EAW's Testing & Measurement Laboratories

Rapid Data Acquisition Facility

TEST SETUP DESCRIPTION

DIRECTIVITY DATA

The directivity data gathered on EAW speaker systems for the APP program is collected using the Brüel & Kjær 2012 Audio Analyzer in TSR (Time Selective Response) mode. "TSR mode enables "free-field" measurements without an anechoic chamber, by rejecting the reflections from an ordinary listening room. The Type 2012 incorporates a technique that allows a useful combination of speed, accuracy, and signal/noise ratio for such measurements." (From the B&K 2012 Reference Manual, p.2.)

The test signal generated by the 2012 is a constant amplitude, linear sine sweep: The instantaneous frequency varies directly with time. Figure 1.1 illustrates a typical test setup. The 2012's output is connected a power amplifier (when testing systems that are powered in fullrange passive mode) or to an MX series CCEP™ (Closely Coupled Electronic Processor™) when testing bi-, tri- or quad amplified systems. When a processor is part of the system under test, its output signals are then amplified by Crest 8001 power amplifiers set at their maximum levels and the resulting signals are sent to the loudspeaker enclosure.

The 2012 allows the user to enter a single output sensitivity factor. For these tests, the maximum gain of a Crest 8001 amplifier is used. The voltage driving the system under test can be set to any desired value—the 2012 automatically scales the resulting SPL values to a level that would have been produced by a reference voltage of 2.83 Volts (one nominal Watt across an 8Ω load).

It is important to remember that the MX Series processor's gain is not factored into the Type 2012's calculations, so the recorded SPL values result from a voltage other than 2.83 Volts.

Directivity data is collected in a full spherical model using 5° increments along both the horizontal and vertical planes. 77, 256 SPL values are recorded for

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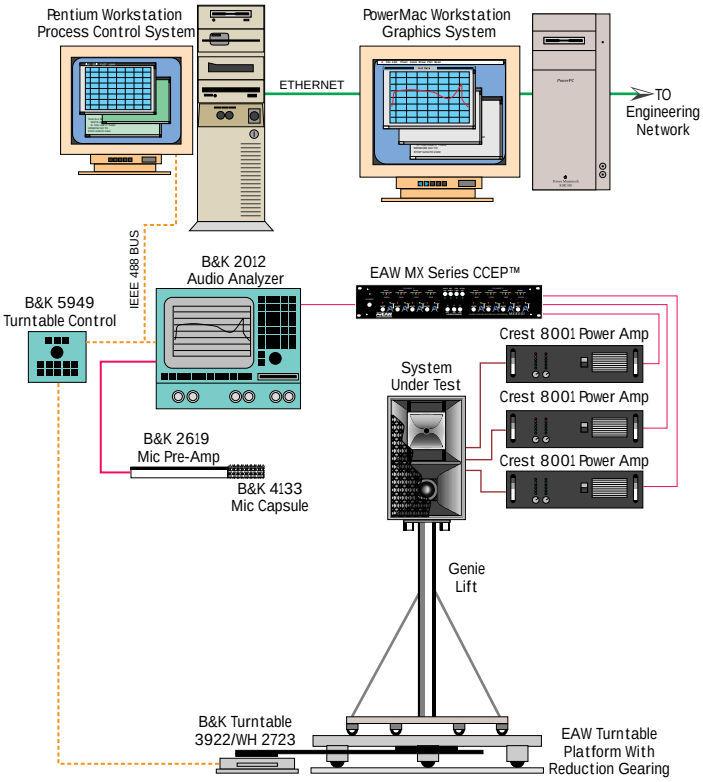


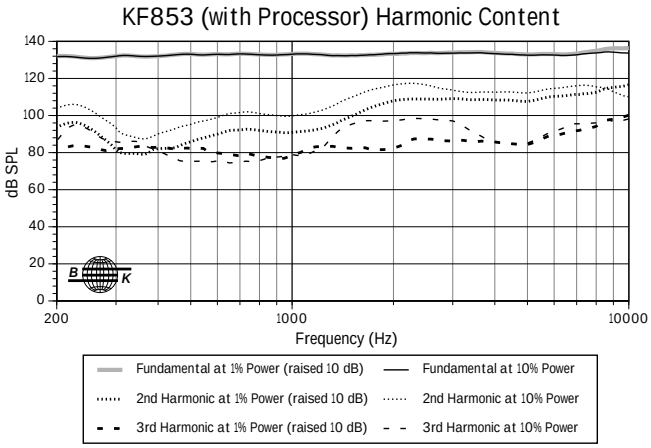
every system (72 points for each horizontal polar [0° to 355°] x 37 vertical polar angles [0° to 180°] x 29 third-octave centers).

IMPEDANCE VS. FREQUENCY

Impedance versus frequency for each speaker system is measured using the Steady State Response mode of the B&K 2012. The output channel of the B&K 2012 is connected to a power amplifier, which is turned into a current generator by placing a 1kΩ resistor in series with its relatively small output impedance. The speaker is connected after the 1kΩ resistor. The voltage across the known resistor can be easily measured, allowing the calculation of current flow through the loop. The unknown speaker impedance is simply calculated using Ohm's Law, R=V/I.

CCEP RESPONSE CURVES

CCEP response sweeps are obtained using the Steady State Response mode of the B&K 2012 audio analyzer.



DISTORTION MEASUREMENTS

Like the directivity measurements, distortion measurements are made using the B&K 2012's Time Selective Response mode. Six measurements are made of each system: The fundamental, second harmonic, and third harmonic are measured at 1% and 10% of each system's rated long term power handling (the highest 100 hour sine wave value of the various drivers in the system).

RELEVANT FORMULAS USED

STANDARD EQUATIONS

A textbook definition of beamwidth is "The coverage angle assigned to a given plane of radiation is that angle formed by the -6 dB points (referred to the on-axis reading) and the source center." (*Sound System Engineering*, 2nd Ed., Don and Carolyn Davis, p. 104.) EAW's automated beamwidth calculation algorithm searches for the last time a specific polar drops below the -6dB point, rather than accepting the first -6dB point. This algorithm works well, but occasionally a polar may hang just below the -6dB point for multiple degrees, slipping through our detection algorithm. Individual polar graphs may provide a more accurate reference in these instances.

All Q calculations are performed using the technique described on pages 116 and 117 of Sound System

Engineering, 2nd Ed. Normalized horizontal and vertical polar plots are used for the calculations, with each value weighted to correspond to measurements taken from points surrounded by equal surface areas.

Once each Q value is known, the corresponding Directivity factor is found with:

$$D=10x(\log Q)$$

The percentage efficiency is calculated using:

$$\%Eff.=10\left[\frac{(On\ Axis\ SPL)-10\log\left(\frac{1m}{0.283}\right)-10\log\left(\frac{1W}{10^{-12}}\right)}{10}\right]x100$$

Total Harmonic Distortion is calculated using both the second and third harmonics.

$$THD=\frac{\sqrt{(2ndHarm)^2+(3rdHarm)^2}}{\sqrt{(Fund)^2+(2ndHarm)^2+(3rdHarm)^2}}$$

MODELER DATA CONVERSION

BOSE Modeler v4.2 requires a sensitivity value in each of the eight octave bands currently utilized by the program. These sensitivity values need to be generated with 2.83V RMS broad band Pink Noise, not by a 2.83V RMS uniform sine wave sweep like the B&K 2012's TSR mode. However, we can calculate the broadband Pink Noise sensitivity from the uniform sine wave sweep value.

Remember that recorded SPL values are automatically scaled by the B&K 2012 Analyzer to simulate a 2.83V stimulus voltage at the system's input terminals. This scaling factor includes the gain of the amplifier and whatever the output level of the analyzer was set to. The one factor not taken into account was the gain of the CCEP unit.

Define the stimulus voltage at each of the octave band frequencies as:

$$S(f)=2.83+G(f)$$

It is also known that the power value for each of these frequencies, assuming a constant 8Ω load, is:

$$P(f)=\frac{S(f)^2}{8}$$

To simulate broadband Pink Noise with an RMS value of 2.83V, each of these power values needs to be normalized so that their total sum is equal to 1 Watt.

$$\sum P(f)\ x\ \frac{1}{\sum P(f)}=1$$

Each of the normalized reference powers can therefore be defined as:

$$NP(f)=P(f)\ x\ \frac{1}{\sum P(f)}$$

The processor output voltage (and thus the power) that produced each of the measured SPL values can be measured, thereby enabling the calculation of the SPL that would have resulted from the normalized power values:

$$SPL(f) = \text{Measured SPL Values}$$

$$SPLX(f) = \text{Extrapolated SPL Values}$$

$$SPLX(f) = SPL(f) - \left(10x\log \left(\frac{P(f)}{NP(f)} \right) \right)$$

But it is known that

$$NP(f) = P(f) \times \frac{1}{\Sigma P(f)}$$

Therefore

$$SPLX(f) = SPL(f) - (10x\log(\Sigma P(f)))$$

EASE™ & CADP2 DATA

EASE and CADP2 accept system sensitivity values as recorded by the B&K 2012. However, both programs specify sensitivity at 10° increments along the horizontal and vertical axes. When exporting data to these programs, our database automatically calculates each 10° data point by averaging the recorded value for that angle with the two 5° points on either side.

EASE and CADP2 cover a smaller frequency band than EAW's internal database. In addition, EASE accepts only a half-spherical model and assumes front-to-rear symmetry. These requirements are met by omitting the unrecognized values from the export file created by our database.

EAW PRODUCT SUPPORT SERVICES

ACOUSTICAL PERFORMANCE PARTNERSHIP (APP) PROGRAM

The APP program provides a full range of engineering resources to system designers and specifiers. Information on EAW products includes horizontal and vertical polar response (octave and 1/3 octave), on- and off-axis frequency response, distortion, impedance, Q/directivity and beamwidth, as well as hardware and cabinet drawings and architectural specifications. Performance data for Bose Modeler®, Ease and CADP2 is available now: AcoustaCADD data will be available in the near future. All APP information is available in printed form or on floppy disk for Mac or DOS computers. It is also available through the EAW OnLine Information Service.

EAW ONLINE INFORMATION SERVICE

Any computer with a modem can access EAW OnLine. The dialup numbers are 508/234-6173 or 800/889-2540 (in the US). TeleFinder Client software is available at logon or by contacting Mitchel Ahern, SysOp, at EAW. EAW OnLine includes forums for APP and VATA members.