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A TIME-ALIGN TECHNIQUE FOR LOUDSPEAKER SYSTEM DESIGN

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It has become increasingly apparent that the design parameters of a loudspeaker system must not only produce a smooth amplitude vs. frequency response, they must also produce a uniform phase and time characteristic. The ability to see the effects of parameter adjustments in the amplitude, phase, and time vs. frequency characteristics of a loudspeaker system, as the adjustments are being made is discussed.

I. INTRODUCTION

The main purpose of this presentation is to discuss a new method of designing loudspeaker systems which allows the effects of time variations to be seen and adjusted in a more direct manner than previously possible. The Time-Align Technique uses a new instrument which will be briefly described. This instrument provides a test signal which is used to align the loudspeaker system in the time domain. The total Time-Align Technique also includes the simultaneous alignment of the loudspeaker in the amplitude vs. frequency domain. However, before beginning, it would be of value to present the case for the importance of time variations.

II. THE IMPORTANCE OF TIME (PHASE)

Since the early 1930s the importance of eliminating gross driver alignment errors has been known and appreciated.(1). For small time errors, a learning process is probably involved.(2)(3)(4) This correlation between listening preferences and learning was a phenomenon discovered years ago with regard to bandwidth. In recent years, the importance of time (phase) in sound reproduction has become a matter of increasing discussion. Arguments with respect to the relative importance of time (phase) have become more prevalent. (5)(6)(7)(8)(9)(10) One of these investigations (11) mentions de Boer's "phase rule" which seems to be equivalent to the minimum phase phenomenon discussed by Heyser.(12)(13)

Some investigations into the effect of time (phase) changes on the timbre of complex tones were carried out using headphones. The possibility of time (phase) errors being introduced by the headphones has not been widely discussed but can be seen to exist in the data presented in some reports. (14)(15)(16) Another problem in determining the effects of time (phase) changes upon timbre, that of noise masking, has been studied. (17)

III. METHODS OF OBTAINING TIME (PHASE) DATA

In recent times, pulse testing techniques for the determination of loudspeaker (and other transducer) characteristics, has become popular.(18)(19) Various methods are available to allow time (phase) information to be derived from pulse measurements. A method of measuring the phase or group delay characteristics of phonograph cartridges has been described which is easily adaptable to the testing of loudspeakers. However, deriving time (phase) information from pulse response requires considerable equipment including computer processing.(20)(21) A method of obtaining phase information which uses sweep techniques has been described. (22)(23) Although phase meters have been available for many years, direct phase measurement of loudspeakers has been difficult. Phase meters which allow a chart record to be made of loudspeaker phase response have recently been described.(24)(25) It has been determined that the delay function is better described by time data.(26) This data can be derived from the phase measurement by mathematical manipulation.(12)(27) From time data it is easy to derive the equivalent distance since it is a direct function of the velocity of sound. The derivation can be used to describe the difference in time of arrival of sound from the various drivers of a multi-way loudspeaker system.(28) Having decided that time (phase) is an important characteristic of loudspeaker systems and worthy of consideration, quantification of the amount of detectable variation is naturally of interest.(9)(29)(30) During investigations of the detectability of small variations of phase, the importance of the absolute phase or polarity (+ or -) of the acoustic output was also discovered to be of importance.(10)(29) (31) In determining the relative spacing between drivers of a multi-way loudspeaker system it has been thought that the distance might be estimated.(32) Another approach is to calculate the amount of physical offset between drivers assuming a certain theoretical transfer function for each driver. This is based upon individual driver phase measurements. The crossover network transfer function must also be considered.(33) As Heyser has pointed out, the acoustic position of a driver relative to its physical position is some inverse function of its high frequency cutoff.(12) This will be verified later.