HANDOUT

All Capacitors are "Audio Capacitors"

Dr. René Kalbitz



There is an ongoing discussion within the audio engineering community about the sound quality of amplifiers concerning the audibility of signal distortions. Apparently, capacitors used for coupling and decoupling signals are suspected to be the source or at least a contributor to high-frequency distortions that influence the hearing impression. We have conducted a thorough study of harmonic distortions caused by commercial electrolytic capacitors as well as purpose-built items.

In order to find parameters that influence the harmonic distortions, we have investigated capacitors with different separation paper and electrolyte compositions. Those sample capacitors were assembled at near-mass production conditions. As a capacitor producer, Würth Elektronik (WE) expands continuously its objective knowledge base for capacitor development as well as a technical marketing strategy.

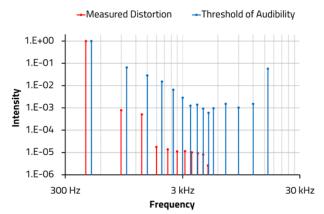


Figure 1: Measured voltage-signal frequency spectrum of 470µF aluminum electrolytic capacitor (WCAP-ASLI, 865080253012) at fundamental frequency of 448.9 Hz. Also shown, is the threshold of audible distortions as determined in psychoacoustic experiments for a fundamental at 500 Hz.

A representative measurement that illustrates the low degree of distortions caused by capacitors is shown in Figure 1. Here the harmonic distortions of a 470 μ F capacitor, measured at a fundamental (frequency) of 449 Hz, are compared to values that constitute the human hearing threshold for distortion at

a fundamental of 500 Hz.^[1] Clearly, the measured amplitudes are orders of magnitudes below the hearing threshold. Although this is just one single measurement, it exemplifies the insignificance of capacitor-induced distortions.

The average of the total harmonic distortions (THD), in accordance with human hearing sensitivity, for all the investigated aluminum electrolytic capacitors is about 0.02%. The results suggest that the harmonics distortions are well below the threshold of audibility, which is at about 7%.

It can be concluded that the capacitors do not add significant distortions to fundamental frequencies as they transfer signals and thus, in good approximation, can be considered linear devices. Modifications of the electrolyte or separation paper have a negligible effect on the THD.

This finding is corroborated by other researchers as well.^[2] In simple terms: All capacitors are "Audio Capacitors" and are suitable for audio applications.

Electrical engineers may still have the need to try different capacitors to meet their specific requirements of audio and other applications. For that, WE can provide a wide assortment of capacitor types with different specifications such as loss factor or connection type. Our portfolio, consisting of catalog- and project parts, contains high-quality products suitable for switching power supplies, electromagnetic interference suppression and audio applications.

If you have further questions concerning this research work or if you need any other support, please contact us via your sales representative.

A.1 References

^[1] H.Y. Lin, Measurement of Auditory Distortion with Relation Between Harmonic Distortion and Human Auditory Sensation, IEEE Transactions on Instrumentation And Measurement, IM-35:2 (1986)

^[2] I. Z. Anderson, Evaluating Electrolytic Capacitors Specified for Audio Use: A Comparative Analysis of Electrical Measurements and Capacitor Distortion Products in Line Level Interstage Coupling Applications, Journal of the Audio Engineering Society, 68:7/8 (2020)

IMPORTANT NOTICE

The Application Note is based on our knowledge and experience of typical requirements concerning these areas. It serves as general guidance and should not be construed as a commitment for the suitability for customer applications by Würth Elektronik eiSos GmbH & Co. KG. The information in the Application Note is subject to change without notice. This document and parts thereof must not be reproduced or copied without written permission, and contents thereof must not be imparted to a third party nor be used for any unauthorized purpose.

Würth Elektronik eiSos GmbH & Co. KG and its subsidiaries and affiliates (WE) are not liable for application assistance of any kind. Customers may use WE's assistance and product recommendations for their applications and design. The responsibility for the applicability and use of WE Products in a particular customer design is always solely within the authority of the customer. Due to this fact it is up to the customer to evaluate and investigate, where appropriate, and decide whether the device with the specific product characteristics described in the product specification is valid and suitable for the respective customer application or not.

The technical specifications are stated in the current data sheet of the products. Therefore the customers shall use the data sheets and are cautioned to verify that data sheets are current. The current data sheets can be downloaded at www.we-online.com. Customers shall strictly observe any product-specific notes, cautions and warnings. WE reserves the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services.

WE DOES NOT WARRANT OR REPRESENT THAT ANY LICENSE, EITHER EXPRESS OR IMPLIED, IS GRANTED UNDER ANY PATENT RIGHT, COPYRIGHT, MASK WORK RIGHT, OR OTHER INTELLECTUAL PROPERTY RIGHT RELATING TO ANY COMBINATION, MACHINE, OR PROCESS IN WHICH WE PRODUCTS OR SERVICES ARE USED. INFORMATION PUBLISHED BY WE REGARDING THIRD-PARTY PRODUCTS OR SERVICES DOES NOT CONSTITUTE A LICENSE FROM WE TO USE SUCH PRODUCTS OR SERVICES OR A WARRANTY OR ENDORSEMENT THEREOF.

WE products are not authorized for use in safety-critical applications, or where a failure of the product is reasonably expected to cause severe personal injury or death. Moreover, WE products are neither designed nor intended for use in areas such as military, aerospace, aviation, nuclear control, submarine, transportation (automotive control, train control, ship control), transportation signal, disaster prevention, medical, public information network etc. Customers shall inform WE about the intent of such usage before design-in stage. In certain customer applications requiring a very high level of safety and in which the malfunction or failure of an electronic component could endanger human life or health, customers must ensure that they have all necessary expertise in the safety and regulatory ramifications of their applications. Customers acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of WE products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by WF.

CUSTOMERS SHALL INDEMNIFY WE AGAINST ANY DAMAGES ARISING OUT OF THE USE OF WE PRODUCTS IN SUCH SAFETY-CRITICAL APPLICATIONS

USEFUL LINKS



Application Notes www.we-online.com/appnotes

REDEXPERT Design Plattform
www.we-online.com/redexpert



Toolbox www.we-online.com/toolbox



Product Catalog www.we-online.com/products

CONTACT INFORMATION

appnotes@we-online.com Tel. +49 7942 945 - 0



Würth Elektronik eiSos GmbH & Co. KG Max-Eyth-Str. 1 · 74638 Waldenburg Germany www.we-online.com



All Capacitors are "Audio Capacitors" | March 2023 WÜRTH ELEKTRONIK eiSos®