# Oakley Sound Systems

# The Mixer
# Audio Mixer and Output Stage

# User's Guide

# V1.01

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# Introduction

A very simple but useful utility module. This allows four CV or audio inputs to be mixed together to form one output. Four pots adjust the relative levels and one pot adjusts the final output level. Two of the inputs may be used as constant voltage sources if the input jack socket has no patch lead inserted. This may be used to control other modules, or to deliberately induce asymmetrical distortion in the mixer.

An electrically balanced output stage is included in the design. This may be hardwired to the output of the mixer or used separately. This provides a fully balanced, but not isolated, output signal that can drive a mixing desk directly. The signal is automatically attenuated down to about an eighth of its original value. Thus the high level signals used within the Oakley and MOTM modulars can safely drive guitar effects units without overload. The output will automatically compensate whether a mono jack (for non-balanced) or TRS jack (for balanced) is inserted.

A peak overload LED is included, which is set to light when the mixer output levels exceed +/-10V. Also, provided is a circuit that drives an LED, or moving coil meter, which can be used to give an indication of signal magnitude.

All the parts for this project are easily obtainable, although the PCB mounted pots and pot brackets are available from me should you find any difficulty in getting these.

# The PCB

The PCB is 14.6 cm high  x 6.6 cm deep in size. It uses double sided copper traces and has through plated holes. It has solder mask both sides for easier soldering, and has component legending on the top side for easier building.

I have provided space for the four control pots on the PCB. These can be mounted away from the PCB, but they can form part of the mounting process. If you use the specified pots and brackets, the PCB can be held very firmly to the front panel. The pot spacing is 1.625” and is the same as MOTM modular synthesiser. The board is fully MOTM panel compatible if the board is fitted vertically, ie. in a 1U wide panel. Four M3 sized holes are provided on the PCB for supporting the board if you choose to use other methods of mounting.

I have included a suggested front panel layout at the back of this document. It shows a 2U wide panel. This will be discussed in more detail later.

The design requires plus and minus 15V supplies, although it could happily work off +/-12V supplies too. These should be adequately regulated. The current consumption is about 30mA per rail. Power is routed onto the PCB by a four way 0.156” Molex or MTA header. You could, of course, wire up the board by soldering on wires directly. The four pins are +15V, ground, earth, -15V. The earth connection allows you to connect the metal front panel to the power supply’s ground without it sharing the modules’ ground line. Again more about this later. The connector used is standard to the MOTM series of modules from Synthesis Technology and my other larger designs.

# Circuit Description

The Mixer circuit is quite simple, but let's run through the design carefully. Looking at the bottom of the schematic you can see the four way header, labeled POWER. Power enters the board here, and is immediately filtered by a simple LC networks based around F3, C26 and C28 for the positive rail, and F4, C27 and C29 for the negative rail. Two grounds are provided, one for the circuit itself, and one for the earthing of the jack sockets on the front panel.

There are five dual op-amp ICs, U6 - U10, on this PCB, and each requires power. The power supply to each IC is shown separately to avoid cluttering the main circuit diagram. Note that the op-amps require both negative and positive supplies. U10's power supply is decoupled further to prevent the LED driver circuit from affecting the power lines.

There are four inputs to the mixer PCB. IN1 to IN4. These go straight into the four gain pots mounted on the board. The pots are wired as potential dividers which has the counterclockwise pin taken to ground. The wiper will then provide a signal that is determined by the position of the wiper on the pot's resistive track. SC1 to SC4 are connected to the module's ground supply. If you use screened cable to connect the input sockets to the PCB, you can solder the screen to the relevant SC pad. The input jack should then be normalised to the screen of this cable. This will be covered in more detail later on in this document.

Pins 1, 2 and 3 of U6 form the main summing amplifier. This is wired as the classic inverting amplifier. Currents flowing through all the input resistors, R47, 48, 51 and 57, come together at the inverting input, pin 2. Pin 3 is held at 0V since it is connected to module ground. The op-amp will try to keep the voltage at pin 1 and pin 2 the same. Thus the op-amp's output will change to suck all the input current through the feedback resistor R60. R60 is selected to make the gain of the mixer around -0.25. Which means that with just one input in use with 4V presented at the socket, we will have -1V have at the output of the op-amp. Now the maximum output of an op-amp powered off +/-15V is around 12V. By setting the gain of the mixer to -0.25 ensures that you cannot get the input stage to distort even with all inputs at 10V.

A master level of fader pot is fitted at the output of the op-amp. This allows you to control the final output level. The recommended pot is a 10K log pot, which works best for audio.

U6 is the pots fader amp. The gain is set to be the inverse of the mixing stage, that is, around minus four. Thus with all pots maxed out the gain of the whole mixer is just one. R74 and R73 set the gain.

C32 and R72 form part of the stabilising network designed to keep the op-amp from oscillating under capacitive loads. A full explanation of this is beyond the scope of this User guide, but more information can be found on the Analog Devices website in their Applications Note AN-257. I was first introduced to this method when I worked at Soundcraft, and have since used it on other Oakley projects notably the VCF-1 filter rack's main output. The audio output is then available at OUT.

This signal is also full wave rectified by the circuitry based around U9a. Full wave rectification can be described by the mathematical 'absolute' function. In other words, the output of the full wave rectifier (FWR) is always positive. If you present +10V to the input, you will get +10V.

But if you present it with -10V you will also get +10V. Likewise, -5V turns into +5V, -3V into +3V. Now if you put an audio signal into this circuit, you will get a series of positive bumps that correspond to the up and downs of the audio signal.

U9b forms a buffer circuit. The output of the full wave rectifier is therefore protected by the odd load presented by the next set of circuits. R44 and R45 actually reduce the signal to half of its original value before the FWR. This will reduce any loading effects on the output of U6

A comparator circuit, based around U10b, is used to operate the **PEAK** LED. This is normally achieved more simply using just a transistor, but I had the spare op-amp half available and the results from this sort of circuit are more predictable. The LED is designed to turn on when the output of the FWR reaches around 5V, ie. the output of U6 reaches 10V. An op-amp running off a +/-15V rail will be able to output around 13V maximum, so enabling the **PEAK** LED to turn on at 10V gives you just the right amount of headroom. You should normally operate the Mixer so that the peak LED only occasionally flickers with the peaks in the music.

A visual indication of the CV outputs is available from the **AMP** LED. This is driven from a current source provided by op-amp U10a. The LED in the feedback loop will have a current that is determined solely by the voltage presented to the end of R52. A 5V CV output, will produce 5mA in the LED. Although in normal operation the LED is always forward biased, it may be subjected to odd negative swings on power up and power down. A normal diode is placed in parallel with the LED pads to prevent damage to the LED.

R52 controls the sensitivity of the circuit. 1K8 produces about 5 mA through the LED for a 10V output of the MultiMix. You may want to reduce this to 1K, to give a brighter reading. Personally, I think 5 mA is fine for most applications indoors. Another thing to bear in mind when you want a brighter LED, is that the current must come from somewhere. Both U12’s output and U13 itself will have to provide this current, and both devices will protest if you try to take too much current out of them. Plus, you have to think about the power consumption of your modular itself. Too many pretty lights will start to demand too much of your power supply.

U7 and U8 with their associating circuitry form an electronically balanced output stage or EBOS. The EBOS circuitry is totally separate from the rest of the mixer and can be used independently, or it can be permanently fixed the output of the mixer stage. The preferred option is to use a normalised EBOS input jack that allows the mixer’s output to go to the EBOS when no jack is plugged in. Plugging in a jack then automatically disconnects the EBOS from the mixer and allows you to use it separately.

U7 is a simple inverting amplifier with a gain of just -0.22. In other words, signals are reduced to just under a quarter of their original height. The value of R64 may be changed to 100K if you would like unity gain through the whole EBOS circuitry. U7 provides a low resistance feed to the EBOS output drivers. Simply put an EBOS will provide two active signal outputs. One will be the inverse of the other.  They are usually described as + and -, or hot and cold. The two outputs are supposed to simulate the signals that would be present from an audio transformer with a centre tap connected to ground. The circuit features a clever use of positive feedback to correct the output levels if one or the other outputs are connected to ground. It is important to use 1% resistors in this circuit to prevent any unwanted stability. The BAL trimmer sets the levels of the hot and cold lines to be the same.

Normally a three pole socket is used for balanced signals. The most common types being XLR or TRS (stereo) jack sockets. For the TRS sockets used in my prototype, the tip is the hot and the ring is the cold. Inserting a mono jack into the TRS socket will automatically short the cold signal, but will not cause any damage and the unit will work in unbalanced mode. You can insert a TRS jack into the socket, with the screen connected to the ring and the signal input to the tip. The sleeve of the socket is left unconnected. This is semi balanced, and this can be effective in driving guitar amps or effects with no fear of earth loops.

Please note, that an EBOS does not offer true isolated balanced outputs like a transformer. The highest differential voltage between the earths at input and output mustn't exceed 5V or so. This is highly unlikely in any studio or audio system though.

The only bit of circuitry that I haven't mentioned yet is the use of the little 47K resistors in the top left hand corner of the schematic. These provide a supply of current to the NC tags of the first two input sockets. Thus, if you do not have a jack inserted into channel one, the gain on that channel will control a positive DC bias signal that is added to final output. With the gain pot and master level pot turned fully clockwise, you will find approximately +7.5V on the output. Channel two performs the same function but allows negative voltages to be added. The EBOS output is unaffected since it is AC coupled. Although, having said this, by adding too much bias you can deliberately cause U6 to distort asymmetrically. This gives a lush distortion that can be quite musical.

Final point, you may be wondering why the component values start from high numbers and not from R1, C1 etc. This is because to keep the cost of this board down, I fitted the Mixer PCB layout onto the same EDWin database as the 'Noise/Filter' and 'MultiMix2' projects. This way, only one set of photoplots was created for the three boards, and only one set of tooling costs were incurred. So you, dear customer, didn't have to pay too much for the boards.

## Components

All the parts are easily available form your local parts stockist. I use Maplin, CPC, Rapid RS-Components and Farnell, here in the UK. In North America, companies called Mouser, Newark and Digikey are very popular.

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, Maplin, CPC and Rapid Electronics sell the Omeg pots at a very good price. However, they do not sell the pot brackets. Omeg will also sell direct, but this is only viable for large orders. I am able to supply a pot kit with all three pots and associating brackets.

The dual op-amps in the audio path should be good audio types. TL072 is OK, but OP275 are better. Other alternatives are the 5532, although this has a poorer DC spec.

I would go for 1% 0.25W metal film resistors throughout, and you must use these in the EBOS amplifier. But you could use 5% types with no problem in the rest of circuit.

The six electrolytics should be over 16V, 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 the non-polar capacitors, C22, 28, 29, 34, is 7.5mm (0.3”). I think polyester types are fine for all decoupling, coupling and filter uses. I like the open frame Siemens polyester layer types, because they are very compact and a rather nice colour! They are normally called poly-layer and are available in many different working voltages. Use 63V or 100V. But remember the pitch spacing. You could also use the Phillips C280 series and their modern replacements, eg. BC-368 series. These are metalised polyester types, but again do be sure you get low working voltages. They easily fit into the 7.5mm spaces provided. Around 100 to 150V is best. In the UK, Farnell can supply all the capacitors. The five low capacitance (values in pF) ceramics have a pitch spacing of 5mm (0.2”).

F3 and F4 are leaded ferrite beads. These are little axial components that look like little blackened resistors. They are available from most of the mail order suppliers. Find them in the EMC or Inductor section of the catalogues. Farnell sell them as part number: 108-267. Alternatively, they can be replaced by 4R7 resistors with no real drop in performance.

All ICs are dual in line (DIL or DIP) packages. These are generally, but not always, suffixed with a CP or a CN in their part numbers. For example; TL072CP. Do not use SMD, SM or surface mount packages.

Please be careful with the orientation of the electrolytic capacitors. All the ICs have pin one to the top. Make sure you get U7 in the right place. This is a single op-amp and will be destroyed if you accidentally fit it into any other op-amp position.

Paul Schreiber of SynthTech has won me over to water washable flux in solder. The quality of results is remarkable. In Europe, Farnell sell Multicore’s Hydro-X, part number: 629-431. This is 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. 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, although, it is probably not a good idea to wash a board with trimmers and pots on. These can be soldered in after the final wash with conventional solder or the better new type of ‘no-clean’ solder. I use Farnell part number: 904-545. Make sure the board is fully dry before switching it on.

I would make the board in the following order: resistors, IC sockets, small capacitors, electrolytic capacitors. Then the final water wash. Then the pots can be soldered in with ‘no clean’ or ordinary rosin based solder. See later for more details on mounting the pots.

Finally, if you make a circuit change that makes the circuit better, do tell me so I can pass it on to others. Any updates are added to the current user guide, and posted on the ‘Mods’ page on my web site.

## Parts List

The components are grouped into values, the order of the component names is of no particular consequence.

**Resistors:** all 1% metal film

| | |
|---|---|
| 22R | R82, 54 |
| 75R | R72, 79, 63 |
| 100R | R53 |
| 1K | R80, 83, 52 |
| 2K2 | R78 |
| 5K1 | R44, 45, 46, 71 |
| 7K5 | R61 |
| 10K | R81, 77, 49, 50, 75, 76 |
| 22K | R60, 74, 64, 55, 56, 69, 70 |
| 47K | R68, 43, 62 |
| 100K | R47, 48, 51, 57, 73, 58, 59 |
| 1M | R65 |

**Capacitors**

| | |
|---|---|
| 47uF,25V elect | C26, 27, 33, 25, 35, 36 |
| 100n polylayer | C28, 29 |
| 330n polylayer | C34 |
| 680n polylayer | C22 |
| 33p ceramic | C23, 24, 30, 31, 32 |

**Discrete Semiconductors**

| | |
|---|---|
| 1N4148 | D1, 2, 3, 4, 5 |
| Red LED | 1 off, fitted externally, PEAK |
| Orange LED | 1 off, fitted externally, AMP |

**Integrated Circuits**

| | |
|---|---|
| TL072 dual FET op-amp | U9, 10 |
| OP-275 dual audio op-amp | U6, 8 |
| TL071 | U7 |

**Miscellaneous**

| | |
|---|---|
| 4-way 0.156” Molex/MTA | POWER |
| 1-way 0.1” headers | For LEDs, optional. See text |
| Leaded Ferrite beads | F3, 4 |
| LED clip/lens | (2off) |
| Sockets | The suggested layout needs six 2 pole Switchcraft APC112. And one stereo (three pole) Switchcraft socket |

| | |
|---|---|
| 47KB log E16 Omeg | GAIN-1, 2, 3 |
| 10KB log E16 Omeg | Master level (fitted off board) |
| P16 Solder brackets | (4 off) |
| Twin screened wire | two pieces |
| Single screened wire | one piece |

You may well want to use sockets for the ICs. I would recommend low profile turned pin types as these are the most reliable.

## Mounting the Pots

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. But only solder the three pins that connect to the pot. Do not solder the pot bracket at this stage. When you have completed the PCB, you can fit it to your front panel. Position the PCB at right angles to the panel. Now you can solder each of the brackets. This will give you a very strong support and not stress the pot connections.

## Connections

The power socket is 0.156” 4-way Molex or MTA. Friction lock types are recommended.

| ***Power*** | ***Pin number*** |
|---|---|
| +15V | 1 |
| Module 0V | 2 |
| Earth/Panel | 3 |
| -15V | 4 |

The PANEL pad on the PCB has been provided to allow the ground tags of the jack sockets to be connected to the power supply ground without using the module’s 0V supply. Earth loops cannot occur through patch leads this way, although screening is maintained. Of course, this can only work if **all** your modules follow this principle. All Oakley modules now fit this standard. It will be still compatible with the MOTM systems.

If you have used Switchcraft 112 sockets you will see that they have three connections for the two pole types. One is the earth or ground tag. One is the signal tag which will be connected to the tip of the jack plug when it is inserted. The third tag is the normalised tag, or NC (normally closed) tag. The NC tag is internally connected to the signal tag when a jack is not connected. This connection is automatically broken when you insert a jack. Note for the TRS (stereo) socket, this has five pins. Two of these are the normalised tags, you do not need to use these ones.

Once you have secured all the sockets to the front panel you now need to earth **all** the ground lugs. The simplest way is to do this is with pieces of non-insulated wire. This will create a wire frame connecting all the sockets’ lugs together. Then solder a small wire from the PANEL pad on the Mixer PCB to the wire frame. **Don’t use the module’s own ground (pin 2), since that will detract from the star grounding system.**

The input sockets are connected to the PCB with screened cable. For the third and fourth inputs, you need to use single screened cable. Use a nice thin type to give you a good deal of flexibility. For this cable connect the screen to the pad marked SC3 (or SC4). Connect the central conductor to IN3 (or IN4). With you sockets in place, connect the screen to the NC tag on the socket, and the core to the signal tag. Do not connect the screen to the ground lug. **This is totally different to what you have been told to do for MOTM modules**. The inputs will be normalised off with no jacks inserted.

For the first and second inputs, you need to use two bits of twin screened cable. Each bit has two conductive cores, and one screen. Connect the screen to the pad marked SC1 (or SC2). Connect one of the cores to IN1 (or IN2). Connect the other core in each cable to POS (or NEG). At the jack end, you must trim off any screen on both cables. Make sure it is not able to touch any other part of the circuit. Now connect the core that was connected to IN1 to the signal lug on the socket that is input one. Connect the other core in that cable to the NC lug. Follow the same pattern for the second input using the socket on input two.

The Master level pot is connected to the PCB either using very short insulated wires or twin screened cable. The former is probably the easiest. Connect the CW pad to the right hand pin of the pot as you look from the front with the pins facing down. Connect the CCW pad to the left hand pin of the pot. The WPR pad must connect to the middle pin of the pot. If you want to use screened cable, the screen must connect the CCW pad to the left hand pin of the pot.

The output sockets are wired with simple insulated wire. The OUT pad goes to the signal lug of the OUTPUT socket. The OUT+ is the hot output of the EBOS. This goes to the tip connection of the TRS socket. The OUT- is the cold output of the EBOS. It goes to the ring lug of the TRS socket.

If you have followed the suggested layout with EBOS IN and EBOS OUT sockets, then you must connect the NC lug of the EBOS IN socket to the signal lug of the OUTPUT socket. This will allow the EBOS to take the output of the mixer when no jack is inserted into the OUTPUT socket.

The LEDs are wired so that their anodes go to pin one of the boxed 2-pin pad, labelled PEAK and AMP accordingly. Pin one is the square pad. The pads are arranged so that you can use 0.1” headers if you wish.

At the rear of this user guide I have included a 1:1 drawing of the suggested front panel layout for a 2U Mixer panel. This will match a MOTM style panel, however, please note that the four mounting holes in each corner fit on a metric grid and are not the same as the MOTM standard.

Actual panels can be obtained from Schaeffer-Apparatebau of Berlin, Germany. The cost is about £25 per panel. All you need to do is e-mail the fpd file that is found on the Mixer web page on my site to Schaeffer, and they do the rest. The panel is black with white engraved legending. The panel itself is made from 2.5 mm thick anodised aluminium. The fpd panel can be edited with the Frontplatten Designer program available on the Schaeffer web site. Please note, the mounting holes are not compatible with the MOTM mounting rails. However, it should be a simple matter to alter these as required.

## What just one trimmer?

Yes, only one trimmer here! The simplest way to set this is to use a 1KHz sine wave, or thereabouts, and connect two scope probes on each of the hot and cold outputs. Set your scope to ‘ADD’, so that the two inputs are added together and displayed on the screen. Make sure both inputs are set to the same V/cm. Now adjust the BAL until you get no sinewave on your screen.

But I haven’t got a scope! Then just set the BAL trimmer to its middle position and leave it there. That’s it, all done.

## Final Comments

I hope you enjoy building the Mixer project. 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. The schematic is always the correct version, since the parts list is taken from the schematic. So if there is any problem, use the schematic as the guide. If you do notice any error, please get in touch. You will be credited on the ‘Updates and Mods’ page, and you may get a free PCB.

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 6 pm, British time.

Tony Allgood. March 2001

Version. 1.01

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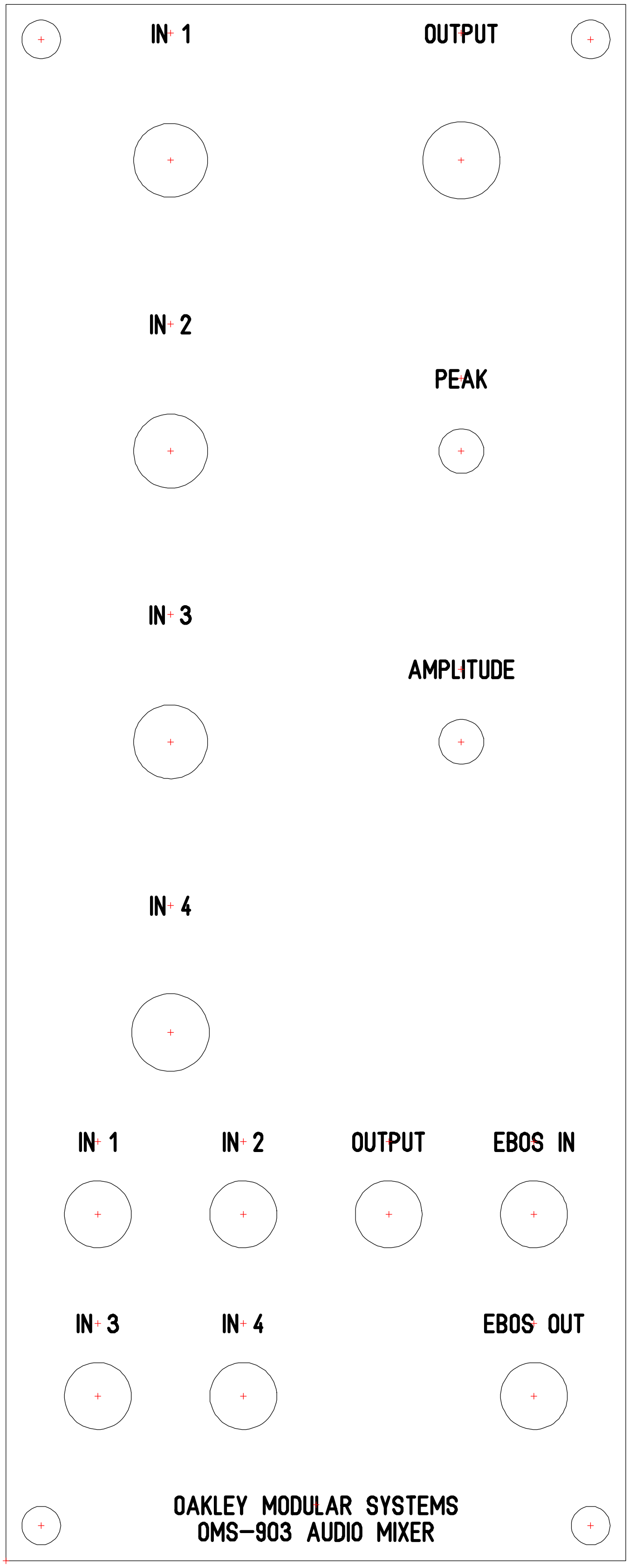
IN 1
OUTPUT
IN 2
PEAK
IN 3
AMPLITUDE
IN 4
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IN 2
OUTPUT
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IN 3
IN 4
EBOS OUT
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