

Special Edition

Power Grid Detectives

Help, my electric hob is whistling!

Modern measuring techniques make an important contribution to ensuring power quality in low voltage distribution grids. Without them, it would not be possible to make a statement regarding the quality of the individual characteristics of the supply or to find the cause of faults.

At the company Energiedienst Netze GmbH (referred to in the following as EDN), it was therefore decided early in 2001 to establish a so-called Power Quality Team in the Operations Department for Local Power Grid Supply. Its purpose is to learn about and apply these modern measuring techniques and, above all, the correct interpretation of results in combination with

operational experience. EDN uses grid analysers from A. Eberle GmbH & Co.KG. Since 1995, the Nuremberg specialists have dealt, amongst other things, with the recording of power quality with fault recording functionality and with the monitoring of supply dynamics.

This article gives a brief insight into the complexity of the topic of ensuring power quality (a topic that is gaining ever more significance for the electricity market).

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The recording of the grid quality in the local grids (low voltage grids) looked after by EDN takes place through spot check measurements on the one hand and through measurements in response to customer enquiries or complaints on the other. These result in suitable measures being taken to actually ensure the power quality. The trigger for the following case in point was such a customer enquiry:

can disturbing noises from an induction hob be caused by the power supply?

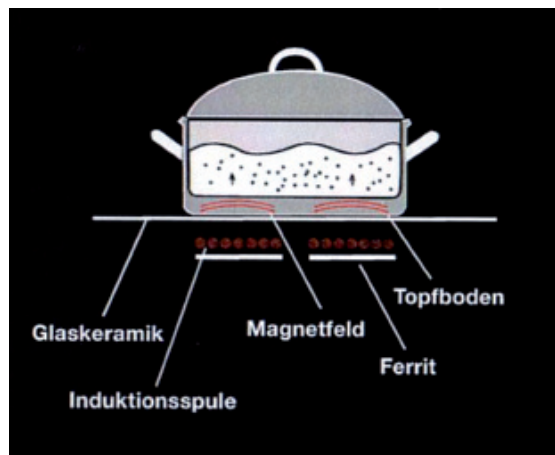


Figure 1: How an induction hob works

This was the question that confronted EDN grid operations foreman in Donaueschingen. Could the loud noises produced by an induction hob have something to do with the public supply grid? (figure 1).

The grid operations foreman passed this question straight on to the Power Quality Team in the Rheinfelden Regional Center.

On checking the address data, Herr Trefzer was able to determine that there had already been incidents in 2002 of interference with heating control units, washing machines and coffee machines in this supply grid area. A number of supply analysis measurements were carried out at the time but no source of interference could be localised. In this supply area there was a joinery with CNC production machines. Acting on conjecture, local grid reinforcement measures were carried out there. After these measures, no complaints were made to EDN for a long time.

Then, however, there were renewed complaints. Thereupon, a standard analysis of the power quality in accordance with EN 50160, "Voltage Characteristics in Public Distribution Systems", was first carried out.

Since EN 50160 gives limit values only up to the 25th harmonic, an additional evaluation was made in accordance with IEC 61000-2-2 of frequencies up to the 50th harmonic. All harmonic levels (2nd to 50th harmonics), were each time within the limits permitted by the standard and permitted no deductions as to a possible "interference source". (figure 2).

To localise the cause of these extraordinary noises, a further measurement was carried out with a noise measuring instrument directly at the induction hob. Particularly prominent were a frequency of about 5 kHz and another of about 10 kHz. The levels beyond 20 kHz were not of interest, as these frequencies are above the range of the human ear. (figure 3).

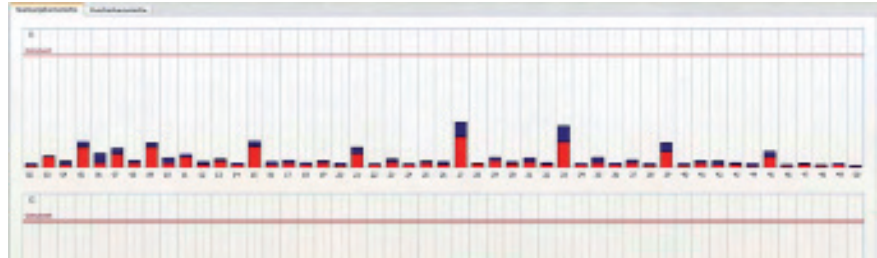


Figure 2: Voltage harmonics 2 to 50 Harmonics according to EN 50160 / IEC 61000-2-2

The following measuring instruments were used:

- NTi Audio XL2 noise level meter
- Netzanalysator PQ Box 100 mains analyser (standard evaluation up to 50th harmonic).

Where is the source of these interfering frequencies?

After a glance at the grid plan, a closer look was again taken at the industrial operation with its CNC machines. They have ten CNC lathes at work. To isolate the source of the interference, the mains

supply was diverted to a small distribution cabinet. By this means, the machines were connected to another mains supply. The interference noise could then no longer be heard from the induction hob. It was now clear that one of the 10 automatic lathes must be responsible for the mains interference. In the next step, the PQ-Box 200 mains analyser was connected to the company's mains inlet. Then, during the company's midday break, all the machines were switched off and one machine at a time was started up for several minutes. In this way, the mains interference from each of the CNC

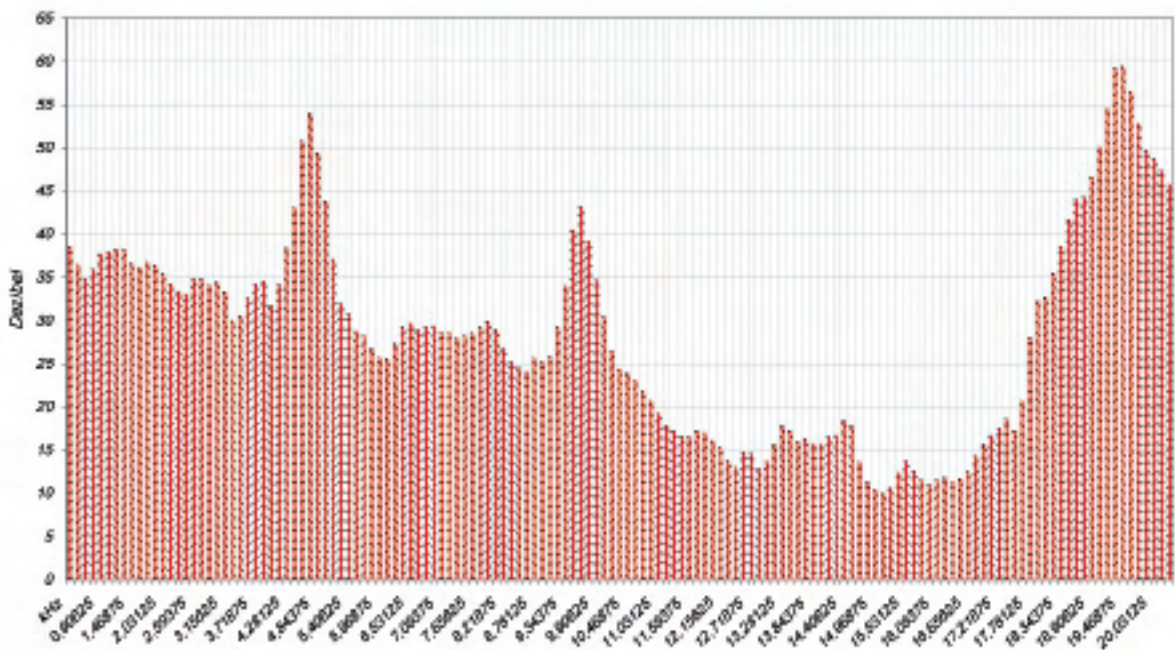


Figure 3: Noise output from induction hob with interference on the mains

lathes could be evaluated. For only one of the machines could interfering frequencies above 2.5 kHz be found on current and voltage.

Since interfering frequencies in the range 2 kHz to 20 kHz are becoming ever more frequent in public grids, A. Eberle has added the PQ-Box 200 to its mobile mains analyser product range. This measuring instrument can detect and record interference levels on both current and voltage from DC to 20,000 Hz.

With this new PQ-Box 200 mains analyser (IEC 61000-4-30 class A measuring equipment), it was very easy to finally localise the interferer. (figure 6).

What can now be done to help the situation?

There are, basically, two possibilities:
Block the interfering signal with an active filter at the point of connection of the electric hob or
filter out the interference directly on the machine.

What is the origin of these interfering frequencies?

A bridge rectifier at the input to the CNC machine produces a DC voltage from the three phase voltages. This DC voltage is chopped at a particular clock frequency into pulses with a variable mark-space ratio to deliver a sinusoidal current to the load. This is called "sine-weighted pulse width modulation". The clock frequency of the pulse inverter and its sidebands can be seen clearly in our measurement in both the mains voltage and the mains current. (figure 7).

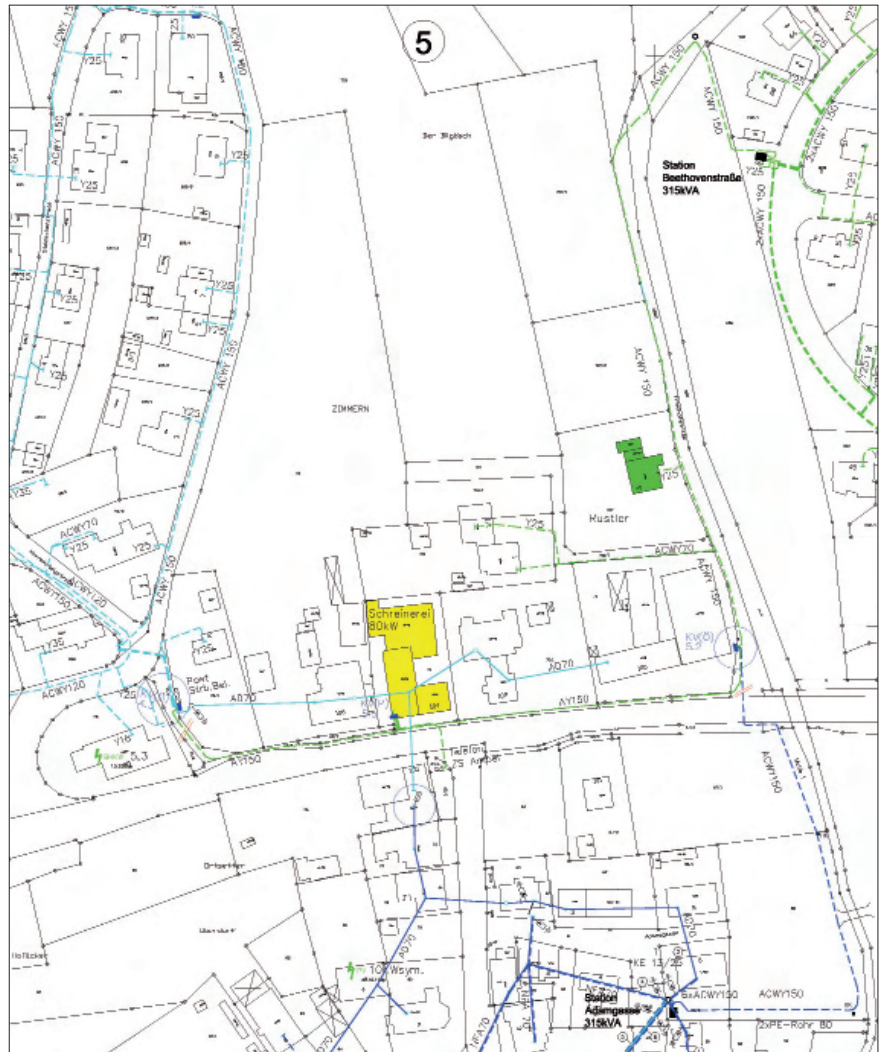


Figure 5: Immendingen distribution grid plan



Figure 6: PQ-Box 200 mains analyser set up on the CNC machine.

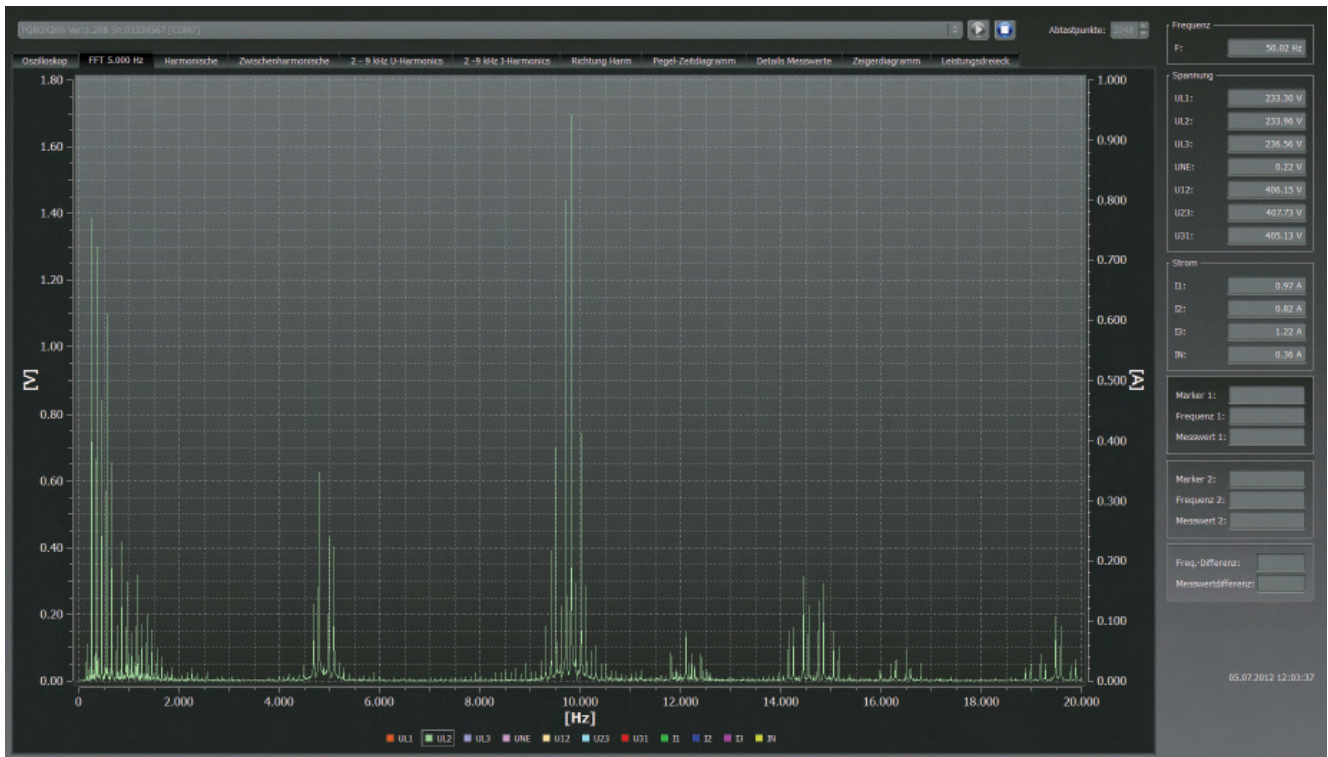


Figure 7: FFT spectrum, voltage, DC to 20.000 Hz (high levels can be seen in the areas of 5 kHz and 10 kHz)
Measured at the connection point of the CNC lathe.

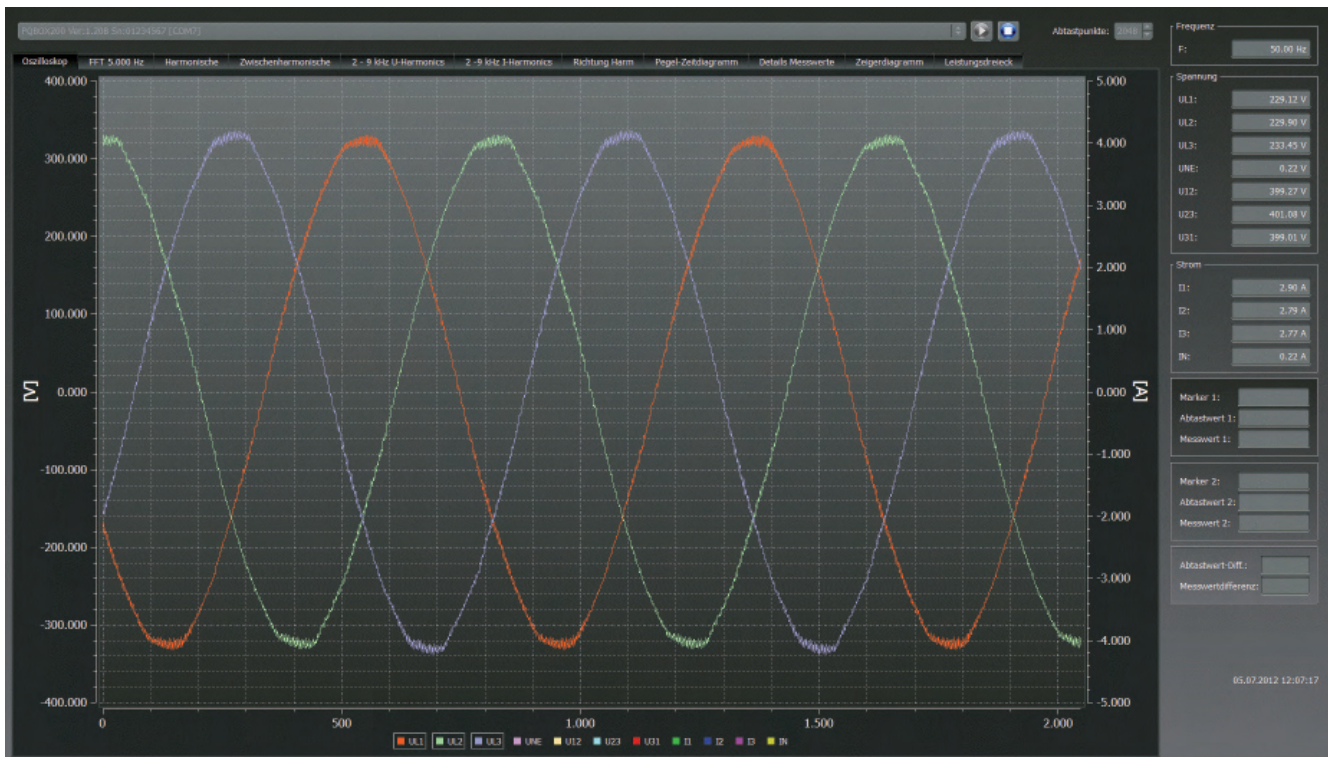


Figure 8: Oscillogram with 41 kHz sampling rate. In the oscillogram, the high frequencies of 5 kHz and 10 kHz can be clearly seen superimposed on the three voltage phases.
Measured at the connection point of the CNC lathe.

The equation for the sidebands of the chopping frequency that are superimposed on the mains supply is as follows.

$$f_{\mu} = n \cdot f_T \pm 2n \cdot f_l$$

f_{μ} = frequency on the mains

n = harmonic multiplier (1; 2; 3)

f_T = clock frequency of the chopper

f_l = frequency of the mains fundamental (50 Hz)

Pressed by EDN, the industrial mould-making operation, in agreement with the CNC lathe manufacturer, retrofitted an EPCOS mains filter.

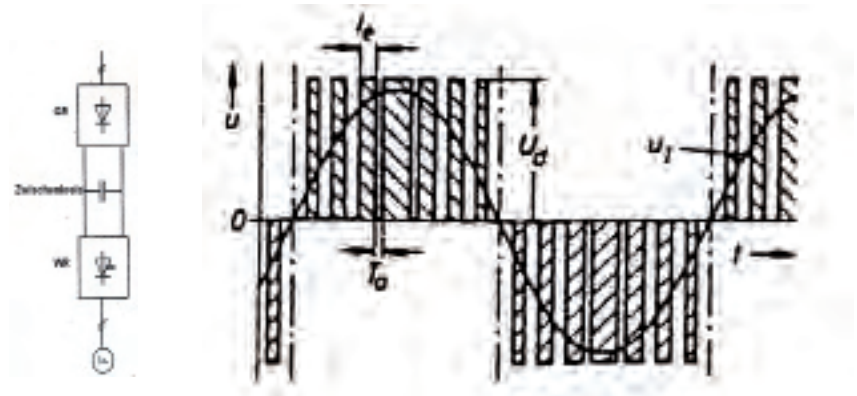


Figure 9: Diagram of the rectifier with inverter of the CNC machine

A connection point measurement demonstrated that the interference levels above 10 kHz were significantly reduced. There was little influence on the interference levels in the area of 5 kHz. However, the noise from the induction hob is

mainly attributable to the 5 kHz frequencies, so the disturbing interference remains. It must now be weighed up whether the filter inserted is to be changed or the induction hob is to be fitted with a blocking circuit.

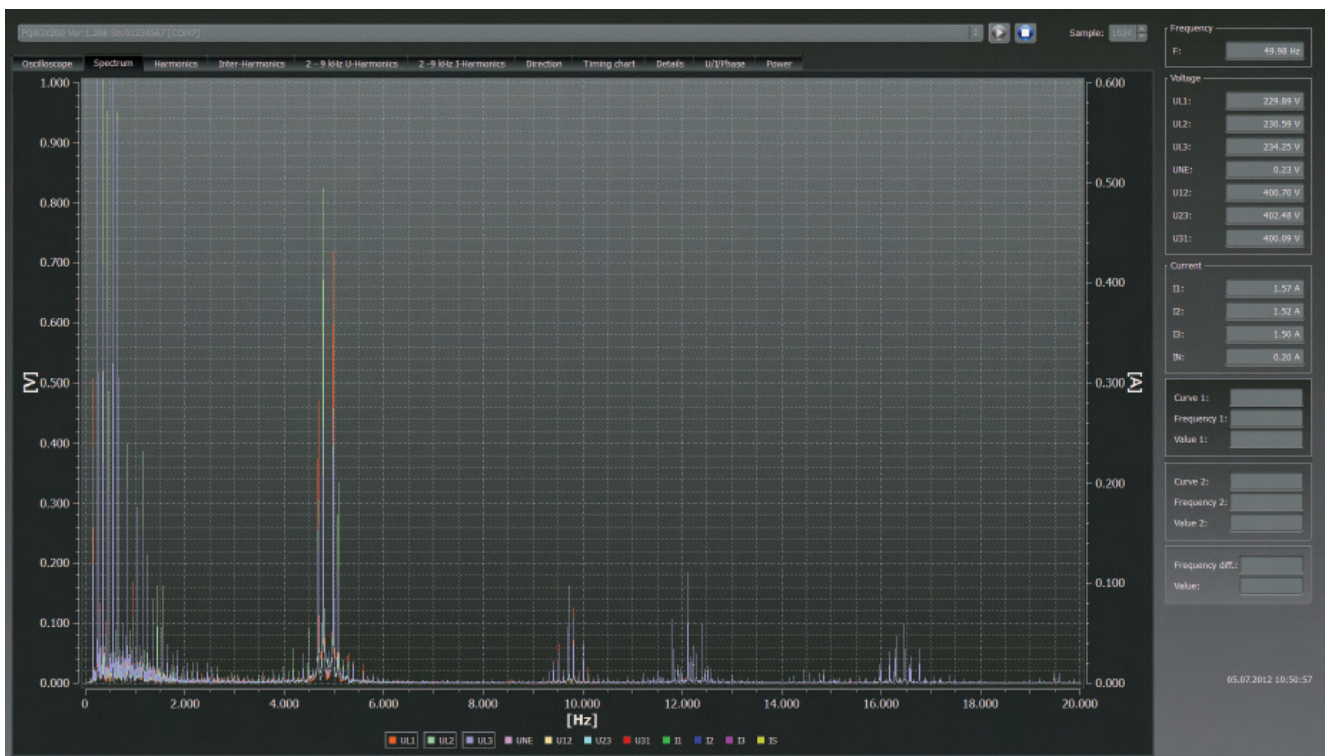


Figure 10: FFT, DC to 20 kHz, voltages LI, L2, L3 with filter inserted
Measured at the connection point of the CNC lathe.

Summary

Mains interference in the range 2 kHz to 20 kHz in our grids is increasing because of the rise in the use of power electronics. Power quality standards for public distribution systems give limit values up to a maximum of 2.5 kHz. For interference sources in low and medium voltage grids, compatibility levels have been defined from 2 kHz to 9 kHz but these do not apply to our CNC machine.

To measure and record mains interference in public distribution systems in

these frequency ranges, A. Eberle has made suitable measuring equipment available by adding the PQ-Box 200 mains analysers to its product range. These can measure and record such interference levels on both voltage and current from DC to 20,000 Hz.

With the user-friendly WinPQ mobil analysis software, detailed measurement reports can be produced. These provide an ideal documentary presentation and record of the measurements.

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Here you can view a video of the mains interference described:
www.a-eberle.de/newsflash/e-herd-mit-pfiff-netzruckwirkungen.html



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