Cohen 3-4 Ratio
A method of measuring distortion products.

Graeme John Cohen July 2008. Adelaide, Australia

Introduction:-

Common methods of measuring distortion is usually by measuring total harmonic distortion or sometimes intermodulation distortion. (Distortions such as transient, slew induced, overload etc are not part of this note).

More use of spectrum analyzers allows a detailed look at the various distortion products. (The sweep oscillator, and suitable use of computers and sounds cards makes for a simple spectrum analyzer for audio use).

By using a ratio of two filtered tones, a simple means is available to analyze individual distortion components. The technique to be described can be used to analyze very low level individual components even if the original two tone signals do not have distortion components as low as would be desired.

Technique:-

- By using two frequencies of a ratio of three to four, second and third order products for both harmonic and intermodulation distortion can be observed simultaneously. This could well be 3 and 4 Kilohertz for audio (or 6 and 8, or 12 and 16 KHz) or up to say 3 and 4 Gigahertz for microwave etc.

- Using two frequencies of say 3 and 4 KHz at audio frequencies it can be shown that second harmonic and third harmonic and also second order and third order intermodulation distortion products can be seen on a frequency scale from approximately zero hertz to ten Kilohertz on the same scale. This is shown in Figure 1.

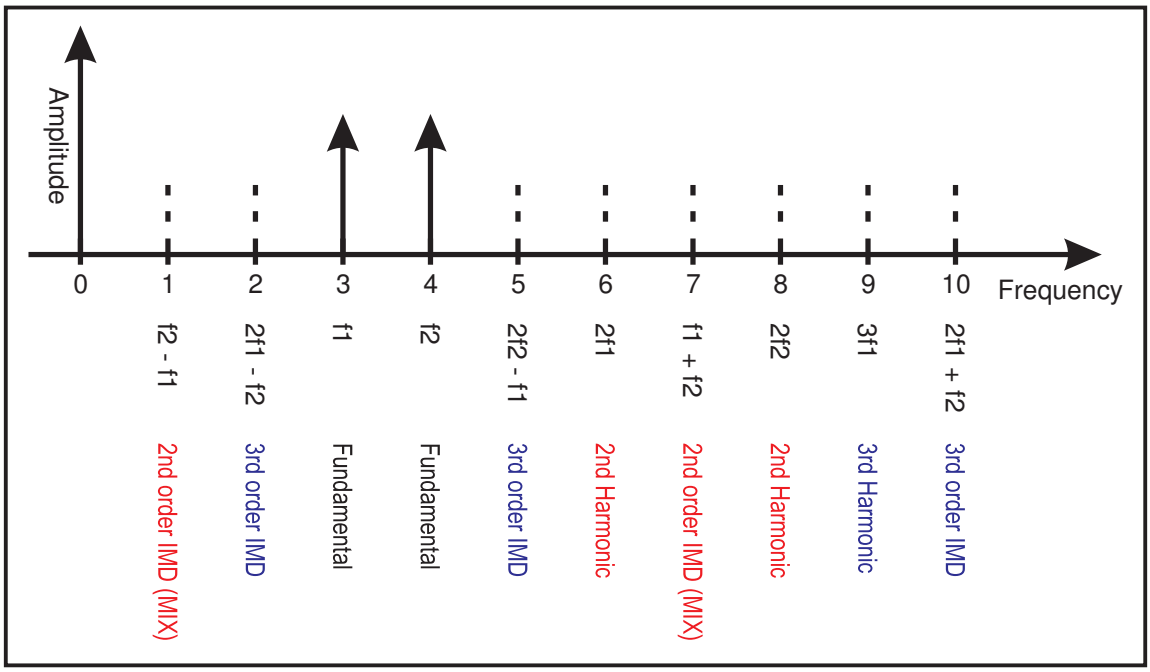


Figure 1.

- The second and third harmonic of the 3 KHz tone (6 KHz and 9 KHz) can be shown and also the second harmonic of the 4 KHz tone (8 KHz) can be seen.
  Also the intermodulation (beat) frequencies at 1 KHz either side of the two tones can be shown (2 KHz and 5 KHz). And another intermod is seen at 10 KHz. These are all third order IMD's. Again see figure 1. Also the mixing products (sum and difference) frequencies can be seen at 1 KHz and 7 KHz.

- There are many other higher order products that are generated by simply using these tones or frequencies in this simple ratio. However it can be demonstrated, and simply proven by experiment, that the higher order complex modifications to this simple useful concept do not in fact cause an undue modification to the basic analysis described.

- By experiment it has been shown that the simple concept shows that the second and third order IMD's are related to the second and third order harmonic distortion products. It is therefore possible to gain a knowledgeable grasp of the 2nd and 3rd distortion products by simply observing 1 KHz, for 2nd order, and 2 KHz, for 3rd order products. It is then possible to use only a 5 KHz span for 3 KHz and 4 KHz to see the second order 1 KHz and third order 2 KHz frequencies.

- A block diagram of the set up used is shown in figure 2. It is essential to isolate the two signal sources and prove integrity before testing sample.

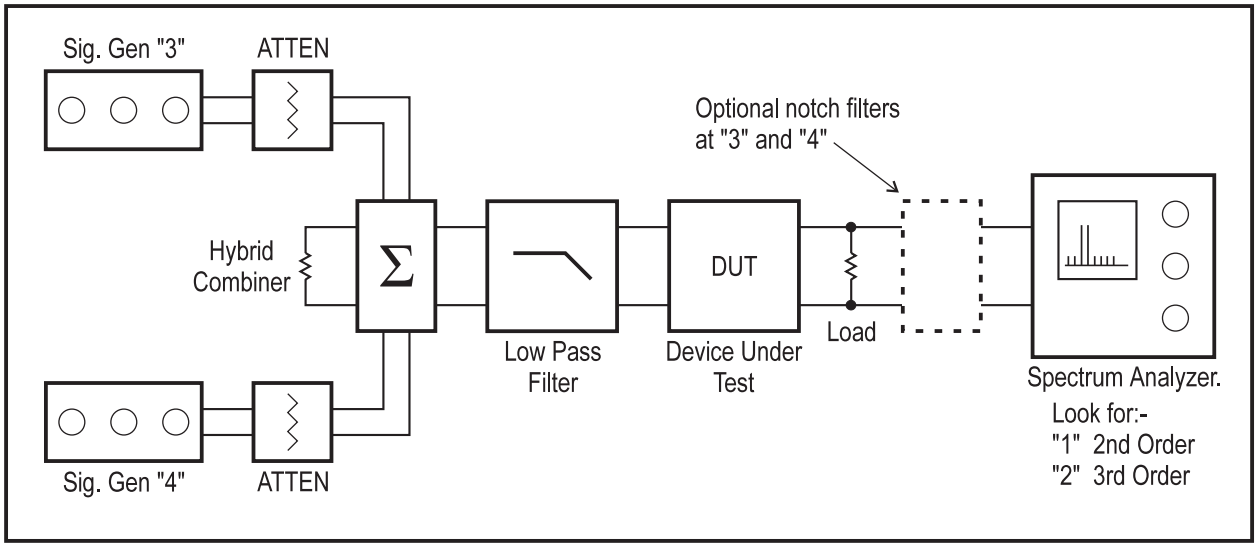


Figure 2.
Cohen 3-4 Ratio. Test Set up.

- The frequency plots (Figures 3 - 5) show the results from different type of sample amplifiers, some single ended and some push pull. It can be seen the tracking of 2nd and 3rd order IMD's to 2nd and 3rd Harmonics.

- A major benefit of this approach is that the harmonics of the two signal sources do not have a major influence.

- Optional notch filters inserted at the input of the spectrum analyzer and tuned to 3 KHz and 4 KHz can enhance the dynamic range of the measurements.

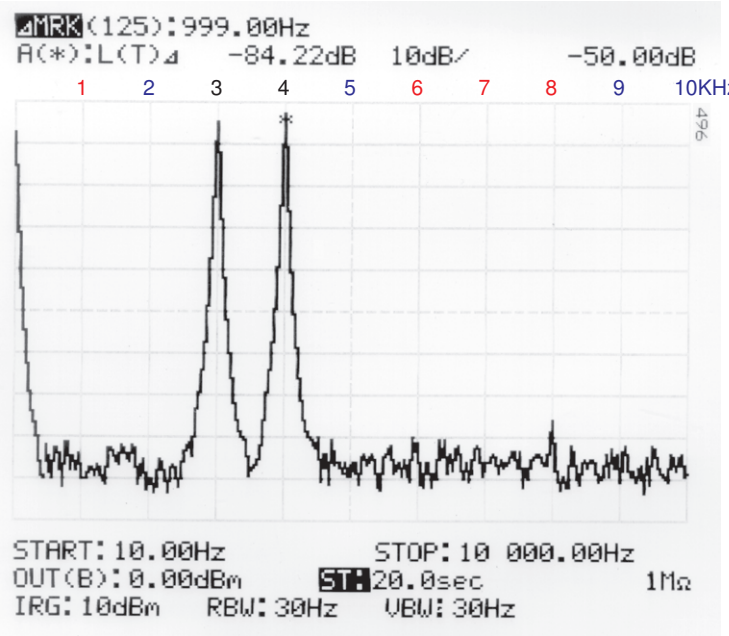
Some of the test equipment now in use as well as wideband CRO;

For IMD measurement & Plots:
Anritsu Network/Spectrum Analyzer MS420B, 10Hz - 30MHz.
2 off Level Generator MG442A with separate combining/filter unit.

For harmonic and noise figure measurements:
Boonton Audio Analyzer 1120, 10Hz - 140KHz

For DC and offset measurements:
7 1/2 digit DVM

Graeme John Cohen
20-7-08
Australia.



Red: 2nd harmonic & 2nd order IMD's
Blue: 3rd harmonic & 3rd order IMD's

Figure 3.
Residual distortion of test setup only.

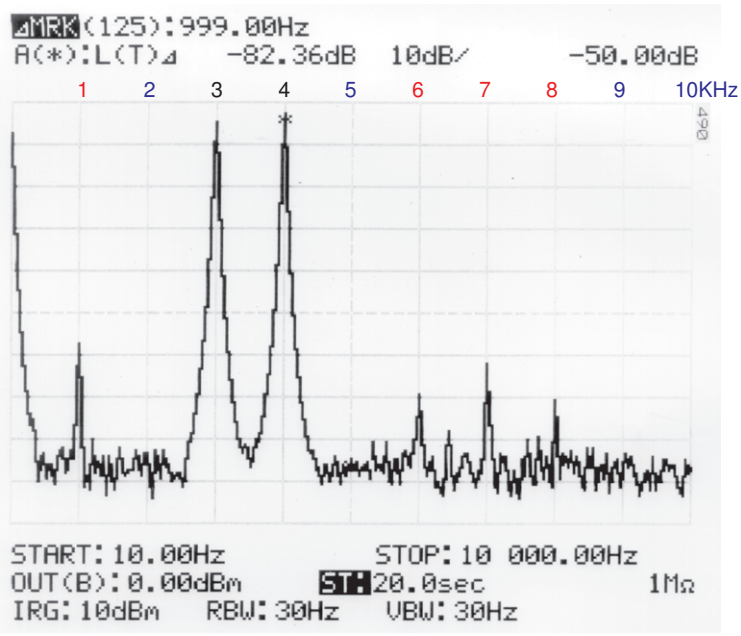


Figure 4.
A grounded grid valve amp showing second harmonic and second order IMD's at similar levels

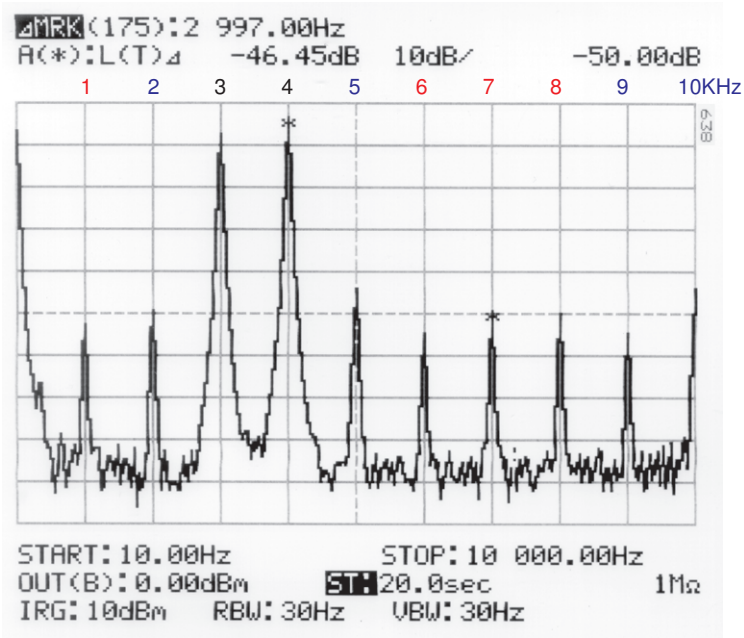


Figure 5.
A solid state amp, showing second harmonic, second order IMD's and 3rd harmonic, 3rd order IMD's at similar levels.

Papers by Graeme J. Cohen.

Technical Papers (Radio)

▷ *Precision RF Channel Development for High Performance HF Systems*
Presented at the Fifth International Conference of Radio Receivers, York University, UK, 1994
(co-author: Winkler, C.)

▷ *Linear Wideband Receiver System*
Presented at the Sixth International Conference of Radio Receivers, Bath University, UK, 1995

Technical Papers (Audio)

▷ *Double Balanced Microphone Amplifier*
Presented at the 1984 Australian Regional Convention of the Audio Engineering Socity (AES), Melbourne, Australia. Preprint 2106.

▷ *A Music Amplifier - A New Approach*
Presented at the 1988 2nd Australian Regional Convention of the AES, Melbourne, Australia. Preprint 2677.

▷ *A Pulse Test Method for Amplifiers*
Presented at the 1991 3rd Australian Regional Convention of the AES, Melbourne, Australia. Preprint 3087.

▷ *A Balanced Analogue Optical Coupler*
Presented at the 1991 3rd Australian Regional Convention of the AES, Melbourne, Australia. Preprint 3089.

▷ *Linear Output Stages*
Presented at the 1993 4th Australian Regional Convention of the AES, Melbourne, Australia. Preprint 3674. Also published in: Glass Audio, Vol. 7, No. 6, 1995.

▷ *Transmission Line Audio Transformers*
Presented at the 1993 4th Australian Regional Convention of the AES, Melbourne, Australia. Preprint 3692. Also published in: Glass Audio, Vol. 7, No. 5, 1995.

▷ *Beam Control Amplifier*
Presented at the 1995 5th Australian Regional Convention of the AES, Sydney, Australia. Preprint 4026.

▷ *Dual Single Ended Amplifier*
Presented at the 1995 5th Australian Regional Convention of the AES, Sydney, Australia. Preprint 4028. Also published in: Glass Audio, Vol. 8, No. 3, 1996.
This concept is patented.

▷ *Split Cascade Microphone Amplifier*
Presented at the 1996 6th Australian Regional Convention of the AES, Melbourne, Australia. Preprint 4296.