Measuring Total Harmonic Distortion(thd) - a simple approach

1. The Objective.

Following the building of a few power amps, some from published circuits and some from scratch, curiosity dictated the need to find what sort of harmonic distortion these amplifiers produced. There are a few different types of distortion of interest to amplifier designers, such as intermodulation distortion(IMD) and noise distortion, but this is a fairly rudimentary exercise and is limited to harmonic distortion.

Having built a number of Nelson Pass's amplifiers, and read the accompanying background, curiosity was further fired with the discussion that revolved around preference for certain types of harmonic distortion. It would seem that some people prefer 2nd harmonic whilst others prefer 3rd. The predominance of one or the other would seem to give a different presentation.

2. The Method

From research it would seem there are a number of methods for determining harmonic distortion level, chief amongst them seemingly to purchase a purpose built distortion analyser such as HP333A. In its most basic form the same can be achieved by applying a notch filter to isolate the harmonic frequencies.

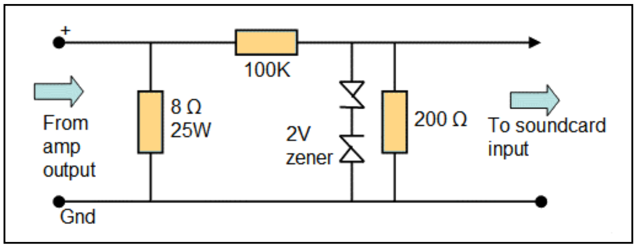
This exercise relates to a budget approach and uses a pc, soundcard, studio recording software, and FFT spectrum analyser.

No matter which approach, the method involves presenting a clean sine wave to the amplifier and measuring the output of the amplifier at the fundamental frequency together with the output at all the harmonic frequencies. By summing the power of all the harmonics, the percentage relationship to the fundamental can be determined. It is this percentage relationship figure which seems to be favoured in the advertising for mainstream amplifiers.

3. The Signal

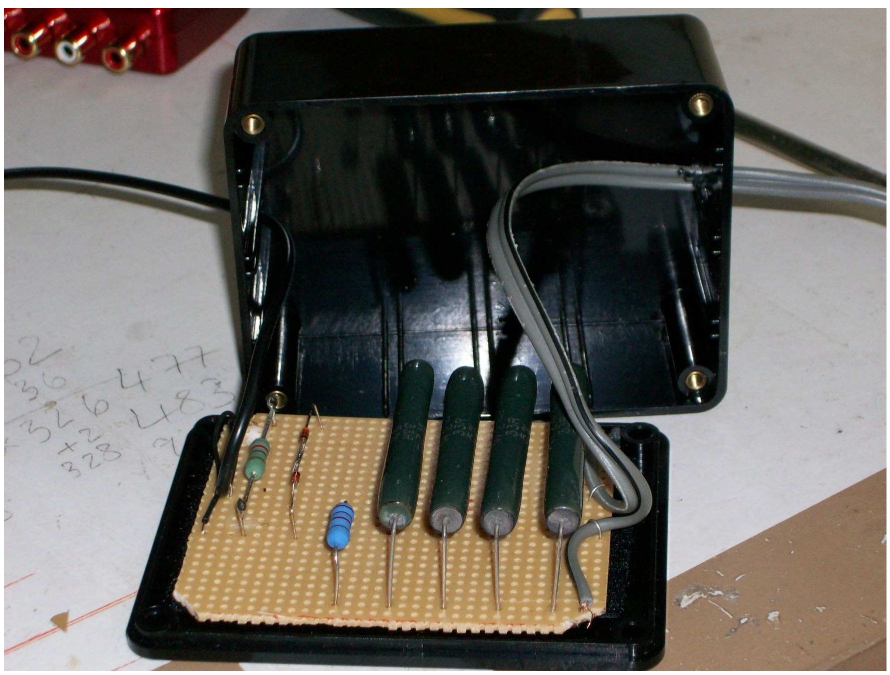
Initially it was decided to build a clamp/buffer to attenuate the output from the amplifier, prompted by reading various reports explaining how easy it was to fry a sound card. It proved difficult to find a standard or even any input specs for sound cards in regard to voltage tolerance, so the question was put on the Diyaudio forum.

A usable approach seemed to be this, recommended by SveinB.



The above circuit is configured for microphone input.

The voltage divider was configured to produce 0.775vrms(representing 0db) when the output from the amplifier was 2.83vrms(1watt), which seemed a good starting point. The voltage divider used was 2k2 and 820R with 2.4v zeners. This seemed to present ample protection for even the most timid of soundcards.



A future enhancement to the buffer is planned, to incorporate a switchable voltage divider. This would allow input voltages of 4, 4.9, 5.65, 6.33 etc, representing the amplifier output at 2, 3, 4, and 5 watts. Further, it has been suggested that the zener clamp may itself introduce a factor of distortion. Future testing will involve measurement without the zener diodes in place.

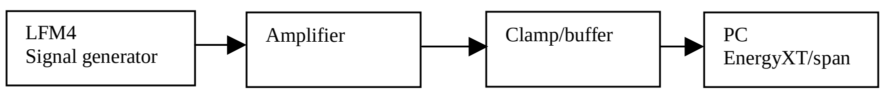
4. The Measurement.

The pc originally earmarked for the exercise was that used for studio recording, principally because it had a high spec digital interface. This was the reason for wanting a clamp. In reality the discovery of a usable USB audio interface allowed a cheap Samsung netbook to be used.

The soundcard/interface used here was the Behringer UCA222 [ref1]which came bundled with free recording software. The UCA222 unit seems to work better with the ASIO4ALL [ref2]drivers, but this may vary from machine to machine. The free recording software, energyXT[ref3] works perfectly well as the host for the spectrum analyser. It should be noted that any recording software should be capable of running this spectrum analyser providing it can support the VST plugin standard[ref4] and at the same time allow hardware monitoring.

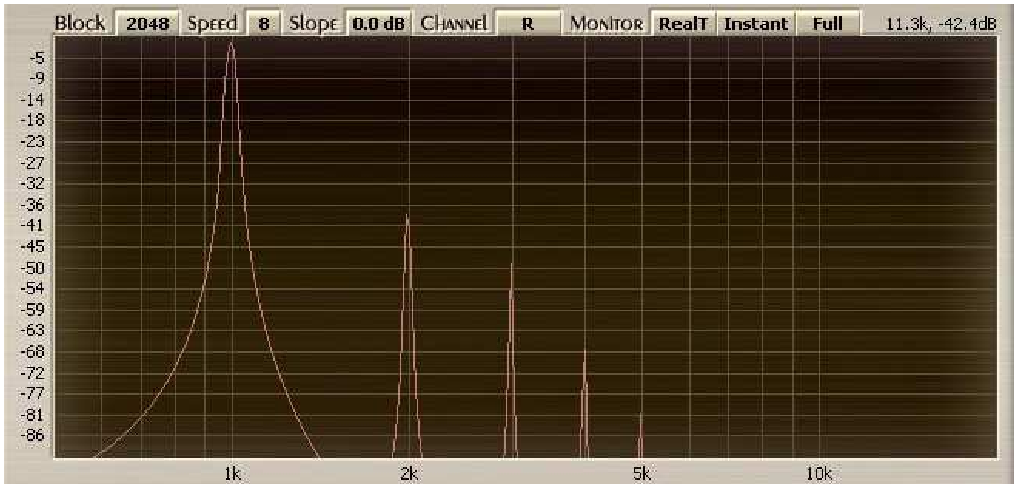
The analyser used here was the VST plugin 'span' produced by Voxengo[ref5] which proved more than adequate for producing the required rudimentary graph. To make life super easy, a version of the span plug-in is also provided in the Behringer bundle.

The measurement chain:



With the set-up described and shown here

The following graph was produced



5. The Calculation

Using the previous graph as an example the following readings were extracted:

F2	-39dbu	0.008vrms
F3	-49dbu	0.002vrms
F4	-68dbu	0.0003vrms
F5	-81dbu	0.00006vrms

The Db figures were converted into Vrms using the conversion calculator found here: [ref6]

The voltages were squared and added together and the square root of the result was obtained.

The relationship of this result to 0db voltage was then deemed to be the percentage thd figure. In this example 1.06%.

A detailed explanation of this calculation can be found on wikipedia at the following location: [ref7]

6. Conclusions

It is considered that the precision of the equipment used here is probably not going to compete with a dedicated distortion analyser. However, for the purposes of this exercise, roughly determining the percentage thd and highlighting the type(i.e 2nd or 3rd etc) is thought to be perfectly adequate in terms of precision.

It is worth noting that similar results could probably be obtained on an even tighter budget by substituting the signal generator for a software version. Using a software signal generator may introduce its own harmonic distortion in which case it may produce less accurate results.

7. References.

Ref1: http://www.behringer.co.uk/EN/Products/UCA222.aspx
Ref2: http://www.asio4all.com/
Ref3: http://www.energy-xt.com/
Ref4: http://en.wikipedia.org/wiki/Virtual_Studio_Technology
Ref5: http://www.voxengo.com/
Ref6: http://www.sengpielaudio.com/calculator-db-volt.htm
Ref7: http://en.wikipedia.org/wiki/Total_harmonic_distortion