Oakley Sound Systems
OMS-410

A companion module to the MOTM-410 Triple Resonant Filter

User's Guide

V1.01

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Introduction

The OMS-410 is a companion module to the MOTM-410 triple resonant filter module. It adds powerful new features to the superb Synthtech module. No component changes are needed to the MOTM module, and the two modules are connected together by one, two or three removable connectors hidden behind the front panels.

The OMS-410 allows you to add five new features to your MOTM-410

1. You now have three individual CV inputs to control each vactrol element of the MOTM-410. Each input is sent through a reversible attenuator, with a control knob on the front panel. This allows incredible tonal sweeps and modulations to be created. Its like having three separate voltage controlled filters in one module.

2. The MOTM-410's two internal VC-LFOs can now be accessed from the front panel. The OMS module shapes the internal LFO's outputs to give smooth sinewaves. Two separate VCAs allow these LFO waveforms to be level controlled individually or together. You can now use the MOTM-410 as a twin VC-LFO, whilst still using the MOTM-410 as filter module.

3. The three audio outputs of the MOTM-410 are combined to produce an outstanding stereo output. These outputs are especially designed to drive long cables and can be tailored to produced ordinary line levels for direct connection a to a mixer.

4. A pad switch can be added to select audio line signal or modular signal levels to be used with the MOTM-410.

5. An inverting amplifier is included on the board to allow for additional signal processing. This could be used to invert LFO2's output as on the MOTM-410.

The module is designed to fit into a 1U MOTM style panel. It requires the usual MOTM or Oakley power supply.

The OMS-410 and the MOTM-410 are connected together by one, two or three connectors. The number of which is determined by the options chosen. The connectors are 0.1" Molex or MTA and can be simply removed if the modules need to come apart at anytime. The wires from the connectors are soldered to special key locations on the MOTM-410's PCB. No component changes are required to the MOTM-410, unless you are fitting the pad switch, where one resistor needs to be snipped out.

Of Pots and Power

There are three main control pots on the PCB. These are the reversible input attenuators. If you use the specified pots and brackets, the PCB can be held firmly to the panel without any additional mounting procedures. The pot spacing is on a 1.625” grid and is the same as the vertical spacing on the MOTM modular synthesiser. The PCB has four mounting holes, one in each corner should you require additional support which you probably won’t.

The design requires plus and minus 15V supplies. These should be adequately regulated. The current consumption is about 20mA. Power is routed onto the PCB by a four way 0.156" Molex type connector. Provision is made for the two ground system as used on all new Oakley modular projects, and is compatible with the MOTM systems. See later for details.

Circuit Description

As with many electronic circuits the OMS-410 can be split up in several little chunks. Grab hold of the schematic now and let's run through each bit in turn.

The reversible attenuators are three identical circuits, each based around one dual op-amp. Since they are all the same, we will concentrate on just the first one.

IN1 is the signal input coming directly from the input socket on the front panel. R47 provides a high resistance pull down to prevent static damage. The signal now goes two ways. The first is through U6 (1,2,3). This is configured as our old friend the voltage follower. The circuit sniffs the input voltage, and presents the same voltage at its output, pin 1. Current may be taken out of this output without affecting the input. It acts as a buffer to the signal

The second path is through the other half of the op-amp. This part is wired as a inverting amplifier with a gain of -1. The minus sign indicates an inversion. For example, an input signal of +2V is turned into a voltage of -2V at pin 7.

The IN-1 pot simply allows the wiper to be moved to either the output of the inverting amp or the output of the buffer amp. When it is turned towards the inverting amp, the signal at its wiper is derived solely from the inverted signal. When it is turned towards the buffer, the signal at the wiper is merely a copy of what is at the input. At the middle of the pot's track the outputs from the two op-amps will meet and completely cancel. Therefore, when the wiper is turned so that it sits in the middle of its travels, there is no output signal at all.

R57 turns the voltage at the wiper to a current to then be sent to the Vactrol controlling node on the MOTM-410. Each of the three reversible attenuator's current outputs are sent to the MOTM module via a five way interconnect, labelled '410-CV'. The remaining two poles on this header are used to transport the MOTM's LFO outputs to the sine shapers and VCAs in the OMS-410.

To create the stereo output we need a stereo mixer. U3 performs this simple function very well. The top half of U3 deals with the left hand signal, while the bottom half of the op-amp deals with the right hand side. Of course, there is no difference between the two sides, but we will stick to this nomenclature to avoid wiring confusion.

The individual band pass outputs of the MOTM-410 are taken via a three way interconnection to the '410-AUD' header. 'OUT 1' goes to the left hand side and is mixed with a proportion of 'OUT 2'. The voltage gain of the mixer is set to be -0.1 for 'OUT 1'. This will reduce the very hot MOTM and Oakley Modular levels to something more like ordinary line levels. Change R36 and R35 to 100K if you wish to retain the 'hotness' of your signals. Note that mixer is configured to invert the signals. The inversion can be tolerated since the band pass outputs are already inverted compared with the audio input to the MOTM-410. Thus the further inversion merely turns all signals the right way around again.

The right hand signal mixes ‘OUT 3’ with a smaller proportion of ‘OUT 2’. Thus, ‘OUT 1’ is panned hard left, ‘OUT 3’ panned hard left and ‘OUT 2’ is sent equally to left and right. To keep the overall volume levels the same for each output, ‘OUT 2’ must be about 70% lower than the other two, since it is being sent to both outputs.

C11 and R38 (and C10 and R37) form a compensation circuit to allow the op-amp to drive fairly high capacitive loads. It has no effect on the audio performance, but reduces any chance of high frequency ringing in long cable runs. 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 with great success.

The MOTM-410 incorporates two voltage controlled low frequency oscillators (VC-LFO). These are controlled by one control voltage (CV), but are essentially separate in every other way. The OMS-410 uses the two triangle output waveforms of the MOTM’s VC-LFOs to create two sinewave outputs that can be controlled in level by another CV.

Each sine shaper and voltage controlled amplifier (VCA) is identical, although the suggested panel layout actually combines the level CV for both VCAs. The design is almost identical too to that found already within the MOTM-410.

LFO1 is the input signal derived from the triangle output of the VC-LFO. It is first attenuated by R54 and R55 before going into U7 the VCA. The amount of attenuation is chosen carefully so that it deliberately overdrives the VCA’s input circuitry by a small amount. This overdrive produces a rounding off of the triangle's sharp edges creating a sine-like waveform. It is not perfect, but good enough for control purposes in a synthesiser.

The VCA is not really a VCA as such, its an operational transconductance amplifier (OTA). Its a sort of very basic op-amp with some crucial differences. The output signal is a current and it can be fed into the inverting input of an op-amp inverter (U5) to get a voltage. R46 sets the transimpedance of the inverter. In other words how much current produces how much voltage. The output is sent via the usual 1K output resistor to the front panel socket.

The gain of the OTA can be changed and is set by the current into its Iabc pin. In this case, pin 1. R27 turns the input CV into a current which is level shifted by Q1 to drive the OTA. D3 prevents any negative going CVs from damaging Q1. R28 and R29 allow a set amount of current to flow into Iabc, when there is no jack connected to the CV in. This means that you will always get a LFO output from the OMS-410, unless you deliberately force the input CV to zero volts with an external signal. This disadvantage of this system is that the input resistance is quite low, about 10K or so. This shouldn’t bother most people. If you are worried by this you can omit R29 and make R28 a 62K resistor, which should still work. If you are fitting the second CV control, then do the same for R31 and R32.

The second VCA and sine shaper can be controlled by its own CV input circuitry, based around Q1. However, in the suggested layout only one CV level input is available due to limited front panel space. Here a wire link, LK, is fitted and the two VCAs operate together. The CV2 circuitry should not be fitted if this is the case. If you are fitting the second CV input, then make R45 and R46 22K resistors. This will prevent the LFO outputs being too large with Iabc not being shared by the OTAs.

Also included on the OMS-410 board but not on the suggested front panel is an additional inverter circuit, based around U1. This will allow you to create a third LFO output that will mimic the inverted LFO in the MOTM-410. However, if you have the panel space you could also use it as a separate inverter circuit for any other CV or audio signal.

There is one bit of circuitry left in the OMS-410 to explain. Its just a simple resistor which, in conjunction with a front panel switch, allows you to select the input pad on the MOTM-410. The resistor is R10 and is connected to the switch via solder pads SW1 and SW2. The 2-way header 'PAD' is the interconnect between the MOTM and OMS modules. If this is to be used you must snip, or not fit, the optional resistor on the MOTM-410. The exact connection details will be given later in this document.

Feel free to make any changes to the circuit to improve or alter the performance. If you do, do drop the Oakley-Synths mailing list an e-mail and tell us all what you have done.

Components

Most of the parts are easily available form your local parts stockist. I use Rapid, RS Components, Maplin and Farnell, here in the UK. In North America, companies called Mouser, Newark and Digikey are very popular. In Germany, try Reichelt, and in Sweden you can use Elfa. All companies have websites with their name in the URL.

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. The pots are 47K linear types and are sold by Maplin, CPC and Rapid Electronics here in the UK. The brackets can be obtained directly from Omeg. I sell both the pots and the brackets as a pot kit.

The resistors are generally ordinary types, but I would go for 1% 0.25W metal film resistors throughout, since these are very cheap nowadays. For the UK builders, then Rapid offer 100 1% metal film resistors for less than 2p each!

For the capacitors, there are no set rules. All the electrolytics should be over 25V, except where stated, and radially mounted. However, don't chose too higher voltage either. The higher the working voltage the larger in size the capacitor. A 220V capacitor will be too big to fit on the board. 25V or 35V is a good value to go for.

Five of the other capacitors are low value 33pF ceramic capacitors. They have a lead spacing of 0.2". 0.1" types can used if the leads are pre-bent with care before putting them into the board. The remaining three capacitors are polyester types, with a 0.3" lead spacing. The actual type is not critical, although the board has been laid out for polylayer types which are sold by Farnell. Chose a working voltage of typically 63V or 100V. 450V versions will be too big to fit on the board.

L-1 and L-2 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.

The BC560 transistors can be any general PNP transistor that has the same EBC pin out.

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. You can use OP-275, TL072 or NE5532 for U3. The OP-275 is specified for low noise and small DC offset. However, you will find that the difference in performance between the TL072 and the more expensive OP275 is very small.

U7 is specified as a LM13700, but you can also use the older LM13600 or Phillips' part, the NE5517. All will behave identically in this application.

Please be careful with the orientation of the electrolytic capacitors, diodes and the transistors. All the ICs have pin one to the top.

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, 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. Make sure the board is fully dry before switching it on.

I would make the board in the following order: resistors, diodes, IC sockets, small capacitors, transistors, 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.

Parts List

The components are grouped into values, the order of the component names is of no particular consequence. Please read the above section for more details about the parts used in this module. NB. 4R7 is 4.7 ohms. 4K7 is 4 700 ohms.

The * by any component means that it is an 'optional' part. Do not fit these parts if you are making the suggested front panel. The Options section, later in this document, will give more details on what components need to be fitted for your the other options.

This is an early issue of the documentation, I have checked the parts list, but I can miss things. If in doubt, check against the circuit diagram, this is always correct. Please e-mail me or the Oakley-synths mailing list if you find any discrepancies.

Resistors

Resistors 1/4W, 5% or better.

4R7	R42, 50
100R	R15*, 37, 38
1K	R33, 34
2K2	R55, 56
10K	R48, 39, 19, 36, 35, 18*
22K	R29, 27, 43, 44, 31*, 30*, 45*, 46*
33K	R28, 32*
47K	R45, 46, 16*, 17*
100K	R49, 51, 57, 40, 52, 41, 20, 22, 53, 23, 26, 54, 58
150K	R24, 25
220K	R47, 21, 14

Capacitors

22uF, 25V electrolytic	C13, 16
100nF, 100V polyester	C7, 9, 14
33pF ceramic	C10, 11, 8*

Discrete Semiconductors

1N4148 or 1N914	D3, 4*
BC560	Q1, 2*

Integrated Circuits

TL072	U2, 4, 5, 6
OP275	U3
TL071	U1*

Other

4-way 0.156” Molex/MTA connector	PSU
5-way 0.1” header and plug	410-CV
3-way 0.1” header and plug	410-AUD
2-way 0.1” header and plug	PAD*
Wire link, eg. resistor lead clipping	LK for suggested panel layout
47KA linear single gang variable resistor	3 off
Three pot brackets to suit	
Leaded or taped ferrite beads	L-1, L-2
1m of multistrand hook up wire	
Three knobs	
Eight decent quality jack sockets, eg. Switchcraft 112	

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

Important: Mounting the Omeg 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. Now fit them into the appropriate holes in the PCB. But only solder the three pins that connect to the pot. **Do not** solder the pot bracket at this stage. When you have 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.

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

Connections

There are several options for this module. At the back of this document I have included three examples of front panels. The first one is the suggested layout and is the one shown on the website photographs. It has the three reversible attenuators, two LFO outputs, but with only one VC level control input, and includes the stereo mixer. The second one has MOTM standard socket spacing, so has two sockets less than the suggested layout in which we loose the stereo mixer. The final one has every option available and is 2U wide.

All the options have things in common. They all need power, and they all use the ‘410-CV’ header.

The power socket is 0.156” Molex/MTA 4-way header. Friction lock types are recommended. This system is compatible with MOTM systems.

Power	***Pin number***
+15V	1
Module GND	2
Earth/PNL	3
-15V	4

The PNL 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.

If you have used Switchcraft 112 sockets you will see that they have three connections. One is the earth 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. In the OMS-410, we have no use for the NC lugs.

The ground tags of each socket can be all connected together with solid wire to make a simple frame. A single piece of insulated wire can then be used to connect all the tags to the PNL pad on the PCB. Do not connect the ground tags to any other ground.

The suggested layout uses eight sockets, and wiring them up is straightforward enough. Use multistrand hook up wire to connect each socket's signal lug to the relevant pad on the PCB. There is no need to use screened cable for such short runs. Keep the wires short but not taut. If you do insist on using screened cable then connect the screen to the socket's ground lug. Leave the screen unconnected at the PCB end. Use a bit of heatshrink tube to keep the end from fraying.

The PCB uses slightly different nomenclature for the sockets and pads. The following table shows which one is connected to which.

PCB pad	**Front panel socket**
IN1	CV1
IN2	CV2
IN3	CV3
LFO1	LFO OUT 1
LFO2	LFO OUT 2
CV1	LFO MOD
L	MIX L
R	MIX R

Right you have now completed the OMS-410. Now to wire the interconnects. You need a 5-way 0.1" female plug. These are normally designed to be crimped but they can be easily soldered with care. Make each wire to be 25cm long. I normally strip back the wire by just 2 to 3mm. Place all the bare wire into the crimp on a heatproof surface. I use 12mm MDF board to protect my bench top, which although not at all burn proof will take plenty of heat from a soldering iron without damage. Rest a pair of pliers on top of the wire to hold it in place and then solder it in. Do not use the water washable flux solder in this application. You must use either good old fashioned ersin or rosin flux based solders or the newer so called 'no-clean' types. I actually prefer the rosin based ones for this because I find they flow better. Once you have soldered it, wait a bit for it to cool, and then push it into the housing until it clicks. If it doesn't go in, then take it out and bend the crimp slightly backwards. Now try again.

I like to use as many different colour wires as possible. It makes wiring easier and looks great. A good source of cheap insulated multistrand wire is 'def-stan' 8-way multicore cable. You'll have to strip off all the outer casing, but its actually cheaper, than buying separate reels of each colour. The type I use is the one with eight 7/0.2mm insulated wires.

For the 410-CV interconnector you need to make the last two wires, pin 4 and 5 of the connector slightly shorter. Cut them down to 20cm only. Each wire now needs to be soldered onto key points on the MOTM-410 pcb. Trim back the loose end of each wire to leave 3mm of uninsulated wire. Tin the end to make sure they are going to solder well. Solder each end onto the top side of the MOTM pcb by adding just a slight amount of extra solder to secure the wire. The wires must be put into the correct positions for your module to work properly. Hold the MOTM module so that the panel is on the right, and the pcb is facing you. We will deal with each pin of the 0.1” socket in turn.

Pin 1: connect to the right hand end of the 2K7 resistor that is next to Q7. Its R54 but its hard to see.

Pin 2: connect to the right hand end of the 2K7 resistor that is next to VR3 and below R56.

Pin 3: connect to the right hand end of the 2K7 resistor that is above VR4. It is labelled R60.

Pin 4: connect to the right end of the 33K resistor next to U5. It is labelled R33

Pin 5: connect to the left hand end of a 33K resistor next to U5. It is not labelled, but it is below R20 and above R34.

Thats all the CV inputs and LFOs sorted. Now we need to connect up the stereo mixer. You need to connect up the three way 0.1" molex, ‘410-AUD’. Again use 25cm long wires for each wire.

Pin 1: connect to the right hand end of R3 down the bottom.

Pin 2: connect to the right hand end of R6.

Pin 3: connect to the right hand end of R9.

That completes the wiring of the interconnects for the standard suggested panel. You are now ready to go and try it out.

For the second panel design, we are not using the stereo mixer. Thus you can omit the following parts on the PCB; U3, C10, C11, R35, R36 and R23-26. We have no need for the 410-AUD interconnect either, and only use the 410-CV interconnect.

For the third design, everything that can be added has been. It needs a 2U wide panel, and features the pad switch and inverter circuit. Don’t forget all component locations are filled on the PCB, except LK which is not needed. Use 22K resistors for R45 and R46.

The interconnects are wired as the suggested layout but you also need to wire up the PAD interconnect too. This is a simple two way header. Make up the wires as before, again, 25cm long wires should be ample. This time twist the wires together tightly to form a twisted-pair cable.

On the MOTM module you need to snip out R68 if you have fitted it. Now connect one of the wires to the one of the pads where R68 used to be, and connect the other wire to the other end of where R68 used to be. It doesn't matter which one is which.

Panels can be obtained from Schaeffer-Apparatebau of Berlin, Germany. The cost is about £25 per panel. For the suggested layout all you need to do is e-mail the fpd file that is found on the OMS-410 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 2.5mm thick anodised aluminium. The fpd of the panel can be edited with the Frontplatten Designer program available on the Schaeffer web site.

Final Comments

I hope you enjoy building and using the Oakley OMS-410 with your MOTM-410. 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. I do offer a get-you-working service. Send your completed non-working module back to me with £10 and I will fix it for you. You will also have to pay for the postage both ways, and for any replacement parts needed. Make sure you wrap it carefully and include a full description of the fault.

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 if its a real howler.

Please further any comments and questions back to me, your suggestions really do count. 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.

Last but not least, can I say a big thank you to all of you who helped and inspired me. For this module in particular, I would like to thank Paul Bower for initial design testing. Thanks also to all those nice people on the Oakley-synths and MOTM mailing lists.

Tony Allgood. May 2001

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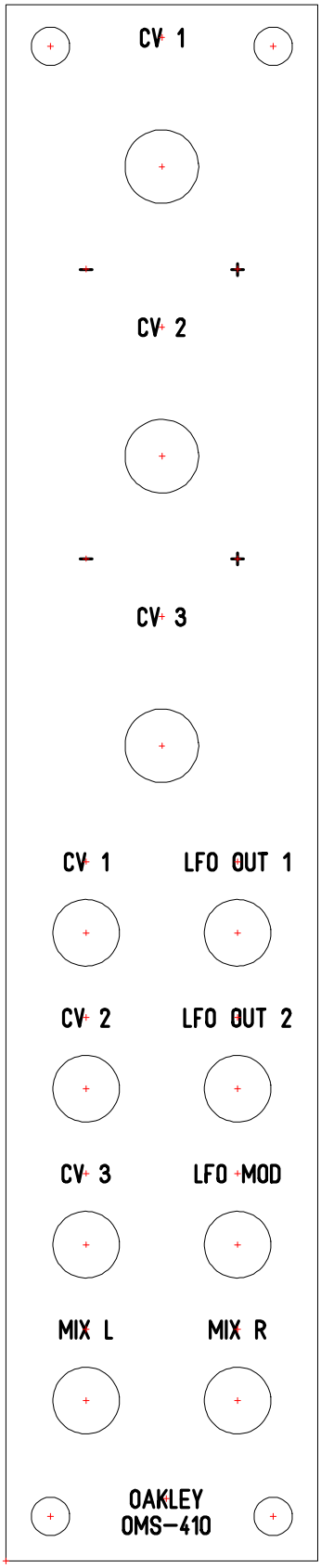
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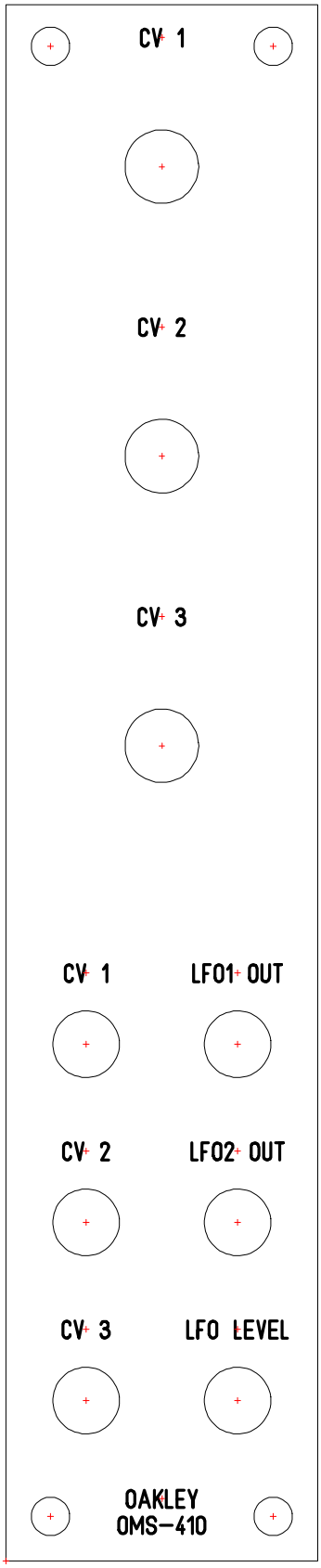
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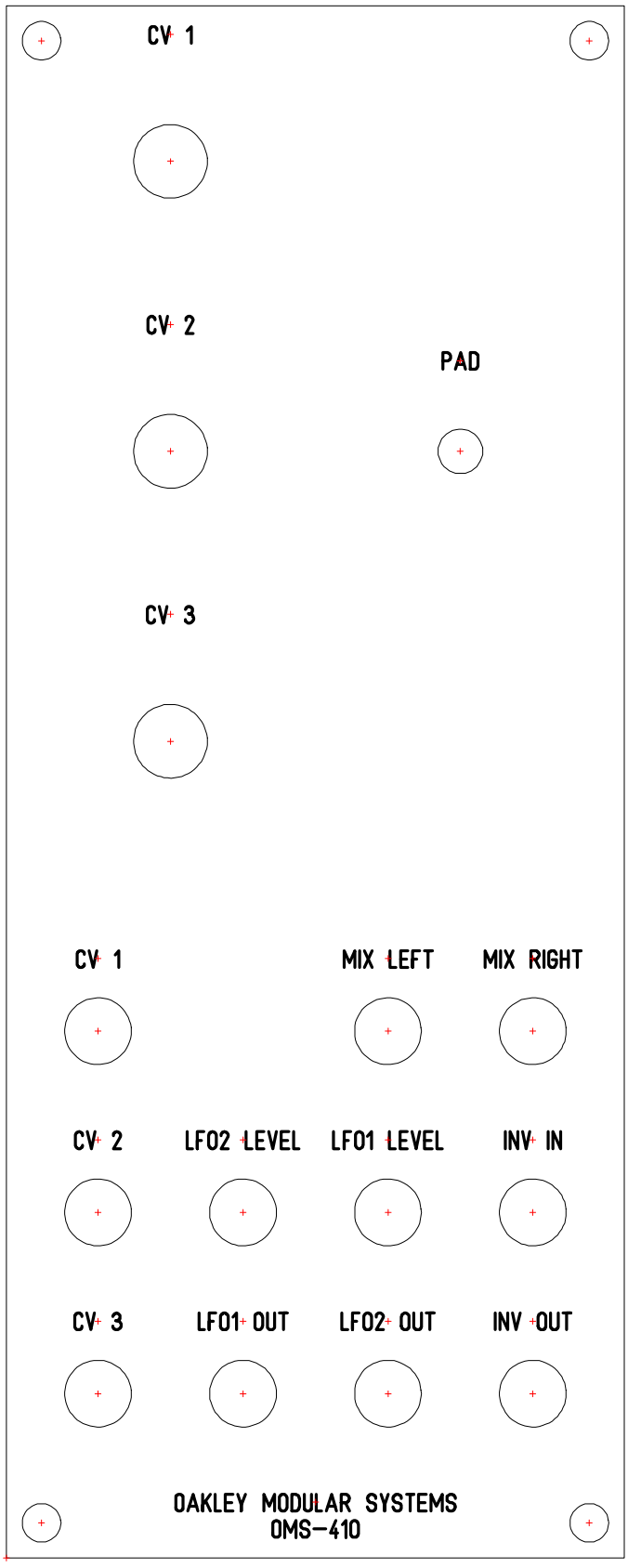
LFO LEVEL
OAKLEY
OMS-410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CV 2
PAD
CV 3
CV 1
MIX LEFT
MIX RIGHT
CV 2
LFO2 LEVEL
LFO1 LEVEL
INV IN
CV 3
LFO1 OUT
LFO2 OUT
INV OUT
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