

Dayton Audio WT3 Woofer Tester

The Dayton Audio WT3 Woofer Tester is available from Parts Express, 725 Pleasant Valley Drive, Springboro, OH 45066-1158. The catalog price is \$99.88¹. See daytonaudio.com and parts-express.com. No serial number was found on the units.

INTRODUCTION (BY GRK)

When I agreed to do an equipment review on the WT3, I recalled that many times coauthor Bob Wright had purchased a WT3, so we agreed to do the review together. Bob has considerable experience in measuring V_{as} via the added-mass method and will concentrate on that topic. This gives results from two WT3 units and two users—a more balanced review because I tend to be a nit-picker.

HISTORY

The “Woofer Tester” name has been applied to several earlier and current devices. In 1994 Dickason² reviewed one sold by C&S Audio Labs (Model DSP-126), and in 1997 Weems³ reviewed a revised version (Version 4.4) sold by Parts Express. These AC powered devices both used DOS-based software. Currently a variety of devices with this name, having additional options and higher cost, are available.

WHAT YOU GET (BY GRK)

The WT3 arrives in a box about the size used for handheld DVMs. Inside are the WT3 tester, a calibration resistor, the software CD, and an instruction sheet covering how to get started. The WT3 itself is a rather small unit with built-in cables (Photo 1). The computer side has a 4' cable with a USB connector, while the test side is a short pair of red and black wires with alligator clips. The WT3 is self-powered via the USB cable with a blue LED indicating power on.

There were four files on the CD:

1. License.Txt—The licensing agreement stating what you can and cannot do with

the software.

2. Readme.Txt—Tells where to get updates and current information. An item I found confusing is this document lists the operating system requirement as Windows 98SE, while other places list Windows 98. If running early Windows 98, you should check with Parts Express before ordering.

3. WT3 Quick Start.Pdf—A copy of the two pages on “Quick Start for the WT3 Woofer Tester” that you can view with

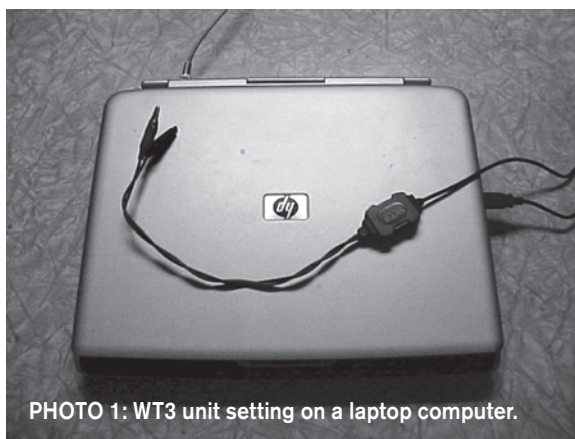


PHOTO 1: WT3 unit setting on a laptop computer.

Adobe software.

4. WT3_setup.Exe—The program that contains and installs the WT3 software.

SYSTEM REQUIREMENTS

To operate the WT3 you need an IBM PC or compatible computer with the following characteristics:

1. 64MB memory RAM or more.
2. 500MHz Pentium III processor or higher.
3. A USB port, USB 2.0/1.1 compliant.
4. MS Windows 98(SE), Me, NT, 2000, XP, or Vista.

GRK operated the WT3 from an HP Pavilion zv6000 laptop computer, 1.99GHz processor, 512MB of RAM, and MS Windows XP Home Edition version 2002. ROW's computer is a custom-built 64-bit CAD/graphics computer using MS Windows XP as an operating system.

WHAT WILL IT DO?

While you may use the WT3 to measure impedance of any passive electrical circuit, we are interested in its application

to speaker work. The WT3 directly measures the input impedance of a driver or a speaker system. With the WT3 you may do the following:

1. Directly measure the f_s and Q_s of a driver.
2. Directly measure the driver V_{as} by any of three techniques.
3. Directly measure inductors of the size used in crossover work.
4. Develop driver zobel and other impedance correction networks for crossover design.
5. Help tune a vented-box design by locating the impedance minimum

frequency which approximates the box tuned frequency.

6. With the proper modeling or previous-test results, you can verify the proper wiring of crossover networks.

7. With additional software you can calculate how severely a speaker system stresses an amplifier.

8. With simple software you can predict the bass response curve for a closed-box speaker system.

9. With additional software you can design all the standard bass enclosure formats.

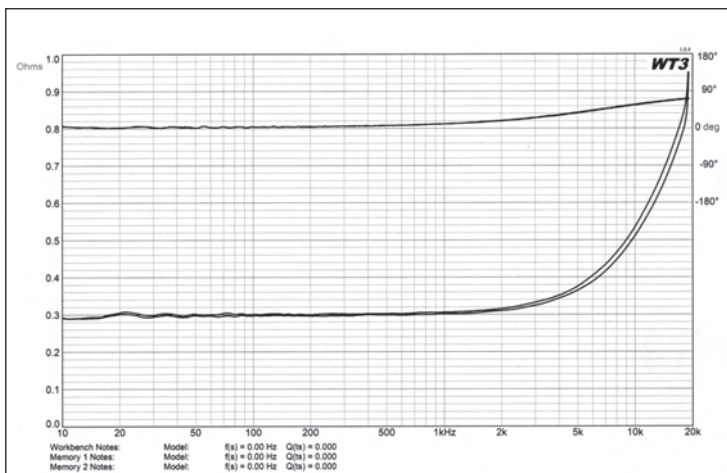


FIGURE 1: Test Lead Calibration with and without leads twisted.

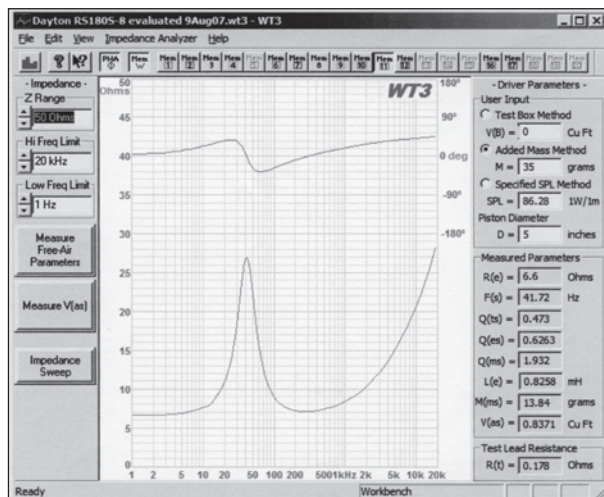


FIGURE 2: WT3 main screen.

GETTING STARTED (BY GRK)

The "Quick Start..." instructions tell you how to install the WT3 program and get the unit running. For me installation went without a problem. Once installation is accomplished, you do two calibration procedures, as noted in the instructions. This calibrates the WT3 with a precision 1k Ω resistor and establishes the resistance of the test leads.

When running the test lead calibration, I noted that the plotted lead "resistance" showed a rising magnitude above 2kHz. The rising phase shift indicates this is due to inductance, which is related to loop area, so I repeated the calibration with the two leads mildly twisted together. **Figure 1** shows that this helps slightly, and for the following testing I kept the leads twisted.

OPTIONS (BY GRK)

When I first started the WT3, I did not like the dark background on the plots (a nit-pick). It made the curves hard to see. After viewing the information in the help section, I found I could change the plot background color. The program has many options of what you can display and print, and it is recommended you study the help files once you have finished your initial playing! The program will print the help information, so I did this for off-line study.

Figure 2 shows the very busy main screen for the WT3 software. It is in color, which helps a lot. You need some study of the help information to really understand program operation. Once you have learned how, the operation is simple

and straightforward.

The program has multiple file options as follows:

1. It will save and recall project files that save what you have committed to the 20 available memories. This allows retrieval of information from saved testing should some question arise.
2. It will save and recall impedance curves to/from export files. It offers the option

of files with the extension of .TXT or .ZMA. These are both text files and look identical. Unfortunately, the .ZMA files do not match the original format developed by Liberty Instruments for the IMP tester. While certain software may properly read the WT3 .ZMA files, the post-processing programs I had written would not. They objected to the long text header before the actual data. If you have this

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CUSTOM WORK

problem, you can use a text editor to put the WT3 .ZMA files into a format your software can read. The quickest solution was for me to write a filter program that takes in the WT3 .ZMA file and writes it out in the classic format of a Liberty Instruments' .ZMA file.

3. It will save and recall driver files (extension .DVR) that are common with the format used by the WinSpeakerz program.

The one missing file option seems to be the ability to output the graphs to files as pictures. This would be useful when using the WT3 to prepare material for publication, such as this review.

The program also offers several options relative to the printed output. You should check the options under both the File -> Print Setup... and the Edit -> Preferences menus.

REPEATABILITY (BY GRK)

One of my first applications for the WT3 was to measure the impedance of a baffle mounted woofer several times. The results for ten tries are shown in **Table 1**.

I think this repeatability is very good. I no longer beat the box design out to several decimal places because the parameters will vary with temperature and humidity, and so on, and the box response changes slowly with minor parameter changes. The WT3 is so quick you should run the free-air test on a driver a few times to verify that the parameters you are going to use for the V_{as} extraction are a typical set.

COMPARISON WITH LIBERTY INSTRUMENTS' AUDIOSUITE (BY GRK)

In an attempt to determine the accuracy of the WT3, I free-air tested the three drivers in **Table 2** with both the WT3 and Audiosuite. **Figure 3** shows the comparison results for the woofer mounted on a small baffle. The two curves match extremely well; only near the resonance and around 20kHz can you identify that there are two curves on the plot. The same comparison is shown for the mid/bass driver in **Fig. 4** with, again, a near perfect match. **Figure 5** is the comparison for the tweeter also showing very good agreement. The slight differences seen

at high frequency may be due in part to the WT3's lead inductance as discussed earlier.

I had both units compute the driver T/S parameters. Only the woofer had V_{as} extracted via the closed-box method. **Table 3** compares the test results obtained with the catalog⁴ data.

The two measurement systems show reasonable agreement with each other but not always with the catalog data. With two different test instruments some variation is to be expected. For the woofer, either measured set of parameters should result in a reasonable enclosure design. It might not be the same size as one based on the catalog data.

For the mid/bass and tweeter the measured data is in better agreement with the catalog data. These drivers were all new and had no break-in. My experience is modern drivers don't change as much with break-in as we saw in the past.

The WT3 allows you to extract the driver V_{as} the "easy way," by specifying the driver SPL in dB/W/M. This technique must be used very carefully. First, some manufacturers will specify the SPL in dB/2.83V/M. If your driver is truly 8Ω , then the two specifications are the same, because 2.83V RMS will put 1W into an 8Ω load. If the driver is other than 8Ω , you must correct the dB/2.83V/M rating according to the following:

$$\text{dB/W/M} = \text{dB/2.83V/M} + 10 * \log_{10}(R_n/8) \text{—where } R_n \text{ is the nominal driver impedance}$$

TABLE 1: MEASUREMENT OF REPEATABILITY OF THE WT3

Try	R_b	f_s	Q_{ms}	Q_{es}	Q_{ts}	L_b
1	5.95	49.8	1.66	0.62	0.45	0.59
2	5.96	49.8	1.66	0.62	0.45	0.59
3	5.98	49.8	1.66	0.63	0.46	0.59
4	5.93	49.8	1.66	0.62	0.45	0.59
5	5.95	49.8	1.66	0.62	0.45	0.59
6	5.98	49.8	1.66	0.62	0.45	0.59
7	5.96	49.1	1.63	0.62	0.45	0.59
8	5.97	49.1	1.64	0.62	0.45	0.59
9	5.96	49.8	1.65	0.62	0.45	0.59
10	5.95	49.8	1.65	0.62	0.45	0.59

TABLE 2: THREE TEST DRIVERS USED BY GRK (ALL NEW WITH NO BREAK-IN)

Woofer	Vifa* P17WJ00-08 6½"
Mid/Bass	Vifa* MG10SD09-08 4"
Tweeter	Vifa* XT25TG30-04 1" dual concentric ring

*Note: Tympany Peerless now calls these V-Line drivers

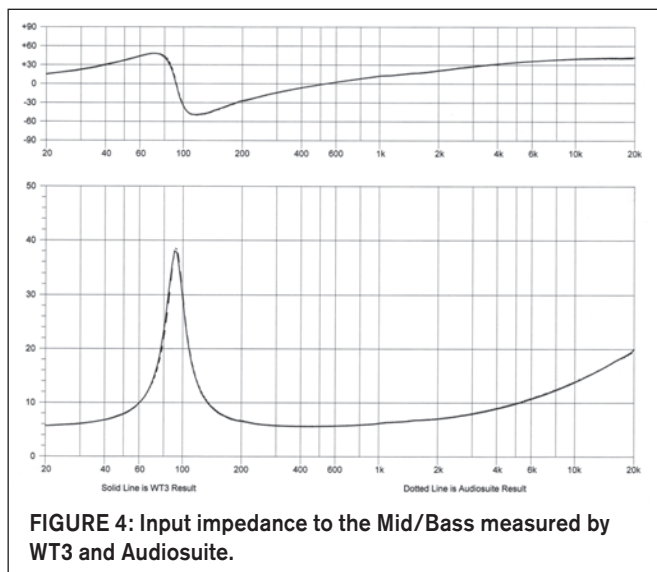
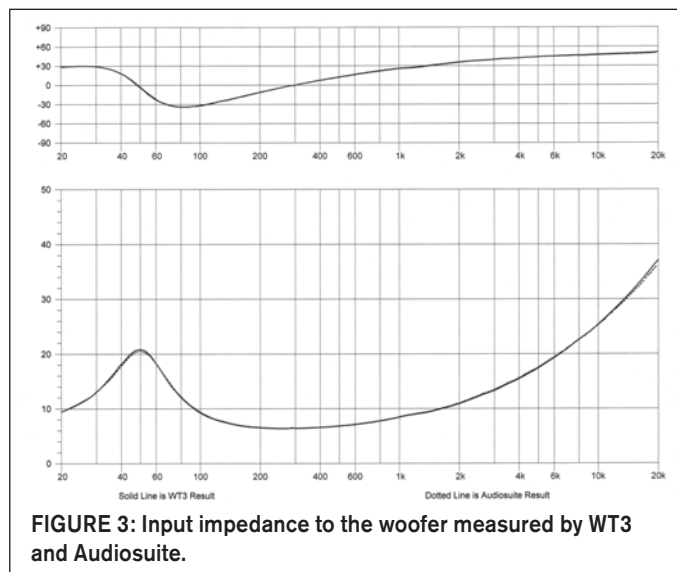


TABLE 3: COMPARISON OF WT3 AND AUDIOSUITE RESULTS

	6½" Woofer			4" Mid/Bass			Tweeter			
	WT3	AuSw	Cat.	WT3	AuSw	Cat.	WT3	AuSw	Cat.	Units
R_e	6.01	5.97	5.8	5.42	5.23	5.5	2.93	3.08	3.0	Ohms
f_s	49.8	48.6	37	91.5	92.0	81	513	513	500	Hz
Q_{ms}	1.56	1.40	1.55	5.34	5.22	3.40	2.84	2.74	2.5	
Q_{es}	0.61	0.57	0.45	0.88	0.82	0.73	0.62	0.63	0.71	
Q_{ts}	0.45	0.41	0.35	0.76	0.71	0.60	0.51	0.51	0.55	
V_{as}	0.45	0.43	1.23			0.09				Cu. Ft.
L_e	0.59		0.55	0.22		0.33				mH
SPL	85.8	85.7	88			85			88.5	dB/W/M

For example, a 4Ω driver with a 91dB/2.83V/M SPL would add 10 * Log₁₀(0.5) or -3dB yielding SPL = 88dB/W/M. This makes sense because 2.83V RMS would deliver 2W to 4Ω, which is 3dB higher than 1W.

I had the WT3 extract the V_{as} in cubic feet for the woofer and mid/bass drivers based on the catalog SPL (Table 4). The value for the woofer does not agree well with the closed-box measured value of 0.43-0.45 or the catalog value of 1.23. The mid/bass result of 0.079 is much closer to the catalog value of 0.09ft³. If the free-air f_s and Q_s reported by WT3 agree well with the catalog values, then this technique is probably safe. If those values do not agree with catalog data, then I would not use the SPL approach to predict V_{as} . If the catalog f_s and Q_s agree with your driver, then you might just as well use the catalog V_{as} value.

TABLE 4: V_{AS} EXTRACTION BASED ON SPL

Driver	SPL	V_{as} - Cu. Ft.
Woofer	88	0.74
Mid/Bass	85	0.079

MEASUREMENT OF DRIVER V_{AS} VIA THE ADDED-MASS TECHNIQUE (BY ROW)

In the WT3 program under "Driver Parameters," the second of three methods provided for in the program for determining the driver characteristics is named the "Added Mass Method." This method uses two physical parameters to generate the basic outputs of the program. These are (1) the effective piston diameter designated "D" in the program input and (2) the added mass designated "M" in the program input. The speakers used in this test were not "broken in." It has been

my experience that the T/S values do not change significantly under these conditions.

It is very important to get a very accurate effective or active cone diameter and/or equivalent cone diameter. It is generally accepted that the mean piston diameter includes one-half of the speaker surround. This measurement must be done as accurately as possible, because the area of the driver cone is a "power" function in the WT3 program. Any inaccurate input to the program will make a more than proportionate difference in the results gener-

ated. Figures 6-8 give real and equivalent mean diameters of the most common driver cone shapes found on the market today.

The mass to be added to the speaker cone must be weighed very accurately to obtain good results. It, too, is a "power" function in the WT3 program equation and must be done quite accurately.

When I was searching for a suitable added mass for the driver, I found that "poster caulk" obtainable at any office supply store turned out to be an ideal choice. It is low-cost, easily obtainable, does not stick to the driver cone, and stores well in a sealed container. The required added mass is almost always 200 grams or less (1 gram = 0.035274 ounces).

To accurately weigh the added mass, I found in my research that there are scales on the open market referred to as "pocket scales" that have a weighing capacity of 0 to approximately 200 or 400 grams and are accurate to within 0.1 grams (0.1 gram = 0.00022046 pounds). This accuracy is excellent for driver measurement work. The cost of these scales is approximately \$25.

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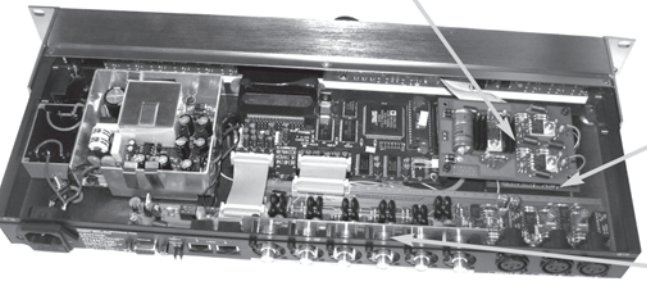


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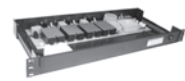
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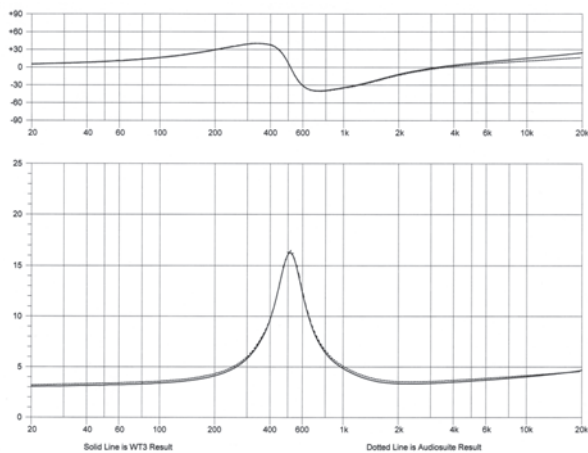
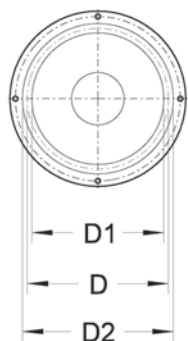


FIGURE 5: Input impedance to the tweeter measured by WT3 and Audiosuite.



Piston Diameter >>>
 $D = 0.5 (D2 + D1)$

FIGURE 6: Effective piston diameter calculation for a circular driver.

WT3 program. The program will analyze the amount of weight added to the cone and determine whether it is adequate to properly calculate the driver parameters

When executing this method shape the poster caulk into a “donut” and apply it to the driver cone. This allows the added mass weight to be evenly spread over the surface of the cone, emulating a balanced cone. The amount of weight to be added is determined by the WT3 program itself. However, there are some suggestions in the help file of the

and, when necessary, instruct the user as to what remedial action should be taken. When all of the input parameters have been satisfied, the program will produce a driver parameter datasheet.

The drivers selected for testing were two 8” woofers and two 6½” woofers. Based on a recommendation by George Augspurger, we tested each woofer with three different values of test weight, then averaged the V_{as} values. The results of these tests are listed in Table 5.

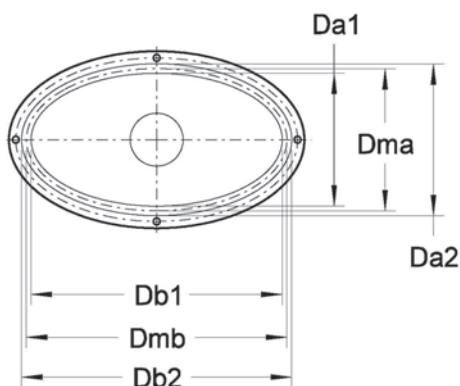
In the 6½” unit 1 of the woofer testing, the V_{as} variations from three different test weight values were 0.958 (44.4g), 0.901 (59.5g), and 0.808 (74.7g), with the average = 0.889 the others are not listed.

ZOBEL AND OTHER COMPENSATION NETWORK DEVELOPMENT (BY GRK)

The WT3 is ideal for developing zobel

TABLE 5: RESULTS FOR DAYTON DC160S-8 6½” WOOFER AND DAYTON DC200-8” WOOFER

	6½”		Catalog	8”		Catalog	Units
	Unit 1	Unit 2	Data	Unit 1	Unit 2	Data	
f_s	31.6	31.6	33	31.6	30.3	29	Hz
Q_{ms}	2.04	2.28	3.89	2.23	1.93	3.23	
Q_{bs}	0.34	0.33	0.34	0.53	0.47	0.44	
Q_{ts}	0.29	0.29	0.32	0.43	0.38	0.38	
V_{as}	0.89	0.92	0.78	1.28	1.31	2.04	Cu. Ft.
L_e	1.54	1.49	2.40	2.08	1.86	1.60	mH
SPL	86.0	86.0	87	84.9	84.9	88	dB/W/M



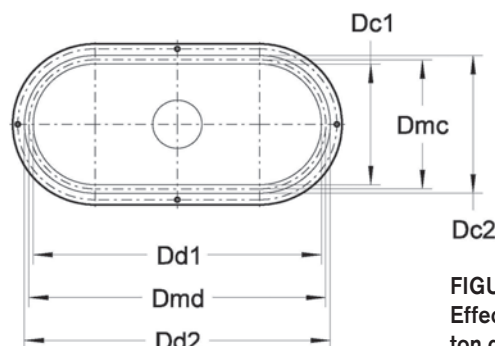
$$Dma = (Da1 + Da2) / 2$$

$$Dmb = (Db1 + Db2) / 2$$

Piston Diameter (Effective) >>>

$$D = \sqrt{Dma \times Dmb}$$

FIGURE 7: Effective piston diameter calculation for ellipsoidal driver.



$$Dmc = (Dc1 + Dc2) / 2$$

$$Dmd = (Dd1 + Dd2) / 2$$

$$A1 = (Dmd \times Dmc) - Dmc^2$$

$$A2 = 3.1416 (Dmc / 2)^2$$

$$A3 = A1 + A2$$

Piston Diameter (Effective) >>>

$$D = \sqrt{4 \times A3 / 3.1416}$$

FIGURE 8: Effective piston diameter calculation for rounded parallelogram driver.

and other impedance compensating networks. **Figure 9** shows the free-air impedance into the test woofer with and without a simple R-C zobel as printed by the WT3. It is easy to play with the zobel values and have the WT3 retest because of its speed.

Last summer I was developing a system using a first-order crossover with a tweeter having a very high impedance peak at resonance. This was causing trouble with the low slope of the first-order high-pass network. **Figure 10** shows the bare tweeter impedance and the impedance with a zobel and series L-R-C network across the tweeter to tame the resonance peak. Note that not only do these networks improve the magnitude, but they also improve the phase angle.

My experience is that correcting such

effects by networks shunted across the driver results in a better-sounding system than doing it with networks placed in series with the driver. My rule for crossover design is to keep the number of components in series with the driver to a minimum. The WT3 is ideal for the development of such shunt networks.

A corollary application of the WT3 is in verifying that you have connected the components in a crossover correctly. If you know, from previously testing or modeling, what the impedance into the crossover should be, then the WT3 can quickly verify you are still showing that impedance.

Last summer I was simultaneously working with three pairs of breadboard three-way crossovers. This involved making changes in them and trying them

on speaker systems. The WT3 would have been ideal in verifying I had the pairs wired the same and that I had not mistakenly connected the woofers where the tweeter should have gone. Using the WT3 would have been a lot safer than firing up the system to verify everything was properly connected.

AMPLIFIER PEAK STRESS LOADING (BY GRK)

Howard⁵ and others have investigated how severe a speaker system is in terms of the peak dissipation it causes inside the amplifier at each frequency. If you have WT3 measure and export the input impedance to a speaker system, you can investigate this effect. **Figure 11** shows the input impedance into a three-way, five-driver system as measured by the WT3.

Using the techniques of Howard, **Fig. 12** shows the Peak Amplifier Stress Ratio and the EPDR for this system. The Peak Amplifier Stress Ratio shows the peak amplifier dissipation versus frequency relative to driving a resistor equal to the system's nominal impedance, which is 4 Ω in this case. Around 2kHz the peak stress

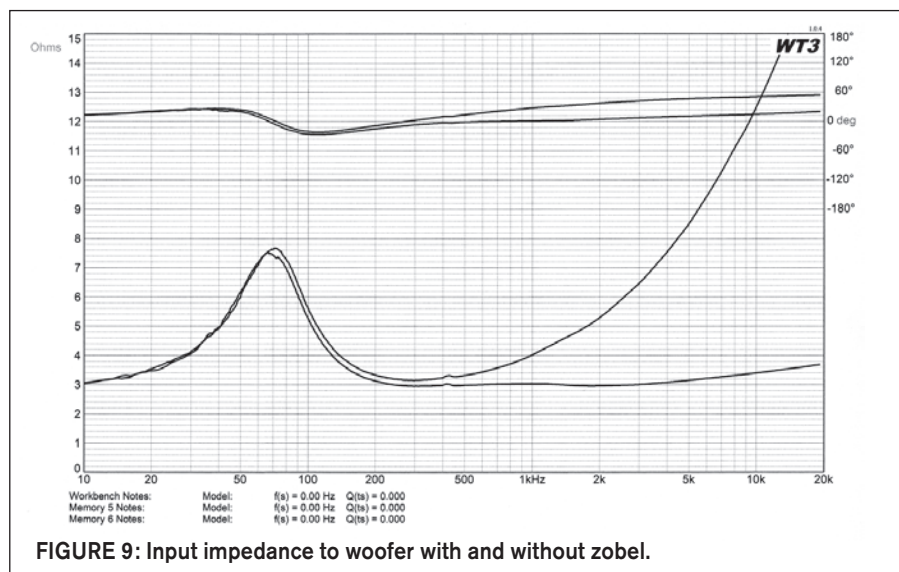


FIGURE 9: Input impedance to woofer with and without zobel.

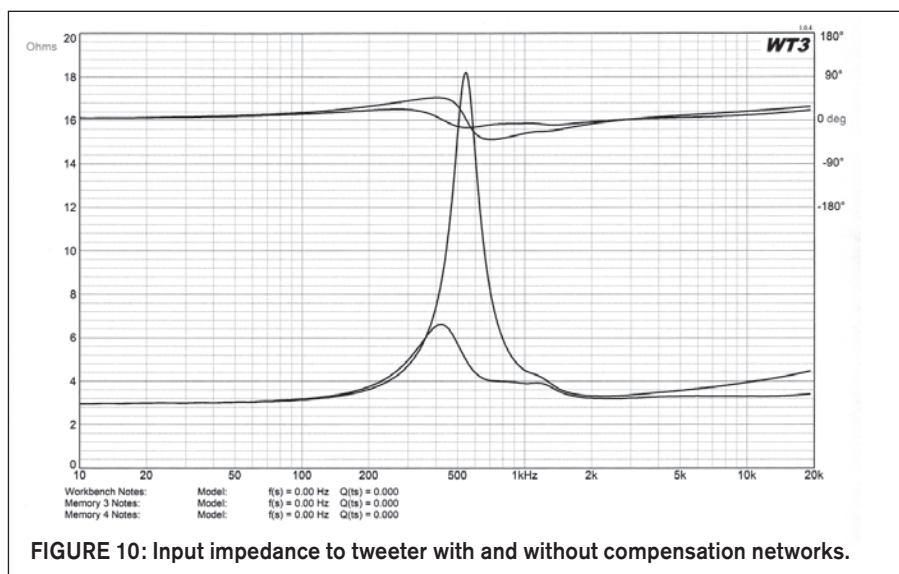


FIGURE 10: Input impedance to tweeter with and without compensation networks.

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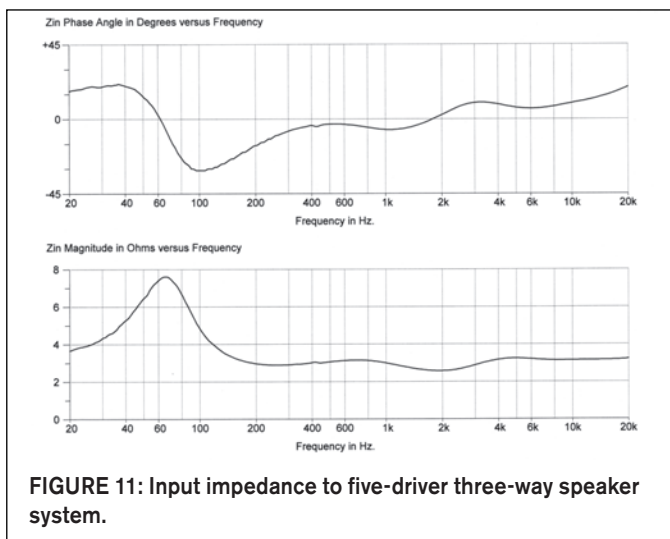


FIGURE 11: Input impedance to five-driver three-way speaker system.

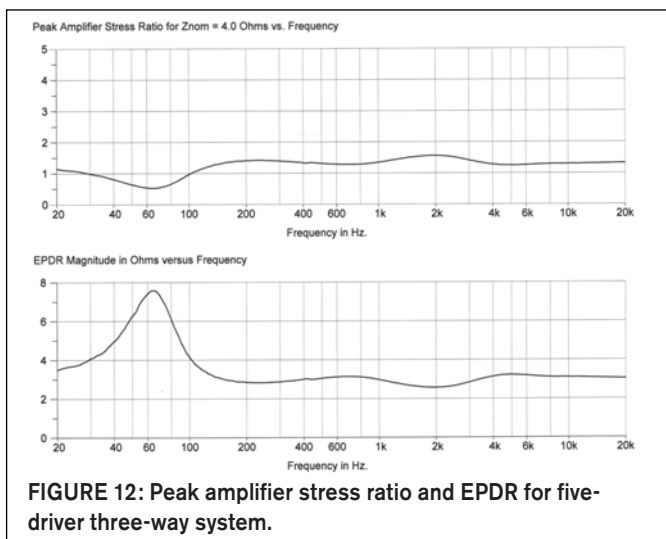


FIGURE 12: Peak amplifier stress ratio and EPDR for five-driver three-way system.

is 1.5 times what the amplifier would see driving a 4Ω resistor. The EPDR is the Equivalent Peak Dissipation Resistance and is the value of a resistive load that would produce the same peak amplifier dissipation at each frequency as does your speaker system.

What these plots show is that this system is really a 3Ω load and is relatively benign in terms of amplifier peak dissipation. Systems that have low impedance

magnitudes at the same time they have large phase angles can be a severe load on an amplifier causing it to have a peak stress much higher than you would normally expect. This is one more area that the WT3 allows you to investigate.

PREDICTING CLOSED-BOX BASS RESPONSE (BY GRK)

The WT3 will allow you to predict the bass response of an existing closed-box system. It is best if you can get directly at the bare terminals of the woofer, but you can try it through the crossover network if that is your only option. You simply have the WT3 measure the woofer in box impedance via the “Measure Free-Air Parameters” button. The value it reports for f_s is the closed-box f_c , and the reported Q_{ts} is really Q_{tc} . Now if the closed-box system is nearly lossless, it will have the response of a second-order high-pass with f_c and Q_{tc} . A lossless closed-box is one with no stuffing and no built-in air leaks (aperiodic vent, and so on).

We used the WT3 to measure the 6½” woofer in a 0.299ft³ closed box, reporting $f_c = 74.69$ and $Q_{tc} = 0.7388$, and then fed these values to a program that plots the second-order high-pass response (Fig. 13). This response predicts an f_3 of about 72Hz. Audiosuite measured the response of the box at low frequency via the near-field technique. The result in Fig. 14 predicts f_3 is about 74Hz. This is a useful technique, but keep in mind it is only an approximation. It can lose accuracy if the crossover is involved or the box is stuffed. If you are interested in the effect of the coil resistance in series with the woofer, you should substitute a matching

resistance rather than test through the crossover.

While this technique is relatively safe to use on woofers, I do not recommend it for subwoofer drivers in a closed box. I have found some subwoofer drivers have a peaking built into their response which this technique will not predict.

MEASURING INDUCTANCE (BY GRK)

If you connect an inductor to the WT3, it will report the inductance in mH in the L(e) box. I decided to give this a try with some inductors measured initially with a B&K-Precision 878 LCR meter. Table 6 shows the results in mH for measurement at 1kHz. The technique shows reasonable results for the larger inductors, but should be viewed with some suspicion for smaller inductances. If you have no other inductance measurement technique, it will at least put you in the ballpark.

TABLE 6: INDUCTANCE MEASUREMENT VALUE IN MH

Inductor	B&K	WT3
Air Core	0.181	0.163
Ferrite bobbin core—small	0.341	0.320
Ferrite bobbin core—large	1.054	1.031
Laminated iron core—large	1.016	0.994

NIT-PICKS (BY GRK)

I noted a couple of items in the software (version 1.0.4) and help information that I think should be changed in any future revision.

1. When I clicked the Help button on the Driver Editing Screen, I received an error message stating that help did not

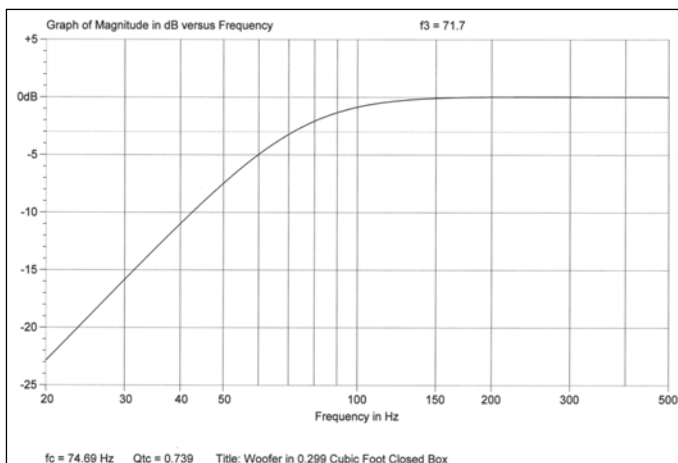


FIGURE 13: Predicted response of woofer in closed box.

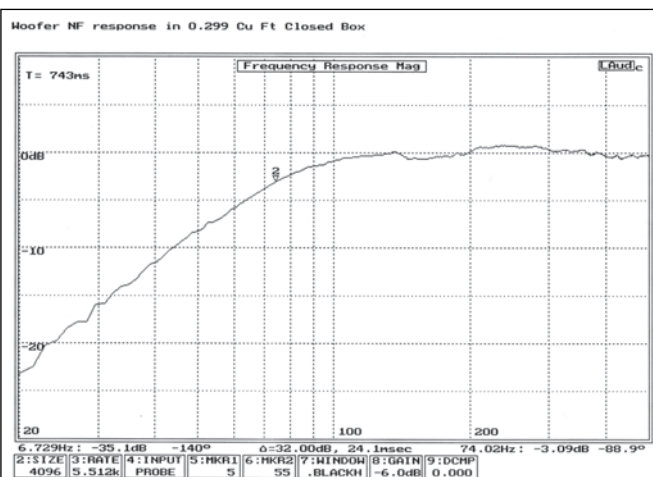


FIGURE 14: Measured response of woofer in closed box.

load, instead of giving me the help I really needed at that time.

2. When you elect to print in B&W, as you do for publication figures, I noted that on the Print Preview and on the print "Ohms" and "0 Deg" were still in color.

3. The help information indicates you can attach individual text notes to each of the 20 memories, but I could never discover how to do this. Probably a misunderstanding on my part.

4. I am at a loss to understand why a passive network impedance measuring devices plots phase over $\pm 180^\circ$. Any passive network that goes past 90° is displaying a negative resistance. Plot limits of $\pm 90^\circ$ would improve readability.

PROTECTION OF THE WT3 (BY GRK)

The instructions warn that you must never connect the WT3 to a driver that is connected to anything else. I don't know how much protection is built into the WT3, but just a bare woofer can be dangerous. You should be careful not to hit or push the cone of a large driver when the WT3 is connected because such drivers can put out a reasonable energy spike if the cone is moved rapidly. For safety I adapted the habit of disconnecting the WT3 as soon as measurements were done or when mounting a baffle mounted driver onto the test box. A bad case might be slamming the trunk lid on a woofer using the trunk volume with the WT3 connected.

SUMMARY (BY GRK)

The WT3 is a very fast and capable im-

pedance measurement instrument which has a lot of flexibility that is very handy in speaker work. It showed good accuracy and repeatability on drivers, but a little less accuracy on inductors. To me a main advantage is its small size offering great portability when used with a laptop computer. For my work it is a must have. Now I must contact Parts Express to see whom I pay to keep the evaluation sample!

SUMMARY (BY ROW)

I found the software easy to install and easy to use. The "Help" file was adequate and informative and gave the tester many excellent procedures in speaker testing. One attribute that would be a nice addition would be the ability to export data to one of the common graphic file formats such as a PDF, PNG, JPEG, TIFF, and/or DOC files. All in all, I believe the WT3 is an excellent buy for the amateur speaker builder who wishes to build his/her own speakers. *ax*

REFERENCES

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2. Dickason, Vance, "The Woofer Tester," *Speaker Builder*, 5/94, p. 56.
3. Weems, David, "The Woofer Tester," *Speaker Builder*, 5/97, p. 44.
4. Madisound catalog May 2006.
5. Howard, Keith, "Heavy Load," *Stereophile*, Vol. 30 No. 7, July 2007, p. 51.

Manufacturer's Response:

Thank you to *audioXpress* and to authors Koonce and Wright for a detailed review of the WT3 Woofer Tester. Evaluating a highly technical product such as this

is no small task. Fortunately the authors were up to the job and produced an informative review of the WT3 without getting bogged down in technical minutia.

First, I would like to note that the software version reviewed here is V 1.0.4. As of 12 May '08, version 1.1.0 began shipping and this upgrade has already addressed two of the issues raised in the review. In particular, inductance measure-

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ment accuracy has been improved and the Notes field has been duplicated at the main screen to facilitate notes entry and visibility. The software upgrade is available to all WT3 users as a software patch file which can be downloaded at www.daytonaudio.com/wt3updates.html.

In the section on measuring inductance the reviewer raises a concern about the accuracy of inductance measurements at low values. Indeed using WT3 with V1.0.4 software the reviewer measured .163mH for a small air core inductor where the reference system measured .181mH—a difference of 10%. Fortunately, accuracy for small inductor measurements was specifically addressed and improved with the V1.1.0 software release. Users should notice significantly improved accuracy on small inductor measurements with the new software release. On a recheck using the new V1.1.0 software the reviewers would likely find that the WT3 measures the small air core inductor more accurately.

In his nit-picks section GRK reports that the Help button at the Driver Editor window failed to open the Help system. This problem is acknowledged and will

be addressed in a future software update. Likewise the appearance of certain labels in color when printing in B&W will be addressed in a future release. Thanks to GRK for identifying these issues.

The reviewer reports that he could not find a way to attach notes to each of the memories. While V1.0.4 did allow you to keep notes with each memory you had to enter your notes at the Driver Editor General Information page which was somewhat out of the way. In V1.1.0 a duplicate Notes field has been added immediately below the Plot window to make it easier to write notes on each measurement. Notes from older projects that were previously entered at the Driver Editor now appear both below the plot window and at the Driver Editor.

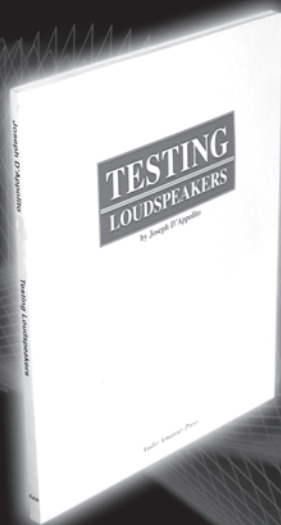
The plot limits of $\pm 180^\circ$ may be wider than strictly necessary but an enlarged view of the phase response is available by clicking the Phase button on the Toolbar. This rotates the phase display among three different modes. First is the reduced display mode at the top of the screen as seen in the WT3 screen shot in **Fig. 2**. Clicking the Phase button once shifts the phase

display to center screen and enlarges it. Clicking the Phase button again hides the phase display. Another click and the small phase response plot is restored at the top of the screen. Based on GRK's comments I may evaluate a change to 90° limits.

I wish the reviewers had also compared the two measurement systems with a few precision resistors as this would have revealed the very high accuracy of the WT3 using readily available 1% and even 0.1% tolerance resistors. Although the unit ships with a 1% 1k Ω resistor for calibration I find that if I calibrate my own units with a 0.1% 1k Ω resistor they will typically measure a wide range of 0.1% resistors accurately to within the resistor's 0.1% tolerance. Other audio impedance measurement systems show their limitations clearly on this simple resistor test. Remember, the accuracy of driver parameters is only as good as the impedance data from which the parameters are calculated—and this is where WT3 excels!

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