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AMERICAN NATIONAL STANDARD

Design Response of Weighting Networks for Acoustical Measurements

Secretariat:

Acoustical Society of America

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Abstract

This standard provides design information for the A-, B-, C-, D-, E-, G-, and U-weighting networks used for acoustical measurements. The analog poles and zeros for each weighting network are given, along with the equations for computing the magnitude and phase responses as functions of frequency. Coefficients and equations for computing the impulse and step responses of the A-, B-, C-, D-, and E-weighting networks as functions of time are provided in an informative annex. Information regarding digital implementation is also provided in an informative annex. Matlab scripts for the design of analog and digital implementations of the weighting networks described in this standard are also supplied.

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Foreword

[*This Foreword is for information only and is not a part of the American National Standard BSR/ASA S1.42-201x American National Standard Design Response of Weighting Networks for Acoustical Measurements. As such, this Foreword may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to the standard.*]

This standard comprises a part of a group of definitions, standards, and specifications for use in acoustics. It was developed and approved by Accredited Standards Committee S1 Acoustics, under its approved operating procedures. Those procedures have been accredited by the American National Standards Institute (ANSI). The Scope of Accredited Standards Committee S1 is as follows:

> *Standards, specifications, methods of measurement and test, and terminology in the field of physical acoustics, including architectural acoustics, electroacoustics, sonics and ultrasonics, and underwater sound, but excluding those aspects which pertain to biological safety, tolerances, and comfort.*

Weighting networks have been widely used for many years to provide standardized means to selectively filter acoustical signals. Since the design of standardized weighting networks has remained unchanged, it is possible to compare measured data from a vast data pool that has been accumulated over many years. For acoustical measurements, standardized weighting networks, test instruments, and test protocols ensure data compatibility and measurement repeatability. In this standard, only the design goals of the weighting networks are given. The tolerances in implementation of the weighting networks are generally found in the specific test instrument standards.

Major changes in this standard since its last revision include:

- Normative references are updated.
- Design targets and pole/zero data for all of the weighting networks are now normative.
- Errors in the response tables are corrected.
- Errors in the poles, zeros, and gain coefficients are corrected. The missing gain coefficient for G-weighting is now included.
- Target response magnitude and phase data from 1 Hz to 100 kHz is provided for the A-, B-, C-, D-, E-, and U-, and AU-weighting networks. Target response magnitude and phase data from 0.250 Hz to 315 Hz is provided for the G-weighting networks.
- Design equations are corrected and updated.
- All graphs are updated.
- Coefficients and analytic expressions for the time response (impulse and step response) of weighting networks are moved to an informative annex.
- An informative annex on digital implementation is added.
- Matlab files for the design of all weighting networks are included with the standard. An informative annex describing the use of the Matlab code is also added.
- The bibliography is updated.

At the time this standard was submitted to Accredited Standards Committee S1, Acoustics, for approval, the membership was as follows:

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William Gallagher	Richard McKinley	Chad Walber
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Working Group S1/WG24, Design Response of Weighting Networks for Acoustical Measurements, which assisted Accredited Standards Committee S1, Acoustics, in the preparation of this Standard, had the following membership:

Christopher J. Struck, *Chair*

Angelo Campanella	Alexandra Loubeau	Jim Weir
Jacob Klos	Richard Peppin	

Suggestions for improvements to this standard will be welcomed. They should be sent to Accredited Standards Committee S1, Acoustics, in care of the Standards Secretariat of the Acoustical Society of America, 1305 Walt Whitman Road, Suite 300, Melville, New York 11747. Telephone: 631-390-0215; FAX: 631-923-2875; E-mail: standards@acousticalsociety.org.

American National Standard

Design Response of Weighting Networks for Acoustical Measurements

1 Scope

The scope of this standard is to specify the transfer functions of weighting networks used for acoustical measurements. The analog poles and zeros that define each weighting network, as well as the resulting magnitude and phase response in the frequency domain, are provided. The scope is restricted to the design, or target responses of these weighting networks. Tolerances on these responses are generally found in the corresponding acoustical instrument performance specifications and are therefore outside the scope of this standard. Additional information regarding time response and digital implementations are found in the informative annexes.

2 Normative references

These references are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ANSI/ASA S1.4-2014/Part 1 /IEC 61672-1:2013 Electroacoustics – Sound Level Meters – Part 1: Specifications

ANSI/ASA S1.6-2016 American National Standard – Preferred Frequencies, Frequency Levels, and Band Numbers for Acoustical Measurements

IEC 60537:1976 Frequency weighting for the measurement of aircraft noise (D-weighting)

IEC 61012:1990 Filters for the measurement of audible sound in the presence of ultrasound

IEEE 260.4-2018 Standard for Letter Symbols and Abbreviations for Quantities Used in Acoustics

ISO 7196:1995 Acoustics – Frequency-weighting characteristic for infrasound measurements

3 Weighting network response characteristics - Frequency domain transfer function

In the frequency domain, the complex transfer function $H(jf)$ of a filter driven by a continuous sinusoidal waveform of frequency, f, can be expressed as

$$H(jf) = K \cdot \frac{\prod_{m=1}^{M} (jf - z_m)^{q_m}}{\prod_{n=1}^{N} (jf - p_n)^{r_n}} \qquad (1)$$

where there are M finite complex zeros z_m of order q_m; N complex poles p_n of order r_n; K is a gain constant chosen so that the level of the magnitude of the weighting network response is 0 dB at the reference frequency; and $j = \sqrt{-1}$.

