STATISTICAL SIGNAL ANALYSIS FOR SYSTEMS WITH INTERFERENCED INPUTS

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Statistical signal analysis approaches have been successfully used in analyzing acoustical problems which can be modeled as multiple input-one output systems. These methods require well identified and measurable input signals. However, in many physical systems it is not possible to separate all input signals because of the measurement technique used or because of the superposition of several signals at the point of measurement. Conventional and conditioned statistical signal analysis produce significantly distorted results due to input signal interference. This has been described in the literature by a number of investigators as well as discussed in detail by Bendat and Piersol in [1].

The objective of this presentation is to introduce a new approach, based on statistical signal analysis,which overcomes the error due to input signal interference. The model analyzed is shown in Fig. 1. The input signals $u_1(t)$ and $u_2(t)$ are assumed to be unknown. The measurable signals $x_1(t)$ and $x_2(t)$ are interferenced according to the frequency response functions, $H_{12}(f)$ and $H_{21}(f)$.

The goal of the analysis was to evaluate the power output due to each input, $u_1(t)$ and $u_2(t)$, for the case where both are applied at the same time. In addition, all frequency response functions $H_{12}(f)$, $H_{21}(f)$, $H_1(f)$ and $H_2(f)$ are calculated.

The interferenced system is described by a set of five equations with six unknown functions being $u_1(f)$, $u_2(f)$, $H_1(f)$, $H_2(f)$, $H_{12}(f)$ and $H_{21}(f)$. In order to increase the number of equations, three sets of measurements are performed. Each time spectral estimates $S_{x_1x_1}$, $S_{x_2x_2}$, $S_{x_1x_2}$, S_{x_1y} and S_{x_2y} are measured using a Bruel & Kjaer model 2032 Frequency Analyzer (FFT). However, each set of measurements is performed for a different input level. An IBM XT Personal Computer, which was interfaced with the FFT, was used to solve the set of equations.

The software was tested on an electrical two-input, one-output system. The results were excellent. The research presented in this paper includes the analysis of the acoustic radiation from a rectangular plate with two force inputs and the sound pressure as an output signal. The acceleration-pressure frequency response functions calculated on the basis of the conditioned spectral analysis is shown in Fig. 2, from our new approach in Fig. 3, and the one-input, one-output technique (when the second input is physically disconnected) in Fig. 4. The results demonstrate the superiority of the new approach when compared to the conditioned spectral analysis technique. More examples involving the sources absolute and relative contributions in the plate acoustic radiation will be presented and discussed.

[1] Bendat, J. S. and A. G. Piersol, "Engineering Applications of Correlation and Spectral Analysis," J. Wiley & Sons, Chapter 9.3.

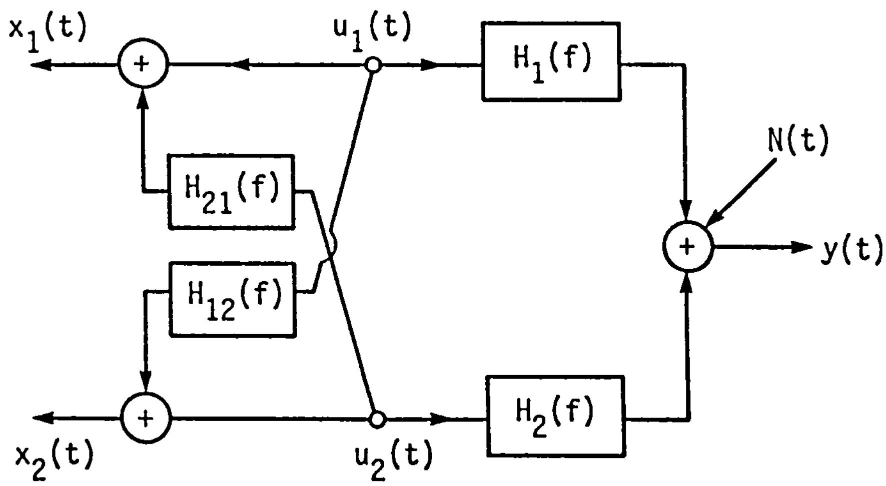

Fig. 1. Interferenced two-input, one-output model

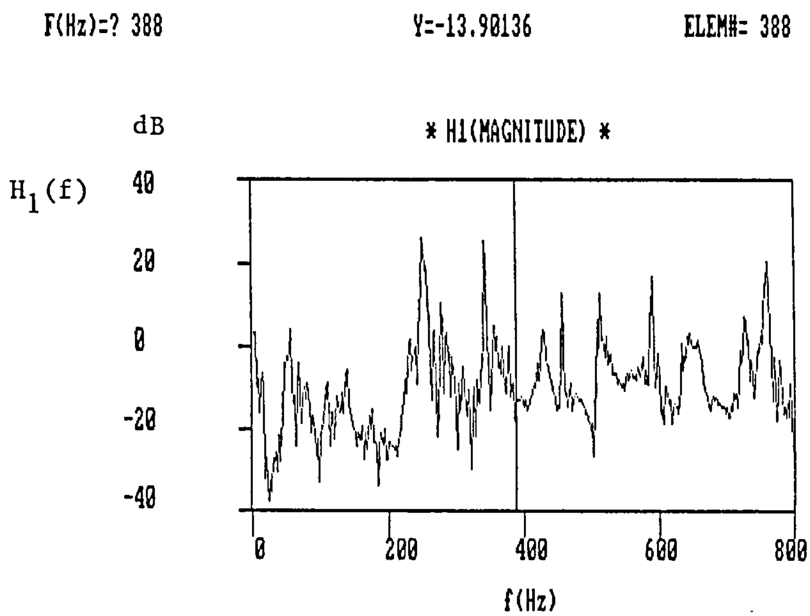

Fig. 2. The frequency response $H_1(f)$ measured using conditioned spectral analysis.

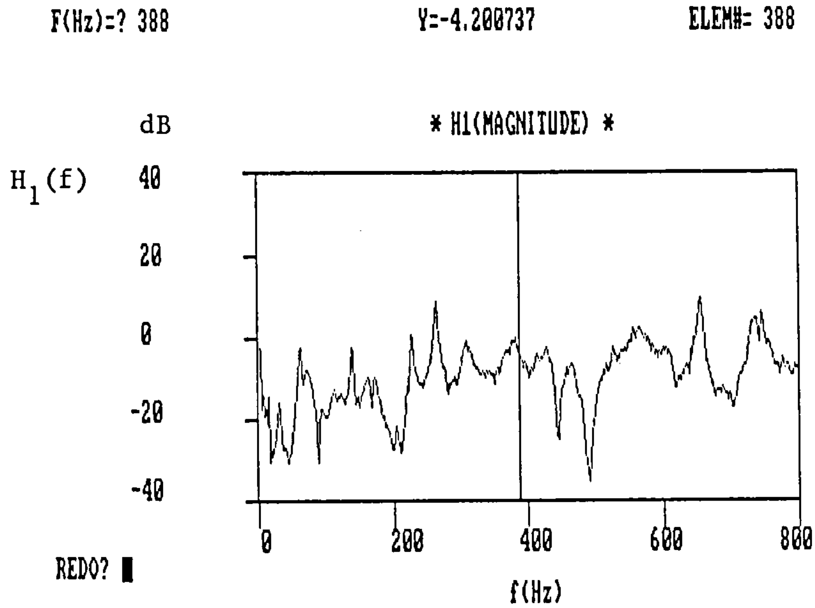

Fig. 3. The frequency response $H_1(f)$ measured using the new approach.

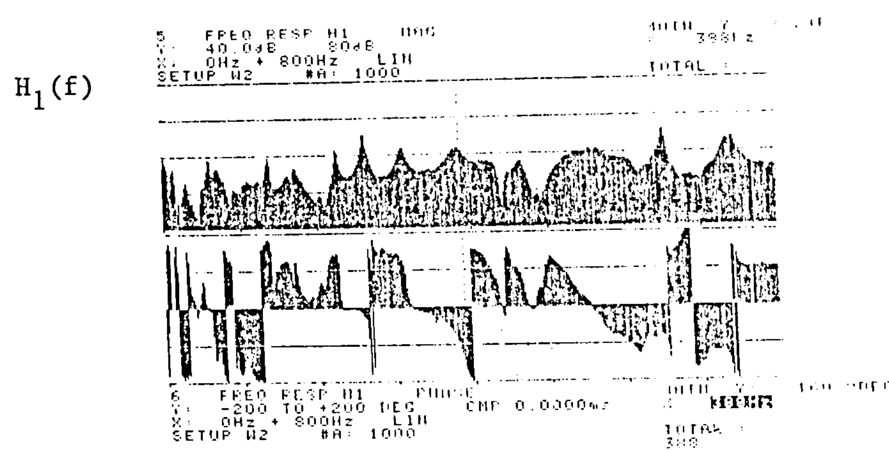

Fig. 4. The frequency response $H_1(f)$ measured using one-input, one-output model.