Brüel & Kjær application notes

Room equalization – FFT in concert

Touring bands present their sound engineer with what often seems like an insurmountable problem – how to produce good quality sound in a multitude of different and varying acoustic environments.

The engineer's experience alone will not always produce the best results, if the tools he has to use are not flexible enough to cope with every situation.

An FFT analyzer has the versatility needed, not only to ensure that the engineer's skill is not wasted, but also to help in producing better sound quality.

A Brüel & Kjær dual-channel analyzer being used in conjunction with a parametric equalizer to optimize sound quality for a concert in the World Theater, Minneapolis, Minnesota.

The problem.

Live sound can be dead. The sound reinforcement system, carefully adjusted and equalized before the concert, is now boomy, dull and hollow. The band is discouraged, the audience disappointed, and the sound engineer suffers sheer frustration for the next few hours. So what went wrong?

The problem is that a live concert is very dynamic and the acoustics of the venue can change dramatically. Conventional techniques for adjusting equalization (EQ) use clicks, chirps or pink-noise as the test signal; these are obtrusive sounds and cannot be used once the audience is present. The room, however, becomes an acoustically different place when filled with people – sound distribution, reverberation-times and floor-reflections change. The humidity and temperature variations caused by the audience and the stage lighting will alter the sound-absorption characteristics of the air. The net result of all these are shifts in room resonances which can ruin the EQ.

In general speaker-room response is measured using a 1/3-octave analyzer, and the observed resonance peaks and notches are then equalized with 1/3- or 1/6-octave graphic-equalizers. Unfortunately, many low-frequency rumble and mid-range ringing problems can be caused by narrow-band resonances which are too narrow to be measured in a 1/3-octave analysis, nor can they be corrected by fixed bandwidth graphic-equalizers.

The use of live music as the test signal, adjustable equalizers, and an analyzer able to pin-point narrow-band resonances would be the ideal solution. This would mean that the EQ could be adjusted for changes in the room acoustics when the audience arrives, and corrected for further changes during the performance.

An FFT analyzer, used in conjunction with high quality parametric-equalizers, provides the answer.

The answer.

The Brüel & Kjær Type 2032 (or 2034) is a dual-channel Fast Fourier Transform (FFT) analyzer. It is designed to investigate cause and effect relationships, in any system where both the cause and effect are electrical signals, or can be converted to electrical signals by transducers such as microphones. The 2032 samples, analyzes and averages the data in both signal inputs and, by comparing the two frequency spectra, computes the frequency response and other characteristics of the system. Because the 2032 operates on both signals, and uses the system input as the reference for analysis the technique is independent of the test signal. Therefore any test signal, *including music*, can be used.

Using an FFT.

The 2032 is easily connected to sound-reinforcement systems to measure room-response (Fig. 1). For the measurements you need two signals, the system input for channel A of the analyzer is taken from the output of the mixing console. The channel B in-

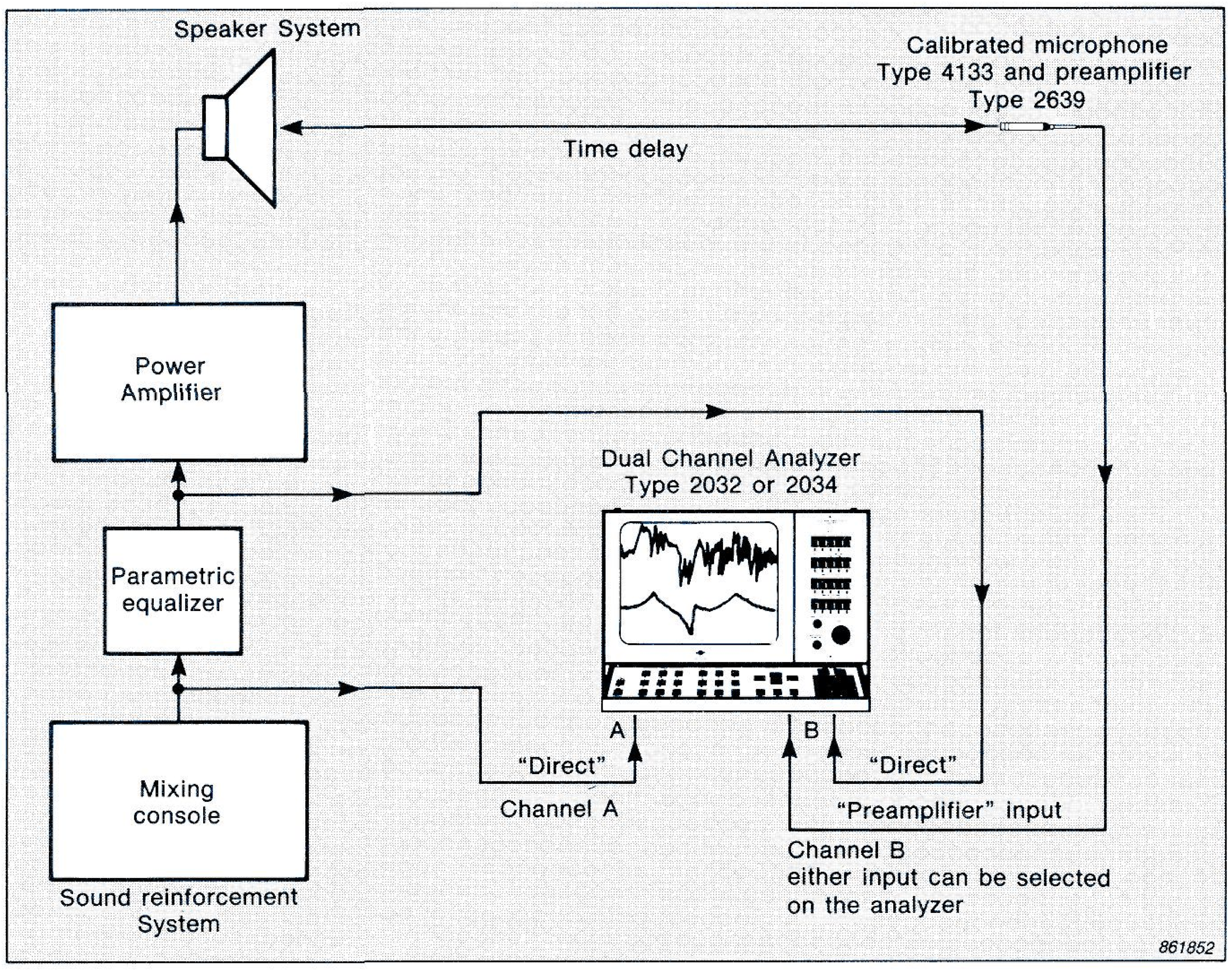

Fig. 1. A block diagram of the dual-channel analyzer connected to the sound system. Measureing between the A and B input signals, with music as the test signal, the analyzer computes the room-response

put is taken from one of two sources in turn, firstly the output from a calibrated microphone located in the audience, usually in the house-mix position, and secondly the output of the equalizer.

An initial frequency response measurement has to be made, between the console output and the calibrated microphone, with live or recorded music as the test signal. From this measurement you can calculate the time delay between the speaker-system and the microphone. This enables you to set the time delay into the analyzer so that the channel A data is delayed, until the microphone response reaches channel B. The built-in user-defined delay eliminates the need for an external delay line, and can also be used to time-align the speaker system.

A frequency response measurement without EQ will then give you the speaker-room response (Fig. 2). This measurement can be stored and displayed whilst, with the delay switched off, the inverse frequency response of the equalizer is continuously measured and displayed in real-time on the split-screen. This enables you to set up the EQ (Figs. 3 & 4) to compensate for the speaker-room response, and to produce the overall response you want. A further speaker-room response measurement, using the microphone and time delay, with EQ applied will then show the effect your equalization has had (Fig. 5).

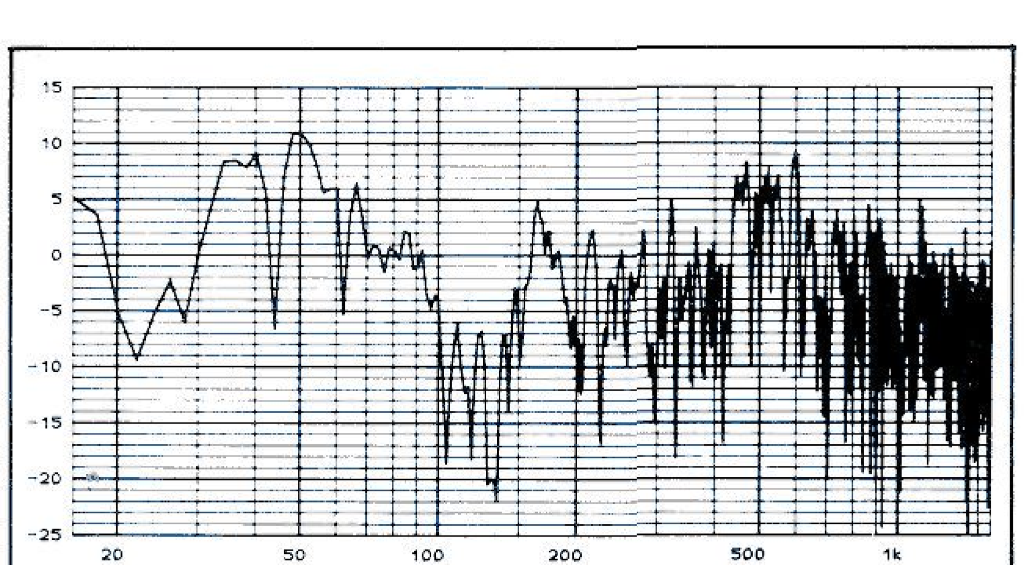

Fig. 2. The room-response measurement without equalization

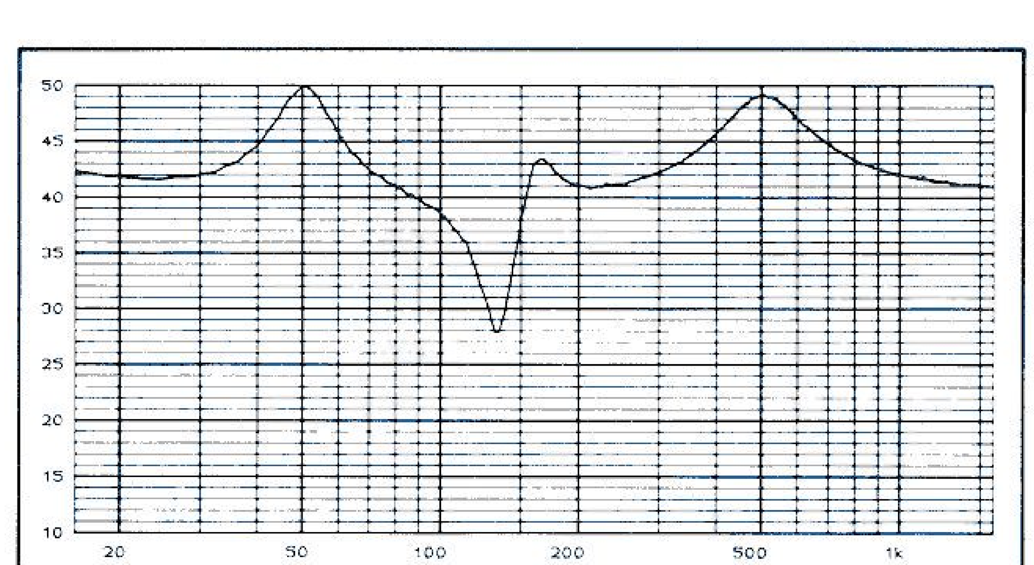

Fig. 3. The inverse frequency-response measurement of the equalizer

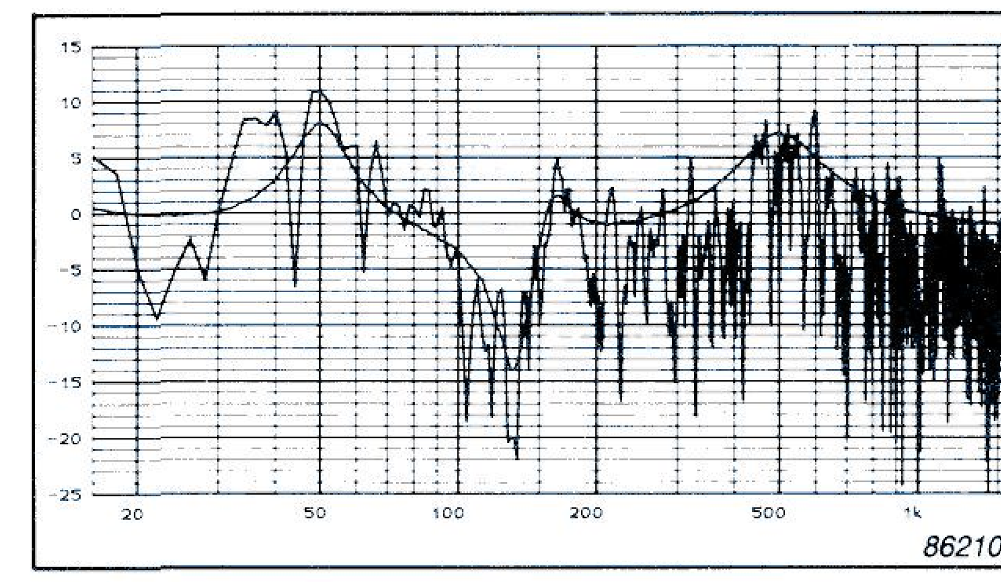

Fig. 4. Figs. 2 & 3 combined to show the fit between the room-response and the equalizer

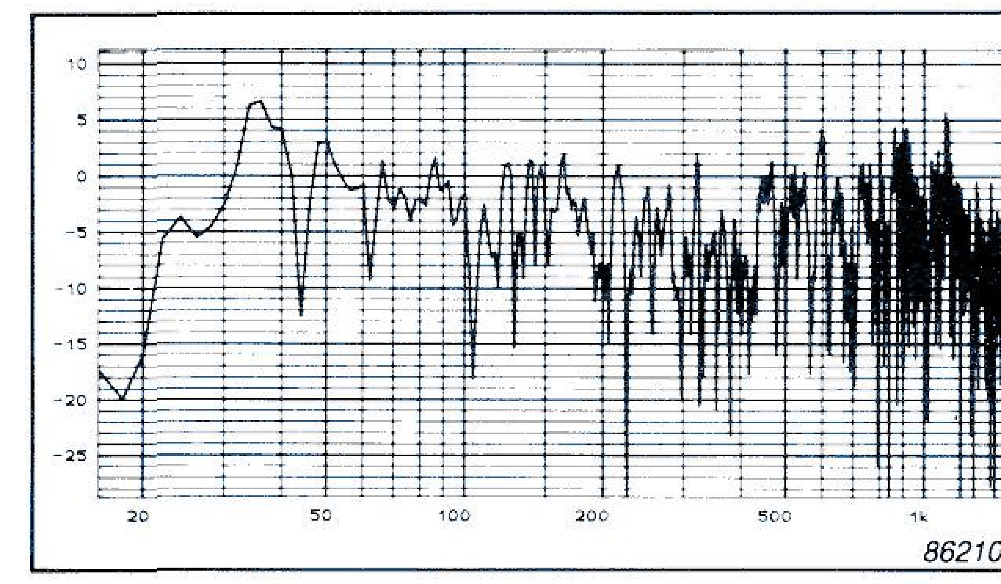

Fig. 5. Room-response measurement with equalization

In performance.

Whilst the audience is arriving, you can check the EQ using recorded music as the test signal. Just before the concert starts, therefore, the EQ will have been adjusted for a full house. The FFT enables you to continue monitoring the speaker-room response during the performance, using the live music for the measurements. Continuous corrections can be made to the EQ as acoustic conditions change.

Audience reaction and other random noises will tend to spoil the measurements, but here the coherence function on the analyzer will help you. Coherence is a measure of how well the data in channel B is correlated with that in channel A. Looking at the coherence, whilst measurements are being made, you can see data averaging reducing the effect of random noise. Continue the measurements until you are sure that enough averages have been taken for good coherence, and therefore a valid response measurement.

Great sound gets great audience reaction – 2032 works with it and helps you get it.

The measurements shown were made in the World Theater.

Brüel & Kjær

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