dCS Ring DAC™ Board

Service Manual

August 2014

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Contents

SAFETY AND CONFIDENTIALITY

Safety Warnings

Servicing must be carried out by qualified service personnel only.

These products contain circuitry that operate at high voltages and/or currents. Removing safety covers can expose personnel to risk of electric shock or other injury.

Take special care when working on the Power Board, as much of the board is at high voltage.

These products contain static-sensitive devices which can be seriously damaged by incorrect handling. Observe standard anti-static precautions at all times.

This product is lead-free to comply with the RoHS directive. If soldering or de-soldering is required, SAC solder (tin / silver / copper) must be used to ensure reliable repairs.

Always use genuine replacement parts supplied by dCS.

Disclaimer

Data Conversion Systems Ltd. accept no liability for any kind for loss, accident or injury resulting from service activities.

Confidentiality

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HARDWARE HISTORY

Classic & Pro

The Ring DAC™ Board DCS002520 was developed in 1994, initially for use in the dCS 950 24/48 professional DAC. Updated versions were used in the 952 24/96 DAC from mid-1995, Elgar 24/96 audiophile DAC from late 1996, 954 24/192 DAC from mid-1997, Elgar Plus 24/192 DSD DAC from 2000 and the 955 24/192 DSD DAC from 2002.

Scarlatti, Paganini, Puccini & Debussy

The imposition of the RoHS Directive (which bans lead and certain other heavy metals from manufactured products) resulted in the DSP & FPGA chips being discontinued. This necessitated a re-design of the electronics used in all dCS products, bringing production of the "Classic" range (Elgar Plus, Verdi, etc.) and the Pro 9xx range to an end, prompting the launch of Scarlatti, Paganini and Puccini in 2007. The Debussy USB-DAC was added to the range in 2010.

DCS002540 versions

The Ring DAC™ Board has been steadily updated to improve performance and accommodate new product designs. The various modification states are identified by a 3-character issue code such as **6e3**, each state is supported by a dCS Modification Note. The modification notes for these build versions are not relevant to field repairs.

The Ring DAC™ Board **DCS002540** build versions used on the products to date are as follows:

9x5 Pro DACs	v1 – v6aA
Elgar	v2 – v6a4
Elgar Plus Mk1	V6a4 – v6a5
Elgar Plus Mk2	v6a5 – v6c1
Scarlatti & Paganini DACs	v6c1 – v6e6
Puccini Player	v6e1 - v6e6
Debussy USB-DAC	v6e4 – v6e6

Do not swap Ring DAC™ Boards between different models, as some builds / variants will not work correctly in all products.

Vivaldi

The design was updated radically for the Vivaldi DAC, launched in 2012. This is not compatible with previous versions, the part number is **DCS400520**. The major changes from DCS002520 are:

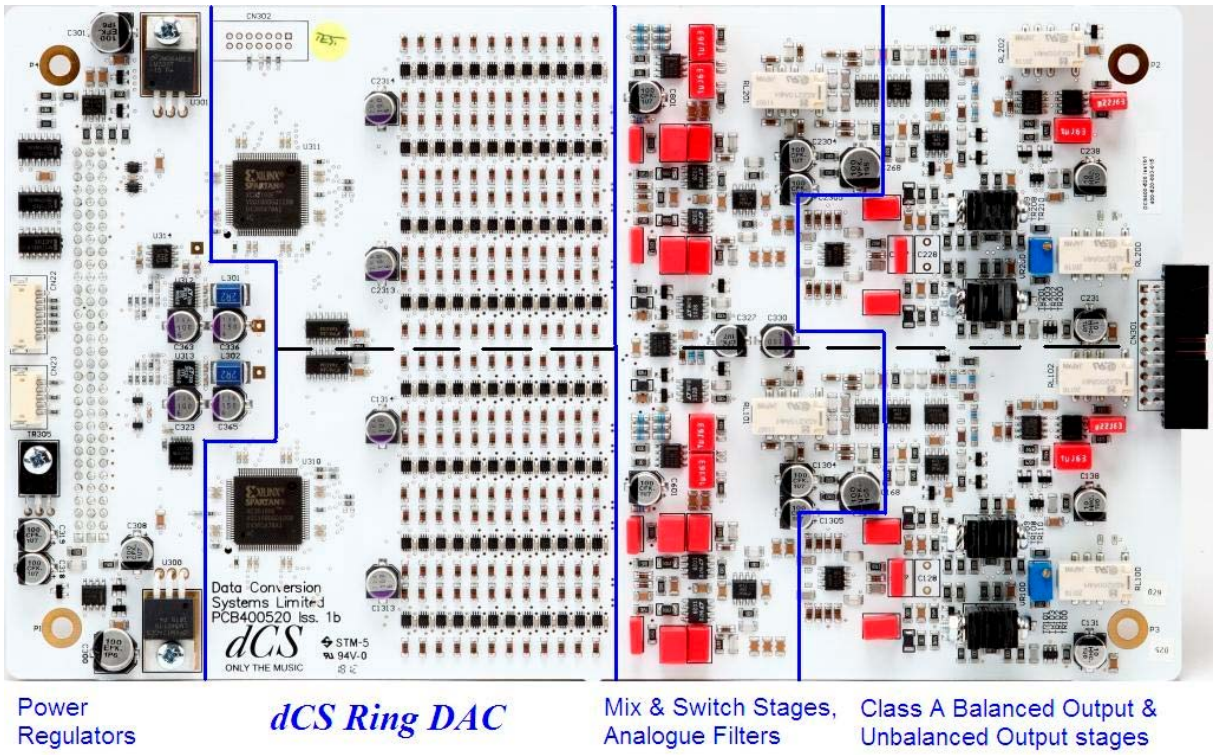
- The board has a complete Left-Right split – this substantially improves the L-R crosstalk.
- The mapping ROMs and the front-end latches have been replaced by a pair of FPGAs, so the Ring DAC functionality can be changed by software updates.
- The quad latch chip array in each Ring DAC core has been replaced by single latch chips, eliminating on-chip crosstalk.
- The original 44 latches have been increased to 48, to make provision for new features.
- The proportion of surface-mounted parts has been increased.
- Some of the op-amps have been replaced by newer, higher performance designs.
- Crosstalk, low-level linearity, noise and distortion have all been improved.

The Vivaldi Ring DAC board is NOT compatible with the hardware/software in older models! Attempts to retrofit it WILL result in serious damage and void any warranty.

VIVALDI

Assembly Description

RIGHT CHANNEL



LEFT CHANNEL

The Vivaldi Ring DAC™ Board DCS400520 performs the digital-to-analogue conversion for the Vivaldi DAC.

Early versions of this board have a white solder resist. This was changed to black for production reasons.

Component reference numbers for the Left channel generally start with 1 (e.g. U102, R1108) and the equivalent components on the Right channel generally start with 2 (e.g. U202, R2108). The Left channel circuitry will be described. The separate sections of dual opamp chips are indicated by suffix letters, such as U102A (= pins 1, 2, 3), U102B (= pins 5, 6, 7). Amplifier blocks with 2 references (e.g. U100/102A) consist of an audio opamp (U100) buffered by a video opamp (U102A).

Excellent left / right crosstalk performance is guaranteed by the black dashed split line shown in the picture above. The circuitry is divided into the following sections:

- Power and digital signals connect from the Control Board via 96-way connector CN1. **Power Regulators** U300 & U301 regulate the VP18 and VN18 rails down to +15V (VP15) and -15V (VN15) respectively. Reference U302 generates an accurate and stable +10.00V from the VP15 rail. R304 & R305/307 divide this down to +5.0V, this is buffered by U304A/TR304/305/307 which provide enough current to drive most of the Ring DAC circuitry (VP5). R305 & R307 divide the +5V reference down to +3.3V to drive high-performance buffer circuit U1303/TR1302/TR1303/TR1306, which provides a clean reference supply (VP6L) for the latches in the Left channel Ring DAC. Regulators U312, 313 & 314 generate the +3.3V (VP3), +1.2V (V1P2) and +2.5V (V2P5) rails respectively, which power the FPGAs. Watchdog chip U353 keeps the DAC muted and disables the gain switch relays during boot-up. When the Control Board commands the DAC to un-mute, the MUTE line (buffered by U305) goes low (+5V falls to 0V), TR301 turns on and muting relays RL100/RL102/RL200/RL202 turn on, connecting the DAC output stages.

- The **Ring DAC™** section consists FPGAs U310 & 311, two array of 48 NC7SZ75 latch chips U400-U447 & U500-U547 and a large number of 10kΩ metal-film resistors. The FPGAs take stereo 5-bit binary data at 2.822 or 3.07MS/s and decode / randomise / re-clock it. Once a full set of data is assembled, the RDY line goes high, latching the data into latches U400-U447 (left channel) and U500-547 (right channel). The complementary voltage outputs from the latches (48 per channel) drive currents through the adjacent 10kΩ resistors (R100-143, R147-150 / R151-198) into a stereo pair of balanced mix buses.

- The **Mix Stages and Analogue Filters** consist of a stereo pair of balanced current-to-voltage converters and a gain switch stage, both with active filtering. The balanced mix stage amplifiers U100/U102A & U101/U102B operate with their inputs at a DC offset of +1.67V, to maintain symmetrical operation in the Ring DAC. The full-scale differential output level from the mix stage is 7.84V rms. The balanced gain switch stage consists of U104A/U105A & U104B/U105B, connected as a pair of inverting amplifiers. A latching relay RL101 switches in some extra input/feedback components to change the DAC output levels by a factor of 3 (9.5dB). When a change in output level is commanded by the Control Board, the GAIN line changes state, causing gates U305/U352/U319 to drive the coil of latching relay RL101 in the appropriate direction for about 30ms. The full-scale differential output level from the gain switch stage is either 9.06V or 3.08V rms, depending on the relay state. Bias amplifier U107A drives DC into one of the mix buses. Servo amplifier U107B drives a compensating current into the other mix bus to adjust the differential DC offset at the output of the gain switch stage to be close to zero (typically +/-0.1mV).

- The **Balanced Output Stage** consists of an opamp U108 driving a discrete transconductance amplifier stage, the circuit behaves much like a transformer. Current sources TR100/101/110/111 and the associated opamps supply 18mA to each of TR102/103/108/109. U108 drives TR104/TR106, which drive TR102/TR108. TR105/TR107 maintain a steady bias for TR103/TR109. Signal current couples from the emitters of TR102/TR108 to TR103/TR109 via resistors R1144 & R1159. The split feedback to U108 ensures the gain is stable, regardless of asymmetric output loading. Servo amplifier U113 trims the current sources via TR114/TR116 to maintain output DC offsets close to zero. Trimmer VR100 adjusts the output signal balance into a floating load – it is factory set and should not require further adjustment. Relay RL100 mutes the output, the output signals connect via CN301. The full-scale output level is 6V or 2V rms, depending on the setting of RL101.

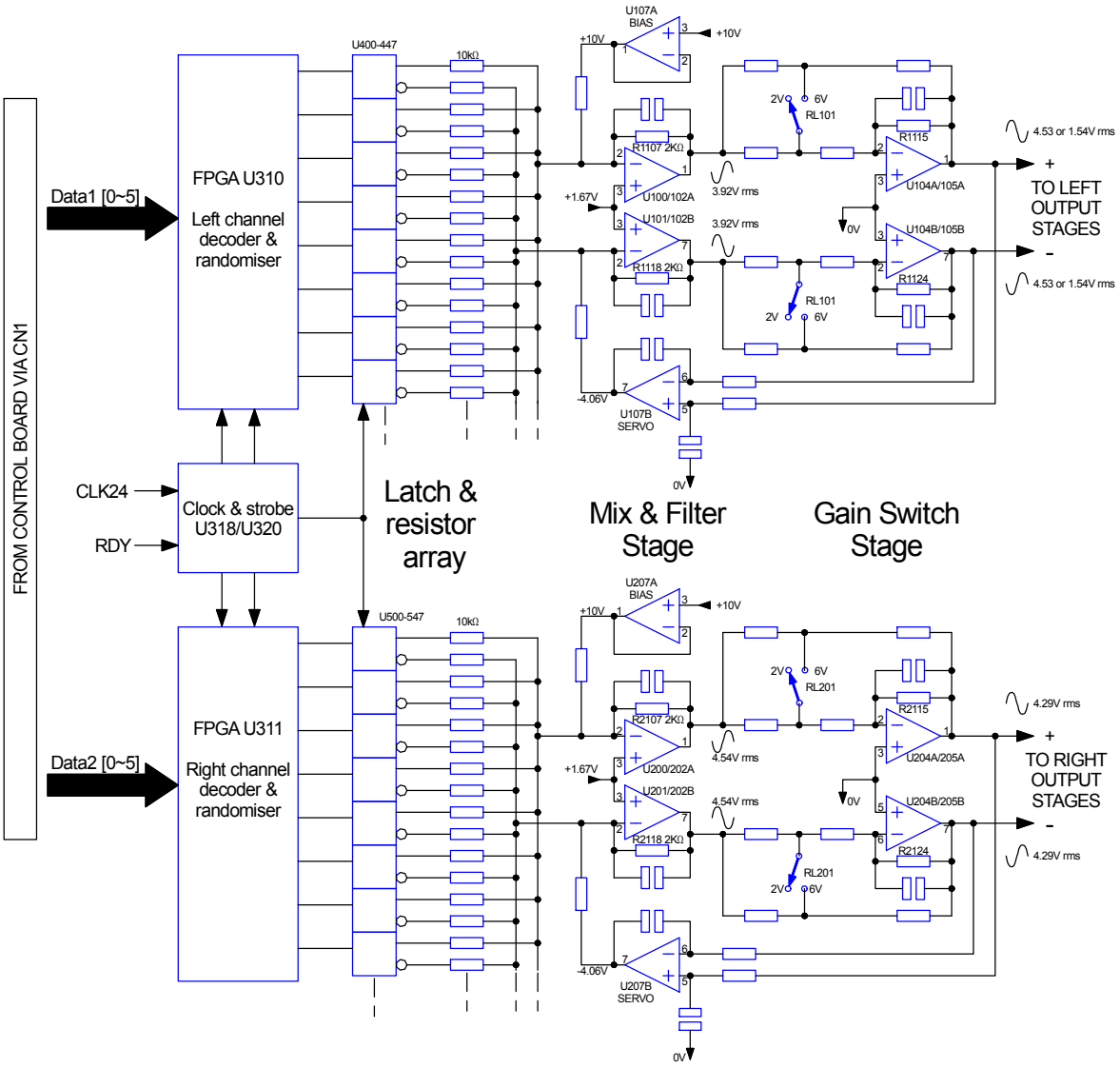
- The **Unbalanced Output Stage** consists of a pair of dual opamps U106B/U109B & U106A/U109A, these convert the balanced feed from the gain switch stage to unbalanced, reducing the full-scale level to 6V or 2V rms, depending on the setting of RL101. Relay RL102 mutes the output signals, which connect via CN301.

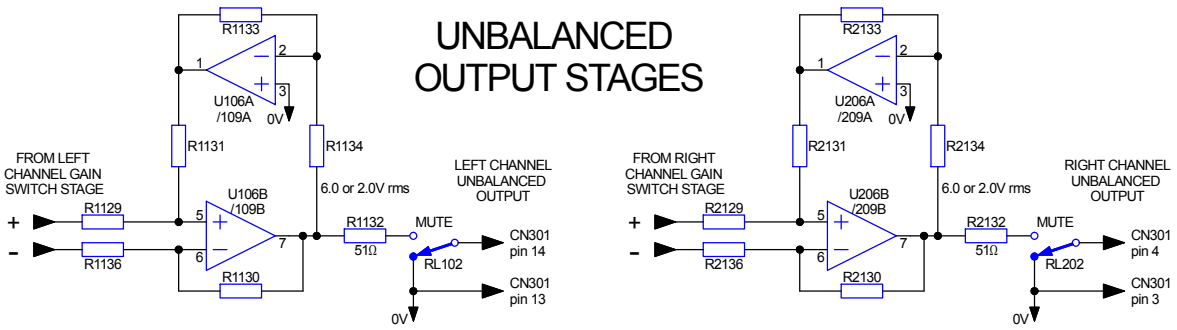
Drawings

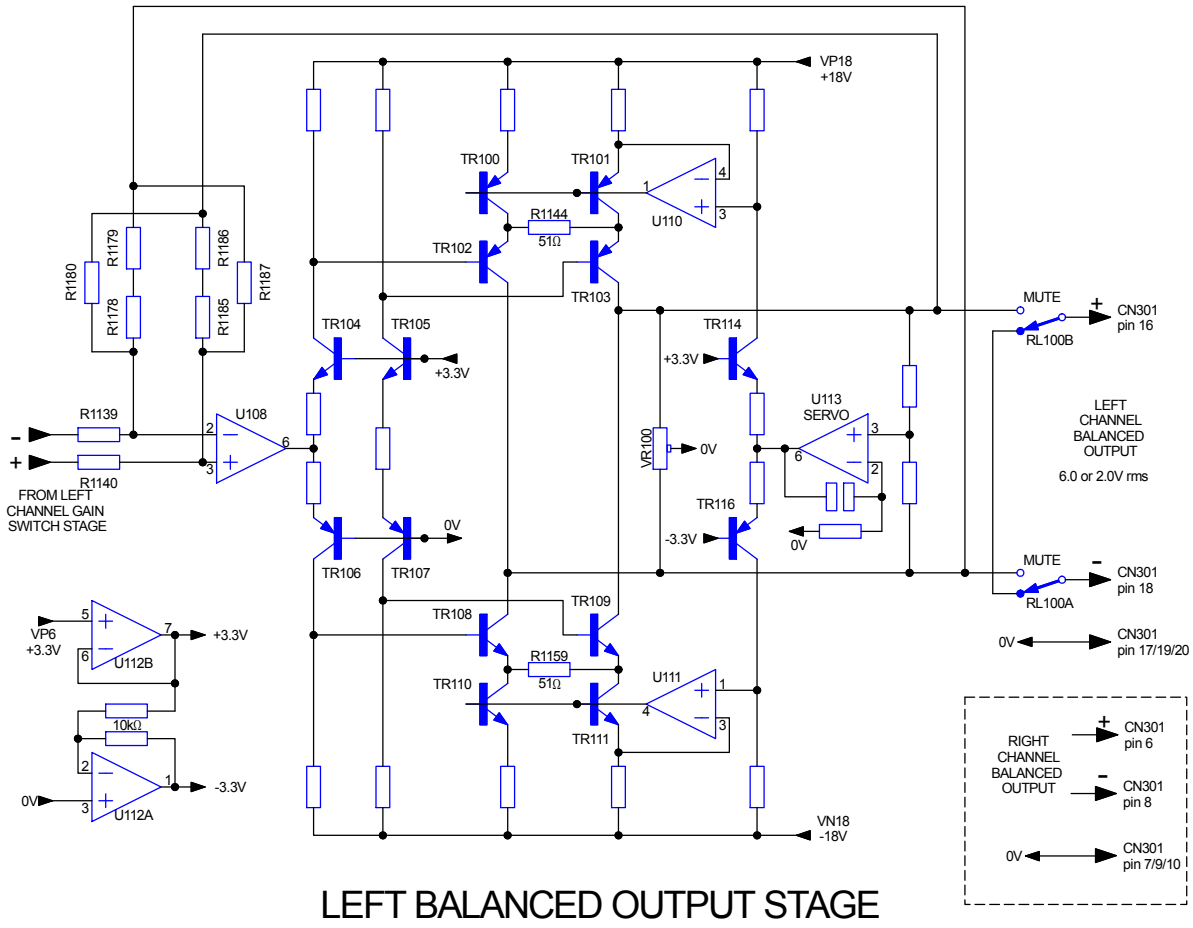
The Ring DAC™ Board circuitry is proprietary to dCS, the circuit diagram is not available to service centres. Circuit diagram sheet 1 covers the power regulator section and the relay drivers. See the block diagram for more information.

Circuit diagram file: 400520cd1d1 sht1.pdf
Component layout file: 400520cl1d.pdf

Block diagram







LEFT BALANCED OUTPUT STAGE

Common Set-up Errors

Symptom: Balanced outputs are noisy, sound is "thin", gain is unstable

- Our balanced output stages behave like coupling transformers, they are designed to have BOTH legs connected to the load. Some amplifiers / preamplifiers have unbalanced inputs on XLR connectors, with pin 3 left floating – this causes dCS balanced output stages to malfunction. To correct this, connect pin 3 to ground at the amplifier end of the cable.

Known Faults & Fixes

There are no known faults at the time of writing.

Fault-Finding Guide

Symptom: The unit boots up but does not output audio.

- Check that the DAC has locked to an active source and the volume control is set to a high level. If the DAC is set to sync to Word clock, check that both the DAC and the source are locked to the Clock, and that the Clock frequency is an exact multiple of the sample rate. Try setting the DAC to sync to Audio – if this clears the problem, the Ring DAC™ Board is not at fault.
- Check the DC power rails on the Ring DAC™ board, between chassis and the locations listed.

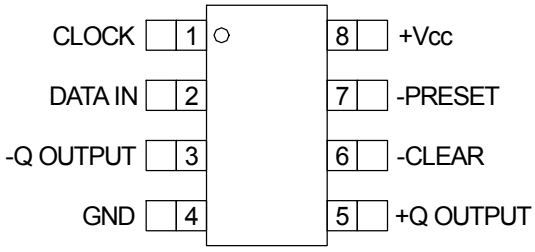
RAIL	TYPICAL VOLTAGE	LOCATION
VP18	+17.9V	U300 pin 1 (direct from Control Board)
VP15	+15.0V	U300 pin 3
VN18	-18.7V	U301 pin 2 (tab) (direct from Control Board)
VN15	-15.0V	U301 pin 3
VP8	+6.5V	TR305 pin 1 (direct from Control Board)
VREF	+10.00V	TR302 pin 6
VP5	+5.0V	TR305 pin 2 (tab)
VP6L	+3.3V	TR1303 pin 3
VP6R	+3.3V	TR2303 pin 3
VP3	+3.3V	Test Point 2 - near C336
V2P5	+2.5V	Test Point 1 – near U314
V1P2	+1.2V	Test Point 3 – near L302

If the measured voltages are not within 5% of those stated above, investigate the cause. Note that VREF should be accurately +10.00V.

- If the MUTE indicator has turned off, check to see if the muting relays RL100, 102, 200 & 202 are operating. A fault in the relay drive circuitry (see circuit diagram sht1) can result in the relays remaining in the muted state.
- If the MUTE indicator remains on and the drive circuitry is OK but the MUTE line from the microcontroller is high (+5V), it is possible that the settings stored in flash memory have been corrupted – contact dCS for advice.

Symptom: Noise and low-level distortion on one channel.

- While this has not been seen on current products, this fault can be caused by failure of one or more NC7SZ74 latches in the Ring DAC™. To check for this, disconnect all inputs from the DAC, power up and measure the DC voltages at the latch outputs, relative to chassis using a multimeter. This is easiest to do by probing on the ends of the 10kΩ resistors closest to the latch chips. The measurements should be either +2.42V, +2.56V, +0.77V or +0.91V. If you measure close to 0V or +3.3V on one or a few outputs, this indicates either a damaged latch output or that the latch is not receiving a pulse train on its data input. Use an oscilloscope to check for activity on the data and clock inputs. If the latch data and clock inputs are OK but the latch output(s) are inactive, replace the chip. The latch data inputs are driven from the FPGA (contact dCS for advice). The pin connections for the NC7SZ74 are:



- Check for soldering faults at the 10kΩ mini-melf resistors.
- Opamp failures occur rarely, but can cause distortion, noise and/or large DC offsets. Trace the fault using the block diagram and replace the part responsible.

Symptom: The output level on one channel is 9.5dB higher than the other.

- The gain switch stage uses a latching relay to set the output level. If the unit is dropped in transit or bumped hard while being moved, one of the latching relays can flip over. The solution is to open the unit's menu, change the Output Level setting to 6V and then to 2V.
- If this cannot be corrected from the menu but the gain of the other channel changes as expected, there is a fault near the gain switch relay – RL101 for Left, RL201 for Right.

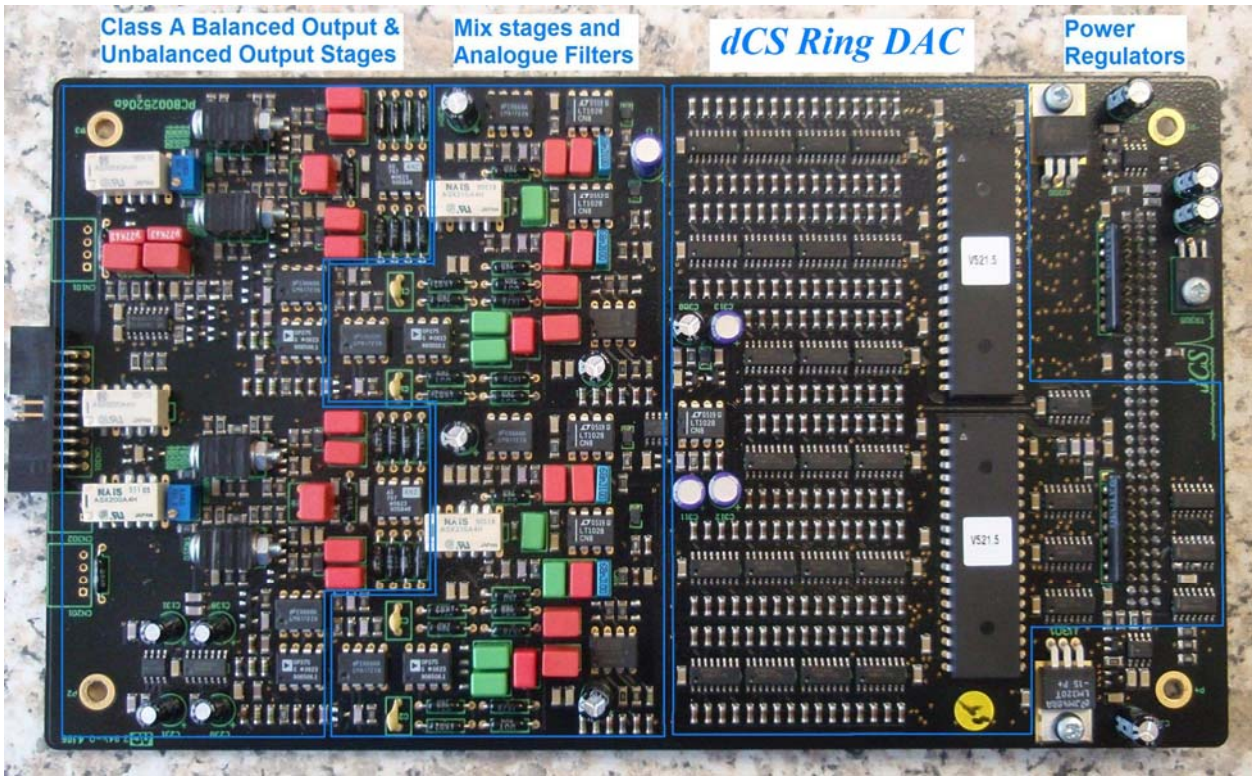
Symptom: During installation, changing the Output Level setting has no effect.

- If the unit is dropped in transit or bumped hard while being moved, it is possible that BOTH of the latching relays can flip over. The solution is to open the unit's menu, change the Output Level setting to 6V and then to 2V.
- If this cannot be corrected from the menu, there is a fault in the gain switch circuitry.

SCARLATTI / PAGANINI / PUCCINI / DEBUSSY

Assembly Description

LEFT CHANNEL



RIGHT CHANNEL

The Ring DAC™ Board DCS0025206 performs the digital-to-analogue conversion for the Scarlatti DAC, Paganini DAC, Puccini Player and the Debussy USB-DAC.
As shown in the photo above, the circuitry is divided into the following sections:

- Power and digital signals connect from the Control Board via 96-way connector CN11. **Power Regulators** U300 & U301 regulate the VP18 and VN18 rails down to +15V (VP15) and -15V (VN15) respectively. Reference U302 generates an accurate and stable +10.00V from the VP15 rail. R304/305 divide this down to +4.76V, this is buffered by U304A/TR304/305/307 which provide enough current to drive most of the Ring DAC circuitry (VP5), while high-performance buffer circuit U303/TR302/TR303/TR306 provides a clean reference supply (VP6) for the final set of latches in the Ring DAC™. Watchdog chip U353 keeps the DAC muted and disables the gain switch relays during boot-up. When the Control Board commands the DAC to un-mute, the MUTE line (buffered by U305) goes low (+5V falls to 0V), TR301 turns on and muting relays RL100/RL200/RL300 turn on, connecting the DAC output stages.

- The **Ring DAC™** section consists of an array of 74ACT377 octal latch chips (mounted on the back of the board), two randomising ROMs, an array of 74ACT175 quad latch chips and a large number of 10kΩ metal-film resistors. The circuit takes stereo 5-bit binary data at 2.822 or 3.07MS/s, and passes it through the decoding/randomising circuitry, consisting of ROMs U310 & U331 and octal latches U306, U311 & U332. The randomised data is clocked into octal latches U312-317 & U333-337, the latching pulses being generated by state machine U307-309. Once a full set of data is assembled, the RDY line goes high, latching the data into quad latches U320-U330 (left channel) and U338-348 (right channel). The complementary voltage outputs from the latches (44 per channel) drive currents through the adjacent 10kΩ resistors (R100-139, R147-190, R195-198 / R200-239, R247-290, R295-298) into a stereo pair of balanced mix buses.

From this point on, component reference numbers for the Left channel generally start with 1 (e.g. U102, R1108) and the equivalent components on the Right channel generally start with 2 (e.g. U202, R2108). The Left channel circuitry will be described. The separate sections of dual or quad opamp chips are indicated by suffix letters, such as U102A, U102B for a dual or U351A, U351B, U351C & U351D for a quad.

Amplifier blocks with 2 references (e.g. U100/102A) consist of an audio opamp buffered by a video opamp.

- The **Mix Stages and Analogue Filters** consist of a stereo pair of balanced current-to-voltage converters and a gain switch stage, both with active filtering. The balanced mix stage amplifiers U100/U102A & U101/U102B operate with their inputs at a DC offset of +2.38V, to maintain symmetrical operation in the Ring DAC. The full-scale differential output level from the mix stage is 9.08V rms. The balanced gain switch stage consists of U104A/U105A & U104B/U105B, connected as a pair of inverting amplifiers. A latching relay RL101 switches in an input attenuator network to reduce the DAC output levels by a factor of 3 (-9.5dB). When a change in output level is commanded by the Control Board, the GAIN line changes state, causing gates U305/U352/U319 to drive the coil of latching relay RL101 in the appropriate direction for about 30ms. The full-scale differential output level from the gain switch stage is either 8.58V or 2.86V rms, depending on the relay state. Bias amplifier U107A drives DC into one of the mix buses. Servo amplifier U107B drives a compensating current into the other mix bus to adjust the differential DC offset at the output of the gain switch stage to be close to zero (typically +/-0.1mV).

- The **Balanced Output Stage** consists of an opamp U108 driving a discrete transconductance amplifier stage, the circuit behaves much like a transformer. Current sources TR100/101/110/111 and the associated opamps supply 18mA to each of TR102/103/108/109. U108 drives TR104/TR106, which drive TR102/TR108. TR105/TR107 maintain a steady bias for TR103/TR109. Signal current couples from the emitters of TR102/TR108 to TR103/TR109 via resistors R1144 & R1159. The split feedback to U108 ensures the gain is stable, regardless of asymmetric output loading. Servo amplifier U351D trims the current sources via TR114/TR116 to maintain output DC offsets close to zero. Trimmer VR100 adjusts the output signal balance into a floating load – it is factory set and should not require further adjustment. Relay RL100 mutes the output, the output signals connect via CN301. The full-scale output level is 6V or 2V rms, depending on the setting of RL101.

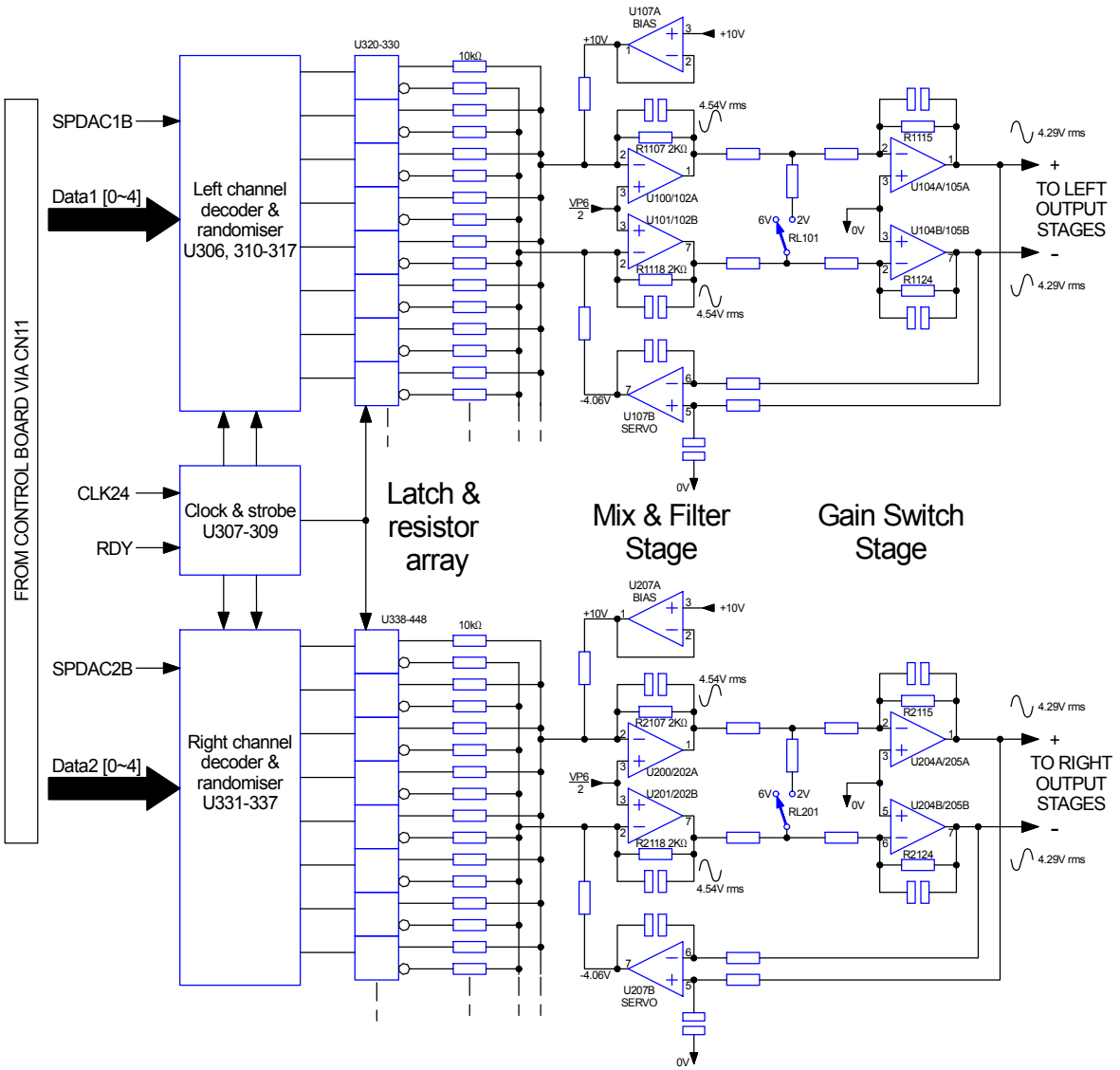
- The **Unbalanced Output Stage** consists of a pair of dual opamps U106B/U109B & U106A/U109A, these convert the balanced feed from the gain switch stage to unbalanced, reducing the full-scale level to 6V or 2V rms, depending on the setting of RL101. Relay RL300 mutes both channels, the output signals connect via CN301.

Drawings

The Ring DAC™ Board circuitry is proprietary to dCS, the circuit diagram is not available to service centres. Circuit diagram sheet 1 covers the power regulator section and the relay drivers. See the block diagram for more information.

Circuit diagram file: 002520cd6e1 sht1.pdf
Component layout file: 002520cl6e.pdf

Block diagram



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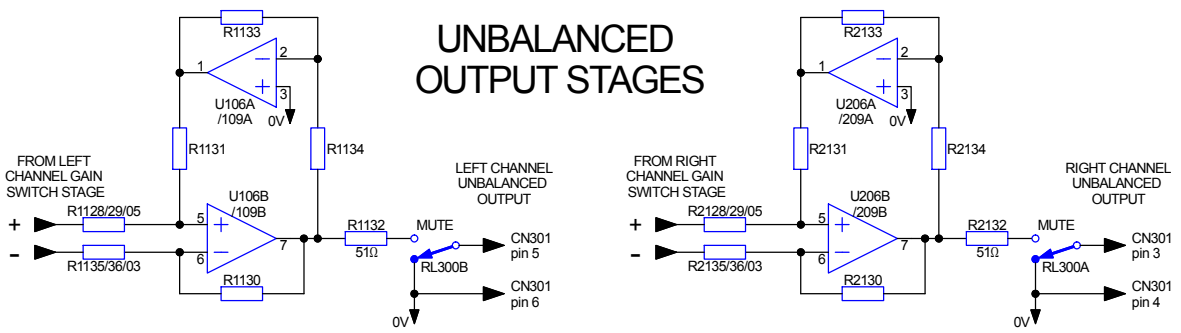
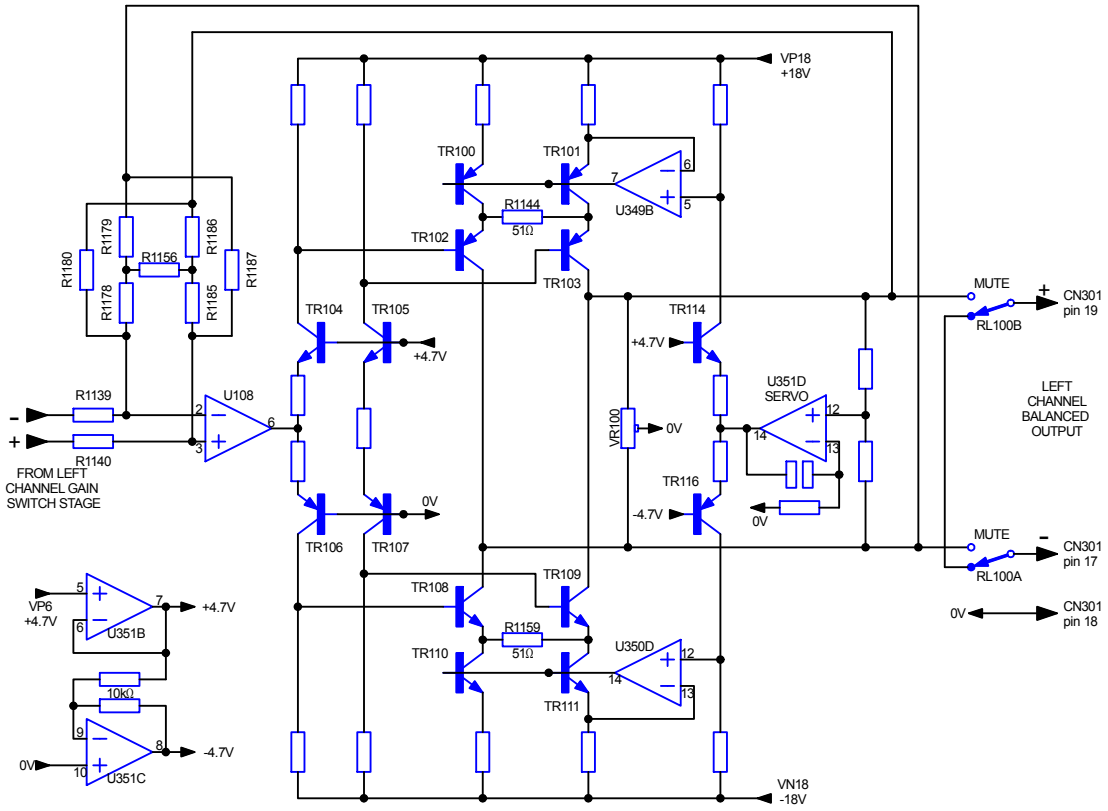
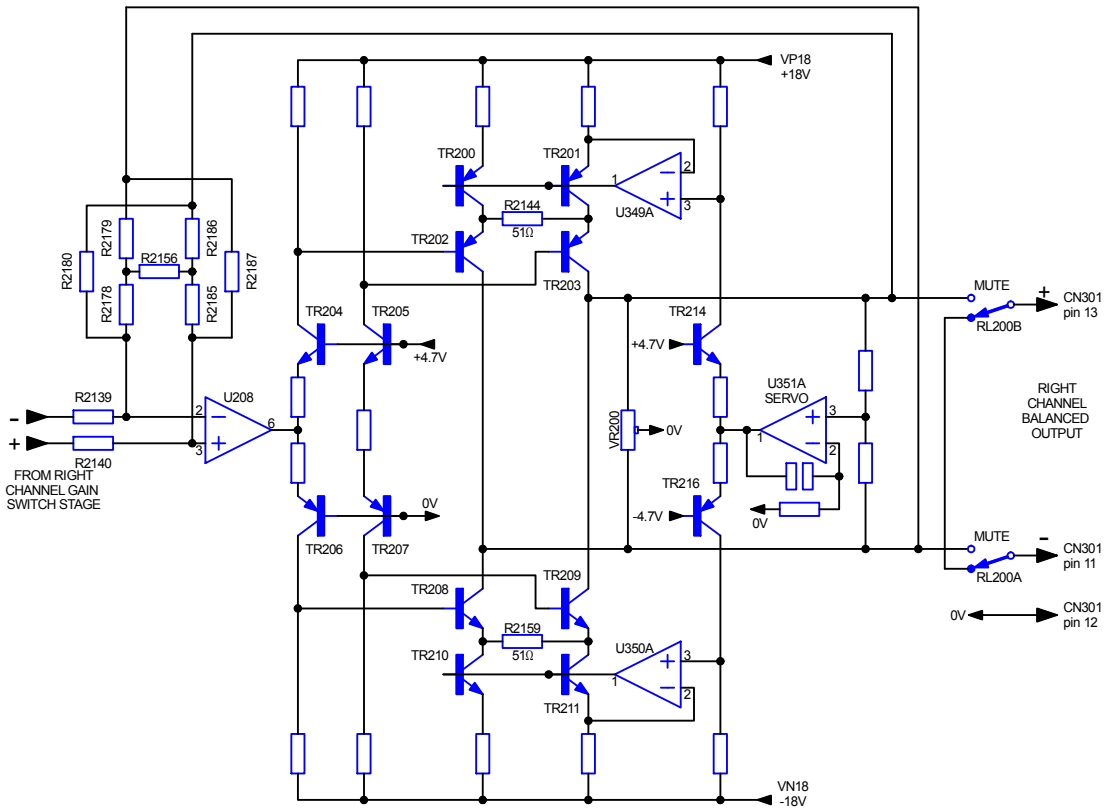




BALANCED OUTPUT STAGES



Common Set-up Errors

Symptom: Balanced outputs are noisy, sound is "thin", gain is unstable

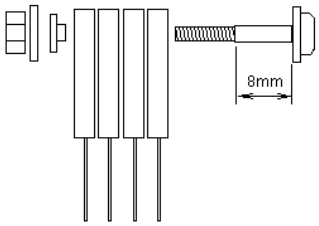
- Our balanced output stages behave like coupling transformers, they are designed to have BOTH legs connected to the load. Some amplifiers / preamplifiers have unbalanced inputs on XLR connectors, with pin 3 left floating – this causes dCS balanced output stages to malfunction. To correct this, connect pin 3 to ground at the amplifier end of the cable.

Known Faults & Fixes

The Ring DAC™ boards used on current products have proven to be very reliable.

Symptom: "Scratching" noise on balanced output, probably on one channel.

- On board versions earlier than 6e3, this may be due to a resistive leak forming between the collector pads of power transistors TR100-103, TR108-111, TR200-203, TR208-211 via the clamping screw. The solution is to remove the 4 M3 screws & fixings clamping the 4 groups of transistors together, insulate 4 M2.5x12 screws with 8mm lengths of 2.4mm heat-shrink sleeving and reassemble using M2.5 shoulder washers, plain washers & nuts . This fault has been reported from the field only once so far.



Fault-Finding Guide

Symptom: The unit boots up but does not output audio.

- Check that the DAC/Player has locked to an active source. If the DAC/Player is set to sync to Word clock, check that both the DAC/Player and the source are locked to the Clock, and that the Clock frequency is an exact multiple of the sample rate. Try setting the DAC/Player to sync to Audio – if this clears the problem, the Ring DAC™ Board is not at fault.
- Check the power rails on the Ring DAC™ board, between chassis and the locations listed.

RAIL	TYPICAL VOLTAGE	LOCATION
VP18	+17.8V	U300 pin 1 (direct from Control Board)
VP15	+15.0V	U300 pin 3
VN18	-18.7V	U301 pin 2 (direct from Control Board)
VN15	-15.0V	U301 pin 3
VP8	+6.49V	TR305 pin 1 (direct from Control Board)
VREF	+10.00V	TR302 pin 6
VP5	+4.76V	TR305 pin 2 (tab)
VP6	+4.76V	TR303 pin 3

If the measured voltages are not within 5% of those stated above, investigate the cause. Note that VREF should be accurately +10.00V.

The VN18 power rail is disabled at initial switch-on and will not measure -18V until the unit has successfully booted up. Similarly, the VN15 regulator has no power until the VN18 rail rises.

- If the MUTE indicator has turned off, check to see if the muting relays RL100, 200 & 300 are operating. A fault in the relay drive circuitry (see circuit diagram 002520cd6e1 sht1) can result in the relays remaining in the muted state.

- If the MUTE indicator remains on and the drive circuitry is OK but the MUTE line from the microcontroller is high (+5V), it is possible that the settings stored in flash memory have been corrupted – contact dCS for advice.

Symptom: Noise and low-level distortion on one channel.

- While this has not been seen on current products, this fault can be caused by failure of one or more 74ACT175 latches in the Ring DAC™. To check for this, disconnect all inputs from the DAC, power up and measure the DC voltages at the latch outputs, relative to chassis using a multimeter. This is easiest to do by probing on the ends of the 10kΩ resistors closest to the latch chips. The measurements should be either +1.30V or +3.46V. If you measure close to 0V or +4.7V on one or a few outputs, this indicates either a damaged latch output or that the latch is not receiving a pulse train on its data input. Use an oscilloscope to check for activity on the data input. If the latch data input is OK but the latch output(s) are inactive, replace the chip. If there is no activity on the latch data input, the fault is probably in the latch chips on the back of the board (contact dCS for advice). The pin connections for the 74ACT175 are:

Data input / pin	Output / pin
D0 4	Q0 2
	-Q0 3
D1 5	Q1 7
	-Q1 6

Data input / pin	Output / pin
D2 12	Q2 10
	-Q2 11
D3 13	Q3 15
	-Q3 14

The 74ACT175 chips used in the Ring DAC™ are of a specially selected type. To maintain the original performance level, please order replacement parts from dCS.

- Check for soldering faults at the 10kΩ mini-melf resistors.
- Opamp failures occur rarely, but can cause distortion, noise and/or large DC offsets. Trace the fault using the block diagram and replace the part responsible.

Symptom: The output level on one channel is 9.5dB higher than the other.

- The gain switch stage uses latching relays to set the output levels. If the unit is dropped in transit or bumped hard while being moved, one of the latching relays can flip over. The solution is to open the unit's menu, change the Output Level setting to 6V and then to 2V.
- If this cannot be corrected from the menu but the gain of the other channel changes as expected, there is a fault near the gain switch relay – RL101 for Left, RL201 for Right.

Symptom: During installation, changing the Output Level setting has no effect.

- If the unit is dropped in transit or bumped hard while being moved, it is possible that BOTH of the latching relays can flip over. The solution is to open the unit's menu, change the Output Level setting to 6V and then to 2V.
- If this cannot be corrected from the menu, there is a fault in the gain switch circuitry.

Faults seen on Elgar / Elgar Plus Ring DAC™ Boards

The versions of the board used on Elgar/Elgar Plus are similar to the Scarlatti version. The Output Level switching was performed by a rear panel switch on all but the last ~50 Elgar Plus units (which use a 6c board with gain switching relay).

Some of the faults listed below may appear on Scarlatti DAC / Paganini DAC / Puccini Player & Debussy DAC as they age.

Symptom: After several years of use, the noise floor on both channels gradually rises.

- This has been seen on Elgar / Elgar Plus units over 5 years old, especially where the unit has not been switched off for very long periods. The usual cause on these older models is deterioration of the electrolytic capacitors used for power supply decoupling. Current products run cooler, so component life will be longer, but the same problem is likely to occur in time. The solution is to replace the capacitors with new parts, the following values apply to board versions 6aA to 6e3:
  10uF 25V 20% radial: C131, C138, C231, C238
  100uF 25V 20% radial: C300, C301, C304, C305, C308, C318, C319, C601, C801.
  Consult dCS for advice on other board versions or to order spare capacitors.

Symptom: One of the 4 outputs does not produce clean audio.

- The most common cause on Elgar / Elgar Plus is that an excessive current or voltage from outside the unit (usually from a power amplifier) has damaged an output stage. Check for overheated parts and burned tracks. In most cases, damaged parts (more commonly in the unbalanced output stage) can be replaced successfully. Damaged tracks may be repairable, but will usually require board replacement. A burned board will usually require replacement. This type of damage has not yet been reported on later products, probably due to improved circuit protection.

Symptom: One or more outputs crackles or is intermittent.

- The output muting relay contacts can deteriorate after several years of use, particularly if the unit is left in standby mode when not in use. If this is the cause, the fault will usually clear temporarily is the unit is quickly muted and un-muted several times. The solution is to replace relays RL100, RL200 and RL300 with new parts (part number SWI0510025).

Symptom: Noise and low-level distortion on one channel.

- Usually caused by a latch failure.

Symptom: Noise and low-level distortion on both channels.

- The reference generator is common to both channels. If similar levels of distortion appear (generally in the -60 to -90dB0 range) and 2nd harmonic dominates, check for damage to transistors TR302, TR303 and TR306. Noise can be caused by a partial failure of U303.

Symptom: Cannot change the Output Level setting.

- 6b boards only: this setting cannot be changed unless the unit is locked and unmuted.