ANSI S1.42-1986
(ASA 64-1986)

AMERICAN NATIONAL STANDARD

DESIGN RESPONSE OF WEIGHTING NETWORKS FOR ACOUSTICAL MEASUREMENTS

Standards Secretariat
Acoustical Society of America
335 East 45th Street
New York, New York 10017-3483

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AMERICAN NATIONAL STANDARD
Design Response of Weighting Networks for Acoustical Measurements

ABSTRACT

This standard provides the design criteria for both the frequency-domain response (amplitude and phase) and time-domain response of the A-, B-, and C-weighting networks used in acoustically related measurements. The poles and zeros for each weighting network are given, along with equations for computing the amplitude and phase responses as functions of frequency and the impulse and step responses as functions of time. In the Appendix, similar information is provided for the D- and E-weighting networks.

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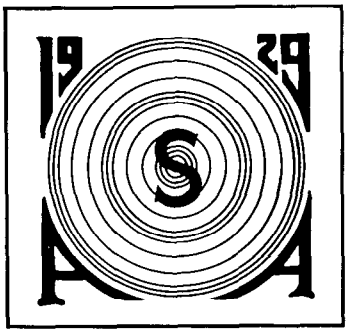
These standards are developed as a public service to provide standards useful to the public, industry, and consumers, and to Federal, State, and local governments.

This standard was approved by the American National Standards Institute as ANSI S1.42-1986 on 10 October 1986.



FOREWORD

[This Foreword is not a part of American National Standard Design Response of Weighting Networks for Acoustical Measurements, S1.42-1986 (ASA Catalog 64-1986)]

This standard was developed under the jurisdiction of Accredited Standards Committee S1 using the American National Standards Institute (ANSI) Standards Committee Procedure. This standard was approved for publication by Standards Committee S1 and by the American National Standards Institute.

Accredited Standards Committee S1, Acoustics, under whose jurisdiction this standard was developed, has the following scope:

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

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Suggestions for improvement of this standard will be welcomed. They should be sent to the Standards Secretariat, Acoustical Society of America, 335 East 45th Street, New York, NY 10017-3483.

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Design Response of Weighting Networks for Acoustical Measurements

0 INTRODUCTION

The A-, B-, and C-weighting networks have been included in sound level meters for many years. The American National Standard Specification for Sound Level Meters, ANSI S1.4-1983, and the International Standard for Sound Level Meters, IEC 651(1979), each provide the pole-zero specifications that can be used to realize these weighting networks. ANSI S1.4-1983 also provides, for information purposes only, equations that can be used to compute the steady-state relative amplitude response level, in decibels, for the A-, B-, and C-weighting networks.

When the standard weighting networks were first introduced, and for many years thereafter, they were used only in sound level meters, for which the overall frequency response involves both the acoustical and the electrical frequency responses of the instrument. The national and the international standards for sound level meters have always specified the overall performance of the complete sound level meter, rather than just the electrical response.

In more recent years, there has frequently been a desire to analyze electrical signals utilizing the A-, B-, and C-weighting filters with instruments that do not include microphones. Under such circumstances, the tolerances on the electrical performance of the weighting networks can be tighter than the corresponding acoustical tolerances, since the acoustical response is much more difficult to control than the electrical response. In addition, it often is desirable to know the phase response as well as the amplitude response for analyses in the frequency domain, or to know the time-domain response.

This standard provides analytical expressions for the theoretically ideal frequency-domain and time-domain responses of the A-, B-, and C-weighting networks. The Appendix provides, for information purposes only, similar expressions for the D- and E-weighting networks, which are not included in ANSI S1.4-1983.

1 PURPOSE AND SCOPE

The purpose of this American National Standard Design Response of Weighting Networks for Acoustical Measurements is to specify the frequency-domain and the time-domain design response of the A-, B-, and C-weighting networks so that analyses made with instruments using such weighting networks will be consistent with one another.

The scope of this standard is restricted to the design, or target, response of the A-, B-, and C-weighting networks. Tolerances are not given, since such tolerances properly belong in the performance specifications for the various types of instruments that are used for such analyses. The design response of the weighting networks can be determined for any frequency or time of interest using the expressions given in this standard.

2 FREQUENCY-WEIGHTING CHARACTERISTICS

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

$$H(jf) = H_0\left(\prod_{m=1}^{M}(jf - z_m)^{q_m}\right) \times\left(\prod_{n=1}^{N}(jf - p_n)^{r_n}\right)^{-1}, \quad (1)$$

where there are M finite complex zeros z_m of order q_m; there are N complex poles p_n of order r_n; H_0 is the gain constant; and $j^2 = -1$.

NOTE: The poles and zeros of a network are usually given as radian frequency values in the complex plane. In this standard, those values have been divided by 2π in order to facilitate relating the poles and zeros to actual frequencies, in hertz

The amplitude level of the network response is given by

$$W(f) = 10\log[K \cdot H^*(jf)H(jf)], \quad (2)$$

where K is a normalization constant chosen so that the weighted level is zero decibels at 1000 Hz. Writing the poles in the form $p_n = \alpha_n + j\beta_n$ and the zeros as $z_m = \gamma_m + j\delta_m$, the amplitude level of the network response can be written in terms of real quantities as

$$W(f) = 10\log\left|K\left(\prod_{m=1}^{M}[\gamma_m^2 + (f - \delta_m)^2]^{q_m}\right) \times\left(\prod_{n=1}^{N}[\alpha_n^2 + (f - \beta_n)^2]^{r_n}\right)^{-1}\right|. \quad (3)$$