



Driver Interference and Display Techniques, Pt. 2

By G.R. Koonce

This noted author and dedicated researcher continues his probe of how interference affects driver response.

The poor mid-frequency performance of the Terra midrange mentioned previously is likely due to the construction of the baffle insert I developed to flush-mount this driver. (See Moriyasu's thorough study of the effects of midrange chambers and mounting on the midrange's response.)⁵ Actually, when I built the insert, I did not plan on driving the midrange, only on mounting it to see its effect on the tweeter. Thus I went ahead and built the insert as I would for a tweeter.

Photo 5 is the back view of this baffle insert with the driver mounted. As you can see, all sorts of wood blocks for driver mounting screws and stiffening the insert exist. This causes no problem with a tweeter, because they don't radiate to the rear. However, this midrange does radiate to the rear. You learned in the grille frame study that a symmetrical structure out in front of a driver could cause big trouble. It makes sense that such structures behind

an open-back driver could be just as destructive. I decided to test for this.

The only other baffle insert I had at the time was for surface-mounting the midrange. I will investigate how much worse my flush-mount insert is relative to surface-mounting in a simple hole.

Figure 36 displays the error curves for the midrange flush-mounted relative to surface-mounted. An expanded view of the error magnitude function (**Fig. 37**) shows 2dB PTP error below 4kHz where this midrange might be used.

In the CRC plot (**Fig. 38**) the on-axis interference is down about 20dB below 4kHz and much higher above this frequency. This high-frequency interference might make the crossover design more difficult than merely hiding the driver's normal cone breakup ripple.

Keep in mind that 20dB down seems

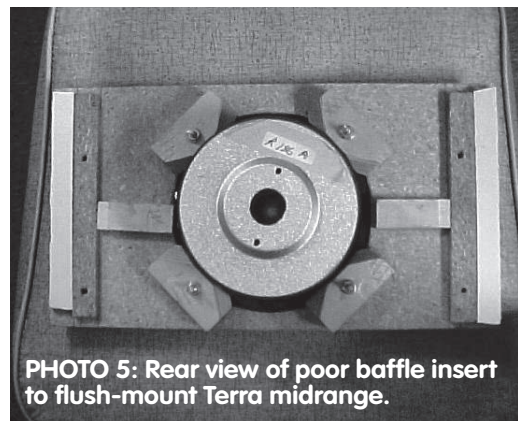


PHOTO 5: Rear view of poor baffle insert to flush-mount Terra midrange.

good, but this interference level managed to pass through the midrange cone (aluminum) and reach the on-axis microphone. The off-axis effects may be worse. Remember also that this is the response destruction of the poor insert relative to the midrange surface-mounted; compared to proper flush-mounting the response destruction would likely be even greater.

Clearly this work supports Moriyasu in that you must be careful what you place behind an open-back midrange, or any

FIGURE 36: Error curves for Terra midrange in poor flush-mount insert.

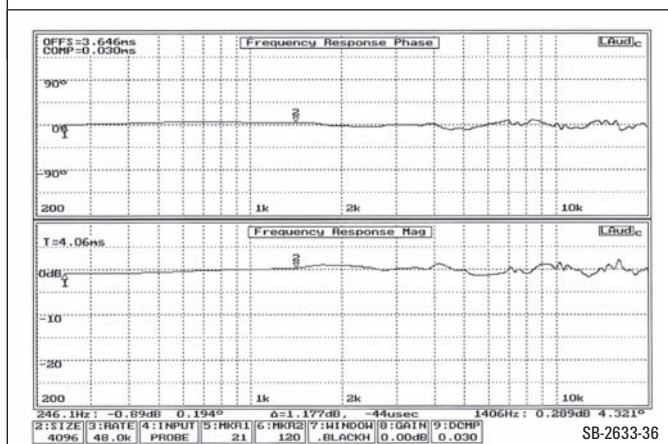
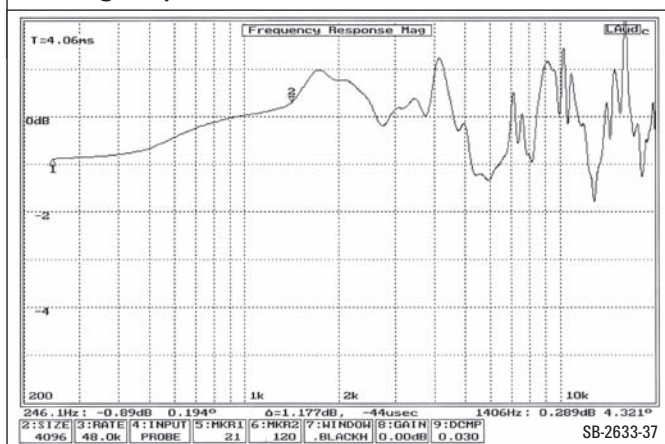


FIGURE 37: Expanded magnitude error curve for Terra midrange in poor flush-mount insert.





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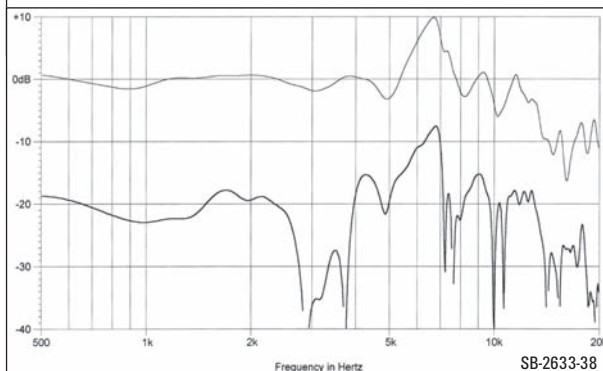
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FIGURE 38: CRC plot for Terra midrange in poor flush-mount insert.



open-back driver for that matter. It is clear you should avoid symmetrical structures behind such drivers, just as you do not want them in front of any driver. It would appear that due to its symmetry the drum midrange is not an optimum driver selection unless the maker has done an outstanding job of damping reflections from the rear cone radiation.

AN IMPROVED MIDRANGE INSERT

I later developed a new flush-mounting insert for the midrange driver. In the rear view of this insert (**Photo 6**) the area be-

hind the driver is kept as clean as possible. The "hole" opens up as smoothly and quickly as possible with the mounting hardware "hidden" behind the driver frame struts. What to compare the new insert to becomes complicated because the original flush-mount insert was destroyed in building the new one.

The midrange is now installed in a different location in the baffle to prepare for tests with items mounted below the midrange. Additionally, I have changed the amount of damping material behind the baffle. It is clear that new test results can't be compared to any of the earlier midrange tests. The new testing was performed on the midrange's axis at 1m.

I first tested the midrange in the new flush-mount insert as a reference and then in the surface-mount insert to see the degradation caused by surface mounting. The surface-mount insert is simply a straight-sided hole that mounts the driver in the 5/8" thick insert. **Figure 39** shows major differences in the responses with the flush-mounted response smoother and flatter in the midrange frequencies. The error plot (**Fig. 40**) shows several dB of magnitude difference caused by surface-mounting, about 2dB peaks and 3dB dips. To cause a 2dB peak requires an in-phase interference signal of around -12dB relative to the reference response.

Looking at dips becomes a bit more complex as the interference can be either greater or less than the reference. Assuming the interference is less than the reference, then to produce a -3dB dip would require a directly out-of-phase interference at about -11dB. The CRC plot (**Fig. 41**) shows the composite interference in the -10dB range throughout much of the

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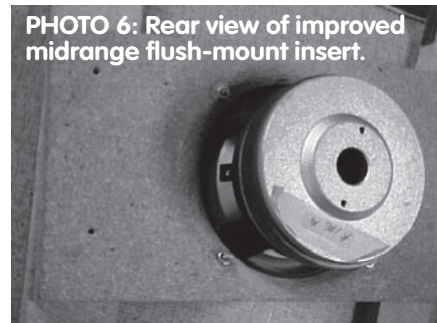
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PHOTO 6: Rear view of improved midrange flush-mount insert.



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frequency range. It is clear that surface-mounting an open-back midrange in a straight hole can make a major difference in the driver's response.

The PC plot for the response in the new flush-mount insert is in **Fig. 42** and that for the surface-mount insert in **Fig. 43**. The major echo group from about 0.3ms to 0.49ms appears in both plots and is thus likely built into the driver. This time delay converts to an in-air distance

of 4" to 6.6" or a reflector about 2" to 3.3" behind the cone. This is a mid-bass driver with a large voice coil and a huge magnet structure, which is likely the cause of this major echo group.

The differences in other echoes in these two plots would not lead me to expect as much response difference as is measured. Again, the CRC plot helps to give a clearer picture of what the interference is and over what frequencies it could dominate.

SYSTEM DEVELOPMENT

For the following interference testing it made sense to investigate the effects on a system rather than on the individual drivers. My test baffle will not support a full three-way system with port, so I needed a two-way. Combining the Terra tweeter and midrange drivers with a crossover produced the system. Remember that while I'm calling the Terra driver a midrange it is really a mid-bass driver with a response

FIGURE 39: Midrange responses in new flush-mount and surface-mount inserts.

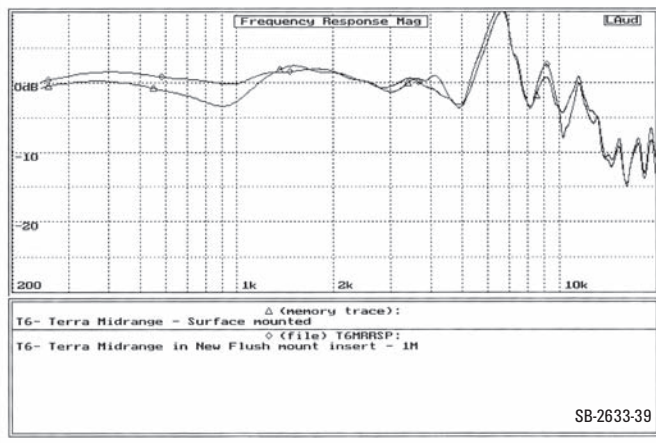
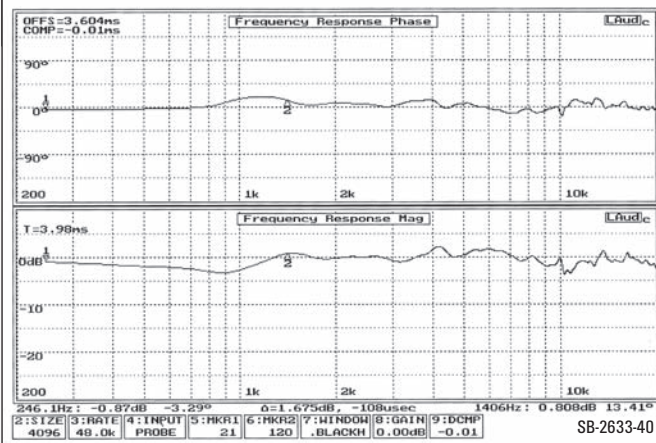


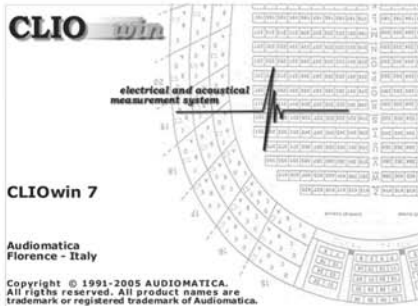
FIGURE 40: Error curves for Terra midrange in surface-mount insert.



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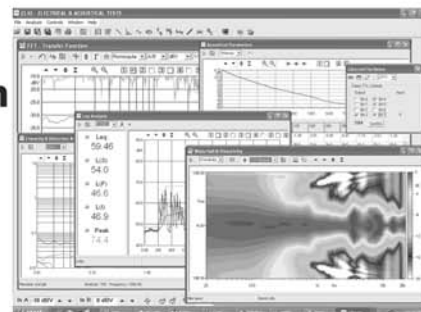


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flat to my lower test limit. While both drivers were moved higher in the baffle to allow mounting things below them, they are both flush-mounted (new midrange insert) and the CTC spacing between the two is still 6".

I developed a crossover via modeling and trial-and-error testing. The low-pass is a fourth-order to attenuate the cone break-up region. The high-pass is a third-order with series padding for tweeter protection with the low crossover frequency used. **Fig-**

ure 44 includes the measured responses of the midrange and tweeter with the crossover, measured on the midrange's axis. The acoustic crossover point is about 2.3kHz, so interference effects above this frequency are modifying the tweeter's response.

Figure 45 is the measured system response with just the midrange and tweeter mounted in the baffle. The droop just above 2kHz identifies where the tweeter takes over from the mid-bass. I performed this test at 60" on the midrange's axis. This

will be the reference response for the following interference studies. The 60" test distance is needed for a valid far-field test when a woofer or port is added below the midrange.

EFFECTS OF A FRONT PANEL WOOFER

David Weems asked me what happens to the tweeter and midrange responses if you add a woofer. I investigated this by adding a flush-mounted 8" Pioneer B20FU20-

FIGURE 41: CRC plot for Terra midrange in surface-mount insert.

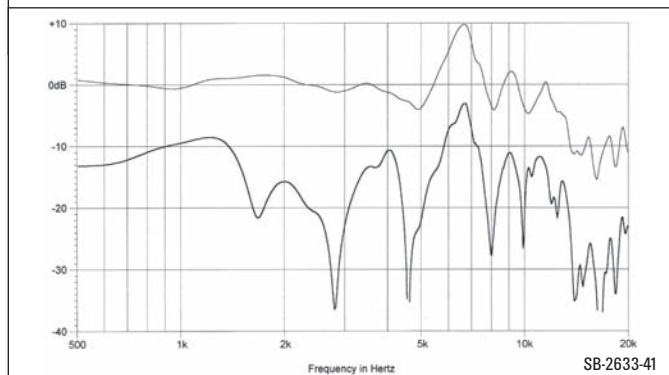


FIGURE 42: Power cepstrum plot for new flush-mount insert.

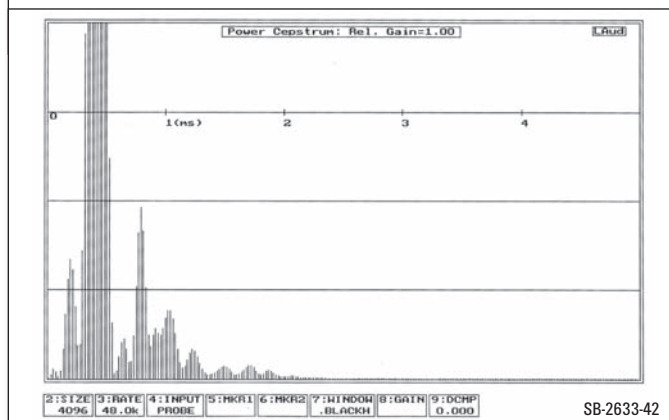


FIGURE 43: Power cepstrum plot for surface-mount insert.

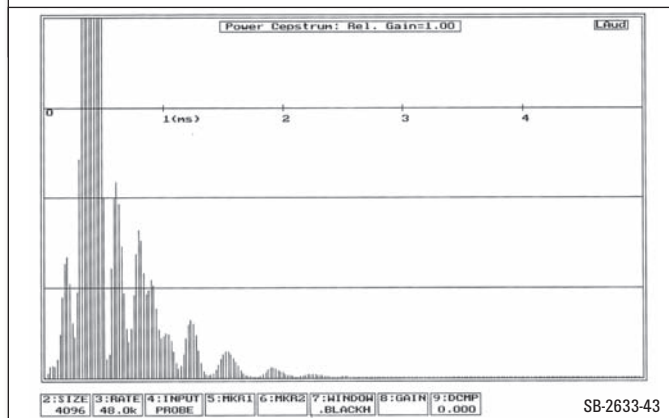


FIGURE 44: Acoustic responses of midrange and tweeter with crossover.

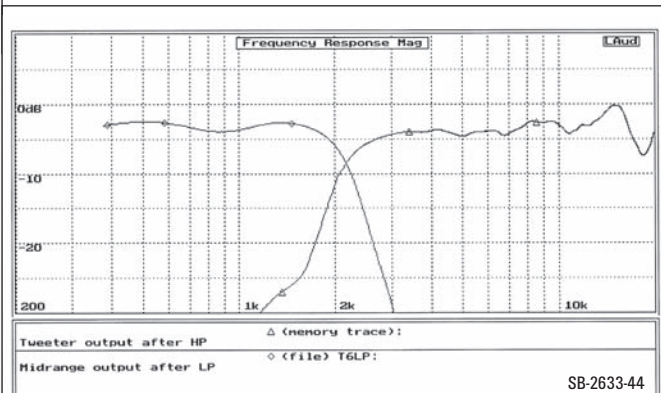


FIGURE 45: Measured response of two-way system on midrange's axis.

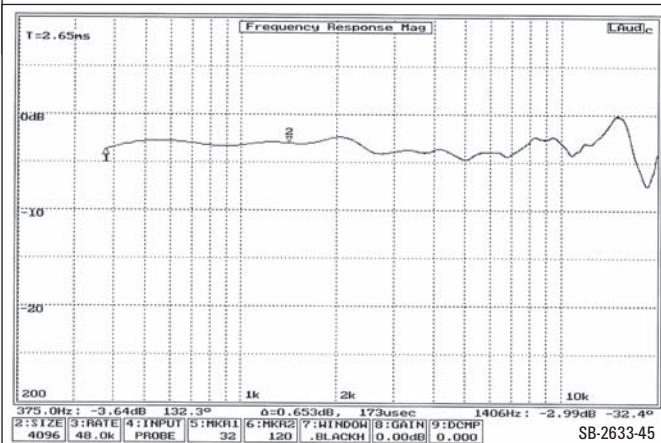
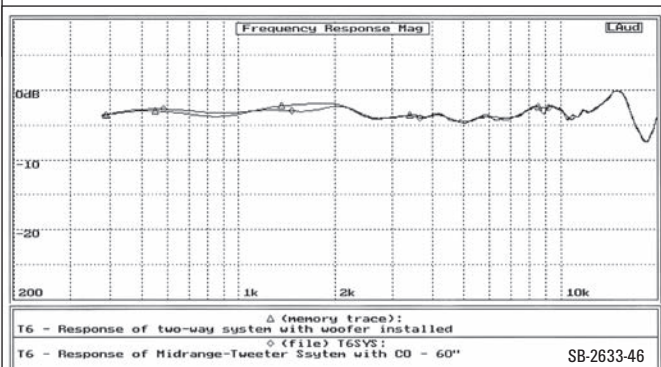


FIGURE 46: System response with and without woofer mounted.



54F woofer to examine its effect on the two-way system response. Due to limitations of my test baffle, I mounted the woofer rather close to the midrange at 7" CTC (**Photo 7**).

The testing is again at 60" on the midrange's axis. Note that this test does not match the typical construction of a three-way system in which the midrange is located in its own chamber. Here the midrange is exposed to the woofer on the backside of the baffle.

Figure 46 illustrates the system response with and without the woofer mounted, indicating some response change in both the midrange and tweeter portions of the frequency range. **Figure 47** is the error curve, and **Fig. 48** is an expanded view of the magnitude error. Changes of over 1dB are noted in the midrange region, while the tweeter region indicates numerous smaller magnitude errors.

The CRC plot (**Fig. 49**) indicates that the interference signal can become as high as about -17dB in the midrange frequencies. Remember that the midrange and woofer are mounted very close together. Throughout the tweeter range the inter-

ference signal stays below -20dB, generally closer to -30dB.

EFFECTS OF A FRONT PANEL PORT

In another personal communication, GLA reported an experience indicating that a front-panel-mounted port might have a destructive effect on the system response. I decided to investigate this on the two-way Terra tweeter-midbass system. Testing is again at 60" on the midrange's axis.

I examined two types of ports, both mounted 8" CTC below the midrange. The first is a typical port duct of 3" OD and 2.75" ID (**Photo 8**). The second is a 3" ID flared port (**Photo 9**).

Note the flare mounts on the surface of the baffle inset presenting a ridge of about 1/8" thickness. To meet baffle limitations,

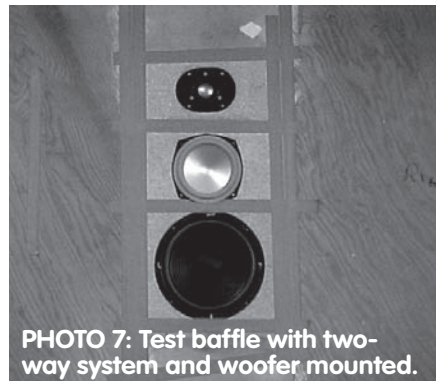
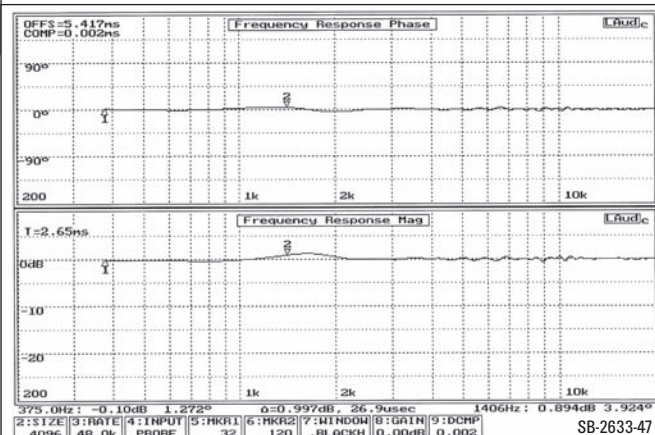


PHOTO 7: Test baffle with two-way system and woofer mounted.

FIGURE 47: System error curves for woofer mounted.



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both ports were just 3" long (they are not tuning anything) with a 1" thick plug of Owens-Corning #705 high-density fiberglass at the rear to prevent any sound leakage from behind the baffle. Testing was at 60" with the microphone on the midrange's axis.

Figure 50 contains the responses of the system without port and with each port type. Small response changes are caused over most of the frequency range. **Figure 51** illustrates the normalized error curves for the flared port added to the test baffle.

An expanded version of the magnitude error (**Fig. 52**) indicates about 0.7dB change in the midrange frequency range and much ripple in the tweeter frequency range. This is with the port center 14" below the tweeter center. In **Fig. 53** the flared port causes an interference signal near -20dB over the midrange and the bottom end of the tweeter range.

Figure 54 displays the normalized error curves for the port duct installed in the test baffle. The expanded magnitude plot (**Fig. 55**) exhibits effects of around ½dB over a good share of the frequency range. The CRC plot (**Fig. 56**) indicates that the port duct generates an interference signal not

much different from that of the flared port. Neither port type seems to have a major advantage, as both show response changes of less than 1dB, but over a large frequency range. Moving the port off the front panel is the obvious cure to this problem.

SUMMARY

This work illustrates the interference that various front-panel-mounted objects have on the response of drivers. It additionally shows how a quantitative value can be placed on this interference by plotting the magnitude of the interference signal.

You can conclude the following:

1. Never place a symmetrical structure in front of any driver or behind any open-back driver. This includes mounting drivers, especially the tweeter, so they are not equidistant from the box edges or the grille frame sections. It also means you must pay attention to the mounting hole and chamber behind any open-back driver, the driver cover-

PHOTO 8: Test baffle with two-way system and port duct mounted.

PHOTO 9: Test baffle with two-way system and flared port mounted.

ing the midrange frequencies being the most critical.

2. It is not just the closest portions of the box edges or grille structure that can cause trouble. You must worry about the entire front panel or grille frame affecting the tweeter's response.
3. Even with both drivers flush-mounted, the midrange of a three-way or the woofer of a two-way can cause a few dB ripple in the tweeter's response.
4. With flush-mounted drivers, very little effect was found on the response of a midrange driver caused by a nearby tweeter.

FIGURE 48: Expanded error magnitude for system with woofer mounted.

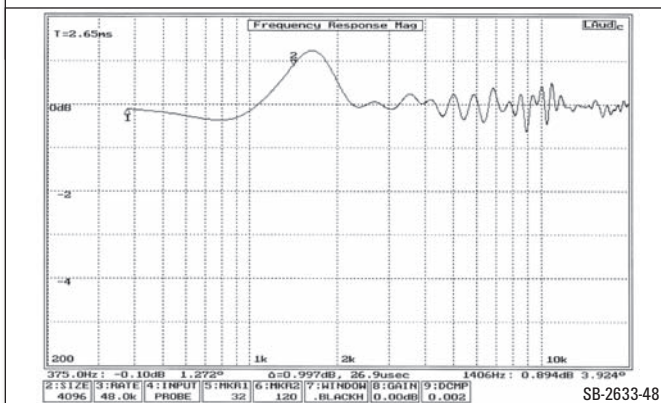


FIGURE 49: CRC plot for system with woofer mounted.

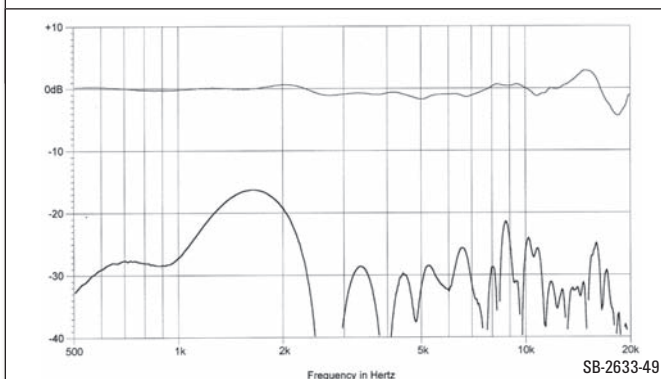


FIGURE 50: System responses with and without a port mounted.

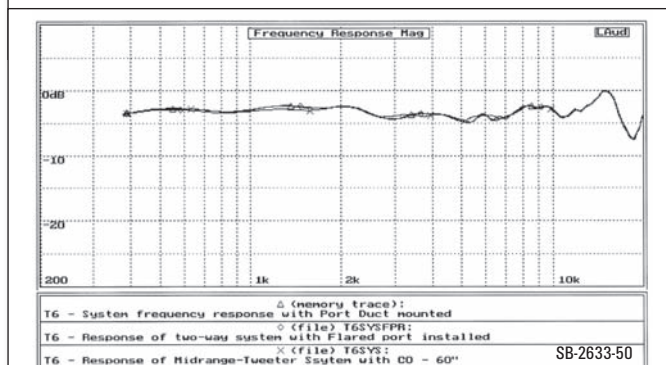
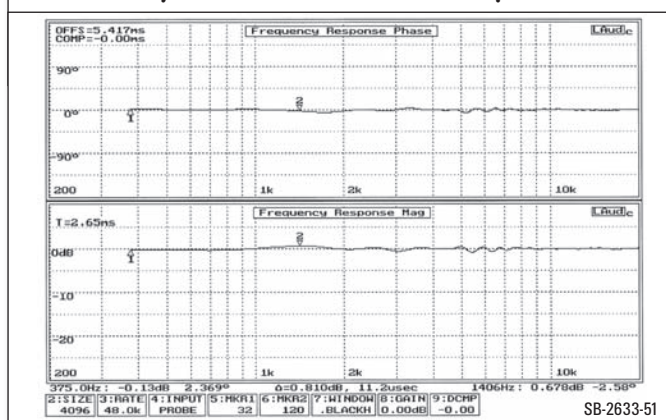


FIGURE 51: System error curves for flared port mounted.

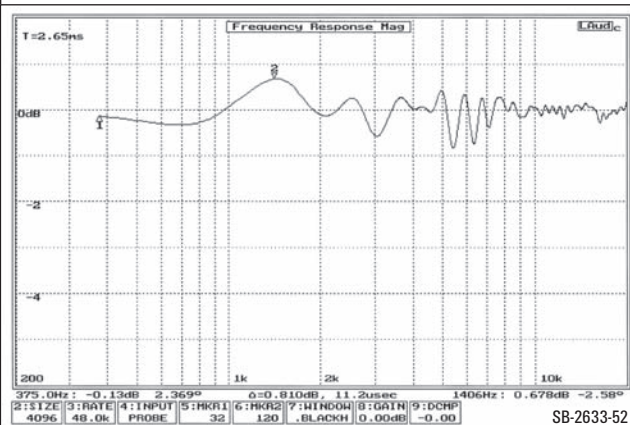


5. Bars of Owens-Corning #701 through #705 fiberglass material mounted between the midrange and tweeter were not effective in limiting their interaction. Good felt or certain foam materials may be effective, but were not tested here.
6. Mounting an open-back midrange can be critical in achieving its optimum response. Surface-mounting in a straight hole produced up to 3dB response variations. Again, Moriyasu's work⁵ is recommended.
7. Adding the woofer of a three-way system caused a response change of up to 1dB in the midrange frequency range and considerable smaller ripples throughout the tweeter frequency range. This test was with a very close mounting of the midrange

and woofer and with no wall between them. Even though the CTC distance between woofer and tweeter was 13", the woofer affected the tweeter's response.

8. Adding a front-panel-mounted port to a two-way system produced response changes of less than 1dB, but covering a good portion of the frequency range. No major difference was noted between a straight port duct and a flared port.

FIGURE 52: Expanded error magnitude for system with flared port mounted.



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In general, you can conclude that any structure added to the front panel might have a destructive effect on the response of the drivers covering the midrange and treble frequency ranges. With open-back drivers anything behind the driver may also cause destructive changes.

The other topic covered was how to develop and plot the composite reflection curve (CRC), which shows the relative magnitude of the interference signal generated by any interfering object. The process starts by measuring the driver response without the interference. Then you generate a normalized error curve for the change produced by the interfering object.

These error curves may seem new to you, but they really aren't. I'm sure everyone has seen plots in speaker test reports of the system response change when the grille is installed. These "difference" curves are simply the error magnitude curves for installing the grille on an "ideal" system. I have seen some grille error curves that were a bit scary⁶.

Here the grille raised the on-axis system response by 1.5 to 2.5dB over the mid-

range frequency range and added several dB of ripple at high frequency. If the grille is not modifying the drivers' acoustic loading, the grille apparently radiates a good portion of the on-axis midband response.

Having the bare driver response and the error curve exported as data files allows you to develop a simple computer program to compute and plot the CRC. This curve indicates the level of the interference signal relative to the bare driver response, and generally has a bandpass shape covering the midrange frequency region where the most response destruction occurs. Less destruction is generally caused in the low- and high-frequency regions. I believe the CRC plot adds new insight into the topic of interference from reflection and diffraction.

While all the work reported in this article involved only on-axis testing, the technique is applicable to off-axis testing. Perhaps some day speaker test reports will show families of interference curves versus listening angles for installation of grilles, much as they do now for system horizontal and vertical directivity. This would cer-

tainly help people to position their speakers if they intend to listen with the grilles installed. *aX*

ACKNOWLEDGMENTS

I would like to thank both George Augspurger and David Weems for concepts and recommendations made during the course of this investigation.

SOURCES

Dayton drivers are available from: Parts Express, 725 Pleasant Valley Dr., Springboro, OH 45066-1158, 937-743-3000, www.parts-express.com.

Terra drivers are available from: CAMM, Inc., PO Box 661, Sabattus, ME 04280, 207-375-4236, www.terraspeakers.com

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5. Jim Moriyasu, "A Study of Midrange Enclosures," *Speaker Builder* 7/2000 and 8/2000.
6. Joe D'Appolito, "Testing the Parts Express MTM Kit," *audioXpress* 4/05, Fig. 12, p. 61.

FIGURE 53: CRC plot for system with flared port mounted.

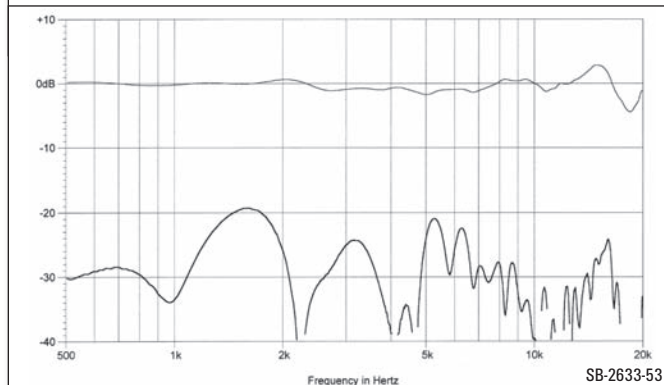


FIGURE 54: System error curves for port duct mounted.

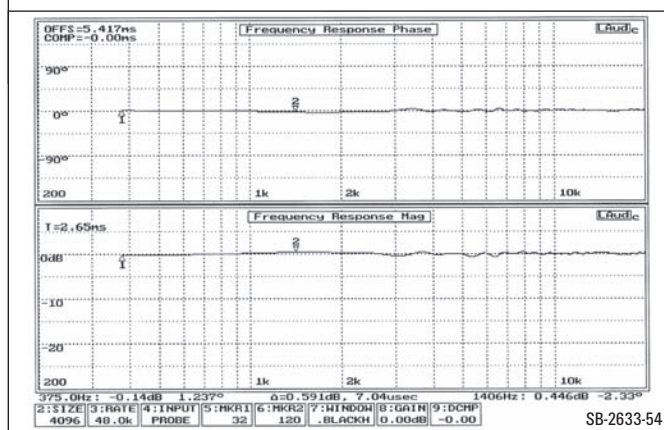


FIGURE 55: Expanded error magnitude for system with port duct mounted.

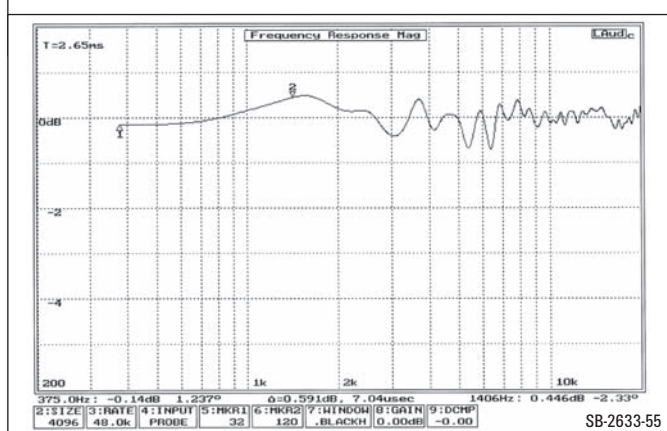


FIGURE 56: CRC plot for system with port duct mounted.

