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MAX436 based non-feedback I/V stage for TDA1541(A) D/A converter

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

This article is somewhat changed version of the texts originally posted here:
http://www.diyhifi.org/forums/viewtopic.php?t=347

The stage, as shown, yields excellent sonic results, however its measured performance wasn't that excellent. This somehow spoils the fun but as long as this is of concern a few fixes may be applied to get something more satisfying in this regard. In other words, consider the following design a very good principle (that works practically and sonically) but also an idea that can be improved.

As I've mentioned earlier, MAX435 and MAX436 are among a few chips that can be used as a basis for the I/V stage without applied feedback. Almost all the info needed for making the first steps was retrievable from the MAX435/436 datasheet and Maxim's Application Note #692. However, some things had to be checked to make really working circuit. And the working circuit looks as follows.

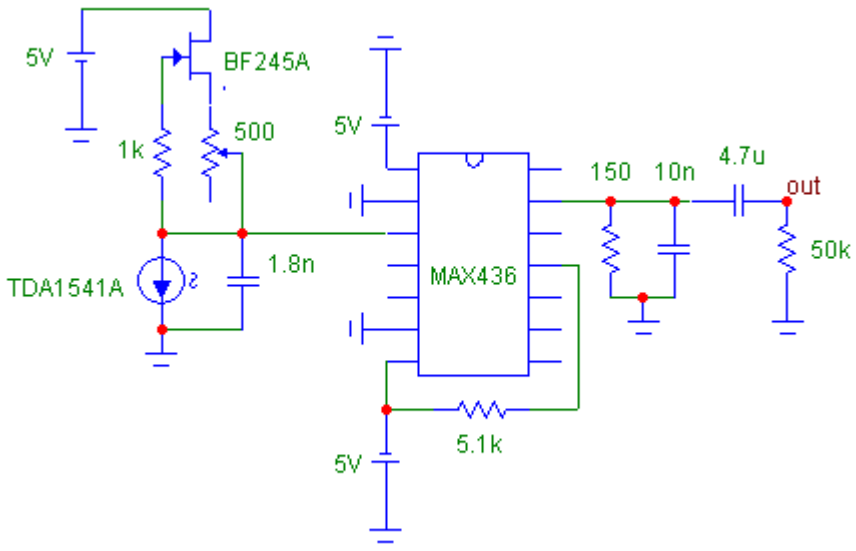

Figure 1: MAX436 applied for use with TDA1541A

All may look simple but a few notices are important. Firstly, the current gain of MAX436 in the given configuration (with pin 5 left open) is 4x, not 8x. This means that the output voltage of the shown stage is about 2.4V p-p or 0.85V RMS (and not 1.7V).

Capacitor 10nF is not only low pass filter, it was necessary to keep the circuit stable. (I've already had that 1.8nF at the input, i.e. DAC's output. I did not remove it to see if it was the cause, but raising capacitance there did not show any change so I doubt.) All is quiet without the signal but with signal (1kHz or 2kHz sinewave) there was an oscillation at 11-12MHz with the amplitude similar to the signal itself.

The first thing I did after I sorted these things out was to listen to it for a few minutes. And as much as I was pleased with what I've heard, I was disappointed with distortion measurements taken afterward. THD was pretty high 0.68%, though it was mainly a second harmonic and others were generally of even order (figure 2). Yet there were other obvious signs of non linearity. So yes, listening to it I was completely unaware of this though having it in mind later I could recognize some "noisy" moments. These however don't occur too often and are related mainly to the female voices.

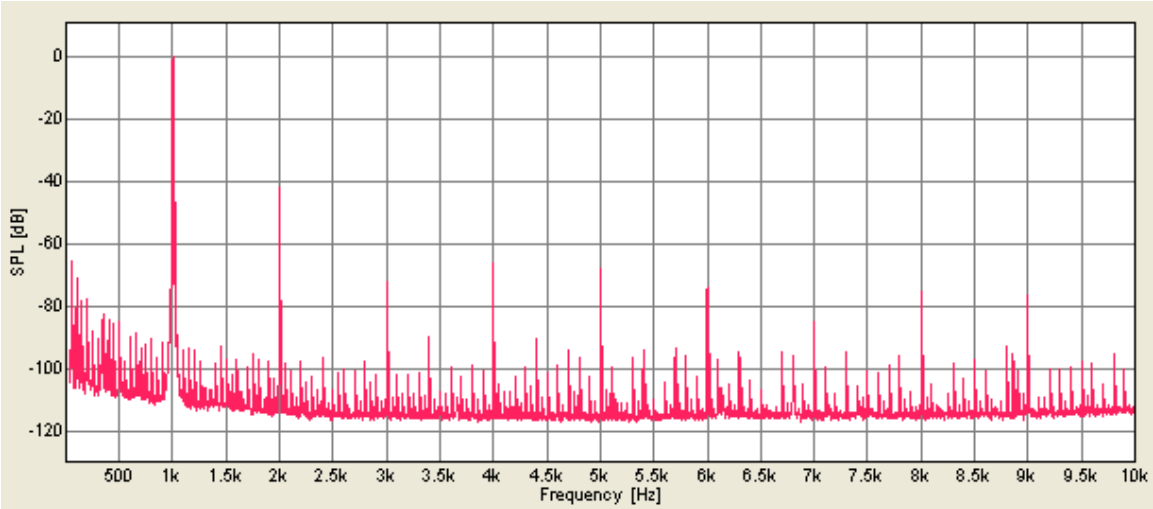

Figure 2: Harmonic distortion @ 1kHz and 0dBFS

There are at least *two ideas* that should be taken in consideration if lowering this distortion figure is a goal. One is associated to the supply used and which also did not employ feedback and had conventional Darlington like an output, or in other words, which had relatively high output impedance. This impedance, combined with variations of the current will normally result in the modulated supply voltage. Variations of the current at MAX436's positive rail are not huge (though exist), however at negative rail they are (can't now remember exactly but it is about tens of mA). The first option was to put somewhat more capacitance here (originally there was 22uF mounted on every chip and one pair of regulators fed both chips) to help lowering this impedance somewhat within the audio band. As the figure 3 shows, one additional 470uF brought the figure down to 0.5%. This improvements is not dramatic but is certainly visible and considering it was only knocking on the door of the low impedance area, I'd say the result is good enough so anyone considering MAX436 should go rather with supply designed with low output impedance like a priority.

The other idea... Because of its inputs, MAX436 may be better suited for differential output DACs. If fed that way, I'd expect lowered even harmonics, which dominate here. Results may be good, but for now it would be on someone else to try and report back the results. (In that case, if needed, MAX435 will provide differential output as well.) Also, note that going differential the power supply modulation caused by each half will tend to null each other somewhat thus also fixing the firstly

mentioned cause of non linearity, so demand for the low impedance supply in this case might not be that rigorous like with single end configuration.

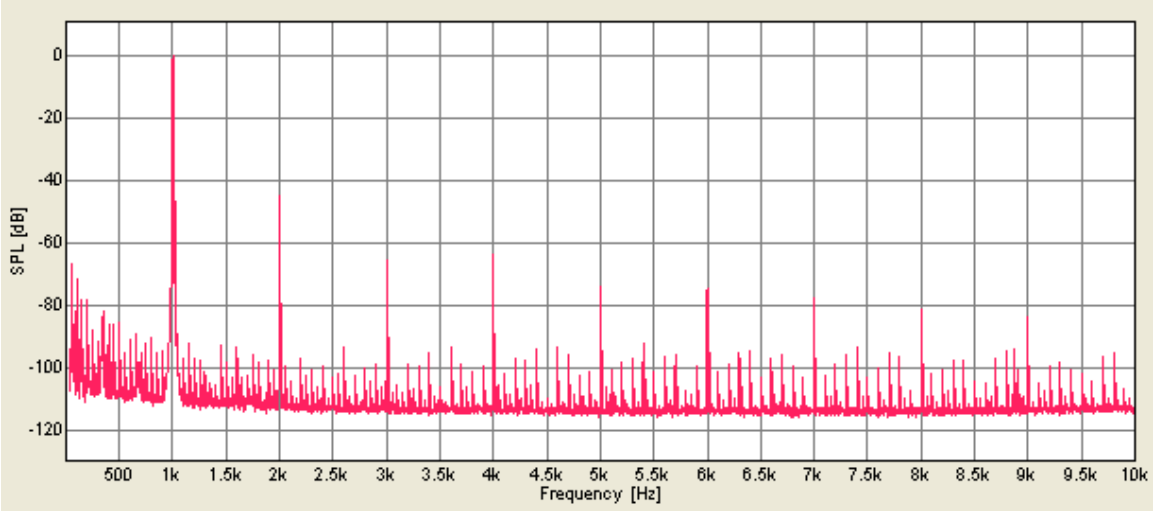

Figure 3: Harmonic distortion @ 1kHz and 0dBFS with somewhat lowered negative supply impedance

But why again a chip when we can make something discrete yet without feedback and get better results? I suggest everyone too look for own conclusions but I personally, even after I've made one discrete non-f/b stage with 0.003% THD and just making another for which I believe will be better in this regard, still wouldn't easily abandon them. And still not only for practical reasons. However, and though I am convinced that it wouldn't be a problem in the technical terms, apparently none semiconductor manufacturer is interested to produce chips really designed for such purpose, i.e. for I/V that doesn't employ feedback. For whatever its worth, (very kind) people from Maxim have told that the distortion measurements of these chips were never taken in the factory and they don't consider such (simple) circuit without feedback appropriate for audio purposes.

The stage, as shown in the schematic above, inverts the polarity, which is here needed. It will work also with DAC plugged to the pin 5 in which case the phase stays unaltered. Though the SPICE model provided by Maxim will tell the phase changes when the signal is plugged to the pin 5. The same model will also tell the current gain of such set up is 8x while in reality it is 4x. It will also say the thing won't work with signal sent to pin 3, i.e. as shown here. In other words, offered SPICE model is not really usable for needs like this.