Oakley Sound Systems
midiDAC
Single Channel midi-CV Convertor

User's Guide

Tony Allgood B.Eng
Oakley Sound Systems
PENRITH
CA10 1HR
United Kingdom

e-mail: oakley@techrepairs.freeserve.co.uk

Introduction

The midiDAC is a top specification single channel midi to analogue convertor. This project is a joint development between the author and Trevor Page. Trevor, who is based at Bangor University in Wales, 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. However, certain features make it perfect for driving the TB3030. 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 can be trimmed to give the maximum bend interval. It can be trimmed to zero if required.

Pitch Bend: This signal is available individually. It is bipolar; so with no bend, the output CV is zero.

Velocity: 0 to 10V proportional to midi note on velocity.

Aftertouch: 0 to 10V proportional to midi channel aftertouch.

Slide: This signal goes to +5V when two notes are played at the same time. This can allow slides to be switched in at will; TB303 style. An external switch may be used to enable the slide function.

Plus two uncommitted outputs: which can be one of these **four** useful options:

1.   Modulation and CC102

2.   Modulation and Note-off (release) velocity

3.   CC102 and Accent*

4.   Modulation and Accent*

*Accent is a +5V gate type signal activated when note on velocity exceeds 100. Useful for controlling the TB3030 and TB303, and others.

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.

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.

Power Requirements

The module requires a split supply of +/-15V, but it will work off +/-12V with a few component changes. With a 12V supply the maximum output CV would be limited by the output swing of the op-amps used. So in this case the reference voltage is halved to allow smooth running of the midiDAC. This means the output voltages are half the value that they were when running at 15V. Thus the +5V gate is now a +2.5V gate. However, the +15V gate

is now +12V, so this shouldn't be any cause for trouble. The pitch CV can be amplified onboard to remain at 1V/octave, and a software CV limiter is available to restrict very high notes from being played. Rail to rail op-amps can be used, but as yet, many have poor DC performance. See later in this document for the circuit changes required for 12V operation.

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.

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. This circuitry can be easily linked out if it is not required.

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 an option. 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.

There is also a pitch CV limiter to allow this unit to drive a TB3030 or TB303 directly. This makes the unit ignore any notes above certain note number, thus preventing the midiDAC pitch CV output going too high as to cause the simple TB style VCO to latch up. It is also useful for any system using 12V power rails. The CV limiter will prevent any of the midiDAC's op-amps from being driven too close to the rails.

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 cm high and 11 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.

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 and brackets are from the Omeg Eko range, supplied by Maplin and Rapid Electronics here in the UK. I carry stock of these items should you need to obtain them. The prices are on my web site.

Circuit Description

The midi data is electrically isolated by U1, a simple transistor output opto-coupler. The output of U1 is pulled up via R6 and R18. The voltage drop across R18 is enough to drive the through circuit based around Q1 and Q3. 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 AD7945 is a 'current output multiplying DAC'. 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, as you may use with a modular synth, the reference comes from a 10V precision reference IC, U10. For use in the TB3030 or other 12V system, you will need to use a 5V reference. In fact, the TB3030 already has one of these, and users can utilise this instead of requiring a separate IC. 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. For TB3030 users, you will need to set this to be half of this value, 5.33V.

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 U9. 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 U9 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, U14, for accurate pitch control.

Some of the outputs are processed further before being sent to the output sockets. TB3030 users will need to build the circuit based around Q7 and U6. This processes the U/C2 output to give a digital type signal that swings from digital ground to the positive rail. This is needed to drive the TB3030's Accent circuit, an important part of the TB3030's sound. The gate signal which goes to Vref/2 when active, i.e. +5V when using a 10V reference, controls Q9 to produce an inverted gate signal. This goes from the positive supply rail to ground when activated. This in turn, controls another transistor, Q10. 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 R62 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 Q10, R61 and R63 as well.

The pitch CV is sent to the optional slide circuit. This circuit is based heavily on the slide circuit from the TB303, and, of course, the TB3030. 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 'Slide' 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.

You can avoid this section altogether by omitting U3 and surrounding circuitry, and linking L1.

The pitch CV is now added to the pitch bend in the circuit block based around U12. 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 or trimmer 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. For TB3030 users, there is no need to have the pot, but for modular users, the TUNE pot is very useful. INIT is a multiturn trimmer that will allow precise setting of the initial pitch CV, and thus aid centralising the TUNE pot's range.

PIC Firmware Data Version 1.1

Operating Modes

Issue 1.1 of the firmware allows for four possible modes of operation, as detailed in the table below. Mode selection is achieved via the use of two switches (or jumpers). The Mode-1 select switches are scanned during initialisation only and therefore the midiDAC must be reset for a new mode selection to take effect. They are facilitated by a two pole DIP switch or links on the PCB. The switches can have four different combinations, 00, 01, 10, 11. These are switches Mode-1 pin 2 and 1 respectively. 0 is open and 1 is closed. These modes affect the operation of the two uncommitted outputs, U/C1 and U/C2.

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 table below.
5	Channel aftertouch
6	Gate. -0.5 of Vref when active.
7	Uncommitted 2, see table below.
8	Slide. -0.5 of Vref when active.

Mode-1	U/C 1	U/C 2
0 0	CC#102	Accent
0 1	Mod. Wheel	Accent
1 0	CC#102	Modulation Wheel
1 1	Release Velocity*	Modulation Wheel

*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.

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.

Slide and Accent Outputs- For TB3030 Users

The midiDAC firmware provides a slide (or portamento) output, which is asserted as soon as two or more notes are being held down. In modes 00 and 01 an accent output is also provided, which makes these two modes useful for TB3030 owners. The accent is asserted when the velocity of the most recent note to be struck exceeds a value of 100.

Gate Trigger Modes

The midiDAC allows the selection of two gate trigger modes via the Legato Mode switch. Marked on the PCB as Mode-2, pin 1. The setting of this switch determines how the gate signal responds to overlapping notes. Closing this switch enables multiple gate triggering for legato playing. With the switch open, the gate does not retrigger for overlapping notes. This is likely the most desirable mode of operation for those who wish to emulate the TB303 sound, such as users of the Oakley Sound Systems TB3030. 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.

Pitch CV Limiter

The midiDAC firmware contains a switchable pitch CV limit feature which, if enabled, causes the midiDAC to ignore any high notes above C7 (note number 84). This is marked on the PCB as Mode-2, pin 2. Short to enable. This is useful for TB3030 owners since the original TB303 oscillator which it incorporates can occasionally latch up on high pitch CV voltages. This is no real problem since it is only a matter of turning the synthesiser off and on again to restore correct operation, but this can sometimes be a slight annoyance if a high note is struck by accident.

Velocity Processor- For TB303 Clones

The midiDAC firmware contains a software version of the TB3030's unique Velocity Processor circuit. This is a feature which allows an alternative form of control over accent and slide using just the velocity CV. Originally intended for keyboards or MIDI sequencers which do not support controllers, it makes control of accent and slide on any TB303 clone especially easy even with something like the MC303 for example, where the four velocity pads can control accent and slides directly. Computer sequencer users will find altering velocity easier that assigning MIDI controllers. It also enables keyboard players to experience an unusual playing style that takes some getting used to, but very powerful once mastered.

The velocity processor is enabled on the midiDAC using the Velocity Processor switch. This is marked on the PCB as Mode-2, pin3. With the velocity processor enabled, switch closed, the accent and slide outputs respond according to the velocity of the last note to be struck as shown below.

Velocity	Slide	Accent
0 - 31	OFF	OFF
32 - 63	OFF	ON
64 - 95	ON	OFF
96 - 127	ON	ON

Note that with the velocity processor enabled, the slide is still asserted when two or more notes overlap.

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.

Components

Most of the parts are easily available form your local parts stockist. I use Maplin, Rapid Electronics and Farnell, here in the UK. In North America, a company called Mouser 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 sell the Omeg pots at a very good price.

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.

For the capacitors, there are no set rules. All the electrolytics should be over 25V, except where stated, and radially mounted. The pitch spacing of the non-polar capacitors is 7.5mm/0.3", except the ceramic types which is 5mm/0.2". I think polyester types are fine for all decoupling and coupling uses. I like the open frame Siemens polyester layer types, because they are compact and a rather nice colour! C7 is a 1uF non-polar capacitor, and these can be quite tricky to get hold of. Again, look for open frame polyester types and you should be lucky. Farnell have one of the best ranges of capacitors in the UK.

In earlier documentation I listed R55 and R67 as 4R7 resistors. Performance can be improved by using leaded ferrite beads. These are available from most component suppliers, usually in the 'Filtering/EMC' section of the catalogue. They are quite simply pieces of wire fixed inside a small ring of ferrite. They are priced around 10 pence.

Please be careful with the orientation of the electrolytic capacitors, diodes and the transistors. All the IC's have pin one to the top. The DAC, 4051 and PIC are very sensitive to static electricity. So don't go shuffling on the carpet before handling these devices.
Most customers hardwire the PIC operating modes with little wire jumpers. I chose to make my prototype have selectable modes via DIP switches. This is fine, although some modes are only 'read' at power up. Mode-2 is selected via three switches. If you can find a 3-way DIP switch, then you can use that, but I found these very hard to get. I used a four way type, and bent back the pins of the unused location so that it would fit into the PCB. Not very elegant, but it works fine.

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

There are **two** parts lists. The first is for the fully featured midiDAC, the second is for the TB3030. Make sure you get the right one. There are quite a few differences. You may also want to check with the circuit diagram for any other features you wish to add or omit.

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

A copy of the PCB legending is available on the midiDAC web page. Please note, I do not supply any other forms of PCB artwork

Full midiDAC option

100K	R10, 7, 27, 35, 34, 1, 62, 51
100K 1%	R57
10K	R11, 12, 14, 22, 24, 17, 4, 9, 8, 60, 33, 61
10K 1%	R65, 45, 52, 68
10K, 0.1%	R59
13K	R48
1K	R13
1K5	R6
1M	R28, 37, 63
20K, 0.1%	R58
220K	R15, 43, 40
220R	R5, 18, 26, 21
24K	R41
27K	R47
2K2	R54, 20
330K 1%	R49
3K3	R3, 53, 69
47R	R66
4K7	R2, 16, 19, 23, 25, 29, 30, 31, 32
5K1	R50
680R	R36, 38, 39, 42, 44, 46, 56, 64
Leaded Ferrite bead	R55, 67
100K 22turn cermet	INIT
10K 22turn cermet	V/OCT
100K lin pot	TUNE
10K lin pot	BEND
470K log pot	SLIDE
Pot brackets	3 off
1000n polyester	C7
100n polyester	C4, 11, 14, 10, 8

100u/10V elect	C3
100u/35V elect	C24
10n poly	C12, 26, 21, 20, 25, 15, 19, 16, 18
18p ceramic	C5, 6, 17
47uF elect	C13, 2, 22, 23
22uF elect	C1, 9
10 MHz crystal	X1
1N4001	D2
1N4148	D1
CD4051	U5
CD4066	U6
7805 or 78L05	U4
AD7945	U7
CNY17-3	U1
LF412 or LT1057	U14
AD711	U9
OP77 or OP177	U3
OP275 or OPA2277	U11, 12
PIC16F84-10	U2
REF-01	U10
TL082	U13
TL084	U8
BC550	Q2, 3, 4, 5, 6, 7, 8, 9, 10
BC560	Q1

You will also need devices for your chose method of selecting mode and midi channel. I have used two 4-way DIP switches to select mode-2 and midi channel, and a 2-way DIP switch for the mode-1 selection. You may also want to have an extra switch to enable the slide circuit.

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.

TB3030 Users Option

Link out L1

100K	R10, 7, 27, 35, 34, 1
100K 1%	R57
10K	R11, 12, 14, 22, 24, 17, 4, 9, 8, 60, 33
10K 1%	R65, 45, 52
10K, 0.1%	R59
13K	R48
1K5	R6
1M	R28, 37
20K, 0.1%	R58, 68
220K	R15, 43, 40
220R	R5, 18, 26, 21
24K	R41
27K	R47
2K2	R54
3K3	R3, 53, 69
47R	R66
4K7	R2, 16, 19, 23, 25, 29, 30, 31, 32
5K1	R50
680R	R36, 38, 39, 42, 44, 46, 56, 64
Leaded ferrite bead	R55, 67
100K 22turn cermet	INIT
10K 22turn cermet	V/OCT, BND
100n polyester	C4, 11, 14, 10, 8
100u/10V elect	C3
100u/35V elect	C24
10n poly	C12, 26, 21, 20, 25, 15, 19, 16, 18
18p ceramic	C5, 6, 17
47uF elect	C13, 2, 22, 23
22uF elect	C1, 9
10 MHz crystal	X1
1N4001	D2
1N4148	D1
CD4051	U5
CD4066	U6
7805 or 78L05	U4
AD7945	U7
CNY17-3	U1
LF412 or LT1057	U14
AD711	U9

OP275 or OPA2277   U11, 12
PIC16F84-10   U2
TL082   U13
TL084   U8

BC550   Q2, 3, 4, 5, 6, 7, 8
BC560   Q1

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4-way Molex   0.156" header 1off (power)
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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.

Important Notice

Whenever a PCB layout is designed it is so important that everything goes right. One mistake could mean that the whole batch of first issue PCBs are useless. Thankfully, the midiDAC has worked first time. But there are two 'features' that require further discussion.

Firstly, the crystal X1 has not been given enough room. If you allow it to sit on the PCB, then it will block the pad for C9. My recommendation is to fit C9 lying down against the PCB. Then solder X1 so that it is approximately 3 mm above the surface of the PCB. Make sure that the left hand lead of C9 does not short to the crystal's casing. Furthermore, when the 5V regulator is installed, make sure that this does not touch the crystal either.

The second feature is a tracking error, however, no tracks actually need cutting. Do not fit R58 into the PCB. You will need to solder R58 on the underside of the PCB. This is messy, but it can be done very simply. You need to solder R58 so that it connects between pin 1 of U11 and pin 6 of U11. The easiest way to do this is to use the *right* hand pad (from underside) of what is marked as R58 and the square pad of U11.

Although, both these mistakes are annoying, they should not affect the operation of the midiDAC if done correctly. Please contact me if you require any further help with these matters. If I sell sufficient numbers of the issue 1 PCB, I will reissue the PCB with these problems corrected.

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

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 on the web site for one way to set up your midiDAC.

The issue of grounding has come up in a few e-mails from customers. The most common question is what to do with the barrel connection of the output jacks for fitting into a modular system. Well, in theory you could leave them floating. A solid ground is already provided in the form of the power supply ground lead(s). This has the benefits of no earth loops occurring because of inserted patch leads. However, depending on your own system, it may be prudent 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.

All my later 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.

Some people have asked me about a gate indication LED. Your best bet is to use the '+15V gate' output. Connect your LED as follows, anode to the '+15V gate' output, cathode to DGND. Make R61 2K7 instead of 10K. However, the gate signal from this output will now be limited to about 2V maximum. Use the '+5V gate' to drive your synths.

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 modes can be selected by wire links, board mounted DIP switches, or panel mounted toggle switches. The 'mode and channel' DIP positions are arranged into two halves. The right hand pads are made to fit 0.1" headers. Thus headers can be used to connect your panel mounted switches for easy maintenance. You will also find an additional pin set out for use with panel mounted switches for mode 1, this provides +5V for the switches. See the circuit diagram for details. If you do decide to go for panel mounted switches for all modes, bear in mind that Mode 1 is read only at power up.

TB3030 owners must first connect the power supplies. Use the regulated +12 and -12V lines from the TB3030 PCB. Take these to the 'POWER' connector, '+12V' going to +15V and '-12V' going to -15V. Use two wires to connect the two midiDAC grounds to the 'GND' pin on the TB3030 PCB. The +5V gate output, actually its +2.5V, will be your gate signal. The pitch CV will go to CV on the TB3030 PCB. 'ACCENT' and 'SLIDE' are connected between the pins of the same name on each board. You may also connect 'VELOCITY' to 'FILTER' on the TB3030. There is no need to use the 'VEL' input on the TB3030 as the operation of the velocity processor is carried out by the PIC. You also have to connect 'REFERENCE' on the midiDAC to pin 6 of U7 on the TB3030. The best way to do this is to solder your wire onto the positive side of C17 on the TB3030 PCB. This is the 5.33V supply on the TB3030. Alternatively, you can fit a REF-02 IC into U10 on the midiDAC. This IC is a very good 5V reference. The 'OFFSET' input on the TB3030 can now be left unconnected.

Trimmers

There are three trimmers on the midiDAC PCB, although you may have only two fitted. Lets run through them all in turn:

1. **V/OCT.** Adjust this to give -10.67V at pin 1 of U11. For TB3030 users adjust it to give -5.33V at pin 1 of U11.

2. **BND.** For TB3030 users or people not using the bend pot. Adjust this to give the desired amount of midi pitch bend.

3. **INIT.** This adjust the offset applied to the pitch CV. Adjust this to tune the pitch of your master VCO. Alternatively, you can use it to centre the TUNE pot.

Final Comments

I hope you enjoy building and playing with this unit. I have two units, one in a permanent installation in a monophonic Oberheim OB-SX clone, and the other as the main interface within my new modular set up.

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 5 pm, British time.

I am also looking for photographs and short sound samples of finished Oakley Sound Systems' projects for my web site.

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 midiDAC design. Thanks also to all those nice people on the synth-diy mailing list.

PS. Don't forget that new projects are being added every month or so to the Oakley web page. The newest projects are the MiniMoog VCO, called the 'One of three', the Basic VCA and the Basic EG.

Tony Allgood. March 2000

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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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