TANTALUM AND OXICAP® CAPACITORS DELIVER THE GOLD STANDARD FOR AUDIO APPLICATIONS

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Audio applications make specific demands on the capacitors selected for use. Total harmonic distortion (THD) must be kept low to ensure noiseless filtering performance and high fidelity in the passing of audio signals. The stability of electrical parameters over temperature and especially over time is required to assure an overall sound quality for a long lifetime. In many cases, portable audio devices demand miniature devices and often designers are constrained to choose smaller and lower profile capacitors.

AVX Corp offers various different tantalum capacitor series for many different applications, but the company's standard and low profile TAJ and low ESR TPS series are especially suitable for audio designs. Standard TAJ devices are available in capacitances from 0.1 to 2200µF and in voltages from 2.5 to 50V. Low profile versions are offered in heights down to 0.9mm. Low ESR TPS devices have similar voltage ranges, but are limited to a maximum capacitance of 1500µF.

AVX also offers OxiCap® technology. Based on niobium oxide (NbO), OxiCap capacitors are also well suited for audio coupling application circuits win over more traditional technologies thanks to many technical advantages. OxiCap NOJ devices are offered in a wide range of capacitances from 4.7 to 1000µF and voltages from 1.8 to 10V. Low profile case sizes with heights reduced to 2mm, 1.5mm and 1.2mm are available. Low ESR NOS series devices are available from 10 to 1000 µF/1.8 to 6.3V. Although OxiCap's voltage range is limited to 10V maximum, it can fulfil many requirements as the recommended derating is just 20%.

All AVX tantalum and Oxicap capacitors are manufactured and tested to comply with the latest lead-free and ROHS requirements. Capacitors are capable of withstanding 3x reflow profile up to 260degC and comply with JEDEC 020C requirements.

Coupling circuits in audio devices

Besides decoupling circuits, where capacitors are mainly connected in parallel to power supply lines for signal processing integrated circuits, amplifiers etc, there are also AC coupling circuits. It is here that the capacitor can directly affect the quality of the audio signal which is why careful selection is important.

The purpose of coupling circuits in audio equipment is to separate the unwanted DC voltage from the useful AC signal, which must be passed through to next signal processing stage or to the output device. A coupling circuit can be thought of as a simple C-R differentiator with nominal capacitance C of the coupling capacitor and input resistance R of the next unit - eg amplifier, signal processor or output device such as headphones or loudspeaker. Here we are discussing the input resistance R, rather than the input impedance Z for purposes of simplification, with resistance R being equal to the modulus of impedance Z. Thus the low pass frequency is:

Equation 1: $f_L = 1 / (2\pi RC)$

Designers choosing the correct value of capacitor for the coupling circuit must consider the input impedance of the following circuit versus low pass frequency (see Eq. 1), which is governed by the human ear ability to hear bass tones and is usually in the range of 20 to 50 Hz. For coupling circuits to high input impedance appliactions like operational amplifiers inputs, a low value of coupling capacitor can be sufficient for a perfect bass tone transfer. In these cases - such as line inputs and outputs - capacitors with values from 1 to 10 µF are usually used.

The coupling of output devices such as headphones or loudspeakers demands higher capacitance because their nominal impedances are low - in the range of only 4 to 32Ω. For example, if the headphones have Z_N = 32 Ω and considering the low pass frequency (f_L) to be 50Hz, the capacitance would be 100µF.

This demonstrates that the transfer ratio of the coupling circuit is optimal when impedance of the capacitor is near to, or smaller than the impedance of the load.

Capacitors made using different technologies can be used for both line and output device coupling circuits. Depending on the technology, devices will exhibit different effective serial resistance (ESR) profiles with frequency. Together with parasitic effects (eg the piezo effect exhibited by MLCC capacitors) high ESR values at low frequencies can affect the sound quality of any product. The following example focuses on how different coupling capacitor technologies affect overall audio quality, measured by total harmonic distortion plus noise (THD+N).

Influence of output coupling capacitor technology on acoustic quality

For the following example, evaluation kit WM8960_6158_QFN32_EV1_REV2 with the WM8960 chip was used (ref. 1). The WM8960 is a low power, high quality stereo codec designed specially for portable digital applications produced by Wolfson Microelectronics plc. Outputs are dedicated for headphone use, and this design takes advantage of an onboard load of 16Ω resistor which is connected at the output of coupling capacitor.

The overall acoustic quality of the evaluation kit design was determined by measuring the THD+N for the fixed input coupling capacitor and different output coupling capacitors.

All the internal amplifiers of the WM8960 remained in the default gain setting of 0dB. The harmonic signal from the waveform generator (Agilent 33220A) within the 10Hz to 20kHz range was connected to the right channel of the evaluation kit input, while the input of the left channel remained shorted to minimise crosstalk. The level of the harmonic signal was
U_{p-p} = 200 mV. The appropriate board output was connected to a digital THD+N meter (NTI Minilyzer ML1).

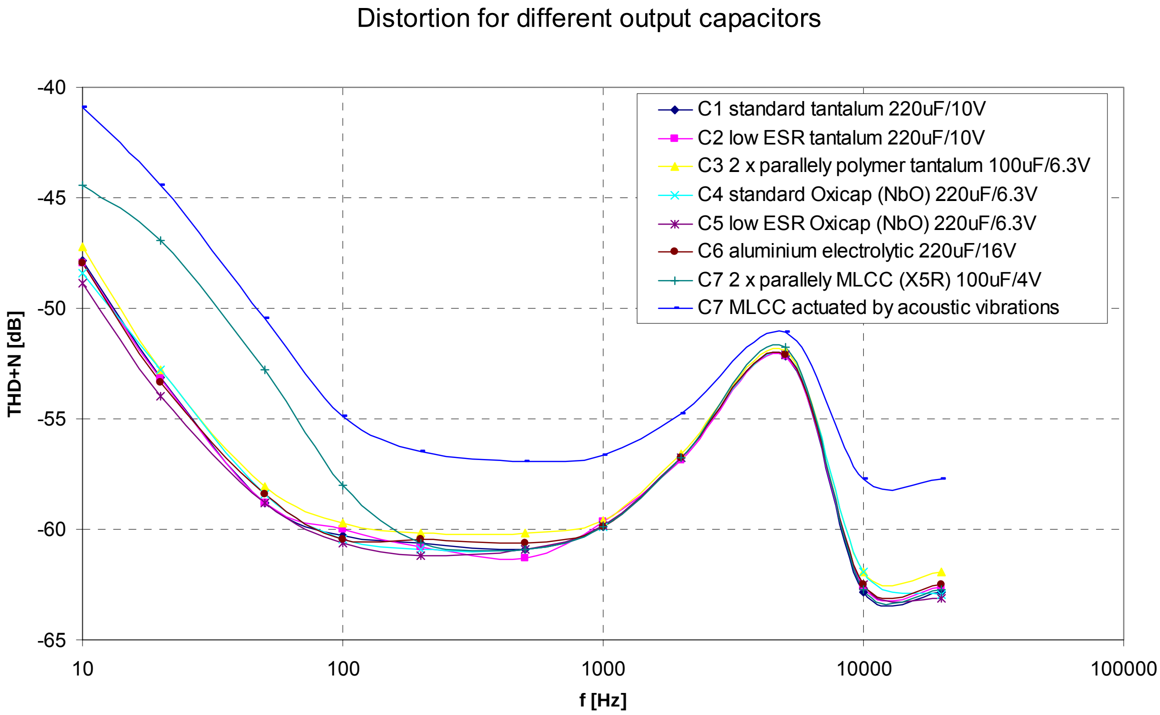

Figure 1: Harmonic distortion for different output coupling capacitors

Figure one compares the highlights the THD+N of different technologies and highlights the piezoelectric effect exhibited by ceramic capacitors. This parasitic effect was observed and measured when an electrodynamic acoustic exciter was mechanically fixed to the board with an MLCC output coupling capacitor C7. The exciter was driven by amplified white noise from waveform generator and its measured input power was 0.18W.

Summary of THD+N measurement

Review table

Technology of the capacitor	Output capacitor influence over THD+N	Insensitivity to mechanical vibrations
standard tantalum	Neutral	Very good
low ESR tantalum	Good	Very good
polymer tantalum	Poor	Very good
standard OxiCap® (NbO)	Neutral	Very good
low ESR OxiCap® (NbO)	Very good	Very good
aluminium electrolytic	Neutral	Very good
MLCC	Poor	Poor

To summarise:

 Low ESR output capacitors exhibited lower overall THD+N, especially low ESR OxiCap® (NbO).

MLCC devices are very sensitive to mechanical vibration when used for either input or output applications, and their piezo effect has a negative influence on THD+N. The performance of the MLCC when used as an output capacitor was inferior to both tantalum and OxiCap products. Therefore they cannot be recommended.

Low ESR OxiCap technology was the best in performance, closely followed by low ESR tantalum types. Standard tantalum and OxiCap capacitors are also suitable, especially for line coupling circuits with high loading impedance. The selection between tantalum and OxiCap depends on application requirements such mounting space and operating voltage. The low profile of the AVX capacitor cases is an advantage in portable audio devices and other limited head room applications.

Aluminium capacitors performed well in the test. However special care should be paid to their limited reliability, capacitance drop with time and lead-free process compliance.

OxiCaps in home theatre applications

A world-leading audio systems maker has taken advantage of the excellent audio and signal coupling performance of OxiCap capacitors in its latest home theatre system. The other big advantage of AVX' capacitors which the maker considered was their low profile construction compared to traditional aluminium electrolytic capacitors. Its home theatre system is shown in figure 2, with figure 3 showing the main board with orange OxiCap capacitors.

Figure 2: Home theatre system

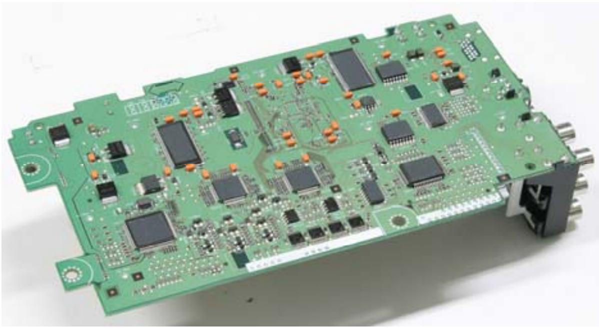

Figure 3: Main board of home theatre system

References

1] Full technical paper R. Faltus, T. Zednicek, “Tantalum Capacitor Benchmark in Audio Portable Applications” available at http://www.avx.com/docs/techinfo/tantbench.pdf

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