Rub & Buzz and Distortion measurement

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Introduction

Measure Rub & Buzz and distortion with K & K International test systems.

In following document a P900 test system is used as an example how to setup and measure and test Rub & Buzz and distortion.

This document can be used as inspiration to setup and use older test systems from K & K International.

To measure Rub & Buzz and distortion different filter technologies are used.

P900 have 4 main display channels. Channel A, B, C and D. Secondary curves and tests can be displayed on each display.

Channel A main display is used for frequency response.
Channel C main display is used for impedance.
Channel B and D main display are normally used for Rub & Buzz measurement.

To measure distortion on a loudspeaker a sine is used. To cover the whole frequency range P900 make use of a swept sine.
Distortion measurements have focus on higher harmonic signals generated out from a test signal. THD (totally harmonic distortion) is a method to measure distortion. However the 2th and 3th harmonic is normally much bigger than the distortion element called rub & buzz. The rub & buzz make the loudspeaker sound bad even with accepted THD.

Before understanding how to use the type of filter and the settings it is necessary to understand how the human ear react on the sound.

Behaver of hearing

The sensitivity of the ear depends of the sound pressure and of the frequency.
Figure 1 show loudness contours of hearing. The most sensitive range for hearing is in the frequency range of 200 to 10 kHz. The sensitive decrease below 200 Hz. The loudness changes with the sound pressure. The red curve at the bottom is the threshold of hearing

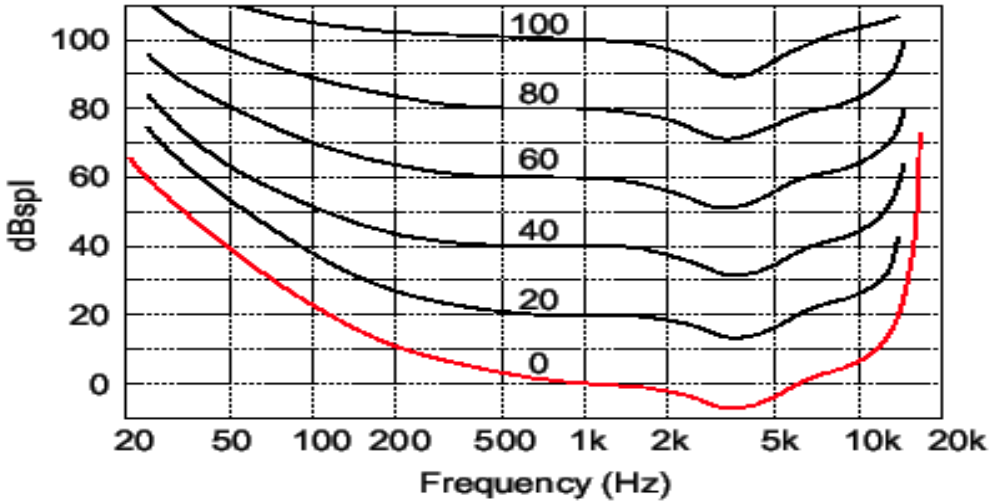

Figure 1: Equal loudness contours (Zwicker and Fastl, 1999).

Furthermore human ear have a threshold to detecting different signals. To detect this threshold two sine signals are used. Figure 2 show this threshold. Note that the threshold masking depends of sound pressure.

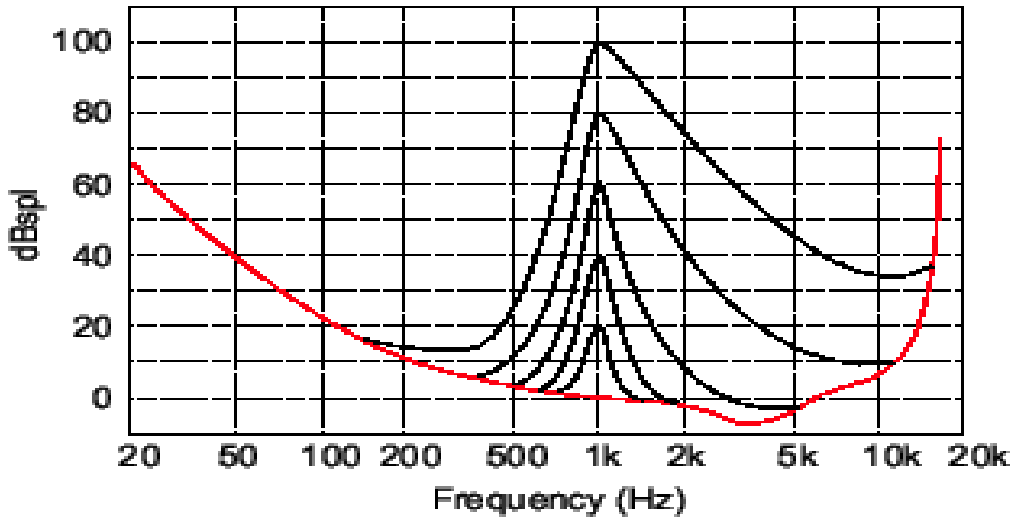

Figure 2: The threshold of detections caused by a masking noise with a bandwidth equal to the critical bandwidth with a centre frequency of 1 kHz and various levels (Zwicker and Fastl, 1999).

Setup P900 for Rub & Buzz

P900 have Run, Setup, Global and Utility menus. Use the Setup menu and select at test or generate a new test setup. Figure 3 show a setup for a test called ‘rub_a’.

Figure 3

In this example a frequency range from 20 to 20000 Hz is selected. Under Filter channel B and Channel D is selected as a type of TRK-HP and a Fix-HP. In the following example the loudspeaker is placed in a free field and with the microphone placed in the nearfield. The selection of filter types is explained later.

With this setup a measurement is done with an accepted reference speaker.
Figure 4 show following 4 graph display for the measurement.
Channel A at left top is the frequency response for the speaker.
Channel B at right top is a Rub & Buzz measurement with TRK-HP filter.
Channel C at left bottom is the impedance measurement.
Channel D at right bottom is a Rub & Buzz measurement with FIX-HP filter.

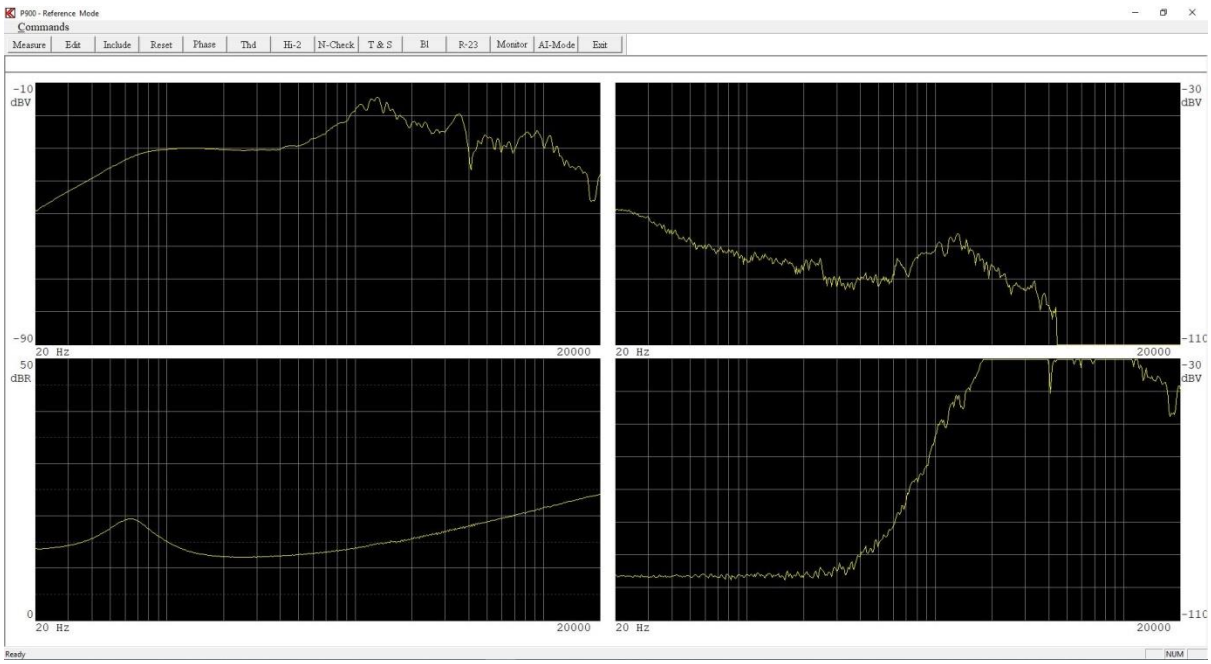

Figure 4: Channel A, B, C and D for an accepted reference speaker

In the following examples a FFT is enabled to show this reference speaker together with a rejected unit of same type. To enable the FFT go to “Edit” and select the “Spectrum”.

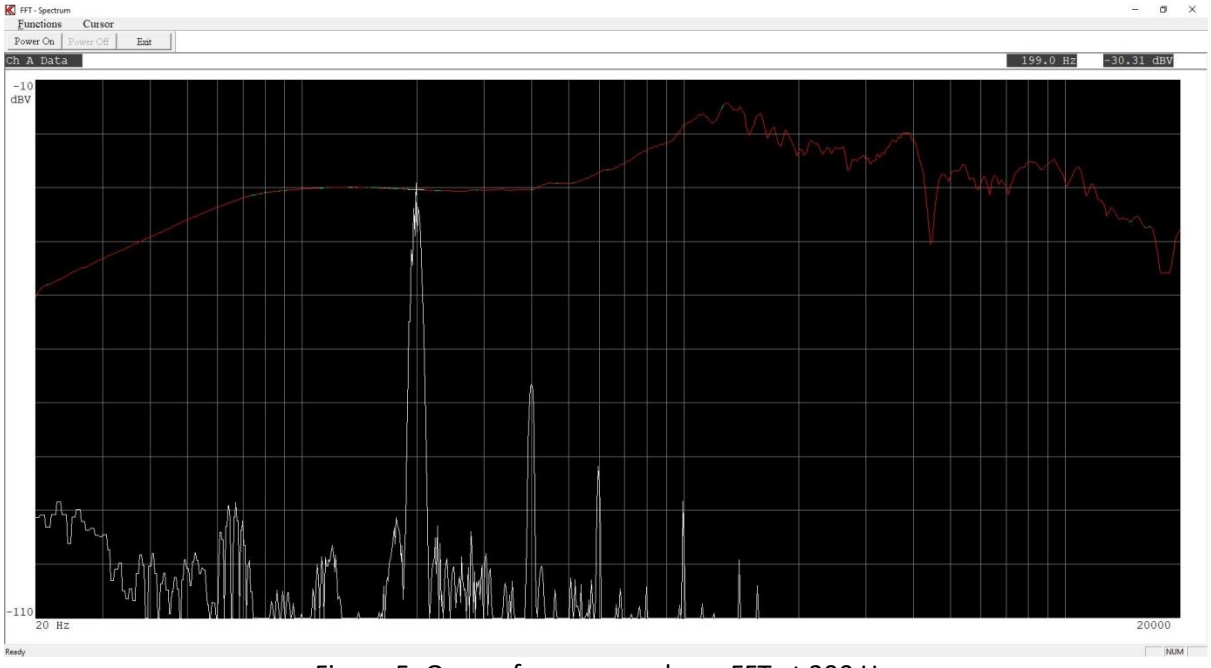

Figure 5: On a reference speaker a FFT at 200 Hz.

Figure 5 show the reference unit with a FFT at 200 Hz. Note the harmonic signals generated and dominating is the 2th harmonic @ 37 db below 200 Hz level. The 3th harmonic is 52 db below and the 5th is 58 db below the 200 Hz level. Due to the 2th and 3th normally is dominating often the 2th and 3th together is the THD value.

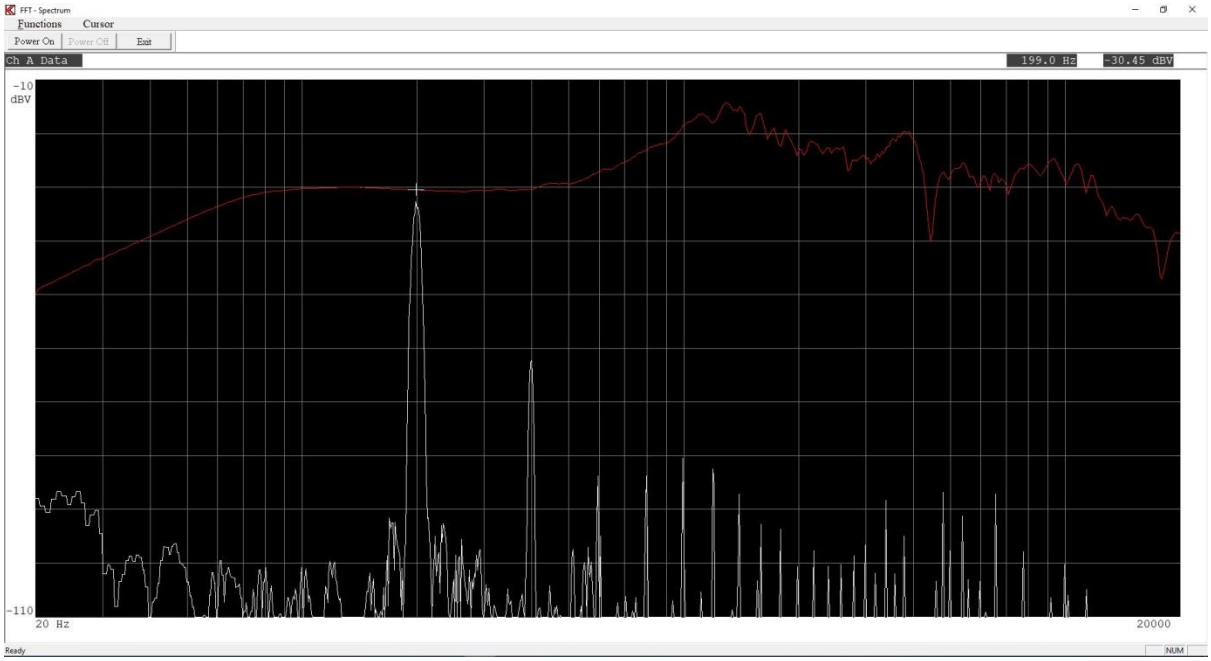

Figure 6: On a bad unit same type as the reference speaker FFT at 200 Hz.

Figure 6 show a bad unit of same type as the reference speaker.
When comparing the reference and the bad unit a lot harmonic signals are generated higher than the 5th harmonic. A way to collect all the signals higher than the 5th harmonic is to use a high pass filter and sum all the harmonic signals together.

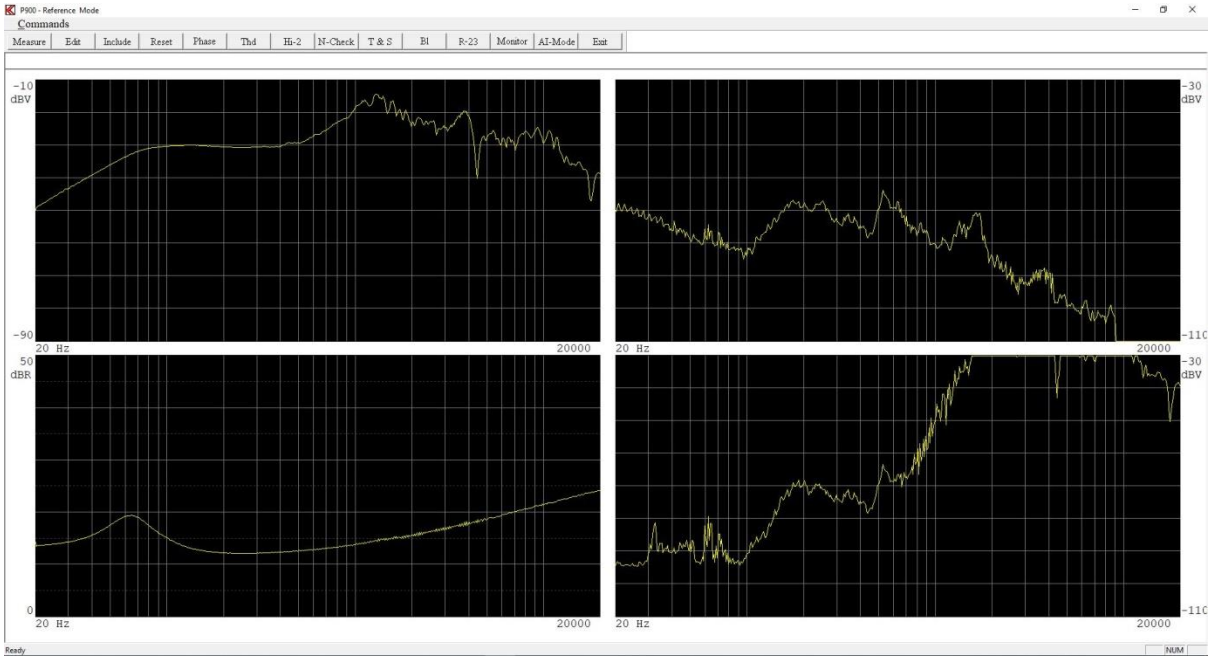

Figure 7: Channel A, B, C and D for a bad speaker.

The figure 7 shows the measurement for a bad speaker unit. The setup is the same as figure 3. The reference see figure 4 and compare with figure 4, 6 and 7. The channel B is the measurement with a TRK-HP filter. Channel D make use of a FIX-HP filter.

TRK-HP

The TRK-HP, Tracking High Pass filter is a high pass filter there has same distance from the output frequency, the first harmonic, to filter high pass corner. This filter is a general purpose filter to detect Rub & Buzz. Figure 5 and 6 a filter harmonic at 5 or 6 will optimise a measurement. Note that the distance from speaker, the sound source, and microphone give a delay of measurement due to movement of sound. The measurements for every point of sine tone on speaker and the sum of signals from the filter are displayed at the first harmonic position, the sound source. Example if the signal is 1 kHz and the TRK-HP filter is set to 5 harmonic the measurement is displayed at 1 kHz. Due to the signal delay care must be taken to not make a sweep to fast. The sweep time depends of the start frequency. Note there are big differences to sweep forward as normally to sweep backward.

The filter has an upper limit. The upper limit frequency for P900 is 22, 34, 45 or 52 kHz. If the sample frequency is below 192 kHz the limit is 22 or 45 kHz.
For a woofer it is recommended to use the 22 kHz limit. The background noise is depending of the band with. A limit of 52 kHz collect 2 times more noise up than a limit of 22 kHz, however normally the noise is not linear and rise more with the increase of bandwidth.
For tweeters limit frequency of 45 or 52 kHz can give a better result.

In practice the TRK-HP filter setting to 5 harmonic will work in the most case.

FIX-HP

A FIX-HP filter is a filter there do not track, it do not move. A filter has a settling time when selected. A Tracking filter has a dynamic range there depends on how fast the filter are changed before it is used due to settling time of filter. A fixed filter do have a settling time however it is only first type the filter is setup.
P900 can have up to 500 different measuring points. So a tracking filter can be setup up to 500 times for a sweep. The FIX-HP filters have on one setup. For that reason a higher dynamic range.

The FIX-HP filter is designed to detect problems with woofers or speakers there starts below a couple of hundred hertz.

Woofers have the biggest movement of membrane around the resonance. Many distortion elements are normally generated around this frequency. Often the distortion element has higher harmonic elements. If a Tracking filter is used some distortion elements are masked out due to higher distortion. See figure 4 and 7 and compare channel B and D.
Further figure 1 and 2 have to be studied. Distortion elements generated in the most sensitive part of the hearing can be in the range of 20 to 40 db sensitive than around 50 Hz.
For that purpose use of a FIX-HP filter is optimal.

Where to place the corner of filter frequency?
As default the filter is set to 2000 Hz. This will select all harmonic elements higher than 2000 Hz. Depending of the speaker type this frequency can be lower to collect element in the sensitive area of the ear. If so the range of the useful part of the filter will be less. With reference to figure 4, channel D (the right bottom one), the useful area for detection is below 600 Hz for the filter set to 2000 Hz. Information higher than 1000 Hz is more or less the frequency response. For midrange speakers the

filter frequency must be higher than 2000 Hz. When the filter has an increased frequency the collected information will be less.

TRK-MOD

The TRK-MOD filter is a modified FIX-HP filter. As example in figure 4 the TRK-HP filter do not have any information higher than 600 Hz with filter frequency set to 2000 Hz. The TRK-MOD filter is changing as a fix filter to a stepping high pass filter stepping with 0.25 octaves. The result is like the tracking filter but with less settling time error. For the user it looks like a tracking filter at the high end. The difference see figure 8.

Rub & Buzz examples

For Rub & Buzz measurement the best results is to using both in combination TRK-HP and FIX-HP / FIX-MOD filters. The FIX-HP / TRK-MOD filter is the most sensitive at low frequency where the TRK-HP take over at the end of sweep.

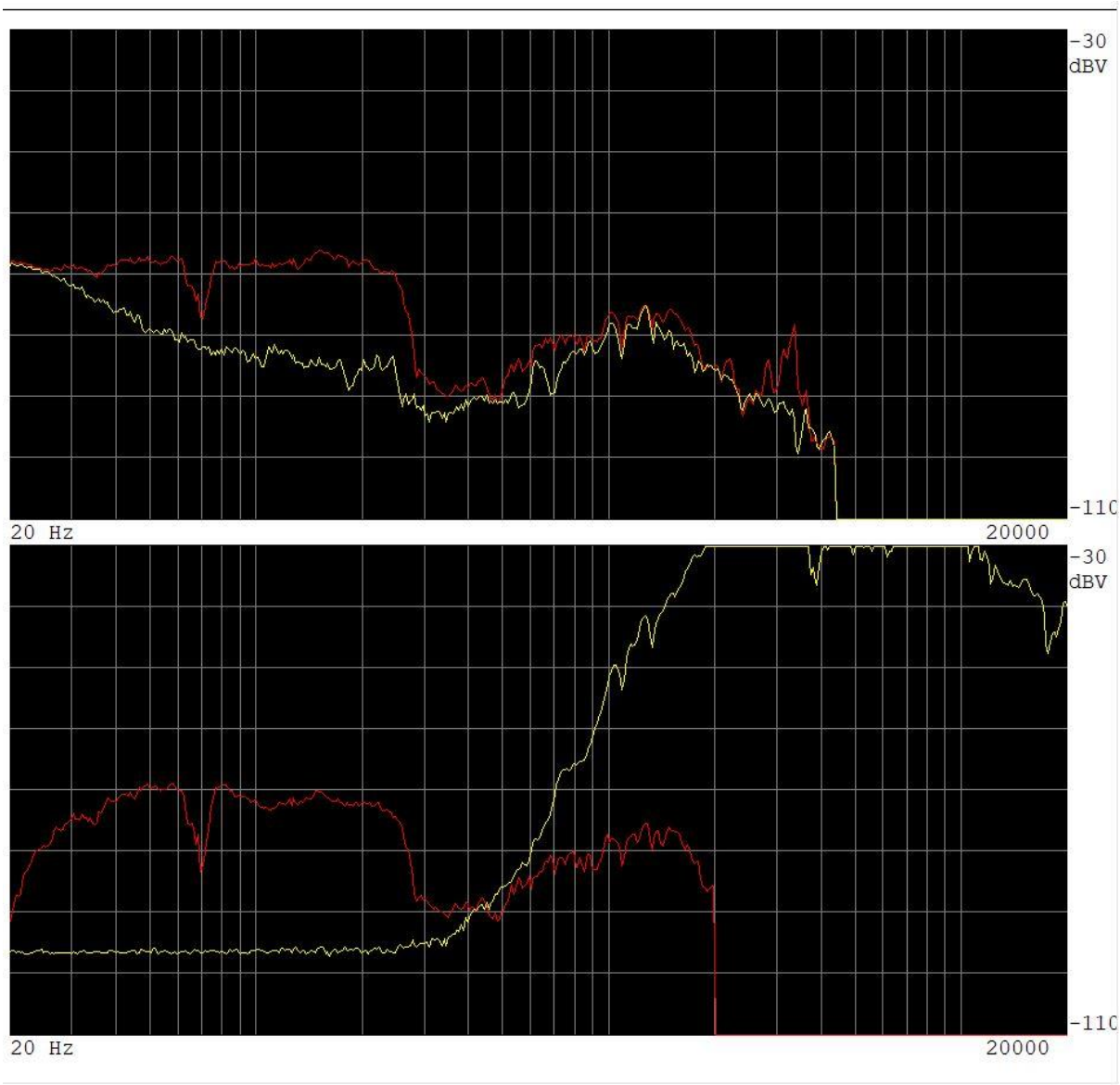

Figure 8: Rub & Buzz Ch B on the top and Ch D on the bottom.

Figure 8 is an example for a Rub & Buzz measurement where the yellow curves is a reference unit and red curves a bad unit. Channel B using a TRK-HP filter. Channel D using TRK-MOD filter. The yellow is a reference with TRK-HP. Note the difference between the two filters at frequencies higher than 400 - 600Hz.

Figure 9 and figure 10 shows same measurement of a selective Rub & Buzz with a TRK-HP and a FIX-HP filter. Note the TRK-HP filter give an indication of approximate 12-13 db, figure 9, while the FIX-HP filter, figure 10, give an indication of approximate 20 db.

Figure 9: A selective Rub & Buzz using a TRK-HP filter.

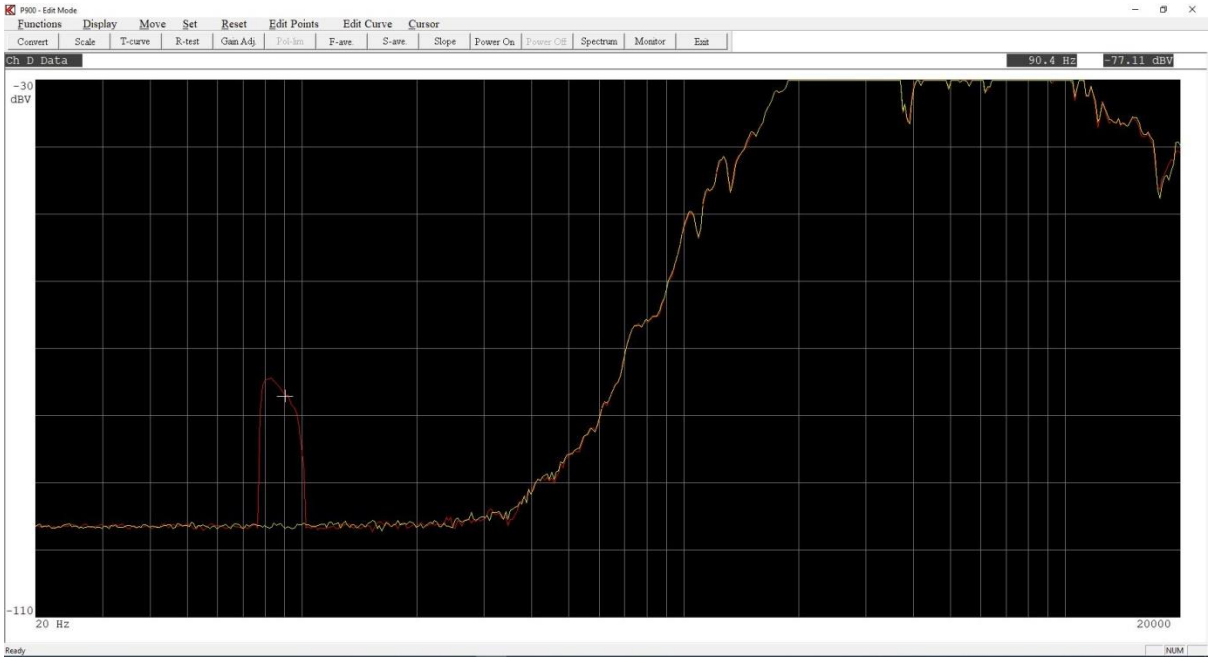

Figure 10: A selective Rub & Buzz using a FIX-HP filter.

THD

THD measurement can be done even other distortion test as Rub & Buzz measurements are enabled.

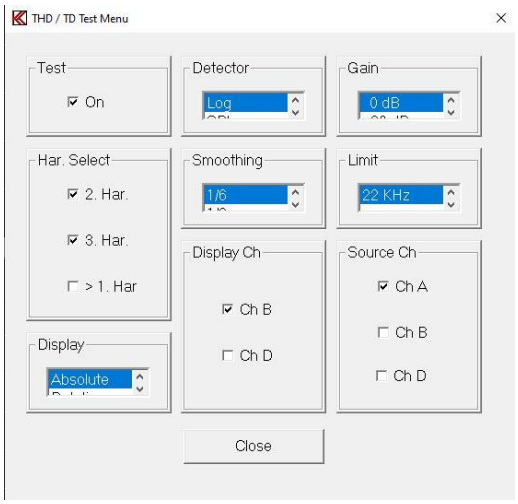

Figure 11: THD setup

Figure 11 show a typical setup for a THD measurement. The menu is found under Setup-> Reference->THD.

If as shown 2th and 3th harmonic are selected the THD measurement include the 2th and the 3th harmonic and the information between the 2th and 3th harmonic.

Another way to measure is to include all information higher than the 1th harmonic.

In the marked the THD often measured different and in some case give different result. In the past the THD was the 2th and the 3th values by using filters. THD can be 2th and 3th harmonic together only or >=2th to <=3th harmonic, or >=2th harmonic. Normally the 2th and 3th harmonics are dominating. If so all the way to measure the THD will the same, however on a bad speaker unit most likely it will give different THD results.

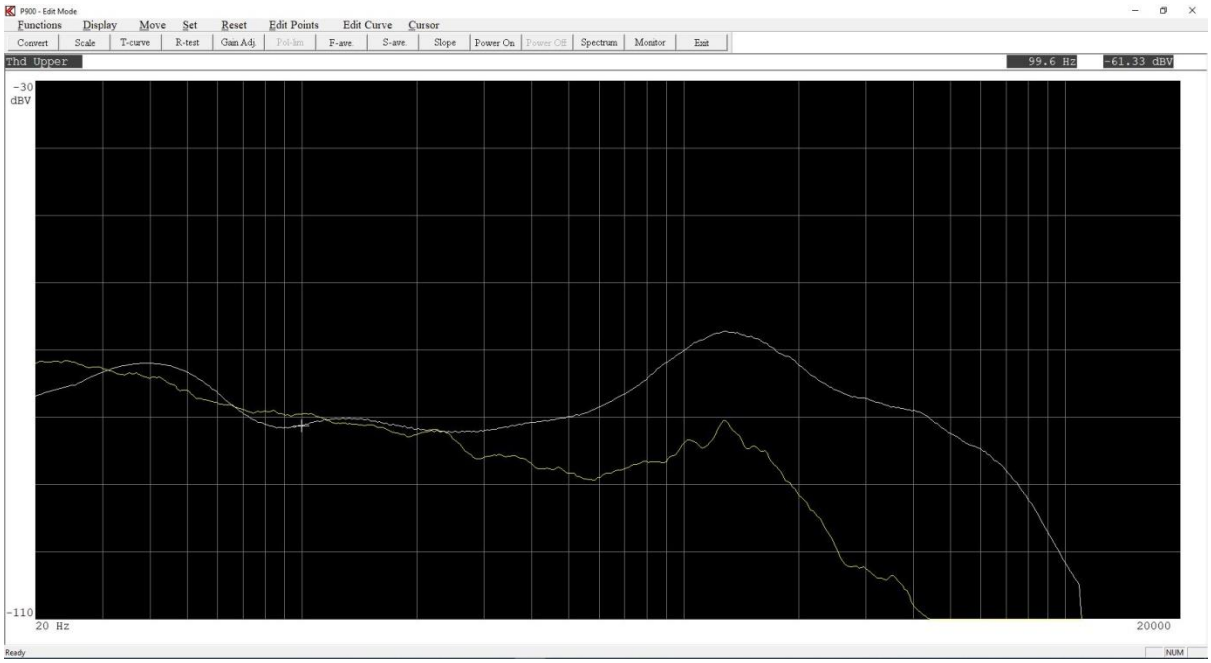

Figure 12: Channel B shows both the Rub & Buzz, the yellow and THD, the white at same time.

Hi-2

Hi-2 or often called Blat distortion. Hi-2 is a distortion test with reference to David Clark paper 950189. Shortly spoken the Hi-2 measure 2th and higher distortion elements where the higher elements are roll out with decreasing amplitudes. The result is a test where the 2th harmonic has a dominating factor.

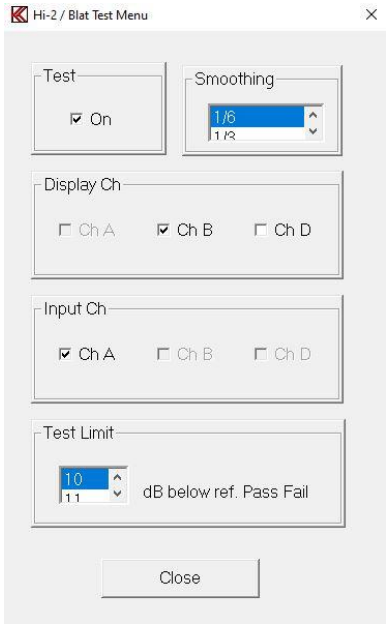

Figure 13: Hi-2 / Blat setup

The Hi-2 test / measurement can be done even other distortion test as Rub & Buzz or THD measurements are enabled.

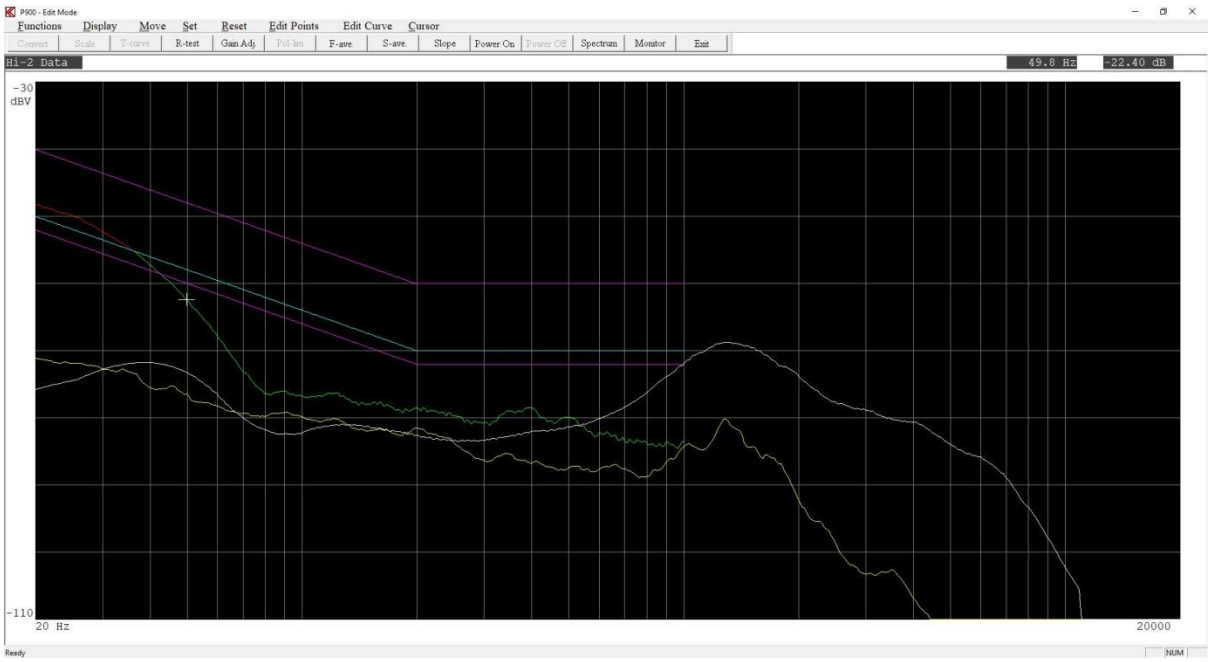

Figure 14: HI-2 measurement together a Rub & Buzz and a THD measurement.

Figure 14 show the Hi-2 limits, the violet curves, a reference Pass Fail curve. The Pass Fail curve is the upper Hi-2 curve. The Standard Target curve is 12 db below Pass Fail curve, the

lower Hi-2 curve. On P900 the test curve limit can be set from 0 to 18 db below Pass Fail curve, the cyan curve. The default is 12 db to get the Target Curve for the test, an acceptable metric. The cursor is on the Hi-2 data. In this example the test limit is set to 10 db below Pass Fail curve. Note the frequency span must a least from 20 Hz to minimum 1000 Hz.

R-23

R-23 test is a distortion ratio test. It compares some odd and even harmonic component in a ratio and as result generates a curve with a reference at -40 db from display top as reference. The range for this test is +/- 40db.

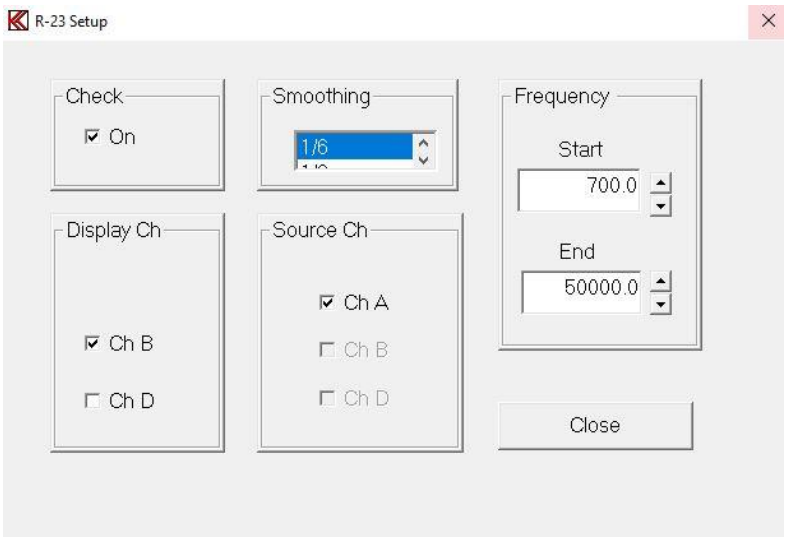

Figure 15: Setup of an R-23 test

This test can for tweeters give an indication for a speaker is defective. For tweeters a Rub & Buzz measurement have a limitation due to limit of bandwidth at higher harmonic components.

Figure 16 show a Rub & Buzz data (red), a THD reference (white) and an R-23 reference. Normally a Rub & buzz have only an upper limit, a yellow. The same for THD use normally only an upper limit, a white. The R-23 uses an upper and a lower limit, yellow limits.

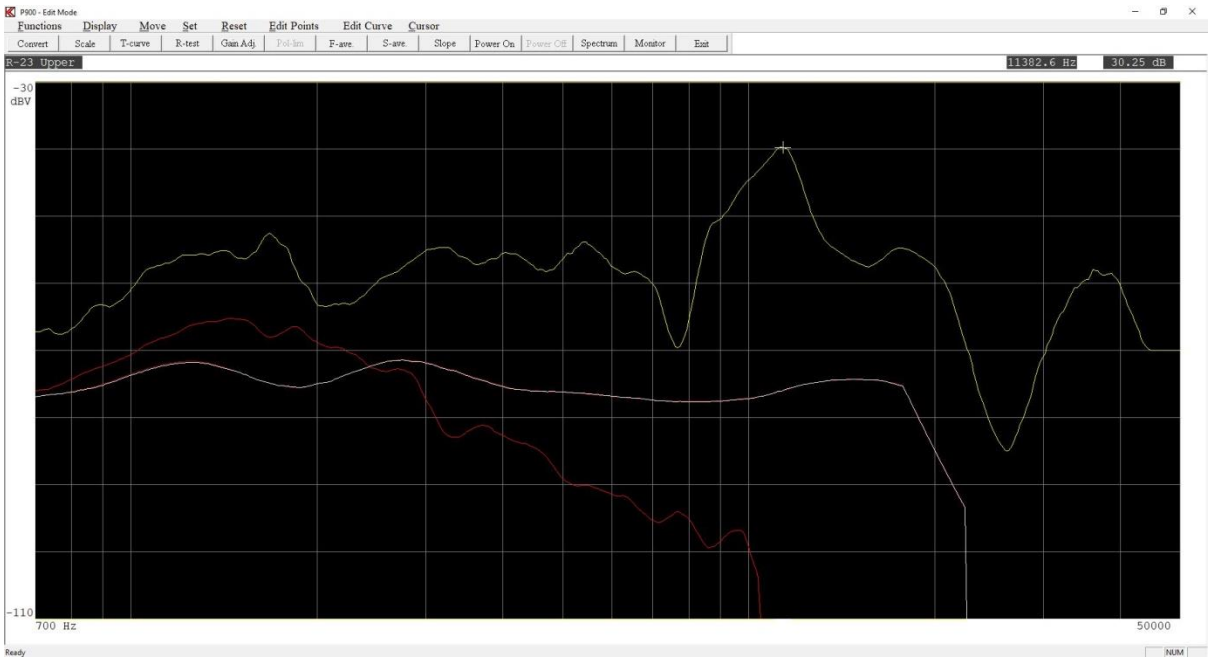

Figure 16: Red - Rub & Buzz, white - THD, yellow - R-23.

Current distortion

It is possible to measure the current distortion. The current distortion is done in channel C. This channel is used to measure impedance, resonance as well the Q.
The purpose to test the current distortion is to catch errors in the impedance measurement there is to less to catch with the limits on a normally impedance measurement.
Normally an error on a speaker unit will be detected on a Rub & Buzz measurement. A Rub & Buzz measurement is an acoustic measurement made by a microphone but a current distortion is a pure electric measurement. An acoustic measurement can be jammed by environment noise. In a production test a current noise reject together a Rub & buzz reject indicate a bad unit. If the current distortion is ok but the Rub & Buzz is bad the problem can come from the environment. Maybe a second test is needed. Figure 17 show an example for setup in Channel C for current distortion.

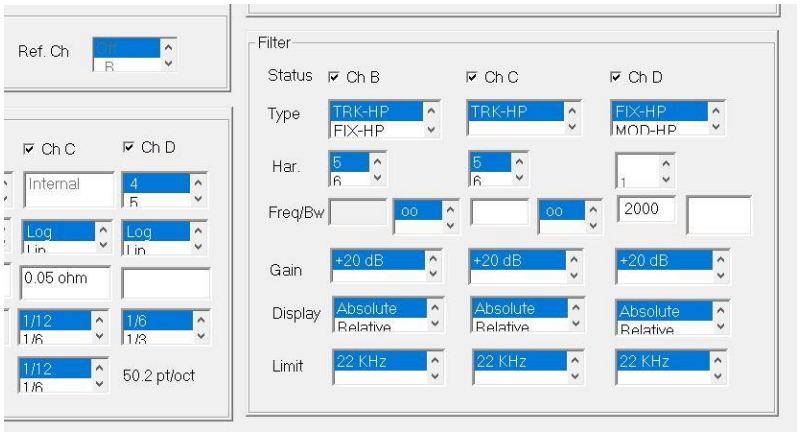

Figure 17: Filter for current distortion enabled in Ch C.

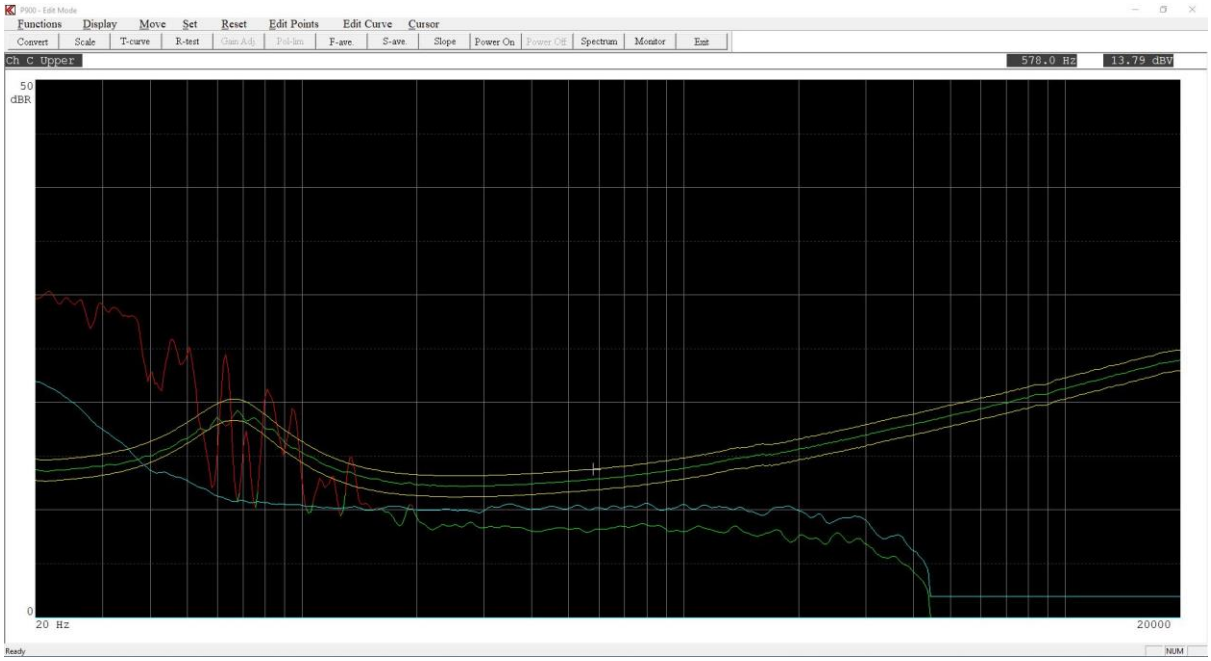

Figure 18: Impedance and current distortion.

Figure 18 show an impedance measurement, in Channel C, together a current distortion. The impedance data, the green between the yellow limits and the current distortion data the red / green exited the cyan limit. Note the impedance only exit limit around 65 Hz where the current distortion goes sky high above the cyan limit.