Oakley Sound Systems
midiDAC2
Single Channel midi-CV Convertor

User's Guide

Version 1.5

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Introduction

The midiDAC2 is a single channel midi to analogue convertor. This project is a joint development between the author and Trevor Page. Trevor wrote the firmware for the processor, a **PIC16F84** running at **10 MH**z.

The midiDAC is designed to drive any 1V/octave synthesiser or modular system. Let us first have a look at the different outputs available.

Gate: 3 available; +5V gate, +15V gate or Moog s-trigger

Pitch CV: 127 steps of 12 bit accurate pitch voltage conforming to 1V/octave (trimmable). Pitch bend is added to this signal, and the maximum bend interval can be adjusted from a front panel control.

Velocity: 0 to 10.7V proportional to midi note on velocity.

Aftertouch: 0 to 10.7V proportional to midi channel aftertouch.

Slide: This signal goes to +5.3V when two notes are played at the same time. This can allow slides to be activated at will; TB303 style. An optional external switch may be used to override the automatic activation of slide. Slide may be turned off by transmitting the standard midi glide/slide command.

Plus one uncommitted output: which can be either CC102 and Note-off (release) velocity. The choice of which is set by either fitting a resistor or omitting it.

The outputs are available on three sets of 4-way 0.1" connectors at the base of the board. The design also features a midi thru.

This new issue of the original midiDAC differs in a few aspects:

1. The setting of the various modes has been greatly simplified.

2. Gate and Slide LEDs are now included

3. TB3030/3031 features are now not implemented. The 3031 now has its own midi-CV convertor called the tbDAC.

4. I have improved noise levels that were affecting the +15V line. Additional suppression has been added to the de-mpx circuitry.

5. Board layout has been improved. There are no modifications to be done, and the crystal now fits perfectly.

6. I have improved tuning stability to power supply fluctuations.

7. Board size has slightly increased.

Please note: this product does not support the use of V/Hz or linear VCOs. These are found on some Yamaha and Korg analogue products, and just one Roland, the SH-2000.

Power Requirements

The module requires a split supply of +/-15V at around 30mA each rail..

Two sets of 0V or ground are required. This is to keep the analogue ground as distinct as possible from the noisier digital ground. Both grounds are required for correct operation of the midiDAC. They must be both connected to the power supply's star point or common ground bus. If you have a complete Oakley Modular System, do not directly connect the midiDAC's power supply to the same power bus as the modules, unless you have a complete *star distribution* system. Connect it direct to the relevant power supply output pins. This will, of course, be still connected to the same power rails as the modules but the **path** to the power supply will be separate and distinct.

Other Features

The midiDAC also includes a TB303 style slide circuit. This can be turned either by pressing a switch, or by playing two notes at once. The pitch will glide up or down to the most recently pressed note. A pot can control the speed of the slide, or you can simply leave it fixed at one value by choosing a suitable resistor.

There is a note stack within the firmware to allow the midiDAC to remember notes pressed. Thus if two or more notes are pressed at the same time, the oldest notes will be remembered so that if the more recent notes are removed the pitch will return to the still pressed older notes.

Note retriggering is option that can be changed on the fly. A simple switch or link can be used to select whether it is on or off. Ordinarily, when a note is pressed the gate always goes high. However, if a second note is pressed while another is still held down, the pitch CV will change but the gate remains high. The envelope generators on your synth will not retrigger. This is typical of Moog synthesisers. It can be useful. 'Retriggering' allows the gate to drop momentarily when any new note note is pressed if there is a note already down. Thus, when the pitch CV changes, the envelopes will be retriggered, just like a normal note. This allows fast keyboard runs to be easily achieved. The suggested panel layout does not incorporate this switch as I prefer to always have re-trigger switched on.

The midiDAC features a built in midi THRU port. This essentially produces a copy of the midi input signal which can be then fed to another midi unit. Due to the design of the midiDAC's drivers, this section adds small delays to the midi signal. These delays can build up if the midiDAC is used to drive another midiDAC. Using two midiDACs in series should be fine, but driving a third from the THRU output of the second may not work. The last midiDAC in the chain may produce erroneous results. It is recommended that you use a multi THRU port device to drive more than two midiDACs.

The Printed Circuit Board

The PCB has been designed to fit within a 2U across MOTM style modular face plate. The size of the board is 14.7 cm high and 11.3 cm deep. It has three PCB mounted pots to facilitate TUNE, BEND DEPTH and SLIDE RATE. These do not have to be fitted for correct operation of the unit, but are there as an option. The pots are spaced at 1.625".

Midi channel is selected by four lines in ‘traditional’ binary fashion. Thus midi channel can be switched by either onboard DIP switches or links, or by a 16 position rotary HEX switch mounted on the front panel. I tend not to change midi channel once I have built the unit, so I use DIP switches only. Because of this, there is no midi channel selector on the suggested front panel layout. However, the board is equipped to take a 0.1” header to allow simple connection to a rotary HEX switch.

The PCB is double sided, has through plated holes, solder mask both sides and has full component legending. Power is admitted to the board via 0.156" Molex connector, just like the MOTM modules.

The PCB has four mounting holes, one in each corner. However, using the midiDAC with the recommended pots and brackets, will give you sufficient support without the need for additional mounting hardware. The pots are from the Omeg Eko E-16 range, supplied by Maplin, CPC and Rapid Electronics here in the UK. I carry stock of these items and the matching brackets should you need to obtain them. The prices are on my web site.

Circuit Description

The midi data is electrically isolated by U2, a simple transistor output opto-coupler. The output of U2 is pulled up via R20 and R27. The voltage drop across R27 is enough to drive the ‘midi-thru’ circuit based around Q1 and Q3. R26 sets the gain of the opto coupler. Most CNY17-3 opto-couplers seem to be happy with this value at 220K. However, one example of a CNY17-3300 I had, required R26 to be 33K to reduce data skew in the ‘midi-thru’ circuit. This bizarre behaviour is not easily explained, but if you have problems with the loosing midi data with ‘midi-thru’ port, lower the value of R26 to 100K first and then 33K. Even so, because of these accumulative timing delays I do not recommend using more than two midiDAC units on one midi ‘daisy chain’.

Notice the midi out connector requires the middle pin to be grounded for shielding purposes.

The heart of the midiDAC is a preprogrammed PIC16F84-10. This is where Trevor’s firmware is located. X1, a 10 MHz crystal provides the necessary timing for the PIC’s internal oscillator. For more details on the operating system of the PIC see the ‘Firmware Data’ section.

Seven of the PIC’s output lines directly drive a 12-bit DAC, U7. All the other data input lines to the DAC are tied low, we only need the top 127 (7-bit) levels of the available 4096 (12-bit). Why use only the top seven? Firstly, midi data is arranged in the main in blocks of seven bits. For example there are only 127 notes that a normal midi keyboard can send out. Secondly, the PIC does not perform any CV scaling or tuning. This is sometimes used on other midi-CV convertors to generate ADSR and pitch bend information that is then merged in the digital domain to the pitch data. 14 or 16 bit DACs are required for this. We do all of our CV processing in analogue hardware. Thus slide time and pitch bend can be simply controlled by a pot or a trimmer. So why not use an eight bit DAC? Well 8-bits, although it gives us 256 steps to play with, the accuracy of the steps is only plus and minus 1/512 of the highest output voltage of the DAC. That is an error of 0.2%. This may not sound much, but it does matter. In musical terms, this means that a semitone between one pair of adjacent notes, will be different to a semitone between another pair. Tim Orr, of EMS fame, reckoned that at least 10-bit accuracy was required for users not to **hear** any difference in the steps. I have chosen to use 12-bits, because 12 bit DACs are cheapish and easily available. Errors in a 12-bit DAC will be negligible compared to VCO tracking errors.

The 7545 and equivalents are ‘current output multiplying DAC’s. This means two other things are needed to get it to convert digital data to an analogue voltage. Firstly, you need a very accurate reference voltage. This will set the maximum output voltage that the DAC circuit will supply. For the standalone midiDAC the reference comes from a 10V precision reference IC, U9. A multiplying DAC will invert the reference signal applied at pin 19. So to get a positive output from our DAC, we have invert the 10V reference with U11a. This is a precision op-amp, configured as an inverting amplifier. Note, that the exact gain can be trimmed using the V/OCT trimmer to allow precise setting up of the 1V/octave output. To do this we actually need -10.67V at pin 19. Lets see how we get this value:

There are 12 notes in one octave, and a jump of 1V must represent one octave when applied to a VCO. Thus, 1/12 = 0.083333V or 83.3mV per semitone step in a perfect DAC. There are 127 notes in the midi scale, so the highest voltage must be 127 x 83.3mV = 10.58V. Add to this the lowest bits that have been connected to ground on the DAC, these essentially count as a semitone gap that can never be played. This gives us -10.67V at pin 19. Accurate setting of this is only of real significance if you are using the midiDAC with several other synths.

The second item the DAC needs to create a voltage output, is a current to voltage convertor. This is strapped onto the output of the DAC, and in practice it simply consists of a single op-amp. This is U10. It needs to be accurate, have low drift over time and be fast settling. I have chosen an AD711 by Analog Devices, other devices are also suitable, and some success can be had with a TL081. C17 provides stability.

Notice, that the op-amps and reference have separate grounds to the digital parts of the circuit. They have a different symbol on the circuit diagram like an upside down triangle. This is called 'analogue ground’. It is at the same potential as digital ground and both are connected at the star point within your system’s power supply. The theory is that any current spikes on the digital ground do not manifest themselves as voltage fluctuations on the sensitive analogue ground.

The DAC’s output is constantly varying. All 8 outputs, sent as a stream of 7-bit words from the PIC, are represented by this fluctuating output. Each output has its own time slot, and each output takes it in turn to control the DAC. This gives rise to a waveform that has eight distinct sections that continuously repeat, once every 4000th every second.

The demultiplexer based around U5 will direct each of these eight outputs to its own output section. U5 is like an electrically controlled rotary switch. The PIC controls this switch via the level shifters, Q2, 4, 5 and 6. The switching is tied in directly to match the output of the DAC so that the correct order of the time slotted output go to the correct destinations. The PIC controls U5 so that the output of U10 has settled accurately before allowing it through to the next stage.

Each output section is called a ‘sample and hold’, although to be strict the demultiplexer also forms part of the sample and hold. The capacitor in each S/H holds or stores the voltage that is briefly connected to it. The op-amp that is connected to it, allows this voltage to be ‘sniffed’ without effecting the actual value. The op-amps are connected as voltage followers or buffers. They have gain of 1. Thus, the sampled voltage can be found at the output of each op-amp. Note, that pitch CV and pitch bend use very low offset op-amps, U13, for accurate pitch control.

Some of the outputs are processed further before being sent to the output sockets. The gate signal which goes to Vref/2 when active, i.e. +5.3V when using a 10V reference, controls Q8 to produce an inverted gate signal. This goes from the positive supply rail to ground when activated. This in turn, controls another transistor, Q9. This produces the large gate signal, which goes to the positive rail when activated. The inverted gate maybe used to trigger some Moog synthesisers. These use s-trigger, a wire-OR type of output which triggers the synth when it is grounded. Omit R58 for this feature. The 15V gate signal will not be available if you use the s-trigger option. So it may be best to omit Q9, R59 and R57 as well.

The gate signal can also drive a LED. The LED is connected to a 2 pin header on the PCB, labelled ‘Gate’. Note that if you use the suggested layout, the LED may be mounted straight into the board for a tidy appearance.

The pitch CV is sent to the slide circuit. This circuit is based heavily on the slide circuit from the TB303, and, of course, the Oakley 3031. When the slide is not enabled, the first portion of the analogue switch, U6, is off. The pitch CV is then passed through the slide pot straight to the op-amp buffer, U3. The resistance of the slide pot has no effect on the CV because the input impedance of the buffer is very, very high. The second portion of U6 is on, and the capacitor, C7 is charged up to the CV voltage. However, when slide is activated, either by the PIC, or manually via the ‘GLIDE’ socket being shorted, the two sections of U6 swap states. The pitch CV now has to charge C7, via the slide pot, every time the CV changes. The higher the resistance of the slide pot, the longer it takes to charge up or down.

The slide signal can also drive a LED. The LED is connected to a 2 pin header on the PCB, labelled ‘Slide’. Again if you use the suggested layout, the LED may be mounted straight into the board for a tidy appearance.

The pitch CV is now added to the pitch bend in the circuit block based around U14. This is a simple op-amp summing circuit. The only special thing of note, is the need to add the pitch bend signal to the inverted reference signal. This allows pitch bend CV to be bipolar. The pitch CV from the S/H goes from 0V, bend low, to +Vref, bend high. We need the pitch bend CV to go negative when ‘bended’ low, and positive when ‘bended’ high. By adding the pitch bend CV to half the reference voltage allows this to be done. A pot, BEND, can be simply used to adjust the depth of bend, without altering the initial pitch of the VCOs.

Two forms of setting the initial pitch CV are provided. One is the TUNE pot mounted on the front of the panel. The other is INIT which is a multiturn trimmer that will allow precise setting of the initial pitch CV, and thus aid centralising the TUNE pot’s range. In this version of the midiDAC, the pot and trimmer take their end voltages from the reference voltage. This should lead to greater stability of the CV output even if the power supplies change slightly.

PIC Firmware Data Version 1.1

Operating Modes

Mode selection has been greatly simplified in this version of the midiDAC. Although the firmware has not been changed, the implementation of the mode selection on the PCB has. The previous issue of the midiDAC allowed the user to select between several modes. This proved confusing to many people, so I have made the selection easier by removing the number of options from four with three subsets to just two. This might sound like a regression, but many of the modes on offer were for the original TB3030. These have now been specifically dealt with in the tbDAC, and will not be needed for modular users.

The PIC generates 8 output control voltages when used with a single DAC and 8-channel demultiplexer:

Output	***CV generated***
1	Pitch CV
2	Pitch bend/lever
3	Note on velocity
4	Uncommitted 1, see below.
5	Channel aftertouch
6	Gate. -0.5 of Vref when active.
7	Modulation Wheel.
8	Slide. -0.5 of Vref when active.

We now have just one uncommitted output. This can either be continuous controller 102, or note release velocity. Now not all keyboards will generate release velocity data. See your controller keyboard’s midi specification for details. However, many sequencers will allow this value to be specified for any midi note recorded.

If you want release velocity from U/C1, then fit R11, which is a 7K5 resistor. If you want CC#102, then do not fit R11, and leave it blank.

Midi Channel selection

Midi channel is selected by four lines which must be either floating or be grounded. The simplest way to set midi channel is with a 4-way DIP switch. 0 is open and 1 is closed. Binary codes are being read pin **4** to pin **1**. Pin 4 is MSB, pin 1 is LSB.

Code	***Midi Channel***
0000	1
0001	2
0010	3
0011	4
0100	5
0101	6

0110	7
0111	8
1000	9
1001	10
1010	11
1011	12
1100	13
1101	14
1110	15
1111	16

For example, to set midi channel 6, set the DIP switch to 0101. That is, from positions 1 to 4:

1- on, 2- off, 3- on, 4- off.

Gate Trigger Modes

The midiDAC2 allows the selection of two gate trigger modes via the ‘Legato Mode’ switch. This is marked on the new PCB as ‘TRIG’. You can connect a simple SPST switch to this or a simple jumper. The setting of this switch/jumper determines how the gate signal responds to overlapping notes. Closing this switch, or fitting the jumper, enables multiple gate triggering for legato playing. This is the re-trig option. The gate signal is taken briefly low at the start of a new note, even if the fingers haven’t left the keyboard from the previous note.

With the switch open, or leaving the position blank, the gate does not retrigger for overlapping notes. This is the classic analogue keyboard method.

Legato Mode may also be enabled or disabled via the Legato Footswitch MIDI messages. If these messages are to be used, the Legato Mode switch on the midiDAC unit should remain in the off position.

Slide

Note that slide is always asserted if two notes are pressed at the same time. You can turn the effect off by simply turning the slide time to zero. You can turn it on permanently by shorting the ‘glide’ header.

midiDAC Implementation of MIDI Controllers

The following table summarises the MIDI controllers supported by the midiDAC firmware.

Hex	***Dec***	***Midi Controller Definition***	***Implementation on the midiDAC***
41h	65	Portamento (Slide)	On / Off Switches the portamento (slide) function
44h	68	Legato Footswitch	Controls the gate retrigger mode. 0 to 63 = off, 64 to 127 = on.

78h	120	All Sound Off	Silences all notes & clears accent/gate/slide. Data byte = 0 for this controller.
79h	121	Reset All Controllers	Centres Pitch Wheel and zeroes various controllers. Data byte = 0 for this controller.
7Bh	123	All Notes Off	Silences all notes & clears accent/gate/slide. Data byte=0 for this controller.
7Ch	124	Omni Mode Off	Unit responds only to selected MIDI channel. Data byte=0 for this controller.*
7Dh	125	Omni Mode On	Unit responds to any MIDI channel. Data byte=0 for this controller.*
7Eh	126	Poly Mode Off	All notes cleared*
7Fh	127	Poly Mode On	All notes cleared*

* In accordance with MMA specifications, all notes are cleared when these controller messages are received.

Note Priority

The midiDAC firmware uses last note priority. That is, it will assign the pitch CV to the last note to be held. However, all 'overlapped' notes are still retained in memory and are reactivated in order should the most recent notes to be held be released.

Copyright Notice

Please note: No permission is granted to copy in anyway, or alter, the PIC firmware provided on the midiDAC PIC. The PIC is copy protected and we will not tolerate any attempt at bypassing this protection. A lot of hard work has gone into the design of the firmware, please do not steal it from us. The firmware is not available separately.

Components

Most of the parts are easily available form your local parts stockist. I use Maplin, RS-Ltd, Rapid Electronics and Farnell, here in the UK. In North America, companies like Mouser, Newark, Allied and Digikey are very popular. In Germany, Reichelt are very good. And in Sweden, try Elfa.

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 sell the Omeg pots at a very good price, but not the brackets.

Many of the resistors are 1/4W 5% or better types. There are some 1% and 0.1% resistors specified. I have used 1% metal film throughout with no trouble.

The op-amps can be chosen to suit your own needs. You have the choice. I have selected good quality opamps, but these come at a price. However, prices vary from country to country. You may also have a few spare ones you would like to use. Trevor got his midiDAC to work on just TL07x opamps. These will drift more than the ones I have listed, but they will be a quarter of the price.

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.

The pitch spacing of the non-polar capacitors 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 look good. 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 physically larger BC-368 series. These are metalised polyester types, but again do be sure you get low working voltages. Around 63V to 100V is best. In the UK, Farnell can supply all the capacitors. Note that the pitch spacing of 0.3” is different to some of my more recently introduced modules which use 5mm throughout.

The low capacitance (values in pF) ceramics have a pitch spacing of 5mm (0.2”). These should be ‘low-K’ or C0G types. These are better quality than the usual ceramic capacitors used for decoupling and non critical applications.

L1 to L4 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 2R7 resistors with no real drop in performance. Some ferrite beads are bigger than others. If you find yours are a little too big to fit L4 and L3 next to each other, then simply swap the the positions of R61 and L3.

The midi channel selection is performed by a 4 way DIP switch. These are available in many different types, but get the ones with 0.3” spacing between the rows. This is the most common type anyway. Avoid the piano key style ones, since they can be very confusing... er, which way is on? Fit the switches so that switch one is towards the bottom of the board. LSB is then switch one.

The crystal is a 10MHz type. Low profile ones are now available and these can be used if you can get them. The usual types will fit no problem. However, it may be a good idea to not allow the crystal’s housing to lie up against the board’s surface. By allowing 0.5mm or so between the PCB and the bottom of the crystal’s case, you will allow water to wash away any flux, and prevent the case from touching the solder pads.

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.

The DAC can be any of the 7545 family. Examples of these include: AD7945BN, AD7545AKN and MP7545. The cheapest device seems to be the AD7945BN, and this has excellent specs. Farnell normally sell this part. But Analog Devices make this DAC very difficult to get hold of for us small customers, so you may have to go for the older but more available 7545. RS Ltd of Corby, England (not Radio Shack) have a good supply of AD7545AKN for a reasonable price. North American users can obtain any AD parts direct from the manufacturer, using their online ordering service.

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

A quick note on European part descriptions. To prevent loss of the small '.'as the decimal point, a convention of inserting the unit in its place is used. eg. 4R7 is a 4.7 ohm, 4K7 is a 4700 ohm resistor, 6n8 is a 6.8 nF capacitor.

Resistors

5% carbon or metal film ¼ W or better unless stated

100K	R10, 13, 58*, 50, 39, 34, 35
100R	R17
10K	R16, 6, 22, 25, 57, 64, 19, 24, 14
10K 1% metal film	R46, 62, 48, 63
10K 0.1% precision	R53
13K	R45
1K	R2, 3, 8
1M	R37
1K5	R20
20K 0.1% precision	R55
220R	R18, 28, 33, 27
220K	R26* see text
2K2	R23, 54
24K	R41
27K	R44
33K	R7
33K 1% metal film	R65
3K3	R51, 52, 5
390K 1% metal film	R47
47R	R61
4K7	R21, 9, 29, 30, 31, 32, 15
47K	R1, 4
470K	R59
5K1	R49
680R	R36, 38, 40, 42, 43, 56, 60
75R	R66

7K5	R12, (R11 = mode select)

Trimmers

Multiturn vertical mounted. Top adjustment

100K 22 turn cermet	INIT
10K 22 turn cermet	V/OCT

Pots

100K lin pot	TUNE
10K lin pot	BEND
470K log pot	SLIDE
Pot brackets	3 off

Capacitors

1000nF, 63V polyester	C8
100nF, 63V polyester	C24, 25, 10, 11, 4, 13, 7
10nF, 100V polyester	C15, 16, 18, 19, 20, 21, 27, 28, 14
18pF Low-K ceramic	C5, 6, 17
33pF Low-K ceramic	C29
47uF, 25V elect	C1, 2, 3, 9, 12, 22, 23, 26

Miscellaneous

10 MHz crystal	X1
Leaded Ferrite bead	L1, 2, 3, 4

Switches to select trigger mode and constant glide if required. SPST types.

Discrete Semiconductors

1N4001	D2
1N4148	D1, 3, 4
BC550/BC549	Q2, 3, 4, 5, 6, 7, 8, 9
BC560	Q1
LEDs	2 off for ‘slide’ and ‘gate’ indicators.

Integrated Circuits

4051	U5
4066	U6
7805	U4
7545* see text	U7
CNY17-3	U2
LF412 or LT1057	U13
AD711	U10
OP77 or OP177	U3

LT1013 or OPA2277	U11, 14
PIC16F84-10	U1 (preprogrammed by Trevor Page)
REF-01	U9
TL082/TL072	U12
TL084/TL074	U8

Connectors

4-way Molex 0.156” header	1off (power)
4-way 0.1” header	3 off (CV and gate outputs)
3-way 0.1” header	1 off (midi thru)
2-way 0.1” header	1 off (midi in)

Don’t forget the sockets for connecting the midiDAC to the outside world. eg. 5-pin DIN sockets for the midi.

You may well want to use sockets for the ICs. I would recommend low profile turned pin types as these are the most reliable. You need seven 8-pin DIL, two 14-pin DIL, one 16-pin DIL, one 18-pin DIL and one 20-pin DIL.

Building the MidiDAC

Occasionally people have not been able to get their Oakley projects to work first time. Some times the boards will end up back with me so that I can get them to work. To date this has happened only four times across the whole range of Oakley PCBs. The most common error with three of these was parts inserted into the wrong holes. Please double check every part before you solder any part into place. Desoldering parts on a double sided board is a skill that takes a while to master properly.

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, but do not wash a board with any trimmers, switches or pots on it. These can be soldered in after the final wash with conventional solder or the better new type of ‘no-clean’ solder.

All resistors should be flat against the board surface before soldering. It is a good idea to use a ‘lead bender’ to preform the leads before putting them into their places. I use my fingers to do this job, but there are special tools available too. Once the part is in its holes, bend the leads that stick out the bottom outwards to hold the part in place. This is called ‘cinching’. Solder from the bottom of the board, applying the solder so that the hole is filled with enough to spare to make a small cone around the wire lead. Don’t put too much solder on, and don’t put too little on either. Clip the leads off with a pair of side cutters, trim level with the top of the little cone of solder.

Once all the resistors have been soldered, check them ALL again. Make sure they are all soldered and make sure the right values are in the right place.

The diodes can be treated much like resistors. However, they must go in the right way. The cathode is marked with a band on the body of the device. This must align with the vertical band on the board. In other words the point of the triangular bit points *towards* the cathode of the diode. When all the diodes are in place, double check all are pointing the right way.

IC sockets are to be recommended, especially if this is your first electronics project. Make sure, if you need to wash your board, that you get water in and around these sockets.

The transistors are all in the same type of packaging and therefore look the same. Make sure you get the NPN and PNP types in the correct places. Only the numbers on the side will allow you to tell them apart. Match the flat side of the device with that shown on the PCB legend. Push the transistor into place but don’t push too far. Leave about 0.2” (5mm) of the leads visible underneath the body of transistor. Turn the board over and cinch the two outer leads on the flip side, you can leave the middle one alone. Now solder the middle pin first, then the other two once the middle one has cooled solid.

Sometimes transistors come with the middle leg preformed away from the other two. This is all right, the part will still fit into the board. However, if I get these parts, I tend to ‘straighten’ the legs out by squashing gently all the three of them flat with a pair of pliers. The flat surface of the pliers parallel to the flat side of the transistor.

For the 7805 regulator IC, it may be necessary to preform the leads before putting them into the board. I use a pair of fine nosed pliers to bend the middle leg outwards. I bend the lead firstly near the body of the device at an angle of 45 degrees. Then where the metal leg thins, I bend it again so that it becomes parallel to the other two. The device should then fit snugly into place on the board.

The polylayer capacitors are little silver oblongs. Push the part into place up to the board’s surface. Little lugs on the underside of the capacitor will leave enough of an air gap for the water wash to work. Cinch and solder the leads as you would resistors.

The electrolytic capacitors are very often supplied with 0.1” lead spacing. My hole spacing is 0.2”. This means that the underside of these radial capacitors will not go flat onto the board. This is deliberate, so don’t force the part in too hard. The capacitors will be happy at around 0.2” above the board, with the legs slightly splayed. Sometimes you will get electrolytic capacitors supplied with their legs preformed for 0.2” (5mm) insertion. This is fine, just push them in until they stop. Cinch and solder as before. Make sure you get them in the right way. Electrolytic capacitors are polarised, and may explode if put in the wrong way. No joke. Oddly, the PCB legend marks the positive side with a ‘+’, although most capacitors have the ‘-’ marked with a stripe. Obviously, the side marked with a ‘-’ must go in the opposite hole to the one marked with the ‘+’ sign. Most capacitors usually have a long lead to depict the positive end as well.

I would make the board in the following order: resistors, IC sockets, small non-polar capacitors, transistors, electrolytic capacitors. Then the final water wash. You can now fit the trimmer to the board with no-clean or ordinary ‘ersin’ flux solder. Do not fit the pots or the LEDs at this stage. The mounting of the pots requires special attention. See the next section for more details.

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. 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.** Now remove all the nuts and washers from the pots and fit the board up to your front panel. Refit the washers and tighten the nuts, but not too tight. Now carefully position the PCB at right angles to the panel. The pot’s own pins will hold the PCB fairly rigid for now. Then you can solder each of the brackets. This will give you a very strong support and not stress the pot connections.

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

The pots shafts may be cut down with a good pair of pliers, or a junior hack saw. Try not to bend or rotate the shaft as you are cutting.

The pots are lubricated with a thick clear grease. This sometimes is visible along the screw thread of the pot body. Try not to touch the grease as it consequently gets onto your panel and PCB. It can be difficult to get off, although it can be removed with a little isopropyl alcohol on cotton wool bud.

Connections

This very much depends on where you are going to use the midiDAC. You may already have an idea of how you are going to connect your midiDAC to your chosen system. For a modular system you may want to have a jack socket for each output. See my MOTM friendly front panel at the end of this document for one way to set up your midiDAC.

The LEDs should be able to be wired directly to the board. Pin1, the square pad, should go to the anode of the LED. And pin 2 to the cathode. You will have to bend the legs of the LED towards to board. This should be done close to the body of the LED and be done carefully so as not to break the resin casing of the device. Use a pair of fine nosed pliers to do the job. A LED clip should be used to secure the LED to the panel. The Cliplite range from Maplin, and others, are perfect for this job and offer a smart finish. Alternatively the integrated Lumex parts come with their own casing and but should still fit into the PCB directly.

The PCB has been laid out to accommodate 0.1” headers for all interconnects. This is very useful for taking the board in and out for servicing. However, for a panel fitting into a modular synth, there is no reason why you can’t solder wires directly into the holes.

The suggested layout uses seven 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. Keep your wires short but not too short and use as many different colour wires as you can. There is no need to use screened cable for such short runs.

If you have used Switchcraft 112 sockets you will see that they have three connections. One is the earth lug or ground tag. The second 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) lug. The NC lug is internally connected to the signal tag when a jack is not connected. This connection is automatically broken when you insert a jack. The midiDAC uses only the signal lugs on each connector. The other two lugs are not used at all in the suggested layout.

Socket name	**Header**	**Pin**
Pitch	OUT-1	4
Velocity	OUT-1	3
Aftertouch	OUT-2	3
Modulation	OUT-3	3
CC	OUT-3	4
Gate	OUT-2	2
Slide	OUT-1	1

The earth lugs of each socket are left floating as a solid ground to the module is already provided in the form of the power supply ground lead(s). This means that no earth loops will occur because of inserted patch leads. However, depending on your own system, it may be necessary to connect each output jack's ground tag to the AGND on the input power connector on the PCB. You can connect all the ground lugs together with a piece of uninsulated wire, and have one piece of insulated wire going back to the AGND pin. But remember a modular panel will probably be metal, and may well be earthed through the panel housing. Your best bet is to leave the lugs unconnected at first, and only connect them to ground if you get problems. My unit has the grounding lugs unconnected.

All my other Oakley modules now have two grounds, one for the chassis and jack screening, the other for the power supply to the module. The midiDAC couldn't use this method with just a four way plug. Here, we have AGND and DGND, both must go back to the power supply separately. It is preferential to use a separate 4-way power lead to the midiDAC that comes straight from the power supply and not via any other module.

The ideal modular would have three grounds, a chassis or safety ground, a clean power supply ground (AGND) and a dirty power supply ground (DGND). To remain compatible with the MOTM system, I have stuck with just two grounds.

If you are fitting your midiDAC into a single box with some other analogue synth circuitry, the connect the two midiDAC grounds to the central power supply star point. You do not need any further connections to ground from or to the midiDAC.

The MIDI sockets require a mention. If you get the connection around the wrong way, a lot of confusion will result. For the MIDI IN connector: pin 1 on the PCB goes to pin 5 on the 5-pin

DIN. Note that pin 5 is marked on the socket and is NOT the fifth pin on the socket. Pin 2 on the PCB goes to pin 4 on the DIN plug. For the MIDI OUT connector: pin 1 on the PCB goes to pin 5 on the DIN plug, pin 2 on the PCB goes to pin 2 of the DIN plug, pin 3 on the PCB goes to pin 4 on the DIN plug. On the PCB pin 1 is always depicted by a square pad. If you have a problem with the midiDAC, chances are that you have wired up the midi socket incorrectly.

Figure 1 was taken from the resourceful Philip Rees website and shows clearly the odd pin numbering on 5-pin DIN plugs. My thanks go to Philip Rees Ltd. for the use of this diagram. This UK based company produce a wide range of midi related equipment including merge and through boxes. Well recommended.

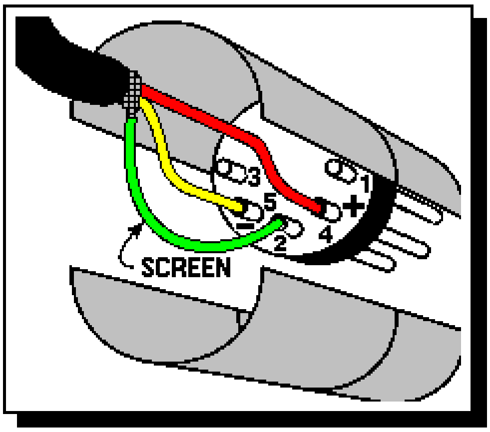

Figure 1. An internal view of the standard MIDI plug

Actual panels can be obtained from Schaeffer-Apparatebau of Berlin, Germany. The cost is about £30 per panel. All you need to do is e-mail the fpd file that is found on the midiDAC2 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.

Trimmers

There are two trimmers on the midiDAC2 PCB.

1. **V/OCT.** Adjust this to give -10.67V at pin 1 of U11 to give 1V/octave output. OR... if you have a modular system already tuned up and playing. Set this so that your VCOs sound in tune and play a perfect scale.

2. **INIT.** This adjusts the offset applied to the pitch CV. Adjust this to tune the pitch of your master VCO. Set the TUNE pot on the front panel to the centre position before you start the adjustment of the INIT trimmer.

Final Comments

I hope you enjoy building and using the Oakley MidiDAC2. 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 £15 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.

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. Special thanks go to Trevor Page who has tirelessly slaved away to bring you the firmware that makes the midiDAC so special. Thanks also go to Jorgen Bergfors. His help has been essential in improving the first midiDAC design. Thanks also to all those nice people on the synth-diy mailing list.

Tony Allgood. June 2002

Version. 1.5

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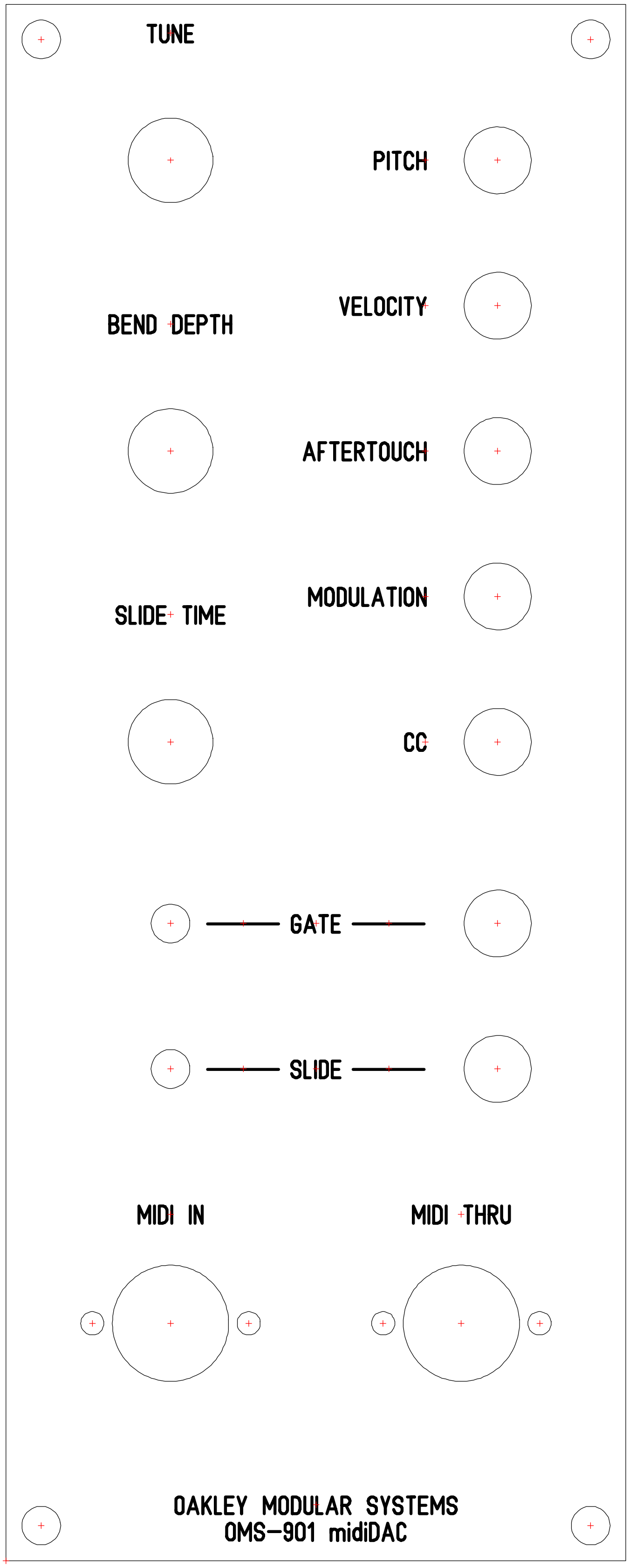
Errors may have occurred in the preparation of this document. Please forward any errors found to me so I can correct them.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