Oakley Sound Systems

3031 SuperBassLine

User's Guide

V2.4

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Introduction

The Oakley 3031, pronounced as 'thirty-thirty-one', is a heavily revised edition of the hugely popular TB3030 project. It is designed to be built into a 1U 19" rack. All the thirteen knobs, the four switches and the four LEDs are designed to be mounted directly onto the printed circuit board. This simplifies building and reduces the possibilities of any mistakes in construction.

There has been some revision of the circuitry compared to the TB3030. Gone is the old 4013 based sub-octave circuit. In its place, a new 'all discrete' divider and waveshaper. You now have the choice of triangle or sawtooth waveforms with a front panel switch. This results in a much more musical sub bass than the old digitally generated square waves.

The Overdrive circuitry has been revised to allow changes in 'overdrive' level without affecting overall volume as much. The overall output noise has been reduced too.

The more difficult to get parts have been replaced with current devices. Careful selection of the replacement parts have led to the new circuitry yielding the same TB sound we all love.

The VCO circuitry is easier to tune and set up, and space is now provided for the more accurate wirewound temp co resistors.

The PCB itself, as well as being a different shape, has been laid out for minimum noise and ease of construction. The legending has been made clearer and its easier to interface to the tbDAC too.

This User Guide is for issue 2 of the 3031. The new issue is identical to the original issue 1 design but for the following changes:

1. The area around the power components has been made larger to accomodate heatsinks if used.

2. The number of ground pads has been increased from just one to three. This should help when wiring up the board.

3. The pitch spacing for the TC resistor has been increased to reflect the larger KRL component now supplied in the ‘odd parts’ kits.

3031 Features

1. The 3031 has an electronically balanced output. This is very useful to prevent earth loops when connecting other pieces of equipment. Midi-CV convertors, for a good reason, use the earth as signal ground. This can cause hum problems when you connect your analogue synth to your mixing desk. The desk will earth the synth and so does the Midi-CV convertor. The matters are made even worse if the synth has a safety ground. This multiple earth connection can be bad news. One way of avoiding this is to cut the ground path in one of the leads. This can cause tuning problems, or if the synth’s safety earth is removed, then it can be dangerous. The best way of solving this is to use balanced connections. The 3031’s output can be

connected to the mixing desk, or whatever, without ground loops occurring. Either use a full balanced connection or a semi-balanced connection.

2. The 3031 features a rather useful distortion circuit, with a depth control. Excellent for a harder sound. If you think you are not into distortion, this circuit will surprise you.

3. The VCF's cut-off frequency can be controlled by an external CV. In the standard format, this CV can come from either the velocity CV or modulation wheel CV. Both these CVs would be generated by a midiCV convertor like the tbDAC. However, any CV source can be used. The voltage range is from 0V to 10V.

4. Audio Rate filter modulation is also possible via the Modulation pot. This will give you brighter, richer and more cutting sounds.

5. The awesome new discrete sub oscillator is provided to give you really deep basslines. Triangle wave or sawtooth outputs. The triangle gives you real deep grumbles without adding harshness. While the sawtooth adds deep bass richness.

6. A unique CV processor allows an external CV to control slide and accent. This was the most controversial addition to the original TB3030. It allows simple two channel analogue sequencers to completely control the 3031. Slides and accents can be programmed with just a turn of the control pots on the sequencer.

Many older digital hardware sequencers will only output gate, pitch and velocity information. Other midi controllers are not implemented, and this makes controlling other 303 clones less intuitive. Slides are often created by having to use legato notes. But with a suitable midi-CV convertor like the tbDAC, you can simply use the velocity CV output to switch in slide, accent or even both. This makes control of the 3031 very easy to program even with something like a MC303 and the like. In fact, using the 3031 with the MC303 is a doddle because the four velocity pads can control slides and accents directly.

Computer sequencer users will find altering velocity easier than assigning midi controllers. And keyboard players will experience a new interesting playing style. It takes some getting used to, but very powerful once mastered.

7. An external audio input to the VCF has been provided. However, the 3031 does not lend itself to filter processing, since you cannot hold the output VCA open without repeatedly triggering the unit. However, it is useful if you have a second VCO output from a modular or another synth. You can then route this in with the 3031's own internal VCO to create really thick basslines.

8. External logic signals to control slide and accent. Logic 0 is ground and logic 1 is 10V to 12V. These are OR'd to the CV processor's output. That is, if either the CV processor or the logic input goes high then that function will be implemented. Do not exceed the 12V maximum level for these signals.

9. External CVs and gate are overvoltage protected, within reason. The VCO conforms to the usual 1V/octave standard if R9 is 100K. R9 may be set to 82K for 0.8V/octave to work with

the tbDAC. The gate is ON when above 3V. A new schmitt trigger circuit is provided for glitch free triggering.

10. Accent Decay has been provided. The original TB303 produces a fixed short decay time when accented. This control allows you to alter it, up to the time set by the ordinary decay pot.

11. VCA decay. The TB303 has a fixed VCA decay of about 3 seconds. This control allows you to change it to some time between 0.1s to 3s.

12. Power supply. The 3031 comes with a very low noise stable all analogue 723 based power supply. You will need a AC wall wart to power it, or you can fit an internal mains transformer if you know how to do it. The on board power supply is over rated. You can, if the wall wart will allow, use the 3031's power supply to drive any other ancillary circuitry. For example, you can supply the Oakley tbDAC with +/-12V. If you do use the 3031 to power other external circuitry, watch out for excessive power dissipation in the pass elements. If you can't touch the power devices because they are too hot, you need heatsinks.

13. The secret grit weapon. In the TB303 the slide function is always triggered prior to any new note. This was not really by design, more of a by-product due to cost saving. However, it may be responsible for some of the grit associated with the attack portion of the TB sound. Many commercial clones have been criticised for not having the bite that the original had. My spike circuit may well do the trick. This, like the TB303, slews the pitch CV before every new note for a small fraction of a second. In the TB303 it was tempo dependent, but in mine it is fixed, since we don't know what speed the sequence will be run.

14. A slide control pot has been added. This can lead to slide times of up to 1 second.

15. The filter frequency and envelope amount pots operate over a wider control range than the original TB303. The TB303's envelope amount could never go to zero, the 3031 gives you that control.

16. The TB303 and the issue 1 TB3030 featured exactly the same VCO design. However, I found the pitch of the TB3030 VCO to go slightly flat at very high frequencies. This was no major problem in a machine designed to play bass sequences of course. However, as I began to use my original dual TB3030 more and more, I realised that the unit was capable of some amazing sounds at the high end of the keyboard. Almost guitar type distortions could be possible. Issue 2 of the TB3030 featured the same VCO core and waveshaping as before, but the exponential current sink has been improved. The VCO tracked very well right up to the very highest notes.

The 3031 improves this still further. Temperature stability is provided by a -3500ppm/K temperature coefficient resistor for a really stable VCO pitch. The CV summing circuit has been improved too this time around. Setting up is easier than before.

Operating Instructions

The following will be a description of the pots and switches in the 3031. Refer to the diagram at the end of this document for a drawing of the front panel.

Reading the front panel for the 3031 from left to right:

TUNE: Alters the frequency of the VCO and thus tunes the whole instrument.

SLIDE: Controls the amount of portamento on the pitch when the note changes and slide is enabled. The little red LED will light if the slide is active.

VCO WAVE: The VCO produces two basic output waveforms. The square wave, a hollow sound; and a sawtooth wave, a more brassy sound. The WAVE switch actually controls two things. When SAW is selected, the sawtooth output of the VCO goes into the audio input of the filter. However, it also routes the square wave to the filter modulation pot. When SQR is selected, the square wave is sent into the filter's audio input, and the sawtooth goes to the modulation pot.

SUB OSC: Adjusts the volume of the discrete sub-octave generator. This will add a triangle or a sawtooth wave output one octave below the VCO's pitch to the filter input, for really deep bass.

SUB OSC WAVE: Selects whether the triangle or the sawtooth output of the sub oscillator is sent to the filter's audio input. The triangle will give you deep bass without the harshness associated with normal square wave waveforms. The sawtooth is far more bolder and harmonically rich, but I think it still sounds better than the TB3030's square wave.

FREQUENCY: Alters the voltage controlled filter's cut-off frequency. The more clockwise the pot the brighter the sound.

RESONANCE: This alters the amount of feedback applied to the filter. What this does is to create a peak in the filter's response. Thus certain frequencies are heavily emphasised. It also controls the amount that the accent signal modulates the filter's cut-off. This last bit is rather unusual, but it gives the 3031 its characteristic 'th-wap' sound when accents are triggered.

FILTER CONTROL: This is a three position switch that selects which external control signal will affect the filter's cut off frequency. Set to VEL, the velocity will control the cut off. This is good for those touch sensitive keyboard solos. Set to MOD, the modulation wheel will control the filter's cut-off. This is great for controlling filter sweeps from your sequencer or master keyboard. The switch's middle position removes any external control on the filter.

AMOUNT: The filter's cut-off frequency can be modulated with an envelope generator. Thus dynamic filtering is possible. By increasing the amount of envelope modulation, the cut-off point is increasingly moved by the envelope generator. The generator itself is triggered by the gate signal, and produces a decaying voltage immediately after being triggered. This produces the characteristic ‘dow’ sound. Oddly, the envelope amount also gets higher for repeated triggering of the gate.

GATE LED: Lights green when an active gate is present.

VCF DECAY: Controls the time it takes for the envelope to decay down to zero. From ‘dit’ sounds to ‘dowww’ sounds.

ACCENT DECAY: This will allow the filter decay time to be a certain proportion of the time set by the VCF DECAY pot when accent has been triggered. In other words you can set the accent decay time from very short to the same as the VCF DECAY time.

FILTER MODULATION: Adjusts how much of the selected VCO output modulates the VCF’s cut-off frequency. This brightens up dull timbres and somehow gives them a burbling sound. Use with high values of resonance for really odd noises. Remember that the source of the modulation comes from the VCO WAVE switch. So changing the waveform makes a huge difference to the sound.

VELOCITY CONTROL: This switch turns the velocity processor on or off. With it off, velocity has no control over the slides and accent modes of the 3031. When on, the velocity processor measures the value of the velocity CV and controls the synth accordingly.

Example velocity CV processor sensitivity:

Velocity CV	Approx MIDI value	Slide	Accent
0-2V	0 -31	no	no
2-4V	32-63	no	accent
4-6V	64-95	slide	no
6-10V	96-127	slide	accent

Adjust the SENS trimmer for actual processor sensitivity.

Although it is called velocity control, you could of course use any external CV. One example I have seen uses the second channel of an analogue sequencer to control the 3031’s processor.

With an internal tbDAC, the user is not aware of any CV control. You just simply bang away at your sequencer, or keyboard, and the velocity value of each MIDI note determines what mode the 3031 drops into.

ACCENT: When accent is triggered the VCA can become louder and more punchier. This pot controls how much the accent has an effect. Like the TB303, the 3031 also modulates the VCF with this signal.

VCA DECAY: The VCAs envelope can be changed from about 0.1s to about 3s with this control. In other words it affects how long the note is heard after initial triggering.

OVERDRIVE: Adjusts how much the output waveform of the filter gets distorted. Fully anti-clockwise gives an undistorted TB sound, while clockwise gives a heavily clipped waveform. This will emphasise certain higher harmonics. Use this in conjunction with the resonance pot and you can get good approximations to hard synchronisation.

VOLUME: Controls the final output level. The 3031's output level is very high and is similar to the output of pro-audio equipment.

Components

Most of the parts are easily available form your local parts stockist. I use Rapid Electronics, RS Components, Maplin and Farnell, here in the UK. The 3031 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 as well as an on-line ordering service.

In North America, companies called Mouser, Newark and Digikey are very popular. In Germany, try Reichelt, and in Scandinavia you can use Elfa. All companies have websites with their name in the URL. In the Netherlands try using www.telec.com.

The pots are Omeg Eco types with matching brackets. You could use any 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, CPC, Maplin and Rapid sell the Omeg pots at a very good price.

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 in the 3031 **have to** be 1% or better types. Failure to use good quality parts in these locations will affect the VCO tuning stability and the stability of your outputs. These critical parts are indicated in the parts list.

All the 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 values between 1nF and 1uF, 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 would fit a close tolerance polystyrene for the VCO timing cap, C9. This will give better pitch stability. Use a cheaper part if you can accept a small drift in VCO pitch with time. The PCB is laid out to accept a 10nF LCR type EXFS/HR series, but these radial types are getting very rare now. Standard axial types will fit into the board if mounted on one end. The working voltage can be quite low, 63V is common.

Other alternatives to polystyrene are polypropylene. But make sure you get low voltage types like 63V or so. Polypropylene capacitors are also used in suppression and can get very very big.

The ceramic capacitors should be ‘low-K’ or C0G ceramic plates. 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 horizontal preset or trimmer resistors are just ordinary carbon types. No need to buy the expensive cermet types for these positions. Carbon sealed units have more resistance to dust than the open frame types. Piher 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.

The multiturn trimmers are the ones that have the adjustment on the top of the box. Spectrol and Bourns make these. 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. Don’t chose the 10-turn ones with the adjustment on the end, they won’t fit on the PCB.

The BC549 transistors can be pretty much any NPN transistor that corresponds to the same pin out. For example: BC550, BC548, BC547 etc. However, I recommend using BC549 or BC550 only as these are low noise devices.

The transistors specified as BC559 can be any general purpose PNP types that have the same pin out. For example the BC560 may be used instead.

Quite often you see an A, B or C suffix used, eg. BC549B. This letter depicts the gain or grade of the transistor (actually hfe of the device). The 3031 is designed to work with any grade device although I have used BC549B and BC559B throughout in my prototypes.

The SCR in the VCO is different. Here I have used BC212L and BC182L because when testing the prototype they gave better pitch stability. I am unsure why this is, so if anyone has any idea I would like to know. I suspect it has more to do with the layout of my original breadboard. The three BCxxxL types needed in the SCR are provided in the semiconductor kit.

The two J-FETs in the TB3030 are the 2SK30A and the J201. The original TB303 used two variants of the 2SK30A, the O and the Y types. These two different types differ only by their value of *Idss*. In earlier editions of the TB3030 User Guide I stated that the variants differed by values of *Vp*, the pinch off voltage. This is true. But they are formally defined on the datasheet as having different ranges of *Idss*. This is the current that runs through the device when the gate and source are grounded and the drain is taken to 10V. The O types are defined as having a *Idss* of 0.6mA to 1.4mA. The Y types are defined as having *Idss* of 1.2mA to 3.0mA. Look at the range of Idss for the 2SK30A-O. It is interesting to note this, because the sound of the squarewave is dependant on the Idss of the O type device. So no wonder that people have commented some TB303s sound slightly different to one another.

The 2SK30A-O is getting hard to find in large enough quantities, so I needed a substitute. The 3031 uses a J201 in place of the difficult to get 2SK30A-O. It has a different pin out, but its electrical performance is very similar. What’s more there is less variation between Idss in various specimens of the J201, so everyone’s 3031 should sound the same.

I do still use the 2SK30A-Y in the 3031. The Y types are still produced by Toshiba and are easily available. I also use the 2SK30A-GR too. This is used in the FET buffer for the new VCA circuit. A Y type may be used in its place, and either may be provided in the ‘odd parts’ kit.

The original Japanese NPN pair is the 2SC1583. It is a superb component and although not made any more is still readily available in most places. Matched pairs are required in two places in the 3031, the exponential convertor and the differential amp in the VCF. The PCB is actually laid out to take the newer 2SC3381. This offers a similar performance to the 2SC1583, and is supposedly geared towards audiophile use. I cannot tell the difference between the two parts audibly, and since the 2SC3381 is still in production I have chosen to recommend this part.

All the other 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. Do not use SMD, SM or surface mount packages.

The PTC is a positive temperature coefficient resistor. This means it resistance goes up with temperature. Its there to keep the VCO’s frequency relatively stable as the ambient temperature changes. The PTC I now use for this job is made by KRL in the US. They are expensive parts to buy, but they are included in the ‘odd parts’ kit. Other PTCs do exist and good use can be had from the cheaper Meggitt series. Farnell part number 732-278. Its a 1K +3000ppm/K 900mW device. The old TB3030 used this part and I thought it was great until I tried the KRL parts. I can simply say that once fitted the KRL parts give much better stability over a wider range of temperatures.

Input and output sockets are not board mounted. You can choose whichever type of sockets you wish. However, to reduce the possibility of earth loops you may be wise to use plastic sockets for all the CV and gate inputs.

The LEDs can be any type, although I recommend the use of standard round 3mm types. You will need to bend their legs if you want them to stick through the panel. More detail about mounting the LEDs is given on this later on this document. Many manufacturers do ready made preformed LEDs in little plastic boxes. These may be perfect for the job, but be careful that your LEDs have the cathode on the right hand side as you look at the front of the device. The Scheaffer front panel database was designed so that ordinary 3mm LEDs are to be used. The prepackaged preformed types will probably not fit my panel design. Two of the LEDs are not fitted to the front panel. These are the overdrive LEDs, LED4 and LED6. They must be 3mm types otherwise they won’t fit on the board. I use green LEDs to get a good distortion sound. Changing the colour of the LEDs will alter the sound of the overdrive.

The switches can be any style if you are not fitting them directly to the PCB. However, the PCB is designed to use the miniature toggle range from C&K, but ones made by MultiComp also fit very nicely. The C&K types are ‘type 2 horizontal’ non-sealed units.

Two of the switches are ordinary ON-ON switches, sometimes called SPDT. The ‘filter control’ switch is an ON-OFF-ON. This is the same as an ordinary ‘up-down’ toggle switch, but it has an additional position in the middle. This third position neither connects the switch's wiper to either the bottom or top connection.

The VCO wave switch is an ON-ON type, but is a two pole (2P) switch. This essentially means that there are two switches internally controlled by one toggle. These are sometimes called DPDT or double pole-double throw.

The manufacturer’s part numbers for the chosen switches are:

SPDT	On-On	7101MD9AV2BE
SPDT	On-Off-On	7103MD9AV2BE
DPDT	On-On (2P)	7201MD9AV2BE

Note that C&K are now part of the mighty ITT-Cannon organisation.

The ‘filter control’ switch may be obtained from Farnell, part number: 917-813. The other two SPDT switches are part number: 917-801. The ‘vco wave’ switch is part number: 917-825.

MultiComp switches are similar and can be obtained from Farnell. Their Farnell part numbers are:

SPDT	On-On	444-2430	2 off
SPDT	On-Off-On	444-2441	1 off
DPDT	On-On (2P)	444-2453	1 off

Heatsinks are probably required. BUT this does depend on the power supply, local temperature etc. If you cannot hold the two power devices for more than 5 seconds after it is has been powered up for at least 10 minutes, then you need heatsinks. I use the clip on type of heatsinks available from most suppliers. These require no nuts and bolts, or heatsink compound. They simply push on, and friction holds them in place. Try not to bend the legs of the power devices when you push the heatsinks into place. If you are using the 3031 to power the tbDAC, then you are recommended to use heatsinks.

The topic of power supplies will be covered in its own section later on in this document.

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.

Parts List

I strongly advise you to read the Components section above before you place any order for parts.

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 5% 1/4W carbon or better except where stated. Some values need to be 1% 1/4W metal film (MF) types or better.

* denotes tbDAC optional value change. R9 is 82K 1% MF for tbDAC, and 100K 1% MF otherwise.

100K	R137, R34, R3, R20, R58, R72, R147, R148, R38, R46, R89, R115, R96, R95, R63, R65, R66, R62, R75, R134, R76, R64, R106, R117
100K 1% MF	R9*, 16
100R	R138, R139, R144, R93, R116
10K	R32, R94, R37, R28, R13, R39, R53, R35, R36, R55, R141, R152, R150, R70, R102, R132, R133, R131, R119, R120, R129, R87, R40, R59, R100, R101, R98, R91, R83, R74, R57, R103, R104, R113, R108, R109, R88, R33
10K 1% MF	R23, R157, R155, R167, R159
10R	R145, R142
120K	R50
12K	R42, R31
150K	R47
1K	R1, R165, R164, R84, R73, R121
1K +3500ppm/K	PTC
1M	R4, R6, R51, R125, R130, R128
20K 1% MF	R22
220K	R135, R26, R17, R5, R19, R56, R71, R162, R171, R18, R136, R107, R118
22K	R123, R29, R127, R126, R92, R90, R114, R122, R111
22K 1% MF	R168, R154, R153, R169
22R	R110, R105
2K2	R27, R11, R163, R30, R49, R52, R67, R41, R54, R12, R81, R99, R80, R82, R140, R97, R86, R60, R77
27K	R14
2M2	R10
33K	R15, R160
390K 1% MF	R7
3K3	R161
3K9	R146

470K	R85, R24, R79, R78
47K	R124, R2, R149, R68
47R	R166, R156
4K7	R48, R61, R151, R45, R44
56K	R25
5K6	R143
68K	R43, R112
6K8	R21
75R	R158, R170
82K	R69
82K 1% MF	R8, R9*

Capacitors

1000uF, 35V elect	C54, C48
100nF, 63V polyester film	C50, C52, C13, C44, C22, C19, C64, C71, C4, C34, C40
10nF, 100V polyester film	C11
10nF 1% polystyrene	C9
10uF, 35V elect	C12, C55, C58, C45, C3, C1, C20, C18, C65, C67, C56, C32, C24, C43
150pF low-K ceramic	C16, C6
15nF 100V polyester film	C15, C35
1nF, 100V polyester film	C5
1uF, 63V elect	C23, C53, C7, C27, C28, C57, C60, C31, C42, C30, C25, C29, C21, C26, C49
220nF 63V polyester film	C2
330pF low-K ceramic	C61
33nF, 100V polyester film	C51, C39, C38, C37
33pF low-K ceramic	C69,C62, C68, C63
3n3, 63V polyester film	C36
47nF, 63V polyester film	C41
47uF, 25V elect	C10, C59, C66, C70, C33, C47, C8
4u7, 25V elect	C14, C46, C17

Discrete Semiconductors

BC182L	Q9, Q8
BC212L	Q11
BC549	Q40, Q1, Q3, Q6, Q10, Q13, Q38, Q15, Q14, Q33, Q2, Q24, Q23, Q22, Q27, Q26, Q4, Q25, Q39, Q30, Q21, Q28, Q12, Q20, Q17, Q36, Q35, Q29
BC559	Q34, Q7, Q41, Q18, Q16, Q32, Q31
Blue LED 3mm	LED5
Green LED 3mm	LED2, LED4, LED6
Red LED 3mm	LED1
Orange LED 3mm	LED3
1N4148 signal diode	D17, D13, D27, D5, D3, D28, D2, D1, D7, D14, D12, D6, D4, D8, D21, D23, D20, D16, D18
1N4001 diode	D29, D19, D15, D30

1N4002 diode	D26, D25, D22, D24
J201 J-FET	Q5
10V 400mW zener diode	D11, D10, D9
2SK30A-GR or -Y J-FET	Q19
2SK30A-Y J-FET	Q37
TIP31A NPN power	Q42

Integrated Circuits

You should consider IC sockets for all of the DIL ICs. You need six 14-pin DIL, and six 8-pin DIL sockets.

2SC3381 or 2SC1583	U6, U9
4066 quad analogue switch	U2, U11
4093 quad schmitt NAND	U13
NE5532 dual audio op-amp	U15
LM723 linear regulator	U14
7912 -12V linear regulator	U10
CA3046 NPN array	U8
CA3080 OTA	U7
LM2901 Quad comparator	U12
TL071 single FET op-amp	U3
TL072 dual FET op-amp	U1, U4, U16, U5

Pots

All pots are Omeg E-16 or Piher P16 type.

1MB	VCA-DEC, GLIDE, ENV-DEC, ACC-DEC
47KA	VCF-FM, FREQ, ENV, ACC, TUNING
47KB	SUB, VOLUME
47KA dual gang	RES, OVERDRIVE
P-16 solder brackets	13 off

Some older versions of the pot kits contained a 100KA pot. This is to be used for the TUNING control.

Trimmers

100K horizontal	SENS
1M horizontal	OFFSET
2K2 horizontal	BAL, PSU
470K horizontal	TRIM
100K multiturn cermet	TUNE
10K multiturn cermet	V/OCT

Switches

See text for more information.

SPDT	SW3, SW5
SPDT (on-off-on)	SW4
DPDT	SW1/2

Miscellaneous

Case, front panel, sockets, mains/power socket, wall-wart power supply/ transformer, connecting wire, knobs, fuse holder (for mains supply).

Populating the PCB

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 four times across the whole range of Oakley PCBs. The most common error with three 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! You may lose the component in this process, but you are far less likely to damage the PCB.

The 3031 issue 2 PCB is flashed with solder around the pads. This helps the soldering process and keeps the board solderable for many years. Please note: this flashing is with solder that contains lead. You should therefore wash your hands after handling the board and do not place the board or the solder in your mouth. It is also recommended that for best results this board is soldered with lead-tin solder.

I always use water washable flux in solder these days for my board manufacture. In Europe, Farnell sell Multicore's Hydro-X, a very good value water based product. You must wash the PCB at least once an hour 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.

I have found that if you are using a very hot soldering iron it is possible to run your iron so hot as to boil the flux in the 'water washable flux' solder. This is not a good idea as it can create bubbles in the solder. If you prefer to have a fixed temperature iron, then it is best to get a

18W one for this purpose. I use an ordinary Antex 25W iron with a Variac power supply running at 205V. This seems to work well for me.

All resistors, apart from the special PTC, 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, quickly check them ALL again. Make sure they are all soldered and make sure the right values are in the right place.

The diodes 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. There are three types of diodes used in this project. Most are ordinary signal diodes, the 1N4148. You have eight bigger black 1N4004 types. And two zener diodes. When all the diodes are in place, double check all are pointing the right way.

LED4 and LED6 are mounted vertically into the board. It is a good idea to let them stand off from the surface of the board a bit. I poke the leads through, and then with about 4mm left between the bottom of the LED package and the board, I cinch the leads to hold them in place when the board is upside down. Be careful to get them the right way around.

The polyester 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.

The bigger 1000uF capacitors should be soldered flush onto the board using no-clean or conventional solder. On no account must these two parts be put in the wrong way.

The transistors all look alike apart from the big TIP31. So look very carefully before inserting each device. 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. Cut off any excess leads.

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 parallel to the flat side of the transistor.

The 2SC3381 simply fits into the board with the pins matching up into the holes. You may need to straighten any bent legs with a pair of pliers. Keep the body of the device about 8 to 10mm above the board surface. Then solder the middle pin. Straighten the device if necessary and make sure the bottom of it is parallel to the board before soldering the rest of the pins.

If you have been supplied with 2SC1583 instead of the 2SC3381, then you need to be more careful. The board is laid out for the 3381, and the leads of the 1583 need to be matched up into the correct holes. The 1583 has just five leads, whilst the 3381 has seven. The PCB has seven holes and they arranged in a staggered fashion on the board to match with the 2SC3381. Pin1 is on the left hand side, and is designated with a square pad. Pin 2 is staggered below it, and so on. The format is show below:

1   3   5   7

    2   4   6

Hold the 1583 so that its number is facing you and the board has its pots facing you. You need to fit the 1583 so that the first three pins from left to right go in the first three holes in that same order. Now ignore the next two holes in the PCB, and fit the remaining two pins into last two holes on the board.

The quick table shows how the pin numbers match up against each other.

2SC1583	**2SC3381**
1	1
2	2
3	3
4	6
5	7

The PTC is the special temperature compensating resistor. It should be mounted so that it sits above the board and rests against the flat face of U6. You'll need to preform the leads to do this. Then push the part into the holes marked PTC, solder and cut the leads form the underside of the PCB. Have a look at the two photographs on the 3031 webpage to see how I have done it.

For U10 and Q42, the two power devices, it may be necessary to preform the leads before putting them into the board. I use a pair of fine nosed pliers to bend the middle leg outwards. I bend the lead firstly near the body of the device at an angle of 45 degrees. Then where the metal leg thins, I bend it again so that it becomes parallel to the other two. The device should then fit snugly into place on the board.

Whenever you need to bend legs of any semiconductor device be gentle. Its a good idea to earth yourself too. Touching a nearby radiator or oscilloscope earthing tag is usually enough.

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.

I would make the board in the following order: resistors, diodes, IC sockets, small non-polar capacitors, transistors, electrolytic capacitors. Then the final water wash. Do not fit the pots, trimmers, front panel LEDs or switches at this stage. The mounting of the pots, front panel LEDs and switches requires special attention. See the next section for more details.

Mounting the Pots, LEDs and Switches

If you are using the recommended Eco pots, then they can support the PCB with specially manufactured pot brackets. You will not normally need any further support for the board. When constructing the board, fit the pot brackets to the pots by the nuts and washers supplied with the pots. Now fit them into the appropriate holes in the PCB. But only solder the three pins that connect to the pot. **Do not** solder the pot bracket at this stage. When you have soldered all the pots you can fit the board to your front panel. Position the PCB at right angles to the panel, the pot's own pins will hold it fairly rigid for now. Then you can solder each of the brackets. This will give you a very strong support and not stress the pot connections.

The Omeg pots are labelled A, B or C. For example: 47KA or 100KB. Omeg uses the European convention of A = Linear, B = logarithmic and C = Reverse logarithmic. So a 1MB is a 1 megohm log pot.

The four front panel mounted LEDs must be fitted carefully if you are using the directly mounted technique in conjunction with the Schaeffer panel design. Although this sounds fiddly, its actually quite easy and it reduces wiring, interference and possible errors.

Remove the front panel so that you just have the board again. Get the four LEDs and find the cathode for each one. Make sure the cathode of the LEDs will go into the round pad, pin 2, on the board. Carefully bend the LED's legs at a point 6mm away from the plastic body of the LED. The legs should be bent by 90 degrees so that the legs are pointing straight down. Check to see if they fit into the board. The bottom of the LED's body should fit just flush to the board edge. Fit all four LEDs to the board but do not solder them in at this stage. Let their legs poke through, there's no need to cut them down yet. Now fit the front panel again to the board and tighten the pot nuts. You should find that the board now fits snugly into position and each LED should be just poking out of its hole neatly, albeit loosely. Align the LEDs if they aren't quite straight and solder each one in turn, trimming its leads nice and short afterwards.

With panel removed once again, you can now fit the switches. The C&K PCB mountable switches should fit tightly into their respective holes on the board. Make sure the 'on-off-on' switch goes into the 'filter control' location. You may need to use a pair of fine nosed pliers to help the flexible gold pins into the board holes.

Make sure the switch body is flat against the board. Now refit the front panel and make sure the round switch barrel fits into its hole in the front panel. Now solder all the pins on the switch including the securing pins to the front.

That completes the soldering of the front panel components.

Housing your unit

The PCB has been designed to fit into a standard 1u high 19" rack unit. Your local parts distributor will have these. Good rack units are quite expensive, and will contribute heavily to the final cost of your completed 3031. Expect to pay around £30 or so.

Your choice of case will also be affected by what else you want in your enclosure. In my prototype, I also have the tbDAC and internal mains transformer. This would require a case that is at least 25cm deep. If you are just fitting the 3031 PCB and a few sockets on the back, you could get away with a smaller depth case.

If you find a good supplier of low depth 1u metal racks in the UK, I would be pleased to hear from you. Maplin sell an excellent range of racks, but all of them are very deep. Bryant Broadcast, Electrospeed and RS Electronics Ltd do have a range of rack units that may be suitable.

The Bryant Broadcast ones are superbly made, but they do not allow you to use the 3mm thick Scheaffer front panel. Their cases actually utilise the front panel as part of the enclosure. Simply swapping the Bryant panel with one obtained from Schaeffer will not work. Of course, if you are drilling out the Bryant panel to the Scheaffer plan, then this would indeed work wonderfully. Bryant do custom metal work, so it may be possible to try their services. This is one area I would like to try in the near future. Another option is to send the plain Bryant Broadcasting front panel to Scheaffer for engraving. Contact Scheaffer for details of this service.

If you buy the cases made by Vero from Farnell and others, you will find that the height of the unit internally is quite restricting. The bottom and lower panels have 6mm folds in them at the front. This effects the amount of space available for the pots and circuit board at the front panel. It is possible to use these cases as I have done, but I needed to cut back the three pins on each pot to prevent them shorting with the case. The pot bracket pins actually prevent the case from then touching the pot's pins. This is all right, but you need to allow a minimum of 0.5mm slack when you fit the front panel to the case.

The other thing to beware is the heatsinks. Don't let either one of them touch the top panel, or the top surface of the PCB since this would cause major problems. This shouldn't happen if you make sure the regulators ICs are fitted tight against the PCB.

For those of you fitting an internal toroidal transformer. Please, please make sure there is no way the top metal disc of the transformer's mounting can touch the top of the casing. If the metal support of transformer together with the case makes a complete loop around the core, then you have a shorted one turn secondary. (‘well, there was a large hum, more of a buzzy rattle really, then a smell of burning rubber and then a lot of smoke... ’). You may also like to consider the use of a nylon bolt to hold the transformer in place.

The PCB will be supported well by the pots and pot brackets. However, this may give some people nightmares so it for them it will be a good idea to provide additional support. Small holes, to fit M3 bolts, have been provided on the outer corners of the PCB to do this. Feel free to enlarge these holes if you wish. My prototypes have been very happy just supported by the pots. However, my rack is bolted to the wall, so it doesn’t get moved around much! If you intend to take it out on the road, extra support may be a good idea.

Power Supplies and things that can kill if you don’t do them properly...

The recommended option is to use an insulated wallwart or AC adapter. These can be bought from most places and are used external to the 3031 housing. They are very safe since all the nasty dangerous stuff is kept inside the wall-wart. You won’t hurt yourself with the output from one of these unless you stick it in your mouth!! You need a 12V or 15V AC output at 250mA or higher rating. Do not use a DC output type. Although the latter are the most common type of wallwart for guitar effects pedals, they will not work with the 3031. To reiterate, because this is really important, it must say 12VAC or 15VAC on it somewhere.

In the UK they can be bought from Maplin Electronics. In North America, US Robotics make various types.

To connect your wall wart to the 3031, you need a suitable connector. The standard type is the barrel type as found on most effects pedals. Make sure you get the right socket for the plug you have on the wall wart. Some wall warts give you a little bundle of different types to choose from. Either way, make sure the socket you get allows the plug to slip in easily yet not break connection when wiggled gently. If you are making up your own plug for it, since it is AC, it does not matter which wire goes to what. There is no + or -.

The socket must be connected to AC1 and AC2 on the PCB. AC3 is left unconnected. If you have a metal power socket and metal case, make sure the that AC2 is connected to the outer shroud of the socket, ie. the one that goes to the barrel of the plug. Failure to do so may result in burnt out wall warts or at the best excessive hum. This is not to do with the polarity of the AC. This is to do with the fact that the AC2 pad on the PCB is connected to analogue ground. You do want the case to be connected to AC1, which will have a voltage on it that is bouncing up and down 50 or 60 times a second.

If you have a metal case I would ground your casing. Simply take a wire from one of the GND pads, G1, G2 or G3, and take this to any point on the case. Use a terminal or solder tag to attach the wire to the metal case.

The following advice is only for those who know how to wire mains rated equipment safely. If you do not know how to do this then make no attempt to do so. I do not endorse this method of powering any Oakley equipment. It is up to you to use your PCB wisely. I take absolutely no responsibility for your actions with this board. I will offer no further advice than what you see below in italics:

Transformer rating: Secondaries: 12-0-12 @ 250mA or 12-0, 12-0 @ 6VA total
Connect common, or centre tap of, secondaries to AC2. Secondary winding end wires go to AC1 and AC3 respectively.
Line fuse: T250mA

The metal case MUST be earthed to safety earth via a suitably low resistance bonding strap or wire.

It is advisable also to connect this safety earth to a spare GND pad on the 3031, or pin 2 on the tbDAC's M-THRU header. This can be done via a wire link or a 1K resistor.

Using the tbDAC

The tbDAC is a midi-CV convertor that was especially designed to interface with the TB3030. The new 3031 is even more suited to this interface thanks to clearer legending and simpler tuning set up.

You'll need to first build the tbDAC as detailed in its own User Guide. There will be references in the tbDAC User Guide that will refer to the TB3030 and the 3031. The TB3030 is subtlety different to the 3031 in its output and input connections. Thus references to the input and output pads of the TB3030 in the tbDAC User Guide are **not** applicable to the 3031. For the 3031, all your interconnection information is given below.

Fit the tbDAC board in side the same box as your 3031. In my prototype I fitted the tbDAC card on left hand side of the enclosure, just above the 3031 PCB. This gives space for the mains transformer, if you are fitting one, on the right hand side at the back of the case.

With insulated hook up wire connect the following pads on the tbDAC to the appropriate pads on the 3031 PCB.

tbDAC	**3031**
AGND	G1*
DGND	G1*
+12V (PIN1 PWR)	+12V
-12V (PIN4 PWR)	-12V
GATE	GATE
MOD	MOD
VEL	VEL
BND	BND
KBD	KBD
SLIDE	SLIDE

* The two wires from the AGND and DGND pad must be brought back separately to the one G1 pad on the 3031. The two wires will fit into one pad quite nicely. The 3031's accent, filter and slide pads are left unused.

The midi IN and THRU connections must be made to the tbDAC as detailed in the tbDAC's User Guide.

CV, Gate and Audio Connections

If you have fitted the tbDAC you need only one audio connection. This is your output. If you are building a completely analogue unit you need five 1/4" sockets to interface to your system. These are: audio output, pitch CV, velocity CV, modulation CV, and gate.

The audio connection is a balanced output but it is simple to wire up. Some people have used an XLR-Cannon socket for this, but this is costly and the large hole makes for a difficult exercise on sheet metal working. You can simply use a stereo or two pole 1/4" jack socket. Most mixing desks use this sort of connector for pro level signals. These type of sockets are sometimes called TRS or tip-ring-sleeve. Use twin screened cable to connect the socket to the board. This is the type that has two cores and one screen surrounding the pair. Its sometimes called microphone cable. You can use a twisted pair instead if you wish. This is just two wires tightly twisted together to form a simple cable.

Connect the tip connection of the jack socket to the OUT+ pad on the PCB. Connect the ring connection of the socket to the OUT-. If you have used screened cable then connect the screen at one end only to the sleeve or earth connection of the jack socket.

If you are not fitting the tbDAC then all your interfacing must come through separate sockets. I would use 1/4" sockets as these are much more reliable for CV and gate than those horrible 3.5mm types. Plastic types are recommended in this case as they will be insulated from the case.

All the CV and gate sockets will be two pole, or mono, 1/4" sockets. Each socket has two connections. One is the tip, and this will carry the signal. The other, the sleeve, is the common ground or earth. The ground tags of each socket must all be connected together by a single piece of wire. I often use uninsulated wire for this purpose. This commoned connection now needs to be connected to the main ground on the PCB. Do this with a single wire. This should connect to the G2 pad on the TB3031 PCB. Thus all the ground lugs are now connected to the TB3031's main ground.

The signal lugs of the sockets, the tip connection, should then go to the relevant pad on the board. Pitch CV to KBD, Gate input to GATE etc.

All those Trimmers

Before you use your 3031 in a real musical situation, you need to set up the presets or trimmers. You will need a small precision screwdriver or a special trimmer adjustment tool. The latter is very useful to have, and it also features a side wall to stop the screwdriver falling out of place when you are adjusting the multiturn types.

The first one to set is the one marked **PSU**. This sets the output voltage of the 12 V regulator. However, to set this one correctly you need to monitor the voltage at TP1. This is a special pad near the top left hand of the PCB. Measure the voltage with respect to ground or the GND pad. Turn PSU until the voltage is exactly 5.33V +/-20mV.

The **BAL** preset is adjusted with the use of an oscilloscope. If you don't have a scope then set it to the middle position. Set up your scope so that when both probes receive the same input you get a straight line on the screen, i.e. add ch2 to ch1. Put one probe on the '+' output, and the other on the '-' output. Now apply a CV and gate signal, or midi, and adjust BAL until the scope no longer registers any output.

V/OCT: Use this to generate a perfect 1V/octave scaling. This trimmer will need to be adjusted along with the **TUNE** trimmer. You will need a scope, or a digital frequency counter, or the best of all, a guitar/chromatic tuner. Some people use another keyboard or a calibrated VCO and listen to the beats, but that can take longer.

Plug your midi-CV convertor or 1V/oct keyboard into the CV input of the 3031. Play a lowish note on the keyboard, then go two octaves higher. Adjust V/OCT until the interval is EXACTLY two octaves. This will probably require some patience and plenty of twiddling of the front panel Tune as well. But you will get there. Now leave it on for one hour, and then check the scaling. Adjust if necessary.

TUNE: This sets the range over which your VCO acts. Set its final adjustment so that the VCO is in tune perfectly when the front panel tune control is in its central position. Note that changing the PSU trimmer will affect the tuning, so leave that well alone.

The **SENS** preset is sets the sensitivity of the velocity processor. Switch the velocity processor on from the 'velocity control' switch, and adjust SENS so that you can get slide and accent to engage when you hit the keys nice and hard. If you have a sequencer attached to the tbDAC, then make sure velocity values of over 100 make both the accent and slide LEDs light up.

Adjust **TRIM** to suit your own taste. This one alters the sensitivity and range of the filters frequency pot.

OFFSET adjusts the VCA offset. Play a sequence into the 3031. Set the filter cut off frequency quite low, and put the 'amount' and 'modulation' pots on their minimum setting. Now adjust the OFFSET trimmer until the little clicks at the start of every note disappear. They probably won't go away completely, but you will be able to minimise them pretty well.

Final Comments

I hope you enjoy building the 3031. Please feel free to ask any further questions about construction or setting up. If you cannot get your project to work, do get in touch with me, and I will see what I can do. Sometimes, it can be the simplest things that can lay out a project. Occasionally, there may be an error in the parts list. I have checked the documentation again and again, but experience has taught me to expect some little error to creep past. If you do notice any error, please get in touch.

Please further any comments and questions back to me, and if you have any suggestions for new projects, feel free to contact me. You can e-mail, write or telephone me. If you telephone then it is best to do this on Monday to Friday, between 9 am and 5 pm, British time.

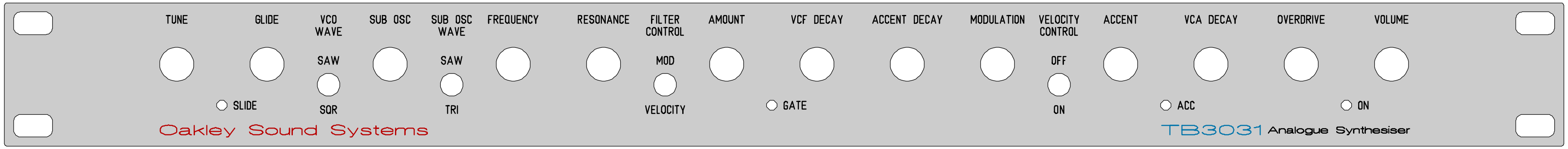
And don't forget the Oakley-Synths mailing group on Yahoo. The link is on the Oakley website. It can be a useful source of information and you can ask all sorts of technical questions and get help very quickly.

Last but not least, can I say a big thank you to all of you who helped and inspired me. Thanks go to all those nice people on the synth-DIY and Oakley-Synths mailing lists. Special thanks to, in no particular order; Trevor Page, Colin Fraser, Juergen Haible, Paul Schreiber, Tom Gamble, Robin 'DevilFish' Whittle, Paul Perry, Rob Hukin, Byron Jaquot, Steve Ridley, Seb Francis and Chris Crosskey...

Happy building!

Tony Allgood

Penrith, Cumbria, England. October 2005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