Oakley Sound Systems

MU Dizzy

The Power Distribution Board

PCB Issue 2

User Manual and Builder's Guide

V2.1

Tony Allgood
Oakley Sound Systems
CARLISLE
United Kingdom

Introduction

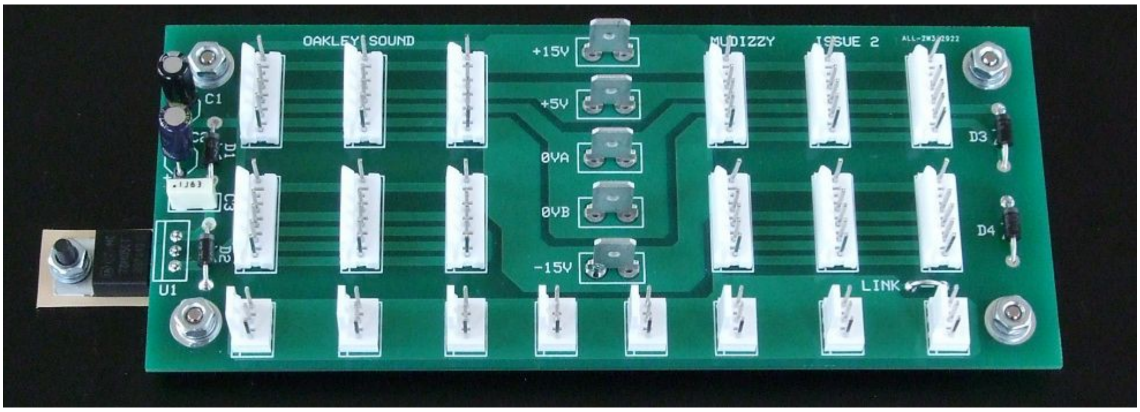
This is the User Manual and Project Builder's Guide for the issue 2 MU Dizzy module from Oakley Sound.

This document contains a basic summary of its operation and some information about how to connect it to your power supply and modules.

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 Construction Guide at the project webpage or http://www.oakleysound.com/construct.pdf.

The Dizzy – A Modular Distribution Board for the MU system



A completed MU Dizzy module with integral 5V regulator fitted. The regulator IC has been mounted onto the metal panel to allow currents up to 250mA to be taken from the +5V rail.

This is a MU power distribution board supporting twelve 5-way 0.1" MTA/Molex headers and up to five 1/4" (6.35mm) Faston blade terminals for power entry. An optional +5V regulator can be built on the board to create a stable +5V 250mA supply from the +15V rail if the main power supply has no +5V available.

Also included in the design are eight 0.1" headers that can be fitted to connect to the Oakley Bus. The Oakley Bus can carry Key CV and gate signals to suitably equipped modules, like the Oakley VCO, VRG, ADSR, etc.

The double sided circuit board is 5.6" (142mm) long by 2.35" (60mm) wide. It is designed to go at the rear of 19" rack units or built into the bottom panel of wooden modular cases. Each row of three headers is 'star wired' back to the blade terminals to ensure to lowest possible resistance and unwanted interaction between connected modules.

It is fully compatible with MU and Oakley/MU power busses. The Oakley/MU power system is identical to MU power systems except that the normally unused pin 5 position on the MU power header is now connected to 0V allowing a five way interconnect to be used between the module and the distribution board. In all newer Oakley MU modules the module's pin 5 is connected to the front panel and socket sleeve connections which, when used with the MU-Dizzy and five way interconnects, can help in alleviating unwanted inter-module crosstalk.

Parts List for MU Dizzy with integrated +5V supply

This parts list is to be used if you are requiring the Dizzy's integrated +5V regulator circuit. On no account should you be using this parts list if you are utilising your main power supply's own +5V output.

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.

Capacitors

100nF, 63V polyester film	C3
2u2, 50V or 63V electrolytic	C1
4u7, 50V or 63V electrolytic	C2

Diodes

1N4004 silicon power diode	D1, D2
1N5819 Schottky power diode	D3, D4

Integrated Circuits

78M05 500mA +5V TO-220 regulator	U1

U1 can fitted either upright or attached to a metal panel which serves as a heatsink. If fitting upright the most current that can be taken from the Dizzy's +5V is 100mA. If fitting U1 to a panel then suitable hardware must be used to facilitate this. eg. a TO-220 mounting kit

Link

A wire link should be fitted across the two pads labelled LINK. You can use one of the lead clippings from the diodes to do this.

Connectors

'Faston' 6.35mm single blade terminal	+15V, 0VA, 0VB, -15V	(+5V is not fitted)
6-way MTA100 (2.54mm) headers	12 off	
3-way 2.54mm KK or MTA header	8 off Oakley Bus headers	(Optional)

Parts List for MU Dizzy using external +5V supply

This parts list is to be used if you are not using the Dizzy's integrated +5V regulator circuit and are connecting the Dizzy +5V rail to your main power supply's +5V output.

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.

Diodes

1N4004 silicon power diode	D2
1N5819 Schottky power diode	D3, D4

Link

A wire link should be fitted across the two pads labelled LINK. You can use one of the lead clippings from the diodes to do this.

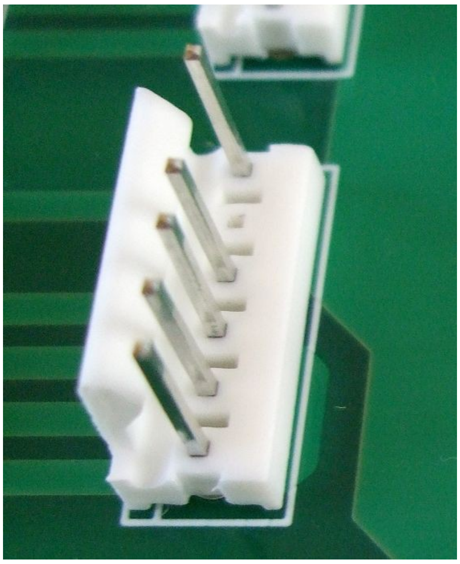
Connectors

'Faston' 6.35mm single blade terminal	+15V, +5V, 0VA, 0VB, -15V	
6-way MTA100 (2.54mm) headers	12 off	
3-way 2.54mm KK or MTA header	8 off Oakley Bus headers	(Optional)

Building your MU Dizzy

Preparation

MU power headers have five pins but use a six way MTA100 header with the second pin removed. This prevents accidental misalignment of the inserted socket. The second pin of all twelve MTA100 headers must therefore be removed prior to soldering. This is easily done by using a fine nosed pair of pliers and simply pulling the second pin out from the underside of the plastic body of the header. Take care that it is the second pin you are pulling out by checking the header with the MU Dizzy board. The Dizzy has no solder pad for the second pin so its easy to see which one you need to pull out.



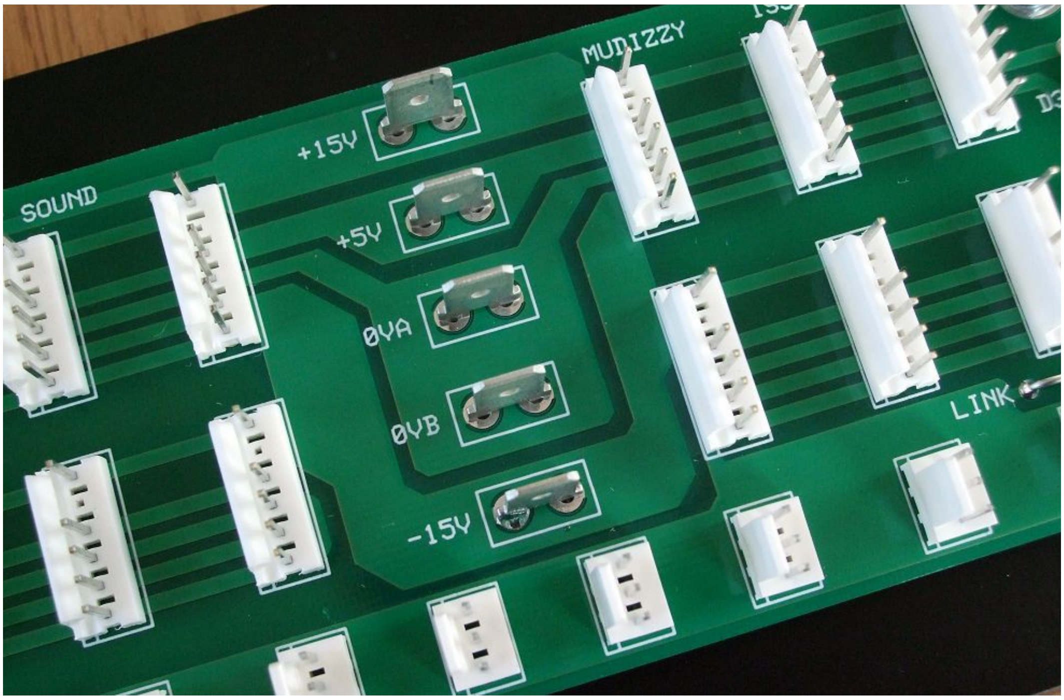
Soldering

The MU Dizzy printed circuit board (PCB) is double sided which means it has copper tracks on both sides to carry the electrical current around the board. The copper layer is 2oz grade which means it is twice as thick as most ordinary circuit boards. This keeps the electrical resistance of the tracks low which reduces the chances of the connected modules interacting with each other.

Thick tracks and lots of copper mean that not only does the board carry electricity well, it also means that the tracks conduct heat well. So when you solder your board you will find you will require more heat than normal to melt the solder effectively. A good well powered soldering iron is essential for getting a good solder joint.

If you find that when soldering you are not getting your solder to wet both parts of the joint then you may need a hotter iron or a more powerful iron. The smaller components should be no problem but the bigger ones like the blade terminals will require some time to heat up to the correct temperature to allow the solder to melt. With the blade terminals I apply the soldering iron to the solder tang for a second and then apply solder to the tip of the tang only. Allow the tang to heat up and then start to apply a small bit of solder to the PCB pad. Keep applying the heat and a nice neat solder joint should form. A small amount of solder will wick through to the other side of the board but not a great deal as the blade terminal itself will steal away the heat and prevent the solder from going all the way through. Each blade terminal has two tangs and it is best to solder the second immediately after the first as the heat already built up will speed things along with the second.

The PCB hole size for the 1/4” (6.35mm) faston single blade terminals is around 1.5mm in diameter. This may not be tight enough for some types of faston terminals to held in place when the board is upside down and ready to be soldered. I recommend fitting all four, or five, at the same time while the board is held upright. Then with something flat and stiff, a small bit of MDF sheet will do, placed on top of them to hold them in place, the board can be inverted and placed onto your work surface. The blades can then be soldered while you hold the board steady and in a position where the blades are mostly perpendicular to the board's surface. Once cool you can gently bend them if they are a little wonky.



The blade terminal in position +5V should not be fitted if you are using the Dizzy's integrated +5V supply.

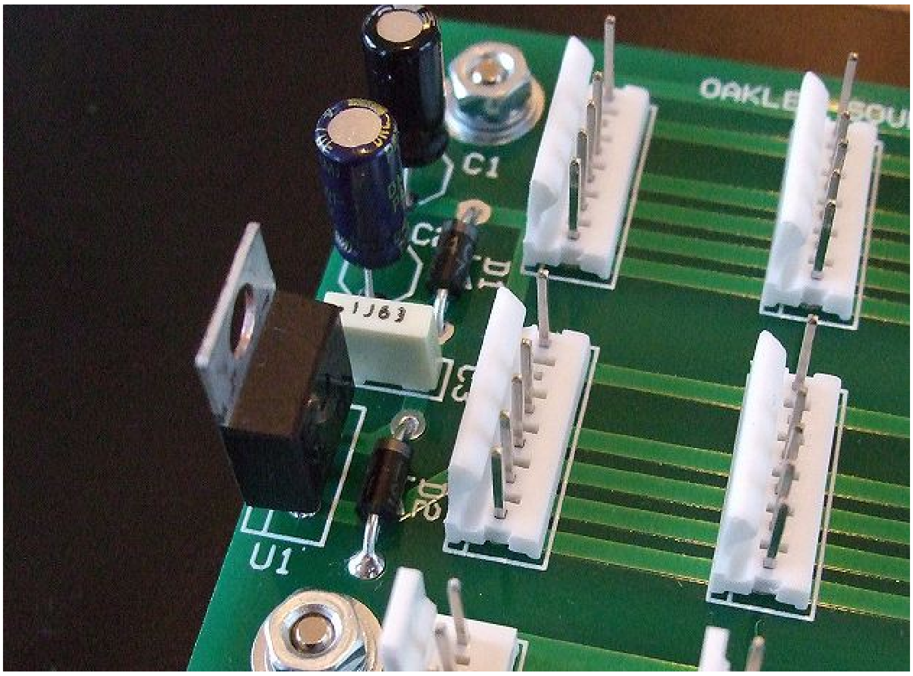
Fitting the optional +5V regulator

The MU Dizzy can be built so that it incorporates a small linear regulator circuit to generate a stable +5V supply that is required by some MU modules. It is not designed to replace a proper 5V supply if the current demanded by those modules is considerable. Some digital modules take a great deal of current from the +5V and a proper power supply with its own 5V output should be used in this case. However, for many systems the current drawn from the 5V rail is very small, and indeed many modules, including all the Oakley MU modules, do not use the 5V at all.

To create the +5V the MU Dizzy must use the +15V supply. It does this by using a 78M05 linear regulator integrated circuit. This device has 10V developed across it and any current drawn from the +5V will require energy, in the form of waste heat, to be dissipated. The amount of power lost in this way is equal to the voltage drop across the regulator multiplied by the current. This means that the more current, the more heat that is generated that needs to be taken away. Taking 100mA (0.1A) from the +5V will generate 1W of heat (because 10V x 0.1A = 1W). That is not insignificant.

Furthermore, any current taken by the +5V rail will have to come from the +15V supply. If you take 100mA from the +5V and 250mA from the +15V, the total current that your master power supply needs to provide from its 15V output is now 350mA.

If the current draw is less than 100mA then U1, the 78M05, can be soldered onto the board in an upright fashion. The surrounding air will be enough to keep it cool so long as the current does not exceed 100mA. The device features a thermal shut down so it should switch itself off should its internal temperature exceed its maximum rating. That said, the device has to get really hot for this to happen and you may burn your fingers if you were touch it just prior to it turning itself off.



The 78M05 fitted in its upright position.

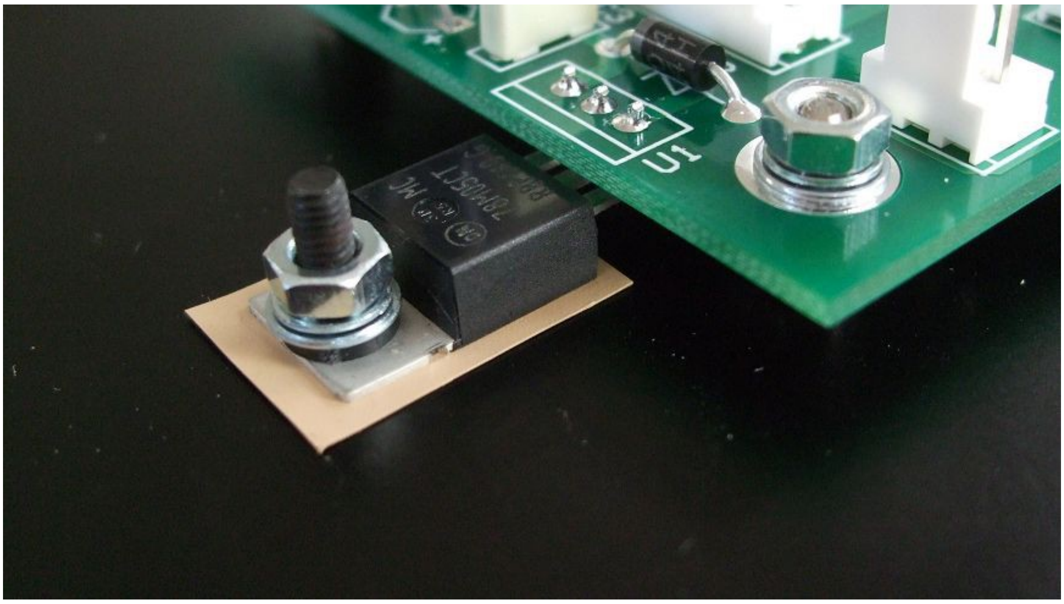
If more than 100mA is required then we need help to dissipate all the extra heat without stressing the 78M05. This we can do by mounting the 78M05 onto a heatsink. Since it is possible that the MU Dizzy will be fitted to a metal plate of some sort then we can utilise this as an excellent heatsink. Even with this additional heatsinking I would recommend not drawing much more than 250mA from the +5V supply.

Use the MU Dizzy PCB as a template for marking the panel and then drilling the four 3.5mm holes needed for the mounting hardware. The board should be spaced high enough off the panel with suitable mounting pillars so as to not short out any of the components' leads should the board be flexed downward, and also not be too high so that the leads from the regulator can't reach through the board to be soldered. I find an 8mm male-female threaded spacer is best.

For the four PCB mounting holes, insert a 6mm screw through each of the four holes in the panel. Fit a star washer over the exposed thread on the inside of the panel. Now fit a hex male-female 8mm spacer over the washer and tighten. Check that the four holes in the PCB line up with the threaded tops of the hex spacers by temporarily fitting the PCB onto the spacers. Loosen and re-align any spacer if it does not fit properly.

Now you need to prepare the leads of the regulator IC. The three legs need to be bent upwards so that the PCB can be fitted over them. Note that the top surface of the device is marked with the name of the component and it is the flat side on the bottom of the device that will be in contact with the panel. You should be able to see that the leads have a thicker section close to the body of the device. Make a ninety degree bend upwards at the point where the lead thickness changes. Do this for all three legs of U1.

Remove the Dizzy from the panel and fit the regulator to the board by poking its legs up through the bottom of the board. Do not solder them and fit the board back into place on the panel. Use the hole in the regulator's metal tab to mark out where you need to drill the mounting hole. Now remove the board and regulators. Carefully drill a 4mm hole in the panel for the regulator. Clear off any swarf and, twisting with your hand only, use an 8mm drill bit to lightly deburr the edges of the hole on both sides. There should be no bumps around the hole.



The 78M05 mounted onto a 2.5mm thick aluminium panel that is fitted to the rear of a 19" rack unit. Note the thin insulation pad between the panel and the regulator.

The 78M05 linear regulator is a TO-220 power device. It needs to be fitted to the panel mechanically and thermally, but not electrically. This means that the metal tab on the device should not be in direct 'metal to metal' contact with the panel. To achieve both thermal transfer and electrical insulation we use a special insulator. These can be made of a 'soft' flexible material in the form of an insulating pad, or a rigid thin glass like plate made from mica. If using mica you will also need to use a small amount of heat transfer paste that needs to be spread very thinly across each side of the mica.

Since the paste is somewhat messy I recommend you use an insulating pad. However, mica and paste does offer better performance in terms of keeping the power device cool and also has the advantage of being reusable should the device need to be taken off the heatsink in the future. The flexible pads are probably OK being reused but they do get a little deformed when the nuts are tightened so it is probably a good idea to replace it each time the device is removed from the heatsink.

Both types of insulation are normally available in 'mounting kits'. The kit also contains a mounting bush. This top hat shaped piece of stiff plastic prevents the mounting screw from touching the regulator's metal tab.

To fit the device to the panel first place the mounting bush into the hole of the power device, with the flange of the bush lying on the top side of the device. Normally, but not always, the plastic bush fits tightly enough so that it tends to stay in place after it has been pushed through the metal tab. Now take the insulating pad and place it against the rear of the regulator. Match up the hole in the pad with the bush that is sticking out from the underside of the tab. If you have used a flexible pad you may find that it will happily stay put held in place by the mounting bush.

Now place the regulator, bush and pad flat against the rear of the panel so that the bush fits into the panel. Make sure the pad does not slip out of place when you do this. Insert a 10mm or 12mm M3 screw into the hole from the reverse side of the panel, and fit a flat washer, a shakeproof washer and nut onto the screw but don't tighten it up just yet.

Now if you have done all this correctly, you should find that the when the Dizzy PCB is presented back onto the four threaded spacers, you can coax the 78M05's leads through the respective solder pads on the board. Because the 78M05 has not been fully tightened you will still be able to move it about a bit on the panel to ensure a good fit. Make sure also that the insulating pad is sitting square under the device and hasn't slipped out of position.

Fit the washers and nuts onto the four PCB mounting screws. Tighten to secure the board in place. Do not over tighten the nuts as this will damage the board. Now gently tighten the nut on the power device. Do not tighten these too much as this will distort the mounting tab and squash, or even tear, the insulating pad. All the nut needs to do is hold the power device up against the panel.

With both the board and regulator secured to the panel with its mounting hardware you can now solder the regulator's leads from the top side of the board. Snip off any excess lead lengths above the solder joints.

Assuming you haven't wired up the Dizzy board to any earth bond or the power supply yet, it is worth checking the insulation under the two regulators is working correctly. Check with your continuity tester, or using the resistance setting on your multimeter, that there is a very high resistance between the tab of the regulator and the metal panel. That is, there should be no continuity between the tab and the screw that runs through it.

The Oakley Bus and Module Normalisation

The Oakley Bus, previously known as the Oakley Buss, is a three way connector found on various Oakley modules. Pin 1 carries the keyboard control voltage (KCV) input for note pitch control, and pin 3 carries gate input for note on and note off. Pin 2 is connected to 0V via the wire link, LINK, on the Dizzy boards and acts only as a 'fire break' between the gate and CV lines preventing any crosstalk between the two. It is possible not to fit LINK and utilise the pin 2 connection for your own purposes.

The word bus is perhaps a little grand for something that has just two control lines and a single ground. However, it still adheres to the principle of a common set of conductors that is available to all modules.

Normalising is the process by which some signal paths are already made for you. In other words no patch leads are needed to make those connections; they are connected internally either within the module or between different modules but behind the faceplates. However, normalising can always be overridden by the user. The name itself comes from the use of normalised connections on sockets. When a socket does not have a jack inserted it is in its normal position. There is often a connection between the signal lug of the socket and an extra contact called the NC (normally closed) lug. It is this third lug on the socket that is used for the normalisation. Inserting a jack plug will break the connection between the NC and the signal lug.

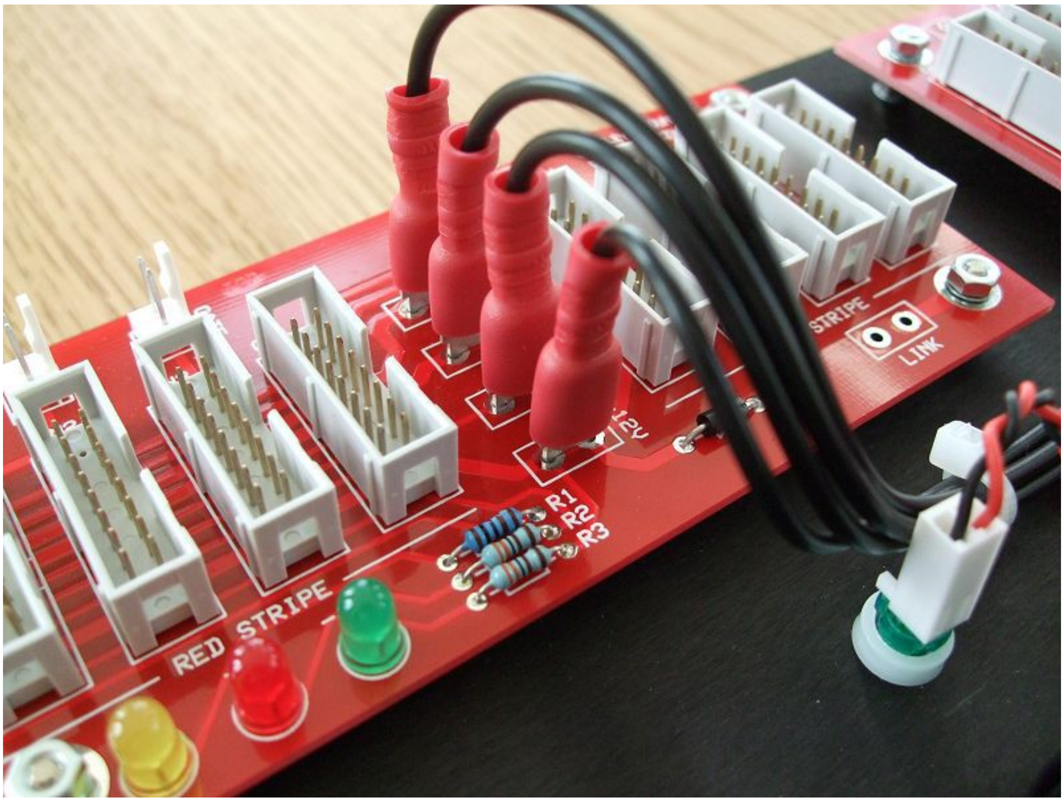
To help us understand where normalisation is useful consider a VCO with a 1V/octave, or Key CV, socket on its front panel. To connect KCV to this socket one would ordinarily need a patch lead. But imagine a system where you have four VCOs and two VCFs that all need the same KCV signal. It can take many patch leads to do this; seven if you have a large multiple panel. Now suppose that the NC lug of every 1V/octave socket is connected to a common KCV bus. All six modules can now be driven without the need for those seven patch leads. This saves you leads, time, and also gives you a better working environment because you don’t have to fight your way through a tangle of leads to get to the module’s knobs. Inserting a jack into any one of those sockets would disconnect it from the KCV bus, so you still have complete modularity.

The Oakley VCO, VCO Controller, midiDAC, ADSR, VRG and ASV have the three pin headers on the main or socket boards ready for easy direct connection to the Dizzy or MU Dizzy.

Note: I have previously used the term 'buss' instead of 'bus'. A bus to me was a form of public transport, and buss was an distributed electrical connection. It seems I was not alone, you'll find various audio sites talking about the 'mix buss'. But from where the extra 's' came nobody seems to know. Perhaps it was a confusion between Bussman the fuse manufacturers. Whatever the history, the use of the word 'buss' is probably wrong. So for now I'll try to stick with bus. Although the plural, buses, looks wrong to me...

Connecting the Dizzy to the Power Supply

Cables



Red faston connectors being used with 24/0.2 wire on the Eurorack version of the Oakley Dizzy. Although I haven't done it here, colour coding your wires is a good idea.

The cables connecting the power supply with the Dizzy board should be as thick and as short as possible. I recommend using wire that has a cross sectional surface area of at least $0.75mm^2$ (18AWG) and be no longer than 30cm. Wire that is defined as 24/0.2 is particularly suitable, its cross sectional surface area is $0.75mm^2$.

The MU Dizzy therefore should be mounted as close to the power supply as possible. It is far better to keep the four, or five, interconnecting wires short and the module power leads long rather than the other way around.

Make sure that the leads are connected correctly before powering up for the first time. The blade terminals on the MU Dizzy are appropriately named, so the +15V terminal should go to the +15V output on your power supply, the -15V to -15V, and so on. Two 0V connections are provided on the MU Dizzy, so if your power supply has two 0V outputs then these should both be used, each one going to its own 0V terminal on the MU Dizzy. If you only have one 0V connection on your power supply then you can use either 0VA or 0VB on the Dizzy.

Remember that if you are utilising the MU Dizzy's +5V regulator nothing should be connected to the +5V blade terminal if there is one fitted.

One of the problems encountered by people when building up large modular systems is unwanted interaction between modules. For example, an LFO module may be modulating the pitch of a VCO even though there is no cable connecting the two. Or perhaps you can always faintly hear a VCO from your main output even though it's not patched up. These are examples of crosstalk. There are two mains causes of this. Firstly, signals can be radiated through the air, much like a radio transmitter. Simply moving the offending module from more sensitive ones can help here. Secondly, crosstalk can occur via the power supply, and although there are different types of power supply crosstalk the main one will be due to the resistance of the power supply cables.

Unless we have access to superconducting materials we cannot have electrical cables without resistance. The thinner and longer the cable, the more resistance. When electric current travels through a cable with resistance a voltage is developed across it. The bigger the resistance, the bigger the voltage drop. That voltage drop along the whole system of wires and circuit boards in the modular means that the voltage any module sees at the end of its own power cable will not be what it was designed to deal with. But worse still, this voltage drop will not be constant. Each module in the modular system will be taking varying amounts of current and this unsynchronised battle for current will see the voltage across the power supply pins of every module be different and be continuously changing. Even the best designed modules cannot be expected to work flawlessly with that amount of noise on the power supply.

So if we cannot rid ourselves of crosstalk completely we must try to reduce it as much as possible. However, do bear in mind what is an acceptable amount of crosstalk inevitably depends on the user of the system. After all, the VCS3, a modular synthesiser of a sort, has problems with crosstalk for a multitude of reasons, but is still very much regarded as a classic instrument. That said if the problems are slight with a small modular system then they will almost certainly get worse as the system grows unless steps are taken to prevent it.

We must do three things to reduce crosstalk when using separate power distribution boards:

a) Minimise the resistance of the cable feeding the distribution boards. That is, the cable from the power supply to the distribution board must be as thick and short as possible.

b) Reduce the current travelling along the cables that connect to each distribution board. This means that each distribution board should not have too many modules attached to it. A single large distribution board feeding over twenty power hungry modules is going to develop an excessive voltage drop along its feeder cables and within the distribution board itself.

c) Reduce the resistance of all connections on the distribution board. This means that the distribution board must be as physically small as possible, use thick copper traces and be arranged so that each header has the shortest distance back to the power entry points as possible.

The first point's objectives are clear and the third point should be achieved by using the Oakley Dizzy. The second point though requires a little more thought even if you are using the Dizzy. It may, in some circumstances, be preferential to put all your heavy current modules on one Dizzy even though this seems to go against point two. If one Dizzy was to power, say, a single digital sequencer (complete with flashing lights) and then a bunch of low current analogue modules, you may find that the varying clock and LED current pulses from the sequencer would be picked up by the more sensitive of the analogue modules. So even though the current draw from that particular Dizzy was average, the fact that the power lines had to supply that one noisy module was detrimental to a sensitive analogue module.

Sometimes the current guzzling modules, even though they may be the source of the problem, are the least sensitive to crosstalk from other modules. In this case it may be better put them together rather than shared across your system. Ultimately it pays to swap things around in your modular so you can achieve the quietest operation without sacrificing usability.

The Power Supply

My own recommendation for very large modular systems is always to use several smaller power supplies with a small number of distribution boards rather than one big power supply driving multiple arrays of distribution boards. I think a good system would have no more than two Dizzy boards per power supply. This could allow for up to 24 modules to be powered from each power supply. Even though this is potentially more expensive than using one big power supply there are several reasons for doing this. Firstly, it keeps the wires between your distribution boards and the power supply as short as possible. And secondly if the power supply breaks in such a way that, say, puts the unregulated 25V on your +15V line you don't smoke your whole modular.

If you do chose to use multiple smaller power supplies then a good solid connection must be made between each power supply's 0V. Not a huge amount of current needs to travel down this cable or cables but if you can use a thick cable connection then any problems of hum and crosstalk will be minimised.

Using the Oakley Power Supply (PSU2) to drive the MU Dizzy is easy. Simply connect four wires from the PSU to the MU Dizzy board using the screw terminals on the PSU2 and the Faston connectors on the Dizzy. Several ring terminals can be fitted to each of the PSU2's screw terminals. Since the PSU2 does not generate +5V the MU Dizzy's linear regulator circuit must be utilised if you need to have +5V.

One final point about using multiple Dizzy boards; watch your maximum current draw. Just because you can have up to 24 power headers does not mean you can actually power 24 modules. Each module takes current, the actual amount should be given in the documentation that came with your module, and your power supply can only supply a certain amount of current.

Tony Allgood