Testing Enigma Acoustique's Oremus Loudspeaker

Reviewed by Joseph D'Appolito and Rita and Dennis Colin

I ran a series of impedance, frequency response, and distortion tests on the Oremus loudspeaker from Enigma Acoustique. *Figure 1* is a plot of system impedance magnitude. At low frequencies, the plot displays the double-peaked curve of a vented system.

The impedance minimum of 6.91Ω at 50.5Hz is a good measure of the vented-box resonant frequency. At 212Hz there is a second local minimum impedance of 6.75Ω. The very small difference between these two minima indicates efficient reflex action.

In addition to the two impedance peaks at low frequencies, a third peak occurs at 1.6kHz, where the woofer and tweeter crossover networks interact to form a parallel resonance. Impedance drops to a low of 4.2Ω at 20kHz, and impedance phase lies between +32° and −55° over the full audio range. The Oremus is correctly rated as an 8Ω loudspeaker.

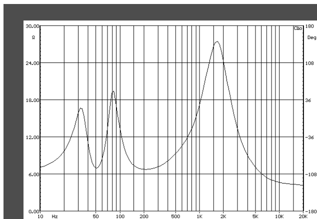


FIGURE 1: Oremus loudspeaker impedance.

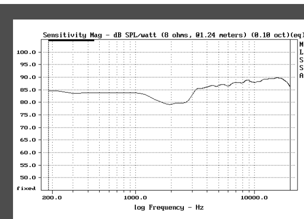


FIGURE 2: Oremus far-field response.

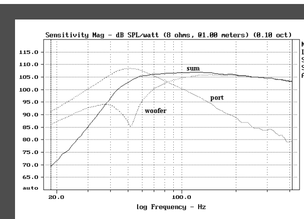


FIGURE 3: Near-field port and woofer responses and their sum.

FREQUENCY RESPONSE

Figure 2 shows the Oremus's far-field frequency response with the microphone placed along the front baffle axial centerline, on a level with the bottom of the tweeter flange and at a distance of 1.24m. This is a quasi-anechoic response.[1] It is valid above 200Hz. The plotted response has been normalized to 1m to obtain system sensitivity.

Figure 3 illustrates near-field woofer and port responses. These responses are summed by the MLSSA system, giving proper weighting to the difference between the woofer and port areas, to obtain the complete low-frequency near-field system response.[1] The dip in woofer response at 50.8Hz is another indication of vented-box resonant frequency and agrees well with the impedance data.

The system near-field response (*Fig. 3*) is spliced to the quasi-anechoic response (*Fig. 2*) at 200Hz to get the full-range response without the use of an anechoic chamber (*Fig. 4*). There are several important features on this plot. First, there is a broad response dip of 5dB between 1 and 3kHz. Above 3kHz, response rises to a peak of 5dB at 15.5kHz. The dip in the critical midrange usually leads to a recessed image; that is, the instruments or soloists appear to be slightly behind the speakers.

The high frequency rise may make the speakers appear overly detailed. Finally, notice the very rapid drop-off of low-frequency response, which falls 26dB in the first octave, to below 50Hz.

The shape of the response curve makes an estimate of sensitivity somewhat problematic. My best estimate is 86dB/3.83V/1m. Relative to this level, the low-frequency −3dB point is 52Hz.

Figure 5 is a plot of system and individual driver responses on an expanded frequency scale. Woofer and tweeter responses overlap by one octave in the crossover region (2–4kHz). Crossover overlap can be an advantage in some designs, but here you see that the phase angle between the drivers is greater than 90° so that their responses actually subtract and cause the response to dip.

SYSTEM STEP RESPONSE

Figure 6 is a plot of system step response, obtained by a numerical integration of the system impulse response. The ideal step response should be a single rapid rise followed by a smooth decay through the 0.00 level.

Figure 6 shows two separate arrivals of acoustic energy. The initial sharper positive spike is the tweeter arrival, followed by the woofer arrival, peaking about 0.25ms later. The drivers are both connected with positive polarity, but the system is not time-coherent.

ABOUT THE AUTHOR

Joseph D'Appolito, regular contributor to *aX* and author of many papers on loudspeaker system design, holds four degrees in electrical and systems engineering, including a Ph.D. Previously, he developed acoustic propagation models and advanced sonar signal processing techniques at an analytical services company. He now runs his own consulting firm specializing in audio, acoustics, and loudspeaker system design. A long time audio enthusiast, he now designs loudspeaker systems for several small companies in the US and Europe.

A better view of this behavior is shown in *Fig. 7*, which is a plot of excess group delay versus frequency referenced to the tweeter's acoustic phase center. This is a plot of delay in milliseconds versus frequency (see reference 1 for a detailed description of excess group delay). In a time-coherent system this plot would be a flat line.

Above 10kHz excess group delay is essentially zero since it is referenced to the tweeter in this frequency range. The curve rises gradually below 10kHz, reaching a peak of 0.3ms at 2kHz and then falling back to about 0.15ms below 700Hz. This plot shows that over its operating frequency range, the woofer is between 0.15 and 0.3ms behind the tweeter depending on frequency.

CUMULATIVE SPECTRAL DECAY

The Oremus cumulative spectral decay (CSD) response is presented in *Fig. 8*. This waterfall plot shows the frequency content of the system response following a sharp impulsive input at time zero. On the CSD plot, frequency increases from left to right and time moves forward from the rear. Each slice represents a 0.06ms increment of time.

The total vertical scale covers a dynamic range of 34dB. Ideally the response should decay to zero instantaneously. Inertia and stored energy that take a finite amount of time to die away, however, characterize real loudspeakers. A prominent ridge parallel to the time axis indicates the presence of strong system resonance.

The first time slice in *Fig. 8* (0.00ms) represents the system frequency response. There is a strong response ridge at 3224Hz coming from the woofer. The ridge extends out to about 1.9ms. There is also a great deal of "hash" in the tweeter decay above 6kHz starting at 0.4ms and lasting out to 1.3ms. The tweeter hash can lend a sense of false "air" to the sound. See the accompanying critique for more about this.

POLAR RESPONSE

Polar response is examined in *Figs. 9–12*. *Figure 9* is a waterfall plot of horizontal polar response in 10° increments from 60° left to 60° right when facing the speaker. All off-axis plots are referenced to the on-axis response, which appears as a straight line at 0.00°. For good stereo imaging the off-axis curves should be smooth replicas of the on-axis response with the possible exception of some tweeter rolloff at higher frequencies and larger off-axis angles.

You can see the expected rolloff of tweeter response at higher frequencies and larger off-axis angles. This performance is fairly typical of 19mm tweeters with a recessed dome. *Table 1* lists the off-axis responses at 15kHz and all angles up to ±60°.

Horizontal polar response is broad and uniform. There is some mild reduction in off-axis response in the midrange at larger angles. This is fairly typical of two-way systems. On the whole, however, imaging should be good.

The average response over a 60° horizontal angle (±30°) in the forward direction is shown in *Fig. 10*. In this plot you see that the broad dip between 1 and 3kHz persists and actually worsens somewhat. I suspect this will make the system sound even more recessed than the on-axis response would indicate.

On the other hand, the rise in tweeter response is reduced due to the tweeter's falling off-axis response. This may make the audible effect of the peaking less apparent since the human ear integrates direct and reflected sound when

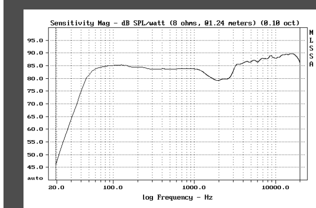


FIGURE 4: Full-range free-standing frequency response.

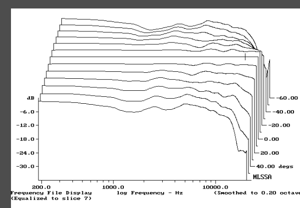


FIGURE 9: Horizontal polar response.

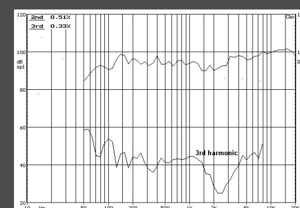


FIGURE 14: Third harmonic distortion.

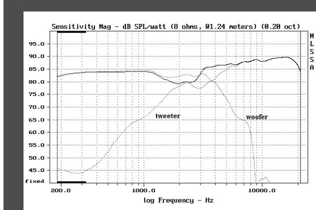


FIGURE 5: System and driver responses.

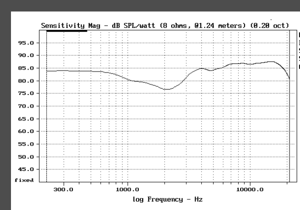


FIGURE 10: Average horizontal response over ±30°.

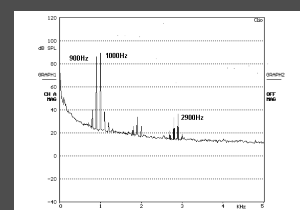


FIGURE 15: Woofer IM distortion.

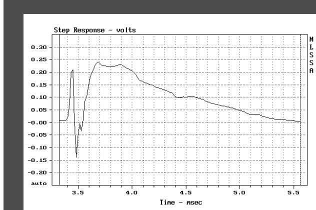


FIGURE 6: Step response.

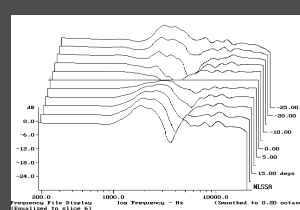


FIGURE 11: Vertical polar response.

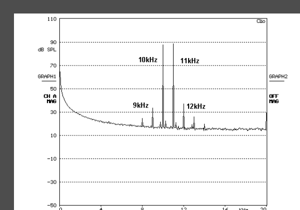


FIGURE 16: Tweeter IM distortion.

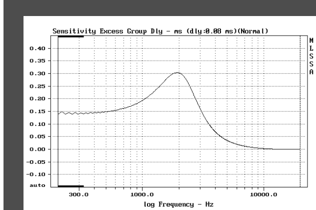


FIGURE 7: Excess group delay.

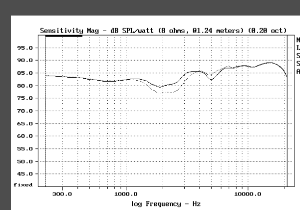


FIGURE 12: Response: on-axis (dotted) and 5° up (solid).

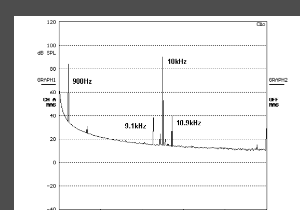


FIGURE 17: Cross IM distortion.

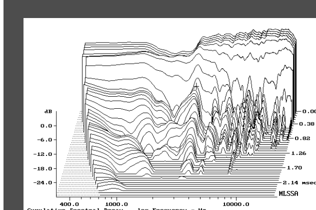


FIGURE 8: Cumulative spectral decay.

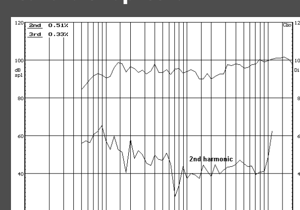


FIGURE 13: Second harmonic distortion.

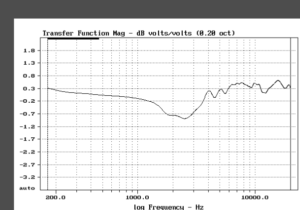


FIGURE 18: Oremus pair match.

■ **Reviewed by Rita and Dennis Colin**

EQUIPMENT AND SET-UP

We used the same Nakamichi AV-1 receiver (100W/channel) and Yamaha CDC 755 CD changer (plus turntable and cassette player) that we've become very familiar with after three years, and on which we've heard many speakers, some very good and some not.

THE LISTENING ROOM

Approximately 20′ × 18′ × 8½′ (3000ft^3), the room is moderately damped with stuffed chairs, carpet, and drapes; it is well dispersed by numerous openings and stepped walls. Room response is smooth (for a room) to below 16Hz. Many other speakers sound excellent in this room, including the Swans M1 (review, *SB* 3/99, p. 36).

We placed the Enigmas on stands with tweeters at seated ear height (≈36″), 3′ from the front wall and 4½′ from side walls (11′ apart); the distance to listeners was approximately 12′.

SOURCE MATERIAL

We used the *Hi-Fi News and Record Review* Test Disc III CD (tracks 2, 4, 5, 6, 7, 10, 14), and also played a variety of other material. The Enigmas were broken in with about two hours of moderately loud music.

THE SOUND

I first heard the Enigmas with Joe D'Appolito at his house, when he was trying them out in a new music/home-theater system. With no thought of reviewing these units, Joe and I simply listened a few minutes to Capriccio Italien and Jacintha, a nice-sounding female jazz singer. We were both immediately impressed with a clean sound and particularly clear and extended treble—an unexpected triangle-type percussion instrument surprised us with "in your face" presence, and Jacintha's voice with saxophone accompaniment had captivating "breathiness."

Several weeks later, Ed Dell asked me to review these Enigmas, which Joe then brought to my house. Joe, my wife Rita, and I sat down for an extended evaluation. My first impression, with Jacintha, was almost the same as at Joe's house (my room is more damped than his; I noticed less midrange "presence," but the speaker sounded close enough that I could "tune out" the room effects).

But after a while, something bothered me—the musical and voice tones were clear enough and smoothly extended, bass and treble, but something was "thin" about the sound. Rita didn't like the sound right from the start—"too thin, weak presence, where's the midrange?"

DETAILED SONIC IMPRESSIONS

1. High-frequency detail, such as bell and violin overtones, was very cleanly resolved. It's interesting that the treble sounded over-present (relative to midrange) after extended listening (to me, immediately to Rita), but not bright in the sense of "screechy" (as did the Kirksaeter SL-60s we reviewed in *GA* 5/00).

2. Listening to the *Hi-Fi News* tracks, we noted the sound lacked the normal "fullness of midrange" necessary to present the sensation of "solidity of tone." On "Peter and the Wolf," for example, there wasn't the "lush feeling of a forest" that this composition normally presents on other speakers. On this and almost all the review source material, the individual midrange tones were not distorted, resonant, or uneven in response; however, the general midrange area sounded suppressed.

3. Bass sounded smooth, detailed, and extended (I would estimate) to about 50Hz. String bass instruments were very naturally reproduced.

4. Dynamic range was good for this size speaker.

5. Overall, the sound was frustrating—individually, the bass, midrange up to approximately 2kHz, and treble seemed to be of high quality, but listening full-spectrum, I would guess that the midrange was depressed (especially around 2–3kHz) and the highest frequencies were upward-sloping.

6. About the latter, I find that with a very good tweeter, such as I believe that in the Enigma to be, sloping up the highest frequencies does not cause "coloration," but simply an exaggerated sense of "air" and "detail." In fact, a good test of tweeter smoothness is to try a preamp with tone controls and turn the treble up full. Unnatural, yes, but with a very smooth-response tweeter there will be just emphasis, not coloration, whereas an inferior tweeter will sound like what it is, only much more so.

7. The depressed midrange effect was most noticeable with voices; they sounded too distant and thin. Also lacking "solidness" or "body" were horns and midrange strings.

8. Rita did not like the sound at all; some of her favorite singers—Linda Ronstadt, LeAnn Rimes, Aaron Neville, Julio Iglesias, and Luciano Pavarotti—simply sounded unacceptably lacking in presence and naturalness. On the other hand (or should I say spouse), I could enjoy some of the individual aspects of the speakers, such as the extended treble and bass, and freedom from audible resonances.

But viva la difference; it makes for spice among spouses!

WHAT'S IN A NAME?

Not much, according to Shakespeare. But these Enigmas are appropriately named! They apparently have very good drivers (Joe tells me the tweeter is by Scan-Speak) but a significantly non-flat integrated output. Another "enigma" is the fact that, while I didn't listen extensively to them at Joe's house, I still think they sounded better there. My guess is that the warmer acoustics there filled in some of the midrange, and/or the favorable first impressions and sparkling-clear highs "rang our bells" for a while.

SONIC CHARACTERISTICS RATINGS

Table 1 gives sonic characteristics ratings. To convey some perspective to my choice of ratings within the 0-10 scale, I submit the following attempt at descriptive characterization examples:

9-the best I've ever heard from a speaker regarding the particular sonic characteristic
7-typical for a good-quality speaker
5-mediocre, good for a boom-box
1-don't even think about it!

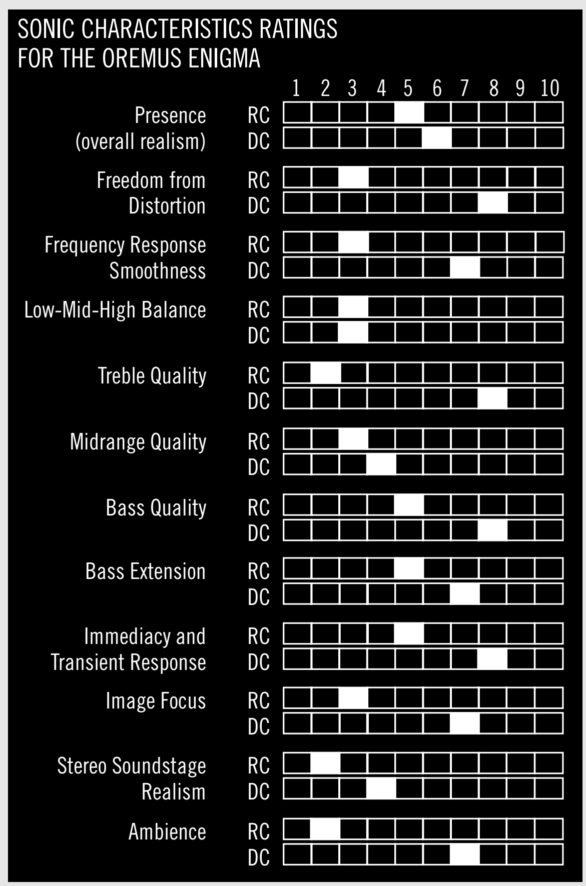
On this scale, 10 would be the best I believe possible from two-channel stereo; the elusive "perfect enough" speaker.

COMMENTS ON MEASUREMENTS

Seeing the axial response affects my eyes just the way the sound affected my ears. Smooth within large regions, but unbalanced.

Does three-of-a-kind constitute a trend? *The Absolute Sound*, Issue 125, p. 97, contains a review of the Mirage MRM-1, which appears to have a frequency balance similar to the Enigmas and Kirksaeters. Paul Seydor says, "Despite the thought and care that have gone into the design of this speaker, I found the MRM-1 to have one of the weirdest tonal balances of any genuinely high-fidelity speaker I have encountered. There is a broad, relatively deep midrange trough that starts around 200–300Hz and extends to between 5–6kHz, where it starts a gradual rise."

The specifics of the Enigma's response are different, but the general shaping appears similar. And another quote from Mr. Seydor (just before the above) may help explain the "enigma" of more favorable impressions initially than long-term: "At the end of



the day, the overall tonal balance determines the sound of the speaker."

Maybe for me, but Rita noticed it immediately. I think I (and dare I generalize to males?) may at first listen too analytically, thereby being overly impressionable by specific "bells and whistles" (bells here being a good example; I liked their sound on the Enigmas). But after a while, this focused analysis-mode becomes tiring; then you stop listening for details and hear, as Mr. Seydor said, the overall tonal balance.

One question: How can a speaker have "one of the weirdest tonal balances" and yet be a "genuinely hi-fi speaker?" Does this mean it's still better than any "non-hi-fi" speaker; the "weirdness" is "acceptably mild?" Sorry, but I find this concept mildly weird!

The Enigmas, however, didn't sound "weird" to me; they sounded like two very good drivers with a crossover that produced a suppressed midrange and upward-sloping treble. Therefore, I suggest these speakers would be a good project for those who enjoy crossover design and tweaking. On the other hand, you might like the stock speaker, particularly in rooms with strong midrange reinforcement and/or high-frequency absorption.

judging the overall spectral balance of a loudspeaker.

Notwithstanding these problems, the horizontal coverage is quite good. There will be only small changes in spectral balance with horizontal position. Image stability should be good.

Figure 11 is the waterfall plot of vertical polar response. Responses are shown in 5° increments from 25° below (–25°) the tweeter axis to 25° above it. In all cases response changes significantly with vertical off-axis displacement. I suspect this is a direct consequence of the driver crossover overlap and inter-driver phase angle. Interestingly, response at 5° up is smoother than the on-axis response (*Fig. 12*).

HARMONIC DISTORTION

I conducted harmonic distortion tests at an average SPL of 90dB at 1m. Ideally, harmonic distortion tests should be run in an anechoic environment. In practice, it is important to minimize reflections at the microphone during these tests. Out-of-phase reflections can produce false readings by reducing the level of the fundamental while boosting the amplitude of the harmonic. In order to reduce the impact of reflections, I placed the microphone at 0.5m from the loudspeaker.

A note on testing: The Enigma Acoustique's Oremus loudspeaker was tested in the laboratories of Audio and Acoustics, Ltd. Measurements were made with the MLSSA and CLIO PC-based acoustic data acquisition and analysis systems using an ACO 7012 ½″ laboratory-grade condenser microphone with a custom-designed wide-band, low-noise preamp. The polar response tests were performed with a computer-controlled OUTLINE turntable on loan from the Old Colony Division of Audio Amateur Corporation.

Figures 13 and *14* show second and third harmonic distortion levels in dB SPL versus frequency plotted in 1/6-octave steps. System frequency response is also plotted on these figures. Worst-case low-frequency second harmonic distortion is 4.5% at 90Hz. The third harmonic hits 3.8% at 56Hz. All system harmonic distortion is well below 1% above 150Hz. Tweeter harmonic distortion is below 0.4% at all frequencies. This is good performance for a small monitor speaker.

INTERMODULATION DISTORTION

Next I measured intermodulation distortion. In this test two nearby frequencies are input to the speaker. Intermodulation distortion produces output frequencies that are not harmonically related to the input. These frequencies are much more audible and annoying than harmonic distortion. Properly interpreted, intermodulation distortion can reveal a great deal about speaker performance.

Let the symbols f_1 and f_2 represent the two frequencies used in the test. Then a second-order nonlinearity will produce intermods at frequencies of $f_1 \pm f_2$. A third-order nonlinearity generates intermods at $2f_1 \pm f_2$ and $f_1 \pm 2f_2$.

TABLE 1
HORIZONTAL POLAR RESPONSE AT 15KHZ

ANGLE	RESPONSE(DB)
10	–0.6
20	–2.0
30	–4.3
40	–7.3
50	–11.5
60	–14.2

I first examined woofer intermods by inputting 900Hz and 1kHz signals at equal levels. These frequencies should appear predominantly in the woofer output. Total SPL with the two signals was adjusted to 85dB at 1m. The Oremus system output spectrum for this test is shown in *Fig. 15*. The two largest spectral lines represent the input signals.

IM products appear at 800, 1100, 1900, 2800, and 2900Hz. The largest distortion product is second order at 800Hz. It is 51.4dB below the main output, which is equivalent to 0.27% distortion. Total woofer IM is 0.4%. This is average for small monitor speakers I have tested.

I measured tweeter intermods with a 10 and 11kHz input pair also adjusted to produce 85dB SPL at 1m (*Fig. 16*). IM products can be seen at 8, 9, 12, and 13kHz. The largest intermods are at 9 and 12kHz. Total tweeter IM distortion is 0.23%. This is better than average for a small monitor speaker.

The last IM test examines cross intermodulation between the woofer and tweeter using frequencies of 900Hz and 10kHz. (A 1kHz signal would produce intermods that fall on harmonic distortion lines, confusing the results.) Ideally, the crossover should prevent high-frequency energy from entering the woofer and low-frequency energy from entering the tweeter. This spectrum resulting from this test is shown in *Fig. 17*.

The principal IM products fall at 9.1 and 10.9kHz. Total distortion is 0.34%. This is somewhat on the high side compared to other systems I have tested. It may be due to the choice of crossover slopes.

PAIR MATCHING

Two samples of the Oremus loudspeaker were available for testing. The two units were arbitrarily labeled #1 and #2. All of the tests described so far were conducted with #1. One question of interest is how well the two samples match?

Frequency response matching is shown in *Fig. 18*, which is a plot of the response difference between the #1 and #2 samples. The two systems match within +0.62 and –0.89dB. This level of match should guarantee good image stability over the full frequency range. ❖

REFERENCE

1. J. D'Appolito, *Testing Loudspeakers*, Audio Amateur Corporation, Peterborough, NH, 1998.