SPEAKER LOAD RESISTOR MEASUREMENTS

Test and evaluation notes

22-Feb-18

Rev 3.0

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http://clk.works

VERSION HISTORY

REV

- 1] 21-Feb-18. Initial
- 2] 21-Feb-18. Removed measurements of bad alligator clip. See http://clk.works/?p=241
- 3] 22-Feb-18. Cleaned up, added results for amp

OVERVIEW

High wattage resistors are used as dummy loads for speaker testing. Some anomalous amplifier readings obtained with some high power resistors[1] led to an investigation about the cause. Originally it was hypothesized that the inductance of the resistors might be a problem, but a separate investigation showed that was not an issue for the amplifier in question. See Figure 11 at the end of this document for an example of the measurements.

Different parts were measured to see if it was the parts or a measurement issue. An AP515 was used for measurement.

The test circuit consist of a 100 ohm series resistor and the Load resistor, as illustrated in the awful word diagram.

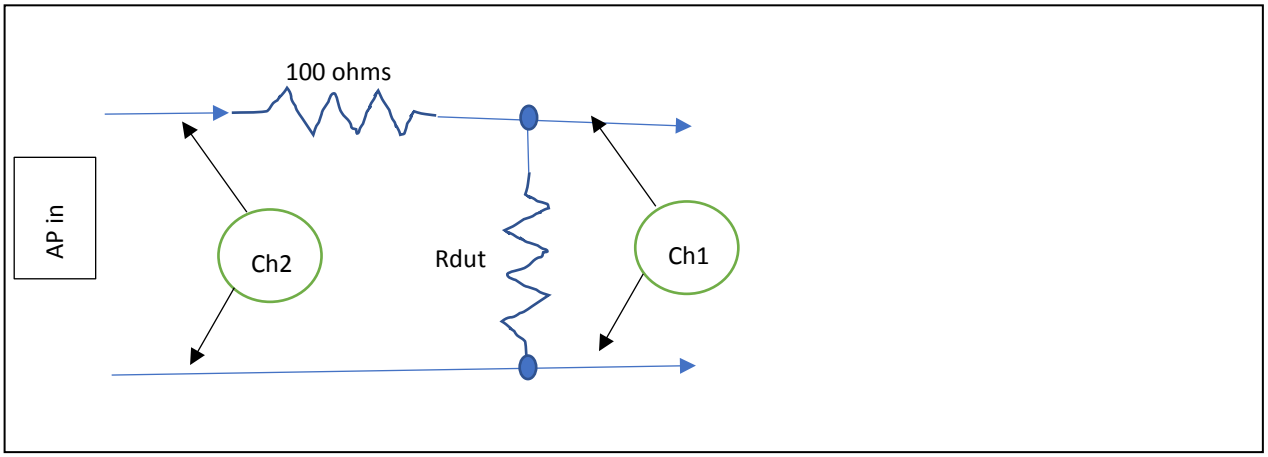

Figure 1 Test setup

The AP's internal 50 ohm source impedance will produce a lower voltage than the generator voltage due to the low load values.

The series resistor is a 100 ohm 1W Ohmite WNB100FECT, a non-inductive wirewound part that has been previously measured and known to not introduce distortion or noise effects at a level measurable by an AP515.

[1] They were purchased used as new parts are relatively expensive. That does open up the possibility that the parts were somehow damaged. Coincidentally some newly purchased parts also showed a similar set of unexpected readings.

Unless noted otherwise AP measurements performed with 48 kHz sample rate (22.4 kHz BW). Measurements performed unweighted.

The parts were connected with alligator clips on a bench so there is some noise pickup, around 1.3 uV RMS with some 60 Hz harmonics.

FFTs are 32 k point with AP-equiripple filter and 4 averages.

RESIDUAL DISTORTION

Unless noted otherwise the AP's output level is adjusted to produce a 1V RMS (0 dBv) input as measured at the Ch2 location.

Three different tests were made using low wattage resistors to establish a baseline for measuring the power resistors against. Other than some higher than expected 60 Hz/harmonics pickup that seemed to vary but couldn't be confirmed from one specific cause beyond this all being done out on an exposed lab bench measurements were all within the nominal values expected.

100 OHM (NON-INDUCTIVE) WIREWOUND LOAD

Using the same part as the series resistor. The AP's output was set to +2 dBv (1.3 V RMS) to produce a 1 VRMS input (Ch 2)

THD+N unweighted:

- Ch1: 0.00047%
- Ch2: 0.00050%

100 OHM METAL OXIDE LOAD

1 W Metal Oxide 5%, unknown manuf. https://www.parts-express.com/100-ohm-1w-flameproof-resistor-10-pcs--003-100 . The AP's output was set to +2 dBv (1.3 V RMS) to produce a 1 VRMS input (Ch 2)

THD+N unweighted:

- Ch1: 0.00047%
- Ch2: 0.00050%

No obvious change from the wirewound part was noted.

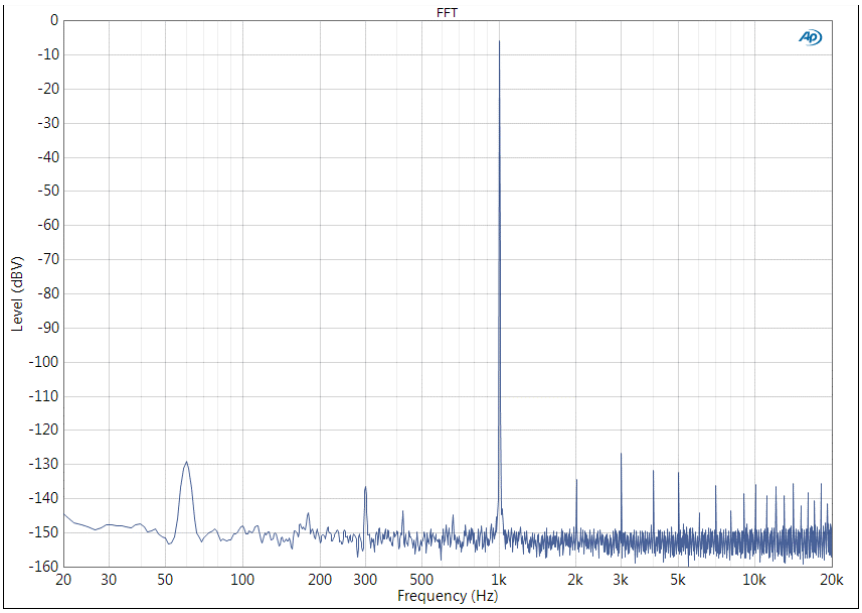

Figure 2 100 ohm load FFT results

11 OHM LOAD

A Rdut was made by nine parallel 100 ohm resistors from the prior test for a total of 11 ohms to place an increased load on the AP's output amplifier.

The AP's output was set to +4 dBv (1.6 V RMS) to produce a 1 VRMS input (Ch 2)

THD+N unweighted:

- Ch1: 0.00096%
- Ch2: 0.00047%

While higher THD+N is observed it does not appear to be from harmonics (as observed in the FFT plot), which are actually lower. Instead there's increased 60 Hz related spikes. The setup was sitting on a bench and clipped together, so some inconsistency is not unexpected. It's also not relevant to the magnitude of the observed problem.

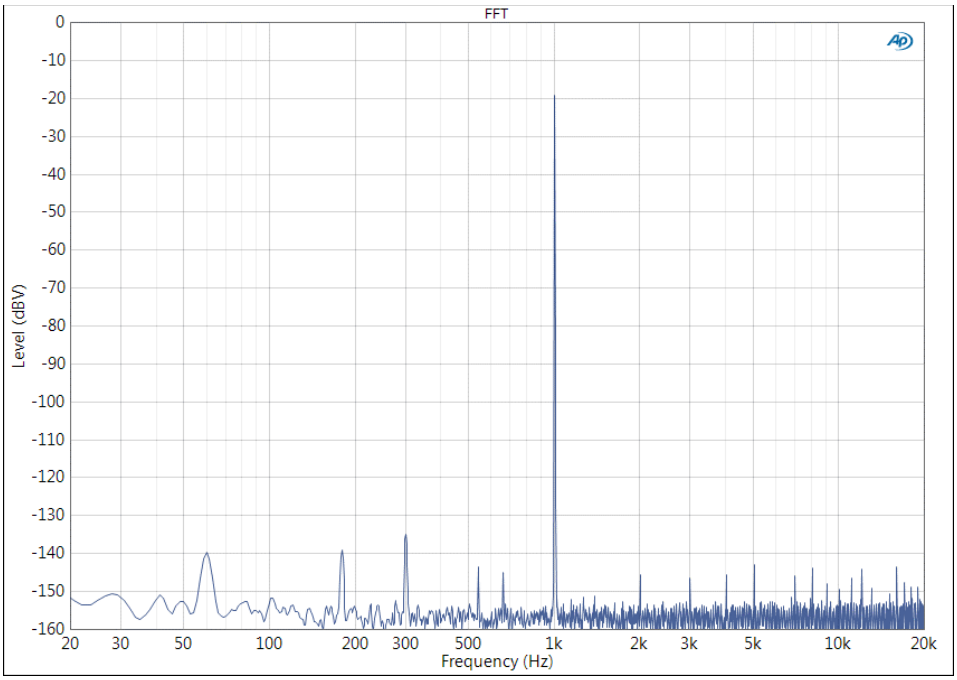

Figure 3 11 ohm load FFT results

This would indicate that the increased load current for the 11 ohm value is not a source of distortion.

A THD+N ratio vs. level test was also performed to establish a baseline for later measurements.

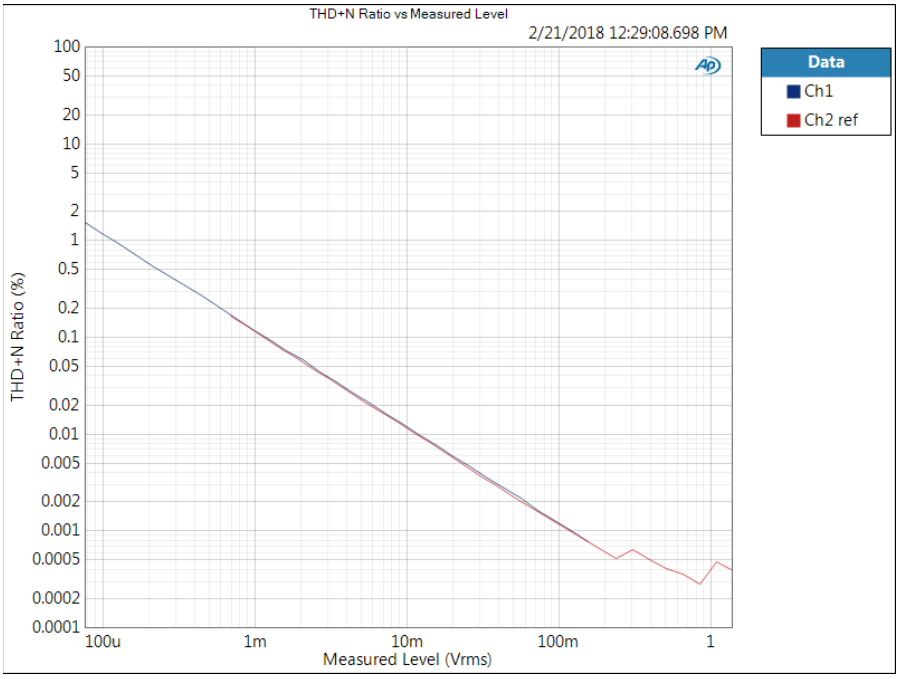

Figure 4 11 ohm THD+N vs. level

Due to the voltage divider nature of the test setup and the AP's 50 ohm source impedance, the voltages applied to the resistors are lower than the generator level. If seeking to interpret data from the plots that must be accounted for.

POWER RESISTOR TESTS

16 OHM LOAD FROM FOUR DALE RH-50

The RH-50 are the standard wirewound parts. Their inductance is low, a rough measurement places it at around 600 nH and not a contribution in the audio band.

Figure 5 Dale power resistor RH series

Four DALE RH-50 4 ohm 50 Watt resistors were connected in series.

The AP's output was set to +3 dBv (1.4 V RMS) to produce a 1 VRMS input (Ch 2).

THD+N unweighted:

- Ch1: 0.0011%
- Ch2: 0.00051%

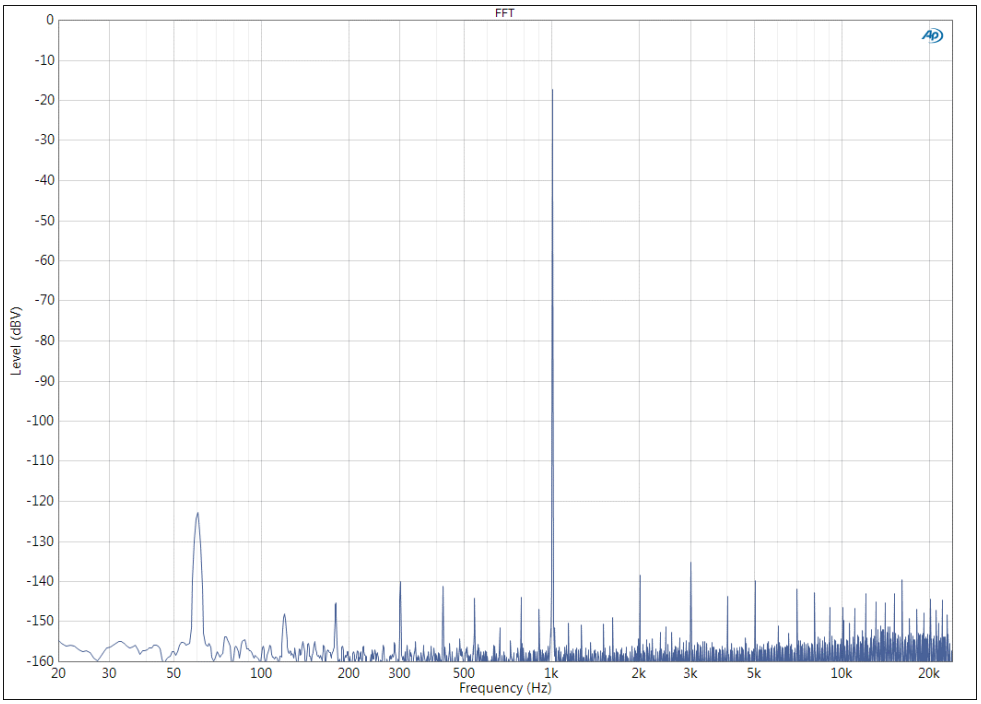

Figure 6 Four Dale RH-50 in series (note increase in 60 Hz crud)

16 OHM LOAD FROM TWO OHMITE 300W 8 OHM POWER RESISTORS (C300K8R0)

The AP's output was set to +3 dBv (1.4 V RMS) to produce a 1 VRMS input (Ch 2).

THD+N unweighted:

- Ch1: 0.0054%
- Ch2: 0.00064%

The higher 60 Hz related harmonics of the prior pass still appear. However the odd harmonics of the 1 kHz are much higher. A second FFT with 4V RMS (15.2 dBV) was done. Comparing Figure 7 and Figure 8 the harmonics are increasing faster than the signal level.

A THD+N plot reveals an unexpected relationship between signal level and distortion.

A check of each resistor individually showed the same distortion measurement.

MEMCOR 450W 4 OHM

This part is no longer made and no details are available on it. Its construction is very similar to the Ohmite parts. The power estimate is based on comparing the physical size to currently available parts.

The lower resistance value makes for small voltages across it. However increasing the applied voltage shows an apparent disproportionate increase in harmonics, suggesting this part behaves like Ohmite C300K8R0 one.

To produce the spectrum plot the frequency was increased so that the two curves did not sit on top of each other. The voltage in the label is the generator voltage, not the actual applied voltage.

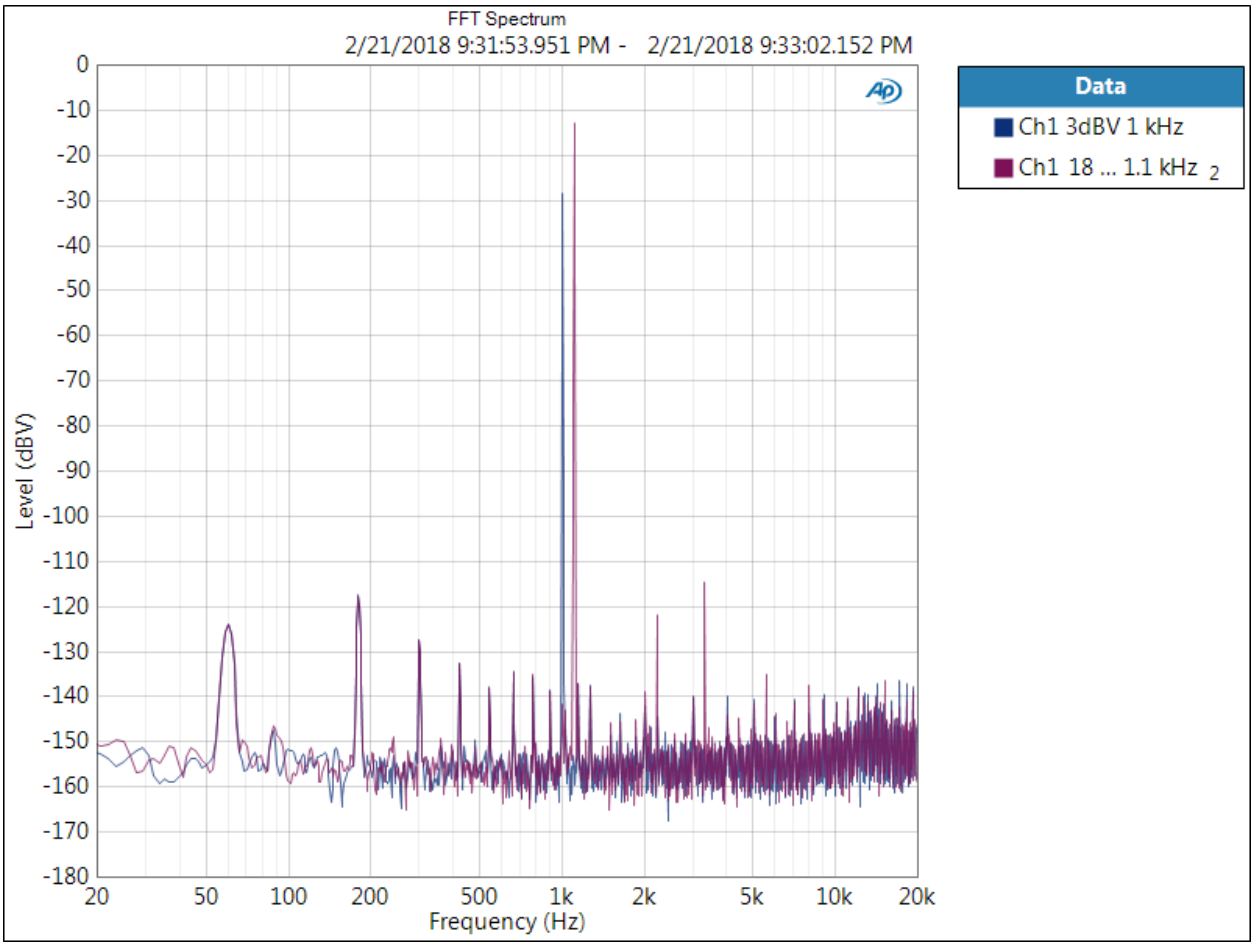

Figure 7 Spectrum from two different voltages/frequency showing rapid rise in harmonics with level

SUMMARY

The reliability of the test setup was tested and appears to be valid.

Three different high power resistors were measured for THD+N and an unexpected rise in THD+N was observed in the large high power (300 – 450 W) hollow core parts. The inductance of these parts was previously measured at about 20 uH.[2] As there is no ferrous component the distortion is not explained by the parasitic inductance of the wirewound parts.

[2] The inductance of the Dale RH-50 4 ohm parts is about 600 nH.

A reasonable guess might be that the material used for the resistor (nichrome perhaps?) and for the attachment point create a metallic junction that behaves non-linearly. For example a copper-nichrome junction acts like a thermocouple with a Thermo EMF of 50 to 200 uV across a 300C temperature difference.

While the distortions of these parts is small for and not of concern for most power electronics applications, these parts would present a non linear load to an amplifier and therefor not be good for measuring amplifier performance. They would however be fine as a load for amplifier burn-in.

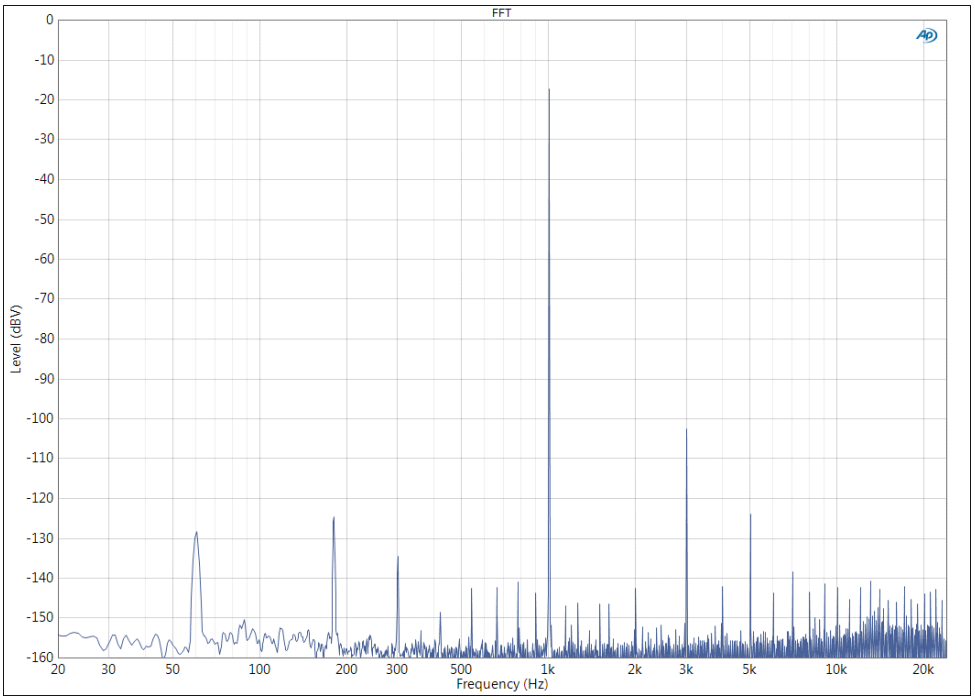

Figure 8 FFT from two Ohmite C300K8 in series (1 V RMS in to test circuit)

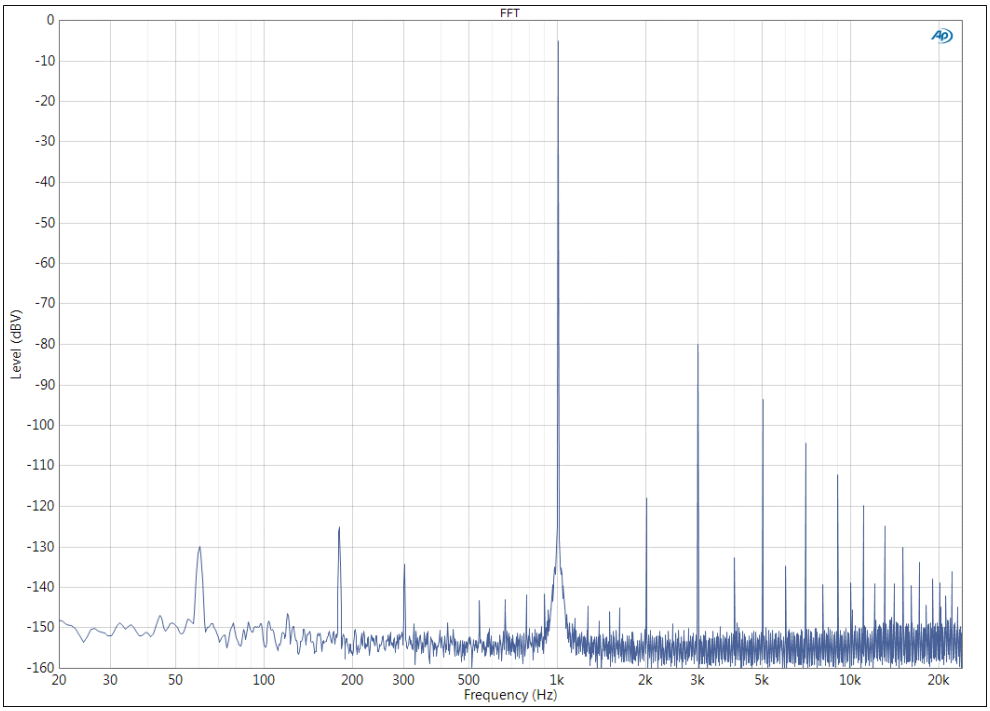

Figure 9 FFT from two Ohmite C300K8 in series (4 V RMS in to test circuit)

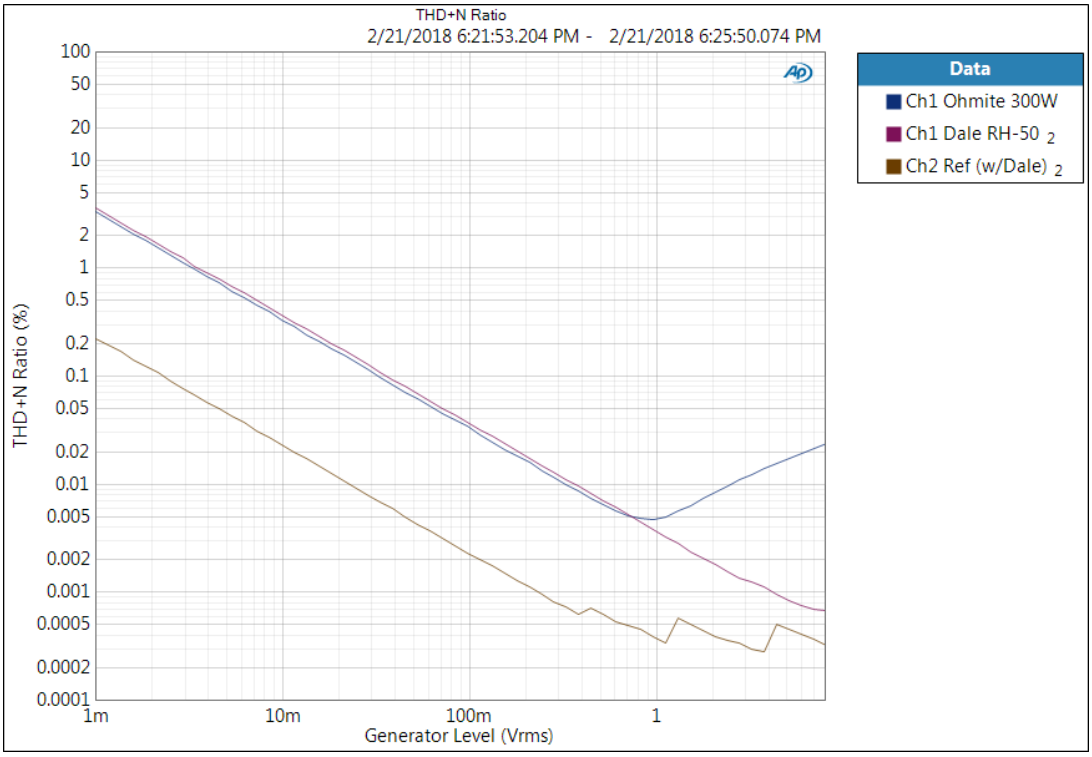

Figure 10 Two Ohmite C300K8 (blue) vs. the four Dale RH-50. 16 ohm total load. Ch 2 AP loopback ref in gold

ACTUAL AMPLIFIER MEASUREMENT DIFFERENCES

This plot shows the effect on a 200W (8 ohms) class D amplifier that the Ohmite C300K8R resistor has on THD+N measurements. The Dale RH-50 is used as the comparison.

This is an AES-17 measurement with the AP with no additional weighting. An external filter similar to the AP AUX-0025 was used to remove high frequency switching noise.

This plot's X axis was not scaled for the actual power output; the right side represents 100W. 0 dBv is 7.6 Watts.

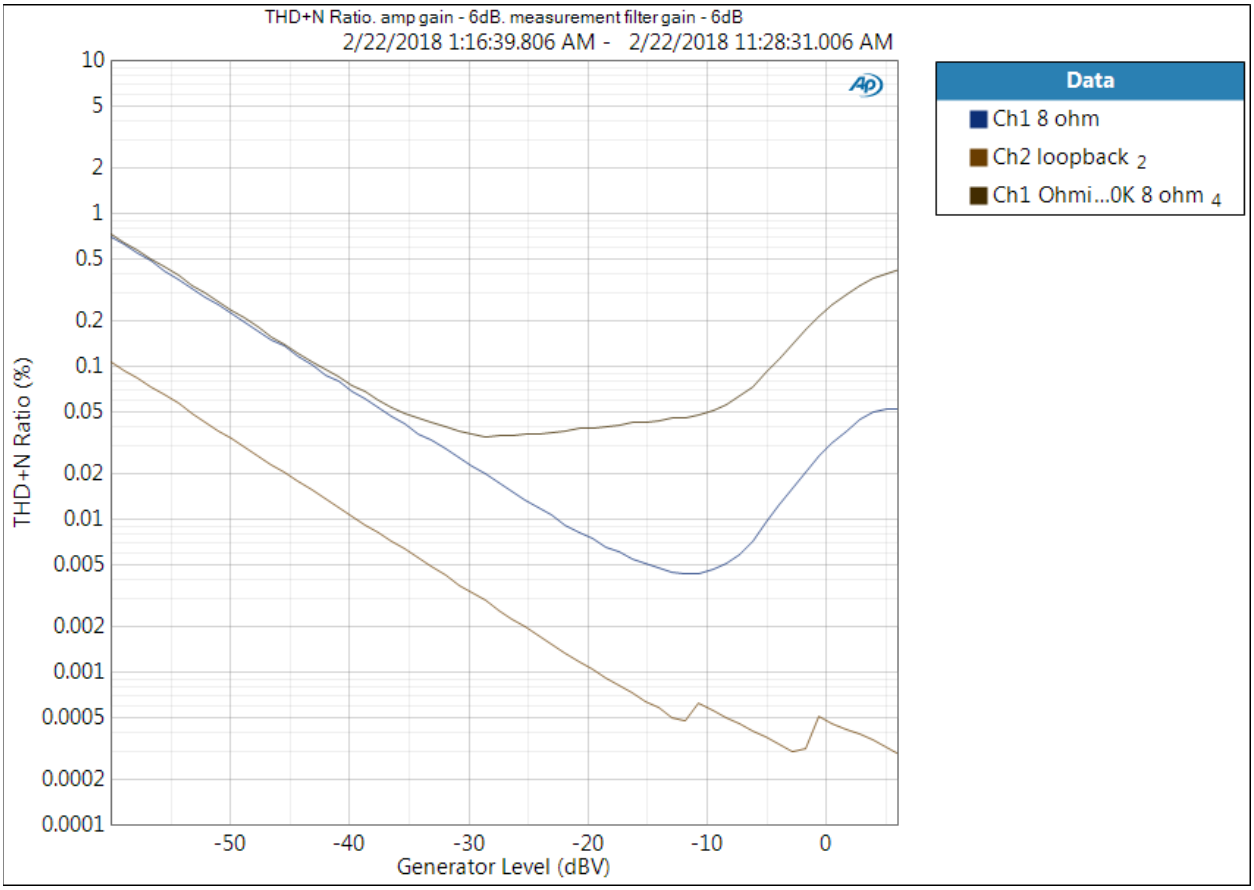

Figure 11 THD+N plot of amplifier output (8 ohms) with Ohmite C300K power resistor (top), Dale RH-50 resistors (middle), and AP loopback (residual instrument distortion).