Oakley Sound Systems

5U Oakley Modular Series

Flanger

PCB Issue 2

User Manual

V2.2

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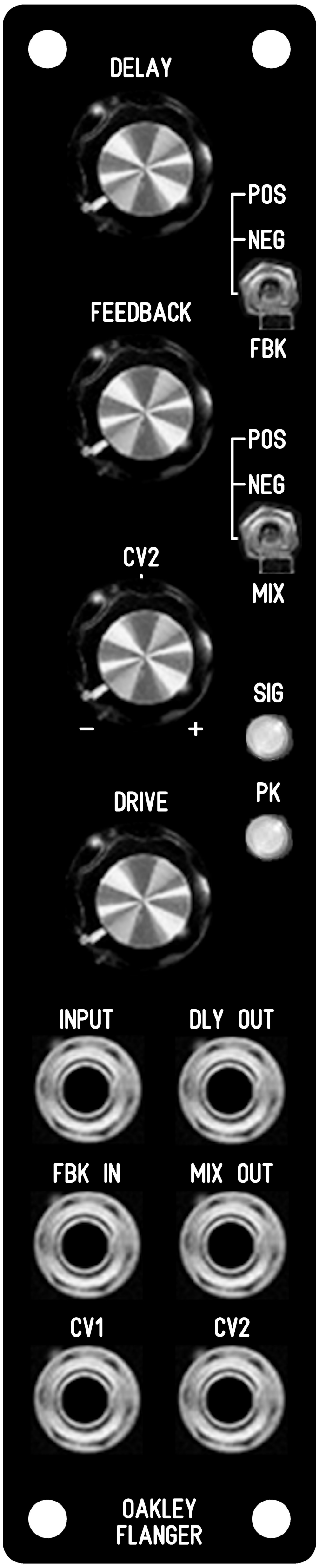


The Flanger module as a 1U wide MOTM format module.

Introduction

This is the User Manual for the issue 2 5U Flanger module from Oakley Sound. This document contains an introduction to the module, some information on how to make the best use of your module and the calibration procedure.

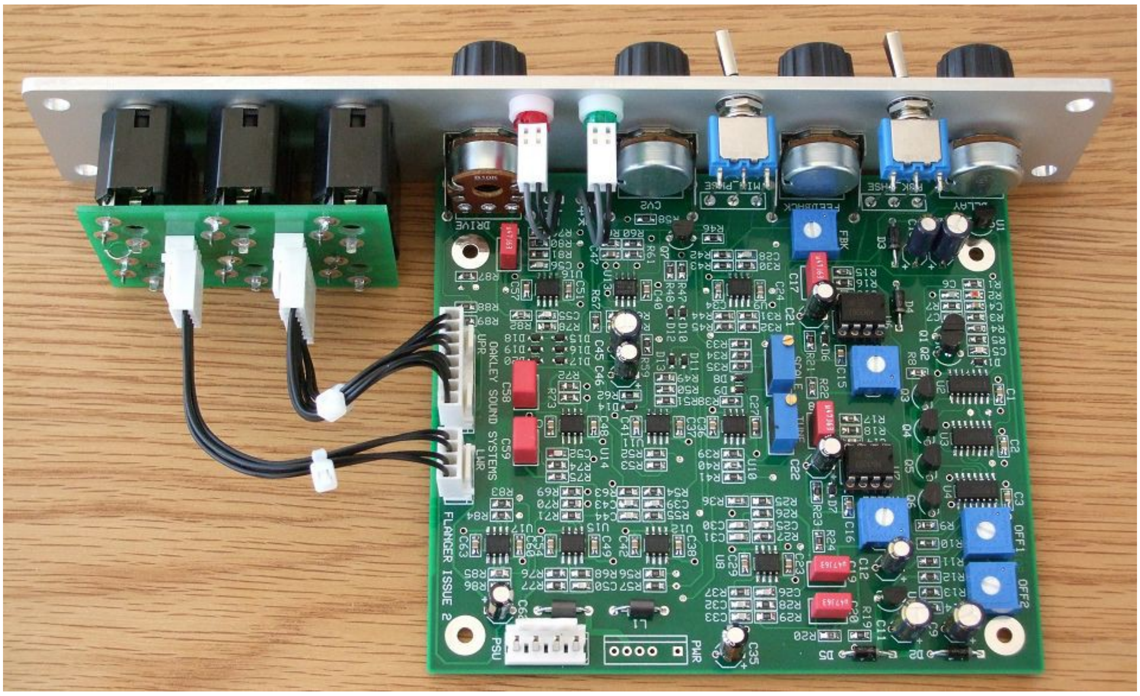
For the latest Project Builder's Guide, which also contains the parts list for the components needed to populate the boards and a list of the various interconnections, please visit the main project webpage at:

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

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

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

The Oakley Flanger Module



The issue 2 Oakley Flanger as a single width MOTM format module in a natural finish Schaeffer panel.

The Oakley Flanger module is an analogue delay line capable of delaying audio signals from 0.5mS to 15mS. In conjunction with an external LFO module this unit can be used to produce real time vibrato, chorus and flanging effects. With the feedback control set to maximum the module can be set to self-oscillate.

The delayed audio output is available from the DLY OUT socket. While the MIX OUT socket has a equal mix of input signal and delayed signal. The phase of the delayed signal that is mixed may be selected to be inverted (NEG) or non-inverted (POS) by the use of the MIX switch. This is particularly useful when used for chorus or flanging as the two modes can create completely different effects.

A feedback path from the delayed output back to the input is available and you have control over both the amount, via the FEEDBACK pot, and phase of the signal, via the FBK switch. Inserting a jack plug into the FBK IN socket will break the internal feedback path and allow another signal to be sent into the delay line. This could allow additional processing of the raw delayed signal, from the DLY OUT socket, prior to being sent back into the delay line again. For example, using a VCA to process the feedback signal would allow CV control of the feedback level.

There are two control voltage (CV) inputs. CV1 has a fixed sensitivity while CV2 has its own sensitivity control. CV2's control pot is a reversible attenuator, so you are able to adjust not only the depth of the modulation but also the polarity. Although not specifically designed to track to 1V/octave, using the CV1 input, the module can be used as tuned delay line over a useful proportion of the full operating range.

The delay line itself is based around two 3207 bucket brigade delay (BBD) devices controlled by a voltage controlled oscillator (VCO) running from around 33kHz to over 1MHz. Audio bandwidth of the delayed signal extends to 14kHz and several unusual design features ensure that the module is relatively quiet compared to other units of its type.

Two LEDs provide visual indication of the signal level being sent to the BBD devices. The DRIVE control should be adjusted to ensure that the green LED remains lit for optimum signal level. The red LED will light when the signal level is close to, or is, being overdriven. The module will not be harmed when the signal is overdriven and there is a soft clipping circuit in place to ensure the overdriven sound is musically useful. The DRIVE control allows a variety of different signal levels to be used with the module although the expected signal level would be expected to be between 0.5V(peak) and 8V(peak).

The Delay Control

The Oakley Flanger uses a high frequency voltage controlled oscillator (HFVCO) to clock the BBD devices. The faster the clock the shorter the delay time. The clock runs from 33kHz to just 1MHz. The clock can be controlled by the front panel delay control pot and control voltages sent to the CV1 and CV2 sockets. Increasing positive voltages will decrease the delay time.

The delay control pot will create the longest delays at its minimum setting and shortest delays at its maximum setting. This may seem counter intuitive if you think about the module as a simple delay line – most delay lines would have a delay control that would increase the delay as it is turned up. However, the flanger creates its distinctive sound by a form of notch filtering whereby some frequencies in the audio spectrum are cut and some are boosted. Shortening the delay time gives the impression that the filtering effect is rising in tone. It's actually more complex than that but having the delay pot work in a reverse fashion does seem to sound more natural.

The delay time goes from approximately 500uS (0.5mS) to approximately 15mS. Control voltages applied to either CV1 or CV2 will extend this slightly but the module has limiters in place to prevent the module from going too far away from its intended range. With the delay pot in its middle position the delay time is around 3mS.

For flanging effects you can use the full sweep of delay times from 0.5mS and 15mS. For chorus and vibrato type one would normally use delay times of around 5mS to 15mS. All of these effects require the use of some form of modulation. That is, the delay time is dynamically altered to create movement in the sound. Modulation sources normally take the form of a connected LFO with triangle or sine waveforms available. However, you can also use a sequencer or envelope generator. With an LFO as the modulation source the delay pot is used to set the mid point by which the modulation shifts the delay time. The effect heard varies greatly with delay time, modulation depth, modulation waveform and modulation frequency.

Vibrato is best heard from the raw delay output and using a sine LFO of around 6Hz to gently modulate the delay time. Chorus is best done with a relatively slow moving triangle wave and using the mix output. The pitch shifting effect created by modulating the delay time is more noticeable at longer delay times even with only small amounts of modulation.

Flanging requires the use of feedback while both chorus and vibrato effects are done with no feedback. The greater the amount of feedback the more pronounced the flanging effect.

Feedback

There is a feedback input socket, a feedback pot and a feedback switch. For the switch and input socket, feedback is abbreviated to FBK.

The FBK IN socket can be used as an additional input which will add to the signal going into the INPUT socket. The Feedback control pot will then control the level of the FBK IN signal. If there is no signal plugged into the INPUT socket and the input is being applied solely to the

FBK IN socket then only the delayed version of this signal will heard at both the DLY OUT and MIX OUT sockets.

When the FBK switch is in POS it has no effect on the signal passing into the FBK IN socket. In NEG mode the module inverts the signal so the audio going into the delay circuitry is now completely out of phase with the FBK IN input signal.

With no jack plug inserted into the FBK IN socket the delayed audio signal is automatically passed to the feedback control pot. When the control pot is at its minimum then no signal is passed from the delay output back into the input. In this case the position of the feedback switch has no effect as there is no signal to invert.

At high levels of feedback the module may self-oscillate – although this will depend on how the unit has been calibrated. The frequency of self-oscillation will depend on a variety of things but the key factor is the delay time. Feedback is stronger at longer delay times, that is, when the delay control pot is at its lowest settings. It also slightly stronger when the FBK switch is in NEG mode. If the unit has been calibrated to self-oscillate then self-oscillation will happen more readily in NEG mode and at longer delay times. The output signal level at high feedback levels can get very loud and be somewhat unpredictable.

For the classic flanger sounds both switches would normally be set to the same mode.

The Drive Control

Whilst having dedicated input level and output level controls is more common in rack effects the Oakley Flanger features a single Drive control. This combines the actions of both the input and output level controls in one control. Turning up the Drive increases the signal level sent to the BBD devices, while at the same time reducing the signal level from the BBD devices. This way input sensitivity can be increased without any change in output level. This is very useful when using the Flanger module to process external instruments or indeed the wildly varying signal levels of a modular.

For clean signal processing the green LED should be mostly lit and the red LED lit only very occasionally. Allowing the red LED to activate shows that the signal is now being overdriven producing a more distorted sound. If the red is lit even with the Drive pot at its minimum this indicates that the input signal level is too large. This will not damage the unit but you should either turn down the signal level via the sending instrument's volume control or use another module (like the Oakley Multimix) to attenuate the signal a little.

Of Signal Levels and Insertion Loss

The signal levels of both outputs are approximately 8dB lower in signal level than the input. This means a 5V peak input signal will be lowered to around 2V peak. This reduction allows the output audio signal more space to rapidly increase in volume, which it may do under certain conditions, without any significant risk of clipping distortion.

When the module's feedback control is at its minimum value the delayed output's signal level pretty much follows that of the input. There are no surprises. However, increasing amounts of feedback, both negative and positive, can produce massive changes in output signal level. The actual peak output level is hard to predict as it can change with the harmonic structure of the input signal, the fundamental frequency of the input signal, the delay time selected and the modulation signals used. This rapid change in volume at certain frequencies is a distinctive part of the flanging sound.

Any 5U modular system is powered from +/-15V so the maximum signal output of any module cannot be more than +/-15V. In practice it actually works out somewhat less than this and outputs of over +/-13V are unlikely. If the output wants to be above this value, but the module cannot produce it, then the output clips. This means the module does what it is supposed to do up to +/-13V and then any desired output greater than that is clipped at +/-13V and goes no further. This abrupt flattening of the top and bottom of waveforms creates distortion and is generally not wanted.

The Flanger module is quite capable, when feedback is applied, to produce signal levels far greater than what goes in. If the output matched the input perfectly, ie. 5V peak ended up as 5V peak with no feedback, then when feedback was applied the output could easily exceed the +/-13V we have to play with. By lowering the nominal output level to approximately 2V peak the output can rise by over seven times before clipping sets in.

The two signal activity LEDs both monitor the signal level going into the BBD devices. The module is calibrated so that the red LED will only light when the BBD audio driver circuitry starts to overdrive. Keeping a signal under this level will help keep the signal as clean as possible. It is, however, still possible, under certain conditions, for the output stages of the module to distort. This should be obvious to the user as output stage clipping can normally be heard. Clipping does not damage the module and some users may find the sound appealing.

When the delay time is very short the signal running through the BBD devices is not passed through as efficiently as it is when the delay times are longer. Engineers say that the insertion loss through the BBD increases at higher clock frequencies. The upshot of this is that you may notice a small volume drop as delay times are shortened. While this has no real detrimental effect, especially for chorus and pitch shifting effects, it does reduce the signal level available for feedback. At very high levels of feedback, that is, close to or at oscillation, and with very short delay times you will notice that the flanging effect is not as pronounced. In practice this means that the position of the feedback control is important to getting the right sound at the desired delay time.

Noise

BBD devices are noisy in comparison to other electronic devices. They hiss and the clock signals that control the delay often sneak into the audio pathway. It is useful therefore to keep the audio running through the module as high as possible but not high enough to cause audible distortion – unless you actually like the distortion.

The Oakley Flanger does not use the noise reduction circuitry that some other devices use. There are two types of noise reduction techniques typically used in BBD based flanger and chorus units; pre-emphasis/de-emphasis and compression/expansion. Both types do indeed reduce the overall level of hiss and grunge. But they also cause other sonic effects that in my view detract from the sound. The best sounding analogue flangers in my opinion are the ones that have no noise reduction circuitry.

That said, to reduce CV and clock breakthrough, the Oakley Flanger uses two flangers running in parallel. Each flanger circuit, based around one MN3207 BBD, is controlled by the same clock signal so the delay produced by each of them is identical. Also the audio signal passing through each one is the same but with one important difference – one of them is the inverse of the other. This is a differential audio signal and when one waveform is going up, the other one is going down. If you were to add the two signals together then they would completely cancel each other out. Here though, our two delayed, but out of phase, signals are subtracted from each other. This reproduces the original signal at twice the size but also any similar noise that both signals would have gained from going through the BBDs is cancelled out. This technique is particularly effective at reducing CV breakthrough – where the CV that controls the delay time sneaks into the audio path producing unwanted thumps and wheezes – but it also improves signal quality too.

If you do find the level of noise objectionable in certain patches try using the flanger module before your final VCA. This way the audio signal, including any added noise, from the flanger will only be heard when the VCA is opened. The audio passing through the flanger will usually drown out the relatively small amount of noise produced by the BBDs.

Calibration

There are seven trimmers, or presets as we used to call them in the UK, on the printed circuit board (PCB). An oscilloscope is required to set several of the trimmers to their optimal positions.

You should use a proper trimmer tool or a fine blade jeweller's screwdriver for adjusting the two multiturn trimmers. Vishay, and others, make trimmer adjusters which are available for very little. The five single turn trimmers need a small electrician's screwdriver.

Switch the module on and allow to warm up for fifteen minutes. Trimmers should be adjusted in the order as presented here.

NULL1 and NULL2

Turn the delay control to its minimum position. Place a scope probe on pin 6 of U7. Adjust the multiturn trimmer TUNE so that the frequency of the waveform seen at pin 6 is 33kHz.

With your oscilloscope probe monitor the voltage on the right hand side pad of the surface mount resistor R22. Set your probe to AC input, 200mV/division and 5uS/division. You should see a waveform with alternate spikes of different heights at 33kHz. Adjust NULL1 until the waveform's peak amplitude is minimised. Essentially we are making the alternating spikes the same size as each other.

Now put your probe on the right hand side of R24. Adjust NULL2 until the waveform seen is minimised.

OFF1 and OFF2

Connect a 5V peak 220Hz (the A below middle C) sawtooth to the input. Adjust the Drive control until the red LED just comes on. The green LED should also be lit.

Set your scope for DC input, 500mV/division and 1mS/division. Probe the bottom pin of R45. A sawtooth waveform with slightly rounded edges should be seen if OFF1 is set correctly. Adjust OFF1 so that the waveform shows no hard clipping on the **lower** part of the waveform. The best place for OFF1 is just backed off from point hard clipping starts to occur.

Probe the top pad of R32 and repeat the above for OFF2.

FBK

This one can be set to taste and it sets the maximum internal feedback level. The way I do it is as follows. Set both switches to NEG. Set the Feedback pot to its maximum setting and set the Delay pot and the Drive pots to their minimum. Connect an amplifier up to the DLY OUT socket. Adjust FBK so that the module starts to oscillate and then gently back it off so that it is sitting on the point that is just, but not quite, about to oscillate.

If you want your module to oscillate then you should know that the two modes of the FBK switch behave slightly differently. The NEG mode's oscillations will be stronger than the POS mode and output signal level can get very big indeed in NEG mode. It may be best to adjust FBK to just oscillate in POS mode.

Remember, the classic flanging effect does not require either mode to oscillate and some folk will find the unstable nature of an oscillating flanger disturbing. So feel free to set FBK as you wish. Whatever position that FBK is set, the maximum feedback levels are always obtained at the longer delays thanks to the inherent gain drop (insertion loss) of the 3207 BBDs as the clock frequency rises.

SCALE and TUNE

If you have no need for Karplus-Strong physical modelling techniques or other tuned delay effects you can skip this bit entirely and just leave the scale trimmer in its default position and adjust the TUNE trimmer to set pin 6 of U7 to 33kHz when the delay pot is at its minimum position.

To set SCALE more accurately involves looking at the output of the high frequency voltage controlled oscillator (HFVCO) directly and using an oscilloscope or frequency counter to measure its frequency. The HFVCO output is available on pin 6 of U7. Applying a 1V signal to the CV1 socket should double the frequency seen at this point. The easiest way to do this is with your midi-CV convertor and then playing octaves on your midi controller. The 1V step change when you play between a C on one octave and then a C an octave higher is ideal.

Set the delay pot to its mid point. With no CV input applied check the voltage on top solder pad of D9. Fine tune the delay pot until it gets as close to 0.00V as you can get it. Using an oscilloscope or frequency counter measure the frequency at pin 6 of U7. Adjust TUNE until it reads 60.0kHz. Set your midi-CV convertor, or octave selector on your controller, to produce 0V when you play a particular C note on your controller. It should then produce +1V the octave above that and +2V the octave above that.

Apply the midi-CV's output to CV1. Pressing the lowest C should not move the frequency of pin 6 U6 from 60kHz. Play the C two octaves above that and adjust SCALE until it reads 240kHz. Play the bottom C and it should still be at 60kHz. The C up from that should produce 120kHz and top one should again be at 240kHz. SCALE is now calibrated.

Now set the delay control to its minimum and remove the CV input. Re-adjust TUNE so that pin 6 of U7 is 33kHz +/-0.5kHz. Note that the SCALE trimmer also affects this final value so TUNE should always be re-adjusted after any re-calibration of SCALE.

To test the accuracy of the scaling you can 'ping' the flanger module by sending a very short AD envelope to the audio input. With the feedback control set to just shy of self-oscillating, the short sharp trigger pulse will tickle the flanger to producing a lovely plucked string noise which can be played via a keyboard using the CV1 input. The feedback control adjusts the decay time of the note heard although higher notes will decay faster anyway.

Remember that the Flanger will not be able to be made to track perfectly over a very wide range. As such, even if you have achieved a perfect octave spread with your two C notes, you won't be able, for example, to have a perfect octave spread from two similarly spaced C notes a couple of octaves above that. I managed to get just under three octaves of playable tracking using the ping method described above.

Final Comments

I hope you enjoy using the Oakley Flanger module.

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

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

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

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