Oakley Sound Systems

Equinoxe Issue 3

Voltage Controlled Phaser Module

User’s Guide

V3.1

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Introduction

The Oakley Equinoxe is a classic four stage OTA based phaser, similar in sound to the phaser used by Jean Michel Jarre on Oxygene and Equinoxe albums.

My version of this unit allows the centre frequency of the phase shifter to be controlled by an external control voltage (CV). Thus allowing envelope generators to be used to sweep the phaser to create filter type effects. It also contains a low frequency oscillator that is connected internally to the phase shifter when a CV is not being applied.

The module has four pots:

Frequency: This controls the frequency of the two notches created by the phase shift network.

Emphasis: This accentuates the feedback signal within the phaser to create a deeper effect.

Modulation depth: A simple attenuator to adjust the level of the internal LFO or incoming CV.

LFO rate: Adjusts the speed of the LFO.

The internal LFO produces a triangle wave output which is also available from a front panel socket. This allows you to use the internal LFO for other modulation purposes. The LFO signal is automatically routed to the modulation depth pot when no jack is inserted in the CV input.

The LFO output can be configured as normal or inverted. In normal mode, the LFO output is simply a copy of the signal being sent to the phaser circuitry. In inverted mode, the LFO output is an inverted signal. That is, when the phaser is being swept upwards, the LFO CV output is going downwards. The mode is selected during the module building stage by fitting a resistor in one of two positions, so it is not intended to be changed on the fly. However, a switch could be added simply to implement this.

By having two Equinoxe modules, one with inverted and one with normal outputs, you can modulate one with the other giving either true stereo phasing, whereby both channels are treated equally. Or stereo phase panning, where each phaser moves in an opposite direction to give a wide stereo effect.

The unit is designed to work with standard MOTM/Oakley signal levels, although it could be easily converted to be run straight from a guitar.

The design requires plus and minus 15V supplies. These should be adequately regulated. The current consumption is about 25mA for each rail. Power is routed onto the PCB by a four way 0.156” Molex type connector. Provision is made for the two ground system as used on all new Oakley modular projects, and is compatible with the MOTM and Blacet systems. See later for details. This unit will also run from a +/-12V supply with a slight reduction in dynamic range.

The Oakley Equinoxe is also available in a small modular format as the Analogue Systems RS400. Ready built modules are available from Analogue Systems, St Austell, Cornwall, UK.

The New Board Issue

This User Guide describes board issue 3. The circuitry and layout has changed over the issues.

Issue 1 was the first version and is easily identifiable by its use of the green Omeg E16 pots. However, during 2003 it was realised that some Omeg pots were failing in the field and, indeed, some were even supplied faulty. During that year we completely revamped the whole Oakley PCB range to use a more expensive part and hopefully a more reliable one.

The new issue 2 PCB thus supported Spectrol 248 pots and used Oakley ‘Spectrol’ pot brackets.

The new issue also corrected the small fault in PCB legending which showed Q2 the wrong way around. It also incorporated two ‘PAN’ pads to allow for easier connection to the sockets.

The LFO and LFO-NC outputs which had to share a pad on the old issue board now have their own buffered and isolated output signals. Any loading on the LFO output will not affect the depth of modulation to the Equinoxe phaser.

The LED driver was made more complex. The issue 1 design simply relied on a resistor to control the current through the LED. When the LFO output was very low, the LED would blank out completely. The issue 2 design controlled the LED through a constant current source. Therefore, although the LED will still vary in intensity with the triangle waveform output, it never actually goes out. This gives a more useful and pleasant display.

Issue 3 is the current issue. The board is now fully RoHS compliant and is made using a lead free process. The board can still be soldered with leaded solder if you wish, but you can also use lead free solder with no problems of incompatibility.

The OTA devices are now two LM13700 instead of four CA3080. The CA3080 was obsoleted by Intersil, formally Harris and RCA. The LM13700 is currently still available. It is also possible to use the LM13600, still made by JRC, and the now obsolete NE5517. There is no discernible differences in sound in the issue 2 and issue 3 designs of the Equinoxe.

The LFO output can now be selected from normal or inverted.

The TUNE trimmer has a bigger usable range and should be easier to set.

Circuit Description

For an excellent starter into phasers and their workings you really should visit R.G. Keen's excellent site at: www.geofex.com/Article_Folders/phasers/phase.html.

The Oakley Equinoxe phaser is based around phase shift network built from operational transconductance amplifiers or OTAs. This type of shifter is not that common compared to the more numerous designs based on FETs and light sensitive devices. Other units that use the OTA are the Moog 12-stage phase shifter and the Electro-Harmonix Smallstone. It is the latter that Jean Michel Jarre used on the Equinoxe album, and the reason behind the Oakley device's name. Jarre had his unit modified by Michel Geiss, and the exact modifications are not known and have become subject to much speculation.

I wanted to create a phaser that was similar in tone to that used on the Jarre albums, but with more compatibility to modern modular synthesisers. The Equinoxe uses just four all pass stages to achieve its sound. Each all pass stage is identical. The core of each stage is half an LM13700 OTA acting as current controlled resistor and invertor in one. This 'resistor' acts in combination with the 6.8nF capacitor to produce an all pass filter whose amplitude response is flat across the audio spectrum, but importantly, but one with a uneven phase response. At a certain frequency, determined by the current driving the OTA, the phase shift will be exactly 90 degrees.

You can think of a phase shift as being like a little time delay but for a specific input frequency only. Here's another way of looking at phase. Consider a child on a swing and then consider another child, next to her on the same length swing. He will move at the same frequency as she does, but it is unlikely that he will have started at the same time in the swing. So as he goes up, the other swing may be coming down. The two swings are out of phase, but moving at the same frequency. Only if they started at exactly the same time will they be in phase, or if he started his swing at a matching point in both their travels.

(OK, its highly unlikely that any two swings will go at the same frequency. Even with the same length of rope, there are other factors at work to make things more complicated.)

A 90 degree phase shift is equivalent to one swing reaching the top, as the other one flies past the middle point. Or vice versa...

And a 180 degree phase shift is when one swing is at the top at one end, while the other swing reaches the top at the other end. Note that the phase shift remains constant so long as both swings are still moving at the same frequency. Thus the phase shift is still 180 degrees when the swings are at any point in their travels. For example, when the two swings pass each other in the middle but going different directions. So the phase shift doesn't just describe one point in time, but the whole relationship between two oscillating bodies.

Now, an all pass filter will create a 90 degree phase shift at one frequency only. All other frequencies will be affected, but to a lesser or greater extent. 90 degrees is important, because if we cascade two **identical** all pass networks together we get 180 phase shift at one frequency. And 180 degrees is exactly half a cycle of oscillation.

Now lets take our two all pass networks and listen to the output. Well, the output doesn’t sound that different. But, let us now mix the output with the input. The overall impact is the signal gets louder. However, at just one frequency, something special happens. This is the frequency at which you have 180 degrees of phase difference between the input and the output. So as the input wave at that one frequency is going up, the output wave is going down. When the two are added together, they cancel each other out. And in theory, completely. So by mixing the ‘out of phase’ and the ‘in phase signal’ we can annihilate the signal.

So if we were to look at output response over the whole audio range we would find it pretty flat but for a very large notch taken out at just one frequency. So a two stage phaser will create one notch. By cascading more stages we can create more notches. Four stages, like we have in the Equinoxe, means we have two notches.

By using an OTA will can vary the frequency of these two notches. All the OTAs work together, hopefully producing the same phase response. (Like the swing example, no two OTAs will behave identically, and there are other things to complicate our simple analysis, but that's the wonder of analogue electronics for you)

Each OTA network is followed by a simple Darlington follower. This two transistor circuit behaves as buffer. The voltage at the emitter of the second transistor follows the voltage on the base of the first. The nice thing is that no current is stolen by the base, and the OTA can go about its business with no fear from the outside world pinching its output.

As we have heard the all pass filters are cascaded together to form a short chain. The input signal enters the chain through C11 and leaves it via C10 and R14. R14 and R15 provide the necessary mixing effect at their junction for the notches to be created. U2a acts as a buffer circuit and also amplifies the mixed signal up to the high levels associated with modulars.

The input signal enters the Equinoxe by means of a resistative attenuator, also called a pad. This reduces the input level so as not to cause distortion in the input stage and the rest of the circuit. R13 and R10 set the 'gain' of the pad.

Q1 and Q4 form a discrete input circuit which buffers the padded input signal. It also provides the means for some additional mixing from the EMPHASIS pot. The emphasis pot provides a resonant type effect to be heard, by creating a positive feedback path within the phaser. So not only do we get the notches we also now get peaks in the response, when the output signal reinforces the input signal. The more positive feedback the more ‘peaky’ the response. Too much positive feedback, and the system gets carried away and oscillates wildly. Getting this right is too complex for me to analyse by mathematics alone... so I just let my ears do the talking (eh??). I played around with various feedback paths and listened to the sound created. In the end I went for the network of resistors and capacitors you see here. A simple solution in the end, and very effective.

It should be noted that the overall gain of the Equinoxe is less than unity or 0dB, in fact, its closer to -6dB. This is deliberate although you may find it less than convenient in some situations where you have a small input signal. The input level is expected to be the typical modular signal of 5V peak, or 10V peak to peak. With the emphasis turned up high it is possible to create large resonant peaks at some frequencies. If the through path gain of the

Equinoxe was left at 0dB, then these peaks would exceed the maximum allowed output level and cause distortion. If you are not going to use a 5V peak input, ie. you are connecting your module to a line level input, then you can increase the gain of the final stage [based around U2a], and decrease the padding on the input. Lowering R31 will increase the gain of the final stage, and increasing R10 will decrease the attenuation on the input pad.

The OTAs are all controlled from one current source. This is clever current source though. Based around Q7 and Q10, its actually a simple exponential convertor. In other words a steady increase in base voltage produces a exponential rise in collector current. For every 18mV increase in Q7's base voltage we double the current sourced by Q10.

The current source is driven from a simple one op-amp inverting summer. Its inputs derived from either the FREQ pot, the TUNE trimmer and the external CV input

The LFO circuit is quite simple and is based around half of one quad op-amp, U1.

One quarter of the TL074 op-amp, U1b (pins 5, 6, 7) forms part of the integrator. Any positive voltage applied to the right of R9 will cause the voltage to fall at the output of the op-amp. The speed at which the voltage falls is controlled by C8 and the size of the voltage applied to R9. If the applied voltage is negative the op-amp's output will rise. It is the integrator's output that will be used as the source for the triangle wave output.

Another quarter of the TL074 op-amp (pins 9, 10, 8) is used as a Schmitt trigger. It's output is either high at +13V, or low at -13V. If the output of the Schmitt is initially low, it requires +6V at the output of the integrator to make it go high. The integrator will need to produce an output of -6V to make the Schmitt go low again.

To make any oscillator you normally require an output to be fed back into the input. Its positive feedback again. In a standard LFO like this one, the integrator is fed by the output of the schmitt trigger. Thus, a low at the output of the schmitt causes the integrator to rise. When the integrator's output reaches a certain point, the schmitt switches state and the integrator's output falls. The schmitt trigger changes state once again, and the process repeats itself....

The 'LFO-rate' pot allows only a controlled proportional of the Schmitt's output voltage to reach the integrator. If the proportion is large, the voltage on R9 is large, and the integrator sweeps fast. If the proportion is small, the integrator sweeps slowly. R7 sets the minimum speed. You can change the value of C8 to get different range of sweep speeds. Setting C8 at 470nF, we can go through the very slow at one cycle per minute to around 10Hz.

The output of the LFO is then split up to do several duties. One branch goes to drive the phaser core via the NC (normally closed) lug on the CV input socket. Another branch goes to feed the LFO output socket via R37. This is an optional component because it is also possible to feed the LFO output socket via the inverting circuit.

A third branch of the LFO output goes to this inverting amplifier based around U1d (pins 12, 13, 14). This simple circuit creates an oppositely going signal at its output, ie. when its input is +1V, the output is -1V. If R37 is not fitted and R40 fitted instead, then the output socket will receive the inverted LFO output. Obviously there is little point in fitting both R40 and R37, as the inverted and non inverted signals will add up and cancel each other out.

The fourth branch of the LFO output is sent to the LED driver, based around U1a (pins 1, 2, 3). The bicolour LED is in the feedback of this op-amp, so whatever current is drawn by R18, is also put through the LED. If one were to connect the LED and resistor straight across the LFO output and ground, the LED would be off when the voltage was less than its ‘turn-on’ voltage. This is normally around 2V which is a fair proportion of the 5V output signal. The old issue one boards did this, and although the LED did give an indication of LED speed, it would go out for some time. This special driver circuit makes the current through the LED proportional to the input voltage. So even at small LFO output levels, the LED is still giving out some light.

Components

Most of the parts are easily available from your local parts stockist. I use Rapid Electronics, RS Components, Maplin and Farnell, here in the UK. The Equinoxe was designed to be built solely from parts obtainable from Rapid Electronics and myself only. Rapid’s telephone number is 01206 751166. They offer a traditional ‘paper’ catalogue and take VISA card orders over the telephone.

In North America, companies called Mouser, Newark and Digikey are very popular. In Germany, try Reichelt, and in the Nordic countries you can use Elfa. All companies have websites with their name in the URL.

The PCB is designed for Spectrol 248 series pots with 1/4” shafts. These are high quality sealed conductive plastic potentiometers. Rapid, CPC, RS and Farnell sell these parts in the UK. The pot brackets are especially made for us, and are only available from Oakley Modular. We also sell the pots should you find it difficult to get them yourselves.

The resistors are generally ordinary types, but I would go for 1% 0.25W metal film resistors throughout, since these are very cheap nowadays. For the UK builders, then Rapid offer 100 1% metal film resistors for less than 2p each!

For the capacitors, there are no set rules. All the aluminium electrolytics (abbreviated to ‘elect’ in the parts list) should be over 25V, except where stated, and radially mounted. However, don’t chose too higher voltage either. The higher the working voltage the larger in size the capacitor. A 220V capacitor will be too big to fit on the board. 25V or 35V is a good value to go for.

The pitch spacing of all the non-polar capacitors is now 5mm (0.2”). This may differ from some of the older Oakley boards you have built. For the values 100nF and 470nF, I use metalised polyester film types. These come in little plastic boxes with legs that stick out of the bottom. Try to get ones with operating voltages of 63V or 100V.

I recommend polypropylene or polystyrene capacitors for the four 6n8 (6.8nF) capacitors in the phase shifter itself. These are higher quality components and have a better tolerance. Again try to get the ones that are radially mounted and come in little rectangular boxes. Working voltages should be either 63V or 100V.

The horizontal preset or trimmer resistor is just an ordinary carbon type. No need to buy the expensive cermet types. Carbon sealed units have more resistance to dust than the open frame types. Citec and Piher-Meggitt make a suitable type to use here. Pin spacing is 0.2” at the base, with the wiper 0.4” away from the base line.

L1 and 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. Farnell sell them as part number: 108-267.

The BC550 and BC560 devices are discrete low noise transistors. You can replace them with BC549 and BC559 types respectively, although the voltage rating of the BC550 and BC560 is higher. Quite often you see an A, B or C suffix used, eg. BC549C. This letter depicts the gain or grade of the transistor (actually hfe of the device). The Equinoxe is designed to work with any grade device although I have used BC549B and BC559B throughout in my prototypes.

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 or TL074CN. Do not use SMD, SM or surface mount packages.

The LM13700 is a dual operational transconductance amplifier, and is some times not to be found in the op-amp section of your parts catalogue. It may be down as ‘special’ or ‘OTA’. You can also use the JRC13600 and JRC13700, as well as the now obsolete NE5517. Surface mount parts are available for these parts, so make sure you don't buy them for this project. You need a sixteen pin DIL or DIP package.

As with others in the Oakley modular series the input and output sockets are not board mounted. You can therefore choose what types of sockets to use. I recommend the excellent Switchcraft 112APC 1/4” sockets.

The LED should be a 5mm diameter bicolour 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 Maplin in the UK. They have a built in lens and hold the LED firmly to the front panel. For bi-colour LEDs, it is best to get an uncoloured lens.

UK builders should know that there is now a ‘Oakley Preferred Parts List’ online. This gives the part codes of our most used parts. It can greatly speed up ordering times. This can be found at www.oakleysound.com/parts.pdf.

Finally, if you make a component change that makes the circuit better, do tell me so I can pass it on to others.

Parts List

This is an early issue of the documentation, I have checked the parts list, but I can miss things. Please e-mail me if you find any discrepancies.

A quick note on European part descriptions. 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 5% or better. 0.25W types.

22R	R35, 34, 62, 61
47R	R2
100R	R7, 8
1K	R24, 52, 29, 59, 42, 65, 39, 18
4K7	R17, 19, 4
6K8	R10
7K5	R31
10K	R16, 1, 44, 25, 43, 53, 55, 56, 30, 60, 11
15K	R3
22K	R5
27K	R23, 50, 51, 27, 57, 28, 58, 14
30K	R15, 22
47K	R36, 33, 32
56K	R13, 41
82K	R64
100K	R6, 26, 54, 20, 63, 48, 49, 9, 38, 45
270K	R66
330K	R47
470K	R12, 21, 46

For inverted LFO output fit R40 as 1K. For normal LFO output fit R37 as 1K

Capacitors

100nF, 63V polyester	C4, 12, 2, 20, 19
1nF, 63V polyester	C5
2u2, 63V electrolytic	C17, 18
22uF, 25V elect	C1, 7, 13, 16, 9, 6
470nF, 63V polyester	C11, 10, 3, 8
6n8, 63V polyprop	C14, 21, 15, 22

Discrete Semiconductors

BC550	Q1, 2, 3, 5, 6, 7, 8, 9, 11, 12
BC560	Q4, Q10

Integrated Circuits

TL072	U2
TL074	U1
LM13700	U3, U4

Others

10KA	EMPHASIS
50KA	FREQ, DEPTH
50KB	RATE
470K trimmer	TUNE
Ferrite beads	L1, L2
Bicolour LED 5mm	LED
LED Clip	
1/4” sockets	IN, OUT, CV, LFO
8pin DIL IC sockets	1 off
14pin DIL IC sockets	1 off
16pin DIL IC sockets	2 off
Suitable knobs	4 off

A small amount of insulated multistrand wire is needed. This will be used to connect the sockets and the LED to the board.

IC sockets are to be recommended, especially if this is your first electronics project. Choose ‘turned pin’ or ‘dual wipe’ types.

Building the Equinoxe

Warning:

Oakley Modular PCBs are now supplied with the RoHS compliant Ni/Au 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 Ni/Au that 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.

These boards can be soldered with either leaded or lead free solder. However, you should be aware that lead solder is toxic. Always wash your hands after handling solder and never put solder, or any products containing solder, in your mouth

We are not 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. To date this has happened only a few times across the whole range of Oakley PCBs. The most common error with four 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!

I always use water washable flux in solder these days for my board manufacture. In Europe, Farnell and Rapid sell Multicore's Hydro-X, a very good value water based product, although you should note that it is not lead free. You must wash the PCB at least once every two or so hours while building. Wash the board in warm water on both sides, and use a soft nail brush or washing up brush to make sure all of the flux is removed. Make sure the board is dry before you continue to work on it or power it up. I usually put the board above a radiator for a few hours. It sounds like a bit of a hassle, but the end result is worth it. You will end up with bright sparkling PCBs with no mess, and no fear of moisture build up which afflicts rosin based flux. Most components can be washed in water, but **do not** wash a board with any trimmers, switches or pots on it. These can be soldered in after the final wash with conventional solder or the new type of 'no-clean' solder.

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.

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.

For the transistors 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' jaws is parallel to the flat side of the transistor.

The polyester and polypropylene capacitors are like little blue or red boxes. Push the part into place up to the board's surface. Little lugs on the underside of the capacitor will leave enough of an air gap for the water wash to work. Cinch and solder the leads as you would resistors.

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, 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.

I would make the board in the following order: resistors, IC sockets, small non-polar capacitors, transistors, electrolytic capacitors. Then the final water wash. You can now fit the trimmer to the board with no-clean or ordinary 'ersin' flux solder. Do not fit the pots or the LED at this stage. The mounting of the pots and the LED requires special attention. See the next section for more details.

Mounting the Spectrol Pots and LED

NOTE: This procedure is rather different to that of the Omeg pots you may have used on older Oakley boards.

The first thing to do is to check your pot values. Spectrol do not make it that easy to spot pot values. Your pot kit should contain:

Value	**Marked as**	**Quantity**
50K linear	M248 50K M	2 off
10K linear	M248 10K M	1 off
50K log	248 J 50K	1 off

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. 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 PCB. 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 itself. Do this for all four pots.

You can now present the front panel up to the completed board. Although, I usually fit the sockets at this point, and wire up the ground tags first. After this is done, I then mount the PCB to the front panel. The washers should go on the pot's bush at the front of the module and the second nut on top of this. Again, do not over tighten.

The pots shafts will not need cutting to size. They are already at the correct length.

The pots are lubricated with a light clear grease. This sometimes is visible along the screw thread 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 cotton wool bud.

The LED may be able to be soldered directly into the board if its leads are long enough. You'll have to bend the leads at ninety degrees near the body of the LED. It doesn't matter which lead goes into which hole of the LED pad. However, I like to make the LED go red when the LFO output goes positive. The integral red LED's cathode must then go to the cathode as depicted on the PCB silk-screen. This is the round pad, the square pad being the anode.

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

If you have used Switchcraft 112 sockets you will see that they have three connections. One is the earth tag. One is the signal tag which will be connected to the tip of the jack plug when it is inserted. The third tag is the normalised tag, or NC (normally closed) tag. The NC tag is internally connected to the signal tag when a jack is not inserted. This connection is automatically broken when you insert a jack. The tags are actually labelled in the plastic next to the tag. The signal lug is called 'T' for tip, the NC lug is labelled 'T/S' for tip-switched.

In this module we are going to 'common' the sockets ground lugs. This means that the sockets' lugs are going to be joined together. I normally do this part of the wiring without the PCB or pots in place.

Fit all the sockets onto this module so that the bevel on the side of the socket is facing top left as you look at the rear of the panel. There are just four sockets in total.

The first lugs we are connecting together will be the ground or earth tags on the two horizontal rows of sockets. I use 0.91mm diameter tinned copper wire for this job. Its nice and stiff, so retains its shape. Solder a length of this solid core wire right across the two earth tags on the top row. Trim off any excess that sticks out on either end. Then do the same on the lower row of sockets. What you have now done is common each row's earth tags together, but each row is still separate for now.

Fit the PCB against the front panel if you haven't done so already. Solder a piece of ordinary insulated wire to the earth lug on the socket furthest on the left on the top row. The other end of this wire needs to go to the pad on the PCB marked PN1. Now solder another piece of wire to the earth lug of the socket furthest left on the bottom row. This wire will be going to the pad PN2. Your earth tags are now commoned together.

The other pads that are going to be connected to your four sockets are IN, OUT, NC, CV and LFO. You will have to make five more connections in all.

I have used slightly different names for the front panel sockets. The table below shows which is connected to which:

PCB	**Front Panel**	**Socket Connection**
IN	'Audio in'	Signal lug
OUT	'Audio out'	Signal lug
CV	'CV in'	Signal lug
NC	'CV in'	NC lug
LFO	'LFO out'	Signal lug

Use small lengths of insulated wire to make your connections. There is no need to use screened cable. Leave the NC tags unconnected on the audio in, audio out and LFO out sockets.

The PN1 and PN2 pads have been provided to allow the ground tags of the jack sockets to be connected to the powers supply ground without using the module's 0V supply. Earth loops cannot occur through patch leads this way, although screening is maintained. Of course, this can only work if all your modules follow this principle. For a suitable power distribution board you may want to consider the Oakley 'Dizzy' PCB.

The 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 GND	2
Earth/PNL	3
-15V	4

At the rear of this user guide I have included a 1:1 drawing of the suggested front panel layout. Actual panels can be obtained from Schaeffer-Apparatebau of Berlin, Germany. The cost is about £20 per panel. All you need to do is e-mail the fpd file that is found on the Equinoxe web page on my site to Schaeffer, and they do the rest. The panel is black with white **engraved** legending. The panel itself is made from 3mm thick anodised aluminium. The fpd panel can be edited with the Frontplatten Designer program available on the Schaeffer web site.

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

Apply power to the unit making sure you are applying the power correctly. The LED should now flash happily. If it doesn't turn off, and check all the parts again thoroughly. If your LED is OK, and there is no smoke rising from the board (yikes!!), then try the LFO rate. It should control the LED's flashing. From around one cycle every 30 seconds to around 10 cycles a second.

Now input an audio signal of some sort, any will do, but a simple sawtooth wave is quite sufficient. Listen to the audio output, and play with the controls. With all controls to the minimum setting, sweep the FREQ pot. Do you hear the characteristic phase sweep? If not, you have got a problem. If yes, now turn up the EMPHASIS. Using the FREQ pot again, does the sweep have a more metallic ring to it. It'll probably be a bit louder too.

Now set the FREQ and EMPHASIS pots to their middle position. Turn up the MOD DEPTH. The LFO should now be modulating the phaser. Check that the RATE affects the speed of the modulation.

Trimmers

There is only one trimmer to set up and its pretty easy to do. Set the FREQ and EMPHASIS pots to their maximum value and the MOD DEPTH and LFO rate to the minimum values. Now turn the trimmer to its fully clockwise position. Power the unit up and input a sawtooth waveform into the input. Any frequency will do, but a low to medium note is best. Listen to the output through your normal listening set up.

Now slowly turn the trimmer in anti-clockwise direction. The moment the sound alters in texture stop turning. You may have to go back a little bit until you get it right. It'll probably be somewhere around its half way point. Its not terribly important that you set this accurately, so don't worry about it if you can't get it absolutely right.

Final Comments

I hope you enjoy building and using the Oakley Equinoxe VC-phaser.

If you have any problems with the module, an excellent source of support is the Oakley-Synths Group that can be found at http://launch.groups.yahoo.com/group/oakley-synths/

If you still 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 email 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 postal costs, any parts used and my time at 20GBP per hour. Most faults can be found and fixed within one hour. The minimum charge is 20GBP plus return postage costs.

Your comments and questions are important to both Oakley Sound and Oakley Modular. In the first instance, please use the Oakley Synths Group where a wealth of experience resides. Please do not contact me or Oakley Modular directly with questions about sourcing components or general fault finding.

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 Oakley-synths, Synth-diy and MOTM mailing lists.

Tony Allgood
Cumbria, UK January 2007

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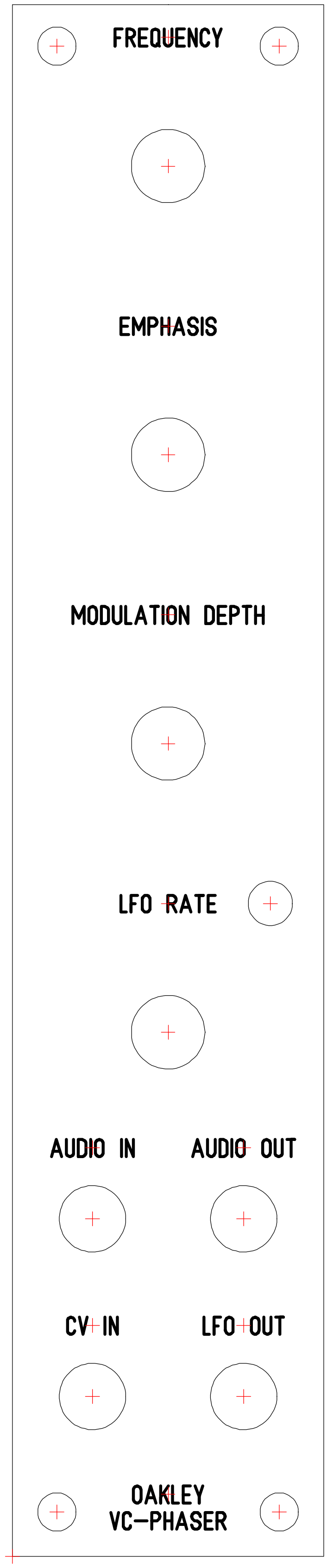
Errors will always occur in the preparation of a document. Please forward any errors found to me so I can correct them.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