Pedja Rogic

TDA1541A DAC rev.1.1b

Distortion Measurements

The article has been originally uploaded in July 2004.

http://users.verat.net/~pedjarogic/audio

Used DAC chip in all the measurements below was the TDA1541A sourced from the Reichelt in the spring of 2003, batch code 11114, date code HSH8844 2 (ergo manufactured in October 1988). In all the measurements used I/V resistor was 1.2kOhm which results in about 1.7V RMS at the output. Hash seen at the bottom end of the spectrum does not coming from the DAC but appears yet connecting to the soundcard the cable used for the measurements.

During the previous TDA1541A project that used AD844 based common base I/V, I was somewhat surprised when I realized that the significant amount of the distortion I see at the output of the AD844' is associated to the AD844's output buffer. A diamond buffer is very low distortion circuit, however, for some reasons, search through the corresponding datasheets reveals that, its monolithic implementations often do not achieve its full potential, and often do not meet the expectations even considering often used relatively low bias currents. Analog Devices was not at the moment able to provide the data about the AD844's output buffer's open loop behavior so I was left to my own measurements, guesses and constructions. The thing that left me a bit uncertain about what is really inside (in the terms of performance) was the fact the measured distortion at the AD844's output was dependent on some things that I wouldn't normally consider as a source of distortion (of such amount of distortion at least) like, for example, the shunt cap at the transconductance node or supply - at the one moment I have tried the local R-C decoupling (similarly to that suggested by the Analog, but the things being said, the usage of the chip this way is not anticipated in that suggestion) instead of the local regulators and the distortion level went notably higher. Finally, lower than 0.11-0.12% for the full level (0dBFS) signal it did not go. The measurements are done on the 15kOhm load. All the graphs are scaled according to the signal written in the test disc.

Figure 1 shows the harmonic distortion at the full level (0dBFS). It may be important to say that the measured performance varies somewhat from sample to sample of AD844, the result can differ a few dB for every harmonic. AD844's buffered output was checked for harmonic distortion also varying the load from 8kOhm till 30kOhm and no significant changes were registered.

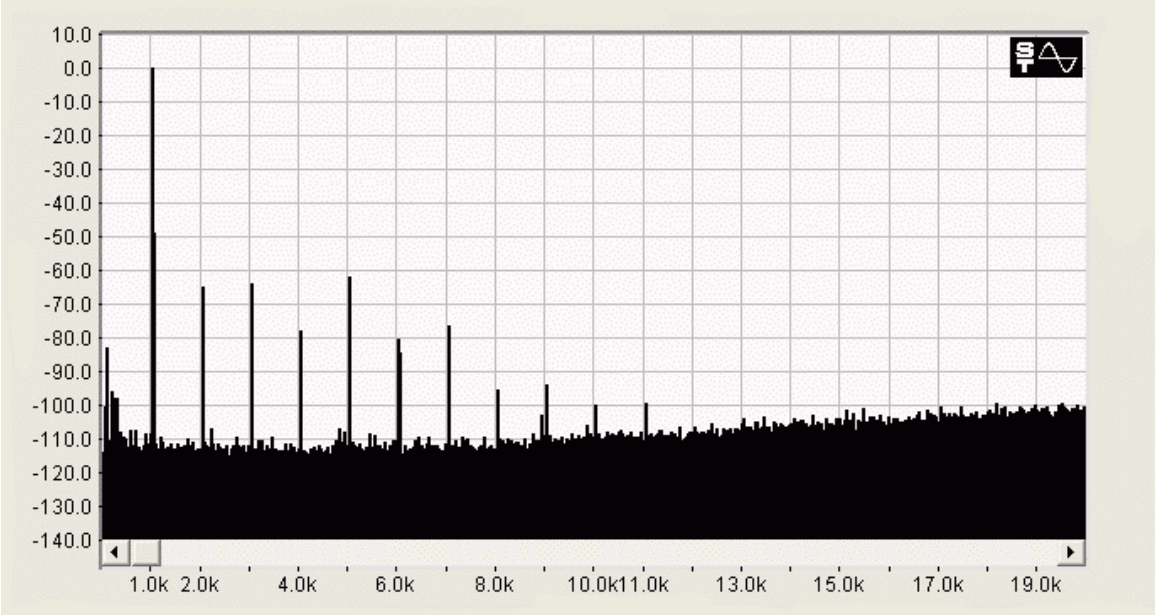


Figure 2: The distortion from above is associated to the full level signal and it drops at the lower levels. With -12dBFS signal, the total amount is 0.04% and it looks this way.

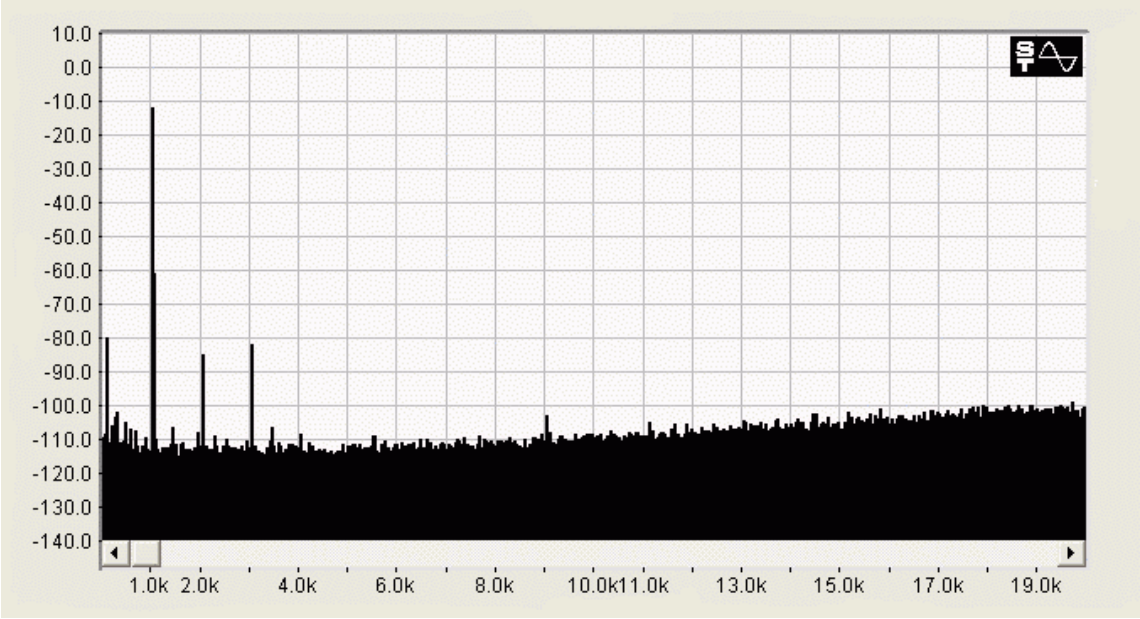


Figure 3: SMPTE/DIN intermodulation distortion is 0.12%.

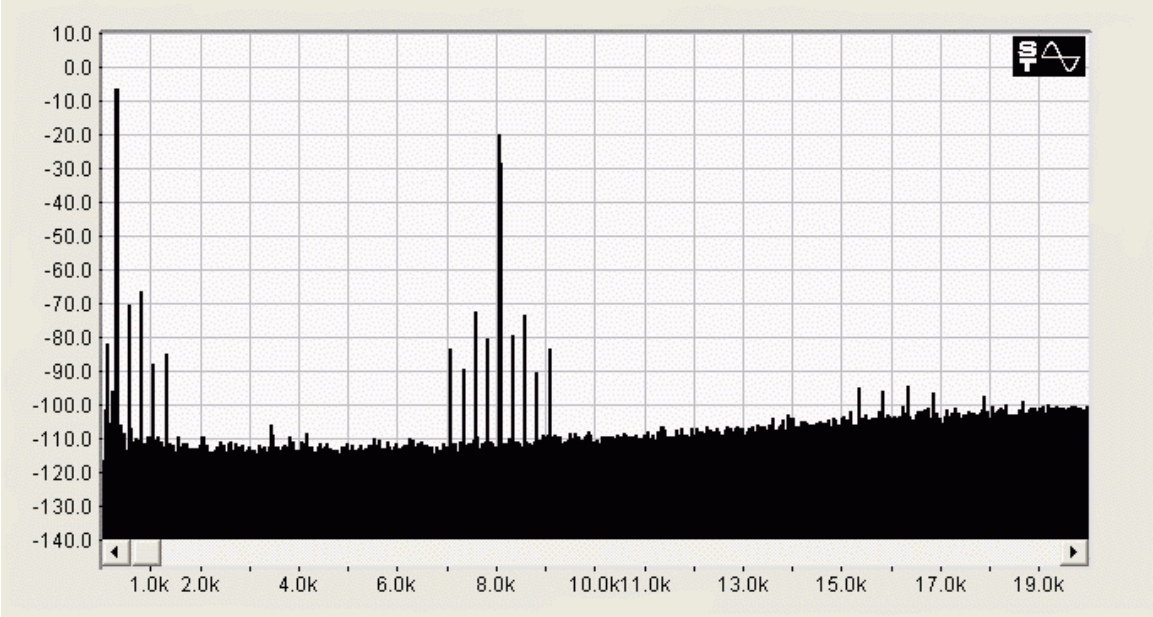


Figure 4: Harmonic distortion measured at the pin 5 is lower, 0.065% at the full level.

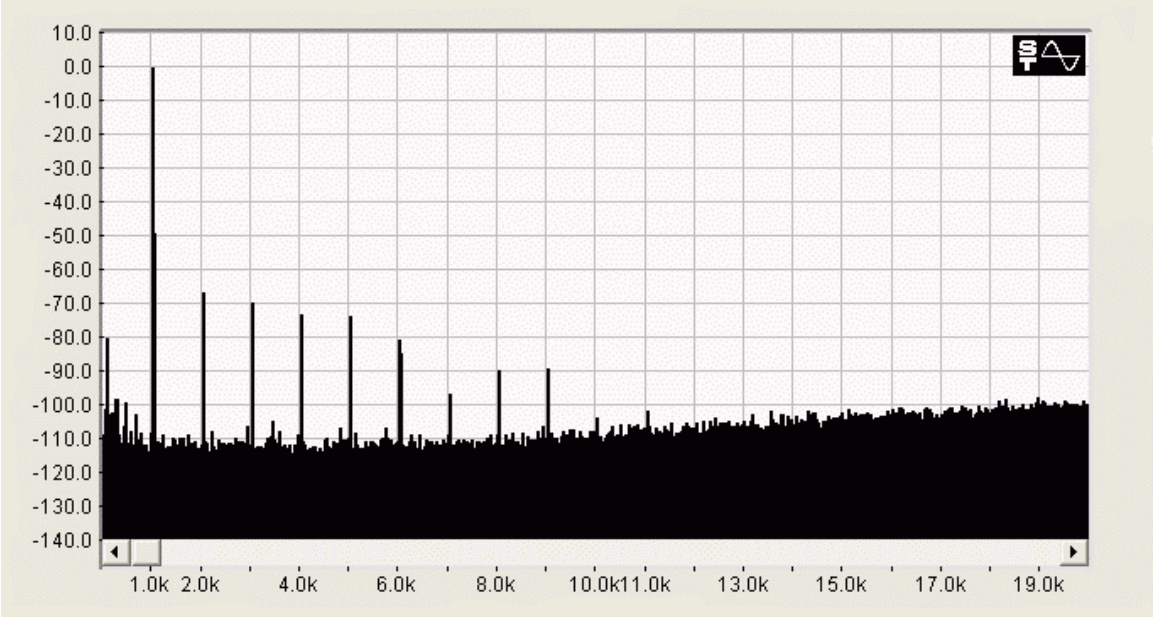


Figure 5: Interestingly enough, certain samples of the AD844 may differ in this part somewhat more than in the output buffer. I have measured THD of 0.035% at the pin 5 of one sample.

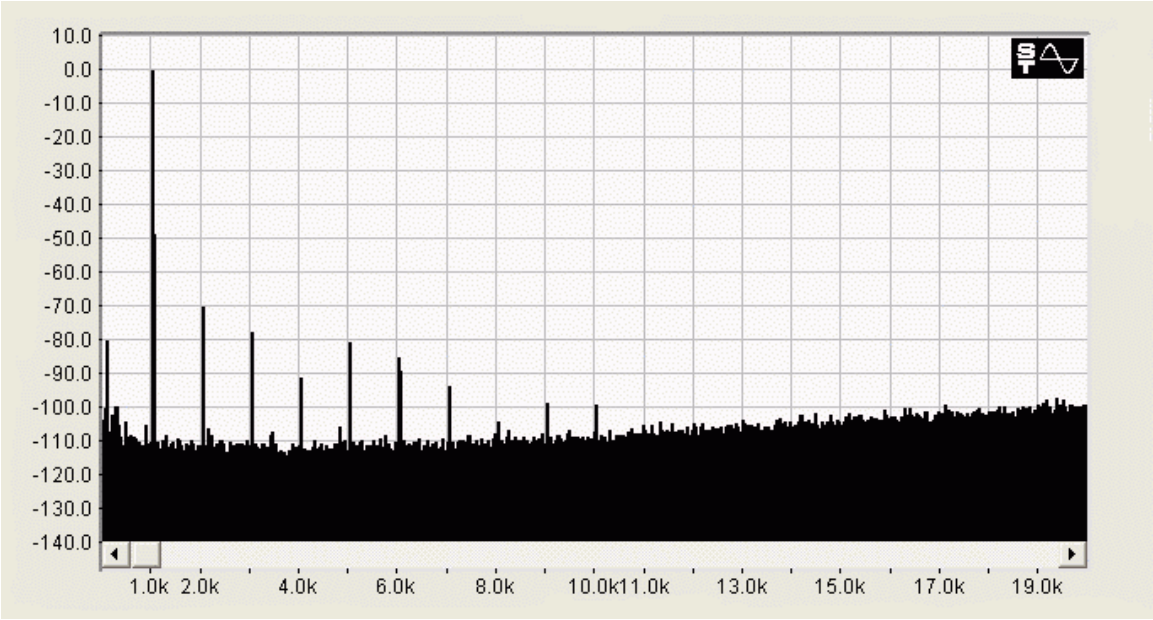


Figure 6: Similarly to this variation, the chips shown in the two graphs above also differ in the measured intermodulation distortion, and they differ in its content as well. This is the first with the total amount of 0.015% (SMPTE).

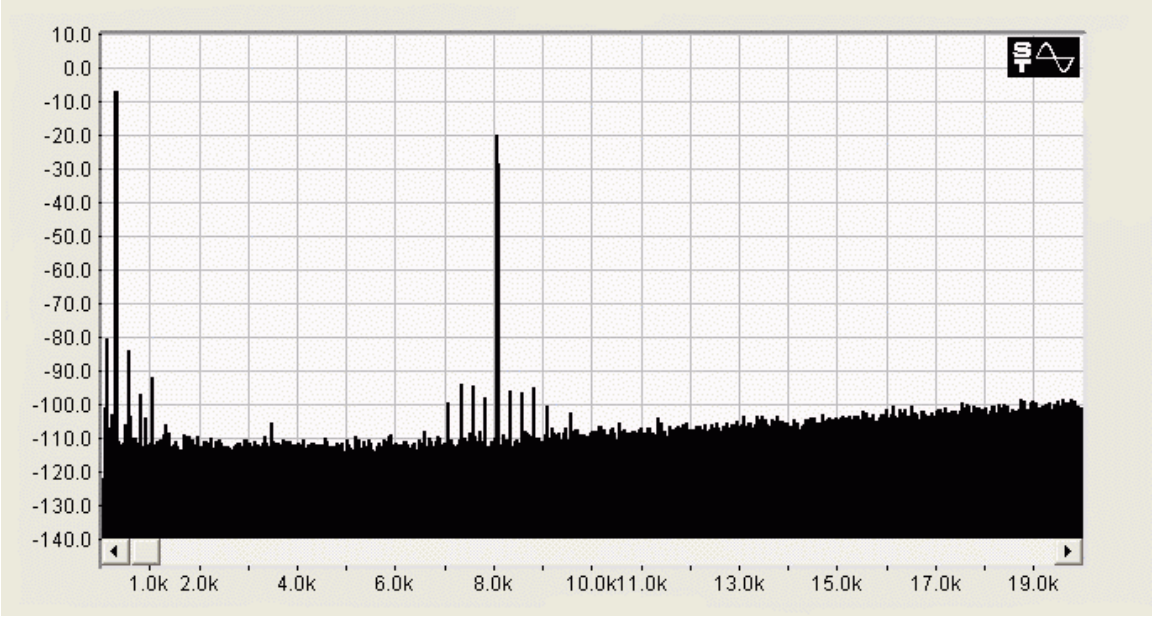


Figure 7: The other, that with lower harmonic distortion, shows a higher overall level of the intermodulation products but its content may look better to some. The total amount is 0.024%. (And contrary to what some (bored) guys would conclude after this, with one chip at one and the other at the other channel, the soundstage is excellent.)

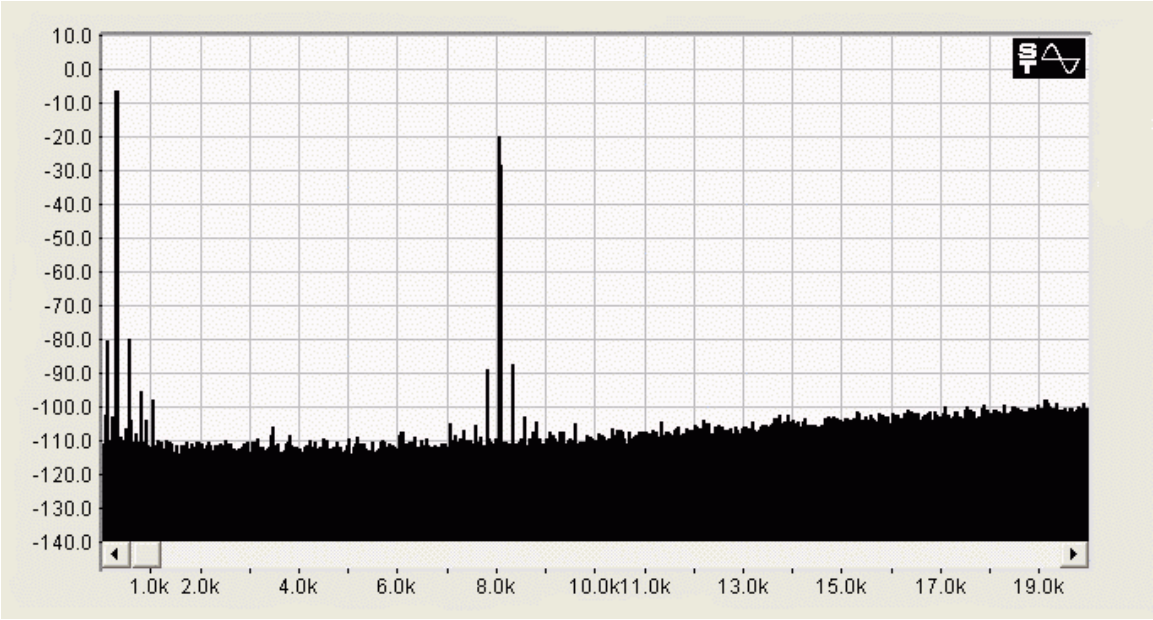
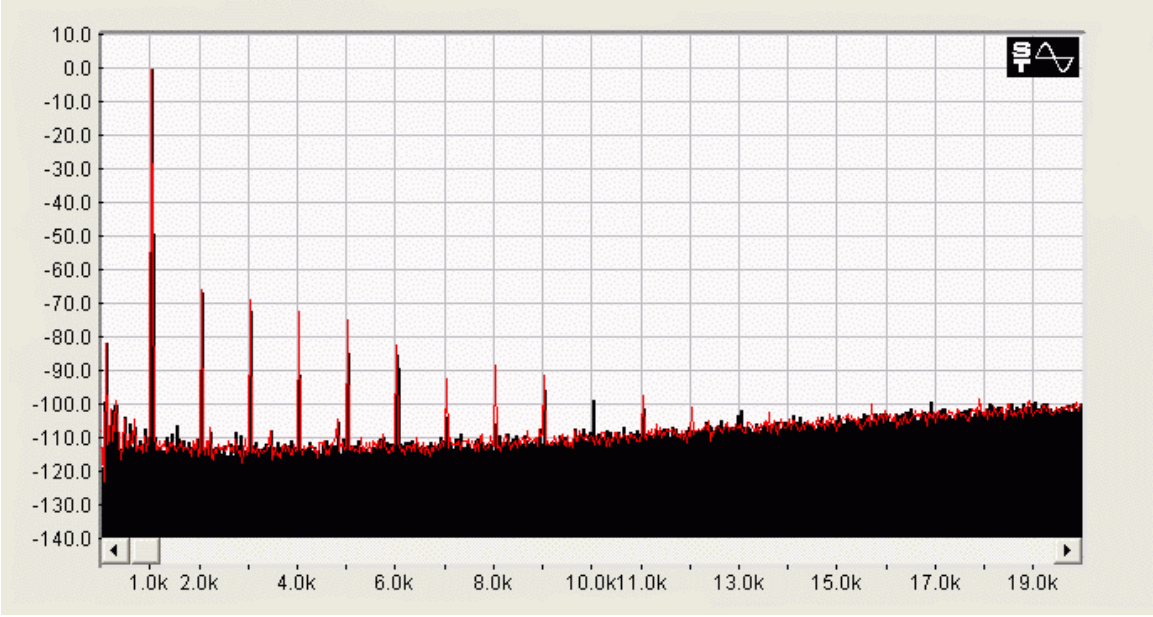


Figure 8: JFET buffer adds somewhat distortion but it is visibly lower than if the AD844's embedded buffer is used. Again, the performance is shown for the cases of the two chips above and the total amount is 0.065% (red) and 0.055% (black). As about the IMD, the figures from above raise to the 0.02% and 0.036% respectively, keeping the existing structure.



But hey, why do we bother will all this at all? We can use a classic opamp I/V. **Figure 9** is the FFT of 0dBFS sinewave with AD844 used like a classic opamp I/V, the number is 0.0017%, rather related to the TDA1541A itself.

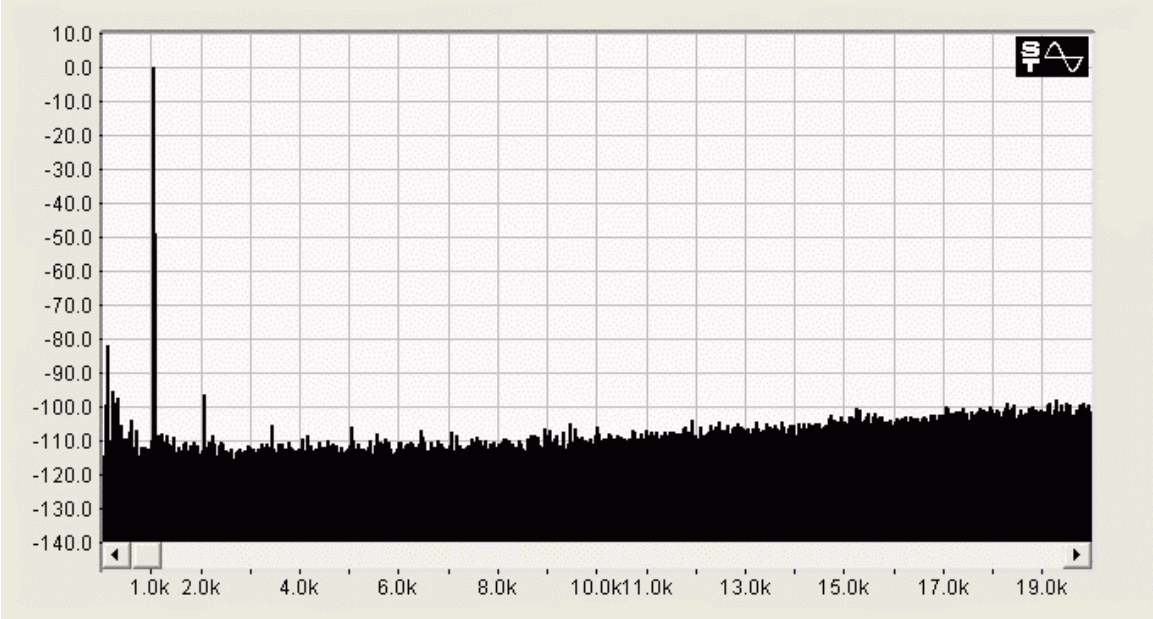


Figure 10: If OP27 is used, the total amount of harmonic distortion raises to 0.007%. The third harmonic followed by the fifth points out the certain clipping which is not uncommon for some opamps yet at this level. However, many modern opamps will yield the figure more similar to the one above.

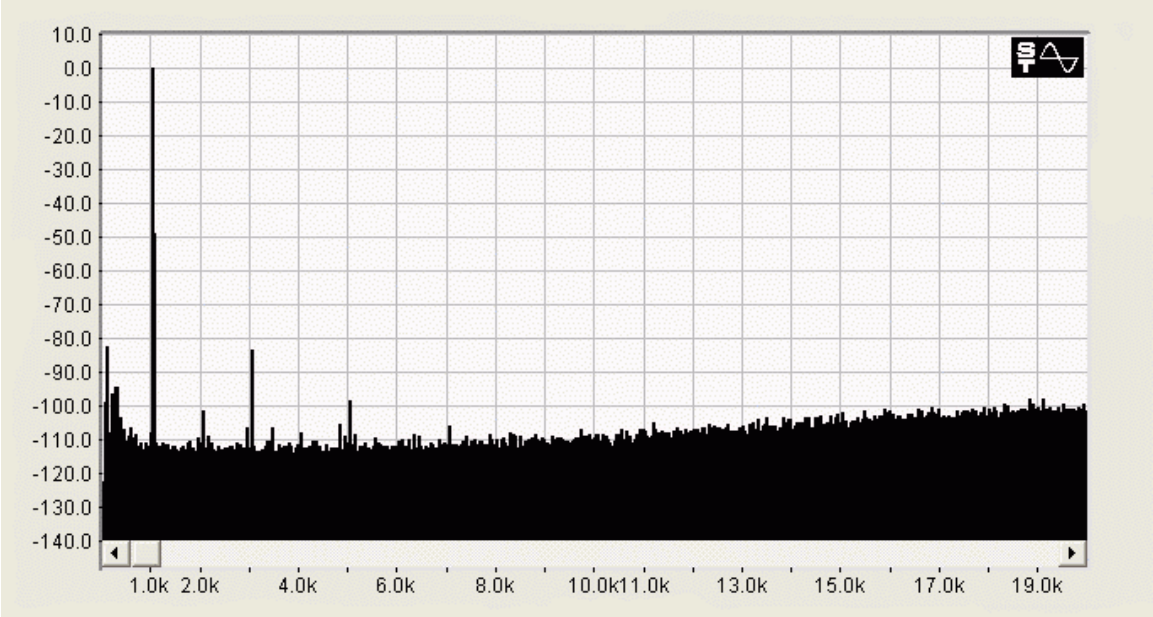
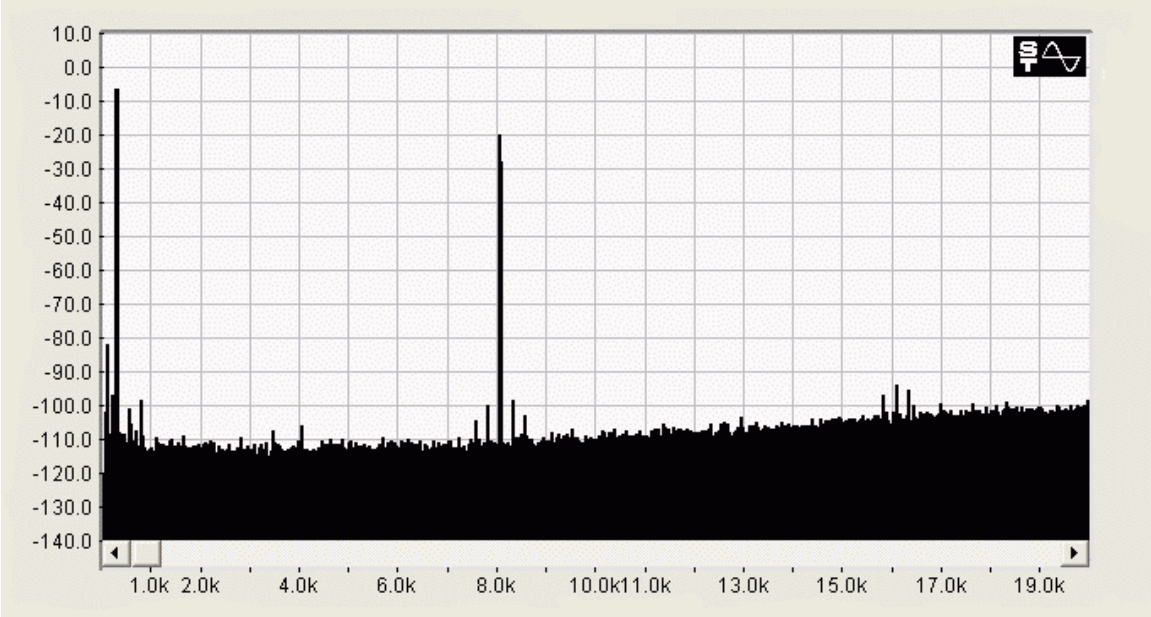


Figure 11: While in the case of AD844 opamp the intermodulation distortion practically was not noticed above the noise floor, here, as expected, intermodulation distortion products became visible. SMPTE/DIN IMD is 0.007%.



In fact, it is not a big problem to make the DAC with ultimate specifications. Unfortunately, though it is not really just a reason for puh-puh, the usage of the feedback at this place apparently have some intrinsic problems. Soundwize at least. Now if we won't feedback here, we lose the chance for the cheap way to the good specifications. However, at what levels static non linear distortion becomes audible and/or can influence the final sonic results? I tried to make one contribution to the answer to this question and I have brewed some files which may be helpful. They are in my site's files area, within the part "Audibility of low level signals and harmonic distortion".
http://users.verat.net/~pedjarogic/audio/files/files.htm
