Trip of over voltage protection device

1 Background

A grid company in the north of Sweden had a customer complaint where the customer's carport trigged for over voltages. An electrician went to the customer and measured the voltage using a voltage meter. The result was that the voltage was ok. Additionally, a power quality measurement was done where it was noticed that there were some existing harmonics. A larger measurement was the done using two Unilyzer 900 in the closest transformer station. One instrument was installed per outgoing feeder, on one of the feeders the load was only private houses and on the other there was a water plant for cleaning of water.

2 Diagnostics

After a period of measuring data, it was clear that the 17th, 19th and 21st order harmonics failed according to the Swedish power quality grid code, EIFS, as seen in figure 1

Harmonic no: limit in % of fundamental

#	Limit [%]	MaxU1 [%]	95% U1 [%]	MaxU2 [%]	95% U2 [%]	MaxU3 [%]	95% U3 [%]	Result
2	2	0,06	0,04	0,06	0,04	0,05	0,04	Passed
3	5	0,21	0,15	0,29	0,16	0,34	0,27	Passed
4	1	0,04	0,02	0,06	0,04	0,06	0,02	Passed
5	6	3,39	3,07	3,43	3,14	3,37	3,04	Passed
6	0,5	0,07	0,03	0,07	0,03	0,08	0,02	Passed
7	5	1,81	1,71	1,68	1,56	1,78	1,67	Passed
8	0,5	0,10	0,06	0,12	0,07	0,12	0,06	Passed
9	1,5	0,14	0,11	0,26	0,19	0,38	0,33	Passed
10	0,5	0,07	0,04	0,07	0,05	0,06	0,04	Passed
11	3,5	1,53	1,41	1,60	1,44	1,87	1,48	Passed
12	0,5	0,04	0,02	0,05	0,02	0,06	0,02	Passed
13	3	1,86	1,68	1,42	1,27	2,31	1,71	Passed
14	0,5	0,15	0,08	0,12	0,07	0,15	0,06	Passed
15	1	0,48	0,34	0,98	0,76	0,50	0,39	Passed
16	0,5	0,16	0,09	0,14	0,07	0,23	0,12	Passed
17	2	3,32	3,12	2,30	2,13	2,47	2,31	Failed
18	0,5	0,10	0,06	0,13	0,07	0,11	0,04	Passed
19	1,5	2,11	1,98	2,29	2,13	3,59	3,30	Failed
20	0,5	0,14	0,11	0,15	0,11	0,09	0,06	Passed
21	0,75	0,76	0,64	1,26	1,12	0,77	0,63	Failed
22	0,5	0,12	0,07	0,16	0,11	0,17	0,11	Passed
23	1,5	0,89	0,76	0,98	0,88	0,55	0,47	Passed
24	0,5	0,05	0,02	0,05	0,04	0,05	0,04	Passed
25	1,5	0,00	0,00	0,00	0,00	0,00	0,00	Passed

Figure 1: All individual harmonic levels and their respective limit

When it was clear that high harmonics existed in the voltage, two different analyses were done to estimate the direction of the harmonics. First, the current was plotted along with the failing harmonics on the measurement which was measuring on the feeder with the water plant, as seen in figure 2 below, the load somehow corresponds to the rise of harmonic levels in the voltage.

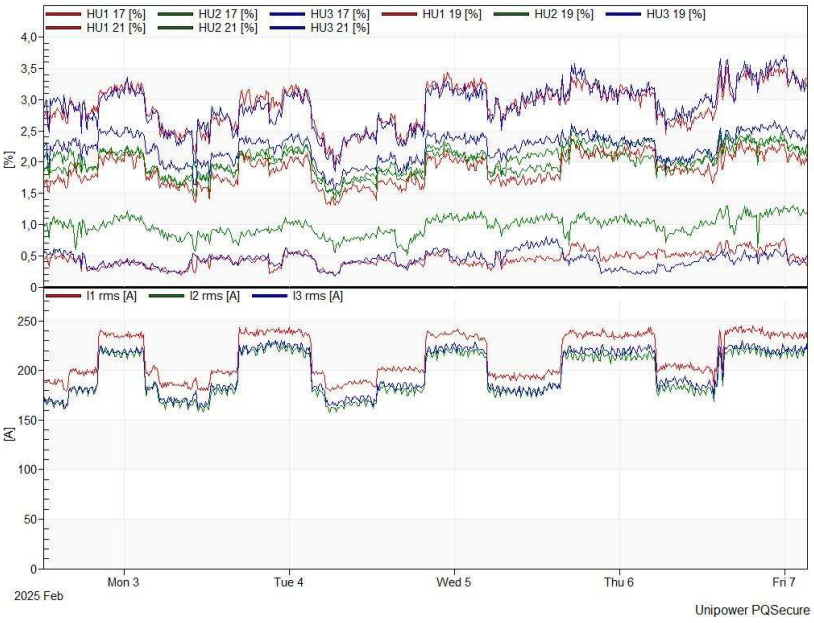

Figure 2: Failing harmonics plotted with the load

Secondly, the power harmonics was compared between the two outgoing feeders. In figure 3, power harmonics are displayed, in the top graph, the feeder to the water plant is shown. In the bottom graph, the feeder to the households is shown.

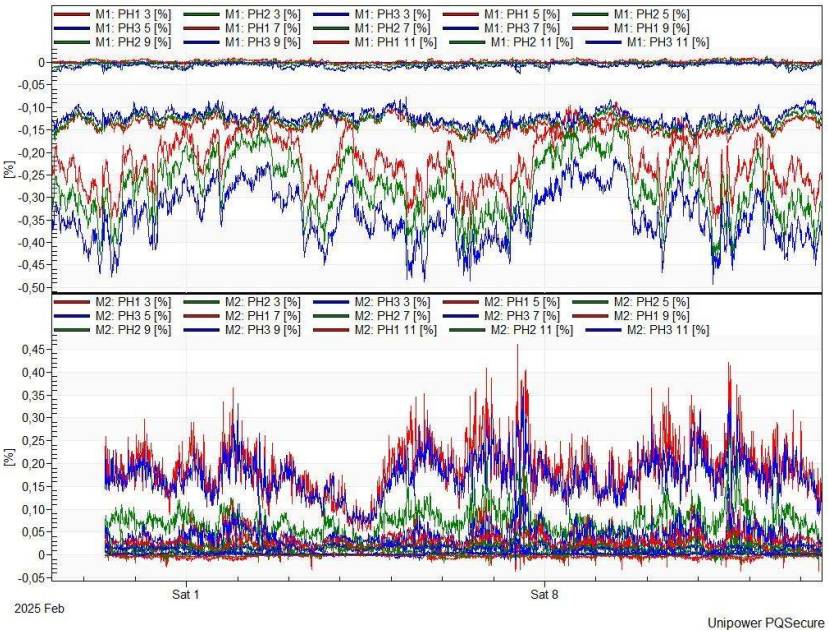

Figure 3: Power harmonics for both feeders separately

The power harmonics are negative for the water plant whilst they are positive for the households.

3 Conclusion

Negative power harmonics could be a sign of the harmonics being created downstream, along with the power harmonics being positive on the other feeder and that the load was correlating to the harmonics in the voltage, the conclusion was that the harmonics was created at the water plant.

Furthermore, the question still was there as to why the overvoltage protection device had trigged. When harmonics are appearing in the grid, the sine wave of the voltage is distorted. This can lead to the peak value of the sine wave being higher than it should be without affecting the RMS value of said voltage. A simple way to calculate the RMS value would be using the formula $U = \frac{\hat{U}}{\sqrt{2}}$, this will give the RMS value when there is a perfect sine wave. But not when the signal is distorted by harmonics making the Û higher. The overvoltage protection device is most probably measuring the voltage using this formula which is causing the trip. This is yet to be confirmed by the grid company. Figure 4 below shows how a waveform distorted by harmonics can look, it is very clear that the top value of the waveform has a peak higher than normal. PQOnline3 will calculate both the top value and the RMS value and display in the top right corner.

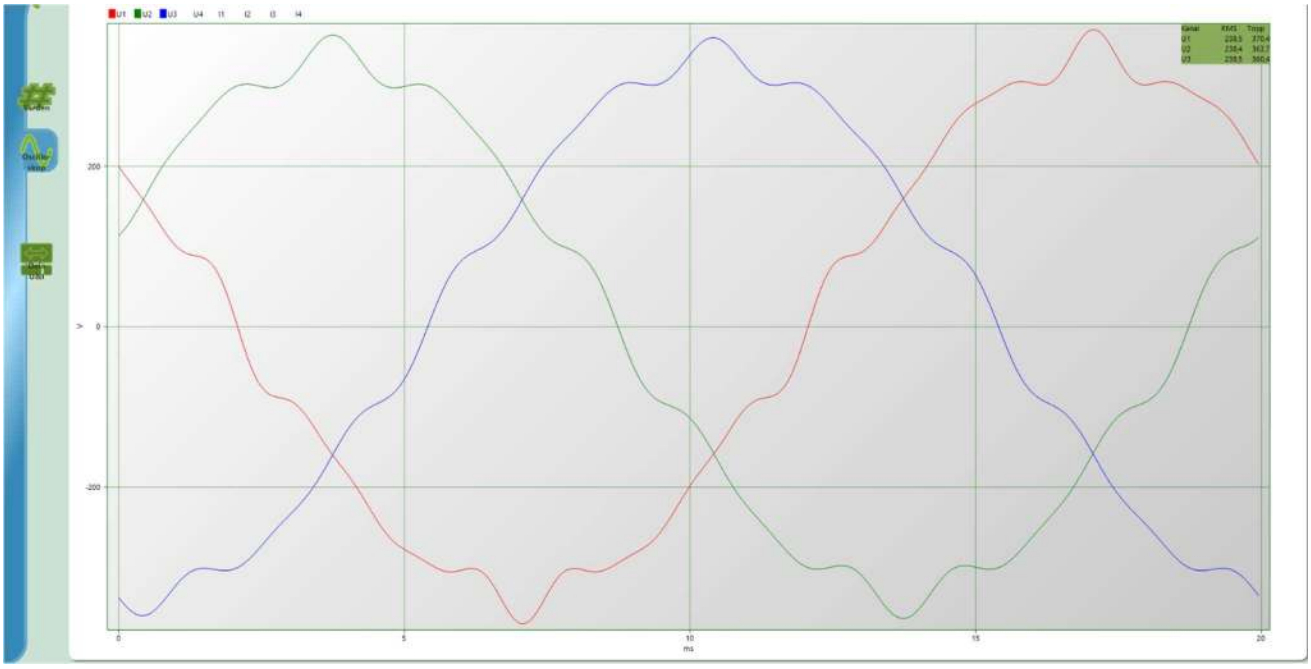

Figure 4: Waveform of a 238V signal with harmonic distortions