

## Developing a Multi-Channel DAC for High-End Audio Applications



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To build the best-sounding audio multi-channel digital-to-analog converter (DAC), French audio company TOTALDAC tested DAC ICs from several suppliers before building a multi-channel digital-to-analog converter (DAC) for high-end audio and settling on a solution using an FPGA and 96 VSR series resistors per channel in a 3-channel configuration.

**Company/Institute:** TOTALDAC

**Industry/Application Area:** High-End Audio

**Product Used:** [VSR series Bulk Metal® Foil resistors](#)

### The Challenge

Our goal was to create a no-compromises DAC and digital crossover with 69-bit processing. The DAC is configured as an R-2R ladder. It is a 24-bit network using 0.01% resistors.

### The Solution

Selecting these ultra-high-precision resistors with Bulk Metal Foil Technology enabled easy, quick and accurate setting of the DAC, and maintained repeatable reliability with excellent stability over time and temperature – paired with fast switching times.

### The User Explains

At TOTALDAC, we build a DAC and digital crossover for high-end audio systems based on an FPGA and discrete resistors. The TOTALDAC board is assembled in an ISO 9001-certified factory in France and each board is inspected and its sound quality tested before shipping.

As I wanted to build the best sounding audio DAC, I tested the sound quality delivered by a number of mass-produced DAC chips from several well-known companies, including Analog Devices, TI, Philips, Cirrus Logic, Wolfson, and AKM.

Some of them were new old stock (NOS) chips known for their nice sound such as the TDA1541, TDA1545 (used in CD723), TDA1543, PCM56, AD1852 (used in Teac VRDS 25x), CS4328 (used in Helios Stargate), PCM1702 (used in many high end CD players in the past), and PCM1704.

Some were really nice, but never very accurate. I listened to them with and without oversampling whenever possible. I used a Pacific Microsonic PDM100 HDCD digital filter, one of the best digital



filters available. I also listened to many new DAC chips from TI and Analog Device in particular. These usually required microcontroller programming. The sound was often a bit metallic. Lastly I listened to the sound quality from a discrete R2R DAC made of simple 1% resistors. The musicality was there but some accuracy was missing. This was the starting point of my ultimate DAC solution. After two years, five PCB revisions, and other improvements to the FPGA, I finally settled on Vishay Foil Resistors' VSRJ 0.01% resistor. Although 96 discrete resistors per channel are used, the signal path is actually very short, going through the 0.01% resistors, into a C-L-C filter, through a capacitor, and then into the potentiometer.



Fig. 1: Each channel uses 96 pieces of Vishay Foil Resistors' VSRJ 0.01% Bulk Metal Foil resistors



Fig. 2: The 3 way TOTALDAC board uses 288 of these resistors.

Once the prototype worked as expected I contacted Vishay Foil Resistors Europe to choose the most appropriate Bulk Metal Foil resistors. While the [VAR](#) series resistors – components specifically designed for audio applications – may have been the absolute ideal resistors to be used, the VSR series through-hole resistors offered sufficiently impressive performance combined with a preferred price tag. That is of particular interest due to the high number of resistors used per channel. To my knowledge, no other DAC for the high-end audio market uses a 24-bit foil ladder configuration. The Bulk Metal Foil resistive technology is the absolute key factor for the success of this design.

## Measurements

Figure 3 shows the quality of the DAC for an extremely low amplitude signal such as concert hall long reverberation. The noise floor on graphic FFT is as low as -156 dB, although 0 dB is really the maximum DAC level (1.6 Vrms).



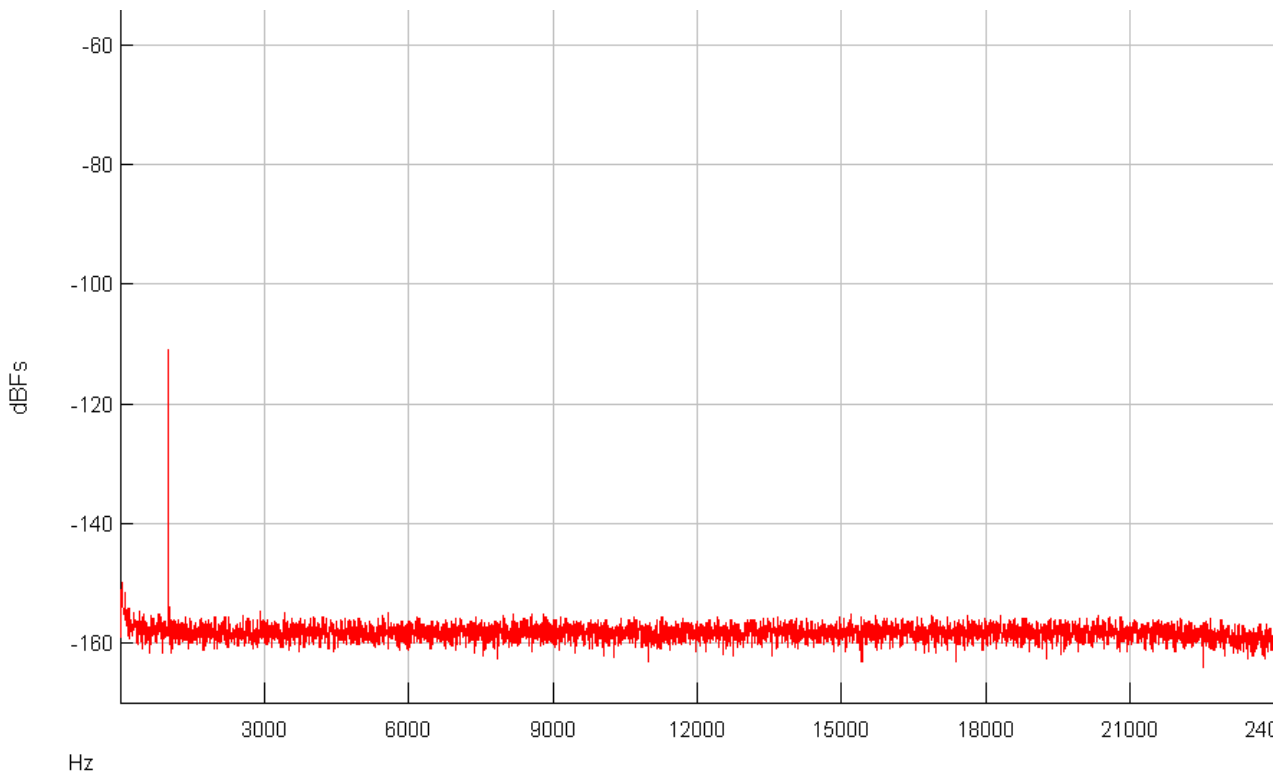


Fig. 3: Spectrum of a 1 kHz sinewave at -110dBFS

***“TOTALDAC relies on the precision, accuracy and reliability of Bulk Metal<sup>®</sup> Foil Technology to deliver its promise for high-performing DACs that meet the discerning expectations of audiophiles.”***

**Acknowledgement:**

TOTALDAC is a French-based company that produces innovative hi-fi digital-to-analog converters (DACs) and streamers for audiophiles that demand the best performance from their systems. TOTALDAC developed its own method of digital signal conversion using a proprietary DAC converter construction that is regarded as the gold standard DAC of many hi-fi reviewers, audio professionals and private users”.

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