VCS4 Project

Updated: 05/10/2019

Goldsmiths College Electronic Music Studios

Figure 1 VCS4 Unit

General Features

Two VCS3 mk1 units (early serials 24/25) atop a base unit.

Base unit houses a keyboard, input mixer for tape/microphones to each VCS3, rotary switches and multiple potentiometers (not all of which are wired up).

From dymo tape labels the features of the base unit appear to be:

- Some kind of Tone/EQ section and then what looks like a Harmonic Filter?
- Keyboard CVs and Envelope triggers to each VCS3 plus CV processing?
- Random voltage generator and random trigger generator
- Keyboard is split Left/Right controlling VCS3 L and VCS3 R. Colour coded stickers on keys.

Date of Manufacture

The 2 VCS3's are sequential very early serial numbers 024 and 025, dated 24/1/70 and 25/1/70 respectively. Approved by 'DHC' which are the intials of David Cockerell, the prodigious electronic designer of many classic E.M.S instruments. It is therefore likely building of the base unit started in 1969 which is the date mentioned in various online recources (e.g. http://emssynthesisers.co.uk/emsprods.html - vcs4)

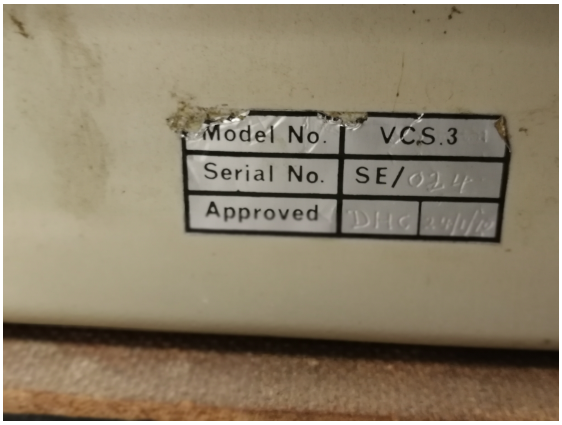


Figure 2 VCS3 L serial plate 024 dated 1970

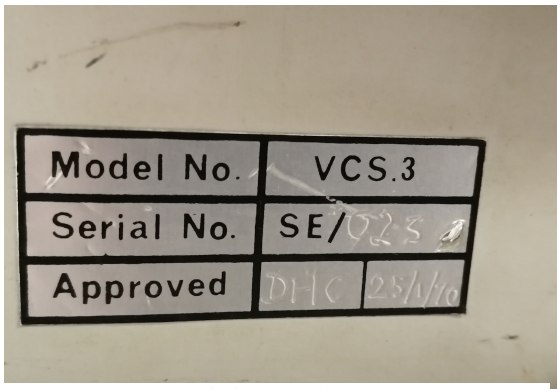


Figure 3 VCS3 R serial plate 025 dated 1970

VCS3 modifications

For reference the standard matrix layout of a VCS3 mk1 Synthi is given below.

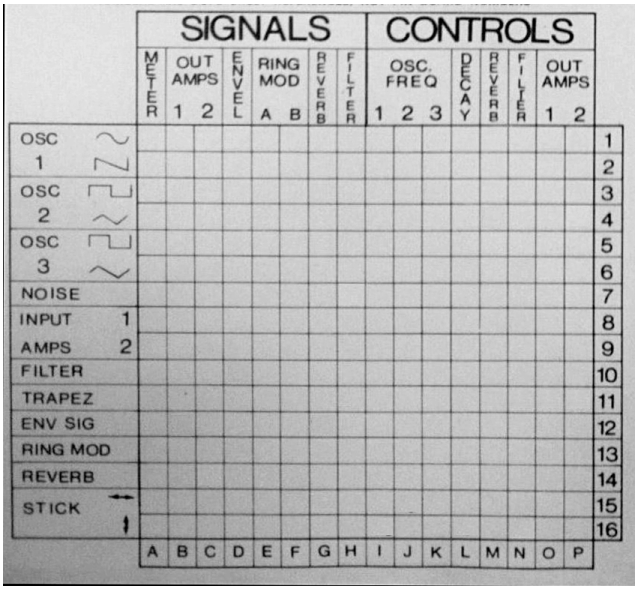


Figure 4 Standard VCS3 mk1 (aka 'Putney') matrix layout

VCS3 L (left hand side)

Modifications to the standard matrix layout are shown below

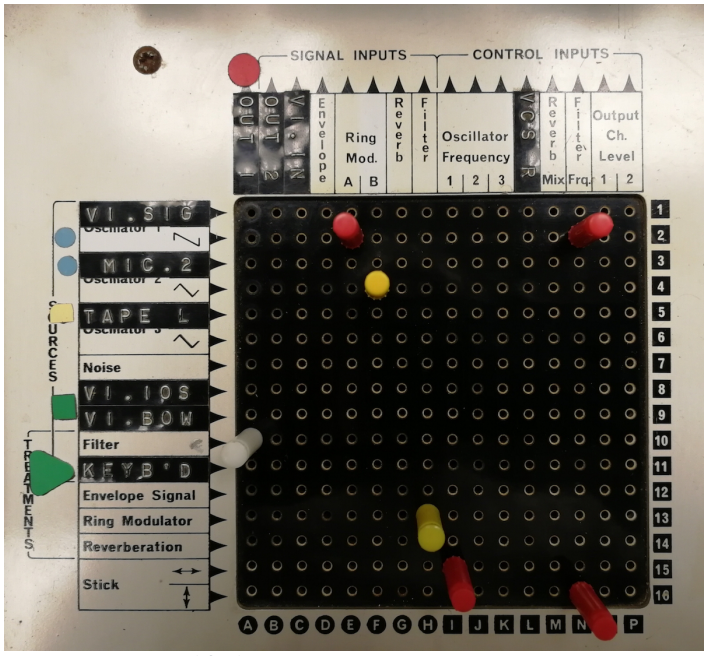


Figure 5 VCS3 L modified matrix

Matrix Modifications

Columns:

Original →	Modified	Comments
Meter	OUT 1	red sticker. This is remapped output Channel 1
OUT 1	OUT 2	This is remapped output Channel 2
OUT 2	'VI.IN'	Audio Input to the BU filter.
Ring Mod. B	missing dymo label?	test show that RingMod inputs A and B function normally
DECAY	'VCS R'	On testing, any source/signal patched to this column appears on VCS3 R, 1st row labelled 'VCS3 L', thus providing a direct signal connection between both VCS3 matrices

Rows:

Original →	Modified	Comments
OSC1 sine	‘ VI.SIG ’	This is the signal out from the BU ‘filter’ controlled by the blue and yellow stickered front panels pots and switches.
OSC1 ramp	missing dymo label?	blue sticker. Test show this is a MIX of OSC1 sine and ramp waveforms (as found later mk2 Synthi’s)
OSC2 pulse	‘ Mic.2’	blue sticker. Tests show signal input to the rear ‘Mic 2’ DIN socket appears here with level controlled by Mic2 fader in the the mixer section (described below)
OSC3 pulse	‘ Tape L ‘	yellow sticker. Tests show signal input to the rear ‘Tape L’ DIN socket appears here with level controlled by ‘Tape L’ fader in the mixer section (described below)
INPUT 1	‘ VI.IOS ’	green sticker. Tests show when an audio signal is fed into the VI.IN column, and the front panel switch row 2, knob 9 is switched to the ‘10sec’ position, filtered audio output appears at this row.
INPUT 2	‘ VI.BOW ’	green sticker. Even with audio fed into VI.IN, no audio appears here just a constant DC. Non-functioning?
TRAPEZOID	‘ KEYBD ’	left split keyboard pitch CV (green arrow stickered keys)

Panel Modifications

Upper Panel

Top right of Oscillator 1. Unlabelled toggle switch. Its function appears to be to reduce the frequency CV range to OSC1. This facilitates quicker tuning. This feature appears also on the Synthi KB1 one-off prototype.

Missing dymo tape under OSC1 sine and ramp level pots?

Under trapezoid level pot 'TO FILTER F'. This mod hardwires the Trapezoid envelope waveform internally, to the Filter frequency control of VCS3 L.

The 'F' here refers to the frequency of the Filter.

N.B There is no trapezoid signal available in this matrix, its normal position has been modified to instead carry the left keyboard CV. But the trapezoid at least still has some use in controlling Filter frequency.

Figure 6 VCS3 L upper panel

Lower Panel

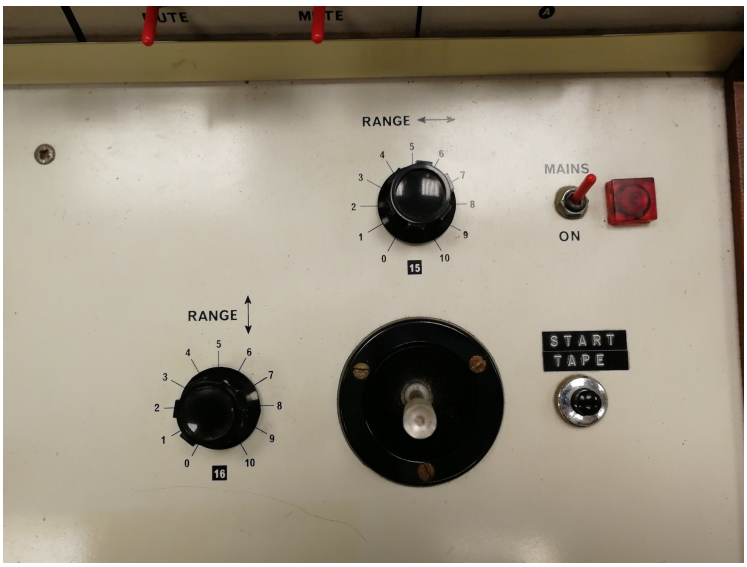


Figure 7 VCS3 L lower panel with modified attack button

Attack button labelled ‘START TAPE’ but also does trigger the Envelope Shaper.

Rear view with cover removed, showing the large reverb tank bolted to the outside of wood case. Original tank is missing inside VCS3 unit.

Figure 8 VCS3 L rear covered removed. No visble modifications to pcbs A,B and C

VCS3 R (right hand side)

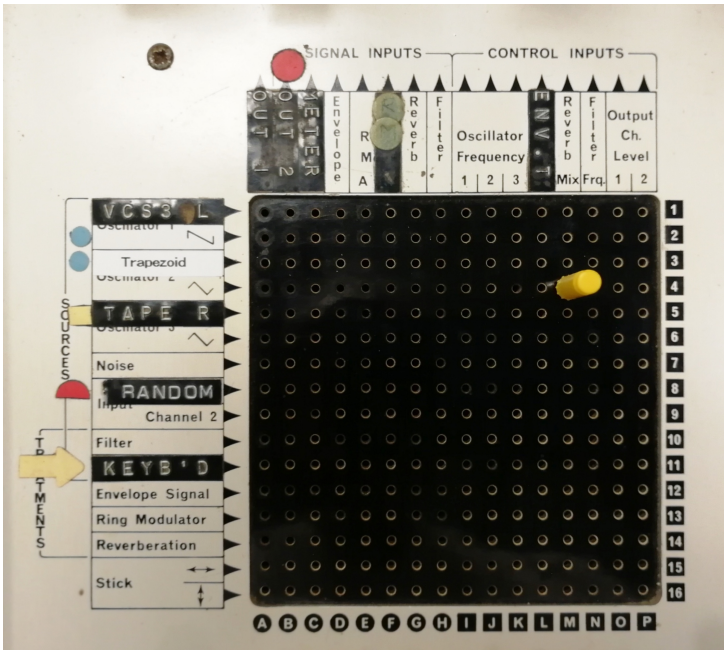


Figure 9 VCS3 R matrix with modifications

Modifications

Columns:

Original →	Modified	Comments
Meter	OUT 1	This is remapped output Channel 1
OUT 1	OUT 2	red sticker. This is remapped output Channel 2
OUT 2	METER	Remapped input to meter
RMOD B	‘ R M ’	Test show that RingMod inputs A and B function normally
DECAY	‘ ENV .T ’	Envelope Threshold control ? Patching eg an LFO CV here and adjusting the ‘Envelope Threshold’ mod on the front panels (see below) has some slight affect on the Envelope Shaper attack light illuminating but does not appear fully working.

Rows:

Original →	Modified	Comments
OSC1 sine	‘ VCS3 L’	This is the output from VCS3 L, when any signal is patched to the column labelled ‘VCS3 R’ on the matrix of VCS3 L (see above)
OSC1 ramp	missing dymo label?	blue sticker
OSC2 pulse	‘ TRAPEZOID ‘	This is remapped Trapezoid of VCS3 R (blue sticker)
OSC3 pulse	‘ Tape R ‘	yellow sticker
INPUT 1	‘ RANDOM ’	Random Voltage source from base unit ? (red sticker)
TRAPEZOID	‘ KEYBD ’	Right split keyboard pitch CV (yellow arrow Stickered keys)

Panel Modifications

Upper Panel

Top right of Oscillator 1. Unlabelled toggle switch. Its function appears to be to reduce the frequency CV range to OSC1. This facilitates quicker tuning. This feature appears also on the Synthi KB1 one-off prototype.

Osc1 sine and ramp level pots dymo tape ‘TO RING MODULATOR’. This is mysterious, as the Ring Mod inputs/output to the matrix work as normal?

Missing dymo tape under trapezoid level pot. Looks like whatever mod was done at the time of construction was undone later and the trapezoid appears normal in the matrix, albeit in a different location (row 3) to a normal Putney VCS3.

Figure 10 VCS3 R upper panel

Lower Panel

Figure 11 VCS3 R lower panel with added Envelope Threshold mod.

Attack switch removed and replaced by a pot labelled ‘ENVELOPE THRESHOLD’

The reverse of the potentiometer is connected to a modification circuit board :-

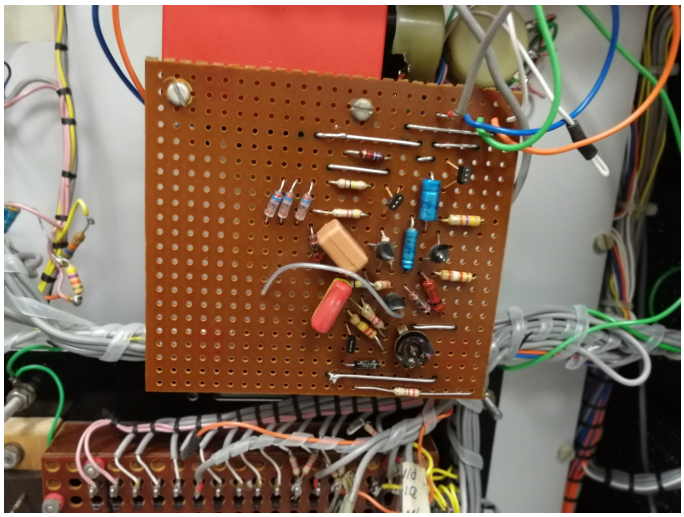


Figure 12 Rear of lower panel showing Envelope Threshold circuit

As noted above, this mod appears to be not working properly. Sending a CV to the ‘Envelope.T’ column of the matrix and adjusting the pot, the envelope comes on only momentarily as the pot is turned. Needs investigating. The mod circuit is not so complex and should be straightforward to check for dead transistors.

Rear view with cover removed, showing the large reverb tank bolted to the outside of wood case. Original tank is missing inside VCS3 unit.

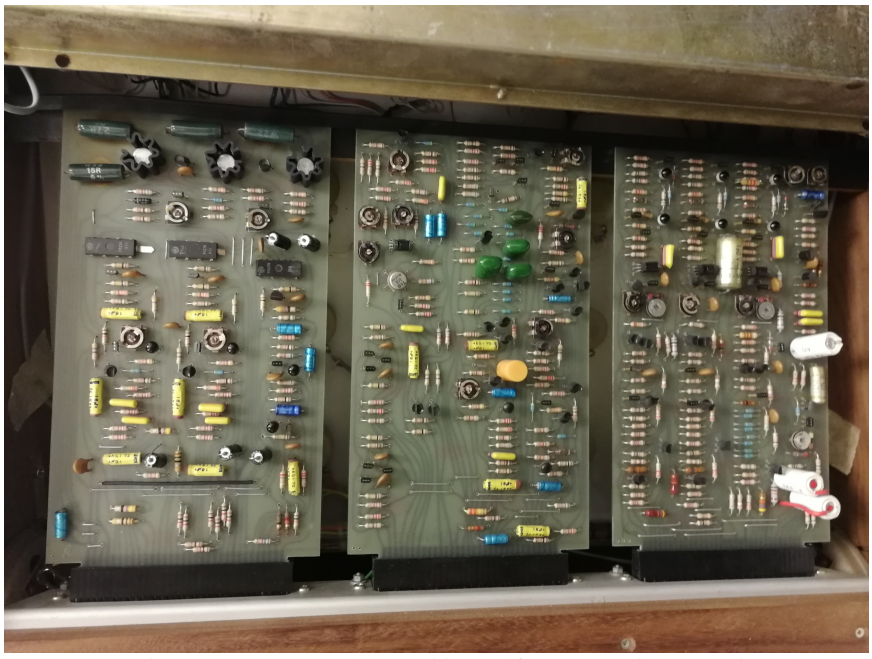


Figure 13 VCS3 R with rear cover removed. No visible modifications to the 3 main boards A, B and C

The VCS4 Base Unit (BU)

Description

Custom built to fit 2 VCS3 mk1 units atop. VCS3s are only connected to the BU via the rear input/output DIN plugs. Mains cables to power each VCS3 are via two bulgin plug leads from the rear of the base unit which are simply connected internally via a junction box to the mains power lead into the BU (again 3 pin bulgin).

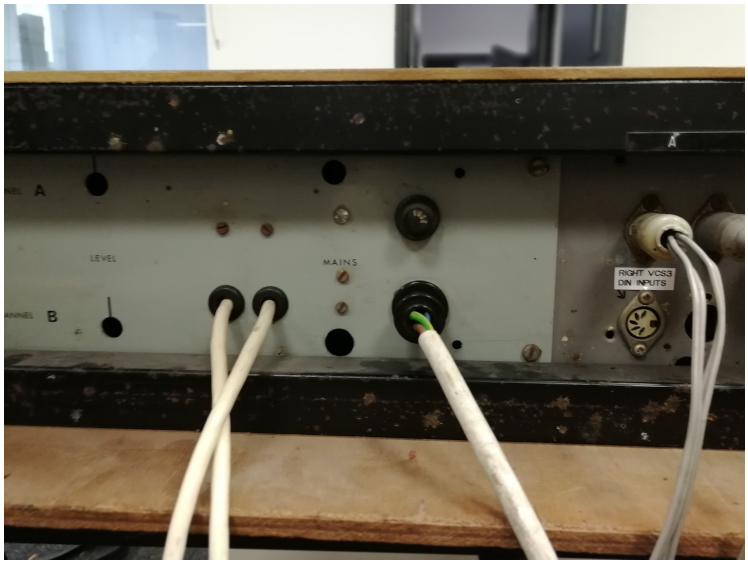


Figure 14 rear of BU showing power leads to VCS3 L/R and the mains in.

The Keyboard

The BU houses a 61-key keyboard, split between VCS3 L and VCS3 R with colour stickers on keys (green for VCS3 L and yellow for VCS3 R). Each keyboard section triggers the corresponding VCS3 Envelope shaper on depressing.

The Front Panel

The left-hand side has a 6-channel mixer, 3 channels each for VCS3 L/R plus 2 master volume controls for the L and R outputs. Each 3 channel mix section is labelled 'Left' and 'Right' referring to VCS3 L and R. Dymo tape labels read :-

MIX LEFT	MIX RIGHT	OUT L	OUT R
'MIC 1' 'MIC 2' 'Tape L'	'MIC 3' 'MIC 4' 'Tape R'		

Fader 1 cap missing, fader caps 2-5 have blue sticker, fader 6 yellow. Master OUT L and OUT R caps have red stickers. There are two lower dymo labels marked ‘UP’ and ‘LW’ between faders 2 and 3 and 5 and 6.

The next section of the front panel has 2 rows of 11 colour coded knobs. Most are potentiometers some are rotary switches. Three are not labelled and are not used (no rear wiring found).

Figure 15 Base Unit left hand section showing mixer and Random voltage/trigger pots (red sticker)

Figure 16 Middle/right section of base unit. Blue and yellow sticker knobs appear to relate to as yet unknown EQ/Filtering circuits/signal processing. Top row last 2 knobs are for left/right keyboard tuning. Furthest right show the ready/go cue light buttons

Figure 17 Rear of front panel showing wiring looms from keyboard and the various pots and switches

Top Row Knobs (knobs 1-11): labels and functions

Knob No.	Label	Colour Code	Comments
1	Main label: 'BAND TRIG 'position labels: 'O', 'R', 'L', 'L+R' (O= off). L, R refer to left/rights VCS3 Envelope Shapers	none	Rotary switch. Selects which VCS3 Envelope Shaper is triggered by the random trigger generator.
2	'V.VARIANCE'. Controls the variation from the mean of the random voltage.	Semi-circular red	Potentiometer. This refers to the random voltage source 'RAND' available in the VCS3 R matrix, which is also colour-coded red.
3	'V.MEAN'. Controls the mean or average of the random voltage.	Semi-circular red	See above.
Knobs 4-9 are colour coded blue and seem to control to a tone or EQ type filter			
4	'LOW'	blue	Tone/EQ
5		blue	Tone/EQ
6		blue	Tone/EQ
7		blue	Tone/EQ
8		blue	Tone/EQ
9	'HIGH'	blue	Tone/EQ
10	'KEYBOARD L'	green	Keyboard CV tuning pot for VCS3 L. Multi-turn.
11	'KEYBOARD R'	yellow	Keyboard CV tuning pot for VCS3 R. Multi-turn.

Bottom Row Knobs (knobs 1-11): labels and functions

Knob No.	Label	Colour Code	Comments
1	None	none	unused
2	'T.VARIANCE' Controls the variation from the mean of the trigger time.	2x semi-circular red	Potentiometer. Controls random triggering time of envelope shapers.
3	'T.MEAN' Controls the mean or average of the random envelope triggers.	2x semi-circular red	See above.
4	'BASS'	blue	Tone/EQ
5	'DIRECT'	yellow	Harmonic Filter??
6	'FUNDAMENTAL'	yellow	Harmonic Filter??
7	'SUB OCTAVE'	yellow	Harmonic Filter??
8	'DIVISION RATIO'	red	Harmonic Filter ??
9	'10SEC'	green	Harmonic Filter ??
10	none	none	unused
11	none	none	unused

Finally, there are red and white illuminated 'Cue' switches labelled 'GET READY' (white) and 'GO' (red) (see fig 16).

Rear views of BU: Inputs/Outputs

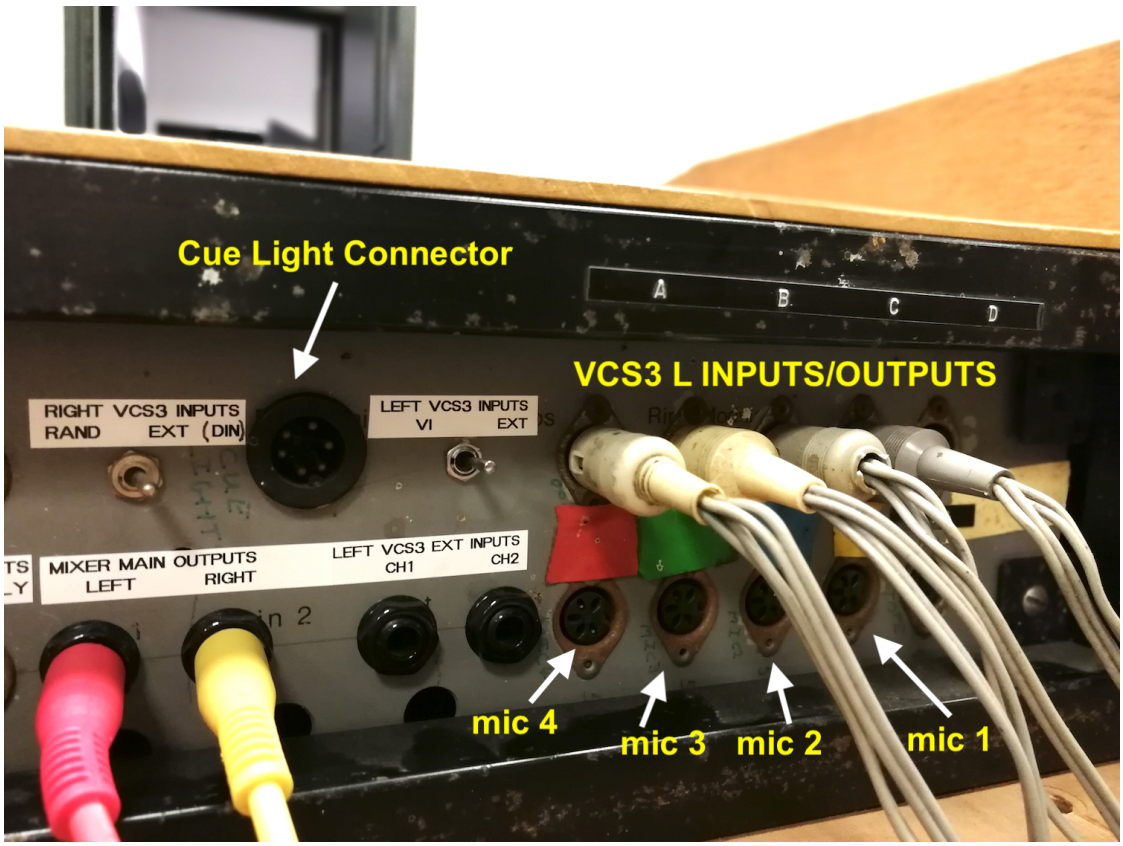


Figure 18 This view shows mics 1-4 input DIN connectors, mixer Left/Right main outs, the 4 DIN connectors for VCS3 L (labelled A-D) and VCS3 L CH1/2 inputs. Note also the 2 toggle switches whose function is described below.

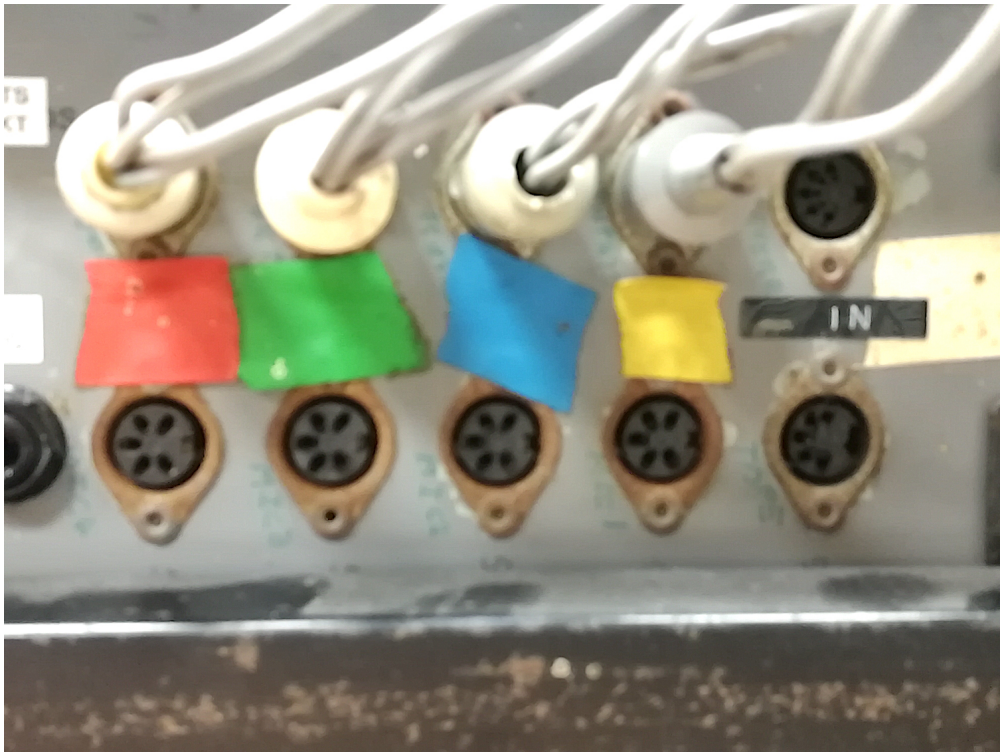


Figure 19 Another view also showing the Tape L and Tape R DIN inputs at far right labelled 'IN'. The DIN connector above this has been identified as an input (or output) to a stereo spring reverb tank that was once housed inside the BU

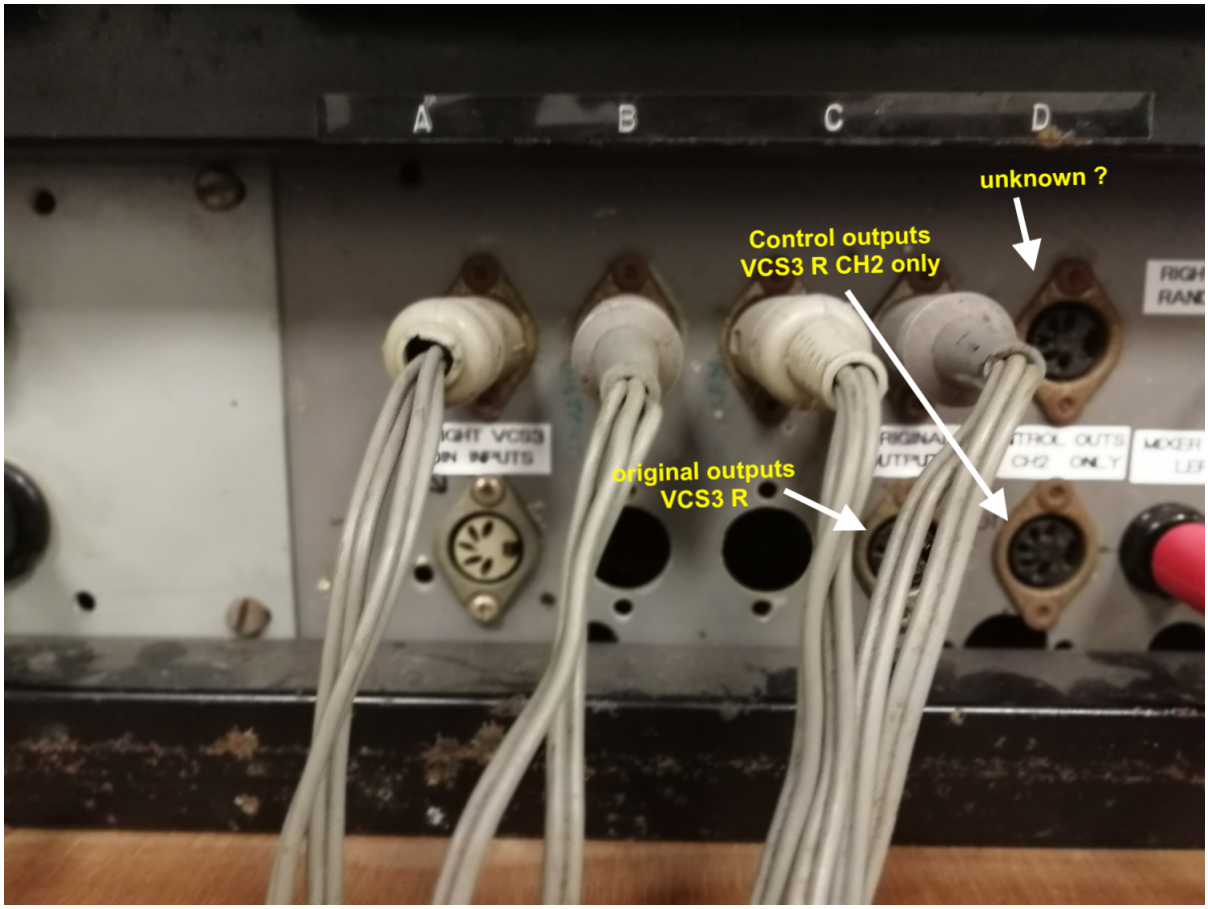


Figure 20 The 4 VCS3 R input/output connectors labelled A-D. Also, the original (unmodified?) outputs and control output (ch2 only) of VCS3 R(?) and an unknown DIN connector. The 'unknown' din connector has now been identified as an input (or output) for stereo reverb tank that was once housed inside the BU.

Rear Toggle switches

There are 2 toggle switches as shown in fig. 19. They function as bypass switches for the modifications to the input channels 1 and 2 found on VCS3 L/R (refer to fig 1. These input channels are located at rows 8 and 9 and are labelled 'input amps 1 and 2').

The left most toggle switch labelled 'Right VCS3 Inputs' switches between 'RAND' and 'EXT'. In the 'VI' position, Input ch2 (row 9) of VCS3 R matrix has the random voltage source present. Row 9 is as normal (input ch2).

In the 'Ext DIN' position, rows 8 and 9 of VCS3 R matrix are as standard, i.e. they carry input channels 1 and 2 signals. Inputs into these channels are via the DIN connector shown below in fig. 21

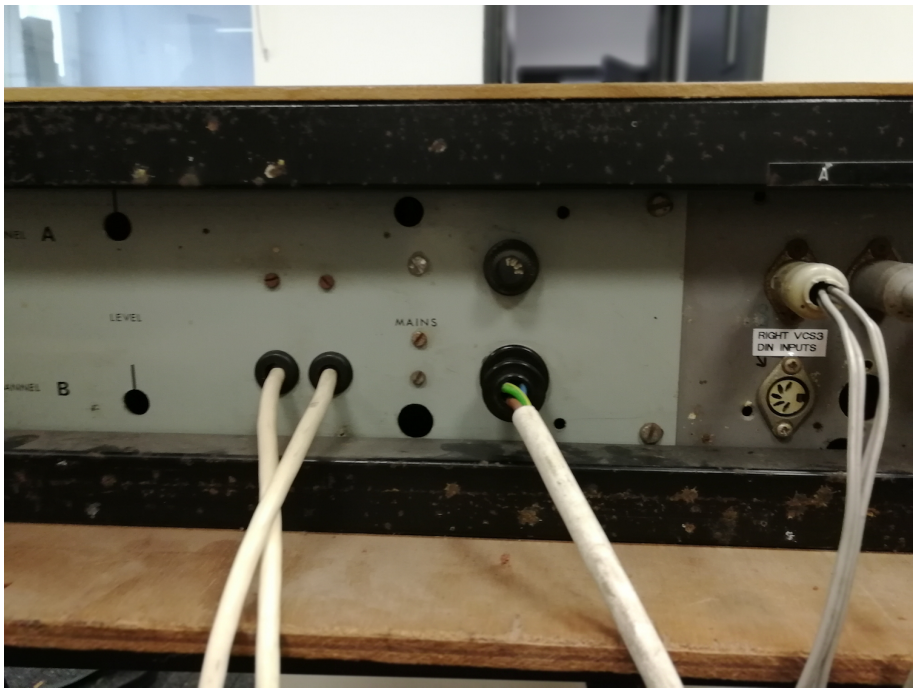


Figure 21 Rear of BU showing location (bottom right) of DIN socket taking signals into inputs channels 1 and 2 of VCS3 R

The right most toggle switch labelled 'Left VCS3 Inputs' switches between 'VI' and 'Ext'. In the 'VI' position, presumably Input ch1 and 2 (rows 8 and 9) of VCS3 L matrix are connected to 'VI.10S' and VI.BOW', although the functions of these signals are as yet unknown.

In the 'Ext' position, rows 8 and 9 of VCS3 L matrix are as standard, i.e. they carry input channels 1 and 2 signals. Inputs into these channels are via the 2 mono jack connectors labelled 'CH1' and 'CH2' in fig 18.

Mixer Section

Mic and Tape inputs

Upon testing the various microphone (1-4) and tape inputs (L and R) into the BU, the signal path seems to be:

Tape L, R inputs are routed to the corresponding rows in the pin matrices of VCS3 L/R and labelled 'TAPE L' and 'TAPE R and thus act as sources to be patched into any of the column inputs. Gain of the level is controlled by the corresponding fader in the mixer section.

The same is true for Mic 2 input. Its gain is controlled by the corresponding mixer fader and it appears a source in VCS3 L matrix row 3.

The remaining inputs Mic 1, 3 and 4 are not present on either of the VCS3 matrices. On testing these inputs no sound was heard at all in the L/R channel mixer outputs.

It could be these signals are routed internally through whatever EQ or Filtering circuits are controlled by the front panel blue and yellow colour coded knobs, which is not clear are fully working. More testing is needed to follow the signal paths of Mic 1,3 and 4 inputs to establish this.

VCS3 L and R outputs into Mixer

VCS3 L and VCS3 R have a red sticker on audio output channels: VCS3 L it is channel 1 and VCS3 R channel 2. Testing shows audio patched into these channels on the VCS3s does appear on the L/R mix out. Level are controlled by the corresponding output level pots on the VCS3's themselves.

It was also observed that output ch2 of VCS3 L and output ch1 of VCS3 R is also present in the mix.

One reason for this is that the VCS3 has panning of its external audio outputs (it does not apply to the internal speakers which is normal on all Synthi's).

Therefore, it is likely that only the outputs with red stickers are indeed fed into the mixer section, but unless 'hard' channel 1/2 panning is selected on the VCS3, some audio from both channels will appear in the mix input via the red stickered channel on either VCS3.

Accessing 4 (6?) channels of audio output

Each VCS3 is stereo (2 output channels 1 and 2) so in theory the VCS4 is capable of 4 independent audio output channels just from the VCS3's themselves. Making use of all 4 would give more creative possibilities. As we have seen above, the mixer section only deliver 2 channels.

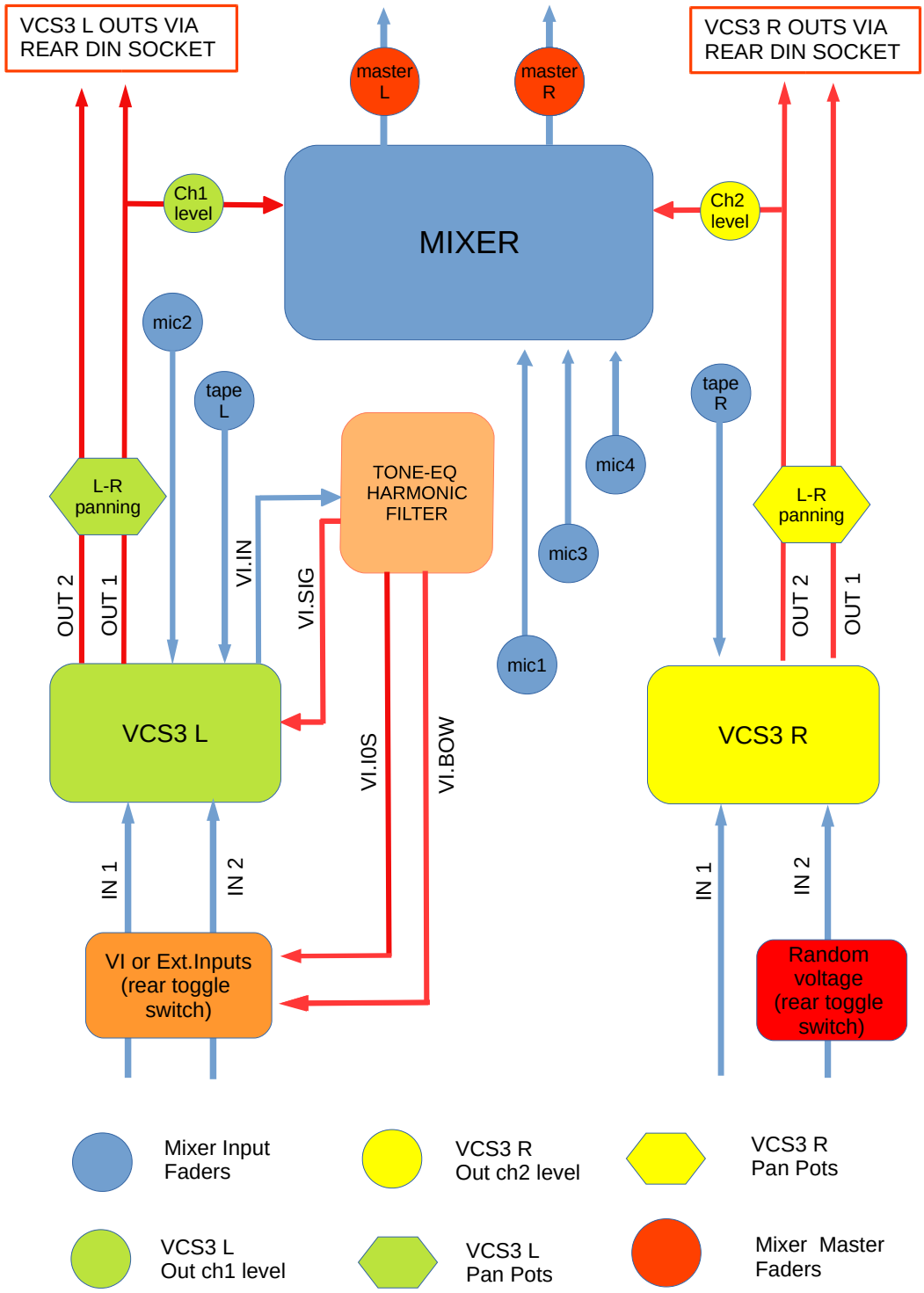
However, one can also access the 'original' output channels of each VCS3 via the rear DIN connectors on the rear of the BU. This means one may have 6 audio outputs: 2 From the mixer section master outputs and then 4 from the 2 VCS3s.

This requires making 2 audio cables, each with 2xmono jack to 5pin DIN plug arrangement to take the direct (i.e. bypassing the mixer section) audio outputs from VCS3 L and R.

Mixer Signal Routings

After some research and point to point continuity and other testing, the diagram below summarises the various audio signal routings to the mixer section. The tape and microphone inputs on the rear of the BU as well as the position of the VCS3 L and R inputs and outputs in this arrangement are shown. Also displayed are the Tone/EQ/Harmonic filter connections and the rear toggle switches that give the input channels on each VCS3 'dual' function.

MIXER MAIN OUTS



Base Unit Internal Signal Routing/Processing

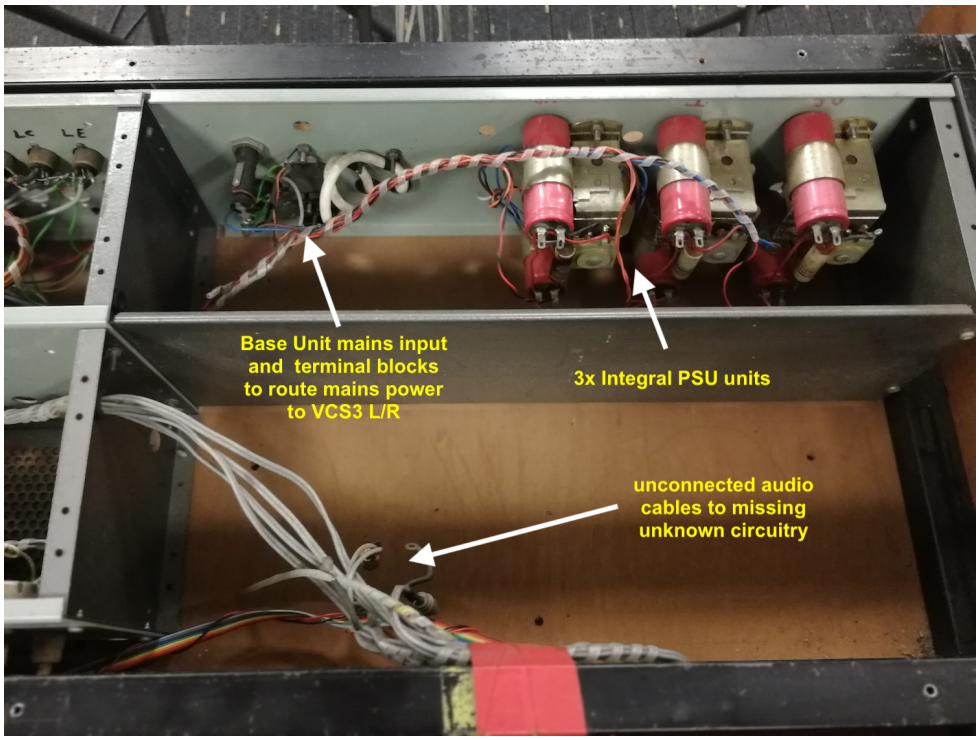


Figure 22 BU showing three (rather large!) independent PSU modules that power the 5pcbs enclosed. The unconnected audio cables are now known to be input and output connections to a stereo spring reverb tank once housed in the BU.

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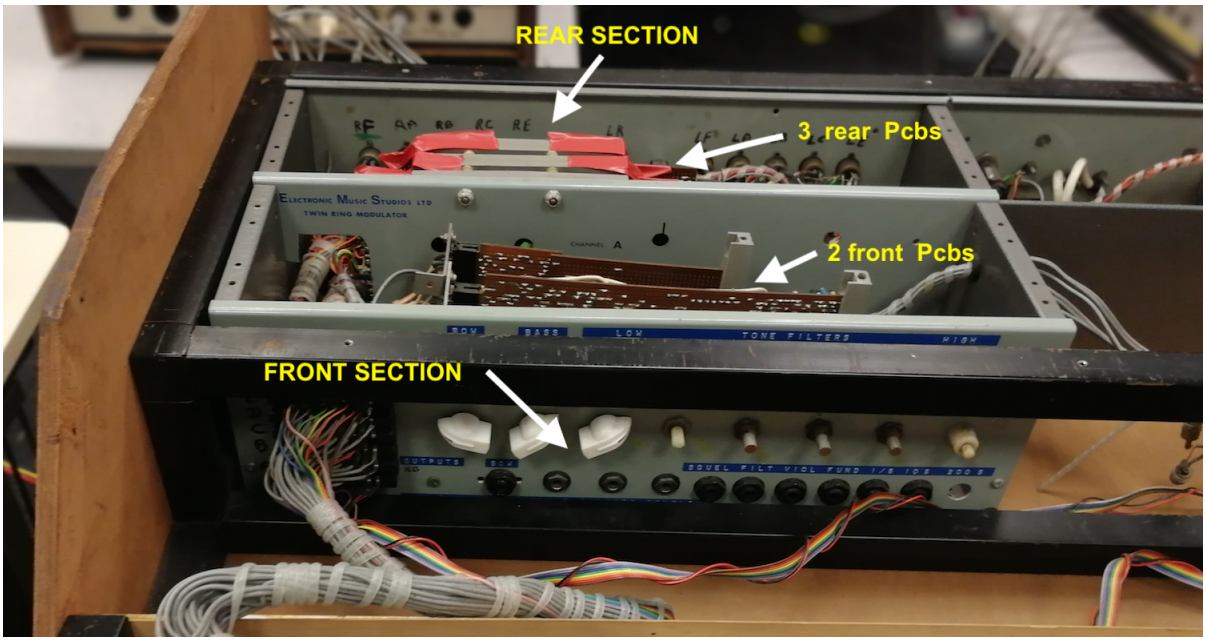


Figure 23 BU 'front' and 'rear' sections. The front section seems to have once been an independent signal processing module complete with potentiometers and audio jacks. Several of the labelled pots are replicated on the BU front panel. Note the recycling of 'twin ring modulator' front panels in several places in the chassis!

‘FRONT’ Section

Figure 24 Further details of the front section. This almost certainly shows it was a separate signal processing module at some stage, some kind of prototype harmonic filter?

Figure 25 More detail

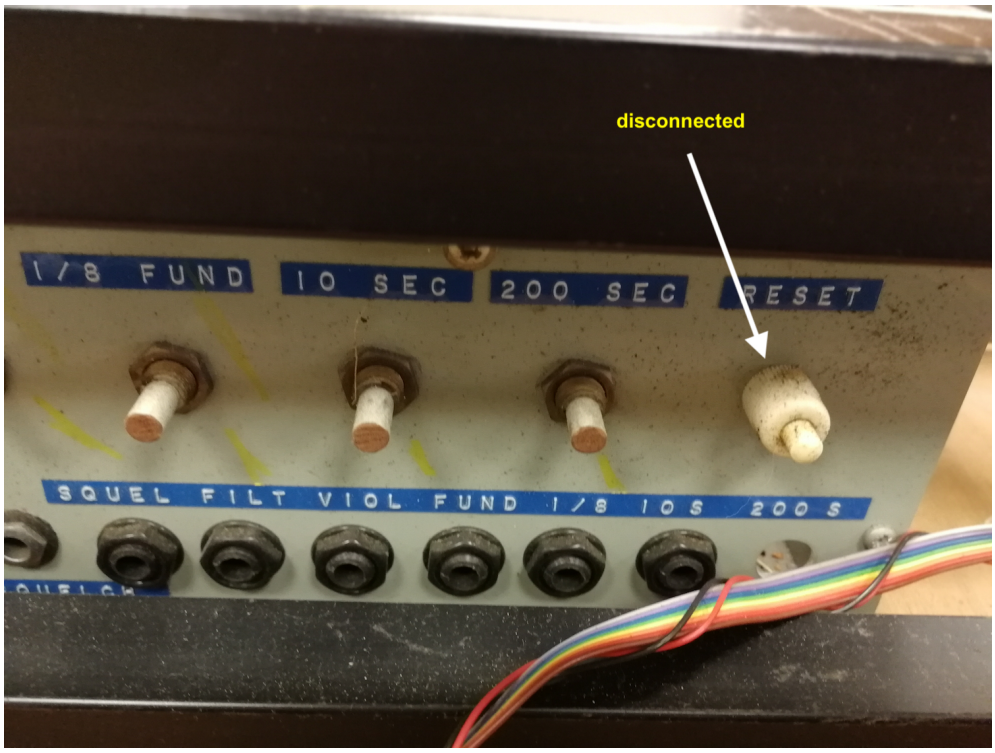


Figure 26 yet more details. The 'RESET' switch is actually disconnected. Original purpose?

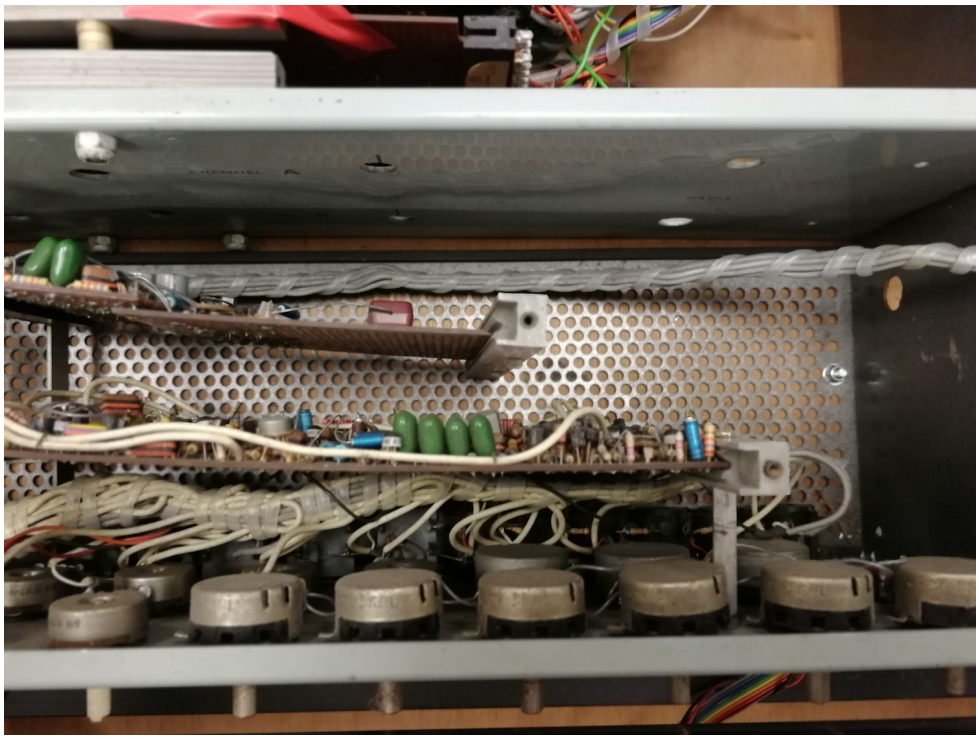


Figure 27 vertical view of front section showing the 2 enclosed pcbs. One is very densely populated.

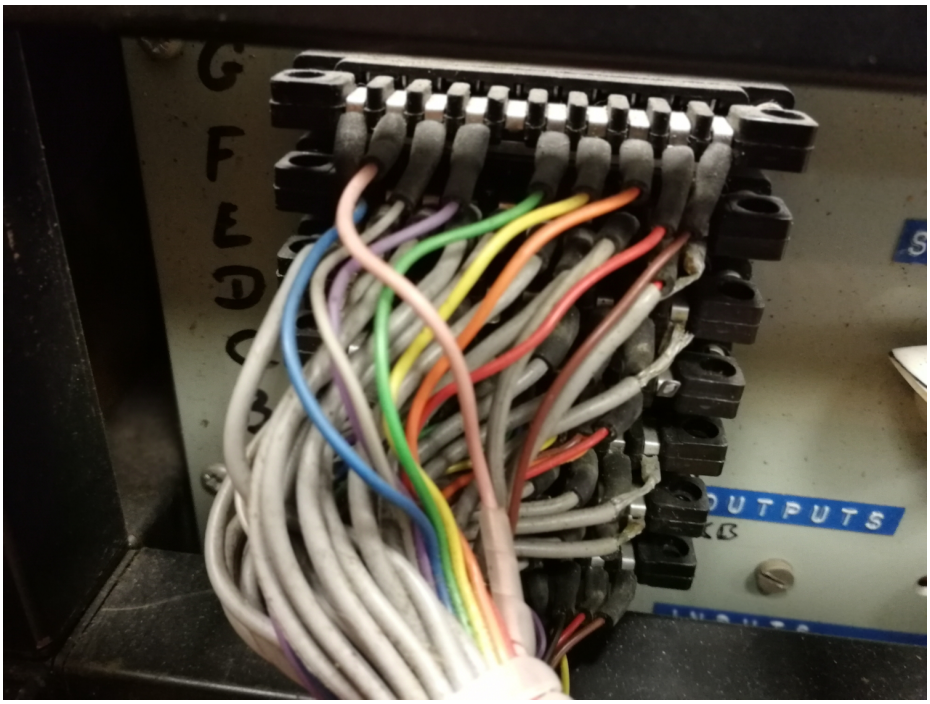


Figure 28 Multi-wired feed through terminal section. Each row is labelled and unplugs from the main 'junction box

'REAR' Section

There are 3 pcbs in this section labelled 'N', 'K' and 'T'

Figure 29 pcb labelled 'N'. Testing shows this is the random voltage/random triggering circuit

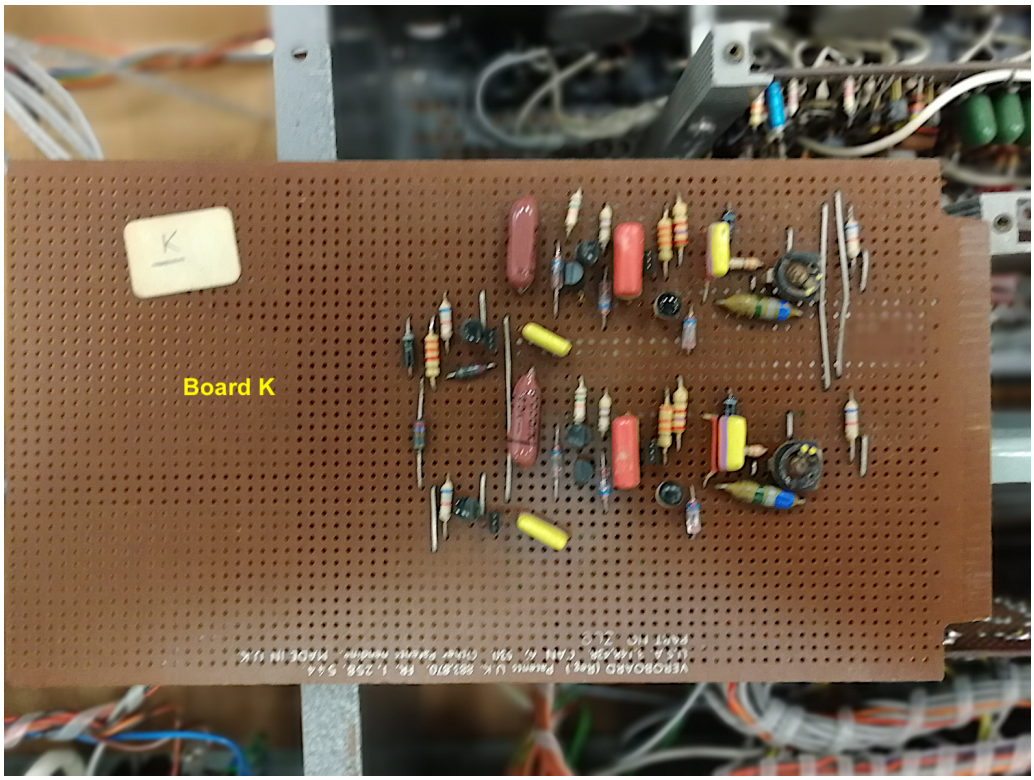


Figure 30 pcb labelled 'K'. Note the 2 replicated circuits. This is in fact the CV/gate signals of the split L/R keyboard

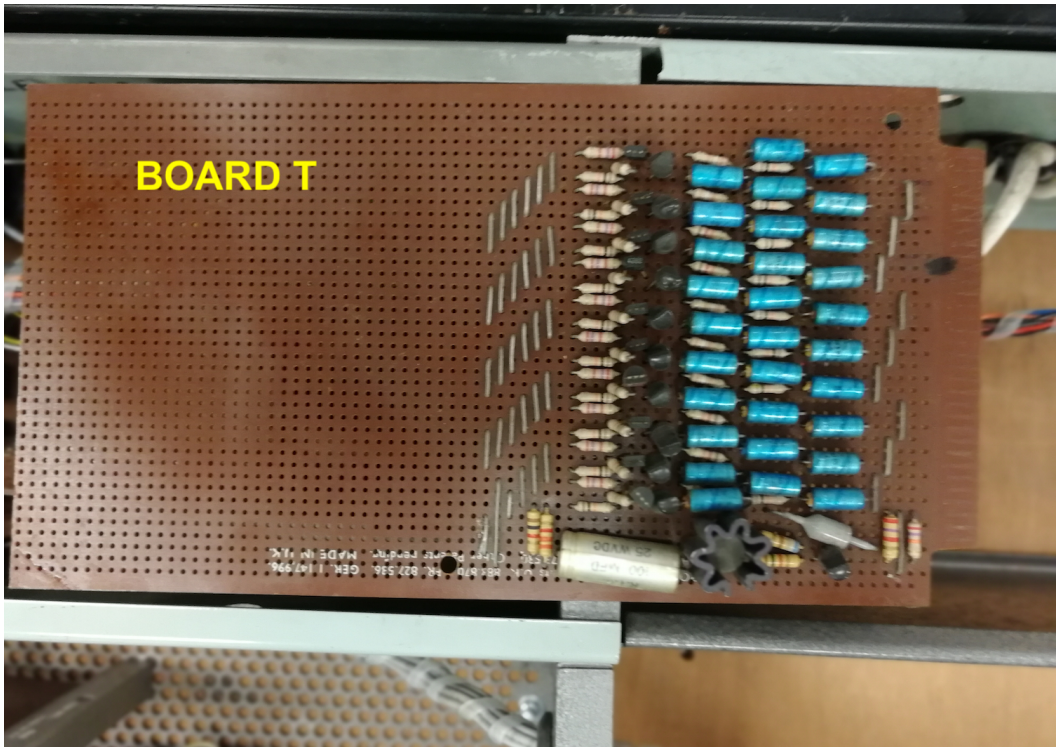


Figure 31 pcb labelled 'T'. This is the mixer circuit board for the BU

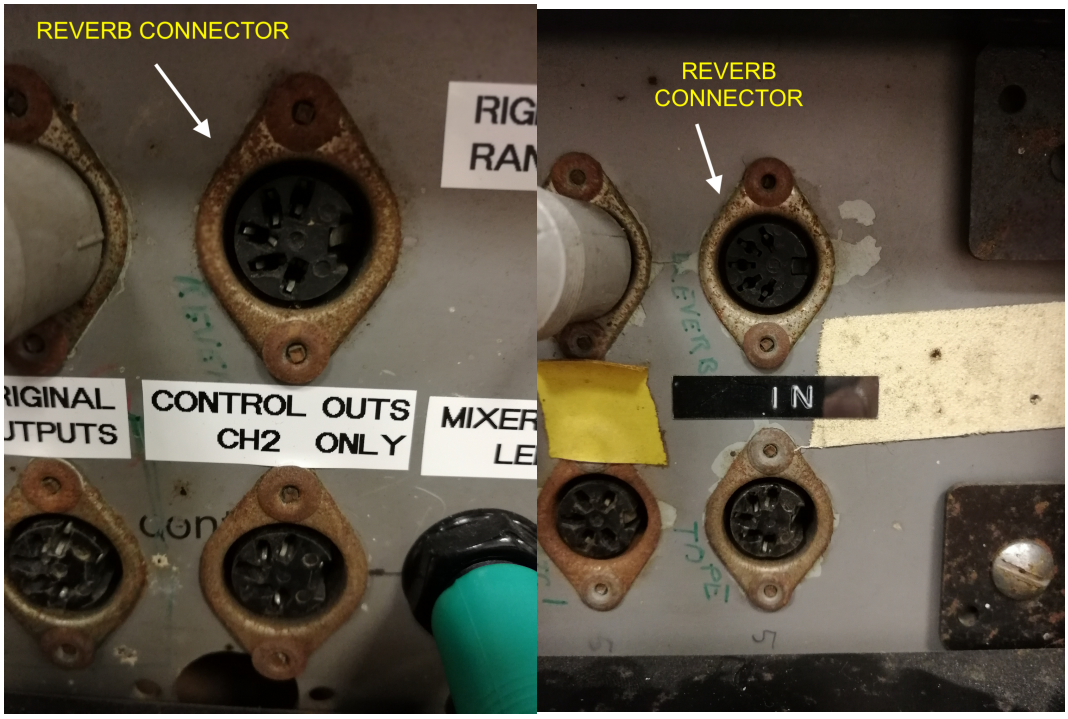
BU PCB summary

The 5 pcbs in the BU are related to the following front panel/BU functions:

- Keyboard (L/R) CV and gate signals **PCB 'K'**
- Random Envelope trigger and random voltage generator **PCB 'N'**
- Mixer section **PCB 'T'**
- The 'Tone-EQ' section (blue stickered pots) **FRONT 2 PCBs**
- The 'VI' (Harmonic Filter ?) section associated with 'Bass', 'Direct', 'Fundamental', 'octave/sub-octave' etc. labelled pots **FRONT 2 PCBs**

The 'Missing' Spring Reverb Tanks?

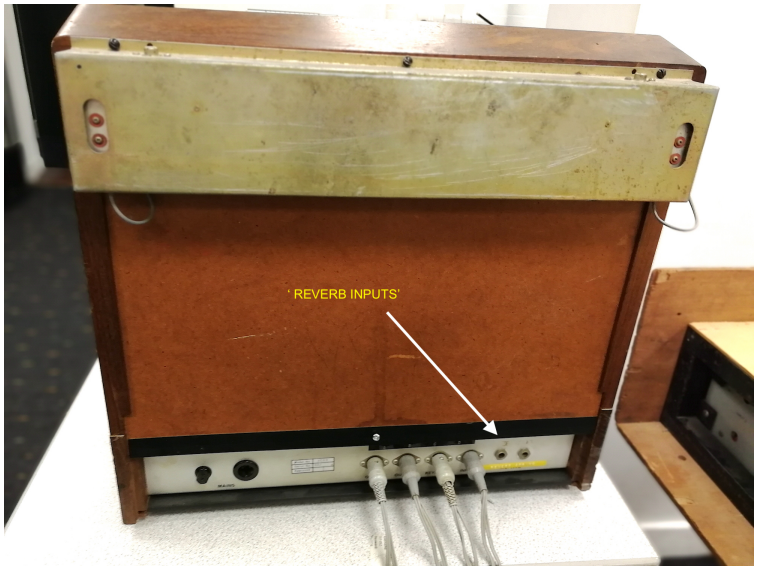
It is pretty clear there were once 2 large spring reverb tanks built into the BU, because there are existing (unconnected) hanging audio cables inside where an empty space is now located. (see fig 22above). These have rca (phono) connectors on them which would have been the standard way of connecting audio in/out of a spring reverb tanks. Testing shows these 4 cables (2 for each tank) connect to the 2 exterior DIN sockets which have 'Reverb' hand written near them in faint pen:



There is no reverb 'driver' circuitry inside the BU. The audio inputs/oupits to the tanks are just direct connections to the DIN connectors.

Any reverb tank needs and audio driver to amplify the current enough to drive the input coil of the reverb.

Speculation: the VCS3's themselves have reverb driver circuits inside them relating to their own smaller reverb tanks. In fact they drive the large reverb tanks currently bolted to their rear. It could be the case that these external tanks were originally housed inside the BU and the audio connections to the tanks made via the DIN connectors. Indeed, on the rear of the VCS3 R are 2 audio jacks with very old looking dymo tape labelled 'Reverb Inputs':



It could be for various reasons, these tanks were later removed from the insides and mounted to the rear of VCS3 L/R. This might be because each VCS3 could then be used separately from the BU and still have a reverb function.

Also by having direct physical contact with the tanks they can be 'hit/banged' to produce distorted reverb, something not so easily achieved if they are housed inside the BU !

Testing of the Tone/EQ and Harmonic Filter Sections

- Feed square or ramp wave into VI.IN of VCS3 L. Monitor the signal out (VI.SIG) with an audio spectrum analyser and see if harmonic content changes when front panel pots are operated.

This test was carried out and it was clear the lower pots and switches on the 'harmonic filter' had some subtle effect on the harmonic content, supressing certain harmonics and boosting others. But not in any dramatic way.

The Tone/EQ section seems to have no affect. This implies some repair is needed (likely dead transistors need replacing in the pcbs associated with this section.)

It is possible that once the Tone/EQ filtering is repaired the harmonic section will also then work as it was intended since the two seem to be intimately connected.

Note: testing for dead transistors on the associated pcbs does not require reverse engineering these very dense prototype boards (which is a very non-trivial task!). It is possible to test for dead transistors in-circuit and without powering up. The pcbs just need to be removed from their card edge connectors and fault tested away from the VCS4.

Repair Work Needed (to be updated).

Filter not working properly on VCS3 L (basically seems no signal through? only self-oscillation heard). Filter failures in VCS3/Synthi's are not uncommon and almost always due to one or more dead transistors in the audio signal path of the filter on PCB B (likely the input section in this case).

Tone /EQ section seems not to be working? (See above).
Investigative fault finding for dead transistors needs to be carried out on the pcbs after removing from their card edge connectors.

Envelope Threshold modification appears not to be working properly(?). PCB is well laid out and repair if needed should be straightforward.

Mic1, 3 and 4 inputs to the mixer pcb appear not to be working. Needs investigating.
The mixer pcb is relatively straightforward and each input channel neatly laid out. A non-functioning channel is almost certainly either bad connections and/or failed transistor(s). Either way the repair is not complicated.

Replace the slightly burned 12ohm shunt resistor in one of the 3 transformer/psu units in the rear of the BU. These look like Erie 1 watt types commonly found in 60s electronics, hifi and guitar amps etc. They can still be found. Straightforward repair.

The VCS4 was last serviced in 2006 by Robin Wood at E.M.S. It is probably worth doing another full service on each of the VCS3's: cleaning pots, faders, switches and checking the Oscillator waveforms, envelope shapers, Filters, Noise, Reverb, Output channel amplifiers etc. are all within spec. Many of these have trimmers to calibrate them on the pcbs. This is quite straightforward servicing.