The amplifier Mike Renardson
Mosfet transistors A

completion and performance

Forr

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Electronic circuit and simple with a few components meet some success with audiophiles. Reversal of this simplicity, often called "Zen", a distortion that is not lower due to a lower overall negative reaction or no. What about an amplifier and stripped but designed to enjoy a high rate of cross overall reaction? This is what Mike offers Renardson with its MRJ-7. This paper illustrated with many photos shows an embodiment accompanied by several measures.

The descprition of this amplifier is on the site of its creator:

http://www.renardson-audio.com/mjr7-mk5.html

It is accompanied by notes on its design:

http://www.renardson-audio.com/mjr7-mk5-notes.html

With a single power supply of 60 V, it is capable of outputting more than 15 Vrms on a resistive load of 8 ohms, about 30 W.
Too quick look at his scheme does not predict anything promising on performance. With five transistors "small-signal" and two MOSFET power transistors, it is provided at the output of an electrochemical capacitor component criticized by some audiophile when disposed on the signal path.

An overview of the measures presented in the author's website can appreciate how the modesty of means employed contributes anything but compromising the objective qualities.

Construction Details

The version of the circuit proposed for MJR7-MK5 is compact, 160 x 100 mm and comprises two channels. Journey of their common ground in conjunction with the food, very short, allows shelter nuisance inductions.

Never having been fascinated by the amplifiers of 75 kg, and enjoying the compact equipment, I set up one of

these wafers in a brand Teko housing 300 x 160 x 70mm. The mains transformer from a former receiver Bang &

Olufsen 2 x 20
W, the filter capacitor had a value of 3300 uF. I have used two 2200 uF 63 V in parallel. It thus adds 1000 uF installed on the wafer locally decoupling after a slow fuse 2A.

The power transistors were fixed internally to the front face of the housing on which is applied, on the other hand, the heatsink. This provision of the radiator on the front, including views of the Quad 405, seems best suited to good cooling, it also facilitates the internal wiring.
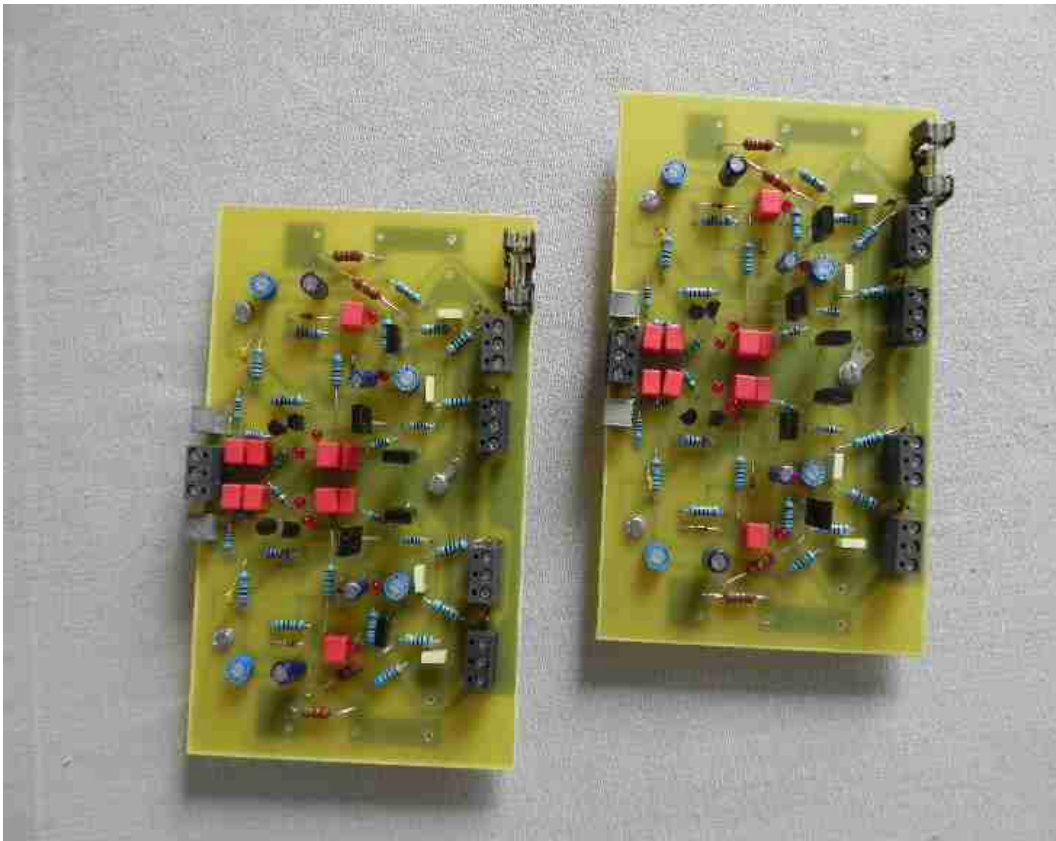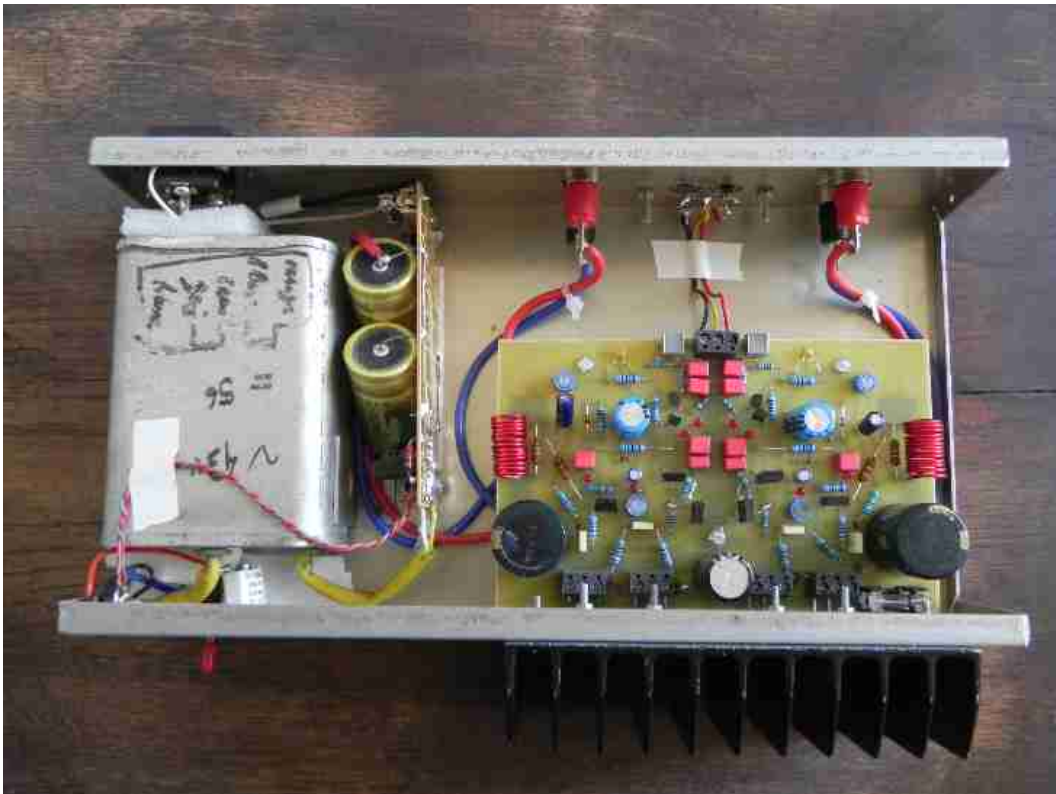
Fig001. printed circuit boards, in the components during assembly. With two amplifiers per wafer, it only takes one to a stereo amp.

Fig002. Final assembly housing Teko 300 x 160 x 70mm. In use, it will be installed on a support, the radiator projecting from the lower face.

Fig003. The ground connection to the housing is made on the screw in the center of the PCB.
There are other possibilities.
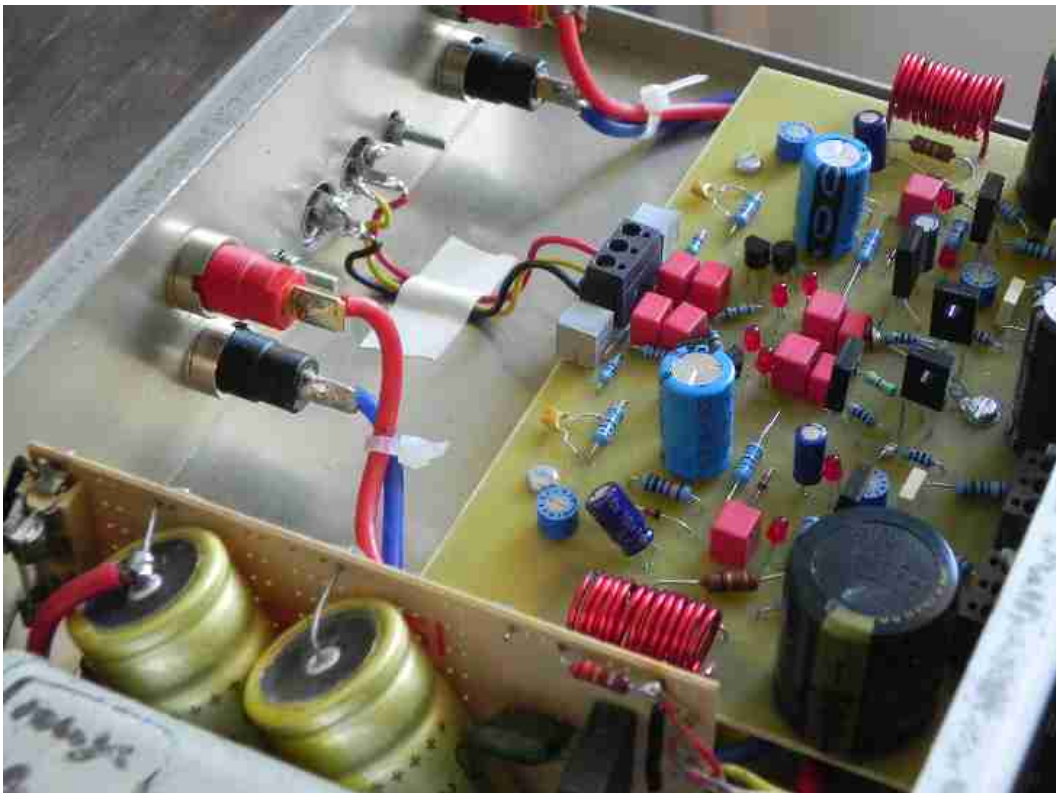
Fig004. The bases "banana" red and black output to the speakers
MultiContact are original, available from St Quentin Radio.

Fig005. The power transistors are fixed with insulation and thermal paste to the front face
on which is attached, on the outside, the radiator. Not very elegant but enough here.

Fig006. The power supply is mounted on an original wafer Conrad.
It hosts two SIC-SAFCO capacitors of 2200 uF, 63 V.

Fig007. Housing before closing the lid.

Fig008. View back cover.

The presentation of the following measures designed to reproduce or rather to check on my realization of measures already undertaken by perfectly Renardson Mile,
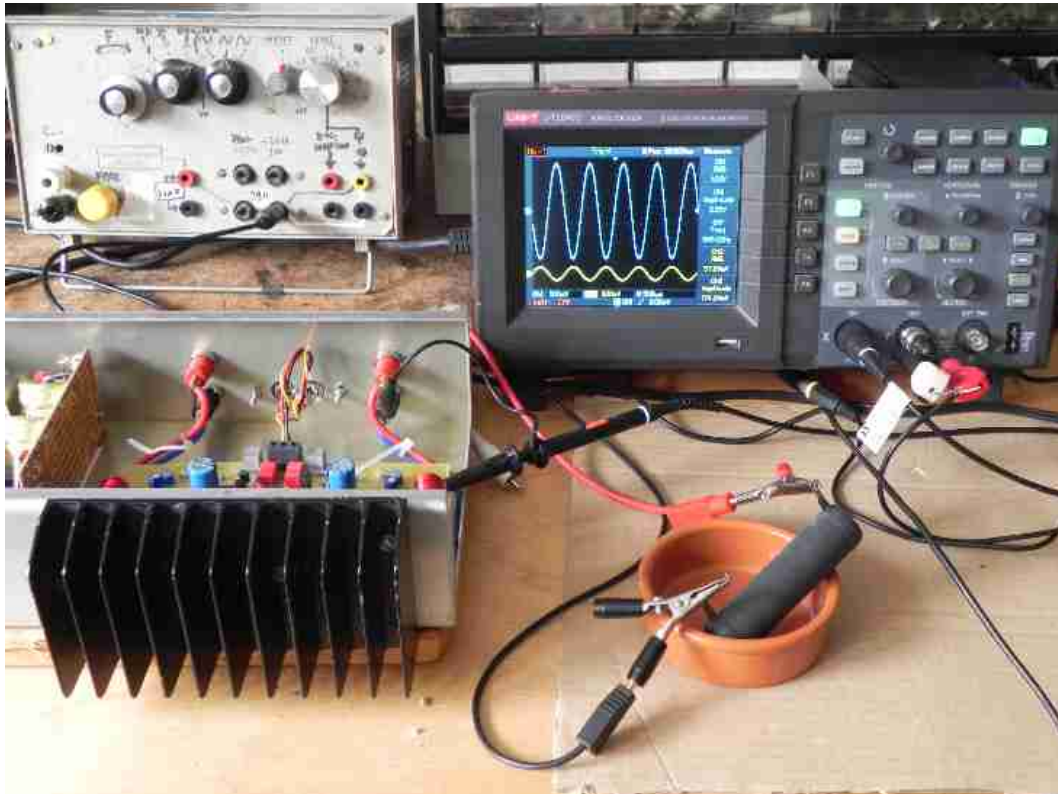
Gain and bandwidth

Fig011. Measurement bandwidth.

On the left, in the background, an old generator low frequency (LF) still fit for service. Before it, the amplifier loaded by a power of 8 Ohm resistor disposed on the right in a stoneware cup so that its temperature rise is not transmitted to the carton below which blacken is liable to ignite if the temperature reaches 451 ° Fahrenheit. Indented to the right, a digital two-channel oscilloscope for displaying the calculated values on the signals shown. Its input to the left is connected via the probe connector white ring directly to the output of the circuit on the wafer; its right input via a home cable monitors the input voltage tapped through a RCA doublet.

The first operation consists in adjusting the LF generator to a sinusoidal signal at 1000 Hz with such voltage, here 0.058 V, we obtain 1.0 Vrms of 8 ohms at the output of the amplifier. A peak voltage of the periodic input signal is a low output, and vice versa. Installation is said inverter and can be calculated in the first place **voltage gain** of the amplifier:

1.02 / 0.058 = 17.6 times or 24.9 dB

It can be seen on the photographs the frequencies where the output voltage is 0.707 (= root of 2) the 1000 Hz and which define the bandwidth at -3 dB. It runs from 7 Hz to 63 kHz. later we will see that, contrary to what one might think at first, its lower limit is definitely not due to chemical capacitor decoupling continuous output but is determined by the high-pass filter input , consisting of a capacitor C of 2.2 uF loaded by the resistive input impedance R of 10 kOhm, according to the formula of frequency f-3

said failure: f-3 = 1 / (2.pi.CR)

f-3 = 1 / (2.2 * 10 ^ -6 * 10 * 10 ^ 3 * 2 * 3.14) = 7.2 Hz
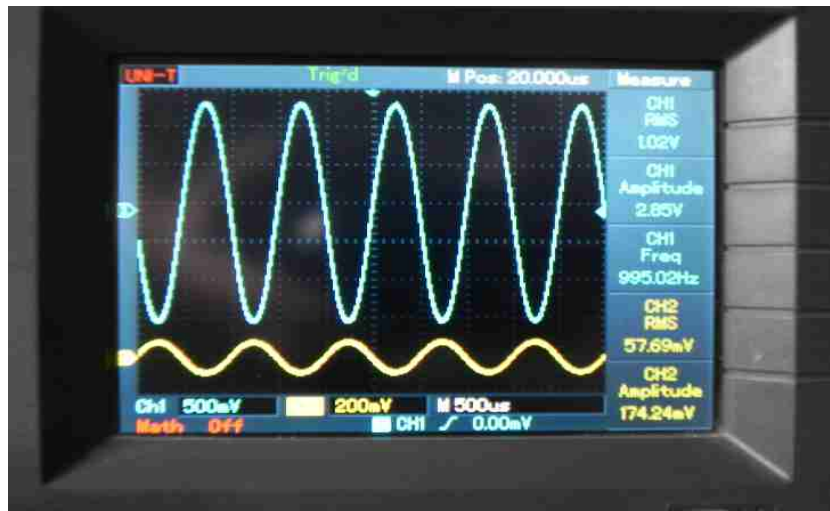

Fig012. Adjusting the input sine signal of 0.58 V to 1000 Hz
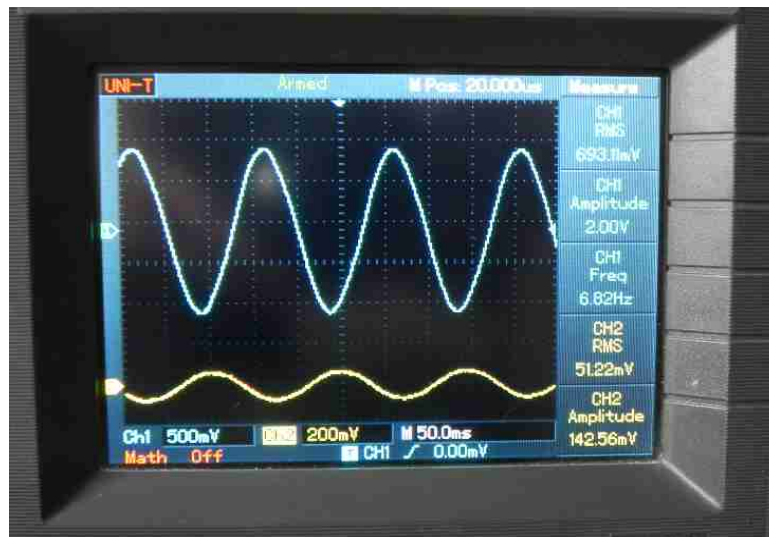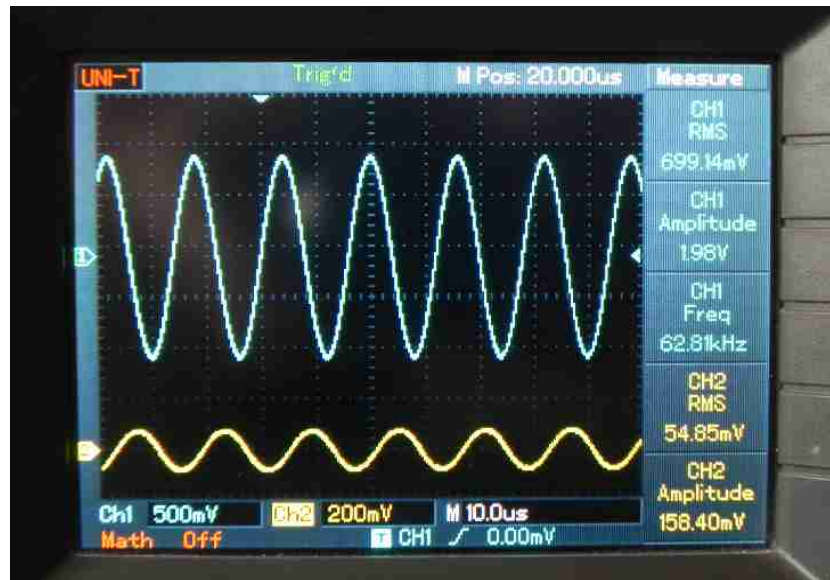*for an output voltage of about 1.0 V of 8 Ohm.*

Fig013. Response at low frequencies;
output voltage 0.707 V to 7 Hz, or -3 dB relative to that at 1000 Hz,
for the same input voltage (approximate values ...).

Fig014. Response in the high frequency:
output voltage 0.707 V at 63 kHz, or -3 dB relative to that at 1000 Hz,
for the same input voltage (approximate values ...).

The continuous feeding and its ripple rejection

The power supply rejection is the ratio, usually expressed in dB, between the ripple of the supply voltage and which remains in the output. In a further analysis, it shows a graph of its value depending on the frequency, here is merely an overall assessment. The non-technical user can get an idea of the rejection by bypassing the amplifier inputs and gluing his ear to the speakers. But be careful not to confuse the residual hearing with hum caused by an improperly performed ground wiring. The sensitivity of this summary analysis can be improved by increasing the power supply ripple by an additional load thereon, comprising a power resistor. If it has a value in ohms nearly equal to the DC power supply, it will make him charge about 1 A.
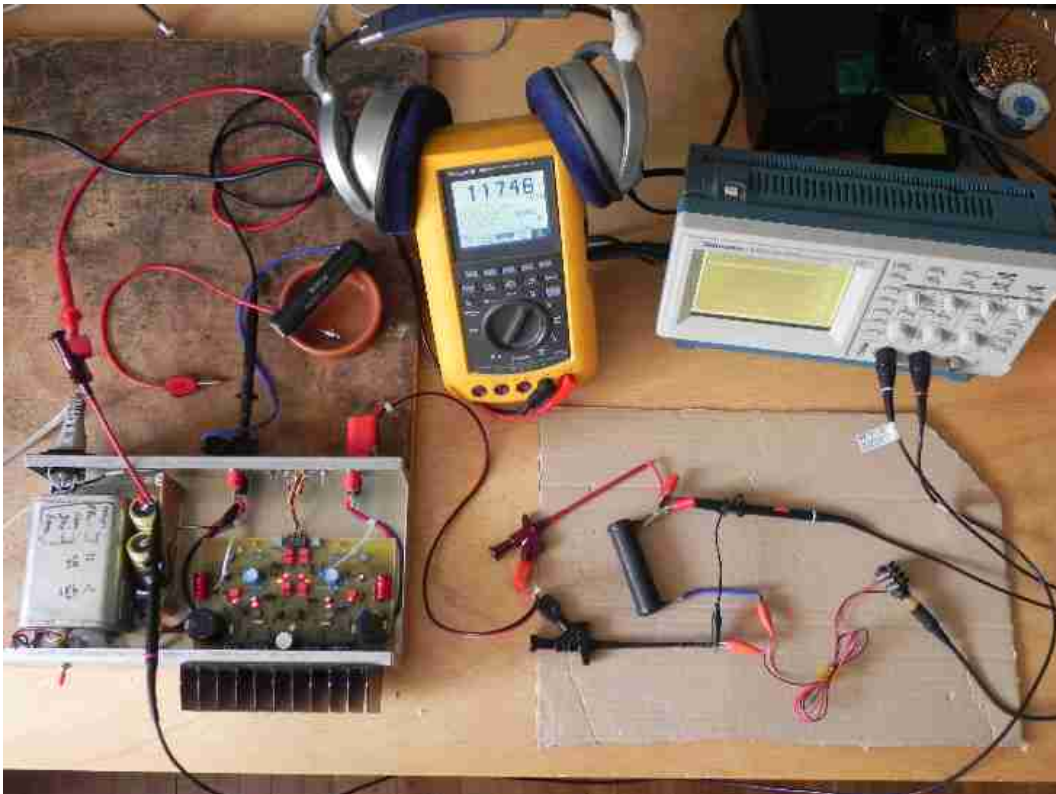
Fig021. View from the top of the food testing facility. The meter indicates the ripple voltage, form and frequency.
When the amplifier does not debit current, we say "empty"
own consumption then being 0,23A.

 The amplifier is single feed to the negative pole connected to ground, its positive pole being at the terminals of the electrolytic capacitors yellow, left

The potential of the positive pole is collected by the probe red ring connected to the right input terminal of the oscilloscope as well as a "grip-thread" to bring the meter. The ground reference is taken from the base "banana" black left output of the amplifier. In order to charge power to the power to increase the ripple during testing, a 39 Ohm power resistor, placed in the cup ceramic, can come in parallel with the circuit of the multimeter.

The inputs of the amplifier are short-circuited and the output of the right channel is connected to a headphone 32 Ohm. We see the jack in series with a power resistor 8 Ohm whose sole purpose is to prevent a short-cicuit in case of mishandling.

The voltage of this straight line output is taken to the left channel of the oscilloscope by the white ring probe; the right track is connected via the probe red ring to food in order to observe the undulation ..
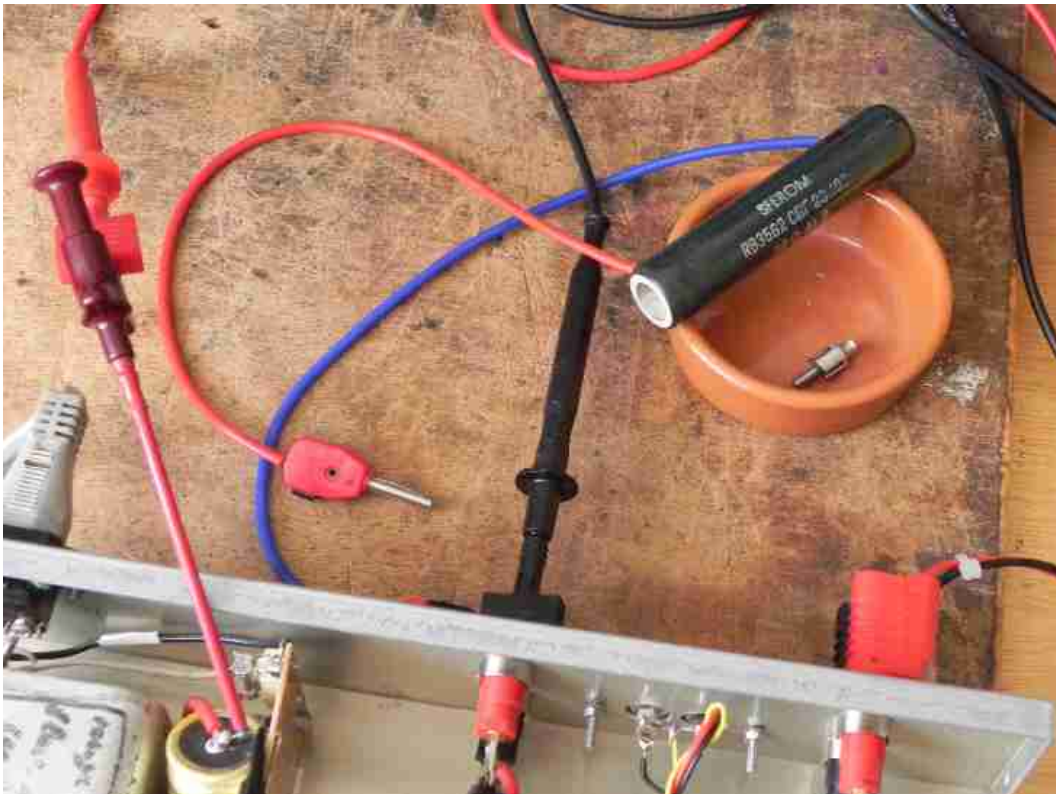
Fig022. 39 Ohm power resistor can be connected on the power supply. At the bottom of the cup, a short circuiting RCA plug used for some tests
connecting the inputs of an electronic grounded.

Fig023. Close-up view of the connection of the right channel to the headphone with series connection of a resistance of 8 ohms. The left and right channels of 6.35mm are connected together.
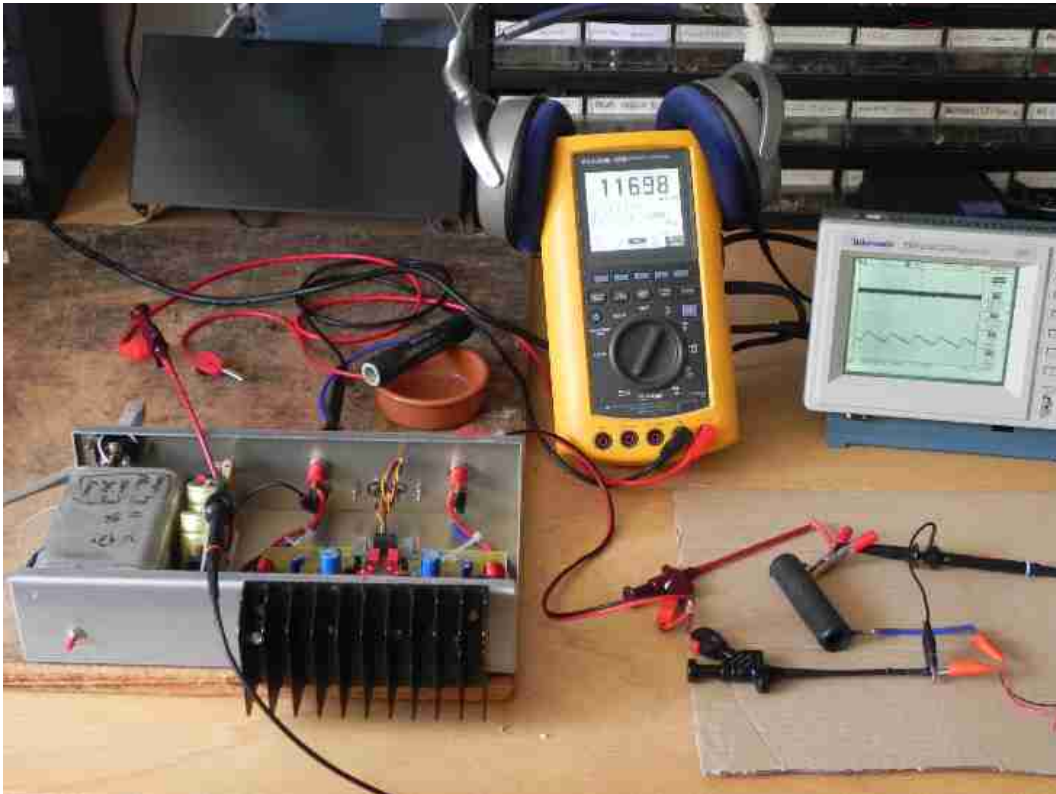
Fig024. Another view where we stand a better display of the oscilloscope.
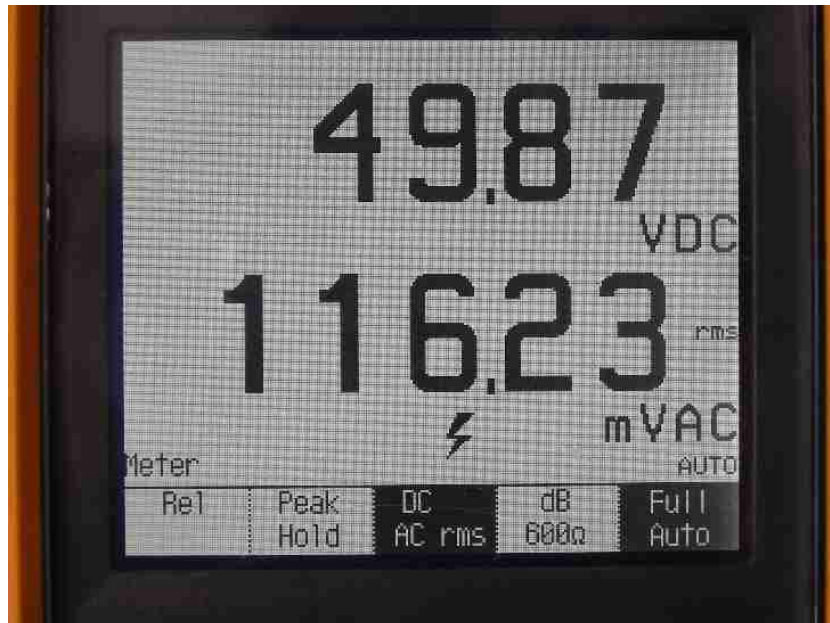

Fig025. The meter display has been programmed to show the continuous power supply 50 V approximately, amp "empty" the same as the ripple voltage.
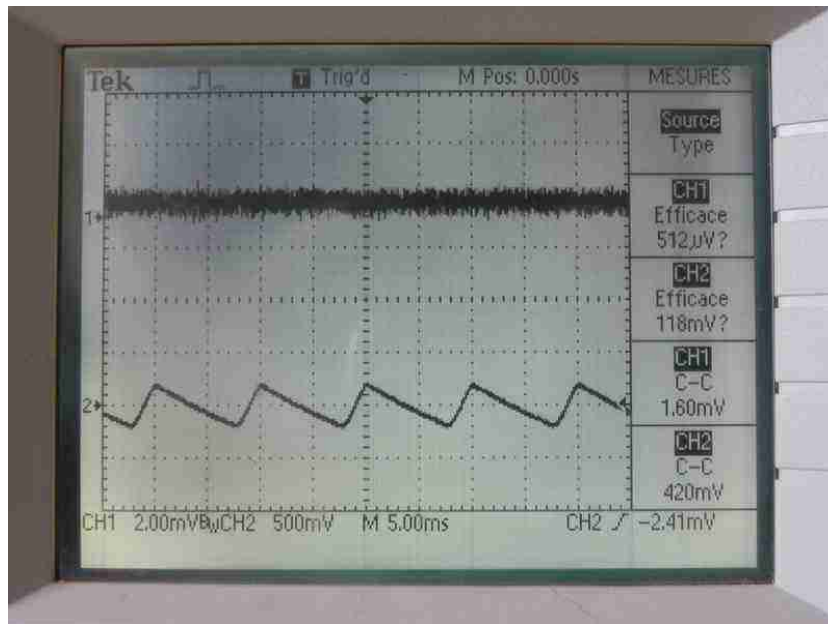
Fig026. On the oscilloscope screen, under the same conditions (vacuum amplifier), the power supply ripple, bottom trace; above the residual output tenson
Amplifier: it's just noise.

Fig027. Connecting power 39 Ohm resistor to the power supply.

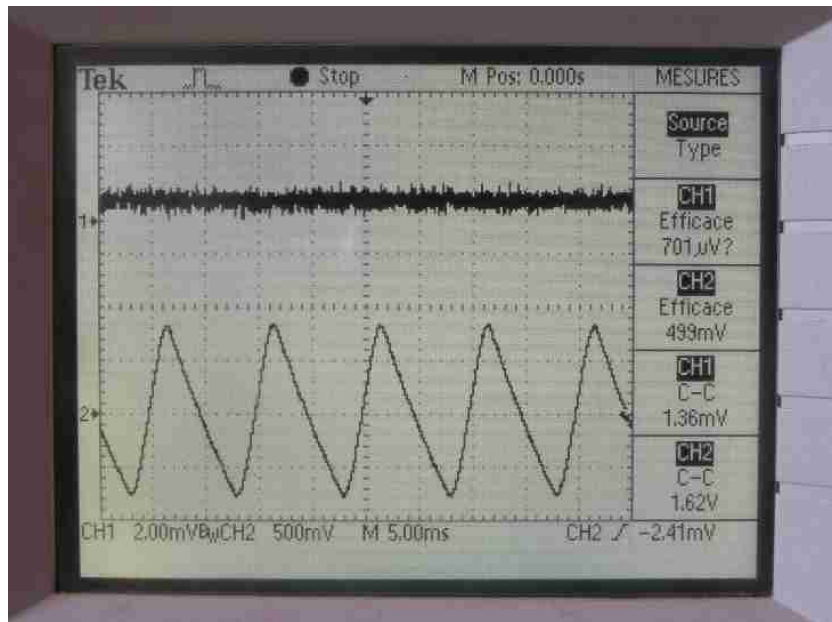*Fig028. The supply voltage drop and ripple increases.*

Fig029. Same settings as above for the number of mV per division for the oscilloscope
500 mV for waving, 2 mV per division for the output residual: only the noise of the
latter increased slightly from 0.5 to 0.7 mV.

The headphones reveals, at most, a rather serious background noise, barely perceptible (blood circulation in the listener's head?).

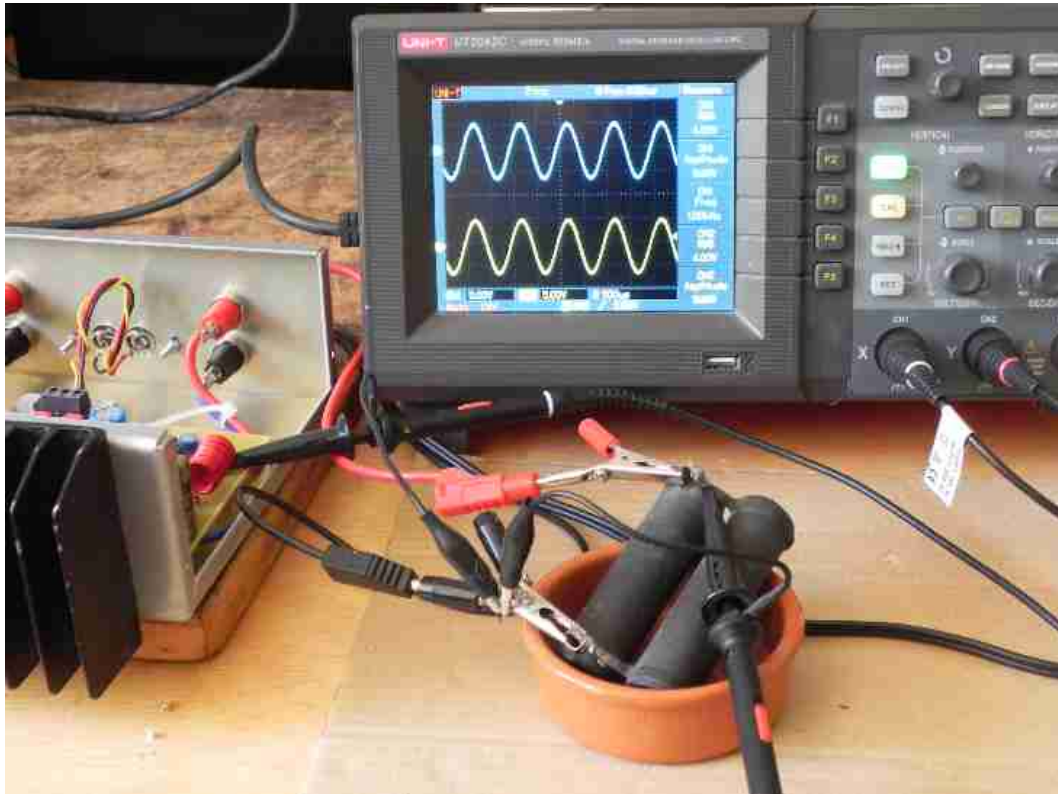**The behavior of the amplifier on a resistive load, the output impedance.**

Fig031. Load the amplifier 4 Ohm, note the location of the probes.

The probe white ring is connected to the output inductor, the downstream side, and not on the bases banana housing. The resistive load is 4 ohms, and the sine generator input voltage is adjusted to obtain 4 Vrms at its terminals, the amplifier thus delivers 1 A. The ground reference is taken to the two probes on resistance.
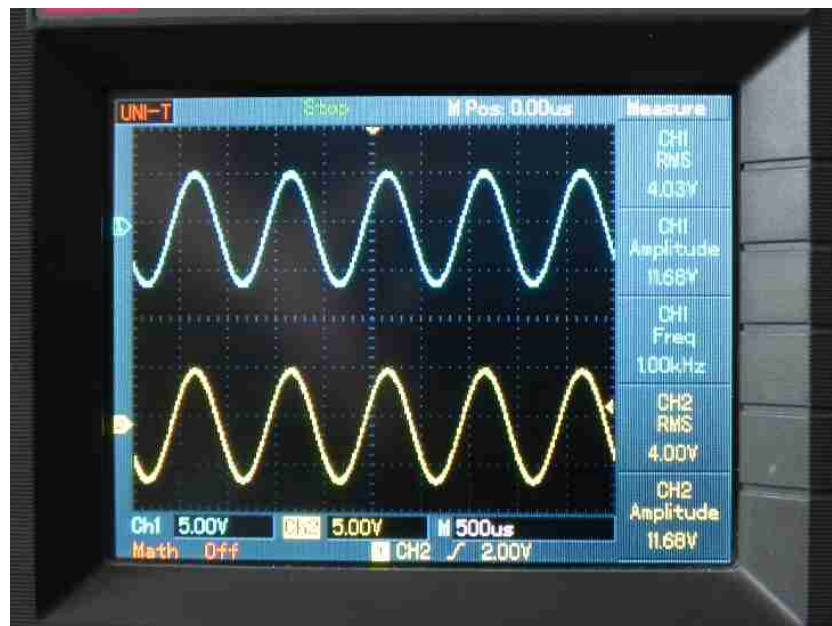

Fig032. Tensions collected by the probes are a little different. It takes little to that parasitic series resistance meddle in the path to the load!

Was a difference of 0.03 V between the two voltage measuring points, the connection introducing a parasitic resistance of 0.03 Ohm. The origin of this lies mainly in the contacts, and especially those crocodiles princes.
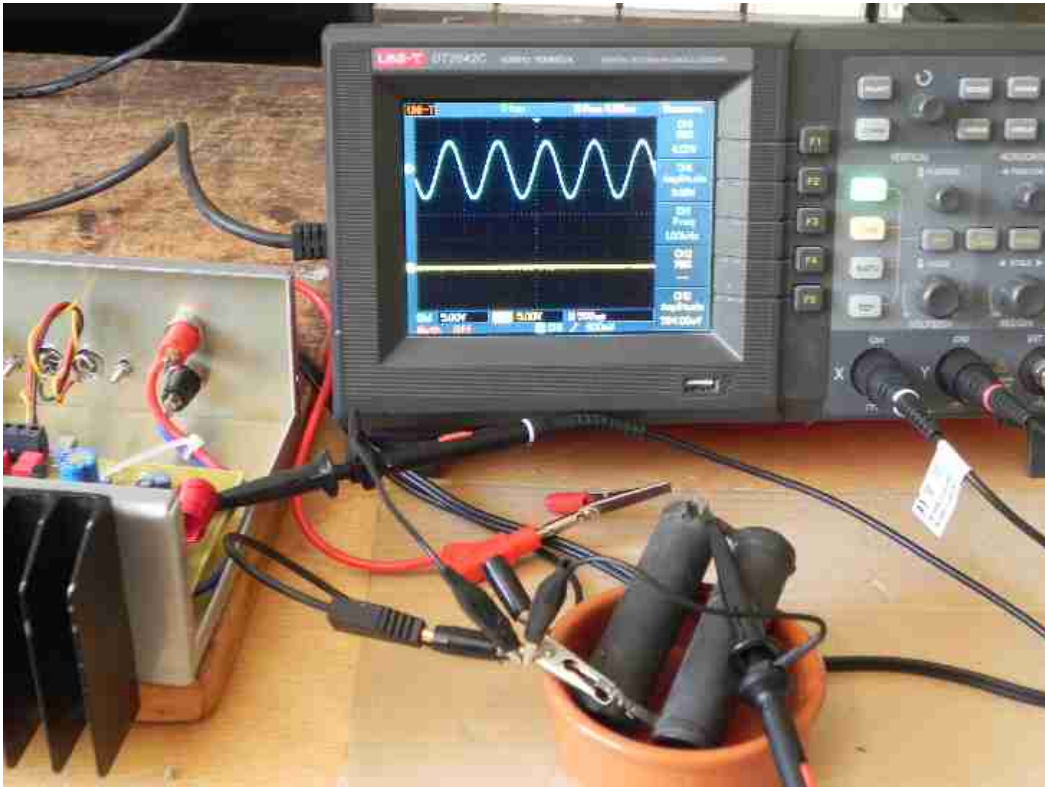

Fig033. Disconnecting the load 4 Ohm by disconnecting one of the rulers crocodiles.

The blue trace is that of the output voltage of the amplifier "empty". It rose to 4.05 Vrms, it was 4.02 Vrms for a flow rate of 1 A. The amplifier output impedance is thus their difference divided by 0.02 V that intensity of 1 A or 0.02 Ohm.

At a load of 8 Ohm, so-called "damping factor" would be 8 / 0.02 = 400. The set of connectors and cable carrying the current to the speakers always introduce a much higher series resistance ....

Another method to raise the output impedance is to move the ground connection of the load to the output of the other channel of the amplifier which has been shorted input. Traveled by the current, the last exit will display a small drop in voltage proportional to its impedance. With this approach, I got too noisy signal to be properly exploited.

After checking (not shown here) by the same procedure as the output impedance at 30 Hz and with a load of 8 Ohm remain similar, continuing our investigations below the low cut-off frequency at -3 dB, which is almost 7 Hz.

The amplifier in the present embodiment comprises an electrolytic capacitor of 4700 uF output. It constitutes a resistance 8 Ohm a high-pass filter 6 dB / o of 4.2 Hz. In other words, the capacitor 4700 uF has an 8 Ohm impedance at this frequency.
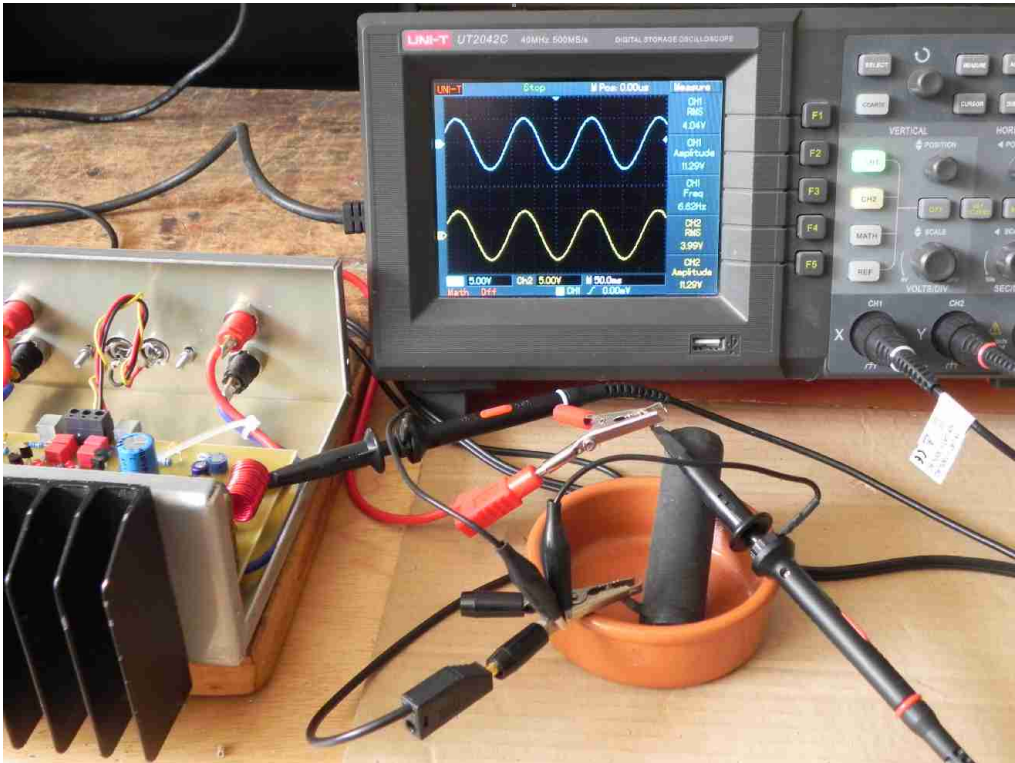
Check ...

Fig034. 4.04 Setting the voltage V across the 8 Ohm load which is covered
by a current of 0.5 A (1%, the accuracy of the resistance is lower).

Fig035. Disconnecting the alligator clip of resistance. This is not very visible,
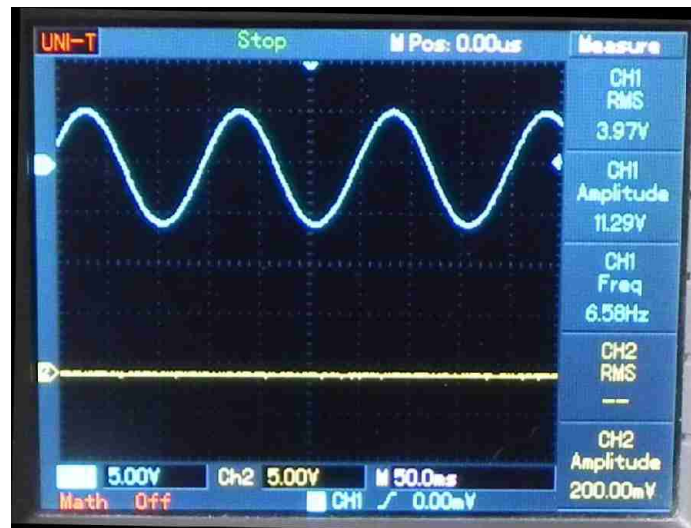it is placed back from the tip of the probe and merges around with it.

Fig036. 4.04 V with load resistance, is increased to 3.97 V vacuum. the open circuit voltage is lower than when the amplifier delivers current!

curious phenomenon: the output impedance normally drops the output voltage when it delivers current ... except ... if this output impedance is negative. This rather rare feature here from a particular behavior of the circuit due to the fact that the output coupling capacitor is included in the feedback loop against.

An amplifier with negative resistance output is a blow to the fallacious concept of damping factor (the impedance ratio of load to the amplifier output impedance) which then exceeds infinity!

Note that obtained even better results for the damping coefficients by sampling the output voltage upstream of the inductor, which is a passive component not included in the feedback loop against.

The behavior of the amplifier with square signals capacitive load
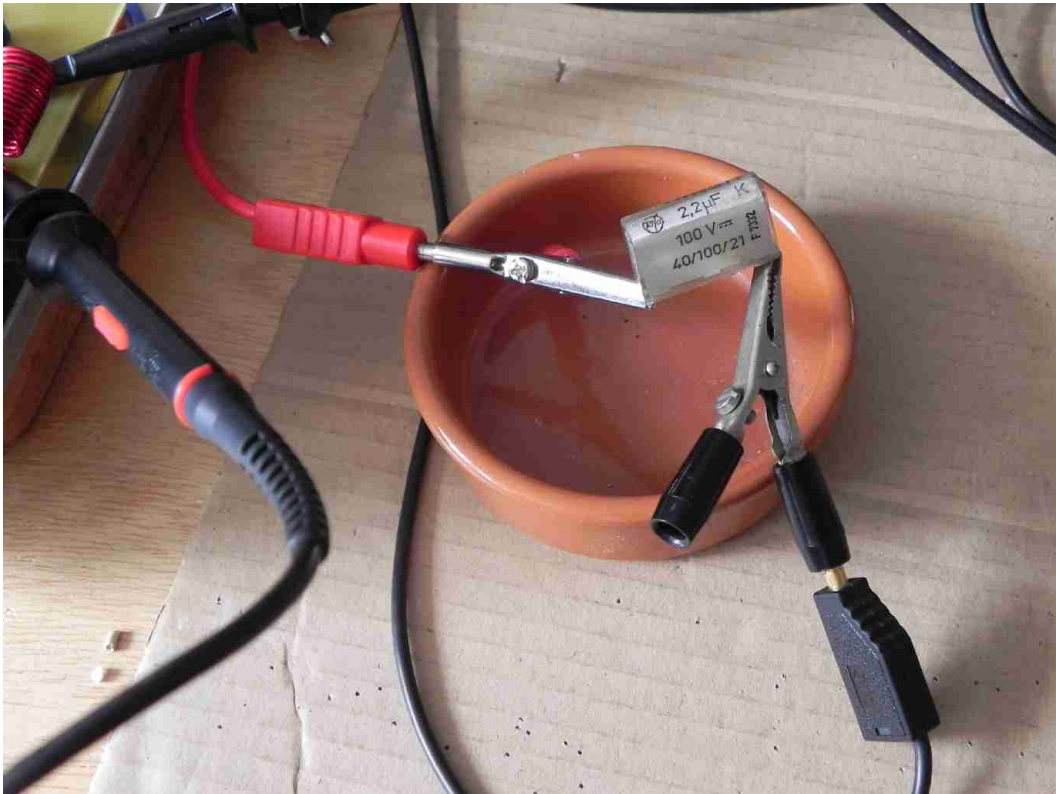
Fig041. Load of the amplifier by a capacitor without 2,2µF resistor in parallel.

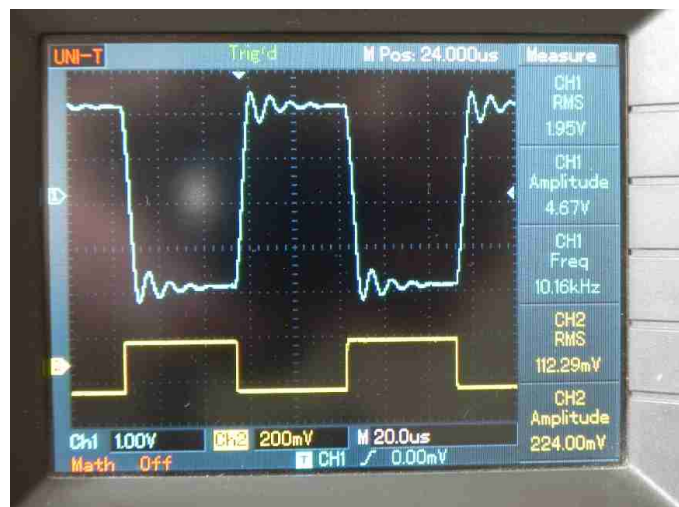*Fig042. Downstairs yellow trace: the amplifier input signal. Above, blue
trace: response to its output by 2.2 uF charged.*

This test is often performed at 1 kHz with, in parallel with the condensteur 2.2 uF, a resistance of 8 ohms. Here the conditions are tougher: 10 kHz "pure" capacity. The overshoot is a classic. Let's take a closer look.
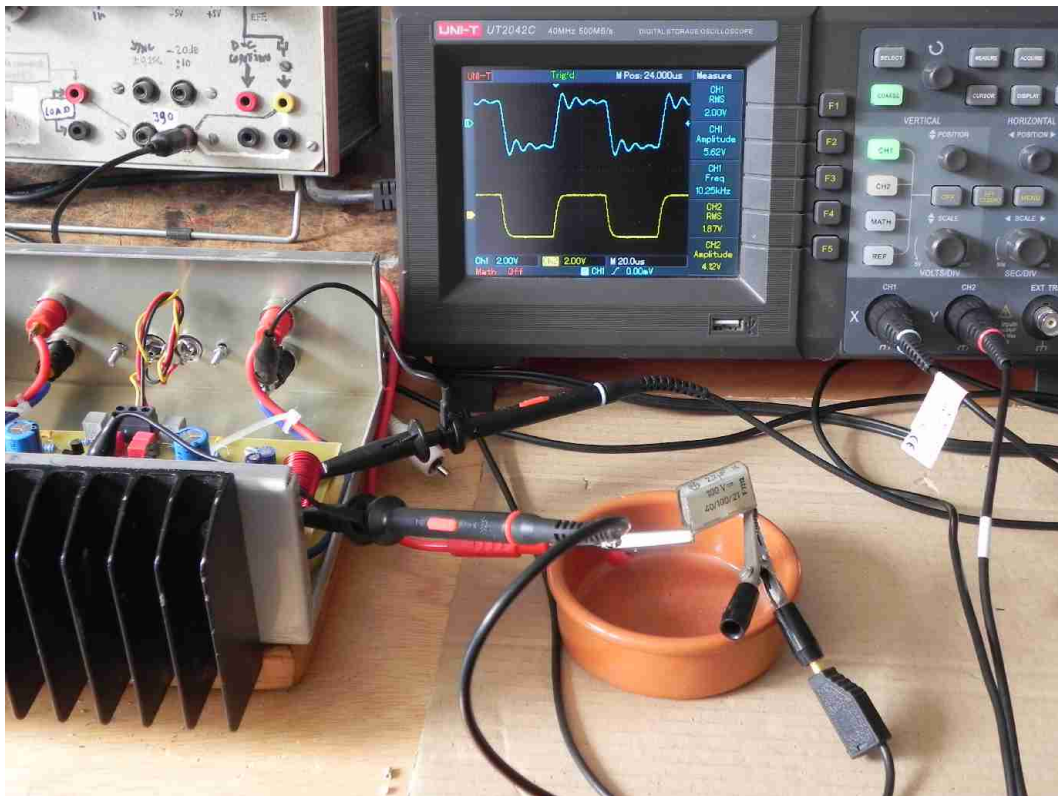
Fig044. Is kept the same excitation square wave. The probe white ring, for blue trace remained in place downstream of the output inductance. But ahead of that, we
a second probe connected to red ring, for yellow trace.
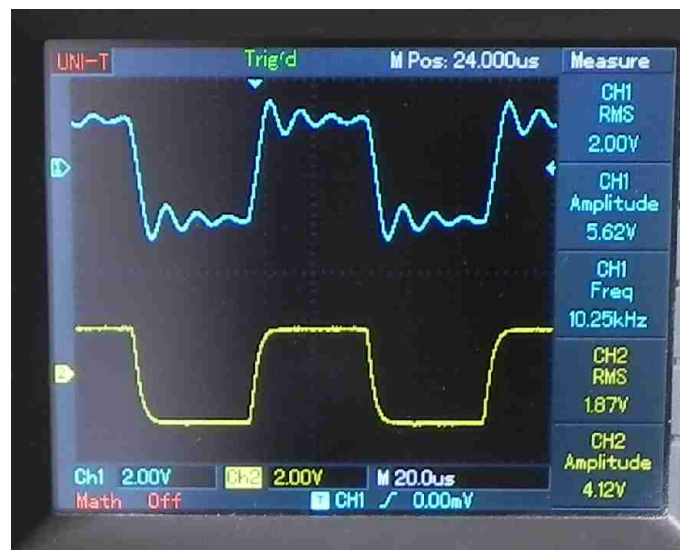
Fig045. This view better shows the two traces.
Moral: an overshoot is not necessarily linked to instability.

There is impeccable behavior upstream of the inductance, yellow trace, the active part of the circuit is not affected by this charge.

This test is not very significant and subject to misinterpretation if the signal after the inductance that you realize the waveform.

The overshoot is due only to the resonant inductance with capacitive load, it is damped by the resistance in parallel to the first.

With 470 nF, not shown test, the blue trace is not far from being superimposed on the yellow trace. It is good to check that everything goes well with 100 nF (the case) some amplifiers, stable 2.2 uF, are no longer out of 100 nF.

harmonic distortion

Its measurement involves all very high performance but limited to a single frequency, 1000Hz here, designed by Cyril Bateman. IL is described in the 6 PDF documents "capsound" the following link:

http://www.waynekirkwood.com/Images/pdf/Cyril_Bateman/Bateman_Notes_Cap_Sound_1.pdf

http://www.waynekirkwood.com/Images/pdf/Cyril_Bateman/Bateman_Notes_Cap_Sound_2.pdf

http://www.waynekirkwood.com/Images/ pdf / Cyril_Bateman / Bateman_Notes_Cap_Sound_3.pdf

http://www.waynekirkwood.com/Images/pdf/Cyril_Bateman/Bateman_Notes_Cap_Sound_4.pdf

http://www.waynekirkwood.com/Images/pdf/Cyril_Bateman/Bateman_Notes_Cap_Sound_5.pdf http: // www

.waynekirkwood.com / images / pdf / Cyril_Bateman / Bateman_Notes_Cap_Sound_6.pdf in the most sophisticated version of the system, analyzing the harmonic distortion has three different display systems:

- instant LED scales, which allows to observe rapid changes in distortion, lower limit -120 dB.

- RMS voltages of harmonics 2 and 3 to be converted into dB, 6V y corresponding to -60 dB and 6 mV to -120
  dB -123 dB lower limit.
- audio spectrum by averaging (I usually has about thirty seconds at least), minimizes the influence of
  noise, can drop to -140 dB.

The biggest problem with an analog sine-wave generator is its stability either in frequency, level, or distortion. It is also always less powerful than the device that analysis, the fault incumbent on the level of regulation that can be precisely linear. adjusted perfectly, the measurement limit of more distortion meter generator set Cyril Bateman is around 0.00005%, also called 0.5 ppm (ppm = part in a million).

I prefer long study of the distortion of the audio signals at voltages around 4Vrms, maximum capability of the sine generator. In amplifier output, it is what is likely the best demonstration of potential crossover distortion. 4 Vrms across the speakers also corresponds to the maximum achieved in many amateur installations. Tests with higher voltage excursions give a little better, the crossover nonlinearity area becoming proportionately less relative to the signal.

Some screenshots of the spectral analysis by Fourier decomposition are set a bit further. For the results of each test are:
- the name of the test circuit, the generator itself or the path of the amplifier, left (L for Left
  in English) or right (R, Right in English)
- the rms value (RMS in English) of the analyzed voltage, which is made to correspond to 0 dB on a spectrum analyzer.

- the load of the amplifier,
- the value of the harmonic 2 (H2),
- the harmonic value 3 (H3)
- the value of the total harmonic distortion (THD, Total Harmonic Distortion in English)

The rig used here is enough clutter and suffers from some fluctuations due to the temperature which will probably add hum residues introduced by a wiring "Italian." Therefore I beg the kind reader kindly excuse me if the results I pulled not appear more consistent. However, they agree quite closely with those of Mike Renardson

Let's start with a brief overview of the battlefield.

Fig051. The test bench. On the right, from the first plane, the generator-distortion meter, Renardson the amplifier. Basically, the computer displays spectrum analysis.
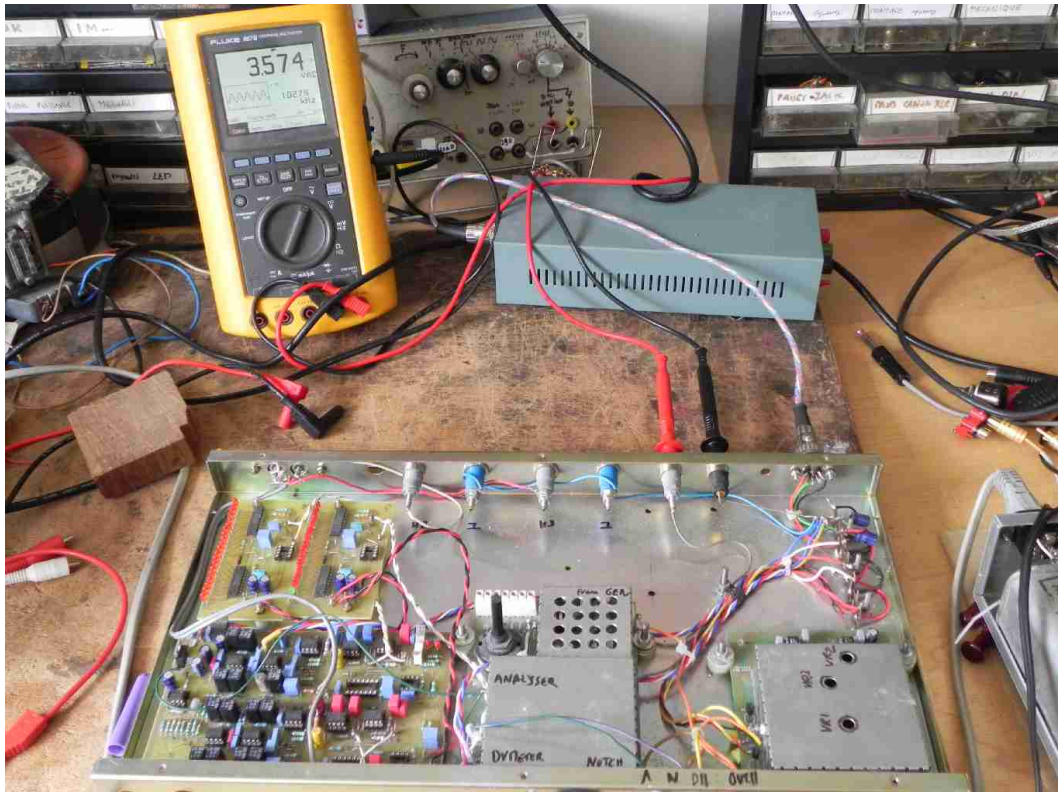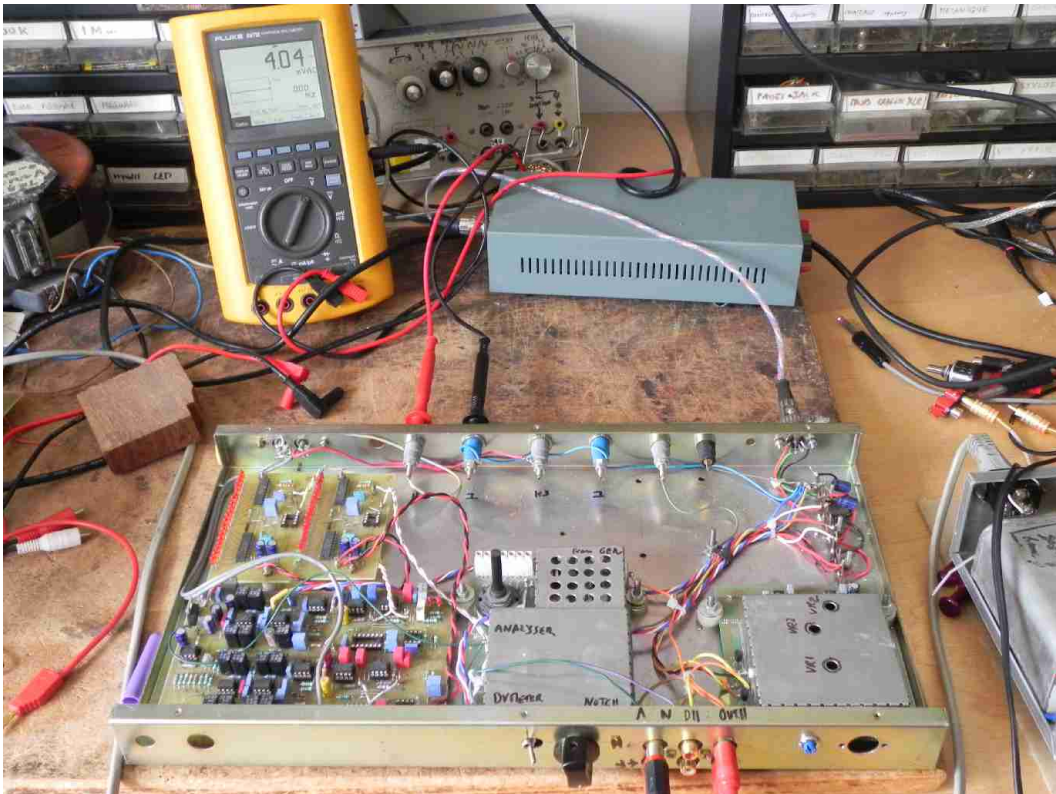
Fig052. The generator-distortion meter: the generator in armored hood right, the rejection ("notch") in the middle, the display circuitry and LED voltmeter left. The analyzed signal
is found on the banana sockets on the right, its voltage is displayed by the meter.

Fig052. On the bases banana left, we find the harmonic 2
6 V to -60 dB, 6 mV to -120 dB. Here, 4 mV to -123 dB.
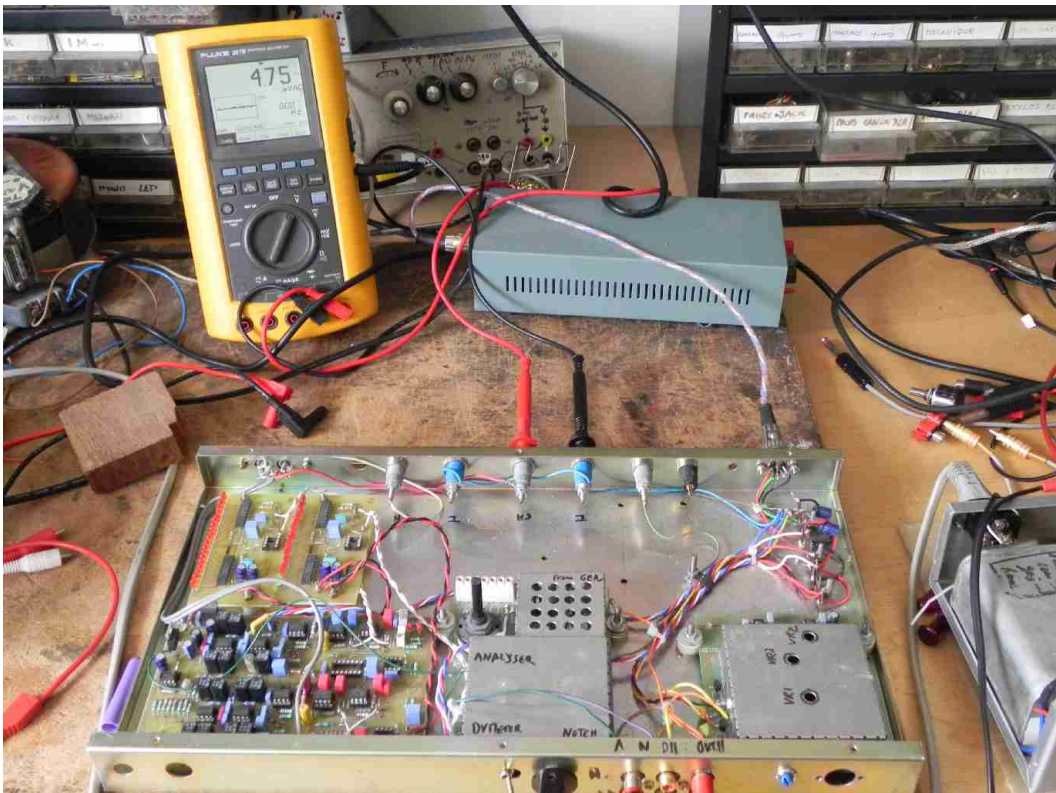
Fig053. In the middle banana bases, harmonic found 3.
Same proportions as before. Here, 4.75 mV to -122 dB.

Fig055. The display "bar-graph" scale from -60 to -120 dB in 3 dB. It allows to visualize rapidly changing distortion, for example with polarization variations of a capacitor. Here, H2 -117 dB to -111 dB H3.
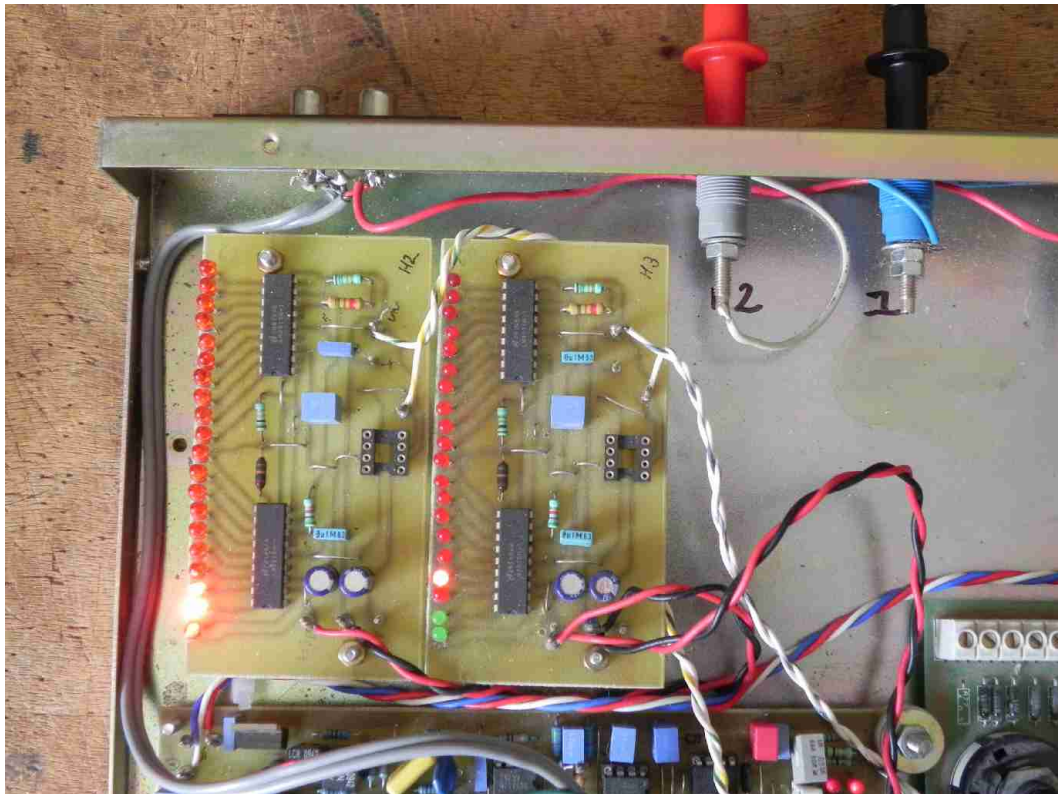
It is the spectrum analysis which was selected for the following results.

The results are more accurate (and more flattering), because the sounds of all kinds are reduced. Given the fluctuations in the system and the very low levels of distortion, it is better to refrain from any attempt relationship between the ratio of harmonics H2 and H3 (the latter is very inconsistent) and the sound reproduction of the circuit.

Analysis of the harmonic distortion at 1000 Hz of the amplifier

3.6V generator   : -136 dB H2, H3 -129 dB THD 0.00005%

The amplifier vacuum 3.6V   : -133 dB H2, H3 -129 dB THD 0.00011%
The amplifier 3.6V 8 Ohm   : -132 dB H2, H3 -122 dB THD * 0.00013%

The amplifier 4 Ohm 6.0V   : -123 dB H2, H3 -122 dB THD 0.00016%

The amplifier vacuum 8.0V   H2 -130 dB, H3 -126 dB THD 0.00011%
The amplifier 8.0V on 4 Ohm: -111 dB H2, H3 -119 dB THD 0.00037% R amplifier vacuum 8.0V

                                                   : -128 dB H2, H3 -125 dB THD 0.00011%
amplifier 8.0V R 4 Ohm: -111 dB H2, H3 -119 dB THD 0.00036% L 12 V amplifier vacuum

                                             H2 -130 dB, H3 -128 dB THD 0.00010%
L 12 V amplifier 8 Ohm: -114 dB H2, H3 -118 dB THD 0.00033% R amplifier 12V vacuum

                                                   : -131 dB H2, H3 -129 dB THD 0.00009%
R amplifier 12V on 8 Ohm: -117 dB H2, H3 -117 dB THD 0.00032%

In all cases the total harmonic distortion is very low. Whatever the load with the above voltages and loads, I have no record of 0.0005% greater than with direct views as described above.

The hunt for the distortion according to Mike Renardson

Rather than the classical harmonic distortion measure that requires a sine generator and a high performance notch filter, Mike Renardson uses an extraction technique of distortion on which he wrote a thesis:

http://www.renardson-audio.com/dtest.html

This is to make a subtraction between the output signal properly mitigated and compensated frequency, and the input signal. With the right settings, there is virtually nothing remains of the useful signal, which can be of any type and not exclusively sinusoidal. It then remains only amplify the intruder signals that make up the gap between what is actually present at the output and what should be if the circuit was perfect, and to observe them.

This idea was proposed by Baxandall Hafler and in the 1980s it has been slow to catch on, but it begins to be implemented by the audio electronics, such as:

http://www.cordellaudio.com/instrumentation/distortion_magnifier.shtml

Now if you consider that it has a signal corresponding to the isolated distortion of a circuit, the following reflection you will probably come to mind: the reinjection of this inverted signal in said system would eradicate in distortion. And you would be right and might for the opportunity finally admit that you are an electronics engineer who ignores. Do not be surprised if Mike Renardson, familiar with this type of distortion extraction, has developed amplifiers using this concept that has taken the name of "error correction".

http://www.renardson-audio.com/classbff.html

http://www.angelfire.com/ab3/mjramp/mjr9.html

Both circuits have taken their inspiration from the fundamental idea of the feedforward ("feedforward") at the base of the famous Quad 405, with a wink to the diagram of the Quad 303 to that of the first link.

The second, MRJ9, sophistication MRJ7, reaches even more dramatic figures but it is not offered on an experimental basis by its author.

Bonus: harmonic distortion on complex load

As a bonus, I suggest you see how it reacts to loads MRJ7 often imagined as "difficult" by some literature to fuzzy electronics. I have never seen such measures published.

Fig061. The amplifier 3.6V vacuum: -133 dB H2, H3 -129 dB THD 0.00011%
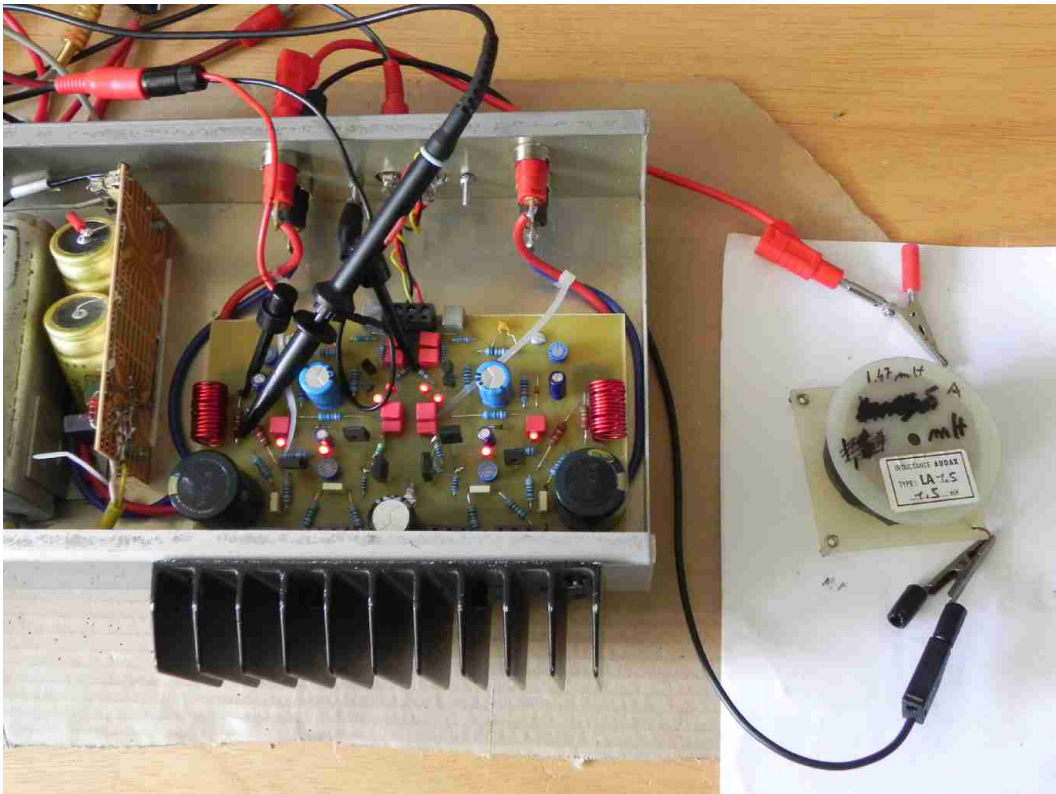
Fig062. Amplifier load: 1.5 mH, 8 Ohm impedance at 1000 Hz.

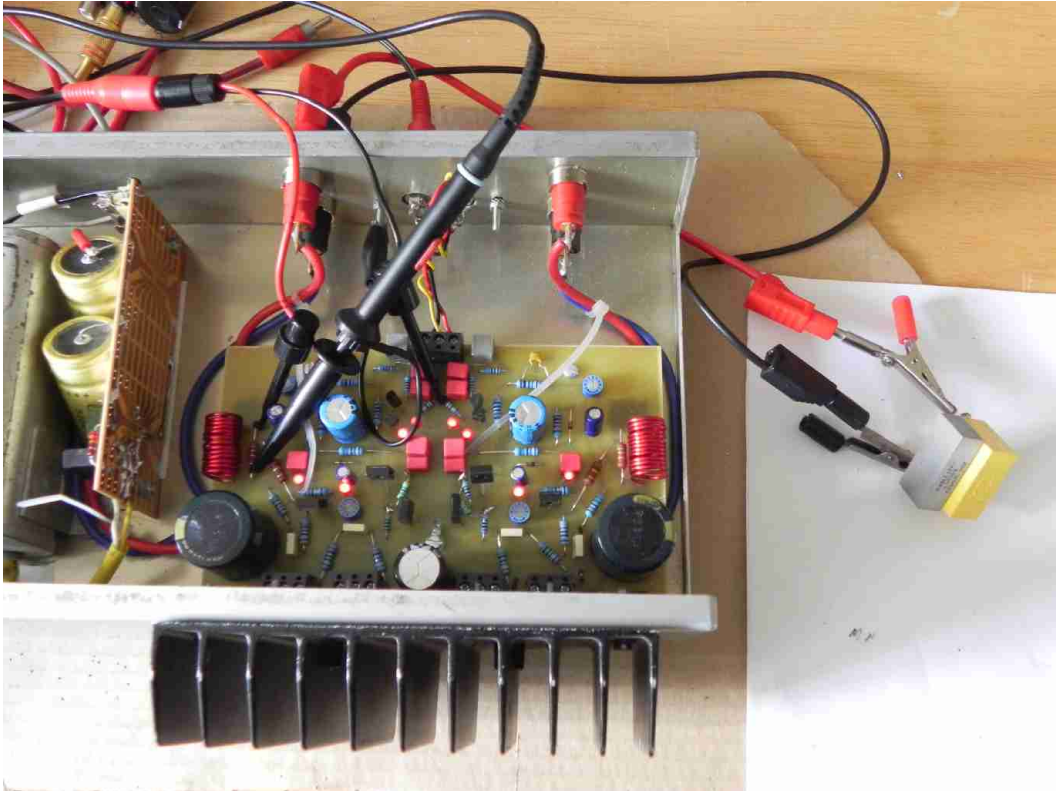Fig063. Amplifier The 3.6V 1.5 MH: -132 dB H2, H3 -130 dB THD 0.00011%.

Fig064. Load of the amplifier 16.8 uF, 8 Ohm impedance at 1000 Hz.

Fig065. Amplifier The 3.6V 16.8 uF: -131 dB H2, H3 -127 dB THD 0.00012%.

Bonus Summary

The amplifier vacuum 3.6V   : -133 dB H2, H3 -129 dB THD 0.00011%
The amplifier 3.6V 16.8 uF: -131 dB H2, H3 -127 dB THD 0.00012% Amplifier The 3.6V 1.5 mH
                              : -132 dB H2, H3 -130 dB THD 0.00011%

In addition to its stability on capacitive load, this amplifier has an imperturbable linearity of inductive or capacitive load. Who said reactive loads disturbed the operation of the reaction against-because of the phase shift between current and voltage? Confusing what keeps the frequency domain and what keeps the time domain, some even talk of late about it!

Conclusion

Designed without any consideration of the most current ideas for thirty year - against local feedback and / or low levels, symmetry, differential stages, streaming links - that this amplifier performance which prove practically above all others, with far more complex circuits and say where ideas were exploited them. In terms of performance measures is a rehabilitation of the search for a maximum aggregate against feedback perfectly controlled, ie that sacrifices not in any way the stability of the circuit.

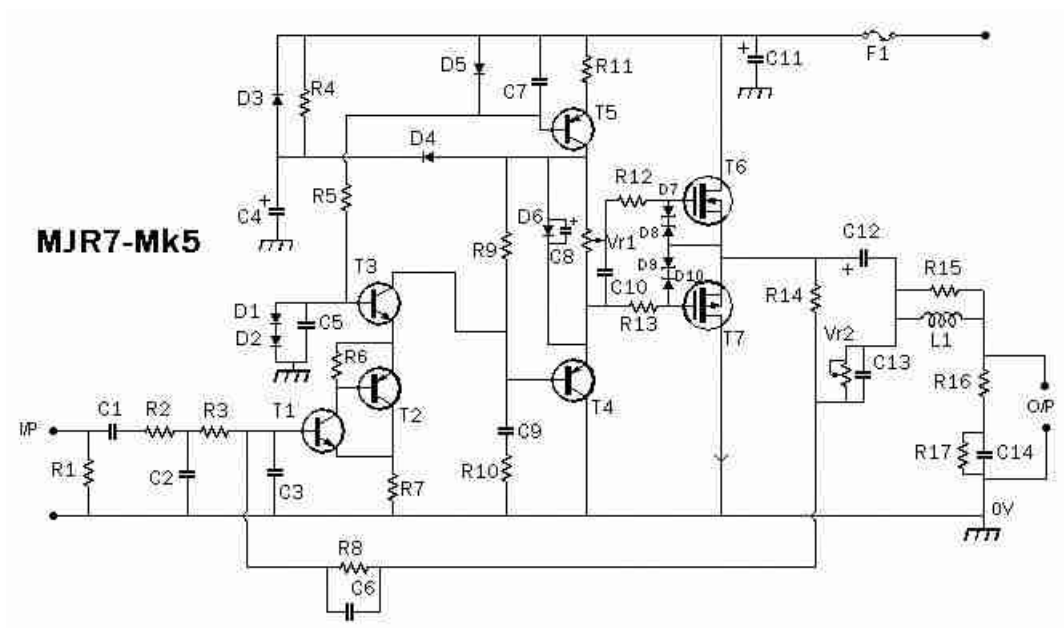It is found on the forum Audax few subjective opinion more favorable to the RJ-7.

Fig71. The diagram of the amplifier. Values of components,
details and information on the site:

http://www.renardson-audio.com/mk5-comps.html

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