point when the threshold voltages have been exceeded. However, the

Discontinuity parameter is inherently tied to the threshold voltage set by the Threshold pot and Thresh CV. The Discontinuity module also allows another control over the level of the replacement voltage. This we call the offset and its controlled by the **Offset** pot, its CV input and a switch called **Track/Oppose**. The key difference between the Offset and the Discontinuity parameter is that the Offset value is added (or subtracted) to the Threshold voltage, while the Discontinuity parameter multiplies the Threshold voltage. The Offset function and Discontinuity parameters can be used either on their own or together. This means that the replacement voltage (or voltages) can be a mixture of both multiplied or added Threshold voltages.

The Offset pot does one of two things. Firstly with no jack inserted into the **Offset CV** socket it acts as a fixed voltage source. In its central position it produces 0V and no offset is added to to the threshold voltages. At its furthest right it produces just under +4V, and at its furthest left it produces -4V or so.

If you do not want any offset to be added you must ensure that the Offset pot is centralised. The sensitivity of the pot is configured to be at its minimum near the centre of its travel. This should make finding the zero point easier than a standard linear pot taper.

The **Track/Oppose** switch controls how the offset voltage is added to the threshold voltage to give us the replacement voltages. In track mode, the offset voltage is added equally to the negative and positive threshold voltages. This means that a 2V threshold and a -1V offset voltage will produce a 1V replacement voltage for the positive part, and a -3V replacement voltage for the negative part. This is because 2 + (-1) = 1, and -1 + (-1) = -2. You can see this in figure 6.

Figure 6. Track mode showing a negative offset voltage making both replacement voltages move downwards.

In Oppose mode the two offset voltages move in opposite directions. This means that the offset voltage is added to the positive threshold voltage to create the positive replacement voltage, while the offset voltage is subtracted to the negative threshold voltage to create the negative replacement voltage. This creates an offset voltage that creates a symmetrical discontinuity to the input waveform. Taking the above example, a threshold voltage of 2V and an offset voltage of -1V will give a 1V positive replacement voltage and a -1V negative replacement voltage. Since 2 + (-1) = 1 and -2 - (-1) = -1.

You may have noticed that the positive replacement voltage is not affected by the Track/Oppose switch. Indeed, only the negative parts are affected by the offset switch's mode. Remember too that if your polarity switch is in the POS position you'll not notice anything either.

The wide range of the offset pot allows you to create negative positive replacement voltages and positive negative replacement voltages. In other words this is another way, besides the Fold pot, when you can actually reverse the polarity of the input waveform when the threshold voltages are exceeded.

The **Offset CV** input is a standard CV input. Once inserted a jack will remove the internal connection to the Offset pot's voltage source. The Offset pot will function now as a standard reversible attenuator to the CV input. This will produce maximum gain in the right hand position with a gain of around +80% and a maximum gain of -80% to the left. The + and – percentages indicate that the pot can also control the phase of the input signal with inversion of the input signals to the left and in phase signals to the right. Middle position is zero meaning that the effects of the CV input are turned off.

When the Discontinuity pot is turned fully left then the threshold voltage has no effect on the replacement voltages. This means that the Offset pot or CV has complete control over the output waveform when the threshold voltages are exceeded. With the Track/Oppose switch in Track module it is therefore possible to splice one waveform into another. If you use an audio signal into the Offset CV input then this signal will replace the input signal when the input exceeds the threshold voltages. Using the threshold pot one can 'crossfade' the input waveform with the offset waveform. Its not like analogue crossfading so expect some very interesting results.

The **Volume** pot is a simple output level control. Its configured to have a gain of 10 which allows you to clip signals down very small and then boost them up again to suit the usual +/-5V signals that any connected modules are expecting. It should be noted that the maximum output of the Discontinuity module is around +/-12V. So if you try to boost too much you'll get clipping at +/-12V. It won't damage the module – but it might hurt your ears!

Components

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.

The resistors can be 5% carbon 0.25W types except where stated. However, I would go for 1% 0.25W metal film resistors throughout, since these are very cheap nowadays. If you do want to use 5% types, the please note that some of the resistors **have to** be 1% or better types. Failure to use good quality parts in these locations will affect the performance of the module. These critical parts are indicated in the parts list.

All the electrolytic capacitors (sometimes abbreviated to 'elect' in my parts lists) should be 25V or 35V, except where stated, and radially mounted. Don't chose too high a voltage. The higher the working voltage the larger in size the capacitor. A 220V capacitor will be too big to fit on the board. 35V is a good value to go for.

The ceramic capacitors should be 'low-K' ceramic plates. These are sometimes called C0G types. The lead spacing is 0.2" or 5mm. Do not chose cheap and nasty ceramic types, usually 'high-K', obtainable from some surplus places. These can lead to a noisy audio output.

The PCB is another Oakley board to feature axial ceramics for the power supply decoupling. These are good components with an excellent performance. The PCB legend for these devices features a lead spacing of 0.3". Various types of axial ceramics exist, each one having a different dielectric. There are the more expensive C0G types from Farnell, but the other cheaper types like Y5V and X7R are perfectly good enough for this application. I use Rapid part number: 08-0240.

All ICs are dual in line (DIL or DIP) packages. These are generally, but not always, suffixed with a CP or a CN in their part numbers. For example; TL072CP and LM13700N. Do not use SMD, SM or surface mount packages. They do not fit at all.

The DG403 is an analogue switch. A variety of companies make this part, although Vishay-Siliconix are probably the most common. The part you need is DG403DJ. We also use this part on our VC-LFO and Little-LFO modules.

The 4558 dual bipolar op-amp is chosen for its latch up free behaviour and its increased output current capability. In the UK, Farnell and RS sell the little chap for peanuts. Various manufactures make the device, eg. MC4558CN and RC4558P.

The LM13700N may be substituted with either the older 13600 (still made by JRC) and the now sadly defunct Phillips' NE5517.

The BC560 devices are discrete low noise PNP transistors. Quite often you see an A, B or C suffix used in their full part name, eg. BC560C. This letter depicts the gain or grade of the transistor (actually hfe range of the device). This Oakley module is designed to work with any grade device.

A BC560 can be substituted with a BC559 of any grade. The only real difference between a BC559 and BC560 is the maximum operating voltage, Vce(max). Both devices have a Vce(max) that is greater than anything they will see in the Discontinuity.

The board mounted pots are Spectrol 248 conductive plastic types or the newer BI TT equivalents. Either type is held onto the board with specially made Oakley pot brackets. Four pot brackets and an extra set of nuts are required and these are provided with the 'pot bracket kit'. You could use any pot type you want, but not all pots have the same pin spacing. Not a problem, of course, if you are not fitting them to the board.

In the UK, Farnell, CPC and Rapid Electronics sell the Spectrol pots.

The track/oppose toggle switch is a standard 'ON-ON 'SPDT (single pole, double throw) switch. The types I use are made by APEM in France, and have a flat toggle. Farnell sell them and their part number can be found in our online part number guide.

The pos/neg polarity toggle switch is 'ON-OFF-ON' SPDT switch. This type looks identical to the usual ON-ON types but has a third position in the middle which disengages the wiper from either of the end contacts. APEM make some nice ones and Farnell sell them at a good price.

L1 to L2 are leaded ferrite beads. These are little axial components that look like little blackened resistors. They are available from most of the mail order suppliers. Find them in the EMC or Inductor section of the catalogues.

The multiturn trimmers, UNITY and ZERO, are the ones that have the adjustment on the top of the box. Spectrol and Bourns make these, although there are many other manufacturers too. Some types are 22 turns, while others are 25 turns. Either will do. They should have three pins that are in a line at 0.1" pitch.

The OFF-1 and OFF-2 trimmers are a more compact single turn cermet type usually described as 6mm. They are vertically adjusted and horizontally mounted. This type of trimmer has a different PCB footprint than the other bigger horizontal types you may have used on other Oakley modules. Lead spacing is 0.2" for the track ends, and the wiper is 0.2" away above a line joining the other two pads.

The LED should be a 5mm diameter bi-colour LED. Do not get tri-colour types, as they have three legs not two, and cannot be made to work in this circuit. I prefer to use 'red-green' types, although other colours are available. The LED clips I use I get from Rapid which are described as '5mm standard lenses'. They stick out proud of the front panel and hold the LED very firmly. For bi-colour LEDs, it is best to get an uncoloured or clear lens.

In the main parts list section that follows I have only included the parts needed to make our Oakley 5U panel module. If you intend to wire up your module differently then you may well need some additional parts for the pot, socket and switch wiring. This I will leave up to you, however, you will notice that the PCB is laid out to accommodate 0.1" headers for all the various 'off board' components. Each component has its own header, although some of them are placed adjacent to one another to facilitate the use of preformed wire jumpers.

The multiway jumper interconnects are a one piece assembly bought ready made from several places. These come as pre-stripped and often pre-tinned with solder too. Make sure you get the 0.1” (2.54mm) pitch variety. I buy the ones I need for this project as three eight way 80 mm long pieces from Rapid. I then cut one down the middle to form one of the required two 4-way jumpers. For the other two I cut off two sections to form two 6-way jumpers. You'll have a four way jumper spare which can be saved for another project. The Rapid part number is 22-1655 for the 8-way jumper.

For my prototype I used Molex KK headers and housings for the two six way and one four way jumpers. This is more complex to build but it does allow the pot and main board to come apart very simply.

For the 0.1” (2.54mm) interconnections between the socket board and the other two boards I use the either the 26 awg MTA parts, or Molex KK or their equivalents.

The MTA parts are made by Amp, now part of the massive Tyco empire. To use these effectively you need a special insertion tool to poke the wires into the special ‘housings’. The housing contains specially shaped contacts that cut through the insulation of the wire so you don’t need to do any stripping. Just simply push down on the wire with the tool to lock it into place in the housing.

The Molex KK strip and crimp systems are actually cheaper although perhaps not quite as neat or as quick to use. These use simple plastic housings that hold the individual crimps. The crimps are normally bought in reels but some places sell them individually. The crimpers, that attach your wire to the crimp, can be quite expensive if you don't shop around. However, they are not nearly as expensive at the MTA insertion tool.

Input and output sockets are now board mounted in the standard module assembly. You could of course use any types if you would like to wire your sockets up with individual wires.

We use the Switchcraft 112A 1/4” sockets in all of our ready made modules. These excellent parts are also used on the Moog and MOTM modulars. The version you need to fit in the socket board is the 112APC. This part is stocked by most suppliers. The PC part of the name means 'printed circuit' mounting. Both Rapid and Farnell sell them at a reasonable price. Rapid also sell a Far Eastern clone of the 112APC part that is considerably cheaper, but doesn’t look as nice. Please note that the standard 112A will not fit easily into the boards as it has solder tags.

Parts List

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.

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

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.

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, 6n8 is a 6.8 nF capacitor.

Resistors

All resistors, except were stated, are 5% carbon 1/4W although 1% metal film types are recommended.

Components designated as 1% should be 0.25W 1% metal film or better.

100K	R48, R49, R18, R19, R33, R35
10K, 1% metal film	R78, R77, R75, R76
10K	R47, R5, R9, R10, R22, R21
150K	R82
15K	R73, R39, R64, R51
1K	R52, R45, R44, R24, R23, R7, R25, R79
1K5	R3
1M	R8, R6
22K	R2, R14, R36, R1, R65, R42, R71, R43, R34, R32, R53
22R	R13, R26, R46
24K	R16, R40
2K2	R17, R41, R38
330K	R80
330R	R69, R68, R67, R70
390K	R72, R66
47K	R28, R4, R81, R12, R11, R30, R29, R31, R61, R63, R59, R60, R58, R62, R56, R55
47R	R50
4K7	R27, R57, R74
68K	R20, R83
82K	R37, R15, R54

Capacitors

33pF ceramic	C5, C15, C24, C25
33uF, 35V electrolytic	C13, C6, C7

100pF ceramic low-K	C1
100nF, 63V multilayer axial ceramic	C9, C2, C14, C20, C21, C17, C19, C11, C4, C3, C18, C26, C10, C16, C30, C27, C8
2u2, 63V electrolytic	C22, C23, C28, C29
47uF, 35V electrolytic	C12

Discrete Semiconductors

1N4148 signal diode	D9, D7, D8, D2, D1, D12, D3, D4, D5, D6, D13, D14, D15, D16
5V1 zener diode	D11, D10
BC560 PNP transistor	Q1, Q3
5mm red/green bi-colour LED	LED

Integrated Circuits

4558 dual bi-polar op-amp	U1
78L05 +5V 100mA regulator	U14
79L05 -5V 100mA regulator	U15
TL072 dual J-FET op-amp	U12, U3, U6, U7, U13, U4, U5, U9, U10
DG403 dual SPDT analogue switch	U8
LM13700 dual OTA	U11
LM2903 dual low power comparator	U2

Miscellaneous

100K, 6mm cermet trimmer	OFF1, OFF2
100K multiturn cermet trimmer	ZERO, UNITY
Ferrite bead axial	L2, L1
6-way 0.1” (2.54mm) jumper	OFF/TRK, CVD/POL ie. 2 off – see text
4-way 0.1” (2.54mm) jumper	CVF/CVT ie. 1 off – see text
0.156” MTA 4-way header	PSU
0.1” 4-way header	SKT-BOT (main board), SKT-BOT (socket board)
0.1” 5-way header	SKT-TOP (main board), SKT-TOP (socket board)
0.1” 3-way header	SCKT (pot board), SCKT (socket board)
0.1” 4-way housing	SKT-BOT (main board), SKT-BOT (socket board)
0.1” 5-way housing	SKT-TOP (main board), SKT-TOP (socket board)
0.1” 3-way housing	SCKT (pot board), SCKT (socket board)
Hook up wire to suit connectors	2 metres
Uninsulated tinned copper wire	6 off 60mm pieces for wiring the switches

Pots

50K linear 'Spectrol 248' or 'BI TT'	DISCON, VOLUME, FOLD, THRESH
Oakley pot brackets	DISCON, VOLUME, FOLD, THRESH

Other panel components

50K linear 'Spectrol 248' or 'BI TT'	DIS CV, OFFSET, FLD CV, THR CV

Oakley pot brackets	DIS CV, OFFSET, FLD CV, THR CV
Clear LED lens clip	LED
SPDT On-On switch	TRK/OPP
SPDT On-Off-On switch	POS/NEG
1/4" Switchcraft 112APC sockets	All sockets
Knobs	Eight to suit

You may well want to use sockets for the ICs. I would recommend low profile turned pin types as these are the most reliable. You need eleven 8-pin DIL, and two 16-pin DIL sockets.

The Front Panel

On the website I have included a 1:1 FPD database of the suggested 2U front panel layouts in both natural silver and traditional black finishes. Actual panels can be obtained from Schaeffer-Apparatebau of Berlin, Germany. The cost is about about £30 for the panel. VAT and the postage is extra, so it usually helps to order a few panels at the same time.

All you need to do is e-mail the fpd file to Schaeffer in Germany, or Frontpanel Express in the US, and they do the rest. You can also use the Frontplatten Designer program's own online ordering procedure which also works very well.

The fpd panel can be edited, including changing the colours of the panel and the legending, with the Frontplatten Designer program. The program available on the Schaeffer web site but it should be noted that the program is for Windows only.

Building the Discontinuity's Main Circuit Board

All Oakley PCBs are now supplied with a RoHS compliant finish. This is a high quality finish but does possess slightly different soldering characteristics to the traditional lead based HASL finish. Handle the boards with care, and avoid touching the solder plating since this can cause premature tarnishing of the finish. Shelf life is hard to predict but we recommend soldering in all the components less than one year from when you receive your board.

Neither I nor Paul Darlow are responsible for any accidents caused whilst working on these boards. It is up to you to use your board responsibly and sensibly.

Occasionally people have not been able to get their Oakley projects to work first time. Some times the boards will end up back with me so that I can get them to work. The most common error with most of these was parts inserted into the wrong holes. Please double check every part before you solder any part into place. Desoldering parts on a double sided board is a skill that takes a while to master properly.

If you have put a component in the wrong place, then the best thing to do is to snip the component's lead off at the board surface. Then using the soldering iron and a small screwdriver prize the remaining bit of the leg out of the hole. Use wick or a good solder pump to remove the solder from the hole. Filling the hole with fresh solder will actually make the hole easier to suck clean!

Sometimes people like to substitute parts in place of my own recommendations. Feel free to do this, but remember that there is normally a good reason why I have selected that particular part. If you do find that, say changing an op-amp with another one, makes an improvement, please do let me know either via the Oakley-Synths list or directly to me.

All resistors should be flat against the board surface before soldering. It is a good idea to use a 'lead bender' to preform the leads before putting them into their places. I use my fingers to do this job, but there are special tools available too. Once the part is in its holes, bend the leads that stick out the bottom outwards to hold the part in place. This is called 'cinching'. Solder from the bottom of the board, applying the solder so that the hole is filled with enough to spare to make a small cone around the wire lead. Don't put too much solder on, and don't put too little on either. Clip the leads off with a pair of side cutters, trim level with the top of the little cone of solder.

Once all the resistors have been soldered, check them ALL again. Make sure they are all soldered and make sure the right values are in the right place.

The diodes, zener and signal types, can be treated much like resistors. However, they must go in the right way. The cathode is marked with a band on the body of the device. This must align with the vertical band on the board. In other words the point of the triangular bit points *towards* the cathode of the diode. When all the diodes are in place, double check all are pointing the right way.

The yellow multilayer ceramics can be treated like resistors too. But try not to bend the wires too close the body of the device since it can crack it.

The ceramic capacitors are strange flat plates made from pot. Be careful with these and make sure you have bought the ones with 0.2" lead spacing. Forcing the smaller 0.1" ones into these larger pads will break them. Another thing to watch out for is the identification markings on these capacitors. For example n47 is actually 470pF.

The smaller electrolytic capacitors are very often supplied with 0.1" lead spacing. My hole spacing is 0.2". This means that the underside of these radial capacitors will not go flat onto the board. This is deliberate to allow the water wash to work, so don't force the part in too hard. The capacitors will be happy at around 0.2" above the board, with the legs slightly splayed. Sometimes you will get electrolytic capacitors supplied with their legs preformed for 0.2" (5mm) insertion. This is fine, just push them in until they stop. Cinch and solder as before. Make sure you get them in the right way. Electrolytic capacitors are polarised, and may explode if put in the wrong way. No joke. Oddly, the PCB legend marks the positive side with a '+', although most capacitors have the '-' marked with a stripe. Obviously, the side marked with a '-' must go in the opposite hole to the one marked with the '+' sign. Most capacitors usually have a long lead to depict the positive end as well.

IC sockets are to be recommended, especially if this is your first electronics project. Make sure, if you need to wash your board, that you get water in and around these sockets. And that any water is thoroughly dried out before you power up. Sockets harbour little pools of water in their pins which can lead to some very odd effects. Several sharp taps face down onto a towel will loosen off any remaining globules of liquid.

The transistors are all in the same type of packaging and therefore look the same. Only the numbers on the side will allow you to tell them apart. Match the flat side of the device with that shown on the PCB legend. Push the transistor into place but don't push too far. Leave about 0.2" (5mm) of the leads visible underneath the body of transistor. Turn the board over and cinch the two outer leads on the flip side, you can leave the middle one alone. Now solder the middle pin first, then the other two once the middle one has cooled solid.

Sometimes transistors come with the middle leg preformed away from the other two. This is all right, the part will still fit into the board. However, if I get these parts, I tend to 'straighten' the legs out by squashing gently all the three of them flat with a pair of pliers. The flat surface of the pliers parallel to the flat side of the transistor.

The 0.1" headers are fitted on the main board so that pin 1 is towards the right hand side of the board. The clip on the side of the header will match with the picture on the PCB legend and should be towards the top of the board.

The 0.156" header should go into the board so that the plastic lock is on the left hand side.

There are two types of trimmer used in this project. Both should be fitted only after your final water wash and soldered with no clean or ordinary flux cored solder. Trimmers and pots are sometimes marked in different ways. If your multiturn pot is marked as 104, then this is a 100 000 ohm or 100K pot. 103 is a 10K pot. The multiturn pots can go in any way around but it looks better if you put both in the same way around.

I usually make the main circuit board in the following order: resistors, diodes, multilayer axial capacitors, IC sockets, small non-polar capacitors, transistors, electrolytic capacitors, and connectors. Then the final water wash. Then the trimmers using no clean or ordinary rosin flux solder.

Do not fit the pots or LED at this stage. The mounting of the pots requires special attention. This will be covered later in this User Guide.

Populating the Socket Board

You have one socket board to populate and the method is a little unusual if you haven't done one before.

On the board the first things to solder are the headers. These are fitted to the **BOTTOM** of the board and are soldered from the top side. This is obviously opposite to what you are normally used to. The legending is on the top of the board, and the bottom of the board is marked as such in copper on the underside.

Fit both the headers so that pin 1 is the square pin. The friction lock on the header should correspond to the legend on the top, ie. the opposite side, of the board.

The sockets will be fitted on the top of the board, and therefore be soldered on the bottom of the board. You may well find your own way of soldering the sockets, but the way I do it is as follows:

Fit all your sockets into one of the boards. The bevel edge should align with the picture on the board legending. Do not solder them at this stage. Take your front panel and align this over the sockets.

Now carefully place your front panel with PCB and sockets upside down onto your bench [or kitchen table]. The holes where the sockets will be should hang over the edge of the bench so that the sockets aren't forced back up through the holes. You'll also probably need a small counter weight to stop the panel from falling over the edge. Now allowing the PCB to rest flat on top of the sockets, you can begin to solder all the pins to the board.

Mounting the Board Mounted Pots and LED

The first thing to do is to check your pot values. Spectrol do not make it that easy to spot pot values. If you have been supplied with Spectrol pots your pot kit should contain:

Value	**Marked as**	**Quantity**	**Location**
50K linear	M248 50K M	4 off	Main PCB
50K linear	M248 50K M	4 off	Pot board

If you have bought TT P260P pots then you should have the following:

Value	**Marked as**	**Quantity**	**Location**
50K linear	B50K	4 off	Main PCB
50K linear	B50K	4 off	Pot board

Note that the pot shafts of the pots will not need cutting to size. They are already at the correct length. However, if you are using the TT pots you will need to trim off the little locating lug near the bush of the pot. Simply snap this off with a pair or wire cutters or fine nosed pliers.

Fit the pot brackets to the pots by the nuts supplied with the pots. You should have two nuts and one washer per pot. Fit only one nut at this stage to hold the pot to the pot bracket. Leave off the washer for later. Make sure the pot sits more or less centrally in the pot bracket with legs pointing downwards. Tighten the nut up carefully being careful not to dislodge the pot position. I use a small pair of pliers to tighten the nut. Do not over tighten.

Now, doing one pot at a time, fit each pot and bracket into the appropriate holes in the PCBs. Solder two of the pins attached to the pot bracket. Leave the other two pins and the three pins of the pot itself. Now check if the pot and bracket is lying true. That is, all four pins are through the board, and the bracket should be flat against the board's surface. If it is not, simply reheat one of the bracket's soldered pads to allow you to move the pot into the correct position. Don't leave your iron in contact with the pad for too long, this will lift the pad and the bracket will get hot. When you are happy with the location, you can solder the other two pins of the bracket and then the pot's pins. Do this for both pots and snip off any excess wire from the pot's pins at this point.

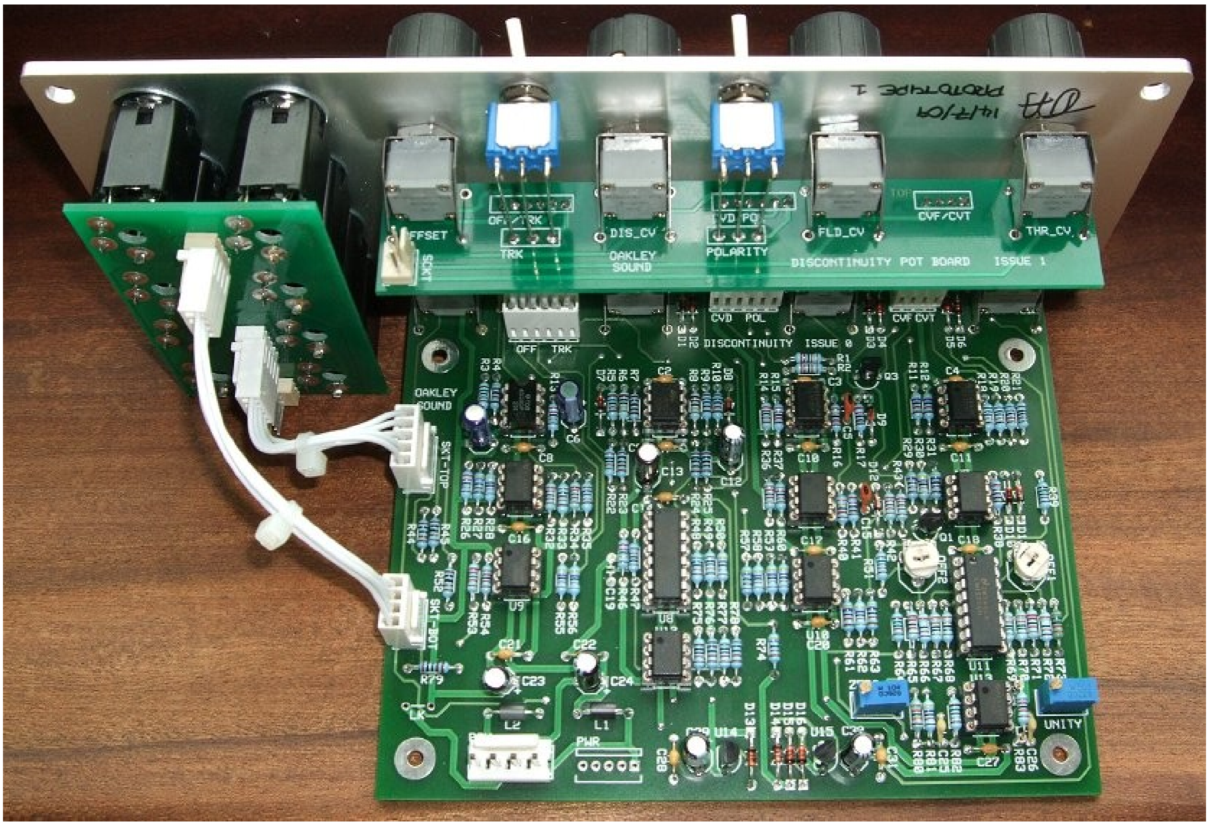
The Spectrol pots are lubricated with a light clear grease. This sometimes is visible along the top of the mounting bush of the pot body. Try not to touch the grease as it consequently gets onto your panel and PCB. It can be difficult to get off, although it can be removed with a little isopropyl alcohol on a cotton wool bud.

You can now present the front panel up to the completed boards to check that they fit. If it does, you may feel tempted to mount both boards up proper. However, I would not fit the pot board permanently just yet. There are two more things you need to do before this is done. You need to fit the LED and also to make the interconnections between the two boards and for this its easier if you have free access to the top of the main board. So at this point just fit the main board into place. Use the nuts and washers provided. The washer going in between the outer surface of the panel and final nut.

The LED should be able to be soldered directly into the board if its leads are long enough. Fit the clear plastic LED clip into the panel first. Then bend the LED's leads at ninety degrees near the body of the LED. Slide the leads into their holes and gently push the LED into its clip. Now it doesn't really matter which lead goes into which hole of the LED pad since we are using bi-colour LEDs. However, I normally try to make sure that when the LED goes red it indicates positive output voltages. Pin 1 of the LED header should attach to the anode of the red LED. You'll need to check which lead is which for your own brand of LED, but sometimes its just easier to build it and change it later if its wrong.

If your LED does not have sufficiently long leads to reach to board from the panel hole, then you may have to wire it to the board with some small pieces of insulated wire. Keep the wires as short as possible without being taut. Use a little heatshrink tubing to insulate the LED's leads from rubbing together.

Connections



The rear view of the prototype module using a natural silver finish front panel from Scheaffer. This is an issue 0 main board – that is the one before the actual production run. There are a few differences between this and the issue 1 board, like component names and some other small changes.

The first things that will need doing are the interconnections between the pot and main board. This is done with two 80mm long 6-way jumper connections and one 4-way jumper connection. If you have bought the recommended part from Rapid you will have ordered three eight way jumpers. You'll need to chop off the last two conductors from two of the jumpers with a sharp knife or a pair of scissors to give you two six way jumpers. You'll then need to cut the third eight way jumper down the middle to give you two four way jumpers, although you'll only be using one of them.

I find it best to solder one end of the jumpers in before mounting the boards to the panel. For Discontinuity module I would suggest that soldering the jumpers to the main board first which is already in place on the panel. Then once this is done you can mount the pot board to the panel. Then coax the other ends of the jumpers into the pot board's holes. You must solder the pot board from the topside of that board. Make sure you trim off any excess jumper wire with a pair of wire cutters from both boards.

That's the two boards with pots joined up so its now time to connect up the socket board.

If you are using the recommended MTA or KK interconnections this section will be very easy indeed. Here you will be using either the Amp MTA system or the slower, but cheaper, Molex KK system. All the wiring between the sockets and the main board is done with one 4-

way jumper and one 5-way jumper. And the wiring between the sockets and pot board is done with one 3-way jumper.

Make up the 5-way interconnect first. This should be made from wires 65 mm long. Make sure you get pin 1 going to pin 1 on the other housing, pin 2 to pin 2, etc. This cable will connect to the headers called SKT-TOP, which stands for 'top row of sockets', on each board.

The second lead is a 4-way interconnect. This is made up to be 95 mm long. This should connect the SKT-BOT headers on the socket board and the main board.

The final lead to make is the 3-way interconnect. This should be made up to be 130mm long. This connects to the SCKT headers on the pot board and socket board.

You can use a cable tie to hold the wires of each interconnect into a neat bundle. Its best to put the cable ties on when the interconnects are in place in the module.

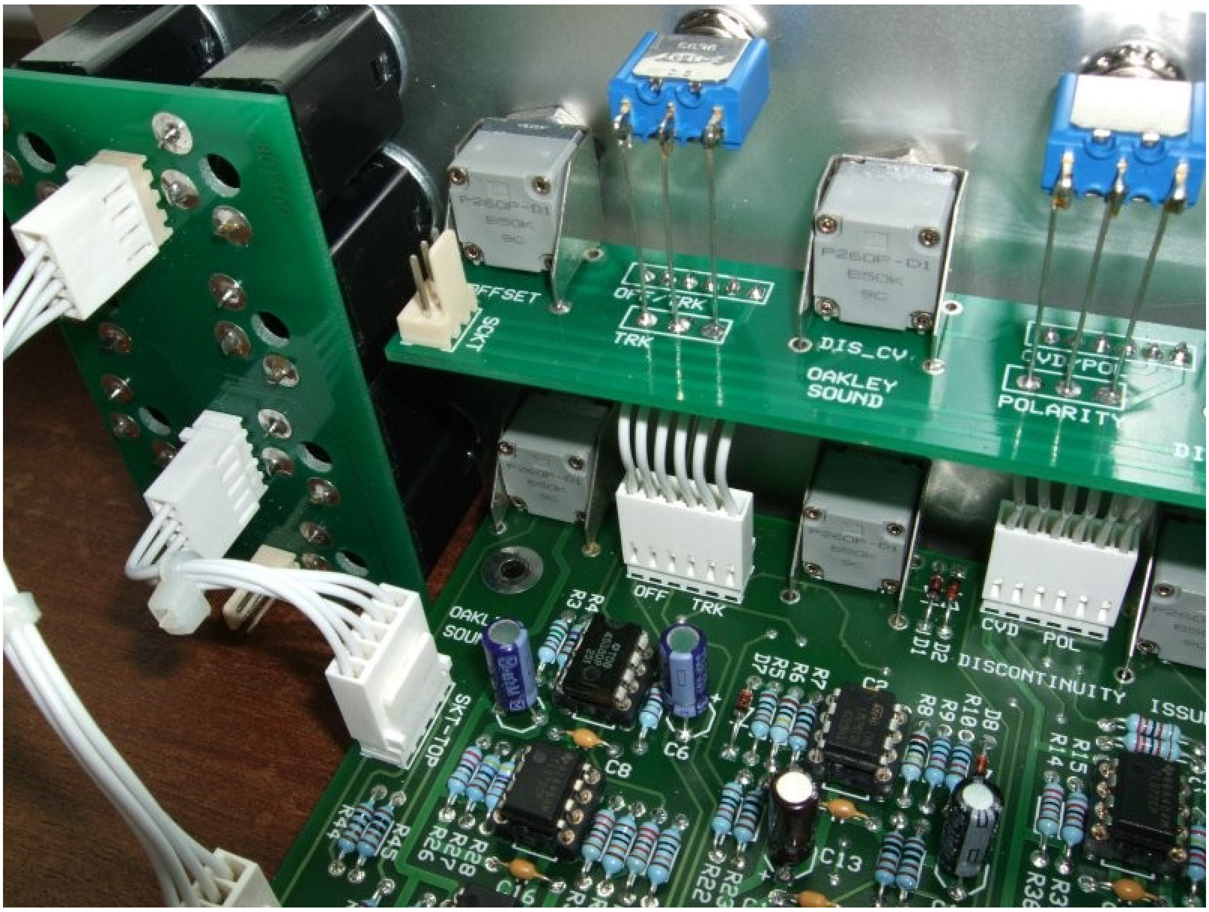
For those of you who want to use the cheaper Molex system, the following information may be useful:

A quick note on the female plugs; these are sometimes called housings, since they aren't plugs themselves but merely housings for the individual crimp terminals. Terminals have to be bought in packs of one hundreds, but this is OK, because they are not expensive. These are normally designed to be crimped and suitable crimpers can be found cheap these days.

They can also be soldered with care: Make each wire the correct length. I would strip back the wire by just 2 to 3mm. Place all the bare wire into the crimp on a heatproof surface. I use 12mm MDF board to protect my bench top, which although not at all burn proof will take plenty of heat from a soldering iron without major damage. Rest a pair of pliers on top of the wire to hold it in place. Slip the crimp under the wire, so that the wire's insulation butts up to the edge of the terminal. Then solder in place. Sometimes I find I need to gently squash the crimp part of the terminal so that it will fit into the housing. This is easier to do before you solder it, although it can be done after with care.

Do not use the water washable flux solder in this application. You must use either good old fashioned ersin or rosin flux based solders or the newer so called 'no-clean' types. I actually prefer the Pb/Sn rosin based ones for this because I find they flow better. Once you have soldered it, wait a bit for it to cool, and then push it into the housing until it clicks. If it doesn't go in, then take it out and bend the crimp slightly backwards. Now try again.

Connecting up the Switches



Here we can see the prototype module's switch and other board interconnects using Molex KK housings and headers. Note the SCKT 3-way interconnect has been left off to show the construction of the KK header.

I have tried to avoid any free wiring in this module and wiring up switches is my only lapse in this area. However, I think I have devised a nice neat way that is both quick and rugged.

Fit your switches in their correct holes. Remember that one of the switches has three positions and this should go in the top hole. For each switch use the one of the nuts and the spring washer on the inside of the panel. Use the second nut to secure the switch to the panel. It doesn’t matter which way the switch goes in so long as the toggle moves up and down. You do not have to use the other washer, the odd shaped lock washer, that the switch kit comes with.

Your job is to connect the three tangs on each switch to the currently empty solder pads directly below them on the pot board. I'm sure you'll find your own way of doing this, but this is what I do: Lay the module on its side with the main board resting on the bench top and rear of the panel facing you. Take a 60mm long piece of uninsulated tinned copper wire. Make sure its nice and straight. Then put a small 90 degree bend in it near the very top. Place the long tail of the wire into the solder pad on the board, right handed people will want to start with the furthest left hand hole, and hook the wire's small bend into the hole of the switch tang. Carefully bend the wire end around the tang and solder. Then snip off the remaining wire from the underside of the pot board. Solder the pad from the topside of the pot board. Repeat for the other tangs and the other switch.

Testing, testing, 1, 2, 3...

Apply power to the unit making sure you are applying the power correctly. Check that no device is running hot. Any sign of smoke or strange smells turn off the power immediately and recheck the polarity of the power supply, and the direction of the ICs in their sockets. If you are able to measure the current taken by the module you should be able to see that the module takes around +50mA from the +15V rail. Anything significantly more than this probably indicates a fault.

Assuming everything is OK so far, it is time to apply an audio input. Use a triangle wave output from a VCO and plug it into the input socket of the Discontinuity module. Middle A, 220Hz is a good note to use. Before we go any further I should re-iterate that the Discontinuity module is a complex device and it is not as intuitive as other modules you may have used. If you have a 'scope you may want to hook it up to the module's output to have a look at what is going on. If you don't have a 'scope then fear not your ears will tell you plenty.

So let us look at each pot in turn and see what affect each has our simple triangle wave input.

Centralise Threshold, Discontinuity, Fold and Offset pots, that is put them all at their middle position. Set the three CV input pots to their minimum position. Initially put the Volume control at its minimum setting but you can turn this up once you apply a signal. Set the polarity switch to its middle position and set the offset mode to track (TRK).

Connect up an amplifier to the output of the module. Be aware that the Discontinuity module can produce some very loud signal levels when its volume pot is set high.

Turn up the Volume a bit and adjust the Threshold pot. As you turn the pot slowly right and towards its maximum point you'll initially hear a square wave type tone. This will gradually become less apparent as you keep on turning and with a little plop the input triangle wave will be heard. Rotate it slowly backwards, past its mid point and you'll then hear the characteristic sound of a pulse wave getting narrower until the pot reaches its end point whereupon the sound will cease. You should also notice that the louder the output signal the brighter the LED shines. Both red and green parts of the LED should be lit since the output signal is alternating current.

Connect up a 1Hz LFO sine or triangle wave signal to the Threshold CV input. Rotate the Thresh CV pot and notice how the output sound is modulated by the LFO. Check that the depth of the modulation is controlled by the Thresh CV pot and that it can be turned off at its minimum position. Familiarise yourself with the action of the Threshold pot and how an external CV can be used to 'automagically' alter the threshold voltage for you.

Now set the Threshold pot to around three o'clock and leave it there while we explore the Fold control. With the Fold pot central the output waveform will be clipped at the Threshold voltage. Turning it clockwise will make the clipping less effective and at around two o'clock the triangle wave input is heard again. Go beyond this point and upper harmonics can be heard in greater strength. What is happening here is that the tips of the triangle waveform are being amplified more than the middle parts of the waveform.

Now go backwards and through the mid point. This time the tips of the triangle waveform come back but are now being folded in on themselves. At a certain point you'll hear the second harmonic get considerably stronger as the output waveform becomes closer to a triangle wave at twice the original frequency.

Try using the LFO in the Fold CV input and see what affect modulating the fold parameter has. You should be able to create some very interesting timbre changes with this. Make sure the Fold CV pot alters the depth of the effect.

Centralise the Fold pot again and remove any modulation. Ensure the Threshold pot is again at three o'clock. The Discontinuity pot allows us to control what is happening to the waveform when the threshold voltage is exceeded. When at its mid position it simply allows the waveform to clipped at the threshold voltage. At positions to the left of centre it will reduce the output level to smaller than the threshold voltage. At positions to the right of centre it will increase the output level to greater than the threshold level.

Turn it now to the right and you'll find the mellow hollow sound of the clipped triangle wave becomes even more hollow as if a square wave is being added to the sound. Turn it to the left of centre and the waveform becomes discontinuous and buzzy sounding. Those sharp edges of the discontinuity cause an increased amount of harmonics to be heard.

Using an LFO in the Discon CV input will allow an external CV source to change the level of Discontinuity. Try this now and see how the depth of modulation and the position of the Discontinuity pot alters the sound. Again, make sure the depth pot does what it should and that you can turn off the modulation completely when the pot is at its minimum value. It should be noted that the Discontinuity pot's affects are controlled in part by the Threshold value.

The Offset pot also adds discontinuities to the output waveform, but it does this independently of the Discontinuity pot. It also allows you to make any discontinuities symmetrical or asymmetrical about zero volts. Track (TRK) is asymmetrical and Oppose (OPP) is symmetrical. Check that the Offset pot has an audible effect on the sound. In OPP mode it should give similar sounding results to the Discontinuity pot. In TRK mode, you'll get a richer sound the further away from the middle position. In TRK mode you should get the same sound on either side of zero, but in OPP mode it will sound different on each side.

Check that using the LFO in the Offset CV input you can get changing textures. You should get no modulation in the middle position while increasing amounts of modulation on either side.

If everything works as above you should have a working module. However, before you fix it into your modular permanently you should calibrate it. The details on how to do that are given in the next section.

Trimmers

In the UK we used to call them 'presets' but trimmer is a word that seems to be catching on even over here. There are four trimmers in this module; two 6mm and two multiturn types. They should be adjusted in the order given here. It is most useful to have a trimmer tool with multiturn trimmers. Spectrol and others make trimmer adjusters for less than a pound. But remember don't use the little adjuster as a normal screwdriver, you'll break it.

In all of these adjustments it is important to ensure that your knobs are aligned correctly. That is, when the pointer is pointing upward the pot is indeed at its central point. The position of the TRK/OPP switch has no effect on the setting up.

OFF2 This adjusts the offset of the VCA in the ring modulator and thus how much Fold CV breaks through into the audio output. Set the Threshold, Fold and Volume pots to their maximum settings. Set the Discontinuity and Offset pots to their middle positions. Set the Polarity switch to its mid-point. All other pots should be set to their minimum positions. Adjust OFF2 until the front panel LED is completely extinguished. On either side of the optimum position the LED will glow either red or green.

ZERO This adjusts the central point of the Fold pot. Put the Discontinuity into ring modulator mode – ie. Threshold and Discontinuity pots set to minimum, Fold and Offset pots to their middle position. The Volume pot should be at its maximum setting. All other pots should be at their minimums. Connect a triangle wave source to the main input of the module and listen again to main output. Adjust ZERO until the sound you hear is minimised. Check that rotating the Fold pot just a little beyond its mid point, on either side, brings back the sound.

OFF1 This one needs a voltmeter; a decent digital one is best and it should be able to measure down to within 10mV. You will be measuring the voltage with respect to ground. This means that the negative probe needs to be connected to ground or 0V. The easiest point to access ground is the top pad of LK near the bottom of the board. Set the Offset, Fold and Threshold pots to their mid points. Set Discontinuity to full. Set all other pots to their minimum. Measure the voltage at pin 7 of U13 – this is down the bottom of the board near the UNITY trimmer. Adjust OFF1 until the voltage gets as close to zero volts as you can get it. Its a bit fiddly but anything between +/-10mV (+/-0.01V) is fine.

UNITY This is the difficult one to set up, but its not going to blow up if you don't get it right so don't worry about it too much. If you have an oscilloscope then this will help, but if not, you can set it up by ear. After all, this is part of a musical instrument. The object of UNITY is to set the mid point of the Discontinuity pot. Set this right and when Discontinuity is set to its middle position the output waveform will not have any discontinuities and be simply clipped or folded.

Set Fold, Offset, Discontinuity and Volume to their middle positions. Set the polarity switch to its middle position. All other pots can be set to their minimum positions. Connect a sine wave to the input of the module and listen to the output. Alter the Threshold until the sound you hear resembles a square wave – a hollower sound, as opposed to the smooth sine wave tone. This will be when the Threshold pot is set to around two o'clock. Now adjust the

UNITY trimmer until you find a point that seems more hollow than reedy. You'll find either side of this point will be more buzzy and harsh.

If you have a scope you'll see your waveform has a neat flattened top. Moving UNITY beyond its optimum point will give the waveform sharp pointy edges and the flattened part will either be below or above the threshold point.

Final Comments

I hope you enjoy building and using the Discontinuity module.

If you have any problems, 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 can't get your project to work, 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 or Paul Darlow directly with questions about sourcing components or general fault finding. Honestly, we would love to help but we 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 those nice people on the Synth-diy, Oakley-Synths and Analogue Heaven mailing lists and those at Muffwiggler.com.

Tony Allgood at Oakley Sound

Cumbria, UK

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