ZeroUno DAC MKII

Digital Preamplifier

Technical Description

CanEVER AUDIO®

INDEX

Introduction

Even very critical listeners accept computer audio as a music source very well. A real landmark in the evolution of computer audio has been the introduction of the *asynchronous transfer mode*, which is available for standard industry use since 2006, using the USB 2.0 interface of standard personal computers. Drivers based on this technology transfer digital music files from a computer to a DAC independently from the - mostly very inaccurately working - internal clock of the computer. All necessary timing now can handled by much more precise oscillators inside the DAC.

Although the market today is flooded by a huge number of DACs ranging from prices of a few hundred Dollars to 10 to 20 k€ or even more, the claim made inside numerous marketing brochures, that the customer now (finally) gets the perfect sound forever is unfortunately (still) not true! It has been not true in 1982 as SONY and PHILIPS introduced the CD with fanfares of marketing - including the support of worldwide famous artists of those times (e.g. Herbert von Karajan) - and it is still not true today - sorry!

Not only is the number of different DACs offered today not easy to overlook by the interested customer. The sound of those DACs can be very different as well – independent from the individual price point. And even very expensive DACs sometimes offer on one hand a very detailed, but on the other hand a *crispy* sound full of details mainly in the mid to high frequencies, which impress the listener in the first run, but make our brain tired while listening for some hours.
Mostly very experienced customers, who grew up with vinyl sound, complain about the sometimes *harsh* and *cold* sound of DACs. For those, who are interested in all the great features of computer audio too, it is not an easy task to find a DAC, who´s sound fits into the analogue sound patterns, they are used to.

Based on this market situation, CanEVER AUDiO® together with a group of experienced listeners developed the *ZeroUno* DAC The design goal was to create a DAC, which is able to present all the details of the recorded material, but never makes the brain of the user *nervous*. Instead of this, the *ZeroUno* DAC should simply play *music* to enjoy and relax even after many hours of constant listening.

Quick Overview

The natural sound and the rhythm of the music have been the key objectives during the design process of the *ZeroUno* DAC.

This is achieved by:
- audiophile grade components
- discrete tube output stage with low noise and audio grade power supply
- DAC interstage coupled by special wounded Lundahl amorphous core transformers
- SABRE ES9018S DAC chip with proprietary audiophile firmware
- independently (quasi battery) powered USB input to eliminate electrical noise
  potentially induced by the USB cable from the connected computer
- four layer mother board for minimum internal wiring avoiding ground loops
  and electromagnetic induction
- dedicated power supply architecture
- comprehensive noise reduction for all digital circuits
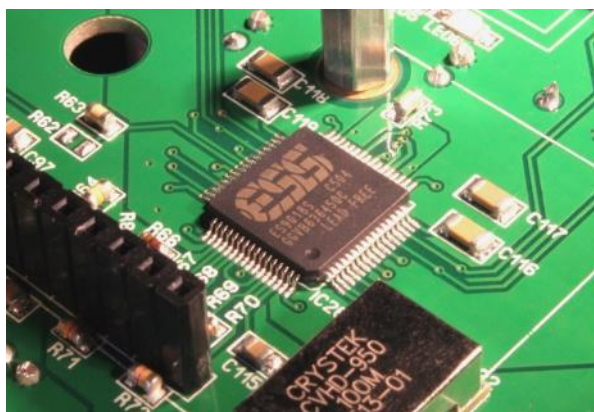- ultraprecise clocks

ZeroUno DAC - Block Diagram
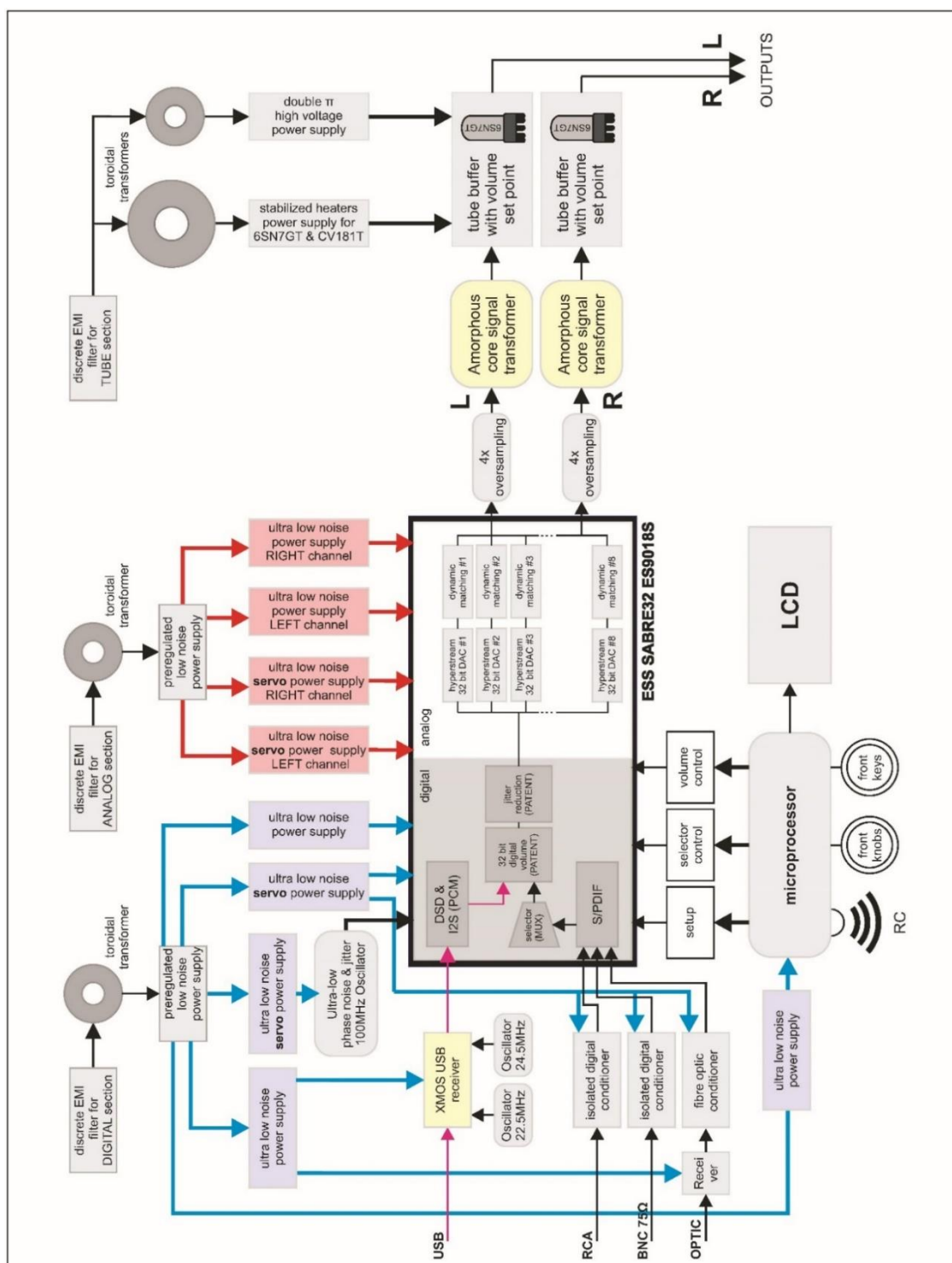
SABRE ES9018s DAC Chip

The *ZeroUno* DAC uses the ESS SABRE32 ES9018s. This chip incorporates eight individual DACs in dual differential coupling. But the ES9018s is not only a DAC! It is one of the most advanced industrial digital chips available today, working with 32 bits math, including 8 pairs of DACs with selectable resolution, IIR filter, FIR filter, de-emphasis filter, notch filter, 8 channels 32 bit volume control, patented jitter reduction algorithm and an 8 channel SPDIF multiplexer.

Although the ES9018s is a very powerful component, it comes from the factory documented for a standard configuration only. This leads to a situation, in which many DACs, using this chip, make use only of the "default" standard configuration. The result often is a sound reproduction, which does not show the real performance level of the ES9018s.

To make full use of the complete ES9018s feature set, it needs sophisticated engineering skills. For the *ZeroUno* DAC a very special and complex firmware was developed to let the ES9018s run at its full potential. The core implementation is a two channel DAC based on four paralleled pairs of differential DACs. The high quality internal 32 bit volume control of the ES9018s guaranties for optimum channel separation and balance even at very low volume levels. Based on the patented internal jitter reduction module of the ES9018s the *ZeroUno* DAC reaches a very low level of jitter.

As the **base** of the *ZeroUno* DAC is the SABRE 9018s chip, the **brain** is the firmware written for it.

The key feature of the *ZeroUno* DAC is the smooth and natural sound without any loss of the rhythm e.g. using the human voice and unamplified natural instruments as the test benchmark. The special internal configuration of the ES9018s chip used for the *ZeroUno* DAC eliminates artefacts in the digital domain, which usually affect the quality of sound. Those kind of distortions are more or less part of digital audio gear since the introduction of the CD in the early '80´s and the *ZeroUno* DAC is developed mainly to avoid them.

The firmware of the *ZeroUno* DAC is stored inside a separate memory chip fitted in a socket on the board. This offers the opportunity to upgrade in the future, if necessary, without any problems.

Power Supply

First of all the performance in any electronic unit is depending on a professional power supply!

The different power supplies of the *ZeroUno* DAC base on four dedicated toroidal power transformers. One for the digital section and one for the analogue section of the DAC circuit as well as two for the power supply of the tube stage. All transformers sit in antimagnetic metal canisters using resin mix as damping material to avoid any kind of mechanical hum and vibrations.

The power supplies for the analogue and digital sections are split into two sections.

The first section is a low-noise power supply that:
- pre-regulates the voltages generating a very clean DC voltage
- isolates the second section from the domestic AC line
  reducing electric noise induced from there

As a result, the second level power supply is sourced by a very clean DC power and works in "quasi" battery mode.

The second section is made of 13 separated ultra-low noise power supplies and sources directly the core circuit of the *ZeroUno* DAC. Four of these ultra-low noise power supplies are consisting of discrete components only to reduce the noise to an extreme low level.

As the power supply is such an important part of the circuit, almost 60% of the time to develop the *ZeroUno* DAC was dedicated to the power supplies, to the signal path as well as to the paths of the power supplies and grounds.
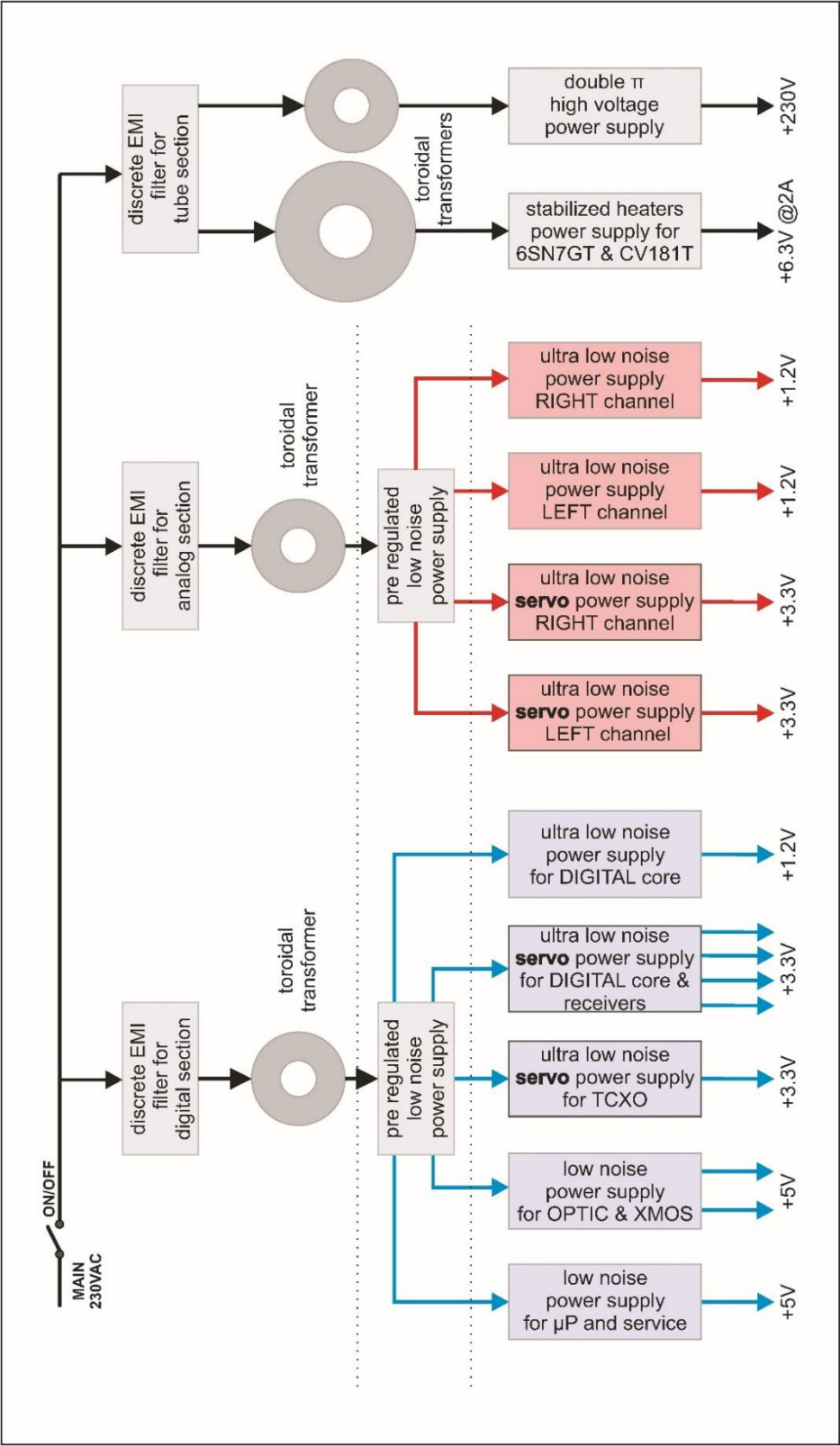
Selected components used in the power supplies of the *ZeroUno* DAC make sure to avoid noise created in the rectifier stage. The diodes in use here are almost free of any "converting spikes", which usually have a negative impact on the sound quality of the audio signal.
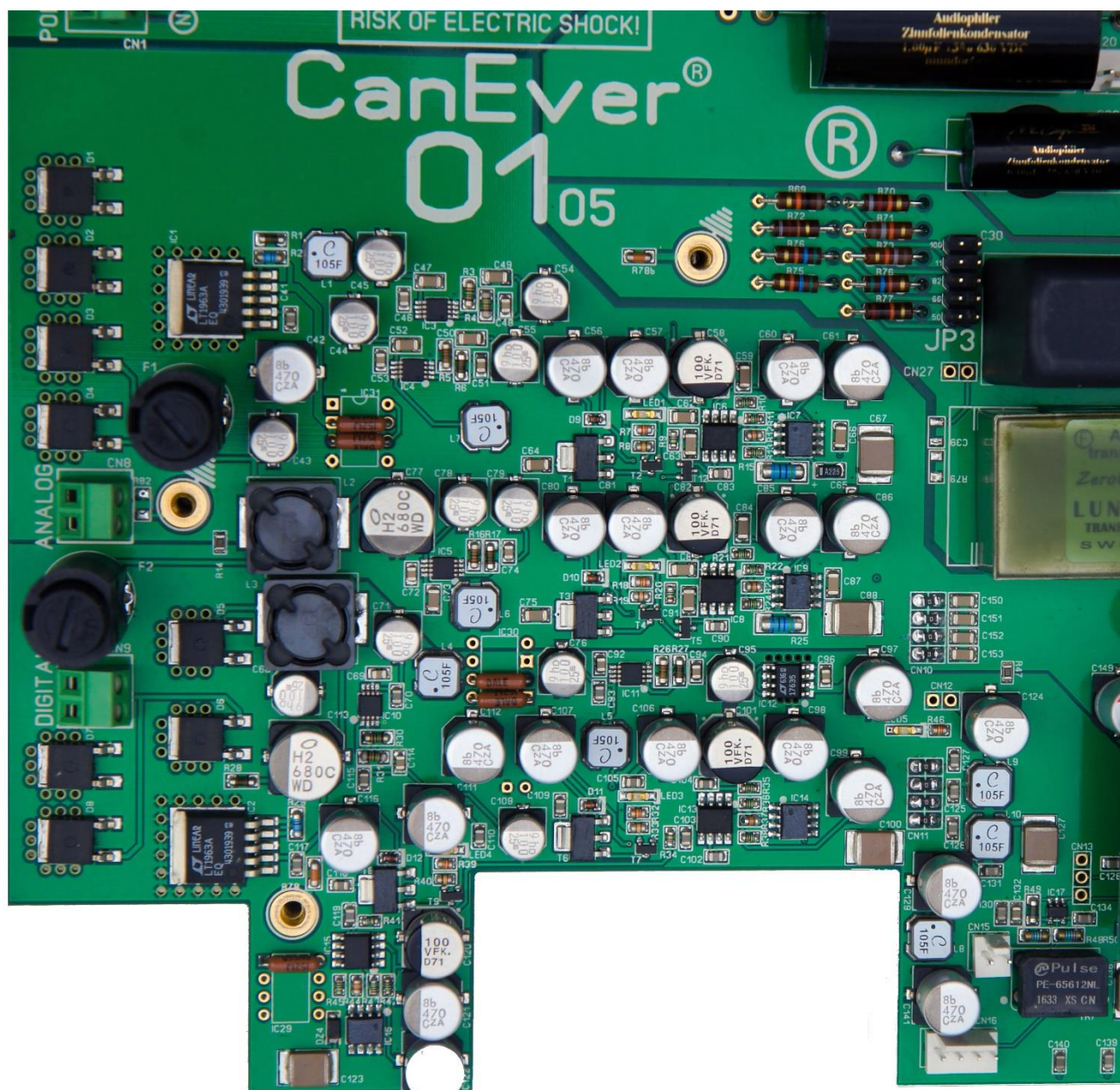
The four "first level" ultra-low noise power supplies make use of the top audio grade operational amplifier AD797 from Analog Device. Commonly used in output stages, the *ZeroUno* DAC uses four of them in the power supplies.
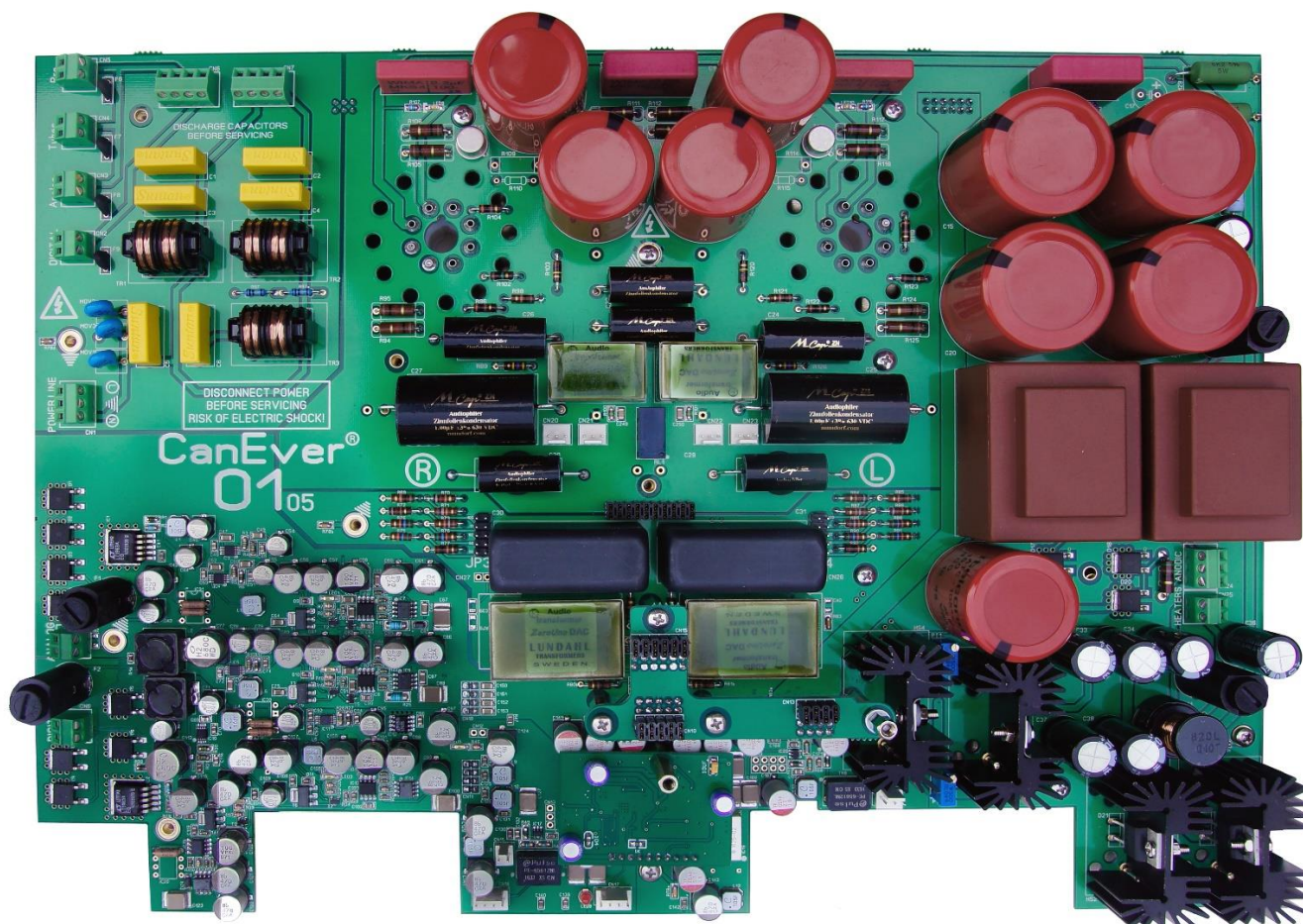
To improve the performance of the power supply furthermore almost all capacitors used in the circuit are *aluminium organic solid polymer* capacitors instead of electrolytic type. In addition, for top noise filtering, there are 13 individual coupling inductors implemented in the power supply.

This architecture is fundamental to keep the noise as low as possible. In many audio components these kind of noise is present, while affecting the sound in a negative way, creating harsh and cold sound textures.

Power supply block diagram labels:

- ON/OFF
- MAIN 230VAC
- discrete EMI filter for tube section
- discrete EMI filter for analog section
- discrete EMI filter for digital section
- toroidal transformers
- toroidal transformer
- toroidal transformer
- double π high voltage power supply → +230V
- stabilized heaters power supply for 6SN7GT & CV181T → +6.3V @2A
- pre regulated low noise power supply
- ultra low noise power supply RIGHT channel → +1.2V
- ultra low noise power supply LEFT channel → +1.2V
- ultra low noise **servo** power supply RIGHT channel → +3.3V
- ultra low noise **servo** power supply LEFT channel → +3.3V
- ultra low noise power supply for DIGITAL core → +1.2V
- ultra low noise **servo** power supply for DIGITAL core & receivers → +3.3V
- ultra low noise **servo** power supply for TCXO → +3.3V
- low noise power supply for OPTIC & XMOS → +5V
- low noise power supply for µP and service → +5V

POWER SUPPLY BLOCK DIAGRAM

Motherboard

In many audio products, one can see a number of individual printed circuit boards connected by numerous cables. The higher the frequencies of the operated signals in the circuit are the higher is the potential of negative influence on the signal quality by electromagnetic induction, e.g. into connecting cables. In a DAC, which can operate digital input signals up to 12.288 MHz, electromagnetic induction can become a nightmare for the engineer. The same is valid for the correct grounding of all the separate modules of the circuit.

To avoid such problems, the whole circuit of the *ZeroUno* DAC consists out of one single four-layer PCB with extra thick copper traces. This PCB supports ultra-short signal paths with minimal wiring. It avoids electromagnetic induction of noise and insures perfect grounding. Extra layers are reserved for the ground planes and the power lines of each stage. The same is valid for digital and analogue signals as well as for the tube output stage.

All the digital and analogue power supplies of the *ZeroUno* DAC (in total: 15) are powered individually including the use of exclusive ground planes.

Clocks
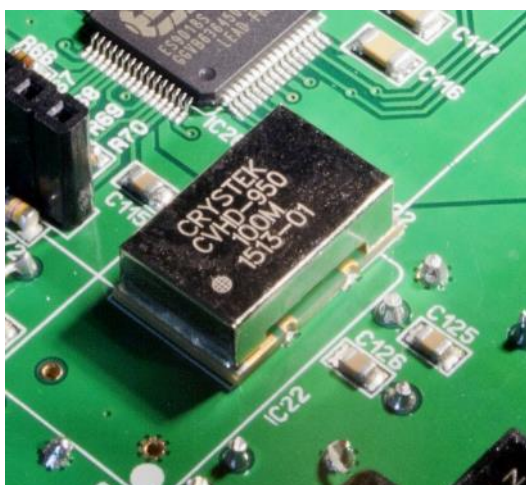
For precise clocking, the *ZeroUno* DAC uses an ultralow phase noise and low jitter voltage controlled crystal oscillator. This 100MHz oscillator works as main clock to make sure, that the DAC works at maximum throughput and synchronizes the whole system.
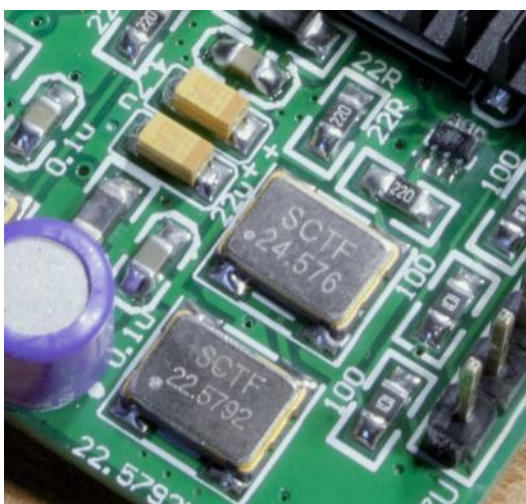
Another two low noise oscillators control independently the sampling rate of the two PCM "families" of input signals:

- 44,1; 88,2; 176,4 and 352,8 kHz
- 48; 96; 192 and 384 kHz

The DSD the sampling rate "families", which the DAC locks, are:

- 2,822; 3,072 MHz - DSD64
- 5,644; 6.144 MHz - DSD128

Digital File Formats

The *ZeroUno* DAC can play almost all the music formats being commercially available today, whether they are in PCM or DSD/DoP format.

PCM: 44.1kHz, 48kHz, 88.2kHz, 96kHz, 176.4kHz, 192kHz, 352.8kHz, 384kHz.
DSD/DoP: DSD64; DSD128

The *ZeroUno* DAC is ready to play native DSD64, DSD128 and DSD256.
At the time of writing (01/2016) the official XMOS driver for consumer applications, that supports native DSD, is not yet released. As soon as this is the case the *ZeroUno* DAC can play native DSD files as well.

Digital Inputs

The digital inputs are:
• 1x RCA, 1x true 75 Ohms BNC (optional, instead of the BNC input, a true 110 Ohms AES/EBU is available) and 1x OPTICAL for S/PDIF signals
• 1x USB Audio 2.0 port for a direct connection to a computer.
All the S/PDIF digital inputs have a galvanic ground insulation from the connected components.

USB Input

The USB interface is located in a separated module mounted above the ES9018S to reduce the length of the signal path to a minimum. The firmware is stored in a dedicated flash memory, to allow easy future upgrading, if necessary.

The USB module is NOT powered through the connected computer by the standard and usually dirty 5V power lines of an USB cable! Instead, a dedicated ultra-low-noise power supply inside the *ZeroUno* DAC powers the USB receiver separately. Furthermore, a dedicated 1 Farad Super Cap buffers this power and acts almost like a pure battery power to the USB receiver chip.

USB signals demand high processing speed and efficiency, robust bit perfect audio streaming and flexible multi-format audio connectivity. To insure this, the *ZeroUno* DAC uses in the USB input board a chip of the xCORE-200 *multicore* family, the XMOS XU216-512.

Unlike conventional microprocessors with only one CPU that handles the audio signal, the XU216-512 microprocessor has got inside 16 CPUs to execute multiple tasks parallel in real time.

By the dedicated *ZeroUno* DAC firmware this 16 CPUs are optimised for handling audio signals, offering:

- the XMOS Hi-Res 2 AUDIO platform
- very low response latency
- high-performance real-time processing,

All these features ensures a bit perfect transfer of all audio data.

The USB interface together with the standard stereo 2-channels XMOS driver is 100% USB Audio 2.2 compliant and support signals up to 384 kHz in PCM mode as well as DSD64 and DSD128 in DoP mode. The driver for the Windows operating system works in ASIO or WASAPI mode. No additional driver is needed for Mac users, because the *ZeroUno* DAC is 100% compatible with the Mac OS and it´s built in *Core Audio*.

The USB interface of the *ZeroUno* DAC is ready to support the native playback of DSD64, DSD128 and DSD256 files.

As soon as XMOS will release the standard ASIO driver for the native DSD formats, this driver can be used with the *ZeroUno* DAC as well.

Interstage Transformers

The output for the left and right channel of the SABRE 9018s DAC chip connects directly to a pair of high performance amorphous core transformers. The result is a minimum number of components in a signal path, which is as clean & short as possible: no capacitors, no resistors and no active components … only a single transformer for each channel!

The interstage transformers are produced by Lundahl due to CanEVER AUDIO® specifications. The coils are wounded around an amorphous core resulting in high sensitivity. There is no loss of any detail in the signals even at very low levels. The very special wounding of the transformers guaranty a perfect transmission even of very low frequencies. Furthermore, the transformers perform very linear across the audio band and even more important, within the human audio bandwidth.
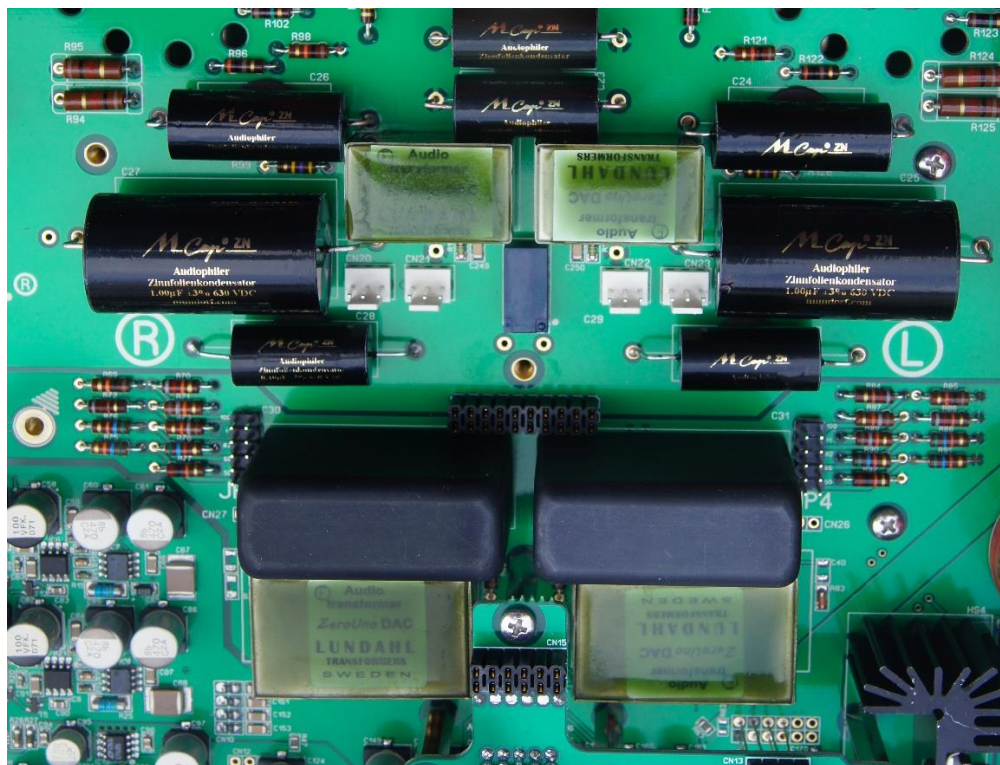
Tube Output Stage

The audio performance of a DAC is not only depending on a top power supply.
The real secret of a good sounding DAC is the topology and quality of the analogue output stage!

As the **base** of the *ZeroUno* DAC is the SABRE 9018S chip and the **brain** is the firmware written for it, the tube output stage is the real **heart** of the DAC!

The stage is built around a full Class A cascade buffer with zero feedback. An uncommon topology is used for a natural and smooth sound and without loss in rhythm and dynamics. The circuit itself is very minimalistic for getting the best sound possible.
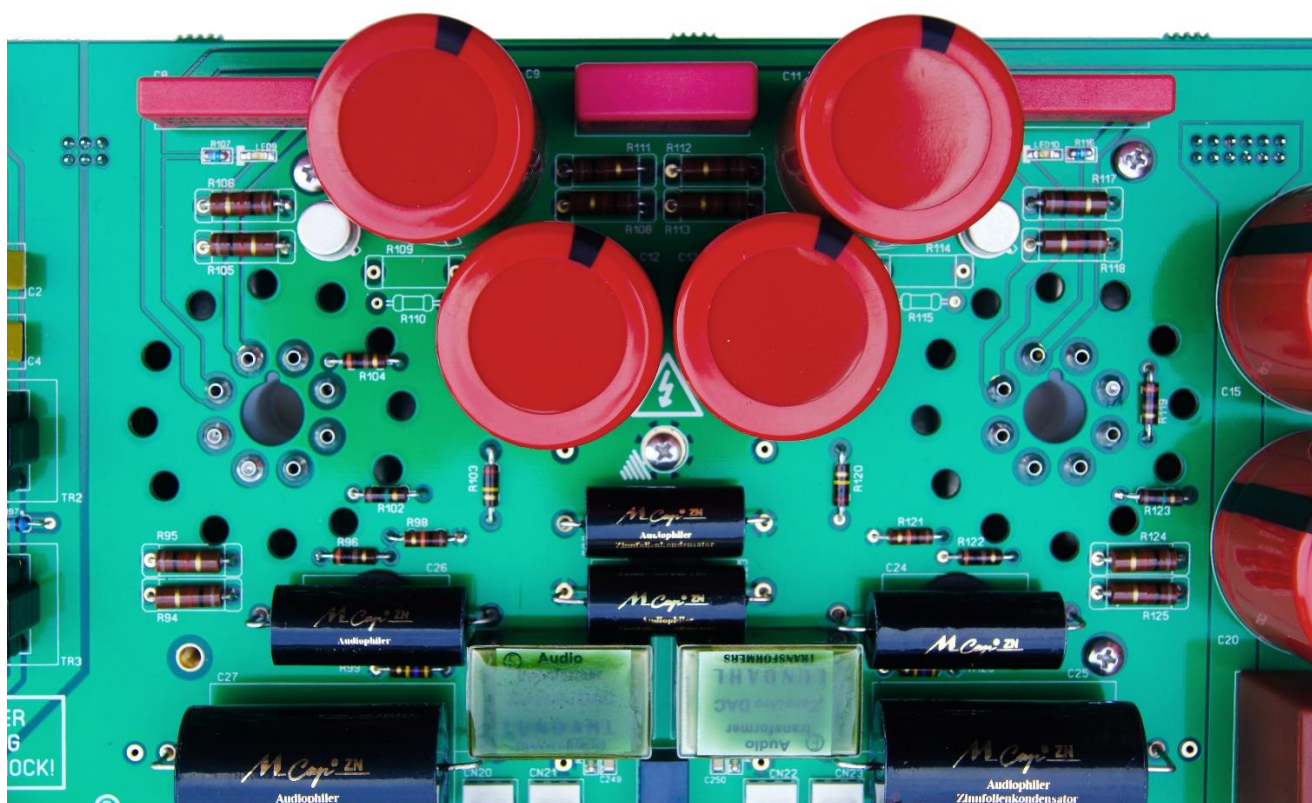
The tube buffer is able to drive the 6SN7GT family of tubes as well as the CV181 without any changes to the circuit. The customer only has to change the tubes in the sockets. The CV181 is a kind of "formula one" version of the 6SN7GT, with the same output curves, and with more current needed to run the heaters. Compared to the "standard" 6SN7GT it has a more solid construction with a graphite screen deposited inside the globe resulting in less microphonic sensitivity, more solid sound in the bass region and a fast sound attack.

Moreover, all the resistors in the tube stage are of the carbon composition type. The best for the sound, but again maybe not for the pure "engineering" approach. If you "listen" by an oscilloscope and a noise analyser, you might decide for metal film or bulk foil resistors, but if you hear by your ears, you will use carbon composition types.

All the high voltage capacitors are for audio use with lead sheet inside to increase the performance and to smooth the influences of the vibrations.
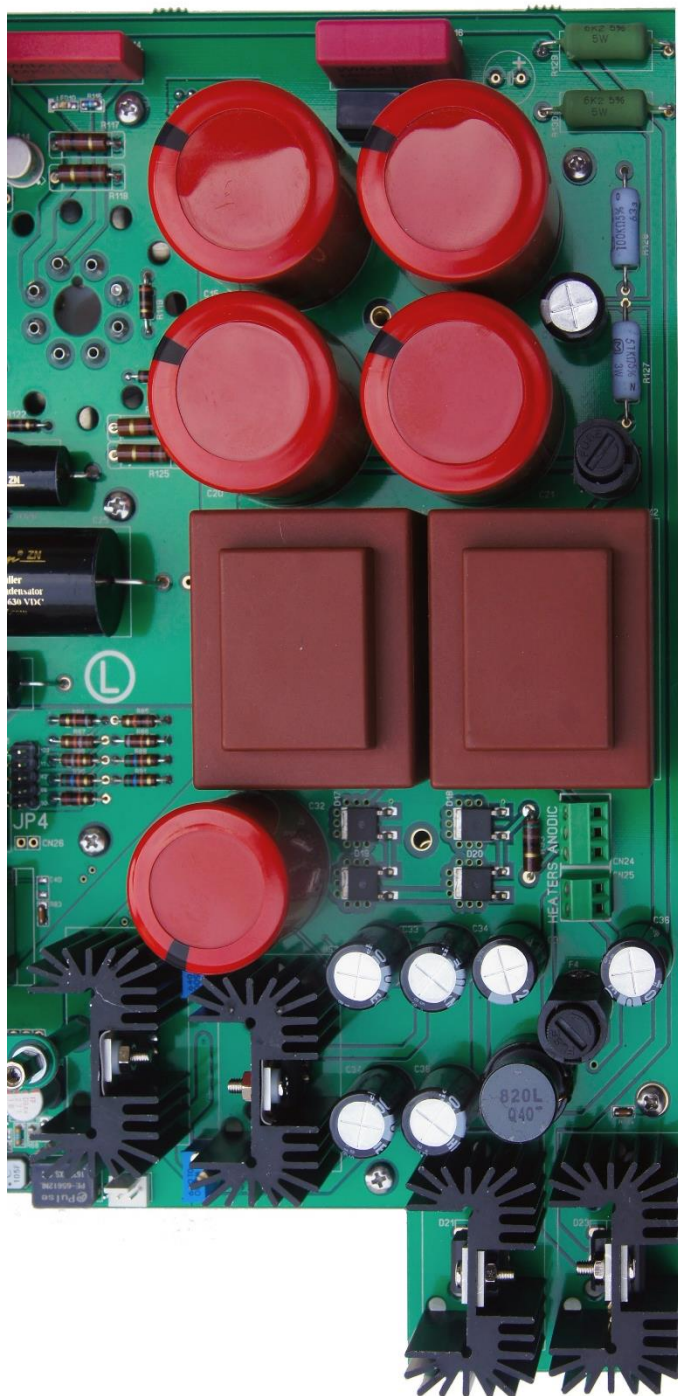
The best tube output stage cannot perform on its peak level without a state-of-the-art power supply. The tube power supply of the *ZeroUno* DAC utilises two dedicated toroidal transformers, which can support both the standard 6SN7GT and the CV181. The rectifier module uses last generation of spike noise free components, followed by a double π filter. As a choke in the rectifier stage is a needed ingredient for better sound … *ZeroUno* DAC uses two of them! The capacity of the filter (choke) used is so big, that it represents quasi a regulated power supply without an active component in the power line! This "no feedback" solution let the Class A output stage create an "emotional" sound coming really close to that of analogue records.

Volume Control

As it is possible to use the *ZeroUno* DAC as a digital preamp too, the implementation of a high performance volume control is key.

Thanks to the 32 bits architecture of the ES9018s the digital noise is below -130dB. Therefore, the volume control performs in the 32 bits resolution without any destructive or audible noise in the audio band.

Moreover, both channels are having exactly the same level even at very low volume. Compared to this, even high performance (analogue) volume potentiometers have problems in channel balance - mainly at low volume levels. Using speakers with high sensitivity, this can cause problems in the "balance" of the stereo panorama, with attenuated the volume.

The volume control can be adjusted by the supplied remote control as well as using the volume knob located on the right side of the *ZeroUno* DAC front panel.
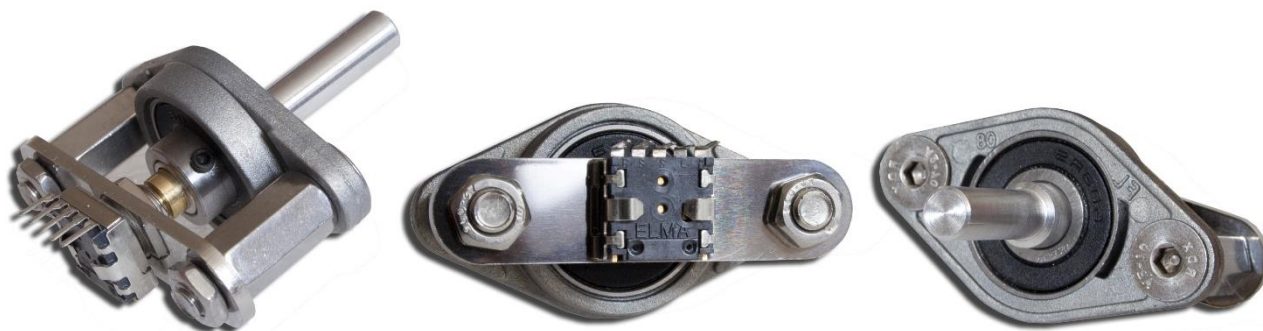
The rotary encoder mounted behind the volume knob is a high quality ELMA rotary encoder.
To ensure maximum mechanical stability the axis of the encoder is supported by an additional bearing.
While turning the knob the user has a "smooth" but precise tactile feedback.

Outputs

The *ZeroUno* DAC is equipped with:
- 2x RCA unbalanced outputs
- 2 x XLR true balanced outputs

Both couple of outputs can be used at the same time. This is useful for bi-amping and to connect a subwoofer if any.

Suggested input impedance of the power amplifier should not be below 47Kohms.

The maximum voltage swing at the outputs is 9.0Vpp, equivalent to 3.2 Vrms.

Remote Control
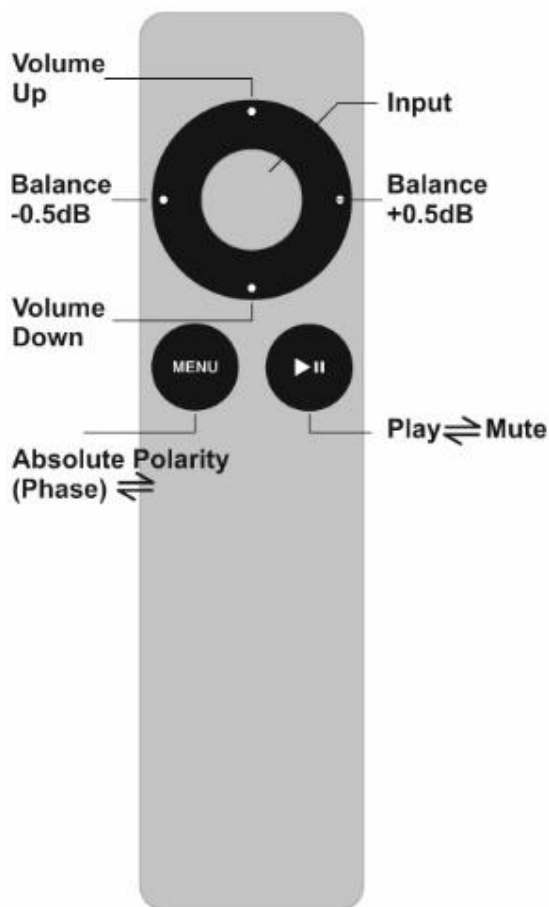
A remote control, which comes standard with each unit, gives access to most of the functions of the *ZeroUno* DAC from a distance. Different from most other DACs on the market, the RC offers in addition to the function "*volume up/down*" buttons for "*balance left/right*" level adjustments! A "*phase*" button for changing the absolute polarity of the music signal and a "*mute*" button for reducing the volume complete the functions on the RC. All those options assist the customer to adjust the sound in a very comfortable way right from the listening position.

To switch between the different input channels, the user has to push the "MENU" button. The name of the selected input then is shown for 5 seconds in big letters at the display.

The Remote Controller coming with each *ZeroUno* DAC has been paired already with the receiver inside the DAC in the factory by selecting one of 256 possible pairing codes.

In case of interference with the RC´s of other electronics in the household, the preselected RC code can be changed at any time.

To change the code, first move the RC close to the *ZeroUno* DAC (about 1 m).

Then press the SETUP and POLARITY buttons at the RC *simultaneously* for at least 5 seconds.
In a second step, the RC must be paired with the DAC again.

To pair the RC, press the SETUP button at the front of the *ZeroUno* DAC for at least 2 seconds to enter the SETUP MODE, release the button and finally press the SETUP and the INPUT buttons *simultaneously*.

If there is still interference with other RC´s in the household, please restart the process described above to generate another code.

Display

For optimal user control the *ZeroUno* DAC has a large display located in the centre of the front plate. In *PLAY* mode this display shows the selected input, volume, balance and absolute polarity.
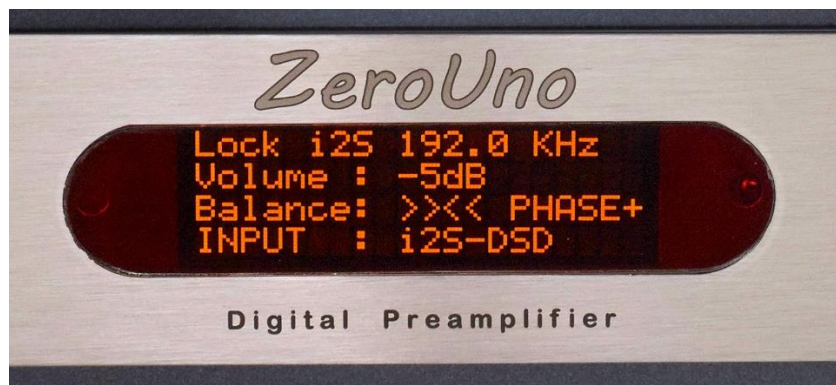
Once an input signal is detected, the lock is displayed.

As an option, the sample rate of the incoming digital data stream can be shown at the display in large letters. This feature is activated by setting the related parameter in the SETUP menu.

In SETUP mode the display shows all possible parameters selectable by the user and their related values.

When pressing the volume or balance buttons (+/-) at the remote control, the display presents the level in large digits for easier reading the display information from a distance. The same happens, if the user presses the MUTE/PLAY or the PHASE buttons. After 5 seconds, the display switches back to the default mode. Then again, the display shows all selected values in standard size together with all other data about the selected input and the active signal.

The brightness of the display can be set to various levels (50% 60% 70% 90% 100%).

After a defined time (e.g. 10s / 20s / 30s / 40s / 50s) of no user interaction via the Remote Controller or the buttons at the front of the DAC the display turns off. Based on individual settings in the SETUP menu, the display could stay ALWAYS ON as well, if preferred by the customer.

If the MUTE function is activated, the display will show MUTE in big characters continuously without any timeout until the MUTE function is turned off again.

Absolute Polarity Listening

As during the recording, the mastering and the production process the absolute polarity of the music data is changing many times, the final digital master file can be stored in inverted polarity. As some listeners are very sensitive to this fact, the *ZeroUno* DAC gives the customer the option to change the absolute polarity of the music file by pushing the round toggle switch at the remote control.

After pressing the toggle switch, the display shows

"PHASE+" (absolute polarity) or

"PHASE-" (inverted absolute polarity) in large letters for 5 seconds.

SETUP Menu

The *ZeroUno* DAC comes completely configured by the factory for top performance!

To give the customer maximum flexibility to configure the unit to according to his personal taste, the SETUP mode is implemented. To enter the SETUP mode the customer has to press the SETUP button at the front for a minimum of 2 seconds.

Then the following list of parameters is ready for change:

PARAMETER	VALUE
Balance	range from 5.0dB left to 5.0dB right in steps of 0.5dB
Phase	absolute polarity vs. inverted absolute polarity
LCD Brightness	display brightness: 50% / 60% / 70% / 90% / 100%
LCD Time Out	display timer: 10s / 20s / 30s / 40s / 50s / always on
Sampling Rate	show / hide (in large digits for 5 seconds)

For each parameter its value is visible at the display.
Rotating the right knob changes the parameter values.
To select the next parameter the SETUP button needs to be pressed shortly.
If no button is pressed or the right knob is not turned within a period of 10 seconds, the *ZeroUno* DAC automatically stores the values shown at the display and switches back to the PLAY/MUTE mode.
A countdown running on the second row of the display assists the user during this process.
All selected parameters are stored in a no volatile memory, so that the setup information is not lost after powering off the unit.
To RESTORE the factory values the SETUP button at the front panel of the *ZeroUno* DAC must be pressed for at least 10 seconds.

Cabinet

The engine of a car can exhibit the maximum performance only, if it has a frame, which can manage the vibrations. This is a mechanical law to follow not to lose power of the engine. The engine in our case is the DAC chip with its 15 power supplies plus the tube buffer and its power supply. The frame in our case is the cabinet, which has to be deaf and rigid without compromises.

It is important to understand, that the cabinet is an "active" part of the *ZeroUno* DAC.

The cabinet of the *ZeroUno* DAC is made of a combination of aeronautic aluminium and sheets of stainless steel joined together to create a rigid, light and vibration free structure. Moreover, the cabinet has a coating of acrylic resin, which further dampens the structure and avoids vibrations. While the cabinet is acoustically "dead", it shields the electronics inside from electromagnetic interference (EMI) from outside as well.

Conclusion

Although the *ZeroUno* DAC is offering high performance technical data, it is impossible to judge it´s value based on these only. The result of the D/A conversion in the *ZeroUno* DAC is a natural, warm, not harsh and very dynamic sound, which is not polished to exhibit the last possible details, but to *let the music play*…………..

Looking at directly heated triode based tube amps (e.g. 300B, 2A3 or 211 and 845) or tube amps in general one can make similar observations. From a pure engineering point of view, there is no reason to prefer a tube amplifier over a transistor based amplifier. Most of the technical measurements are even voting against a tube amp. However, if we do not leave it up to the instruments alone to qualify such an amp and instead we use our ears to listen and feel our emotions, the picture in many cases can change a lot!

Have fun with the *ZeroUno* DAC!

Product Specification

- The circuit of the *ZeroUno* _{DAC} is based on three integrated hardware platforms: ESS Technology SABRE32 ES9018S DAC, XMOS XU216-512-TQ128 and Atmega1284p.
- the ESS SABRE32 ES9018S DAC chip
- For optimum performance the SABRE chip runs on a proprietary implementation of special developed firmware
- One motherboard based on a four-layer PCB with extra thick copper traces to achieve ultra-short signal paths with minimal wiring, to avoid electromagnetic induction of noise and to insure perfect grounding
- Discrete built power supplies for the digital and the analogue section using two toroidal transformers, last generation of ultra-low noise rectifier diodes and high quality audio operational amplifiers AD797
- Discrete built ultra linear power supplies for the heating power and for the high voltage of the tube output stage using two toroidal transformers with last generation of ultra-low noise rectifier diodes, double π filter, audio grade resistors and capacitors
- Comprehensive noise regulation for all digital circuits
- Jitter free operation by patented high performance algorithm
- Integrated 32 bits volume control with a residual noise below -130dB for best performances even if at very low output levels
- On board output level setup to match different sensitivity of the direct connected power amplifiers
- PCM and DSD digital roll-off filters as well as asynchronous sample rate conversion of the Delta-Sigma DACs are user selectable in the set-up menu
- Voltage-compensated, ultra-low phase noise and low jitter crystal oscillators (clock) acts as master clock. Two separated clocks for sampling families of 44.1, 88.2, 176.4, 352.8 kHz and 48, 96, 192, 384 kHz
- DAC output stage with shortest possible signal path based on custom made amorphous audio transformers produced by Lundahl with first order discrete analogue filter for best THD and digital noise suppression
- True Class A discrete built analog tube output stage with zero negative global feedback for use with 6SN7GT tube family, including the CV181
- Separately powered USB chip by a "quasi battery power supply" using a 1,0 Farad super-cap to avoid any distortion induced by the connected computer (no connection to the +5V powerline of the USB cable)
- USB input based on XMOS xCore audio chip with bit perfect transfer for 16bit, 24bit or 32bit data in PCM format up to 384 kHz including support for native DSD and DoP
- 4 Digital-Inputs: 1x USB 2.0; 1x true AES/EBU 110Ohm XLR or (optional) true S/PDIF 75 Ohm BNC; 1x S/PDIF RCA; 1x S/PDIF OPTICAL
  - USB input compatible with following audio formats via PC and MAC:
    - PCM: 44.1; 48; 88.2; 96; 176.4; 192; 352.8 and 384 kHz up to 32 bits
    - DSD (DoP): 2.822 MHz / DSD64, 3.072 MHz, 5.644 MHz / DSD128
  - SPDIF inputs (AES/EBU,BNC, RCA) compatible with PCM signals from 44.1, 48, 88.2, 96, 176.4 and 192 kHz, up to 24 bits. The OPTICAL input accepts music files with a resolution up to 24/96 kHz
- 2 Output : 2x RCA unbalanced outputs + 2x XLR true balanced outputs, 9V_{pp} / 3.2V_{rms}
- LCD Display with variable brightness, changing letter size for better reading from listening position
- Infrared remote control with direct function keys for volume, balance, absolute polarity, mute and setup menu
- No drivers required for LINUX or MAC OSX
- USB Audio 2.0 driver available for Windows XP/Vista/7/8/10

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