Testing Panasonic's WM-61A Mike Cartridge

This microphone study measures how distortion affects performance.

I recently had access to a high precision Bruel & Kjaer Sound Level Meter type 2230 equipped with a ½˝ pre-polarized condenser microphone type 4155. This gave me the opportunity to test the Panasonic WM-61A omnidirectional back electret microphone cartridge. I had ordered the units used for testing from Digi-Key (part number P9925-ND) at the end of 2006.

This article presents the results of these tests. I investigate how a cheap microphone cartridge compares with a high precision, high price (at least for the audio amateur) microphone. The article is divided into two parts: first, I tested the microphones as provided by the manufacturer, and, second, I modified the Panasonic microphones according to Mr. Linkwitz's recommendation. The purpose of this modification is the reduction of the microphone distortion at high SPL levels.

I placed all the cartridges on the front side of an aluminum tube, which had an inner diameter of 7mm, an outer diameter of 10mm, and a length of about 10cm. A complete Panasonic microphone together with the Bruel & Kjaer Sound Level Meter is shown in **Photo 1**.

I performed the evaluation of the microphones with the following measurements:

A) For the standard Panasonic microphones

Test A1: the low-frequency response of the standard microphone.

Test A2: the middle- and high-frequency response of the standard microphone.

Test A3: the phase response of the standard microphone.

Test A4: the distortion of the standard microphone at the level of 115 dBSPL.

B) For the Linkwitz modified Panasonic microphones

Test B1: the low-frequency response of the modified microphone.

Test B2: the middle- and high-frequency response of the modified microphone.

Test B3: the phase response of the modified microphone.

Test B4: The distortion of the modified microphone at 125 and 130 dBSPL levels.

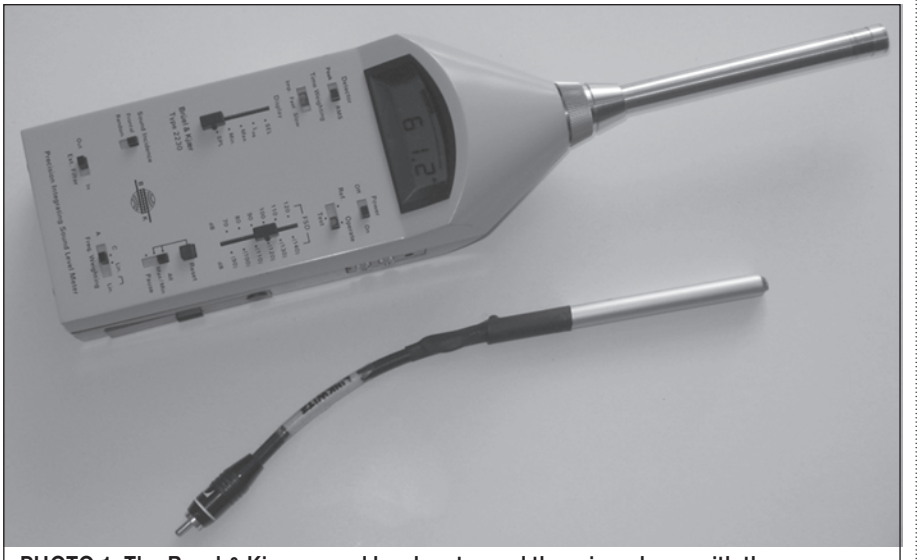

PHOTO 1: The Bruel & Kjaer sound level meter and the microphone with the Panasonic cartridge.

THE TESTING METHOD

For this simple testing method, I used an acoustic source and measured the frequency response with the reference B&K microphone. Then I used the same source to measure the response of the uncalibrated Panasonic microphone. I compared the two measurements and determined the response of the uncalibrated microphone.

I placed the reference B&K microphone and the Panasonic microphones as close together as possible. Actually, the Panasonic microphone was supported on the body of the B&K microphone as shown in **Photos 2** and **3**.

I also performed some measurements for the evaluation of the test method. I took two frequency response measurements of the Bruel and Kjaer microphone: the first with the B&K alone, and the second with the Panasonic microphone supported on the B&K in order to determine the influence of the Panasonic microphone to the response of the B&K. The result is shown in **Fig. 1.** The two responses are very close. Differences exist in the range from 5 to

10kHz with a peak about +0.6dB and in the range from 15 to 20kHz, which is down about -0.5dB.

According to the calibration chart provided by Bruel & Kjaer for this specific microphone, the response is absolutely flat up to 11kHz. Then the response rises with a peak of +1.2dB at 16kHz. The response is flat again at 20kHz. Based on this, I conclude that the following measurements will have an accuracy better than ±1dB.

For the testing of the standard microphones I used four samples. I connected the microphones to a preamplifier that provided a DC supply voltage to the microphone of 4.1V and had a gain of 16dB. It is a modified version of the original Mitey-Mike preamplifier (*Speaker Builder* 6/90, p. 12).

TEST A1

The test setup is shown in **Photo 2**. Each Panasonic microphone was tied together with the B&K microphone. For this test I used an 8˝ woofer without a box or baffle as the acoustic source. The microphones were close to the center of the woofer, and I took a frequency response measurement for every microphone. **Figure 2** shows the results.

The responses of samples 1 and 2 were very close to the B&K with a maximum deviation of 0.5dB at 10Hz. Samples 3 and 4 had a maximum deviation of 0.7dB at about 40Hz, but otherwise they were close to the B&K except at the very low frequencies down to 10Hz where the deviation is about 1 to 1.3dB.

TEST A2

I performed this test by using a loudspeaker with an Audax 130mm woofer/midrange and an Audax TW025 tweeter as the acoustic source. The microphones were 1m from the loudspeaker.

The height of the microphones was about 1.2m from the floor. This setup gave me an impulse response that was reflection free for the first 3 milliseconds. The results of the tests are shown in **Fig. 3**. All the microphones have similar responses, which are flat up to about 2kHz. Then they measure +2dB at about 6kHz, +3 to +4dB at about 10kHz, and finally a broad peak of about 3.5 to 5dB at about 12 to 14kHz.

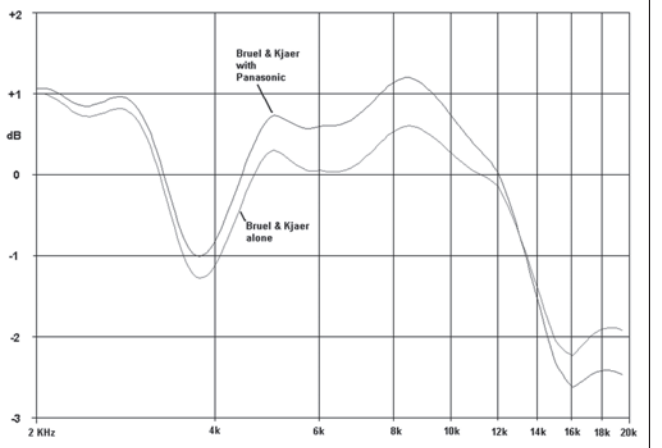

FIGURE 1: Differences in the responses of the Bruel & Kjaer microphone due to the proximity of the Panasonic microphone.

PHOTO 2: The test setup for the measurement of the low-frequency response using an 8˝ driver.

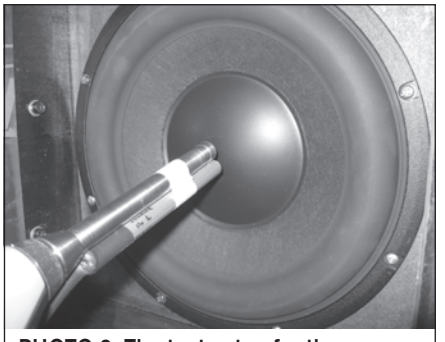

PHOTO 3: The test setup for the measurement of the low-frequency response and the distortion using a 10˝ driver.

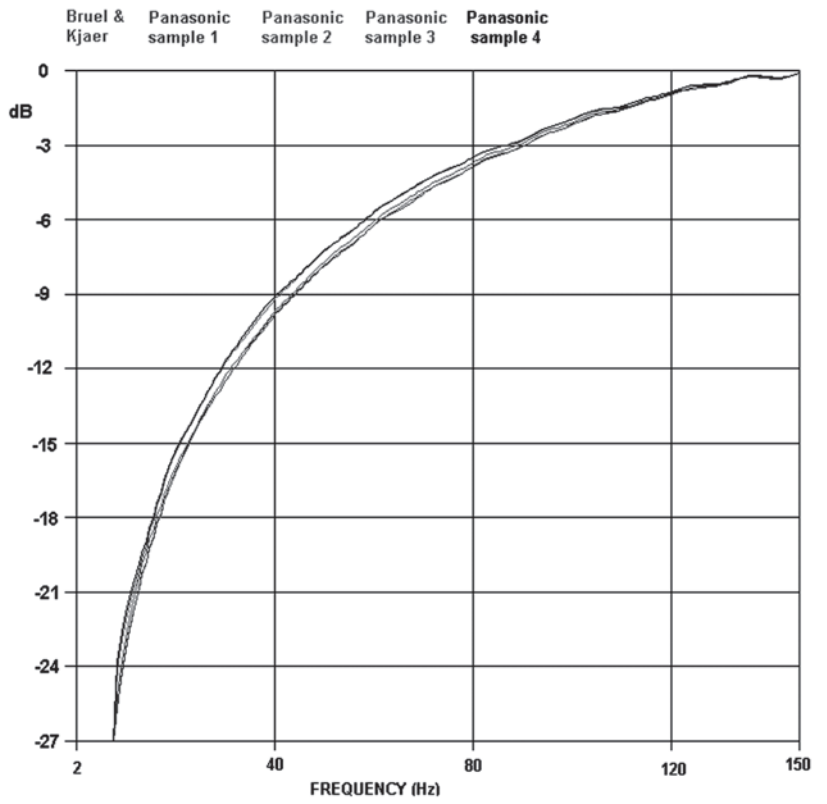

FIGURE 2: The low-frequency response of the standard microphone.

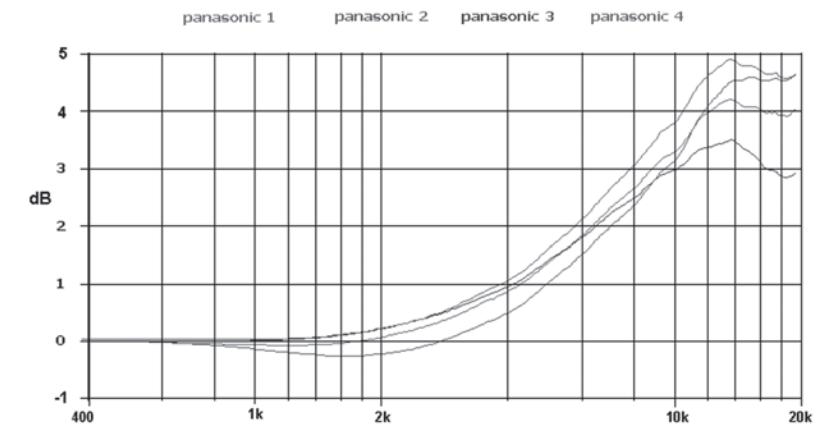

FIGURE 3: The middle- and high-frequency response of the standard microphone.

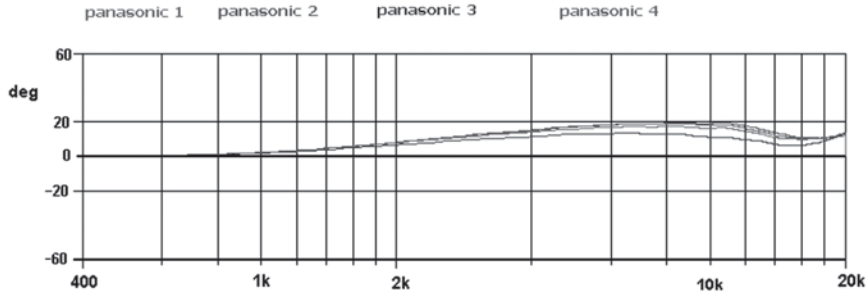

FIGURE 4: The phase response of the standard microphone.

TEST A3

The phase response was measured with the same setup as for the test A2. The results are shown in **Fig. 4**. The phase is flat up to about 1kHz, then +10° at about 2.5kHz, and +20° in the range from 6 to 12kHz.

TEST A4

According to the technical specifications of the B&K microphone, its second harmonic distortion is 0.13% at the level of 120 dBSPL, 0.23% at 125 dBSPL, and then increases linearly up to 4% at 150 dBSPL. The third harmonic distortion is 0.06% at the level of 140 dBSPL and increases linearly up to 0.6% at the level of 150 dBSPL. No data is given for the distortion at higher harmonics.

The measurement of the distortion of the Panasonic microphones at high levels is not an easy task because I don't have an anechoic chamber available. The measurement should be unaffected (as much as possible) by the room influence, so the only solution to this problem is the near-field measurement. Each Panasonic microphone was tied up with the B&K microphone (as shown in **Photo 3**) and placed very close to the center of the cone of the loudspeaker, which was used as the acoustic source.

I used different speakers according to the frequency. For the low frequencies of 15, 58, and 165Hz, I used a 10˝ Peerless XLS woofer; for the frequencies of 580Hz and 2kHz, I used an Audax 130mm woofer/midrange; and for the frequency of 4k an Audax tweeter. I measured the distortion for all frequencies at the level of 115-dBSPL-peak. The level was monitored for each measurement with the B&K Sound Level Meter. Above that level the distortion of the Panasonic microphone increases rapidly and above about 120 dBSPL you cannot use the mike.

The results are shown in **Table 1**, from which you see that the distortion of samples 1 and 4 is much better than the distortion of samples 3 and 4. At 15Hz the distortion of the microphones is close to the distortion of the B&K. As the frequency increases, the distortion of the Panasonic also increases and the average distortion is from 2 to 5

TABLE 1 Distortion of Standard Mikes at 115 dBSPL Peak						
Hz	Bruel & Kjaer (%)	Average of the four Panasonics (%)	Panasonic sample 1 (%)	Sample 2 (%)	Sample 3 (%)	Sample 4 (%)
15	5.3	6	5.9	6.8	5.5	5.8
58	0.24	0.6	0.24	1.2	0.7	0.24
165	0.16	0.71	0.5	0.74	1	0.6
580	0.16	0.65	0.4	1	0.8	0.4
2k	0.32	0.81	0.65	0.84	1	0.7
4k	0.17	0.82	0.5	1.1	1.1	0.6

times worse than the distortion measured by the B&K.

An interesting note is that the distortion of samples 1 and 4 at the frequency of 58Hz is comparable to the distortion of the B&K. Conclusively, the distortion levels of the Panasonic microphones are good at a level of 115 dBSPL.

MODIFIED MIKE TESTS

The modification of the microphones is described on the S. Linkwitz site (www.linkwitzlab.com/sys_test.htm#Mic). The purpose of this modification is to reduce the distortion of the original Panasonic microphones by changing the connection of the capsule to the built-in FET amplifier stage.

This mod is not very easy to perform and requires some delicate work. Expect to spend some time and some cartridges before you succeed with this modification.

Here are my recommendations:

a) Avoid heating the cartridge. Use a low temperature when soldering the cables on the capsule.

b) Don't solder the ground cable to the body of the capsule. The heat may destroy the capsule. I use conductive epoxy to connect the wire on the body of the capsule.

c) Cover the whole backside with glue to avoid low-frequency rolloff due to a possible broken air seal, which might have been caused by the modification (Linkwitz recommendation).

Two problems might appear with the modified microphones: either some loss in the low-frequency response or some loss in the sensitivity of the microphone. You must check both for a properly working microphone.

I modified four Panasonic microphones for the tests. The microphone preamplifier was similar to the one described in the Linkwitz site. The gain was 15dB and the DC voltage supply to the microphone was -9V. (A negative supply voltage is required after the modification of the microphones.)

TEST B1

I used the setup shown in **Photo 3**. The speaker was a 10˝ Peerless XLS woofer in an open baffle. The microphones were, again, at the near field of the woofer, close to the center of its apex.

I took a frequency response measurement for each microphone in comparison with the B&K microphone. **Figure 5** shows the results. The responses of

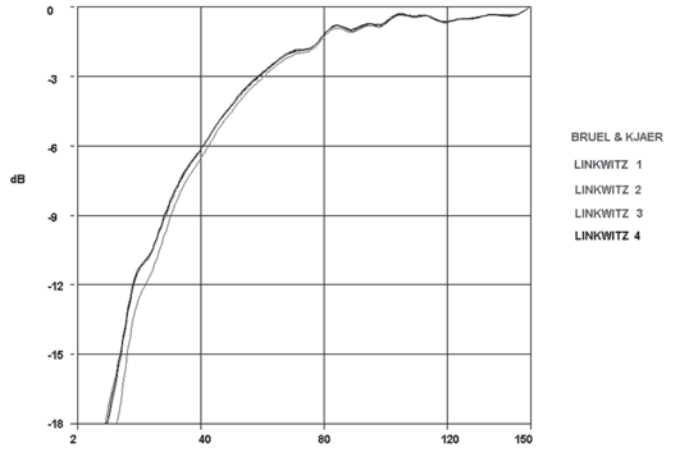

FIGURE 5: The low-frequency response of the modified microphone.

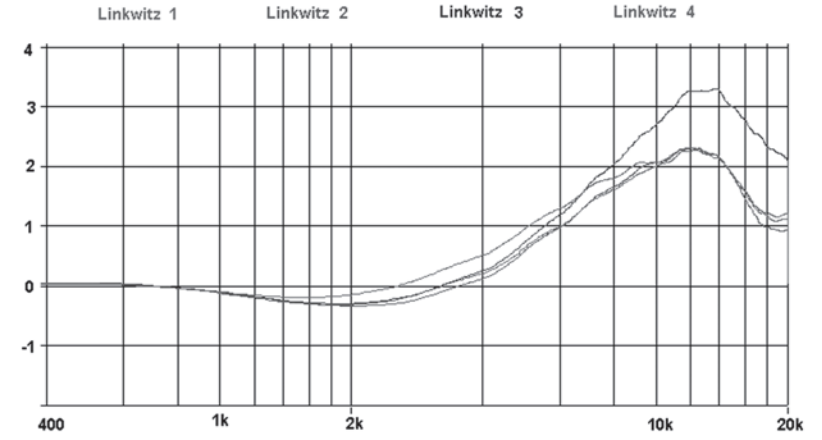

FIGURE 6: The middle- and high-frequency response of the modified microphone.

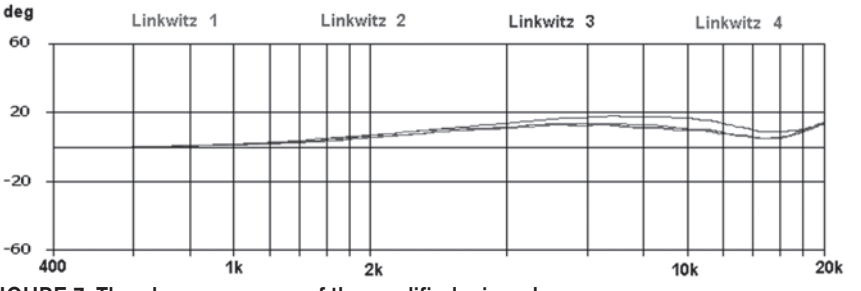

FIGURE 7: The phase response of the modified microphone.

TABLE 2 Distortion of the Linkwitz-Modified Mikes at 125 dBSPL Peak

Hz	dBSPL	Bruel&Kjaer (%)	Average Panasonic (%)	Linkwitz 1 (%)	2 (%)	3 (%)	4 (%)
15	125	44	48.3	55.2	46	46	46
58	125	0.86	0.77	0.8	0.7	1	0.6
165	125	0.26	0.61	0.7	0.6	0.34	0.8
580	125	0.29	0.34	0.36	0.33	0.26	0.4
2k	125	0.45	0.87	0.9	0.83	0.74	1

TABLE 3 Distortion of the Linkwitz-Modified Mikes at 130 dBSP

Hz	dBSPL	Bruel&Kjaer (%)	Average Panasonic (%)	Linkwitz 1 (%)	2 (%)	3 (%)	4 (%)
165	130	0.26	0.61	0.7	0.6	0.34	0.8
580	130	0.56	0.54	0.56	0.53	0.47	0.6

samples 2, 3, and 4 are within ±0.1dB from the B&K response down to 20Hz and go to -1dB at 10Hz. Sample 1 is not as good and has a deviation of -0.4dB at 40Hz, -1.5dB at 20Hz, and -3.7dB at 10Hz.

Maybe the backside of this microphone was not covered very well with the glue that I used, resulting in an air leak. According to Linkwitz, this could result in some loss at the low frequencies.

TEST B2

This setup is similar to the one described for test A2. The results are shown in **Fig. 6**.

As you can see, the peak in the response is much lower than the peak of the standard microphones. Because I didn't measure the microphones before the modification, I cannot tell whether this is due to the modification.

The responses of the four samples are flat up to about 1kHz, then down –0.3dB at 2kHz and +0.3dB at 4kHz. Above this frequency the response rises with a peak of +2.3dB at about 12kHz for samples 1, 2, and 4 and +3.2dB for sample 3. At 20kHz the deviation is from +1 to +2dB.

TEST B3

The test setup is similar to the one described for test A2. The phase response is shown in **Fig. 7**. It is flat up to 1kHz, then about +10° at 4kHz, and +11 to +17° from 8kHz and above.

TEST B4

The measurement of the distortion of the modified Panasonic microphones was a difficult job. In addition to the problems already described for the standard microphones, I also needed to contend with the higher sound level. Because I didn't have access to an anechoic room, I performed all the measurements in my typical listening room. And although I used the near-field method, the level of the sound was very uncomfortable (even using earplugs).

I measured the distortion of the microphones at 15Hz, 58Hz, 165Hz, 580Hz, and 2kHz at a sound level of 125-dBSPL-peak. Additionally I measured the distortion at 165Hz and 580Hz at a level of 130-dBSPL-peak.

The sound level was always monitored with the B&K meter.

For the frequencies of 15, 58, and 165Hz, I used a 10˝ Peerless XLS woofer, and a 130mm Audax woofer for the frequencies of 580Hz and 2kHz. The results for the measurement at 125-dBSPL-peak are given in **Table 2**. Indeed, the modification is very effective because the distortion of the modified microphones at this high level is very good. Actually, it is about the same with the B&K microphone at 15Hz, 58Hz, and 580Hz, and about double at the other frequencies.

The results of the measurement at the level of 130-dBSPL-peak are given in **Table 3**. Again, the results are excellent, especially for sample 3. All the modified microphones at 580Hz have distortion comparable or even better than the B&K microphone.

CONCLUSION

Keep in mind that all the measurements presented in this article were obtained with samples from a single order, so I assume that the microphones are from the same manufactured lot. It is possible that microphones from different lots may present different results. Having said this, here are my main conclusions from the tests:

a) You can use the standard microphones without any calibration for frequencies up to about 2 to 3kHz. Above this limit, if you require accuracy, the microphones should be calibrated.
b) The distortion of the standard microphones is acceptable, providing that the peak sound pressure level is always below 115-120 dBSPL.
c) You can use the microphones modified according to Linkwitz without any calibration for frequencies up to about 4 to 5kHz. Above this limit, if accuracy is required, the microphones should be calibrated.
d) The Linkwitz modification offers a dramatic improvement on the distortion, making the microphone suitable for near-field measurements. *aX*