Oakley Sound Systems

Euro Power Supply Unit (Euro PSU)

PCB Issue 1

Project Builder's Guide

V1.4

Tony Allgood
Oakley Sound Systems
CARLISLE
United Kingdom

Introduction

This is the Project Builder's Guide for issue 1 of the Euro PSU circuit board from Oakley Sound. This document hopefully contains everything you need to know to build and install the Oakley euro power supply unit.

The Oakley Euro PSU allows for various options in the installation. You can use the unit either in full wave rectification mode for connection to tapped linelumps or twin transformer secondaries, or in half wave rectification for single phase AC output wallwarts and linelumps. If all this sounds very confusing at the moment, do not worry, in this manual I will try to make it clearer so that you make the right decision about what power source you will need.

It is designed to be mounted onto a metal panel which is used as a heatsink for the two or three power devices used on the board. Mounting your power supply to a metal panel on the outside of your case helps keep your modular cool.

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

The issue 1 Oakley Euro PSU board with +5V DC-DC convertor option fitted to a 4U panel awaiting connection to three Euro Dizzy distribution boards..

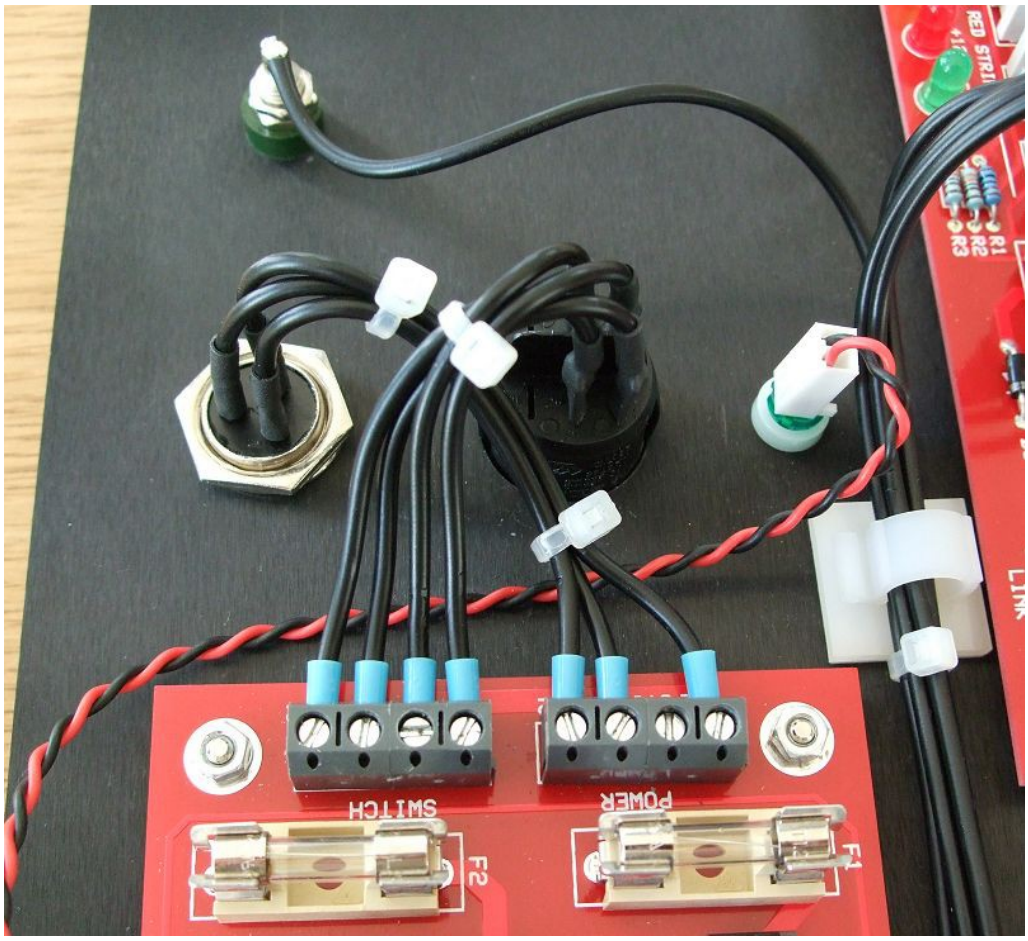
Safety Warning

The Euro PSU has been designed to work with isolated low voltage AC inputs. Connection to any other supply, such as an internally mounted mains transformer, is done at your own risk. Low voltage is classified as being less than 25V with respect to the ground potential. Voltages above this level can, and often are, lethal to living creatures.

Oakley Sound Systems will not advise on building or modifying this board to allow for direct connection to the mains, or other high voltage sources, further to what is provided in this document. Please do not ask me for any additional information pertaining to direct mains connections or using internally mounted transformers as I will not give it.

For safety and legal reasons I cannot recommend powering this board from any other supply than low voltage AC output mains adapters.

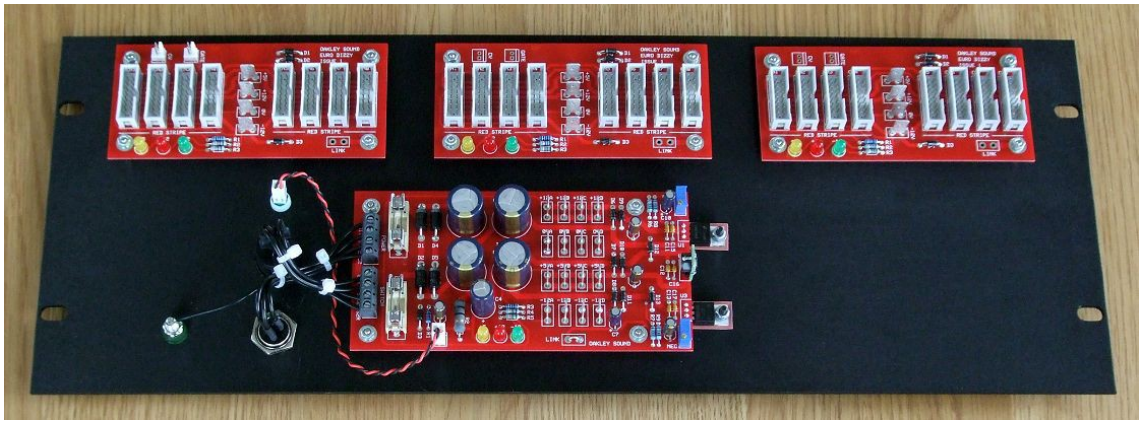
Oakley Sound Systems are not liable for any damages caused by the misuse of this product. It is your responsibility to use this product safely. If you have any doubt about installing a safe power supply, then please do not attempt to do so.



The recommended way of doing things with safe low voltage wiring. Boot lace ferrules are fitted to the ends of the wires that fit into the screw terminals for neatness.

The Oakley Euro Power Supply Board

The power supply board will allow the conversion of a suitable low voltage alternating current (AC) to be rectified, smoothed and regulated for operation with your eurorack modular. The module is designed to be fitted to a suitably large metal panel, usually the rear facing panel of your modular synthesiser, which functions as a heatsink for the regulators connected to the Euro PSU circuit board. This metal panel should have adequate airflow around it. An example of such a panel is a standard 4U high 19" rack blank panel. These are particularly suitable if you are mounting your modular synth in a 19" rack case. The greater surface area on the 19" blank panel allows you to mount not only the power supply module but also up to four Euro Dizzy power distribution boards.



A standard 4U high 19" panel with an issue 1 Oakley Euro PSU and three Euro Dizzy boards. Note the grounding point to the left of the main power inlet.

The voltage output of the power supply module is a split rail 12V supply. This means it generates both +12V and -12V. That is, two power rails, one of a positive voltage, the other a negative one. These voltages are measured with respect to a common ground which is normally connected, via your house's wiring, to the earth that you stand on. The voltage across both rails is 24V, with the common ground sitting exactly in the middle of this at 0V.

The output current capability is the maximum current you can draw out of the power supply. The current taken from the supply is, for the most part, determined by the amount and type of modules you are connecting to the power supply. However, the actual patch also has an effect on the current draw – the more outputs that are connected to inputs increases the current draw slightly. Also, when lit some front panel LEDs may increase the current draw.

The eurorack standard power supply bus also contains +5V, originally conceived as to provide power for digital circuitry. Most eurorack modules, even digital ones, have no need for a +5V supply but it can be wise to provide it all the same. To provide the +5V the Oakley Euro PSU can be built with either a simple linear design which provides only a limited amount of current to drawn from the +5V rail, or with a switch mode DC-DC convertor module with the potential to provide a lot more current. Neither has to be fitted if you have no requirement for +5V.

To supply the power to the Oakley Euro PSU I recommend that you use a Yamaha PA-20 or PA-30 'linelump' power supply. These are neat and tidy external power supplies that keep the dangerous mains voltage away from your modular.

The PA-20 will allow a maximum current of 520mA (0.52A) to be drawn from both the +12V and -12V rail. While the PA-30 will allow up to 780mA (0.78A) for each. Any current taken from the +5V rail must also be considered. The current drawn from the +5V rail comes from the same supply that supplies the +12V. So with the linear option the current from the +12V and +5V together must not exceed 520mA (or 780mA).

Other power supplies are available and they come in lots of different variations. Other than AC output voltage the two key specifications are output current (please don't call it 'ampage'), and whether the output is centre tapped or single phase. In almost all cases the outputs of standard AC output power supplies are single phase. You can tell because they only have a cable with two wires inside which terminates in a two pole connector.

A single phase AC output supply will allow you take not much more than a quarter of its rated current output. For example if you are using a 500mA (or 0.5A) AC wallwart* then the most current you can take from this power supply module is around 125mA from each rail. That is, take no more than 125mA from either the +12V supply and 125mA from the -12V supply.

Various companies make linelumps** with a greater capacity than 500mA. If you can get a 1A output one than this will be able to drive up to 250mA per rail.

Some linelumps, like the recommended Yamaha PA-20 and PA-30 mentioned above, use a split AC output or a centre tapped AC output. This means it has three wires coming from it and will use a different plug from the usual round barrel one you see on the single phase AC wallwarts.

The Oakley Euro PSU can be used with full wave or half wave rectification. The former allows it to utilise split AC outputs very effectively. With full rectification and using a centre tapped power supply the amount of current taken from each 12V rail can be up to just over half the rated current output of the power supply. The Yamaha PA-20 supply is rated to give an output voltage of 35Vac (with a centre tap) at a load of 0.94A. Once rectified and smoothed this means that a maximum current of 0.52A can be drawn from each rail.

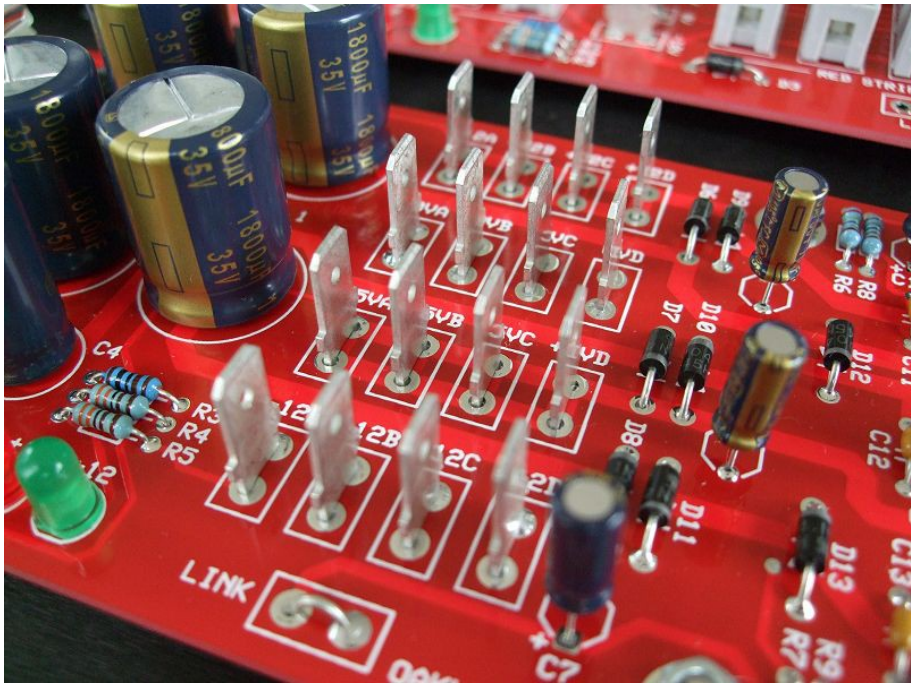
Two sets of screw terminal blocks are provided for connecting the low voltage AC power source to the board and the optional power switch. If you are using a single phase wallwart to power the PSU module than you need only to use two terminals per terminal block.

The board has four mounting holes for stable placement onto your modular case. Care should be taken so that the board's various board mounted components do not come into contact with any part of your modular's enclosure. One of the holes, the bottom right hand one, can be connected to 0V via a wire link, or 1/4” faston terminal blade, fitted to LINK. I recommend this be done as this connects the metal mounting panel to 0V and reduces noise within the modular.

The power supply has two integral fuse holders in case of a problem with the power supply circuitry itself. Two fuses are needed if you are using full wave rectification, but only one, F1,

is required for ordinary half wave rectification. The fuse type should be a slow blow or anti-surge type. The size is 20mm. It should be rated at between one and two times the maximum current of your wallwart. Thus a 500mA AC output mains adapter should have a fuse that is rated between 500mA and 1A, ideally 750mA. A 1A linelump should have a fuse that is between 1A and 2A, ideally 1.25A.

Three on-board LEDs, a red one for +12V, a green one for -12V and a yellow one for +5V and an externally mounted green one for the AC input, provide a quick visual reference that all is well. All four LEDs could be fitted externally to the board and be mounted on a front panel. However, the recommended way is to mount only the AC indicator on the front of the synthesiser along with the AC power standby switch.

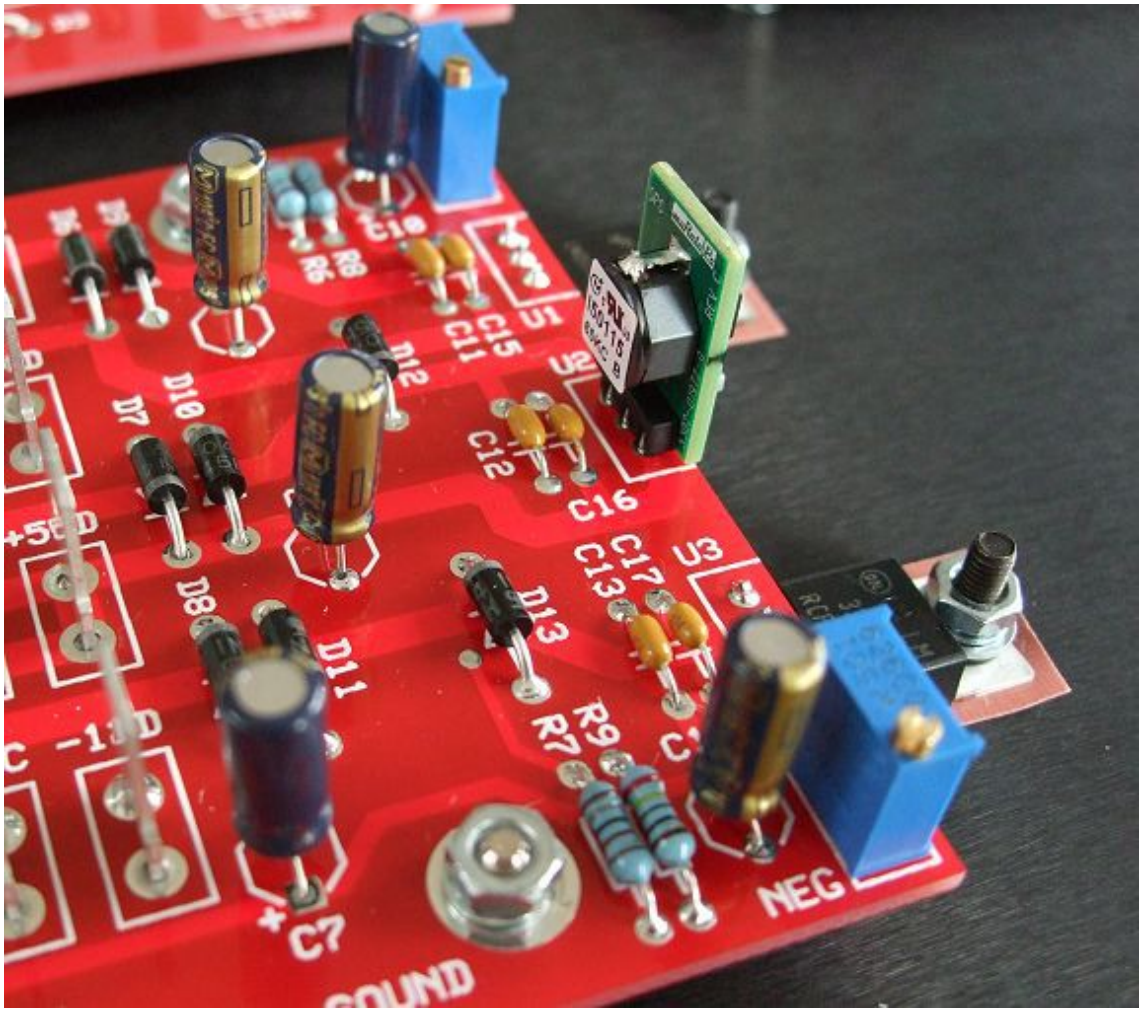


The output voltages are available from an array of single 1/4” (6.35mm) 'faston' blade terminals. Great care must be taken when connecting your distribution system to these terminals to ensure the cables go to the correct places.

* A wallwart is the vernacular term for a low voltage mains adapter that plugs directly into the wall. These take the form of a black plastic block that is shaped like an oversized mains plug. It is called a wart simply because its appearance is somewhat uglier than a normal slimline plug.

** A linelump does the same job as a wallwart but it generally can handle greater currents. Because of its increased size it cannot be made so that it will safely fit into a plug socket directly. Thus the adapter sits in a black plastic box and connects to the wall via a cable and traditional mains plug. It is therefore a black plastic lump connected to a line. The Yamaha PA-20 and PA-30 are such linelumps.

+5V: Linear or Switch Mode?



The switch mode DC-DC convertor option can provide more current and an easier build.

The Oakley Euro PSU can create the +5V rail with either a traditional low noise linear regulator (for currents less than 100mA) or use a more modern switch mode DC to DC convertor module (for higher currents).

The DC-DC convertor module is a miniature switch mode power supply that uses high frequency current switching and an inductor to create a stable +5V supply. It is reliable and is easy to use as it requires no additional heatsinking even though it can supply more current than its linear counterpart. The device I am using is the OKI-78SR-5/1.5-W36-C and it is pin compatible with traditional 7805 linear regulators. The disadvantage with using this device is that it is more expensive and creates a small amount of high frequency noise that is both transmitted through the air and into the power rails. The amount of noise depends on the current draw on the +5V line with greater currents creating more noise.

The linear design, which uses a 78M05, is comparatively silent in terms of electrical noise and is the preferred option in an all analogue or mostly analogue modular synthesiser. It should be noted, however, that it is unlikely that any well designed analogue modules would be significantly and detrimentally affected by the switch mode option.

Note that the lower current 78M05 device is used instead of the more common and more powerful 7805. Generally I would not recommend taking more than 500mA from the +5V of the Euro PSU with the linear option even if you fitted a powerful enough mains transformer. A linear +5V regulator creates its output by effectively turning the difference between its input voltage and output voltage into heat. In the Euro PSU it is possible that the +5V linear regulator will have to drop over 15V. With a load of 500mA on the +5V rail that is over 7.5W of power to be dissipated in the device which will produce a significant rise in temperature.

The benefits of using a 78M05 over the 7805 are its inherent current limiting during fault conditions. Whereas a 7805 would be happy supplying well over 1.5A into a near short circuit and potentially destroying the transformer, the 78M05 limits at just over 600mA which should be low enough not to cause any damage.

The current drawn from the +5V supply comes from the same supply that drives the +12V. With the linear option this can present us with a big problem if the current required by the +5V line is relatively large. For example, if the maximum current the PSU will supply is 520mA and you are already taking 420mA from the +12V supply, the +5V supply cannot supply any more than 100mA without possible damage to the transformer or mains adapter.

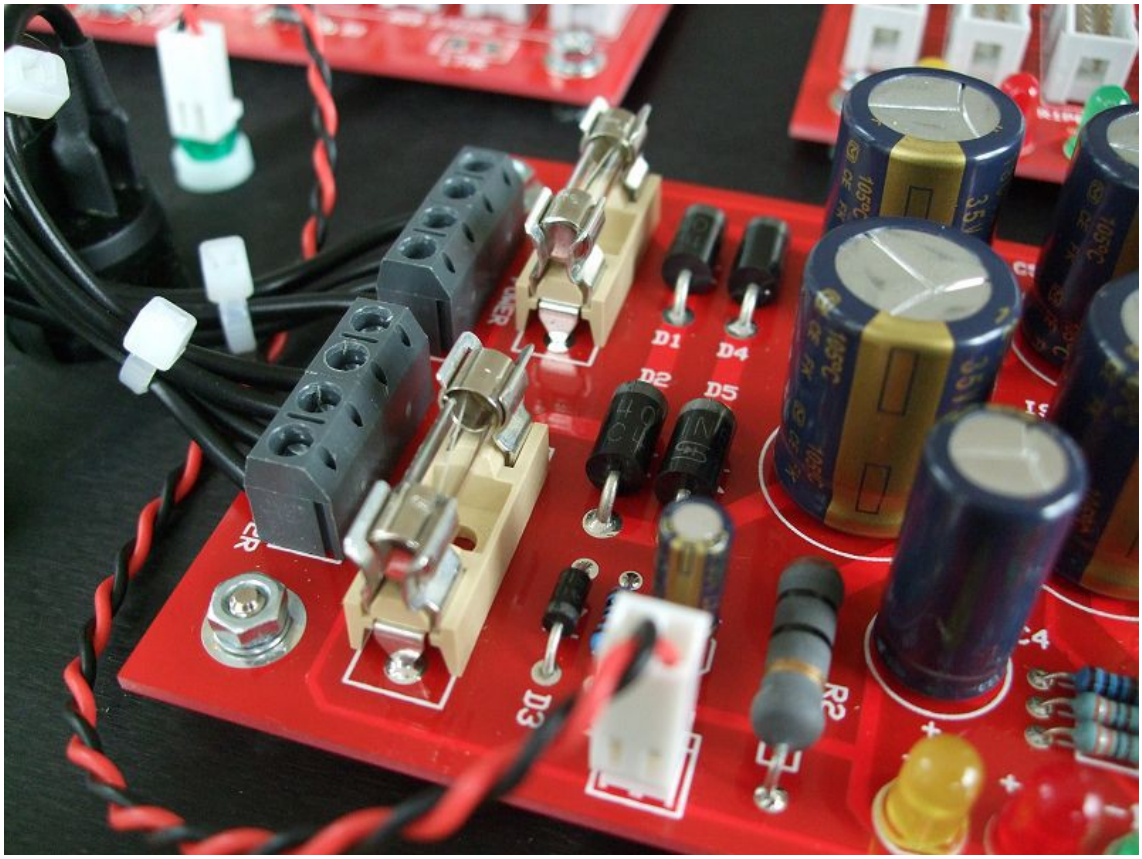
The DC-DC convertor is far more efficient that the linear design because it uses a switch mode power supply. However, the maximum current draw cannot be calculated quite so easily as it partly depends on the raw supply voltage coming from the mains adapter or power transformer. One can roughly calculate that for every 100mA that is taken from the +5V only around 35mA is taken from the mains adapter or transformer when you use the switch mode option. This means in the example given above you might be able to get away with drawing not just 100mA but 290mA from the +5V rail without causing damage to the main power supply. Thus the switch mode option is the one to go for if you need to draw a lot more current from the +5V. That said the absolute maximum current you can take from the OKI-78SR-5/1.5-W36-C device is 1.5A irrespective of the rest of the power supply.

The amount of current drawn by the DC-DC convertor can be easily found once your modular is all connected. Simply measure the voltage across R2 and apply ohm's law. The voltage divided by 10 ohms will give you the current. If you have, say 2V across R2, then you are drawing 0.2A or 200mA.

Note that the value of R2 will be different according to the option chosen. For the linear version R2 is only 2.2 ohms. While for the switch mode option, R2 is 10 ohms. Both, however, are 3W resistors.

If you have no need of +5V in your system then you can omit either power device and all their ancillary components. This would be R2, C4, C9, C12, C16, D7, D10 and U2

Our Recommended Power Supply



This Euro PSU is wired up for full wave rectification. Both fuses and all four big rectifier diodes are fitted. Note the use of a twisted wire to connect to the standby LED to keep things neat.

The safest available option is to use a ready made 'wallwart' or ‘line lump’ supply. As already mentioned one can use any 15V or 18V AC output wallwart of linelump you can source. The current capability of the mains adapter will be the chief limiting factor in determining the maximum current draw of your PSU. For a variety of reasons I recommend the Yamaha PA-20 and PA-30 supplies.

Yamaha PA-20

This is a linelump supply and features a fixed 17.5-0-17.5 volt AC output at 0.94A maximum. This means it gives us two AC outputs with a centre tap or mid point reference voltage. So unlike the single phase AC adapter output with two leads, this one has three. This means you need to use the Oakley PSU in full wave rectification mode.

The PA-20 is made for Yamaha products and they are available from Yamaha spares departments as well as many music shops, eg. Thomann. These are CE approved and connect to the mains via your local mains connector. They will be different types depending on the country you need them for. It comes with a handy three way plug at the low voltage end that you can use with an appropriate socket. If you wish you can ditch their connector and use your own. Oakley Sound sell a suitable three way connector to fit the Yamaha one perfectly.

In the UK the line lump's part number is V9812300 and the total cost is around £30 including VAT and postage. We do have permission from Yamaha-Kemble in the UK to use this particular part for the Oakley system, but in other countries this may be not so clear cut. The liability issue once again rears its ugly head and they may not want to sell power items for third party use. If you are buying these direct from Yamaha and, for some reason, are asked why, the best thing is to say it is for your own MG12/4 mixer.

Once rectified, smoothed and regulated the Yamaha PA-20 can deliver up to 0.52A continuously into both 12V rails.

You should fit both fuses and both should be anti-surge types and rated at either 1A or 1.25A.

The European version of the PA-20. Other country's units are similar but will have the local mains connector fitted.

Yamaha PA-30

This is essentially a bigger version of the PA-20 as detailed above which supplies 18V-0-18V at 1.4A maximum. Once rectified, smoothed and regulated it can supply up to 0.78A continuously. You should again fit both fuses and both should be 2A anti-surge types.

If you have successfully used the Oakley Euro PSU with any other types of power pack please do let people know via the Oakley Sound forum at www.muffwiggler.com

Parts List

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

The components are grouped into values, the order of the component names is of no particular consequence. A quick note on European part descriptions:

For resistors: R is shorthand for ohm. K is shorthand for kilo-ohm. M is shorthand for mega-ohm

For capacitors: 1uF = 1,000nF = 1,000,000pF. Sometimes the F is not included on the circuit diagram to indicate a capacitor's value, ie. 100n = 100nF.

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, 4n7 is a 4.7 nF capacitor.

Link

A piece of wire (eg. diode lead clipping) should be used to connect the two pads of LINK together. Alternatively, if you wish to use the LINK as a header for any banana plug 0V or grounding system you can solder a 1/4" faston blade here. This will act as both header and link the 0V with the bottom right hand mounting hole. See section 'Fitting a Grounding Point'.

Resistors

5% 1/4W carbon or better (1/4W 1% metal film is recommended)

1K	R3
3K3	R4, R5
6K8	R1

1% 1/4W metal film

240R	R6, R9
1K8	R7, R8

3W metal film or metal oxide (5% or better) mounted 5mm above the surface of the board.

Linear option:

2R2	R2

Switch mode option:

10R	R2

Capacitors

100nF, 63V multilayer axial ceramic	C12, C15, C17, C16, C11, C13
10uF, 35V or 50V electrolytic	C10, C14, C7, C8, C9
22uF, 35V or 50V electrolytic	C1
1800uF, 35V or 50V electrolytic	C2, C3, C5, C6
470uF, 35V electrolytic	C4

C2, C3, C5 and C6 are 105 degree Celsius radial types and have standard wire ended leads. Lead spacing is 7.5mm. I recommend Panasonic type EEUFK1V182S but any decent 105 degree part, with a ripple current rating of over 1.5A, and that will fit on the board can be used.

Integrated Circuits

LM317T 1A variable regulator	U1
LM337T 1A variable regulator	U3

Ensure that both devices are TO-220 types and not any surface mounting or TO-3 packages. I much prefer the devices that are made by National Semiconductor. They are available from other manufacturers but National's devices have a thicker and more rigid heatsink tab.

Do not fit solder these into the board just yet. They are only to be soldered once the board is fitted to the panel. See the section on mounting the Euro PSU board later in this document.

Linear option:

MC78M05CTG	+5V 500mA regulator	U2

As above do not fit this into the board just yet.

Switch mode option:

OKI-78SR-5/1.5-W36-C	+5V 1.5A DC-DC convertor	U2

This can be soldered into the board as it is populated. See pictures for orientation.

Discrete Semiconductors

1N4004 rectifier diode	D3, D6, D7, D8, D9, D10, D11, D12, D13
1N5401 rectifier diode	D1, D2, D4, D5

For D3, D6, etc. you can use any other 1N400X part such as 1N4001, 1N4002, etc.

D4 and D5 do not need to be fitted if you are using a single phase wall wart or line lump.

However, for full wave rectification D4 and D5 are required. So if you are using a split output line lump or an internal transformer with twin secondaries D4 and D5 have to be fitted.

5mm red LED	+12V
5mm green LED	-12V, LED
5mm yellow LED	+5V

The component marked as LED is the front panel power on or standby indicator. This is connected to the board via wires and is not fitted to the board.

Trimmer

500R multiturn cermet trimmer	POS, NEG

Miscellaneous

20mm fuseholder PC mount	F1, F2 (F2 is not required for single phase inputs)
4-way screw terminal 5mm	POWER, SWITCH
1/4" Faston blades	16 off for +12V, -12V, 0V & -5V
Power switch DPST	Standby or power switch
2-way 0.1" Molex KK	LED (header for front panel LED)
0.1" Molex KK or MTA housing	2 off for LED cable

Two anti-surge (time lag or slo-blo) fuses to suit.

For internal mains transformer (or any installation not requiring a standby switch) then you do not need to fit the screw terminal SWITCH.

You will also need thick wire to connect between the power inlet, switch and any connected distribution boards. I recommend 24/0.2 (0.75 sq. mm) insulated wire.

If the standby LED is to be fitted then you will also need standard hook up wire – I use 7/0.2 for all my low current connections. The thicker 24/0.2 wire would be too thick for this.

Linear option:

3 off TO-220 insulator	For mounting of U1, U2 and U3 to panel
3 off TO-220 insulating bush	For mounting of U1, U2 and U3 to panel
Heatsink paste	For mounting of U1, U2 and U3 if using mica insulators

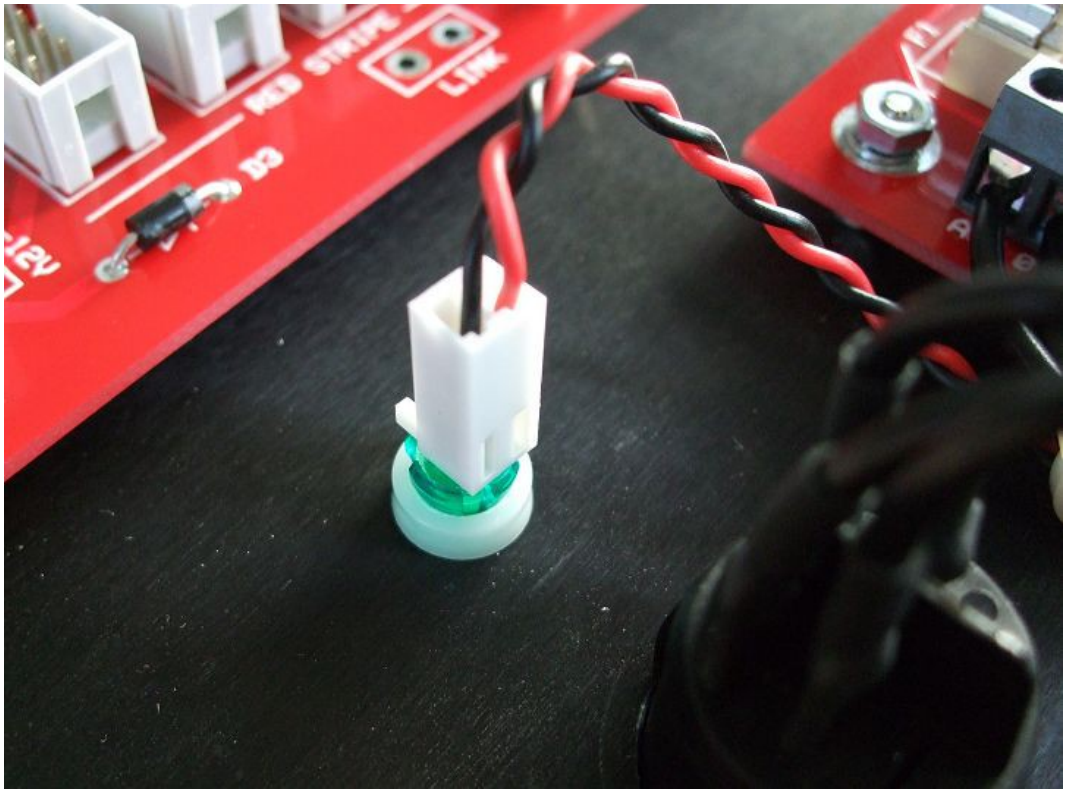
Switch mode option:

2 off TO-220 insulator	For mounting of U1 and U3 to panel
2 off TO-220 insulating bush	For mounting of U1 and U3 to panel
Heatsink paste	For mounting of U1 and U3 to panel if using mica plates

Mounting hardware for 19” rack panel

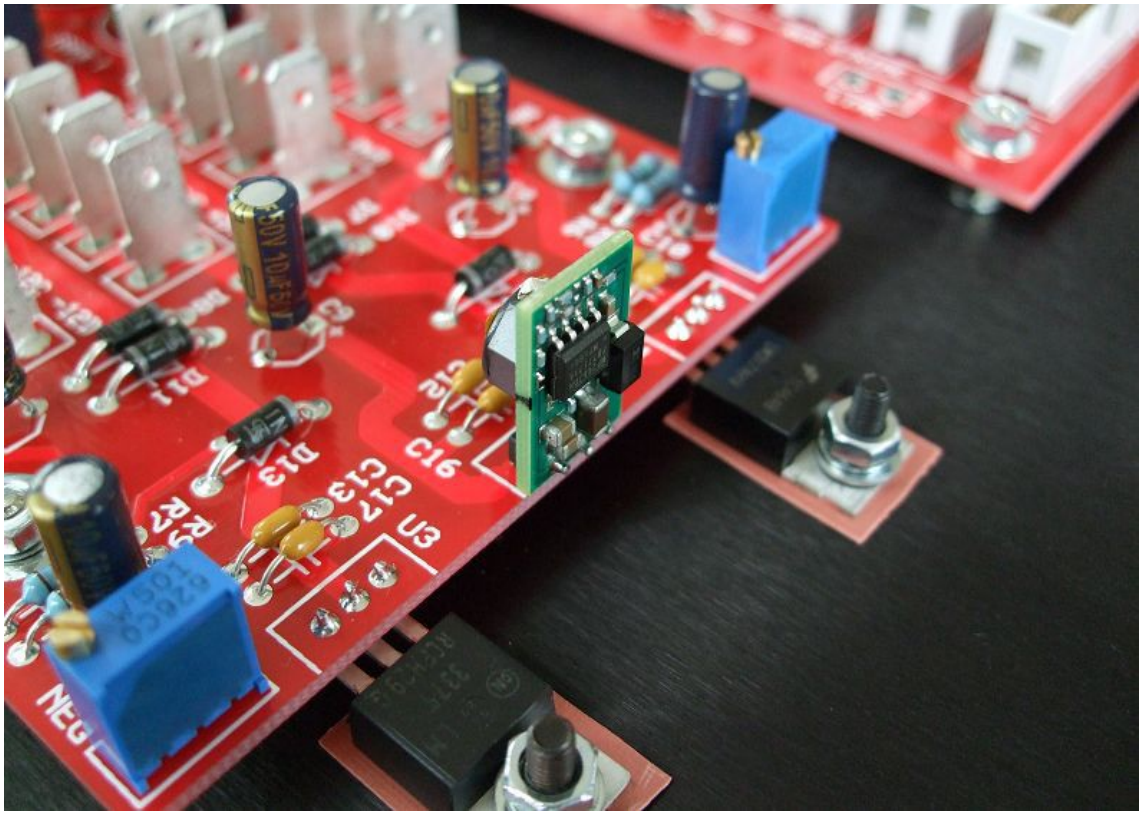
M3 6mm pan head screws	4 off
M3 10mm or 12mm pan head screws	For power devices, ie. 2 or 3
M3 hex threaded 5mm male-female spacers	4 off
M3 star washers	8 off
M3 plain metal washers	For power devices, ie. 2 or 3
M3 hex nuts	For power devices, ie. 2 or 3
M3 spring washers	For power devices, ie. 2 or 3

And any mounting hardware for the Dizzy boards if needed.



My usual way of mounting and connecting LEDs. I use a two way 2.54mm Molex KK housing to hold crimped 7/0.2 wires. These simply slide onto the LED's leads and will stay in place until one needs to remove the connection by simply pulling on the housing. The 5mm green LED is held in place by a low profile green LED clip and mounting ring. The LED needs to be wired so that the anode is connected to the positive connection, ie. the square pad.

Attaching the Power Devices



In this build the two regulators are insulated from the panel with pink insulating pads from Multicomp (pt. no. MK3306/S). Note that with the +5V DC-DC convertor 'switch mode' option only two power devices need to be fitted to the heatsink.

The Euro PSU PCB needs to be fitted to your case metalwork. Use the PCB as a template for marking the panel and then drilling the four 3.5mm holes needed for the mounting pillars. The board should be spaced high enough off the panel with suitable mounting pillars (spacers) so as to not short out any of the components' leads should the board be flexed downward. The mounting pillars should also not be too long so that the leads from the regulators can't reach through the board to be soldered. I find either a 5mm or 8mm spacer works very well.

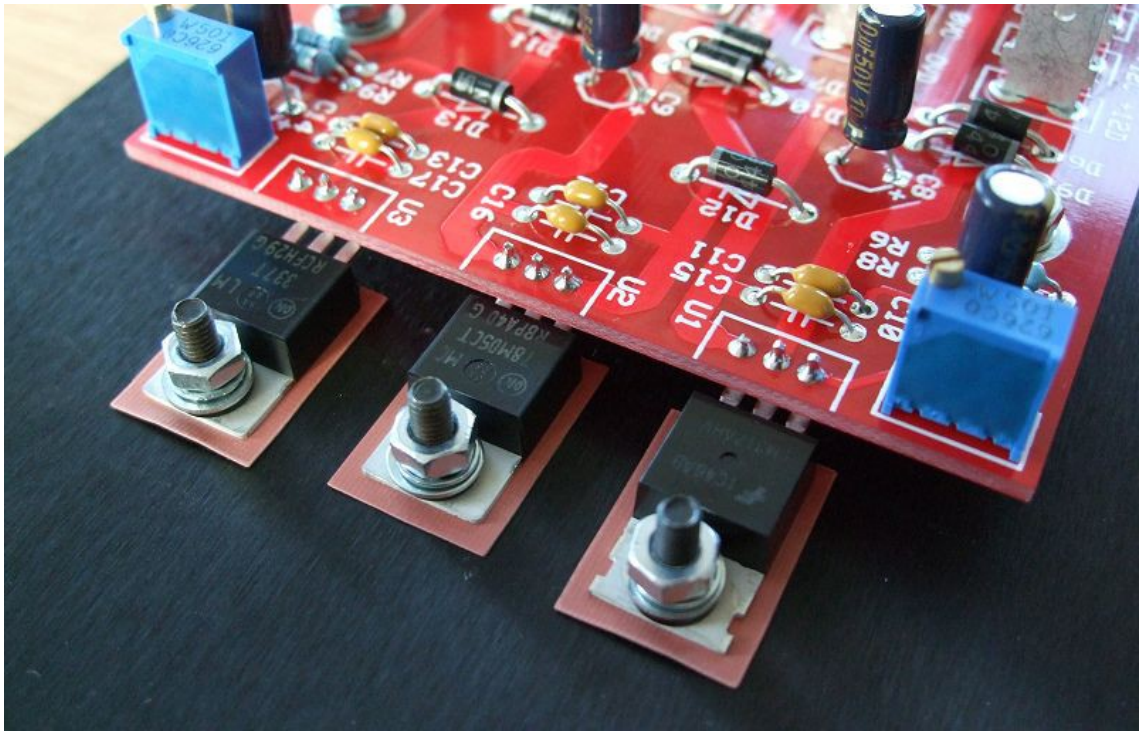
Now you need to prepare the leads of the two (or three if you are building the linear option) power devices. The three legs need to be bent upwards so that the PCB can be fitted over them. Note that the top surface of the device is marked with the name of the component and it is the flat side on the 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 90 degree bend upwards at the point where the lead thickness changes. Do this for all three legs of the device.

Remove the board from the panel and fit the power devices to the board by poking their legs up through the bottom of the board. Do not solder them but fit the board back into place. Use the hole in each regulator to mark out where you need to drill the mounting hole for the two devices. Now remove the board and regulators. Carefully drill a 3.8 or 4mm hole in the panel for each of the regulators. Clear off any swarf and, twisting with your hand only, use an 8mm

drill bit to lightly deburr the edges of the holes on both sides. There should be no bumps around the holes.

The linear regulators are TO-220 devices. They need to be fitted to the panel mechanically and thermally but not electrically. This means that the metal tab on each 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 the 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 the insulating pads. However, mica plus paste does offer better performance in terms of keeping the power device cool so if you are planning to draw over an amp from your power supply it may be better to use mica and paste. Mica also has the advantage of being reusable should the devices 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 them each time the devices are removed from the heatsink.



The three regulators used for the linear option. The small 'top hat' black plastic insulating bush can just be seen underneath the flat metal washers on each power device.

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 one of the insulating pads 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 power device, 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 spring washer and nut onto the screw but don't tighten it up just yet. Do the same for the other regulator, or regulators, making sure, of course, that each one is in the correct hole.

Now if you have done all this correctly, you should find that the when the power supply PCB is presented back onto the four threaded spacers, you can coax the power devices' legs through the respective solder pads on the board. Because the power devices have not been fully tightened you will still be able to move them about a bit on the panel to ensure a good fit. Make sure also that the insulating pads are sitting square under the devices and haven'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 nuts on the power devices. Do not tighten these too much as this will distort the mounting tab and squash, or even tear, the insulating pad. All the nuts need to do is hold the power devices up against the panel.

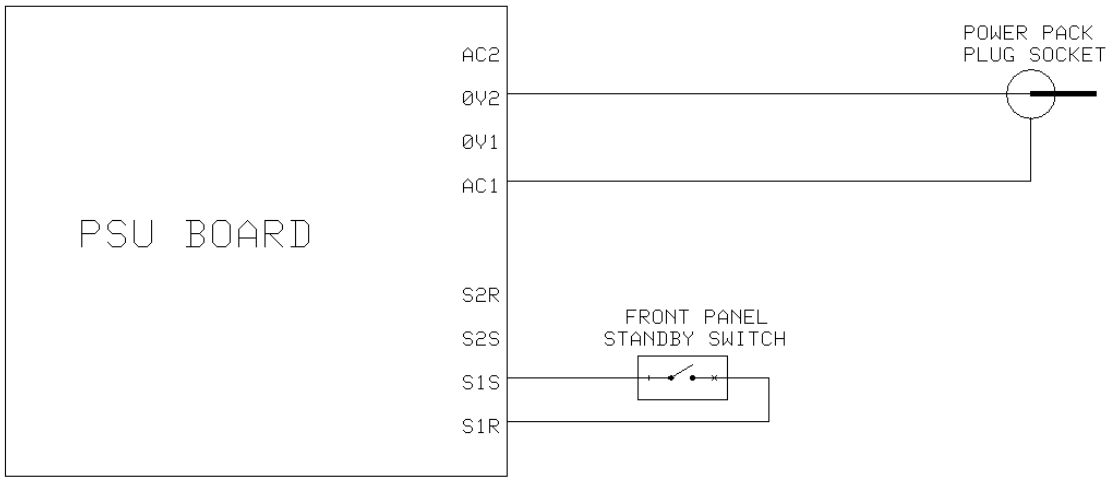
With both the board and power devices secured to the panel with their mounting hardware you can now solder the regulators' leads from the top side of the board. Snip off any excess lead lengths above the solder joints.

Linelumps and Wallwarts: Wiring Diagrams

Input wiring will depend on the type of wallwart or linelump you will be using.

Standard AC output wallwart

Single phase, two wire, wallwarts or linelumps need to use half wave rectification so the Oakley PSU can generate both positive and negative supplies simultaneously. They only need the terminal's AC1 and 0V2 wired to the power socket. AC2 and 0V1 are left unused.



Wallwart with single phase AC output.

The front panel switch is a single pole single throw (SPST) switch which simply connects S1R and S1S together when switched on. You can replace the switch with a simple wire link, but I do recommend that a switch be fitted so the socket doesn't have to take the full surge current when you insert it with the wallwart powered up.

I also recommend fitting the AC indicator LED too. This is so you know the wallwart or linelump is on. The AC indicator is designed to indicate the status of incoming power and is not determined by the position of the standby switch.

The standby switch should not be used to turn the unit off permanently. This should be done by either switching the adapter off at the mains socket, or by pulling the adapter's plug out of the mains socket.

An optional earth or grounding connection can be made. See later for more details.

Recommended Option: Centre tapped wallwarts and linelumps

Centre tapped linelumps like the Yamaha PA-20 will have three wires coming from their connector. It will have two AC outputs and one 0V. Take one of the AC outputs to terminal AC1 and the other AC output to terminal AC2. It should not matter which AC output goes to AC1 or AC2. The 0V should go to the 0V2 terminal. The 0V1 terminal is left unused.

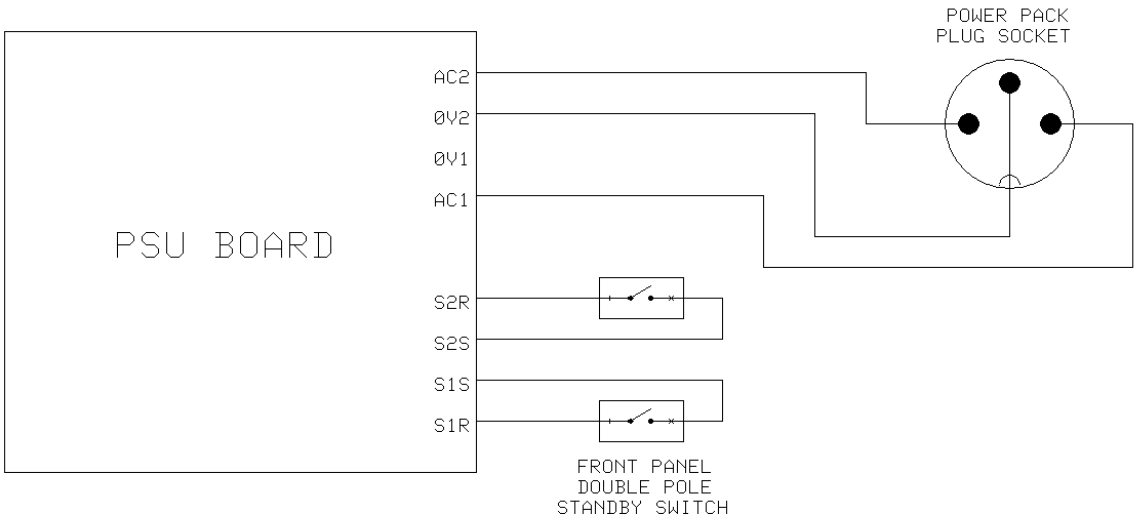


Figure 2. Linelump wiring with centre tapped output, eg. Yamaha PA-20

The front panel switch is a double pole single throw (DPST) switch which connects S2R and S2S together, and S1R and S1S together, when switched on. You can replace the switch with two wire links, but I do recommend that a switch be fitted so the socket doesn't have to take the full surge current when you insert it if the linelump is powered up.

I also recommend fitting the AC indicator LED too. This is so you know the linelump is on. The AC indicator is designed to indicate the status of incoming power and is not determined by the position of the standby switch.

The standby switch should not be used to turn the unit off permanently. This should be done by either switching the adapter off at the mains socket, or by pulling the adapter's plug out of the mains socket.

An optional earth or grounding connection can be made. See next section for more details.

Linelumps and Wallwarts: Fitting a Grounding Point

Using double insulated wallwarts and linelumps mean that you do not have to have a mains safety earth fitted to your modular. However, if your modular is to talk to the rest of the studio you need to make sure that the modular's 0V or ground is tied to earth somewhere in your system. The most usual way of doing this is via the connecting cable's shield or screen connection. Your mixing desk or monitoring equipment will be earthed and simply connecting a cable to any module within your modular will tie the modular's ground to the other equipment's earth. This seems pretty straightforward and it is so long as you have a small system and only have one or two interconnecting cables in use.

However, a larger more complex system will have perhaps more than one modular, more than one mixing desk and perhaps a heap of other outboard equipment. This is when it makes sense to look at grounding your modular cases together.

The additional 4mm socket to the right of the power inlet provides a way of connecting the 0V lines between cases.

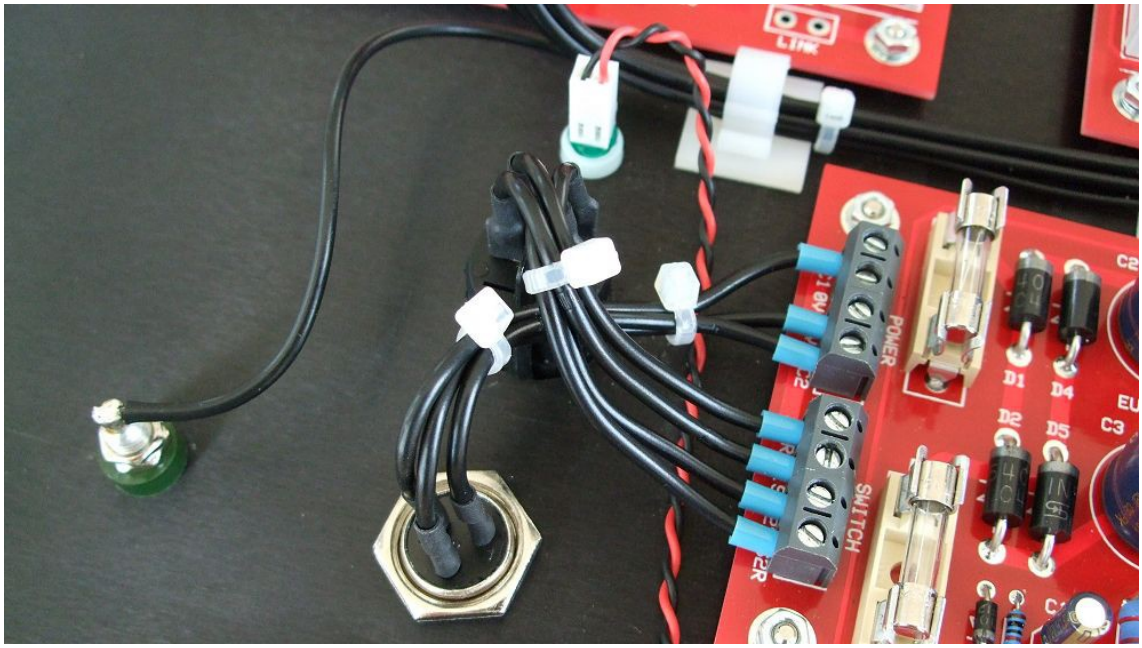
Let us consider a more simpler scenario for the moment. Say we have built ourselves two modular cases and we would like to connect the modules in them together to form an awesome monster patch. Each case has its own Euro PSU and each one is powered by a Yamaha PA-20. It is useful in this situation to ensure that both PSUs are grounded together. In other words, the two 0V lines from each power supply are firmly connected together. Although this will be done the moment that one patch lead goes from one case to the other it is beneficial to do this with a dedicated thick bonding wire.

We can do this in a variety of ways but one useful method involves having a 4mm banana socket mounted near each power supply. The banana socket is then connected to 0V, via one of several places, on the Euro PSU board.

If both power supplies have a banana socket then it is a simple matter of patching the two power supplies together with a banana patch lead. The great thing about bananas is that they are stackable so it's easy even if you have more than two PSUs to connect up.

I recommend that you use thick multistrand cable to make your grounding leads and that you use good quality 4mm banana sockets and plugs.

You can connect the banana plug to one of three places on the E-PSU board. The best place is one of the four 0V faston blade terminals, 0VA, 0VB, 0VC or 0VD. However, if you will be using all four of these to wire your distribution boards then the next best choice is to use a faston terminal blade in the LINK position. In any system with four Dizzy boards this is the option to use. For the final choice, and the least preferential, you can use the empty screw terminal 0V1. It is possible that using the 0V1 screw terminal in this way could introduce a small amount of mains noise into any signals travelling between the cases but I have not noticed this.



A close up of the 4mm banana socket being used as a common grounding point for a rack mounted power supply. In this build the banana socket is connected directly to the 0VD terminal with a nice thick piece of wire.

Using an Internal Mains transformer

Be afraid, be very afraid...

Some of you old hands will laugh about the level of hysteria that surrounds direct mains connection to DIY projects. However, this fear is more to do with our litigious society than the real danger to the builder. Even so, I have had more than my fair share of high voltage shocks over the years and it is not something I would want any builder to have to experience. It has been purely luck that has saved me in several of those cases.

So I will say again – do not attempt to build a mains transformer into your modular case, or any other project, without realising that to do so carries a risk of death to either you, or to the person who may inadvertently put their fingers into your half built construction. Furthermore, it is up to you as the builder of such an item to make sure, that once built, the item is safe to use and meets all current safety legislation.

This is not a complete set of instructions on how to fit a transformer into a piece of electronic equipment. This information is offered only as a guide and should not be considered as your only source of information. No further information, other than that included here, will be provided by me regarding the construction of mains powered items.

The mains transformer's secondaries should be rated:

15-0, 15-0 (or for a single tapped secondary 15-0-15)

80VA

This will give you a power supply that should be theoretically capable of supplying of 1A into each of the +12V and -12V rails assuming your heatsink and smoothing capacitors are up to the job. The maximum current taken from the +5V rail depends on whether you are using the linear or switch mode options. If using the linear option then the maximum current to be taken from the +5V must not exceed 1.4A less the current taken by the +12V rail. In other words the total current taken by both the +12V and +5V rails must not exceed 1.4A.

A 4U 19” 3mm thick black aluminium panel mentioned earlier may well be adequate for a 1A supply but remember that the secondary voltage will affect just how much heat needs to be dissipated. It is up to you to verify that your chosen panel is up to the job of keeping those power devices cool. Remember that air flow to the panel is essential so make sure any tests you do are representative of the situation your heatsink will eventually be fitted to.

The transformer secondary voltage is suggested to be 15V. Slightly higher transformer secondary voltages can also be tolerated although you need to consider three things:

1. You may need a physically larger transformer for the same output power.

2. The power supply's components, including the smoothing capacitors, should be rated at a high enough working voltage to handle the increased voltage across them.

3. The heatsink will need to dissipate even more energy because of the greater voltage drop across the regulators.

In the wiring diagram shown later I have included a suggested wiring method for connecting up a mains transformer. Not all mains transformers are the same, some have additional windings, others have tapped windings. I have simply used a single primary, double secondary type for example only.

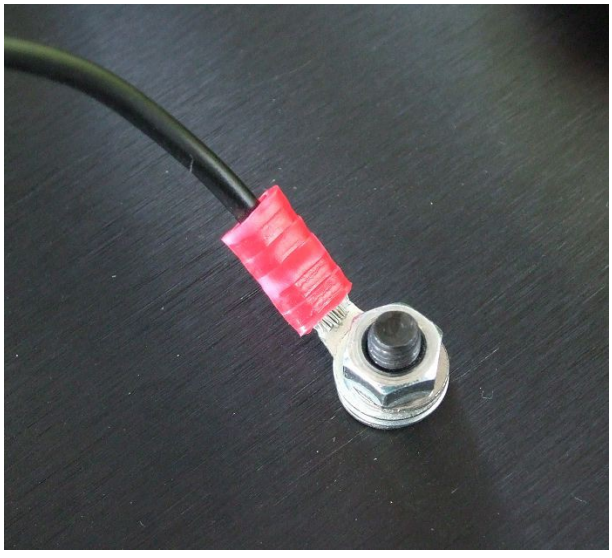
For the mains fuse you should use a 500mA anti-surge type. All wiring at mains potential should be adequately insulated and protected from straying fingers.

There is no need to fit an AC standby switch since you will be fitting a proper mains power on switch in series with the transformer primary coil. So you should link S1A to S1R, and S2S to S2S, on the PCB.

Earthing

Remember it is up to you, the builder of the equipment, to make sure that your item is safe and is built to the required safety standard in your country. These notes are only a guidance and it is up to the reader to establish the exact obligations required in their own country.

It is essential that everything you build, that has both live mains inside and a metal case or panels, has a safety earth fitted. UK legislation says that any metal panelling should be adequately insulated, ie. double insulated, or connected to earth. Since making a double insulated case is not practical you should ensure that any exposed metal parts be properly earthed.



A bonding point using a crimped ring terminal onto a M4 bolt secured to the panel.

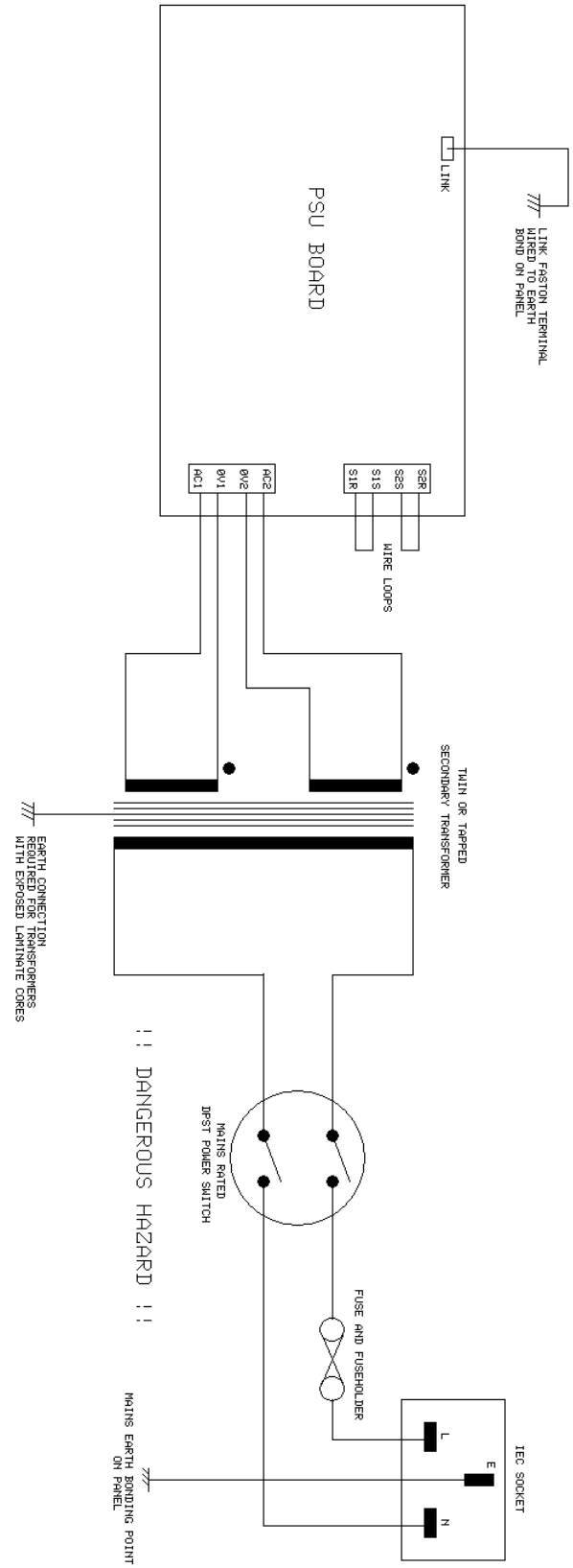
Firstly you need to ensure that the heatsink panel is earthed. Given its size and required air flow this will certainly be an exposed piece of metal and thus should be earthed well. It should be bonded to earth via a thick piece of wire back to the earth tang of the IEC power inlet or a common earth bonding point.

The PSU board should be securely mounted (using all four mounting holes) onto the earthed heatsink using appropriate screws and toothed washers. LINK on the power supply board should be a 1/4” faston terminal blade. Make a connection with a thick piece of wire from LINK to either the main safety earth bond, or another bonding point on the panel.

This alone may not be sufficient for a solid safety earth bond for the whole modular system. All modular panels should be earthed directly, either with their own direct connection to the earth tag on the power inlet, or via the modular's earthed metal mounting rails and suitable toothed washer and screw. If you have a wooden case with wooden mounting rails and you are toying with the idea of using a mains transformer with open mains wiring for your DIY power supply project then you may want to rethink your plans.

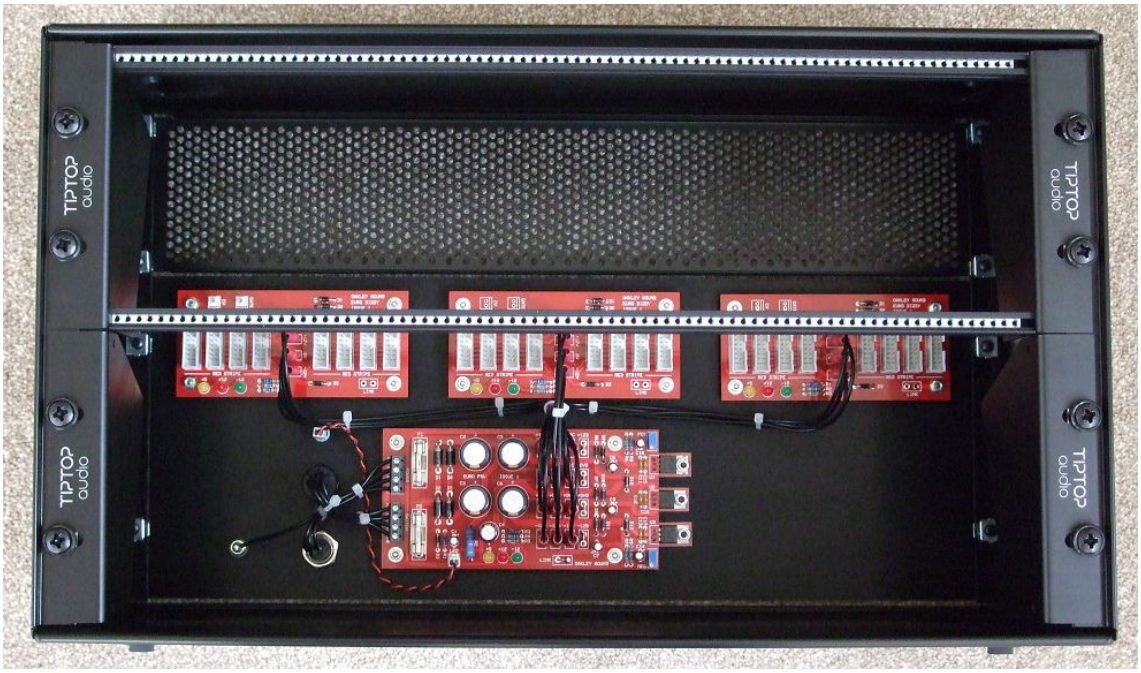
You will also need to provide earthing to any exposed transformer core. This does not apply normally to toroidal types but EI types should have their metal frame earthed.

It is possible that by earthing the front panel you may introduce earth loops when you connect your mixer to the sockets of one of the modules. The outcome of this is audible humming at 50/60Hz and its harmonics. It is produced by earth currents travelling down the screen of the connecting cable(s). This can be avoided by careful studio wiring and/or by using balanced audio lines to pipe signals to and from the modular and mixing desk. Most mixing desks will have balanced outputs and inputs.



Mains wiring diagram. For experienced builders only!

Testing and Calibration



A complete 24 way power supply system with one E-PSU and three E-Dizzies fitted to a 6U 19" rack case.

Note all testing must be done with the heatsink or panel attached to the power devices.

After wiring the unit according to the instructions given in this document you should apply power to the unit. Check that no device is running hot. Any sign of smoke or strange smells turn off the power immediately and recheck the all the external wiring first, and then the components on the board. All three onboard LEDs should be lit and none of them should be too bright or too dim. Check too that the standby LED is lit.

Assuming everything is OK so far, it is time to check the output voltages. Measure the output voltages with respect to ground. This means connect your black lead of your voltmeter to the 0VD terminal blade. Measure the voltage on +12VD and check that is within +10.5 and +13.5V. Now measure the voltage on +5V and check that this is around +5.0V. And now check that the voltage on -12VD is between -10.5V and -13.5V.

Leave the unit for about ten more minutes. Now adjust the voltages with the trimmers (multiturn presets) on the board. Adjust POS to make the +12VD terminal equal +12.00V. Adjust NEG to make -12VD equal to -12.00V.

The voltages will vary a little with load. That is, it will change marginally depending on how many modules you connect up to the power supply board. Feel free to re-adjust the trimmers when you add more modules to your project.

Final Comments

I hope that the Oakley Euro PSU lives up to your expectations and provides you with a reliable source of power for your modular system.

If you have any questions about 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 document, 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 have helped and inspired me over the years. Thanks especially to all those nice people at Muff's and the Synth-DIY and Analogue Heaven mailing lists.

Tony Allgood at Oakley Sound

Cumbria, UK