Comparative Evaluation of the Performance of Various Harmonic Measurement Systems to EN 61000-3-2, and the Deviations in the Measurement Data Obtained

Some years ago, it became apparent that there was a great variation in the measurement results obtained from various commercially available test systems when performing tests in accordance with the harmonic emission standard EN 61000-3-2. Measurement deviations of up to 100% were apparent, although the EN 61000-3-2 standard specifies a required measurement accuracy of 5%.

As a direct result, the German DKE* founded the "measurement uncertainty" working group to investigate this problem. The members of the working group agreed to commence an inter-laboratory test, with the aim of establishing the reason for the variation in the measurement results. Several measurement laboratories, and companies, participated in the inter-laboratory test.

The participants received two different "reference" rectifier circuits, each of which was constructed from very precise and accurately measured components. Each participant then carried out a series of defined measurements in accordance with the standard EN 61000-3-2.

The results confirmed that the various measuring instruments (harmonic analysers) produced more or less acceptable measurement results, but that the various AC sources (amplifiers) used were responsible for the majority of the measurement deviations.

As a reference against which to compare the actual measurement results recorded by the participating measurement laboratories and companies, the behaviour of the constructed rectifier circuits was carefully characterised, and a very accurate FFT analysis of their behaviour, was obtained by utilising PSpice. Thus, the precise behaviour of the "reference" rectifier circuits was now absolutely defined.

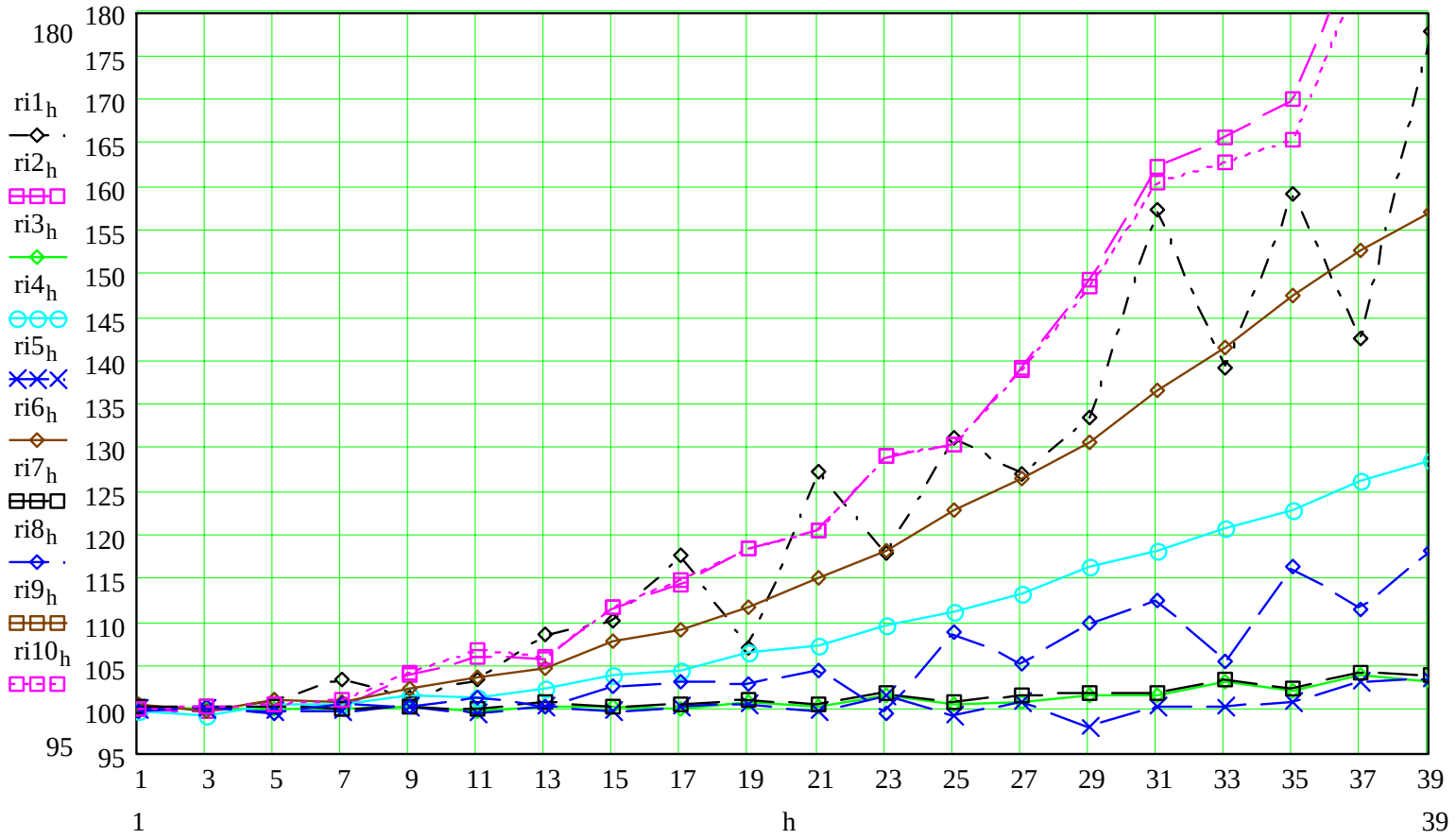
***** *The DKE is the German organisation responsible for the production of standards and safety specifications covering the area of electrical engineering, electronic and information technologies. It constitutes a joint organisation of DIN and VDE, the juridical responsibility for running the DKE being in the hands of the VDE. The DKE is the German member within International and European standardisation organisations (IEC, CENELEC, ETSI)*

Subsequent comparison of the theoretical data with the actual measured data resulted in deviations of up to 70% and 80% being observed (see Figure 1). A source (amplifier) produced by another manufacturer, which was placed at our disposal, resulted in a deviation up to 90% being recorded.

Subsequently, a second inter-laboratory test was organised. The harmonics of the supplied test specimens were adjusted so as to simulate a class A device for the harmonic range (approx.) 13 to 39. Furthermore, various real-life test specimens (e.g. a TV-set, various lamps etc.) were also measured during this second test for additional comparison purposes. Again, the measurements were performed according to the standard EN 61000-3-2. It should also be noted that, during both the first and second inter-laboratory tests, most laboratories also measured the harmonics of the test voltage (see pictures 2 and 3).

Analysing the voltage harmonic data, it was noticeable that the test equipment that had produced measurement results that had the closest correlation to the predicted results of the PSpice simulation analysis also exhibited the smallest voltage harmonics. Comparing the simulation data with the actual measurement data for these test systems showed that the actual measurement results of these devices were within the defined 5% specification limit (actual result was within approx. 4%). These results were for a test system owned by VDE, which was for a system designed and manufactured by Spitzenberger + Spies, and a test system installed at the Spitzenberger + Spies production facility.
Some of the other test systems, including those with a AC source manufactured by Spitzenberger + Spies (but used together with a measurement devices from other manufacturers), as well as those with test sources older than 15 – 20 years, had slight deviations but were acceptable when compared to the remainder of the sources used.

Figure 1. Deviation of the harmonic currents from the reference value (reference value = 100%)

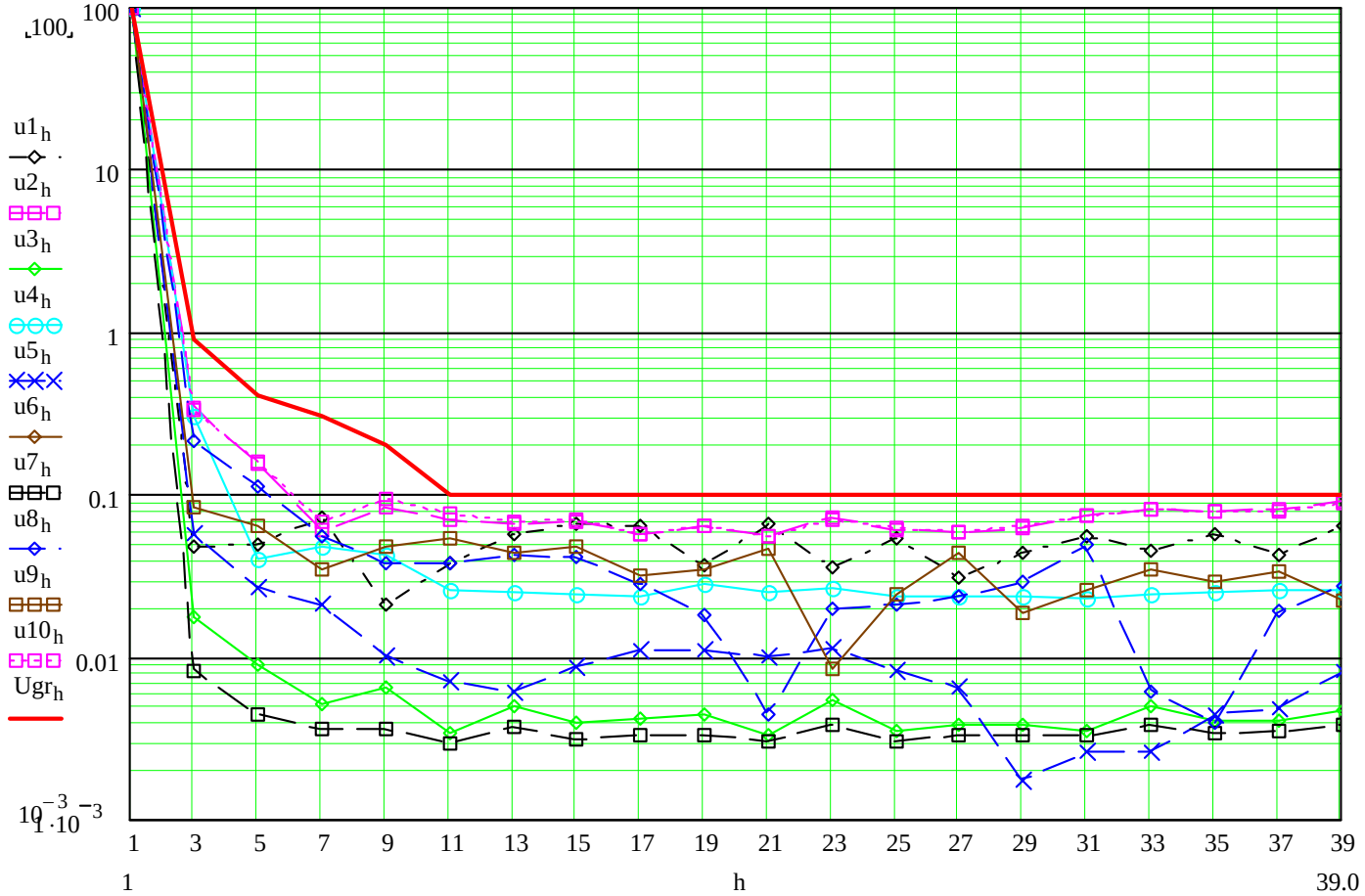


ri1 - ri10 = I.D. of the participating laboratories / h = ordinal number of the harmonics

Only laboratories 'ri7' (VDE Offenbach, using SPS-system 3 x PAS 10000) and 'ri3' (SPS PAS 5000) are within the specification limit of <5%

Although the measured harmonics of the test systems were generally within the permissible limits, according to the standard EN 61000-3-2, it was noticeable that the actual values of those harmonic amplitudes varied widely.

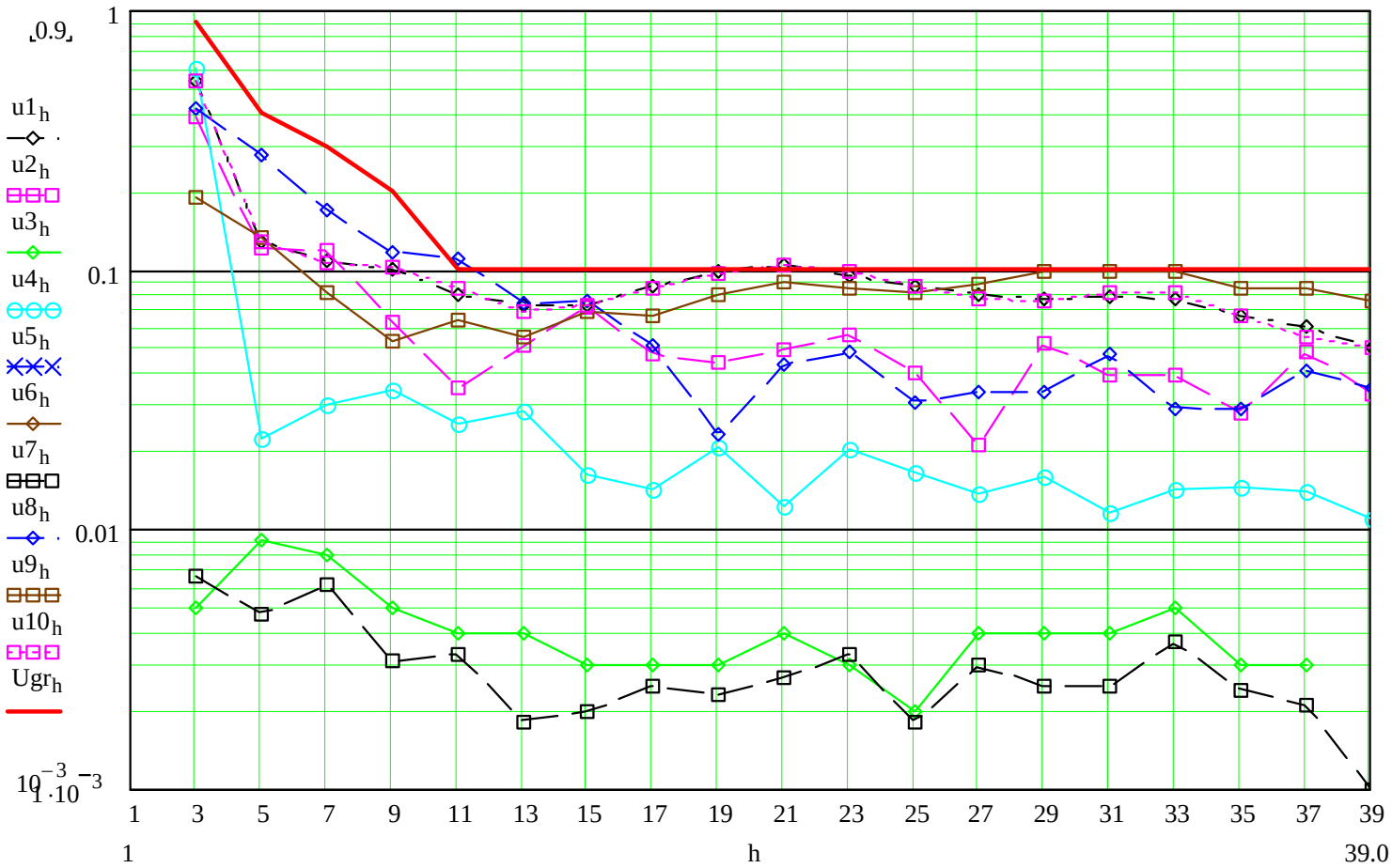
Figure 2. Harmonics of the source voltage when driving the 600W test specimen



Only systems u7h and u3h (VDE and SPS) consistently have harmonics of the voltage which are within the specification limit

Test systems which produced measurement results which had the closest correlation to those predicted by the PSpice simulation analysis also had the smallest harmonic voltage amplitudes by far (see Figures 2 and 3).

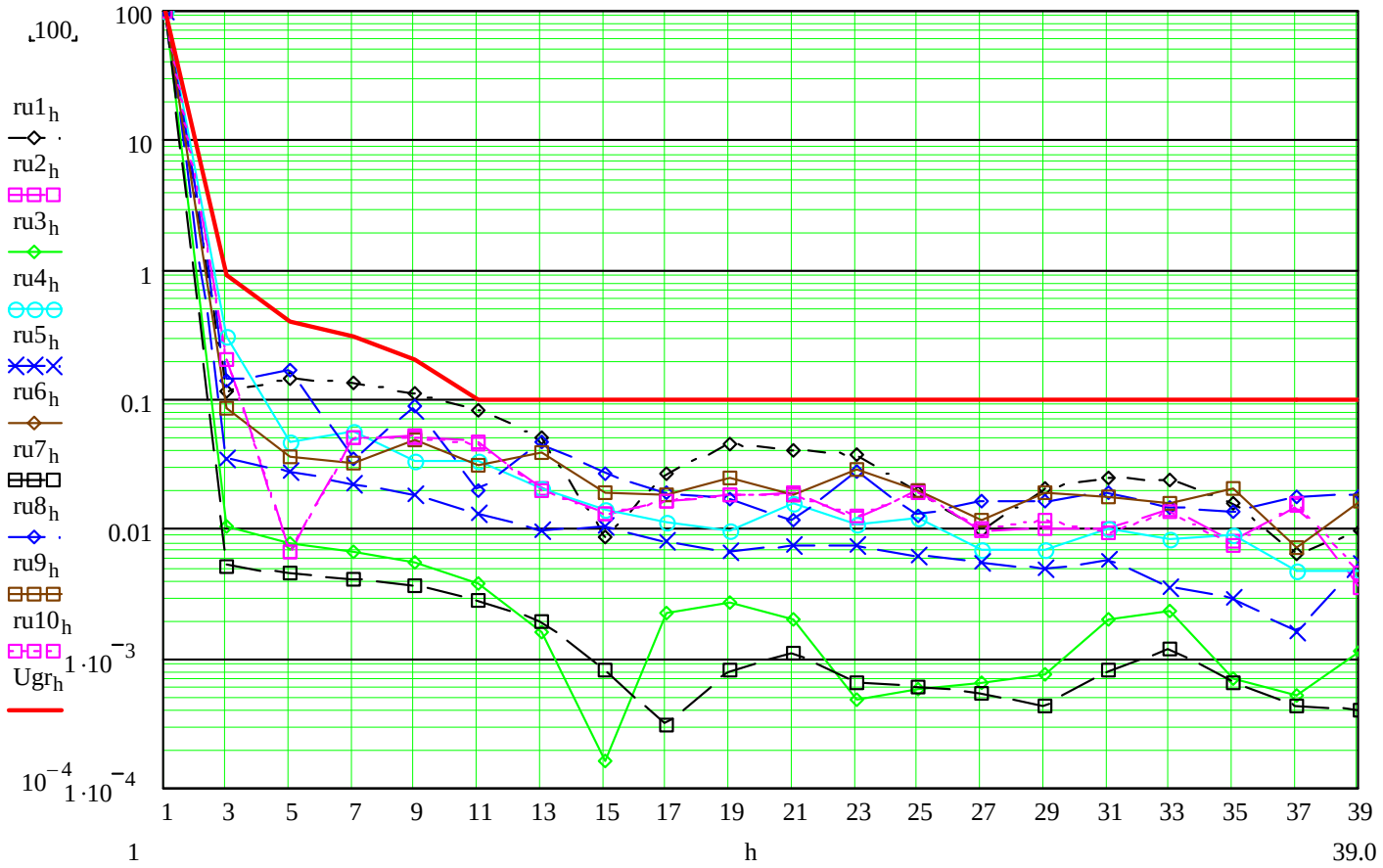
Figure 3. Harmonics of the source voltage when driving the 44Watt test specimen



Despite the small power (44W) some of the sources are already pushing the limits. The PAS-sources are only at approx. 3% of the max. limit!

Generally, the harmonic performance of the SPS-sources (type PAS) is approx. 30-100 times better than that required by the standard. Additional measurements support this view (see figure 4).

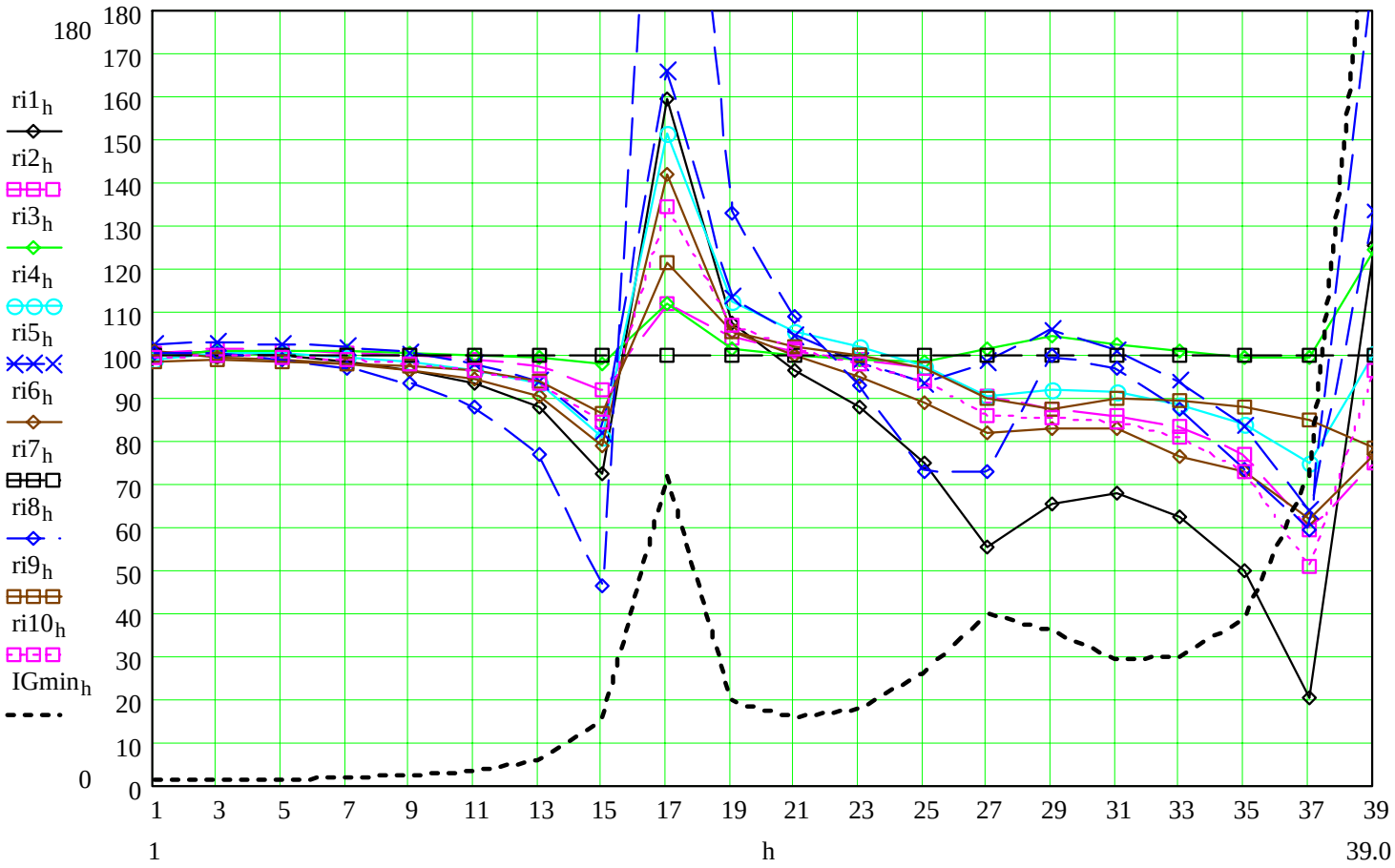
Figure 4. Harmonics of the voltage of a TV set



Again, the voltage harmonics of the PAS-series sources are much smaller

Overall, taking the source with the lowest harmonics 'ru7' (VDE-PAS) as a reference, the following picture of the measurement uncertainty appears:

Figure 5. Harmonics of the currents of the TV set from figure 4



Considerable deviations of the measured harmonic currents are apparent, although values for h>35 are below the minimum.

Summary

The comparison measurement approach, utilising various measurement systems, two verifiable reference test specimens and a commercially available TV set, showed that there are very high deviations in the measurement data obtained – errors which are directly attributable to the characteristics of the AC sources used.

The only test systems which were found to perform within the EN 61000-3-2 specified measurement limit were those utilising the PAS-series of 4-quadrant-amplifiers manufactured by Spitzenberger + Spies.

In most of the other cases, the use of unsuitable AC sources is resulting in the generation of additional harmonics and the consequent recording of incorrect measurement data.

Specific source technologies (e.g. switching amplifiers) have been seen to cause extremely large measurement errors; comparison measurements, conducted directly from the domestic mains supply hardly resulted in worse measurement results.

The aim of conducting tests in accordance with a published standard is to obtain accurate and repeatable measurement results.

Inaccurate measurement results may result in very high costs – both as a result of over-engineering undertaken on the basis of the false measurement data and again due to the loss of the CE-mark!