The Controller

Power Supply

To obtain a signal-to-noise ratio of 130 dB in the TRINITY®-DAC, it was necessary to relocate the power transformer since its stray field, despite its small size, would superimpose a measurable component of the ac line frequency on the audio signal.
In the TRINITY®-DAC, the three galvanically separated operating voltages are supplied by only one transformer. Some manufacturers place particular emphasis on the fact their appliances have several transformers to supply the required voltages. One transformer for the analog circuits, a second for the digital circuits, etc.
Despite this complexity, it does not necessarily produce a better signal-to-noise ratio. As test results of the TRINITY®-DAC show, use of a single transformer produces no disadvantage. On the contrary, it turns out to be the better solution.
To avoid the occurrence of power-line hum right from the start (frequently caused by incorrect wiring), the two channels of the TRINITY®-DAC were galvanically separated.
Each converter has its own galvanically separated voltage supply. A third voltage supplies the necessary power to the control electronics.
The signals generated in the controller for volume control and for digital filter selection are routed to the two converter modules via galvanically separated optocouplers to remain consistent with the design philosophy.
A specially manufactured multipolar cable with an additional internal 50-Ω coaxial cable is used to connect the controller to the converter modules. The specially manufactured precision connectors have, of course, gold-plated contacts that feature low transition resistance and a long service life.

Digital Inputs

The controller also houses the electronics to select the digital input source.
The SPDIF signal (**S**ony **P**hilips **D**igital **I**nterf**a**ce) is not simply passed on, it is first regenerated.
Figure 1 shows the output signal at channel A1 as supplied by a UPL Audio Analyzer from R&S. Channel A2 shows the regenerated signal leaving the TRINITY®-DAC controller. It is clear proof that it is still possible to improve on an almost perfect measuring-instrument input signal.

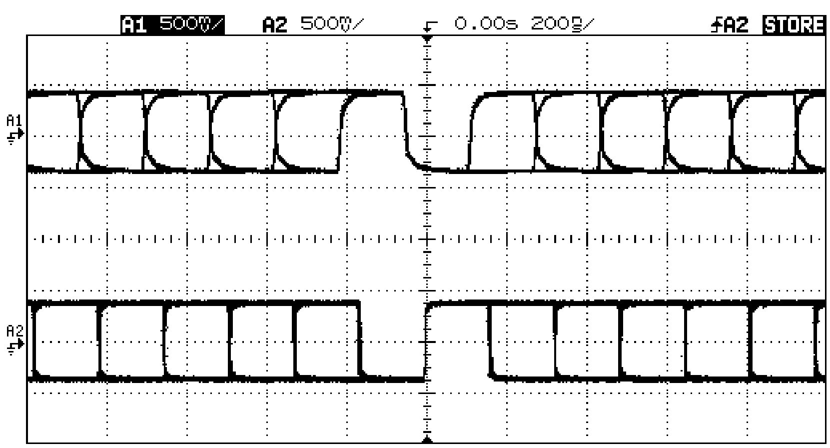


Figure 1

The audio analyzer features an option for simulating a 100-m long cable. *Figure 2* shows the same test setup but with the cable simulator activated.

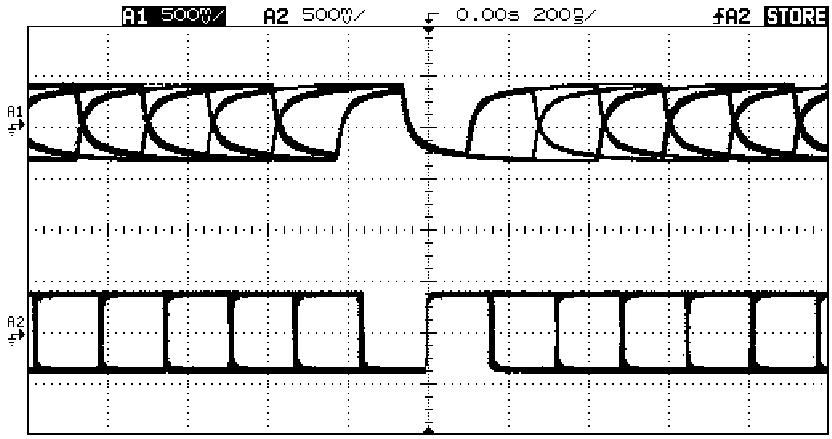


Figure 2

This clearly demonstrates the capabilities of the controller input electronics. Even highly distorted signals are restored to a standard-conforming level and then passed on to the TRINITY®-DAC.

A special circuit was designed for this purpose. It produces a very low noise level of only 25 µV across the full 40-MHz bandwidth. This circuit has a dynamic range of 55 dB and is therefore capable of regenerating input signals itself at an amplitude of only 2 mV.

This high sensitivity is achieved by an additional offset-compensation circuit. *Figure 3* shows a simplified extract of the circuitry.

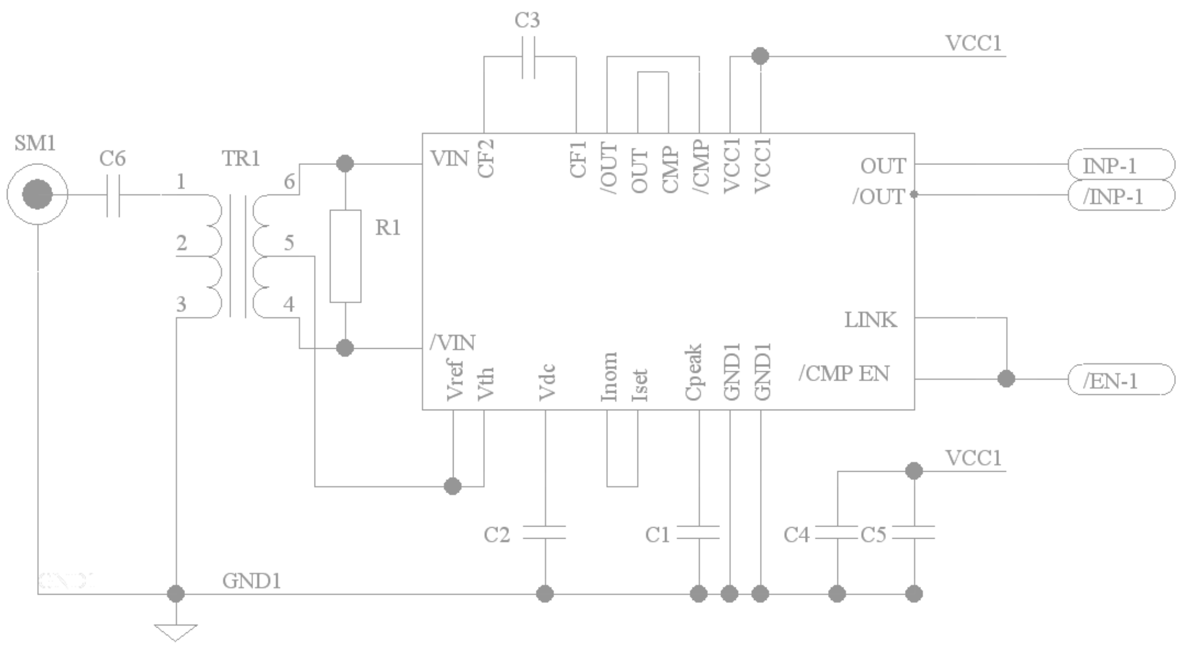


Figure 3

The regenerated signal is then routed to two specially designed 500-Ω line drivers. Here, too, the two channels are galvanically separated, this time by a broadband transformer instead of an optocoupler, which would be totally unsuited for this purpose. These drivers are capable of driving signals in the GHz range.
This also explains the very steep clock pulse edges. Figures 1 and 2 above each show the output signal in channel A2 downstream of the HF transformer and the additional 10-m coaxial cable. In this way, A2 represents the input signal of the converter modules.
The same complex circuitry is also used in the input section of the converter modules. Here, its main task is to decouple the digital interface receiver from the outside world. This additional stage permits better, that is to say, more jitter-free, clock recovery.

Circuit Boards

The design of a digital/analog converter is always a particular challenge since the task is to link analog circuit architecture with digital circuits. The design of the circuit boards and their location within the housing is therefore highly critical.
Firstly, the circuit-board layout must be designed in such a way that the right blocking capacitors are placed at the correct positions. The TRINITY®-DAC uses 4-layer gold-plated circuit boards, where the two outer layers act as shields. The signals and the operating voltage run along the inner layers. A special circuit-board program achieves a layout design where each pin in a circuit is actually surrounded by a grounding ring at a distance of 0.2 mm. Conventional circuit-board programs do not include this feature.
When selecting the blocking capacitors, special attention must be given to their resonant frequency. Some capacitors have so-called piezoelectric effects and this rules them out right from the start. The TRINITY®-DAC uses selected MLCC, tantalum, and OS-CON capacitors. Large electrolytic capacitors act as buffers for the strong stepping magnets that draw a rather large current of 3 A.
Ten low-noise voltage regulators supply the power for various stages. Since the converters have been developed with extreme care over a period of several years, the acid test was to benchmark them against the best appliances in the world.

Test Results

Readers of the American journal "Stereophile“ (http://www.stereophile.com/digitalsourcereviews/) are certainly familiar with the tests of digital sources published in that journal. In order to provide the possibility of comparison, tests of the TRINITY®-DAC have been posted on our website (http://www.gte-audio.com/de/dac_messprotokolle.htm) and adapted to Stereophile test procedures.
Time-domain tests indicate the extent to which the output signal is distorted and/or affected by noise as a result of nonlinearities and other converter errors. In this case, a very small signal of -90.31 dBFS and 24 bits is applied to the tester. The output signal is then recorded by an audio analyzer. A DENON DVD A1 was used for the following comparison.

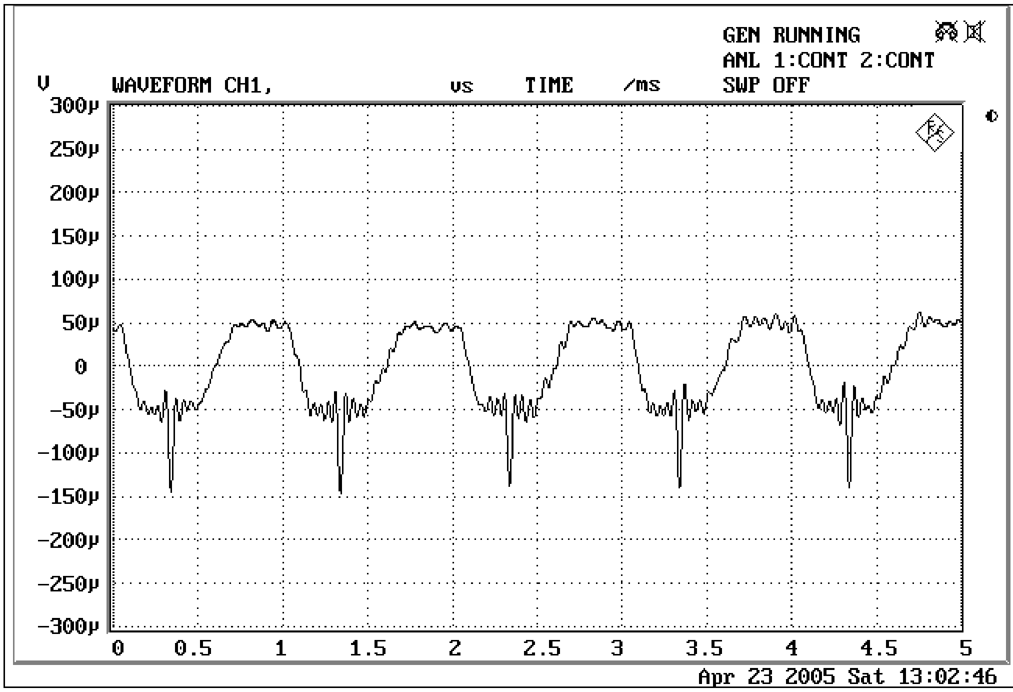


Figure 4
This chart shows the output signal from the ***DENON DVD A1****.*

Apparently, the DVD A1, with its *AL24 Processing Plus* algorithm, has some difficulty in representing small signals since a sinusoidal output signal is what is actually expected.

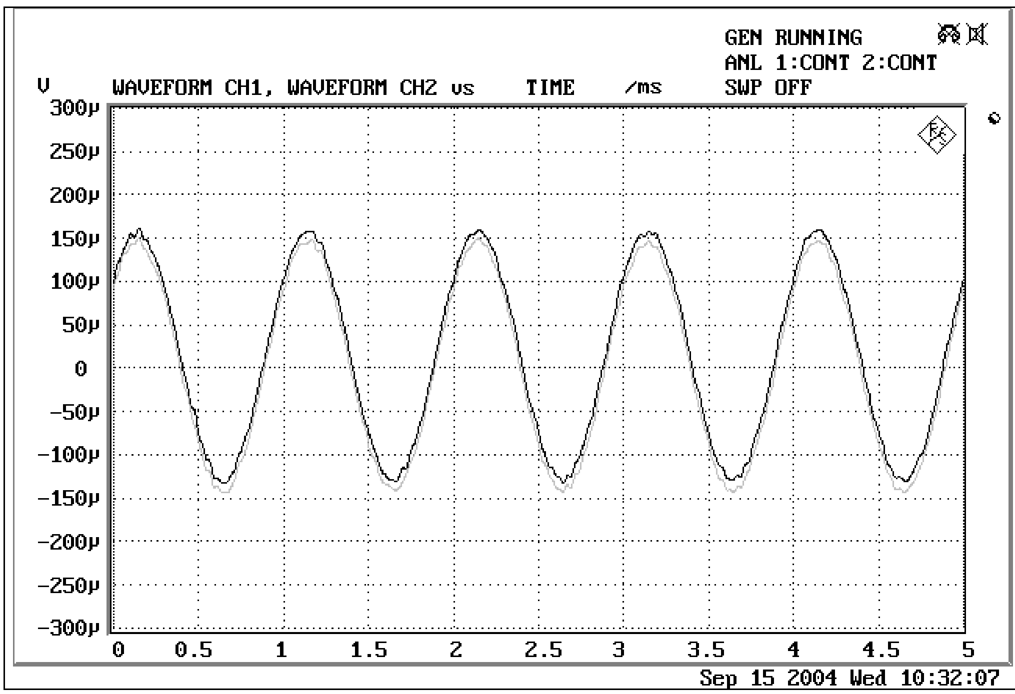


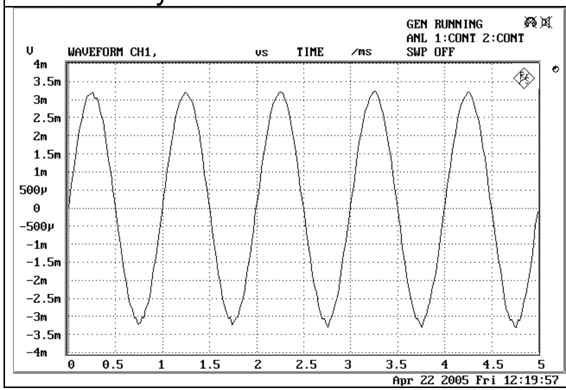
Figure 5
This chart shows the output signal of the TRINITY®-DAC.

This type of test can only provide a first impression of the noise component since both the tests were performed using the audio analyzer. In time-domain tests, these analyzers have only a limited bandwidth, which means that higher-frequency noise components are ignored. The simple reason is that the analyzer performs a lowpass filtering process.

An additional test with a simple scope fails to produce any further clarification or explanation with respect to digital sources. Since the smallest measuring range in scopes of this type is about 1 mV, the input signal was raised to –60 dB.

EIAJ CD-1 Test Disk Track 5 –60dB reproduced on a **Denon DVD-A1**

Audio Analyzer UPL



Digital Scope HP54645D 100MHz Bandwidth

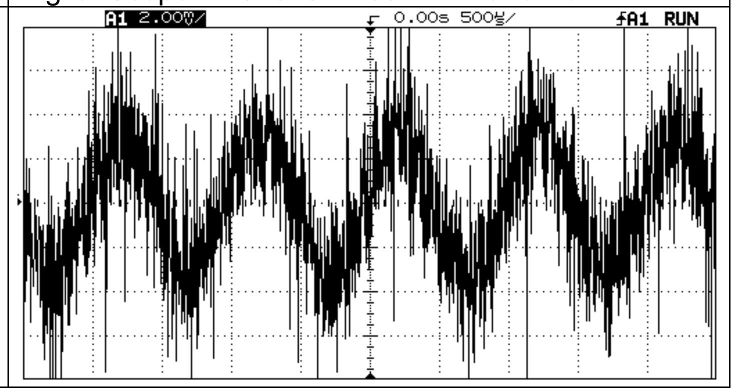


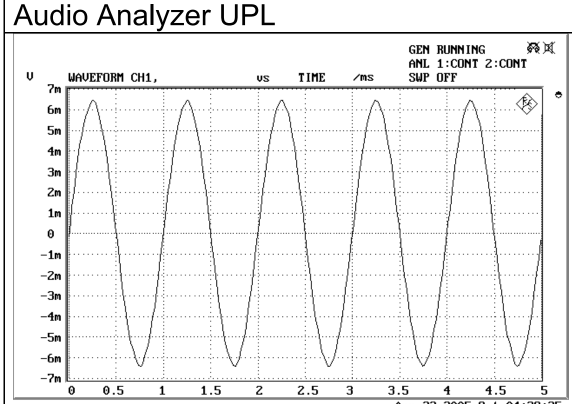
Figure 6

Figure 6 shows the same 3-mV output signal measured by the audio analyzer and by a 100-MHz digital scope. Here, it is obvious that the audio analyzer is unable to reproduce the high-frequency noise components due to its limited bandwidth.

The next figure, *Figure 7,* shows the same test with the TRINITY®-DAC. Despite the fact that the TRINITY®-DAC has no analog output filter, the high-frequency interfering components are significantly smaller than with a conventional converter design.

EIAJ CD-1 Test Disk Track 5 –60dB reproduced on a **TRINTY-DAC**

Audio Analyzer UPL



Digital Scope HP54645D 100MHz Bandwidth

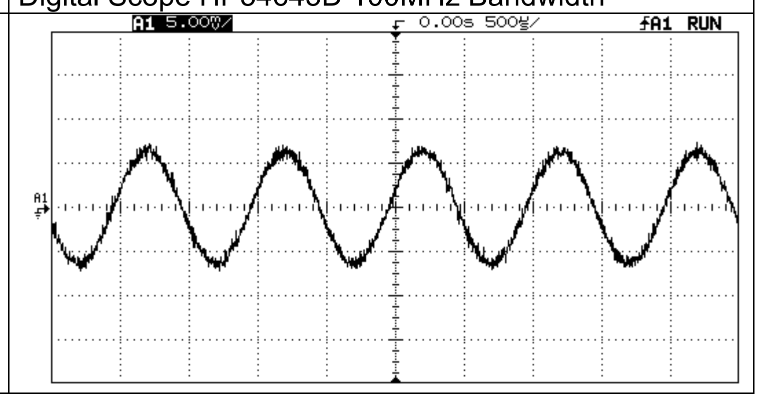


Figure 7

This then begs the question: What is the reason for these interfering components, since every conventional CD or DVD player is fitted with an analog output filter whose limit frequency lies within the 20 to 100 kHz range. In fact, the task of this filter is to remove all the frequencies outside of the audio bandwidth. Apparently, they do not.

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