NOKIAN CAPACITORS

Operation Principles and Applications of **MaxSine Active Filter**

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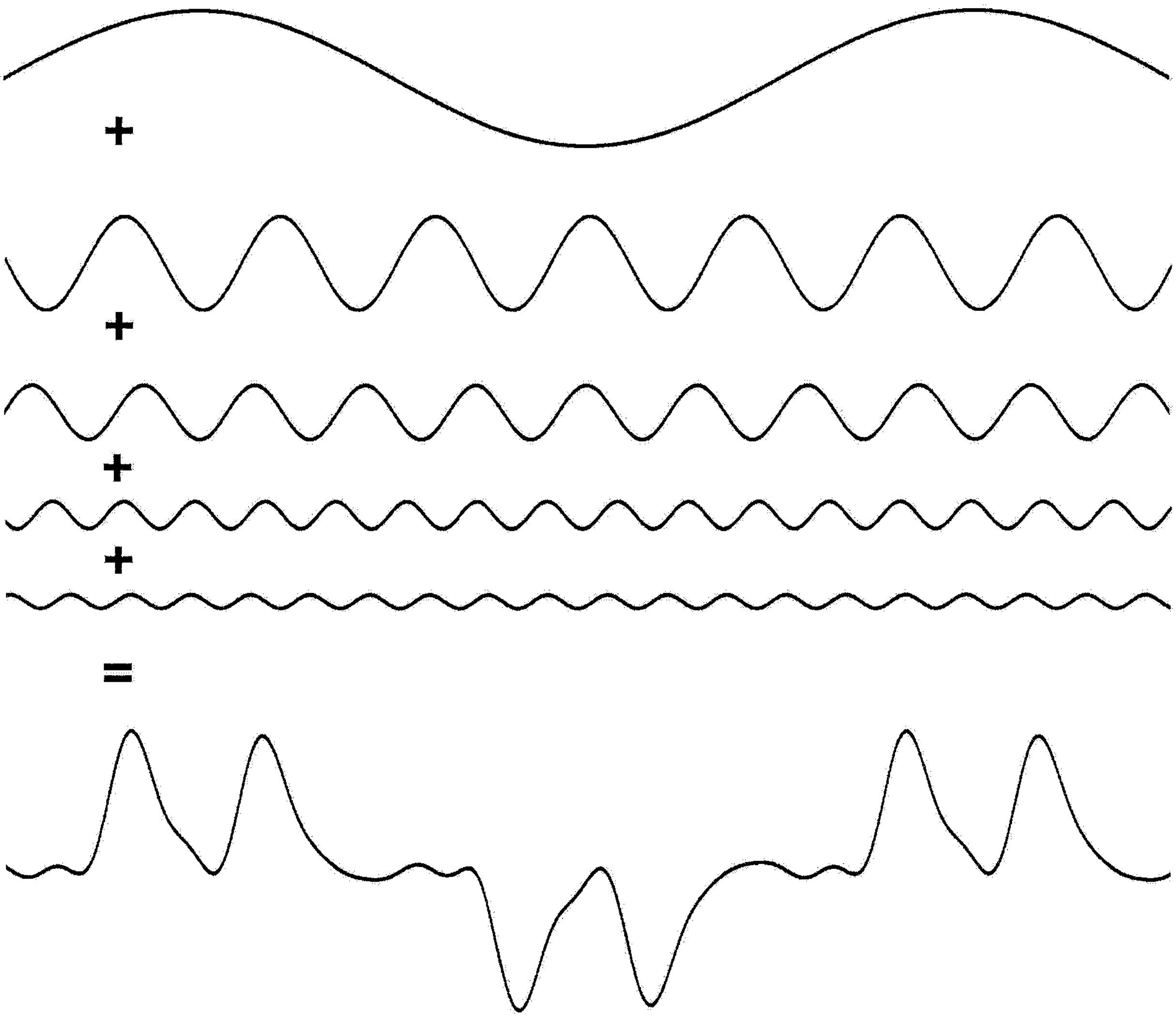
1. Content

2. Harmonics in General

Harmonics currents are caused by electrical consumers like:

- Static inverter drives
- Dimmers
- Power supplies in televisions, computers, printers, etc.
- Medium frequency induction furnaces
- Lightings (gas-discharge lamps, neon tubes, etc.)
- Transformers in saturation etc.

Harmonics are quantified by using Fourier transformation. Hereby a non sinusoidal periodical wave will analyzed in one sinusoidal fundamental and sinusoidal harmonics with integer multiple frequencies of the fundamental frequency. The relevant results of a Fourier transformation over a certain wave form are the amplitude, phase and the frequency of each harmonic.



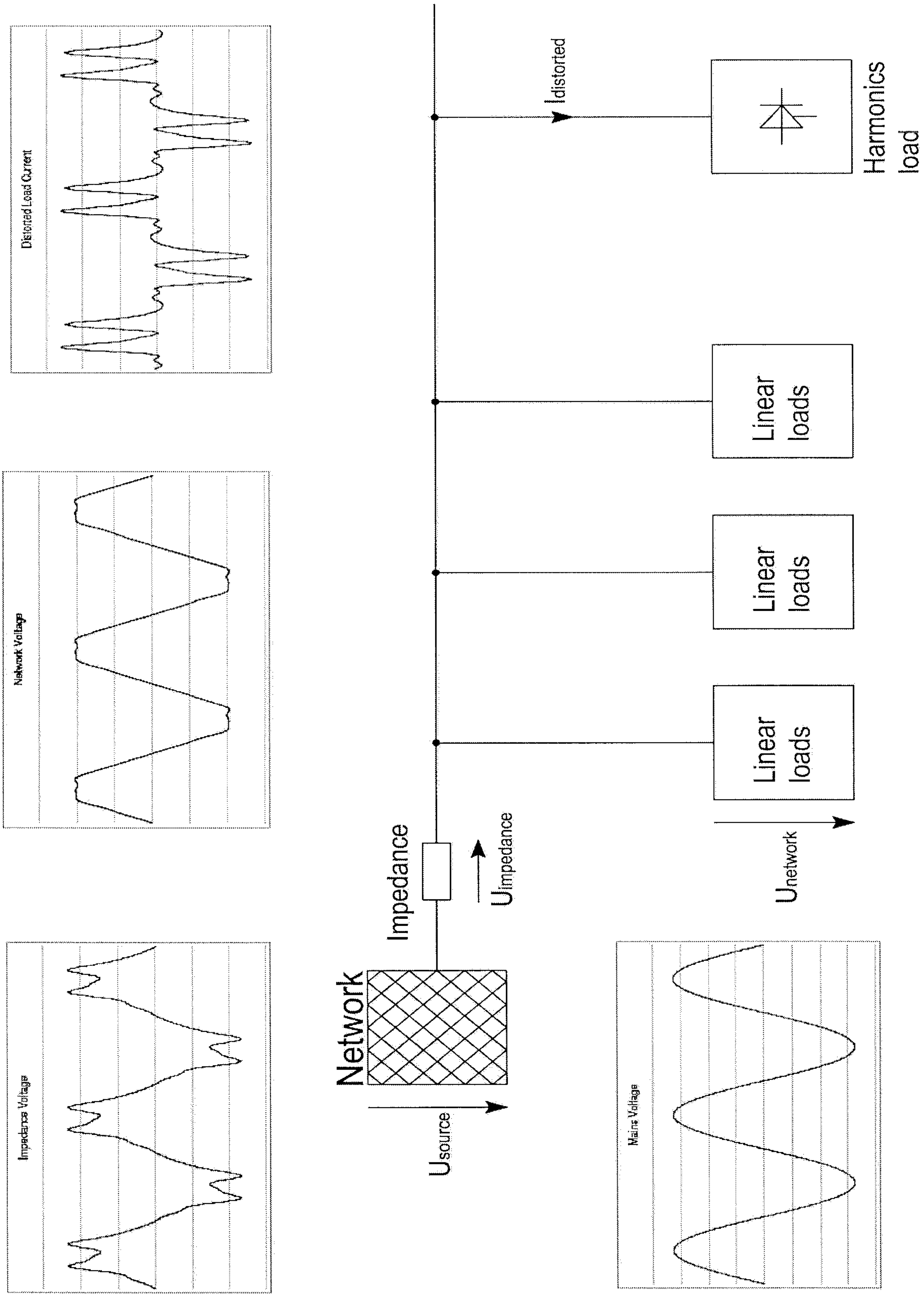
Picture 1: Fourier transformation of a typical 6-pulse current

Harmonics currents are reactive currents like fundamental reactive currents. They are called reactive currents because they are not able to contribute to active power. Currents which are able to contribute to active power have to be in frequency and phase equal to voltage. It means that only fundamental current in phase to the voltage is able to contribute to active power.

Harmonics currents cause additional stress to lines, transformers etc. like fundamental reactive currents. Additionally harmonics voltages can cause disturbances to consumers installed in the electrical network:

- Reduction of the life span and thus premature failure of condensers and electric motors due to thermal overloading
- Malfunctioning with electronics
- Malfunctioning of protection device
- Malfunctioning of ripple control systems
- Impairment of the ground fault deletion

Harmonics voltages occur because harmonics currents floe through the network impedance where harmonics voltages superimpose to the sinusoidal source voltage.



Picture 2: Why harmonics currents cause harmonics voltages in electrical networks

3. What to do against harmonics

The general rise in use of electrical devices with non-sinusoidal power input is forcing electricity supply companies to place stricter limits on their customers in order to avoid network problems caused by harmonics distortion.

In general there are two possibilities to compensate harmonics currents:
- Passive harmonics filters (tuned parallel resonance circuits)
- Active harmonics filters (MaxSine)

Passive harmonics filters work by short cutting voltages with certain frequencies. For each harmonics frequency a tuned parallel filter (inductivity in serial to a capacitor) has to be dimensioned. If the voltage distortion of a certain network has to be compensated by passive harmonics filter it has to be dimensioned dependent of the network impedance.

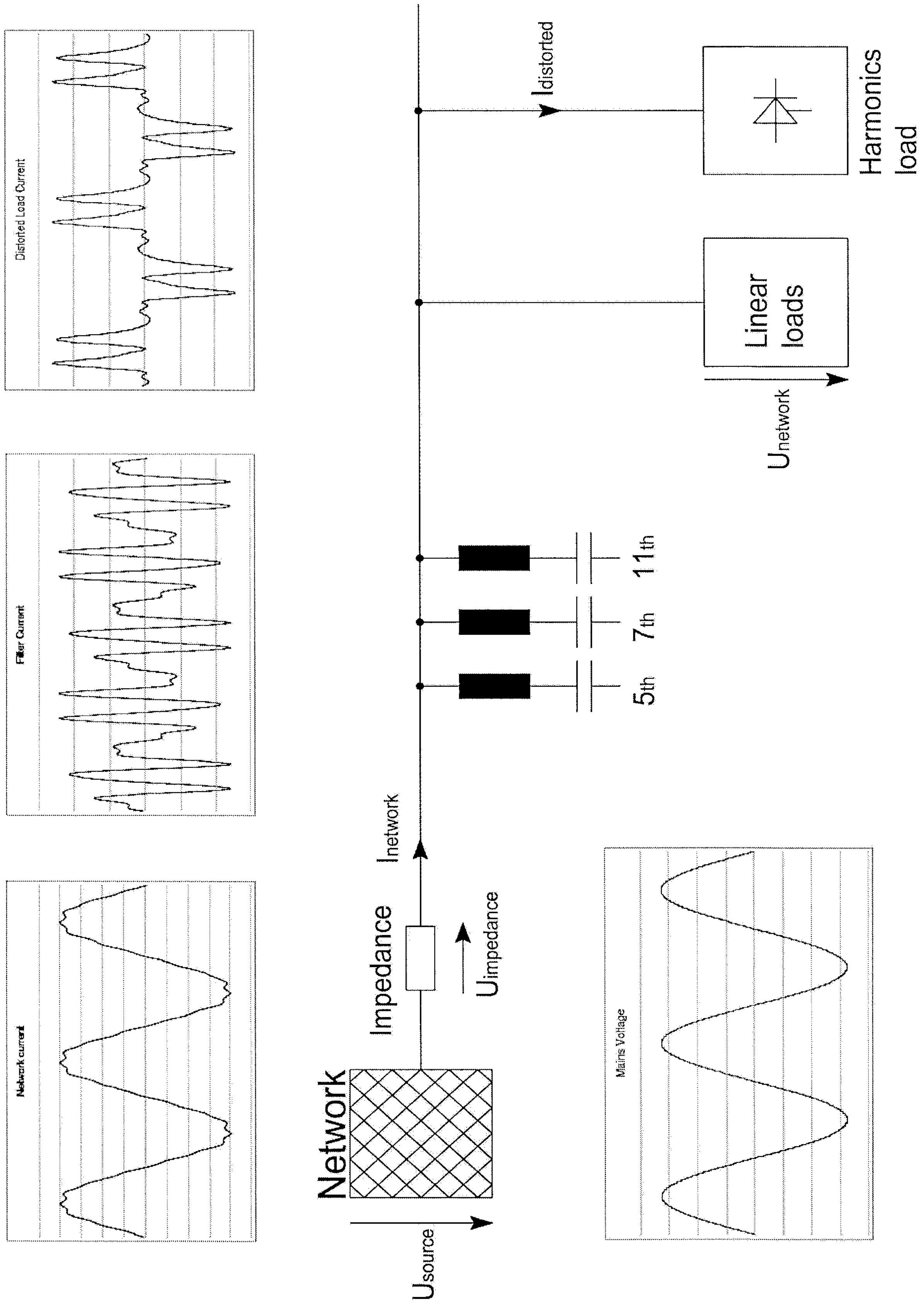
Disadvantages of passive filters:
- Difficult to dimension
- Central compensation only
- No dynamic
- Easy to overload
- Danger of network resonances

Advantages of passive filters:
- Cheap (in comparison to active filters)
- Lower power losses (in comparison to active filters)

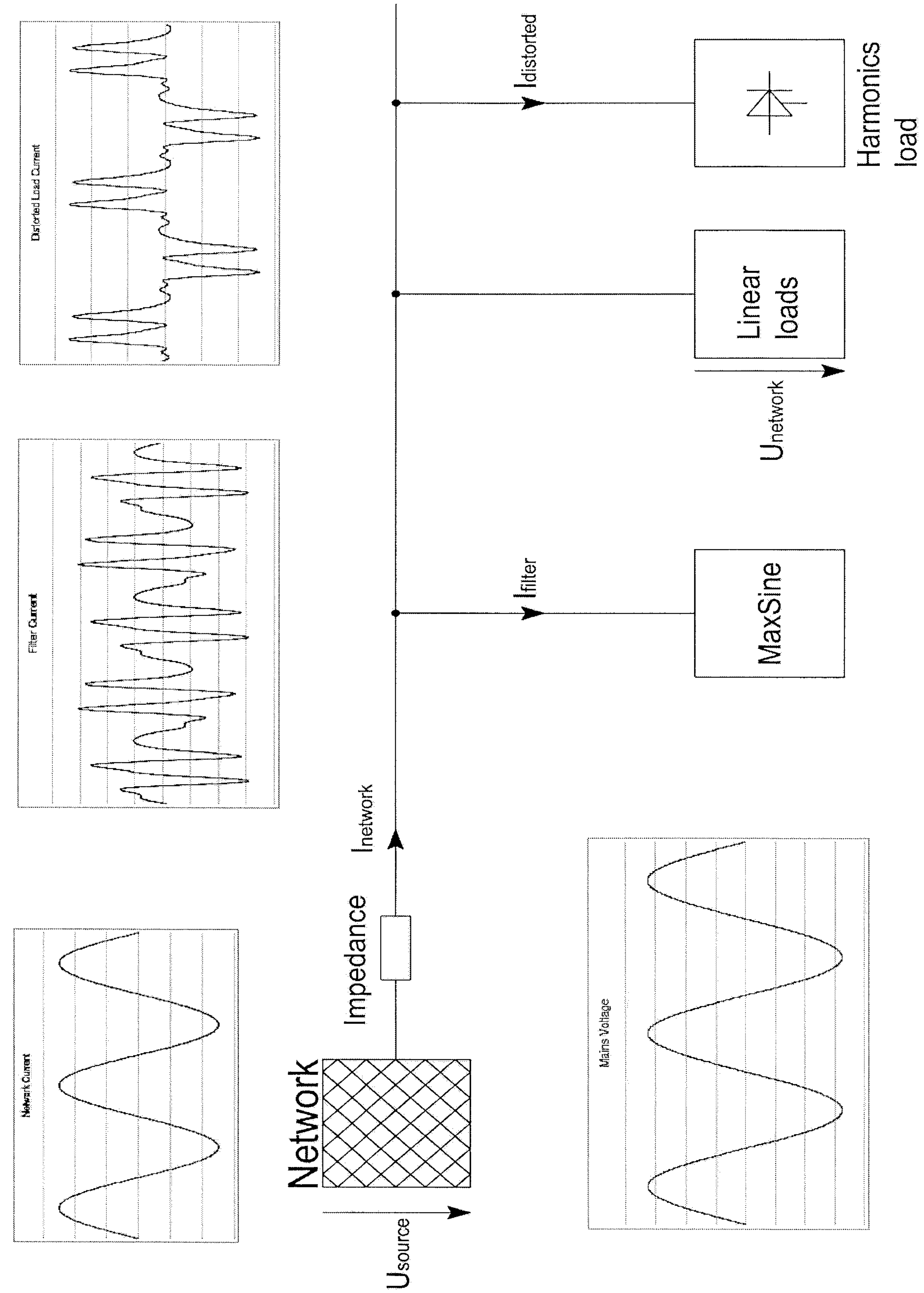
The active compensation of harmonics currents, using pulsed current rectifiers with IGBT (Insulated Gate Bipolar Transistor) technology, enables both harmonic power and fundamental reactive power can be compensated dynamically using the shunt active filter (MaxSine). The system is therefore also extremely suitable for the avoidance of flicker, caused by idle current eddies in the electrical supply network.

Disadvantages of active filter MaxSine:
- Expensive (in comparison to passive filters)
- Higher power losses than passive filters

Advantages of active filter MaxSine:
- Direct compensation of harmonics currents
- Easy dimensioning
- Independent of the mains voltage quality
- Independent of the network impedance
- Excellent dynamics
- No influence to ripple control systems
- Electronically overload protection



Picture 3: Passive harmonics compensation (tuned parallel resonance circuit)



Picture 4: Active harmonics compensation with MaxSine

4. Measuring harmonics

To measure harmonics voltages and currents the following equipment can be used:

- Oscilloscope (the data can be analyzed after the measurement results were stored)
- Power meter ("Fluke", "Tektronix" etc.)
- Data logger ("TOPAS", "Dranetz" etc.)

We assume a sinusoidal course of voltage and a non-sinusoidal course of current in a one phase network for the following derivations:

1. Total harmonics distortion factor
   In Europe THD_R is more common than THD_F. THD_F is used in the USA.

$$THD_R = \frac{\sqrt{\sum_{\nu>1}^{\infty} I_\nu^2}}{I} \quad ; \quad THD_F = \frac{\sqrt{\sum_{\nu>1}^{\infty} I_\nu^2}}{I_1} \quad ; \quad THD_R = \sqrt{\frac{THD_F^2}{1+THD_F^2}}$$

2. Power

$$S = U \cdot I \quad ; \quad P = U \cdot I_1 \cdot \cos\varphi_1 \quad ; \quad Q_1 = U \cdot I_1 \cdot \sin\varphi_1 \quad ; \quad D = U \cdot \sqrt{\sum_{\nu>1}^{\infty} I_\nu^2}$$

$$Q = \sqrt{Q_1^2 + D^2}$$

$$S = \sqrt{P^2 + Q_1^2 + D^2}$$

3. Power factor

$$\lambda = \frac{P}{S} = \sqrt{1 - THD_R^2} \cdot \cos\varphi_1$$

Often made mistakes:

- No difference is made between THD_R and THD_F!
- No difference is made between Q and Q_1!
- No difference is made between γ and $\cos\varphi$
- The results of Fourier transformations sometimes are given as RMS values and sometimes as peak values

5. Differences of MaxSine to competitor products

- Response time less than 1ms (in other products at least 40ms are needed for the calculation of the compensation current).
- Possibility of real 4-wire (three phase plus neutral) compensation (the most well known competitor products cannot really compensate 4-wire loads, at least if they are asymmetrically)
- MaxSine doesn't provide individual programming of each harmonics (harmonics selection needs calculation time, the filter would become too slow).

6. Dimensioning MaxSine, first step

To give customers a first imagination about the size of MaxSine, as a first step the following measurements have to be done:

- THD_R of the load to be compensated
- Phase current of the load to be compensated
- Neutral current of the load to be compensated

Note:
Depending on the time period of the measurement the results can be very different. In high dynamic loads each value always can change.

For the first MaxSine size imagination the calculation is the following:

$$I_{MaxSine} = I_{Phase} \cdot THD_R$$

A 4-wire device is needed if:

$$I_{Neutral} > 10\% \cdot I_{Phase}$$

The following standard devices are available:

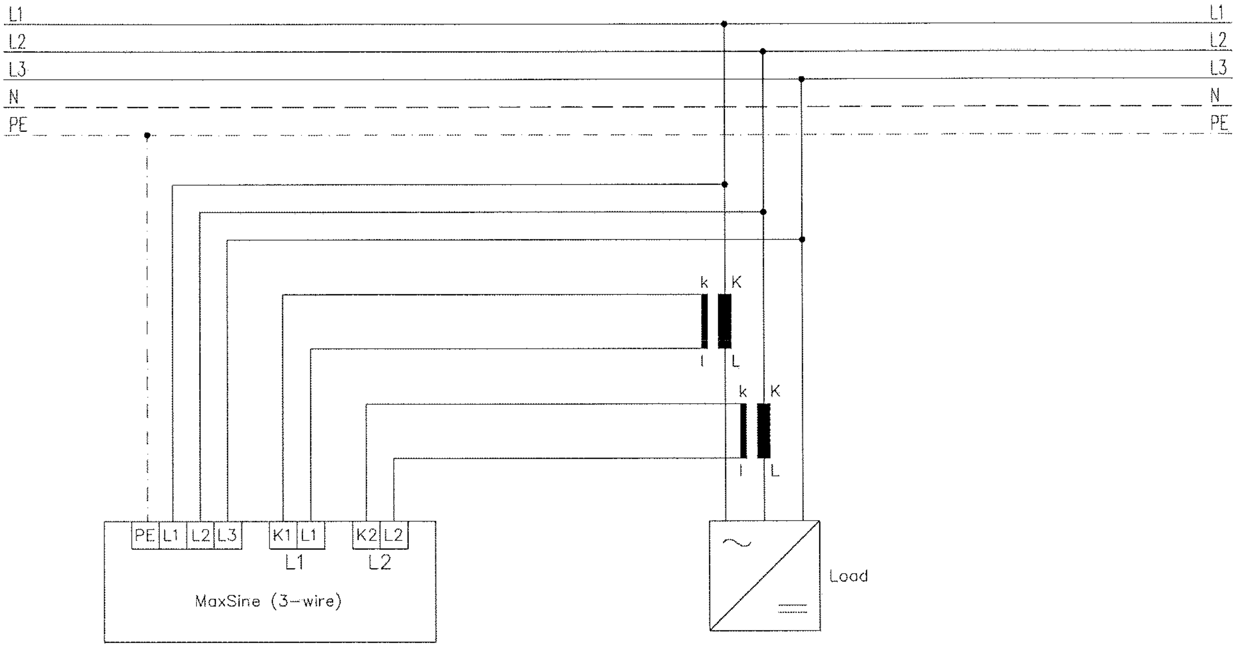
1. 3-wire:
   MaxSine 50A-3L (compensation current: 50A)
   MaxSine 100A-3L (compensation current: 100A)
2. 4-wire:
   MaxSine 30A-4Lx2 (compensation current: 30A phases / 60A neutral)
   MaxSine 60A-4Lx2 (compensation current: 60A phases / 120A neutral)

Explanations:
3-wire: 3-phase connection without neutral
4-wire: 3-phase connection with neutral
x2: Double compensation power for the neutral

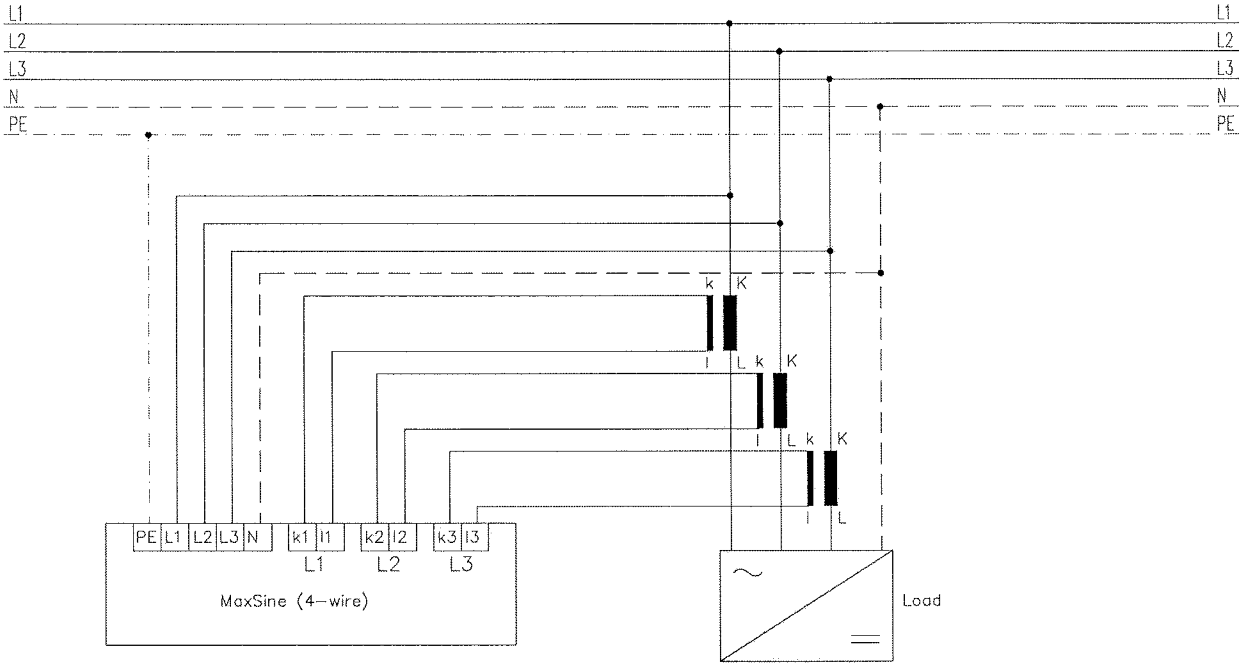
Attention:

- The first step of MaxSine dimensioning gives only an imagination to the customer. A final device selection can be made only after detailed measurements and/or simulations are made.
- Typical 3-wire loads (e.g. frequency converter) can be compensated by 4-wire-MaxSine as well
- Typical 4-wire loads (e.g. Personal computer) **cannot** be compensated by 3-wire-MaxSines!
- To increase power of MaxSine the devices can be switched in parallel! It's also possible to switch MaxSines with different sizes in parallel, but only 3-wire with 3-wire and 4-wire with 4-wire –devices.

6. Connection of MaxSine



Picture 5: Connection of MaxSine 3-wire



Picture 6: Connection of MaxSine 4-wire

7. Compensation of total reactive power

MaxSine provides two compensation modes:

1. Compensation of harmonics power (standard)
2. Compensation of total reactive power (harmonics and fundamental reactive power)

MaxSine dimensioning for total reactive power mode:

$$I_{Phase\,MaxSine} = \sqrt{(I_1 \cdot \sin\varphi_1)^2 + \sum_{\nu>1}^{\infty} I_\nu^2} = \sqrt{(I_1 \cdot \sin\varphi_1)^2 + (I \cdot THD_R)^2}$$

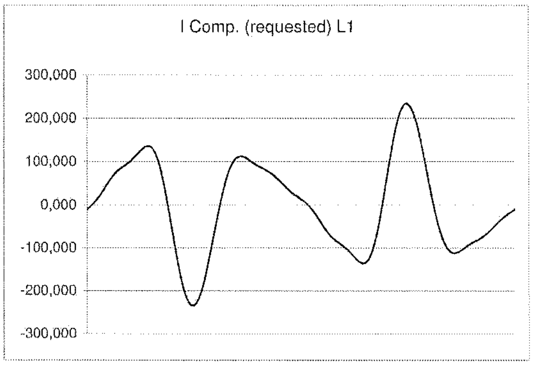
$$I_1 = I\sqrt{1 - THD_R^2}$$

$$\sin\varphi_1 = \sin(arc\cos\varphi_1)$$

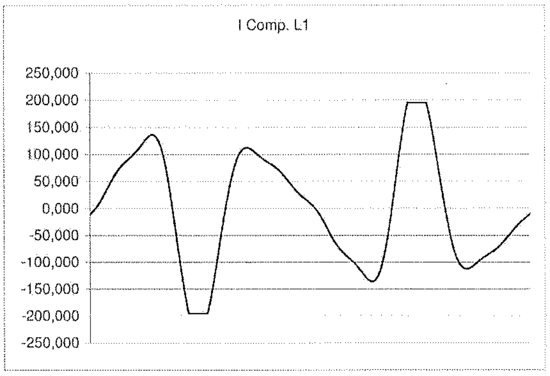
8. Limits of MaxSine

The limits of MaxSine are caused by:

- Electronically internal over-current limit
  (Compensation current peaks which touches the over-current limit will be cut)
- Input inductance
  (Compensation currents which are too steep cannot be pressed into the network)



Picture 7: Requested compensation current



Picture 8: Limited compensation current

The electronically internal current limits of MaxSines:

MaxSine 50A-3L: Approximately 80A
MaxSine 30A-4Lx2: Approximately 50A
MaxSine 60A-4Lx2: Approximately 100A
MaxSine 100A-3L: Approximately 160A

The compensation current becomes as steeper as
- higher the amplitude
- higher the frequency

Limits of standard MaxSine:

MaxSine 50A-3L and
MaxSine 30A-4Lx2:

Approximately: $\frac{100kA}{s}$

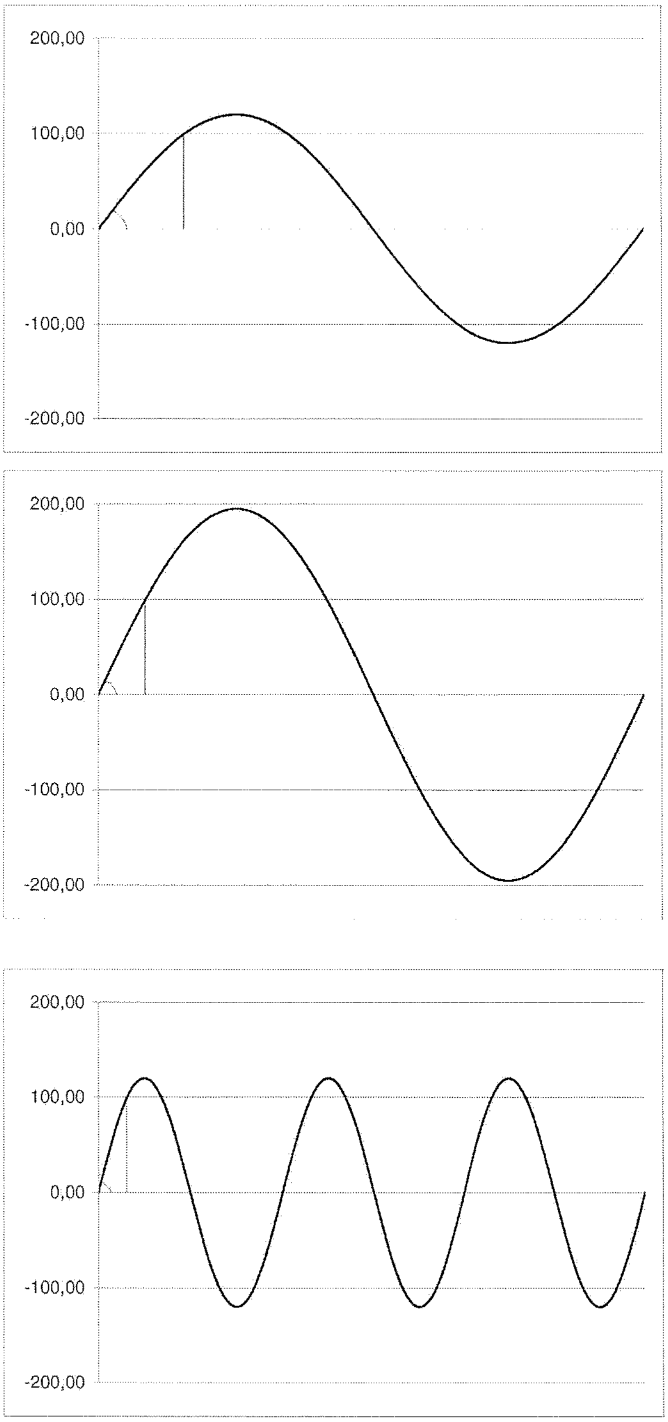
MaxSine 100A-3L and
MaxSine 60A-4Lx2:

Approximately: $\frac{170kA}{s}$

Note:
As bigger the size of a MaxSine, as higher the ability to feed steep currents in the network!

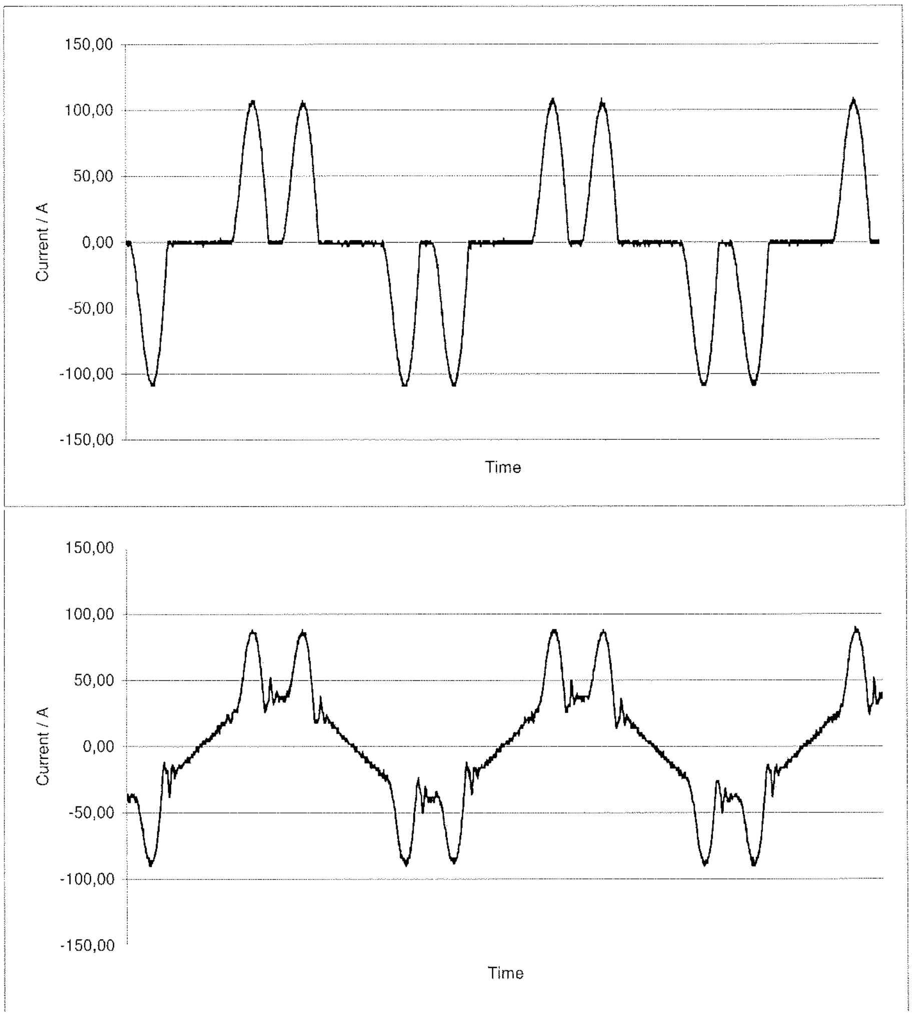
As higher order and amplitude of the harmonics currents to be compensated, as higher the probability of limitations by MaxSine.

In applications where MaxSine works on its limit, sometimes the result becomes better by switching the device to "part wise compensation".

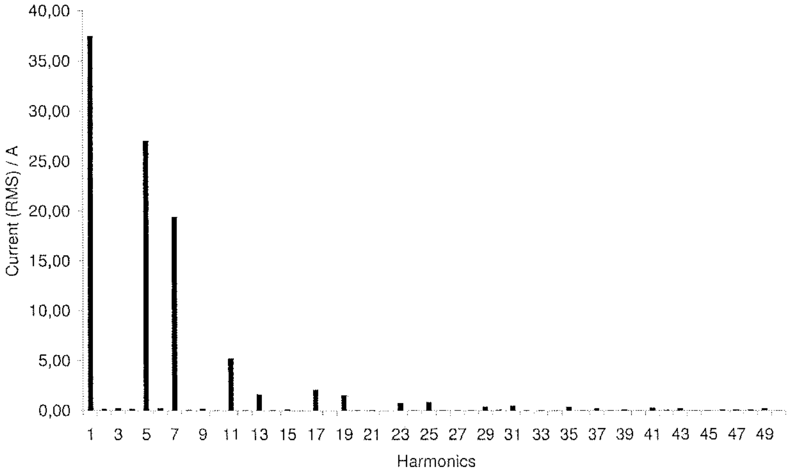


Picture 9: Steepness of compensation current

Current steepness of the load current in the following example: About 100kA/s



Picture 10: Example of network current before and after compensation with MaxSine running on its limit



Picture 11: Fourier transformation of the load current (uncompensated current)

Order:	**f / Hz**	**I RMS / A**	**THDr:**	**THDf:**	**Total-values:**
1	50	37,48	74,04%	100,00%	
3	150	0,27	0,54%	0,72%	**I RMS / A:**
5	250	27,08	53,51%	72,26%	50,61
7	350	19,45	38,42%	51,89%	
9	450	0,23	0,46%	0,62%	**THDr:**
11	550	5,23	10,34%	13,96%	67,03%
13	650	1,63	3,23%	4,36%	
15	750	0,15	0,29%	0,40%	**THDf:**
17	850	2,11	4,18%	5,64%	90,53%
19	950	1,53	3,03%	4,09%	
21	1050	0,06	0,12%	0,16%	
23	1150	0,78	1,55%	2,09%	
25	1250	0,87	1,72%	2,32%	

Table 1: Fourier transformation of the load current (uncompensated current)

9. Detailed dimensioning of MaxSine

To take consideration to the fact that higher order harmonics has to be compensated with higher power; the following equation shall help to find out the correct size of MaxSine:

$$I_{MaxSine} = \sqrt{\sum\left[\left(1+\frac{5\%\cdot(\nu-1)}{2}\right)\cdot I_{\nu Load}\right]^2}$$

$$= \sqrt{\sum\left[(0{,}975+0{,}025\cdot\nu)\cdot I_{\nu Load}\right]^2}$$

ν = Harmonics order

$I_{\nu Load}$ = Certain harmonics currents of load which MaxSine shall compensate

Example with the values from above:

$$I_{MaxSine} = \sqrt{\begin{array}{l}\left[(0{,}975+0{,}025\cdot 5)\cdot 27A\right]^2+\left[(0{,}975+0{,}025\cdot 7)\cdot 19{,}5A\right]^2\\ +\left[(0{,}975+0{,}025\cdot 11)\cdot 5A\right]^2+\left[(0{,}975+0{,}025\cdot 13)\cdot 2A\right]^2\\ +\left[(0{,}975+0{,}025\cdot 17)\cdot 2A\right]^2+\left[(0{,}975+0{,}025\cdot 19)\cdot 1{,}5A\right]^2\end{array}} = 38A$$

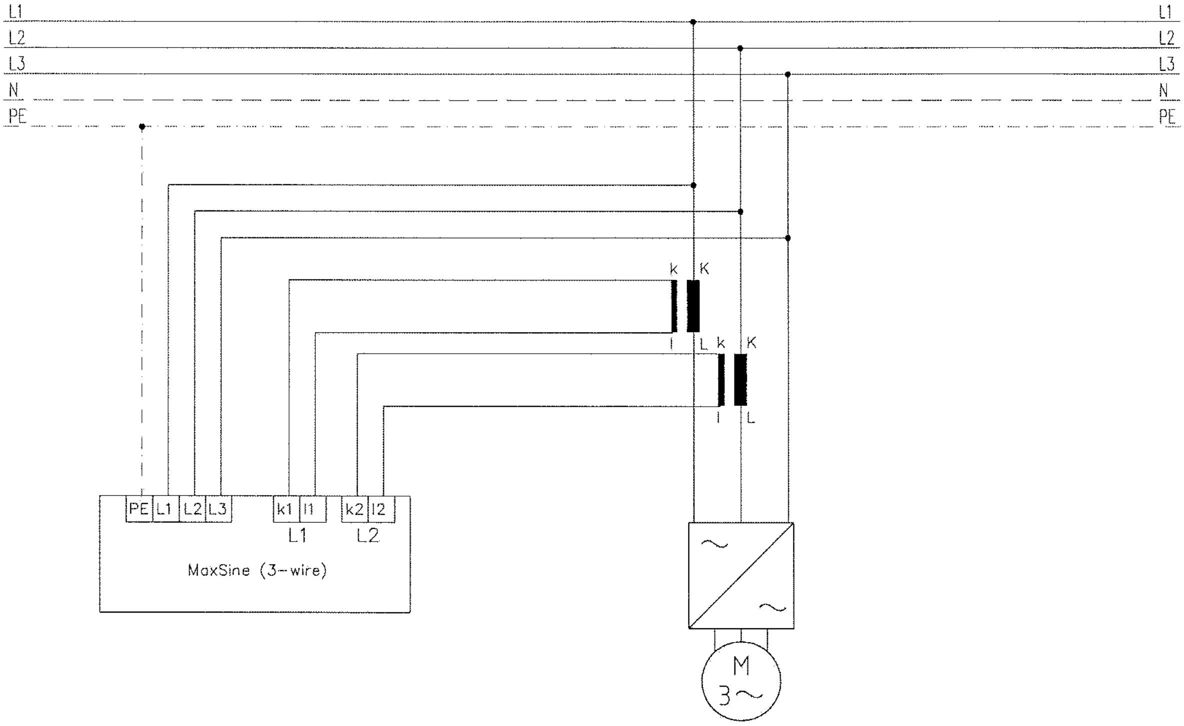
The selected MaxSine should be able to compensate at least 38A.
For the example above MaxSine50A-3L would be suitable. The measurements were made with MaxSine35A-3L

Nevertheless, the steepness of the load current (100kA/s) is as steep as the capability of a MaxSine50A-3L!!!

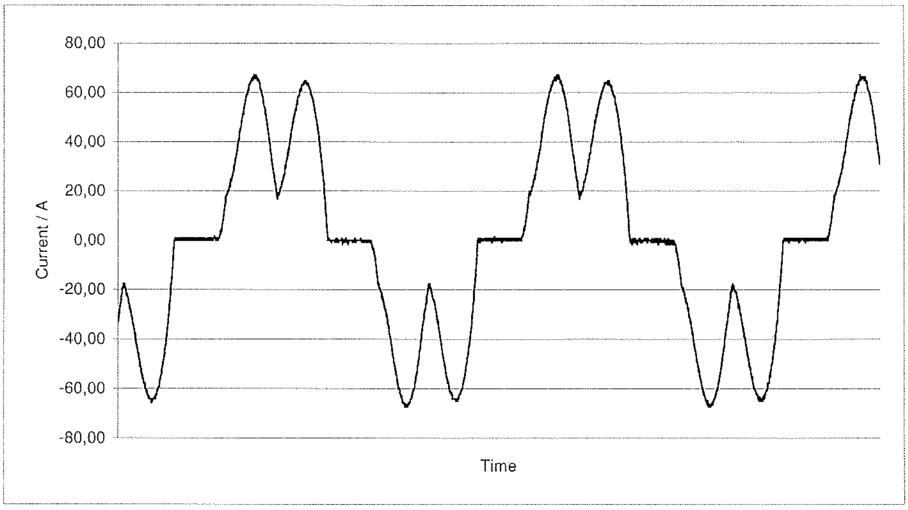
Note:
If the load current which has to be compensated is very steep it's recommended to install input coils in serial to the load to reduce current steepness.

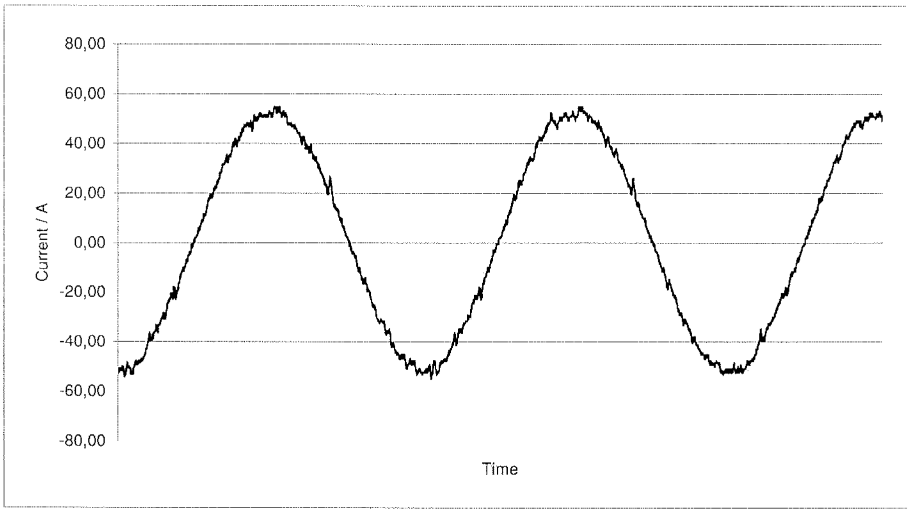
10. Applications for MaxSine

a) Frequency converter



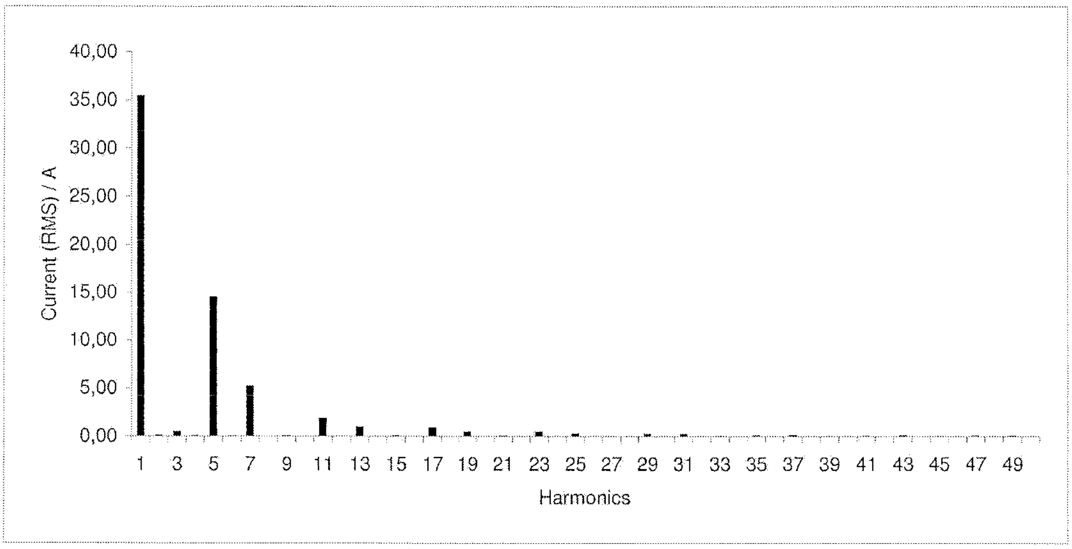
Picture 12: Sample of an application: Frequency converter





Picture 13: Network current (frequency converter) before and after compensation with MaxSine

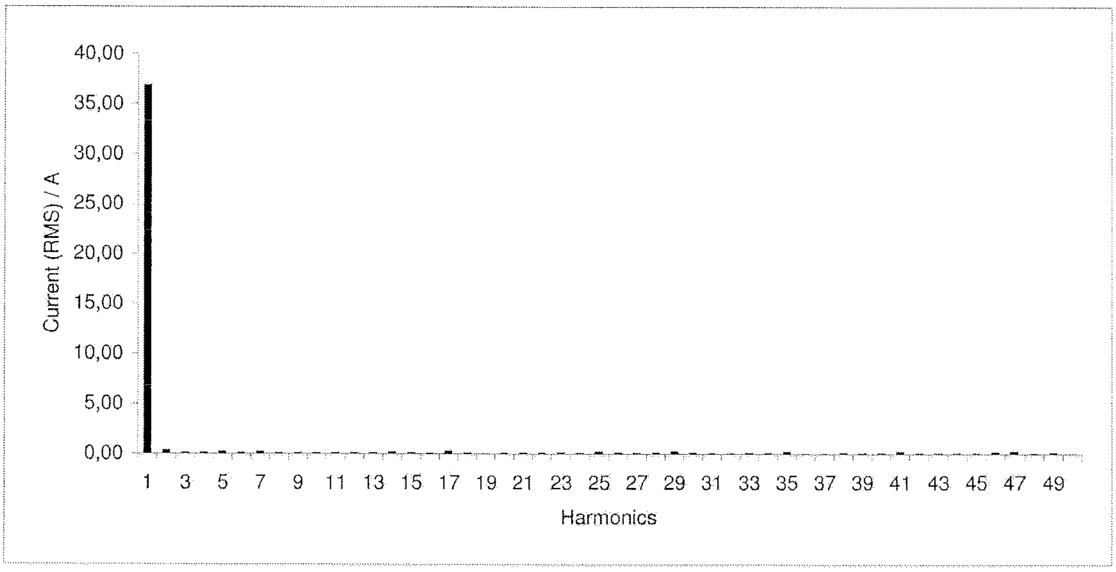
Note:
In this diagram only the current wave forms of L1 are mentioned. L2 and L3 are the same as L1!



Picture 14: Fourier transformation of frequency converter current before compensation

Order:	f / Hz	I RMS / A	THDr:	THDf:	Total-values:
1	50	35,50	91,55%	100,00%	
3	150	0,52	1,33%	1,45%	**I RMS / A:**
5	250	14,57	37,57%	41,04%	38,77
7	350	5,25	13,55%	14,80%	
9	450	0,08	0,20%	0,22%	**THDr:**
11	550	1,93	4,98%	5,44%	40,51%
13	650	1,03	2,66%	2,91%	
15	750	0,10	0,25%	0,27%	**THDf:**
17	850	0,92	2,37%	2,59%	44,24%
19	950	0,52	1,33%	1,46%	
21	1050	0,08	0,20%	0,22%	
23	1150	0,51	1,31%	1,43%	
25	1250	0,33	0,86%	0,94%	
27	1350	0,04	0,09%	0,10%	
29	1450	0,26	0,67%	0,73%	
31	1550	0,26	0,66%	0,72%	
33	1650	0,06	0,15%	0,17%	
35	1750	0,15	0,39%	0,42%	
37	1850	0,19	0,48%	0,52%	
39	1950	0,05	0,12%	0,13%	
41	2050	0,09	0,23%	0,25%	
43	2150	0,14	0,35%	0,38%	
45	2250	0,03	0,07%	0,08%	
47	2350	0,11	0,29%	0,32%	
49	2450	0,11	0,29%	0,32%	

Table 2: Fourier transformation of frequency converter current before compensation

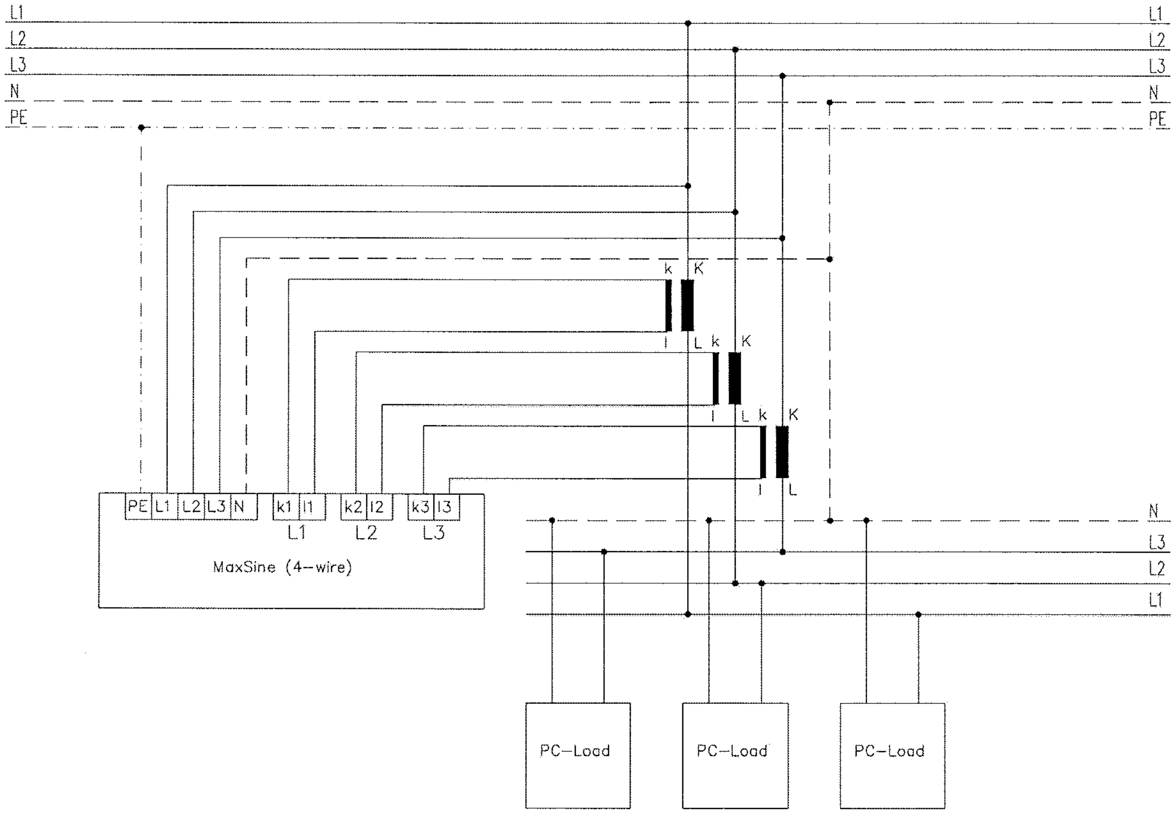


Picture 15: Fourier transformation of frequency converter current after compensation

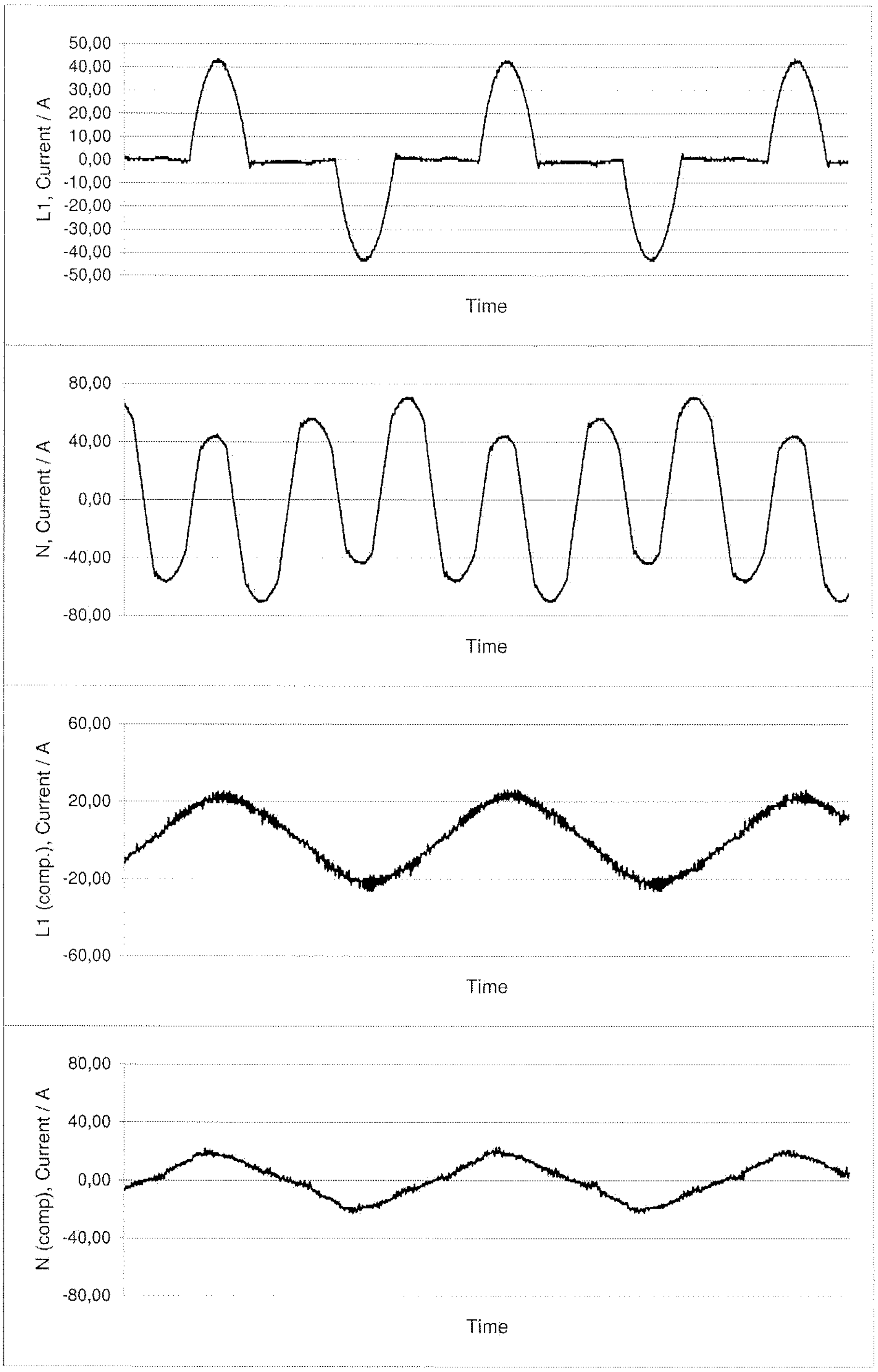
Order:	f / Hz	I RMS / A	THDr:	THDf:	Total-values:
1	50	36,91	99,49%	100,00%	
3	150	0,16	0,44%	0,44%	**I RMS / A:** 37,10
5	250	0,27	0,73%	0,73%	
7	350	0,27	0,73%	0,73%	
9	450	0,12	0,33%	0,34%	**THDr:** 3,20%
11	550	0,16	0,43%	0,43%	
13	650	0,16	0,43%	0,43%	
15	750	0,17	0,46%	0,46%	**THDf:** 3,22%
17	850	0,34	0,91%	0,92%	
19	950	0,03	0,08%	0,09%	
21	1050	0,12	0,33%	0,33%	
23	1150	0,14	0,38%	0,38%	
25	1250	0,26	0,69%	0,70%	
27	1350	0,10	0,27%	0,27%	
29	1450	0,30	0,82%	0,82%	
31	1550	0,07	0,20%	0,20%	
33	1650	0,13	0,34%	0,34%	
35	1750	0,26	0,71%	0,71%	
37	1850	0,07	0,19%	0,19%	
39	1950	0,09	0,25%	0,25%	
41	2050	0,27	0,72%	0,73%	
43	2150	0,10	0,27%	0,27%	
45	2250	0,08	0,22%	0,22%	
47	2350	0,30	0,81%	0,82%	
49	2450	0,18	0,50%	0,50%	

Table 3: Fourier transformation of frequency converter current after compensation

b) Personal computer

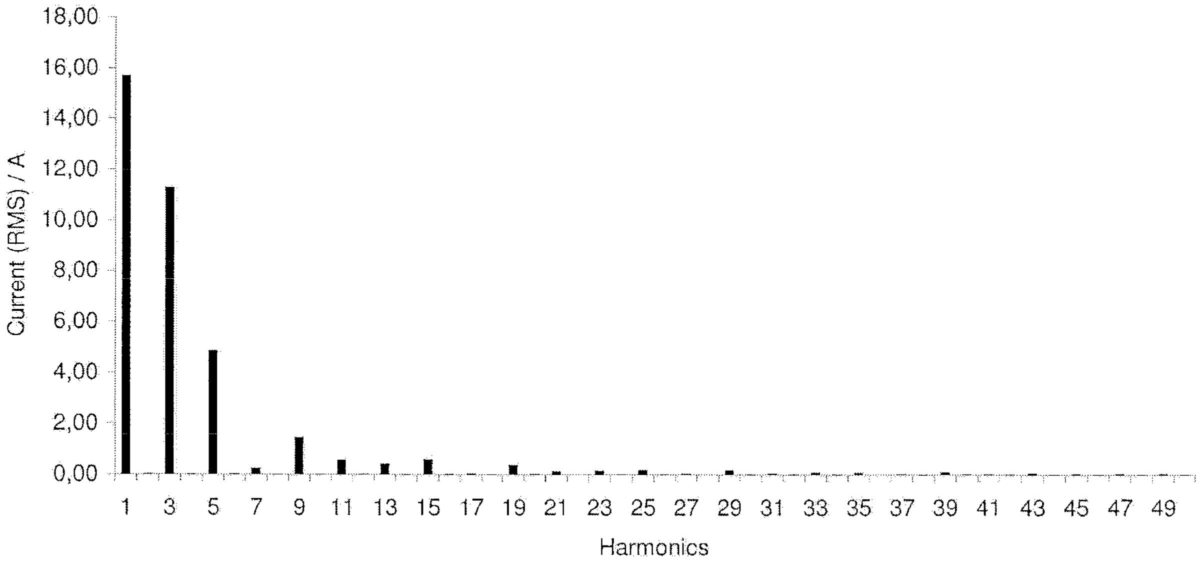


Picture 16: Sample of an application: Personal computers



Picture 17: Network current (personal computers) before and after compensation with MaxSine

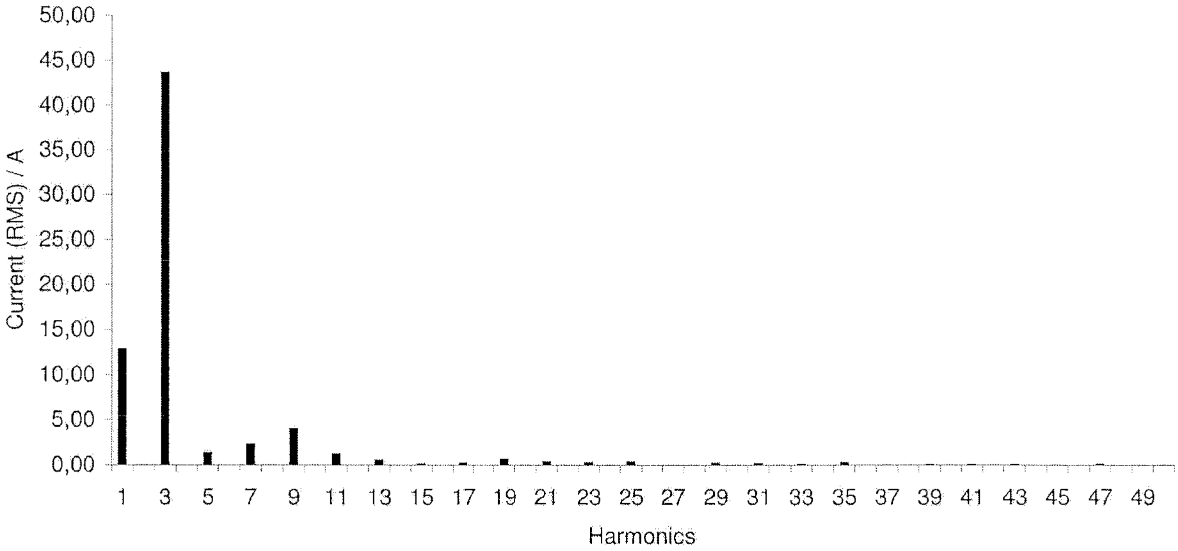
Note:
In this diagram only the current wave forms of L1 and N are mentioned. L2 and L3 are the same as L1!



Picture 18: Fourier transformation of personal computers current (L1) before compensation

Order:	**f / Hz**	**I RMS / A**	**THDr:**	**THDf:**	**Total-values:**
1	50	15,70	78,62%	100,00%	
3	150	11,31	56,66%	72,07%	**I RMS / A:**
5	250	4,86	24,33%	30,95%	19,97
7	350	0,25	1,27%	1,62%	
9	450	1,48	7,40%	9,41%	**THDr:**
11	550	0,58	2,91%	3,70%	62,37%
13	650	0,43	2,18%	2,77%	
15	750	0,61	3,05%	3,88%	**THDf:**
17	850	0,05	0,26%	0,33%	79,33%
19	950	0,38	1,89%	2,40%	
21	1050	0,14	0,69%	0,88%	
23	1150	0,16	0,81%	1,03%	
25	1250	0,19	0,93%	1,19%	
27	1350	0,06	0,30%	0,38%	
29	1450	0,19	0,97%	1,24%	
31	1550	0,07	0,34%	0,43%	
33	1650	0,10	0,49%	0,62%	
35	1750	0,09	0,44%	0,55%	
37	1850	0,03	0,17%	0,22%	
39	1950	0,11	0,53%	0,67%	
41	2050	0,03	0,15%	0,19%	
43	2150	0,07	0,36%	0,46%	
45	2250	0,05	0,26%	0,33%	
47	2350	0,06	0,28%	0,35%	
49	2450	0,05	0,26%	0,33%	

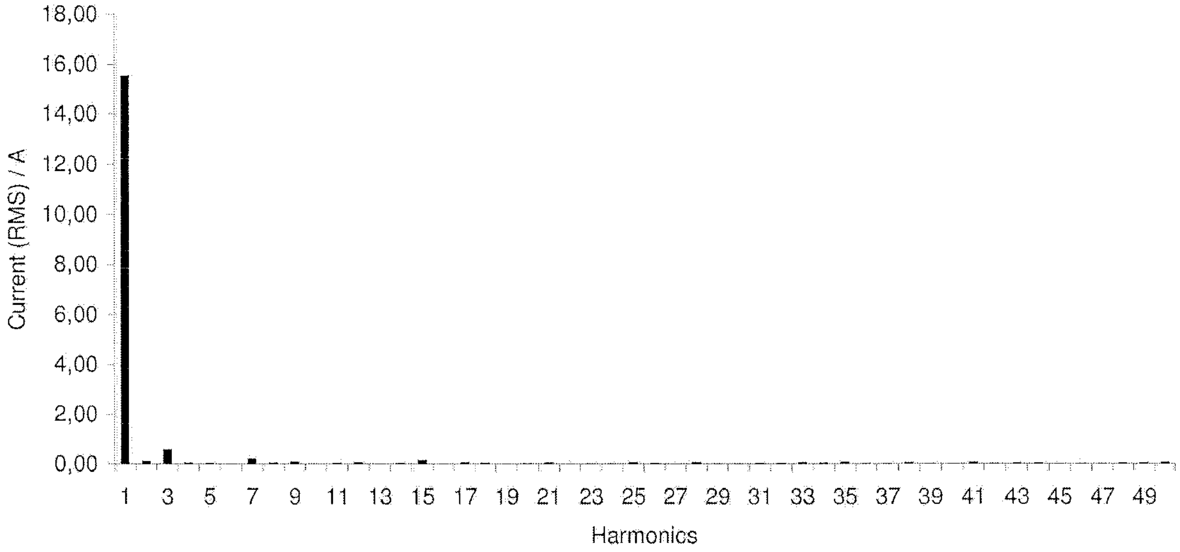
Table 4: Fourier transformation of personal computers current (L1) before compensation



Picture 19: Fourier transformation of personal computers current (N) before compensation

Order:	f / Hz	I RMS / A	THDr:	THDf:	Total-values:
1	50	12,94	28,16%	100,00%	
3	150	43,70	95,11%	337,70%	**I RMS / A:**
5	250	1,42	3,09%	10,98%	45,95
7	350	2,38	5,17%	18,36%	
9	450	4,11	8,94%	31,75%	**THDr:**
11	550	1,31	2,85%	10,11%	95,81%
13	650	0,64	1,39%	4,94%	
15	750	0,19	0,41%	1,46%	**THDf:**
17	850	0,32	0,70%	2,47%	340,18%
19	950	0,75	1,63%	5,79%	
21	1050	0,40	0,88%	3,13%	
23	1150	0,35	0,75%	2,68%	
25	1250	0,40	0,87%	3,08%	
27	1350	0,02	0,04%	0,16%	
29	1450	0,27	0,59%	2,09%	
31	1550	0,23	0,49%	1,75%	
33	1650	0,14	0,31%	1,10%	
35	1750	0,32	0,70%	2,48%	
37	1850	0,08	0,18%	0,63%	
39	1950	0,11	0,24%	0,87%	
41	2050	0,10	0,21%	0,75%	
43	2150	0,10	0,22%	0,77%	
45	2250	0,03	0,07%	0,24%	
47	2350	0,18	0,39%	1,40%	
49	2450	0,05	0,12%	0,42%	

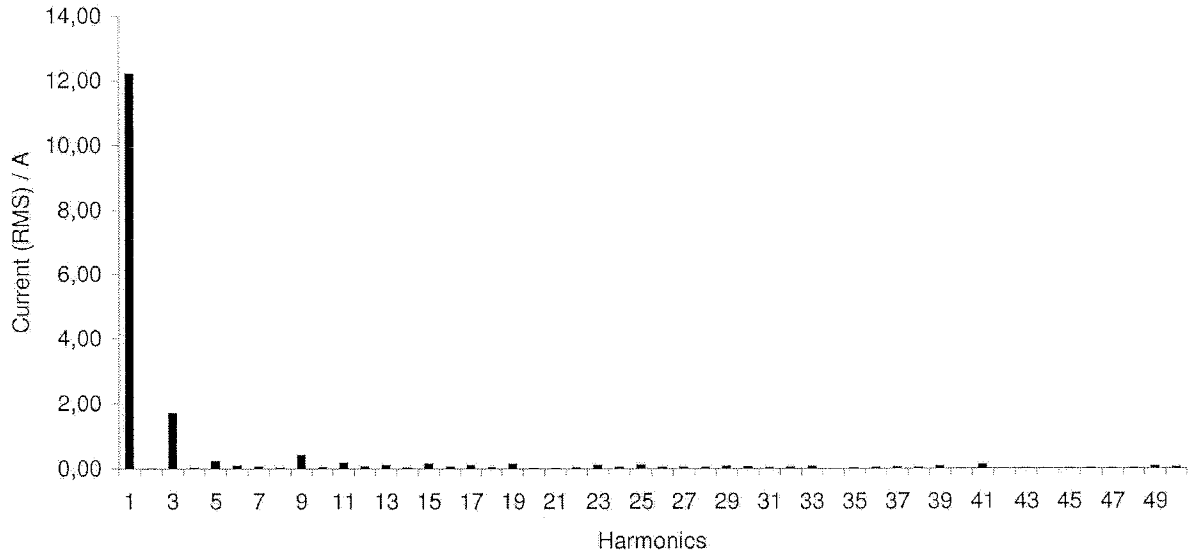
Table 5: Fourier transformation of personal computers current (N) before compensation



Picture 20: Fourier transformation of personal computers current (L1) after compensation

Order:	f / Hz	I RMS / A	THDr:	THDf:	Total-values:
1	50	15,56	101,66%	100,00%	
3	150	0,61	3,96%	3,89%	I RMS / A:
5	250	0,04	0,24%	0,24%	15,30
7	350	0,24	1,54%	1,51%	
9	450	0,11	0,70%	0,69%	THDr:
11	550	0,05	0,34%	0,33%	5,07%
13	650	0,02	0,12%	0,12%	
15	750	0,17	1,13%	1,11%	THDf:
17	850	0,09	0,57%	0,56%	4,99%
19	950	0,01	0,06%	0,06%	
21	1050	0,07	0,44%	0,43%	
23	1150	0,03	0,21%	0,21%	
25	1250	0,09	0,56%	0,55%	
27	1350	0,02	0,11%	0,11%	
29	1450	0,02	0,16%	0,16%	
31	1550	0,03	0,23%	0,22%	
33	1650	0,08	0,54%	0,53%	
35	1750	0,09	0,61%	0,60%	
37	1850	0,03	0,21%	0,21%	
39	1950	0,03	0,20%	0,19%	
41	2050	0,09	0,61%	0,60%	
43	2150	0,04	0,23%	0,23%	
45	2250	0,01	0,07%	0,07%	
47	2350	0,04	0,26%	0,25%	
49	2450	0,07	0,44%	0,44%	

Table 6: Fourier transformation of personal computers current (L1) after compensation

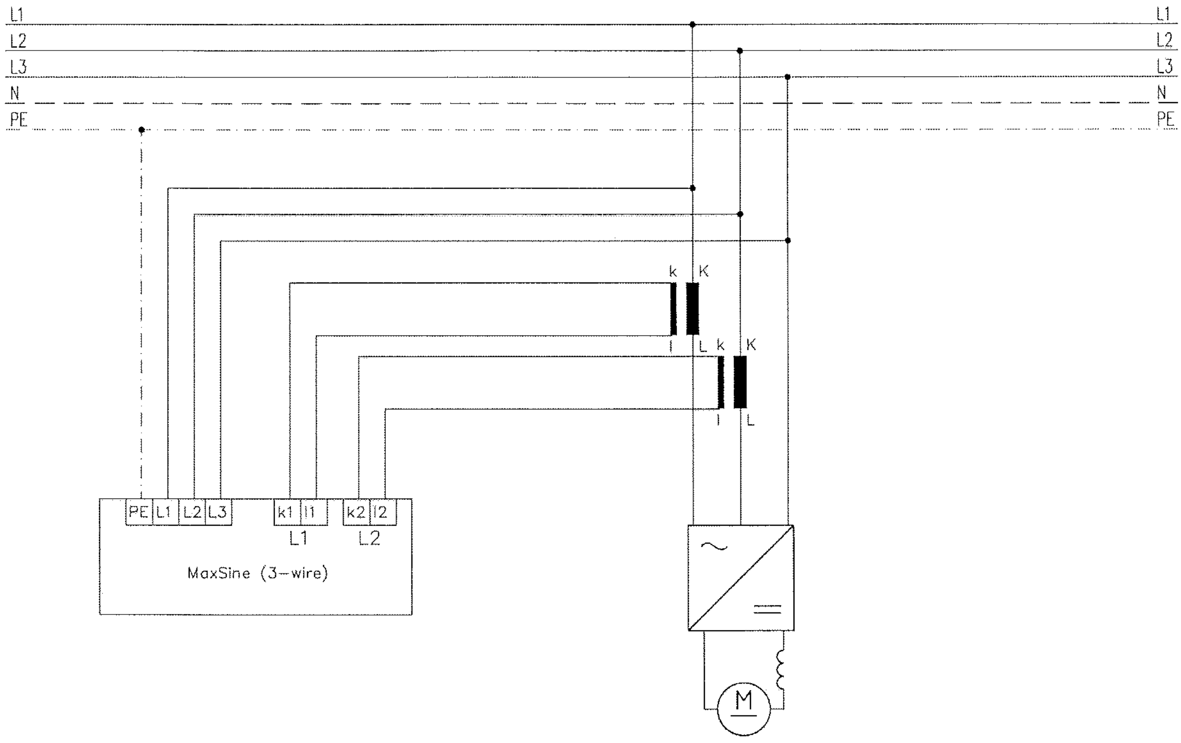


Picture 21: Fourier transformation of personal computers current (N) after compensation

Order:	f / Hz	I RMS / A	THDr:	THDf:	Total-values:
1	50	12,23	101,10%	100,00%	
3	150	1,73	14,32%	14,16%	**I RMS / A:**
5	250	0,25	2,09%	2,06%	12,10
7	350	0,08	0,63%	0,62%	
9	450	0,44	3,63%	3,59%	**THDr:**
11	550	0,20	1,62%	1,61%	15,58%
13	650	0,13	1,07%	1,06%	
15	750	0,18	1,45%	1,43%	**THDf:**
17	850	0,13	1,06%	1,05%	15,41%
19	950	0,17	1,39%	1,38%	
21	1050	0,03	0,26%	0,25%	
23	1150	0,12	1,02%	1,01%	
25	1250	0,14	1,12%	1,11%	
27	1350	0,05	0,41%	0,40%	
29	1450	0,09	0,75%	0,75%	
31	1550	0,04	0,33%	0,33%	
33	1650	0,09	0,71%	0,71%	
35	1750	0,04	0,29%	0,29%	
37	1850	0,06	0,53%	0,53%	
39	1950	0,09	0,75%	0,74%	
41	2050	0,13	1,09%	1,08%	
43	2150	0,02	0,20%	0,20%	
45	2250	0,02	0,17%	0,16%	
47	2350	0,03	0,22%	0,21%	
49	2450	0,08	0,66%	0,65%	

Table 7: Fourier transformation of personal computers current (N) after compensation

c) Dynamic load (DC-drive)

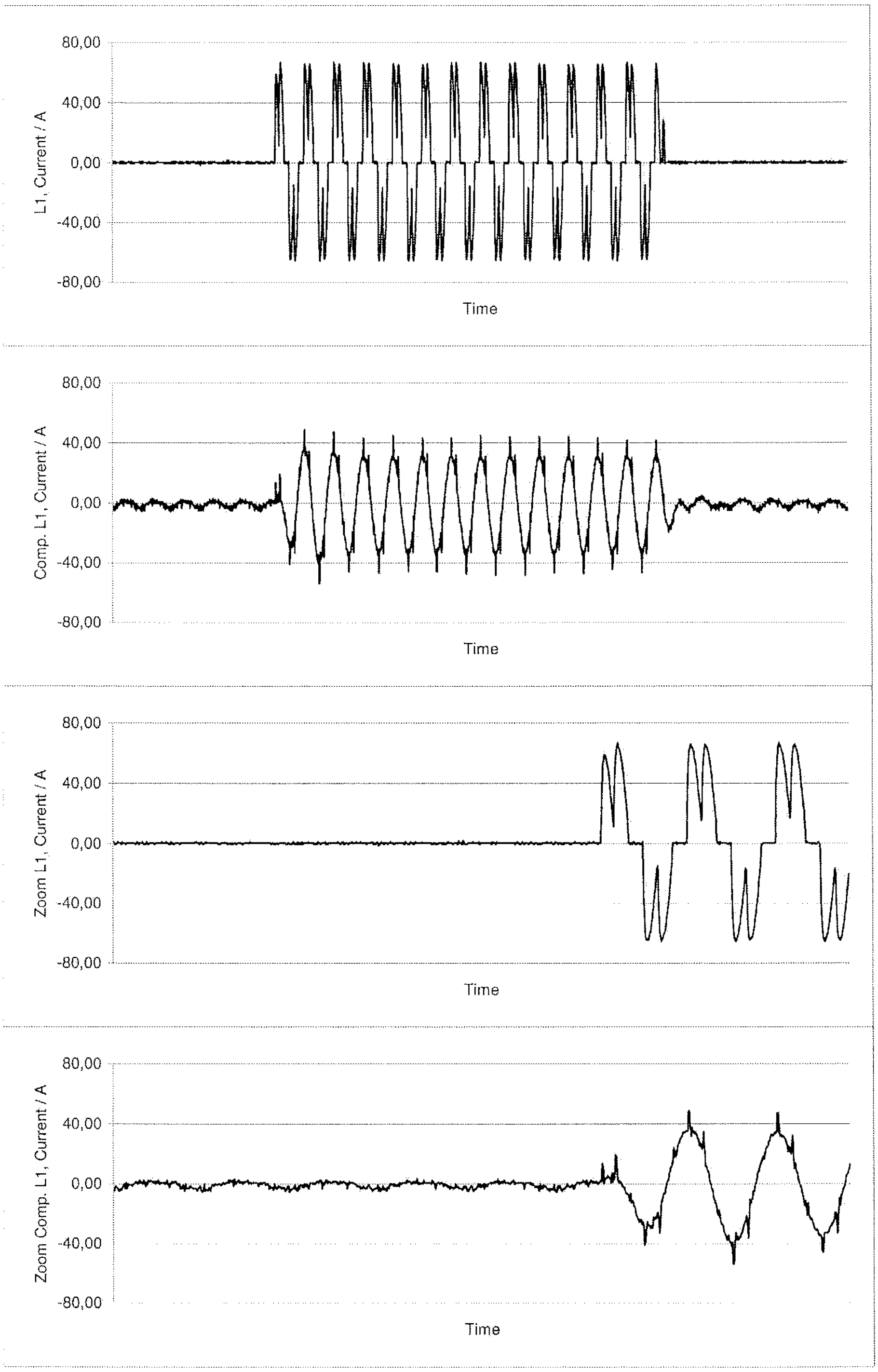


Picture 22: Sample of an application: Dynamic DC-drive

Dimensioning:

For high dynamic applications the MaxSine current has to be equal to the total load current:

$I_{MaxSine} = I_{Load}$



Picture 23: Network current (dynamic 3-phase load) before and after compensation with MaxSine

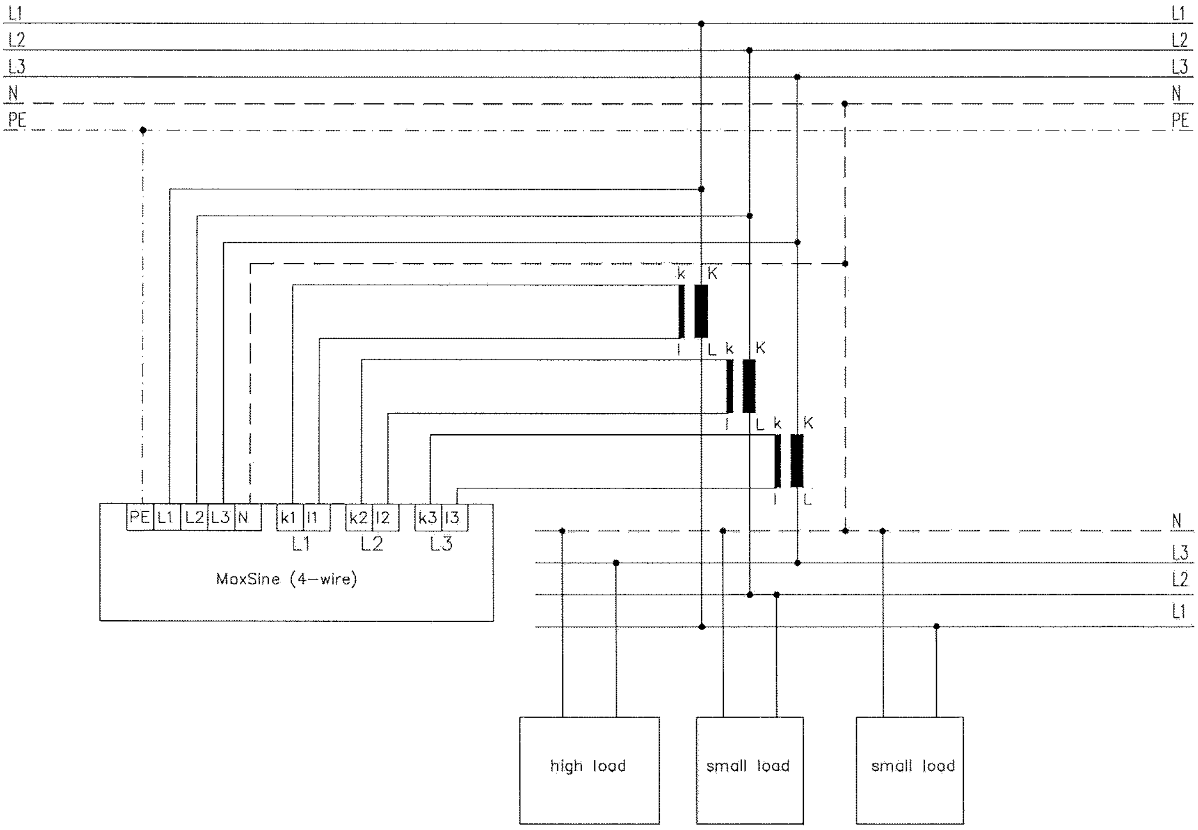
Note:
In this diagram only the current wave forms of L1 are mentioned. L2 and L3 are the same as L1

d) Very different 1-Phase loads in a 3-phase (+ neutral) system

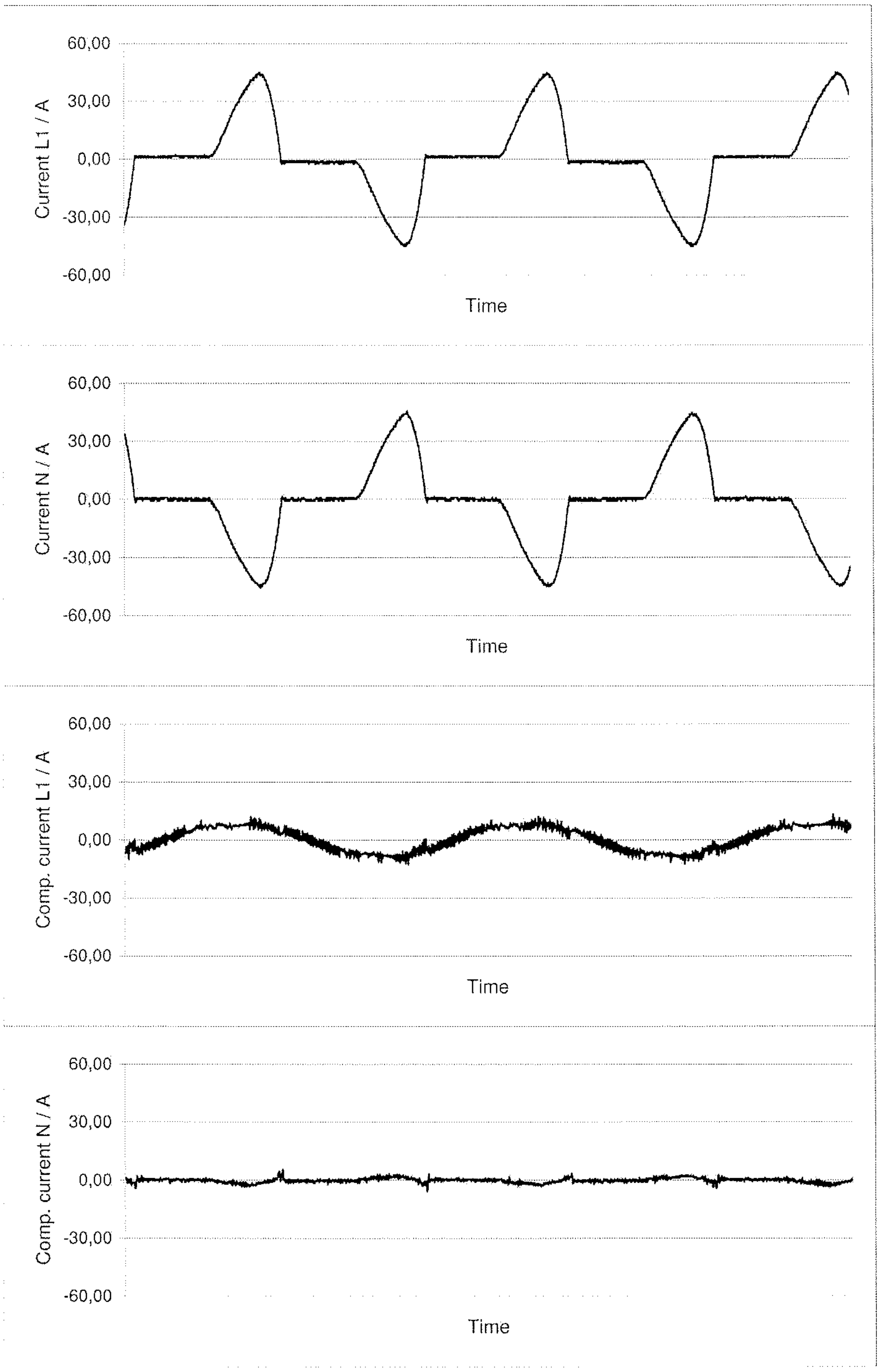
Problem:
High power load connected in between L1 and N (L2 and L3: nearly 0A).

MaxSine had to provide a symmetrical network and eliminate neutral current.

Note:
The same application is also possible in 3-wire networks (3 phases without neutral) if the high power load is connected e.g. in between L1 and L2.



Picture 24: Sample of an application: Asymmetrical 3-phase + neutral network



Picture 25: Network current (very asymmetric 4-wire load) before and after compensation with MaxSine

Note:
In this diagram only the current wave forms of L1 and N are mentioned. L2 and L3 are the same as L1

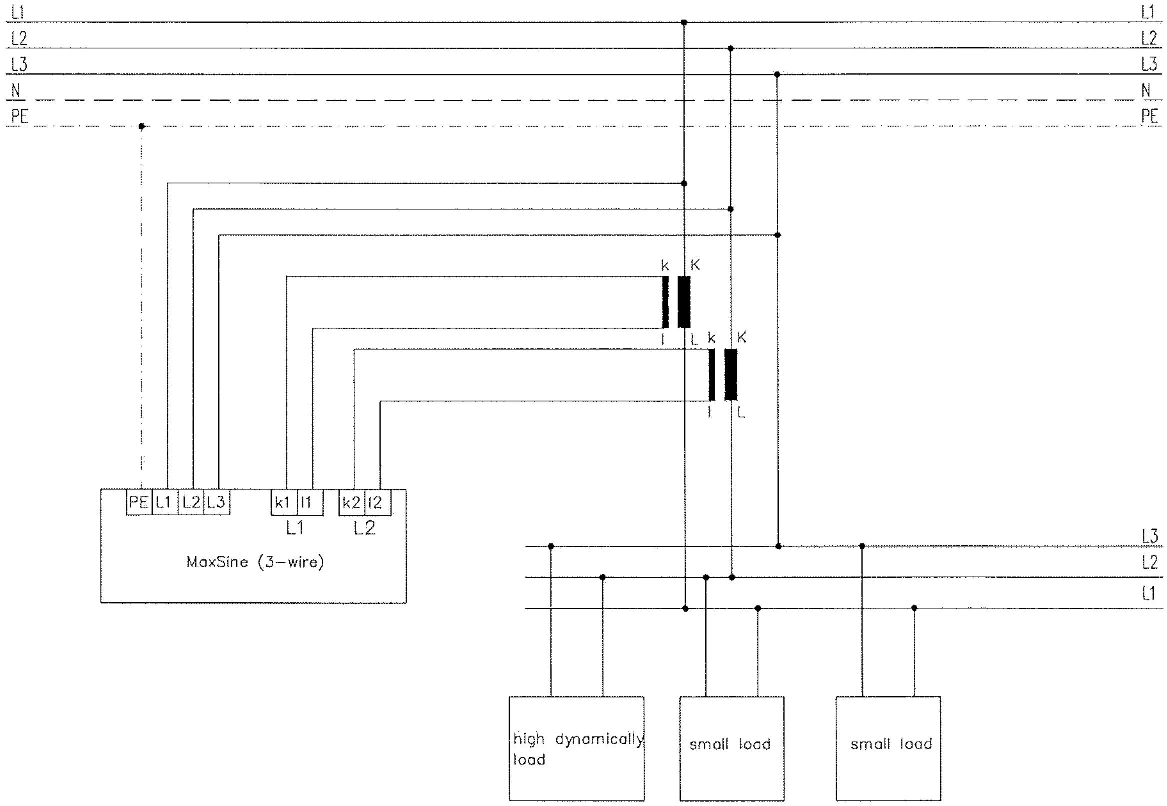
e) High dynamic 2-phase load (spot welding machine)

Problem:
A high dynamic load connected in between L1 and L2 (L3: nearly 0A).

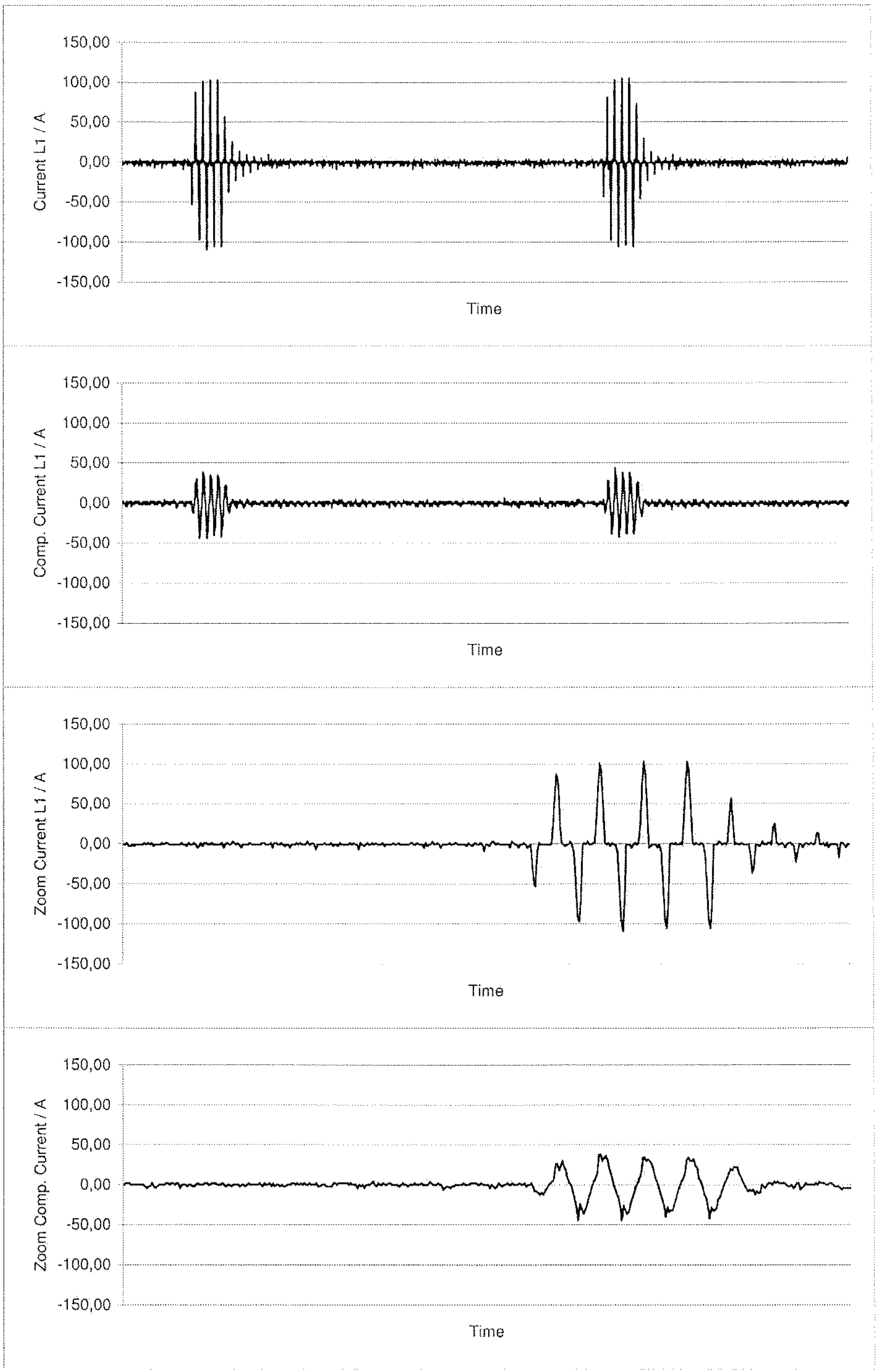
MaxSine had to provide a symmetrical network.

Note:
The same application is also possible in 4-wire networks (3 phases with neutral) if the high dynamic load is connected e.g. in between L1 and N.

Dimensioning:
For high dynamic applications the MaxSine current has to be equal to the total load current:
$I_{MaxSine} = I_{Load}$



Picture 26: Sample of an application: High dynamic 2-phase load



Picture 27: Network current (dynamic, asymmetric 2-phase load) before and after compensation with MaxSine

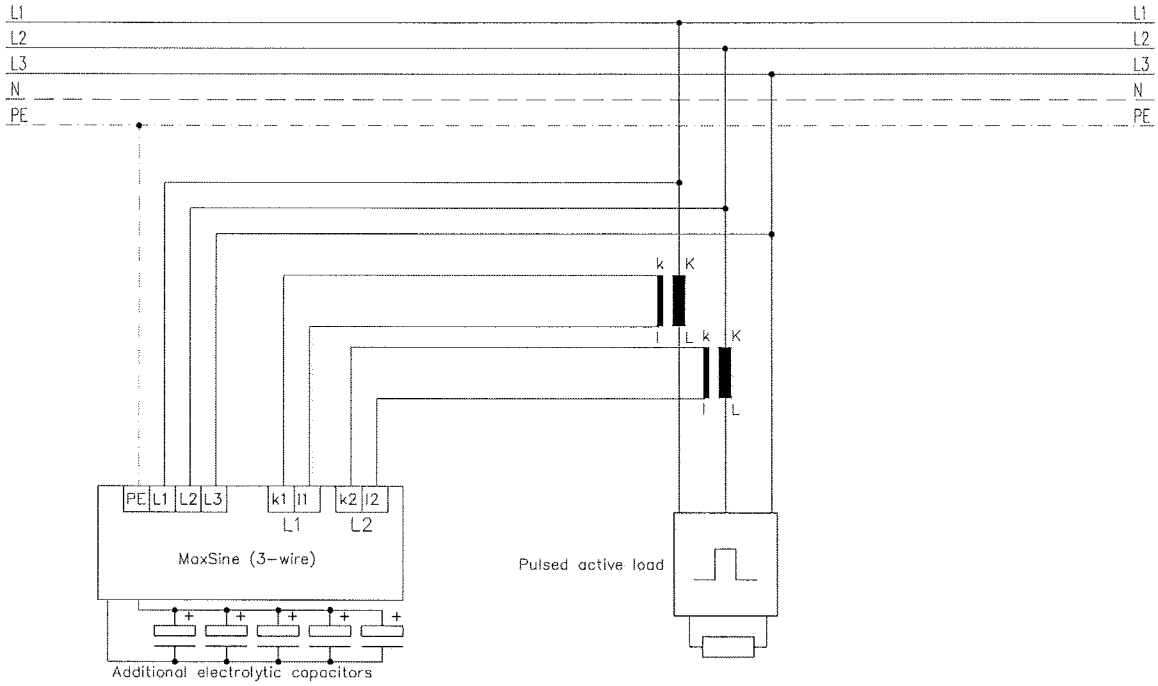
Note:
In this diagram only the current wave forms of L1 are mentioned. L2 and L3 are the same as L1

f) High dynamic 3-phase active load

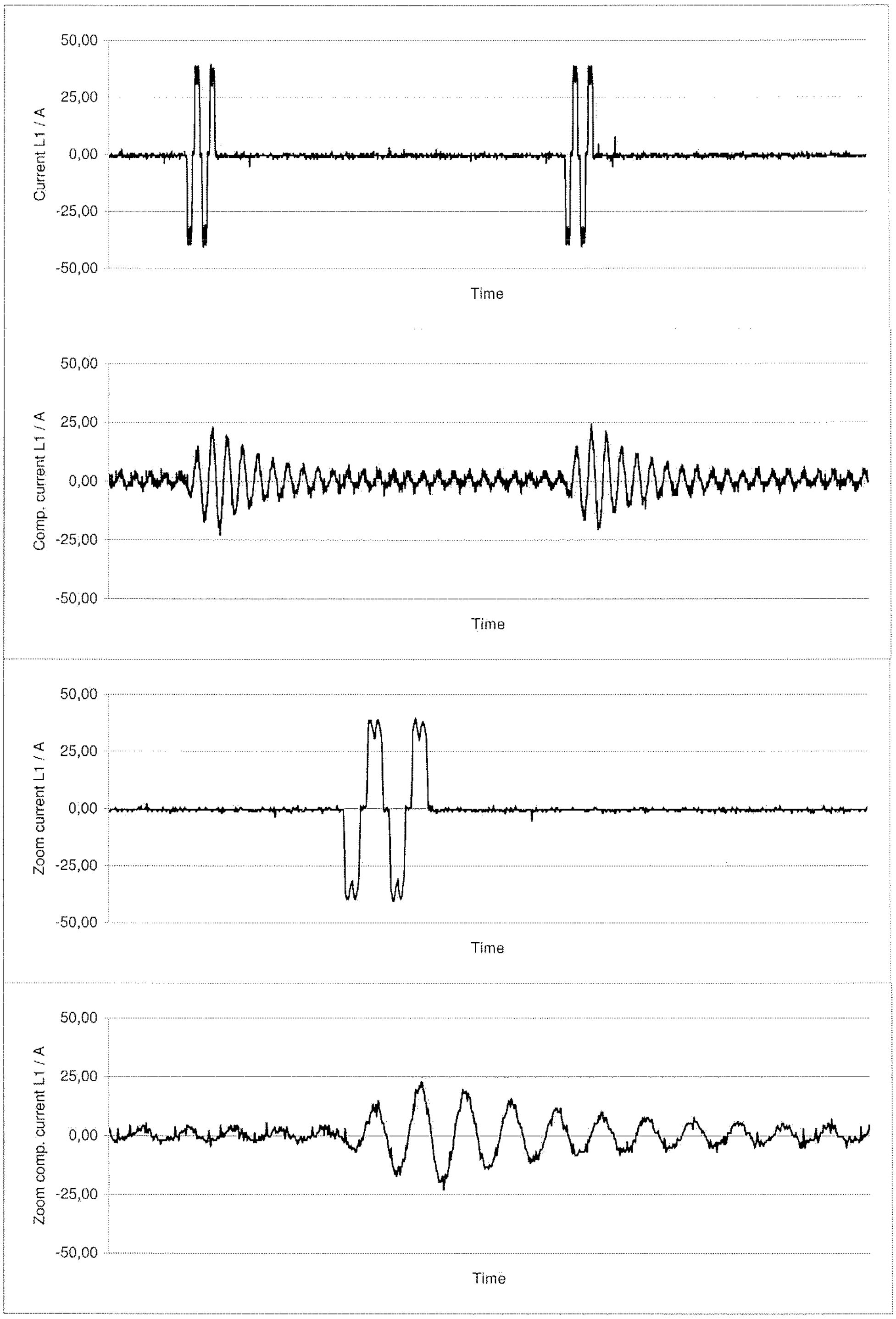
Problem:
A high dynamics (nearly) active symmetrical 3-phase load.

MaxSine had to convert very short active current pulses in longer lasting currents with lower amplitudes.

Dimensioning:
For high dynamic applications the MaxSine current has to be equal to the total load current:
$I_{MaxSine} = I_{Load}$



Picture 28: Sample of an application: High dynamic 3-phase active load

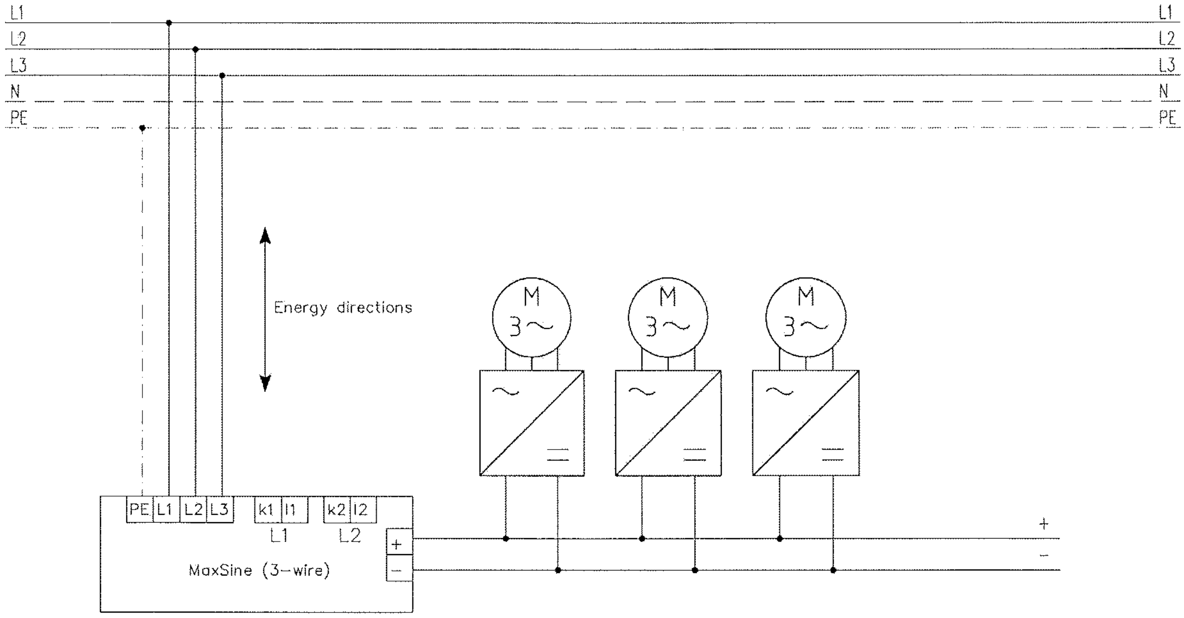


Picture 29: Network current (dynamic active 3-phase load) before and after compensation with MaxSine

Note:
In this diagram only the current wave forms of L1 are mentioned. L2 and L3 are the same as L1

g) MaxSine as an active rectifier (e.g. for frequency converters)

Situation:
MaxSine works as an active rectifier which feeds sinusoidal currents in phase to the voltages to the network. It provides a DC-voltage-link with both energy directions (brake jobber are not needed).



Picture 30: Sample of an application: MaxSine as an active rectifier

11. Problems with MaxSine / Problems caused by MaxSine

MaxSine is:
- an electrical device which helps to avoid disturbances
- an electrical device which solves certain problems
- an electrical device which is as good as all other electrical equipment in the networks with advantages and disadvantages

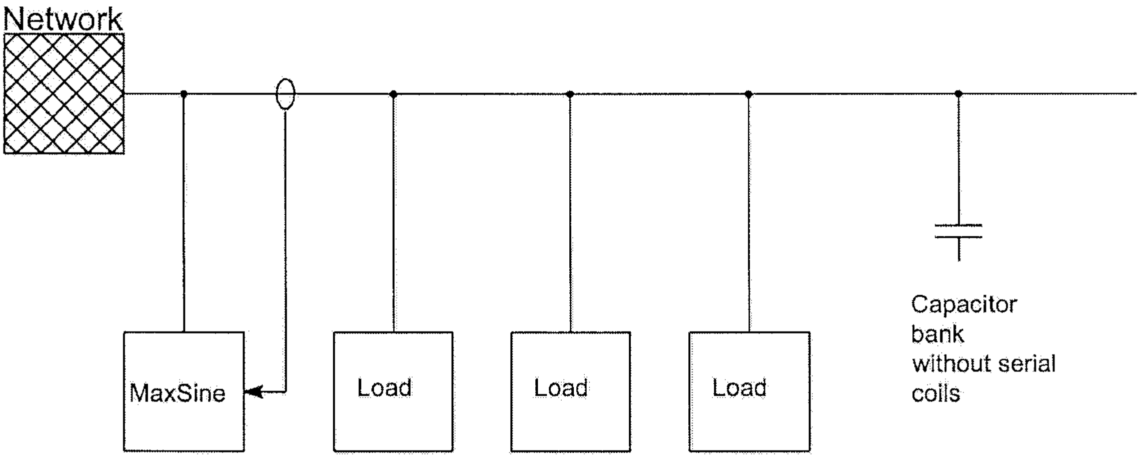
MaxSine is not:
- a magic box which is able to perform miracles
- a wonder machine which solves all the problems in electrical networks

Possible problems with MaxSine:

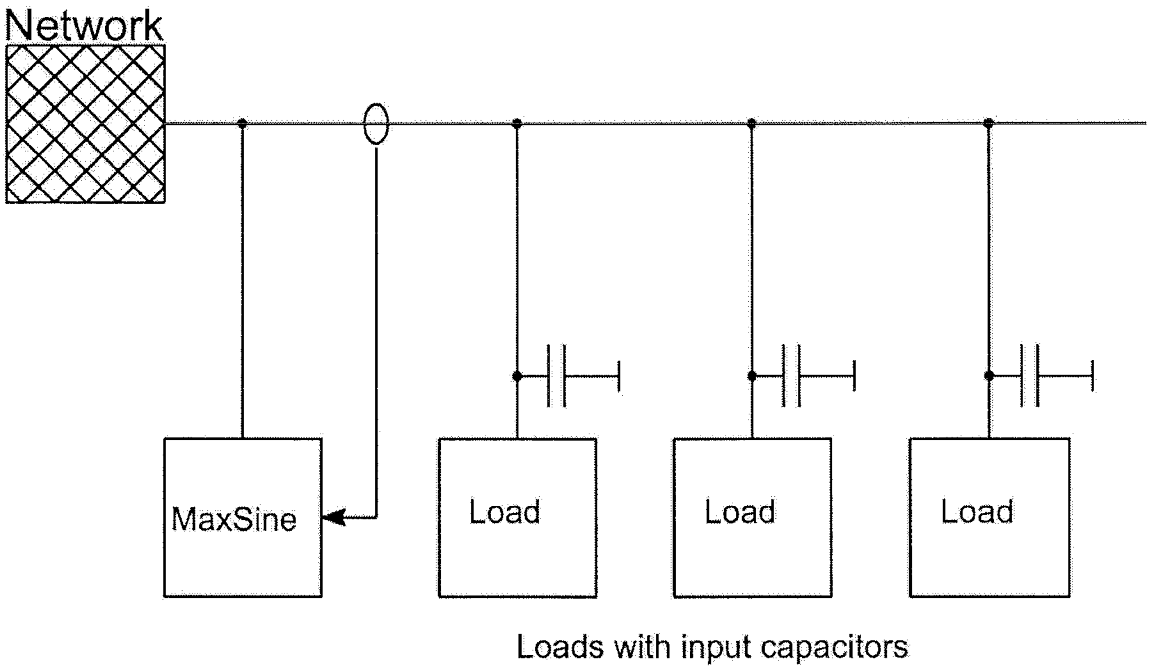
1. In very weak networks the ripple current of MaxSine could disturb other consumers!
   Solution:
   - By installing an additional ripple current filter sometimes it's possible to solve the problem. Attention! The compensation quality becomes as lower as higher the class of the ripple current filter.

2. Resonances caused by capacitances in the network.
   Capacitors e.g. in capacitor banks without serial coils can cause resonances with MaxSine because MaxSine's very fast response time. Resonances also can happen if many consumers in the network have installed input capacitances.
   Solutions:
   - Removal of the input capacitances
   - Replacement of the capacitor bank against a capacitor bank with serial coils
   - In some applications it's possible to avoid resonances by adjusting the ripple current filter

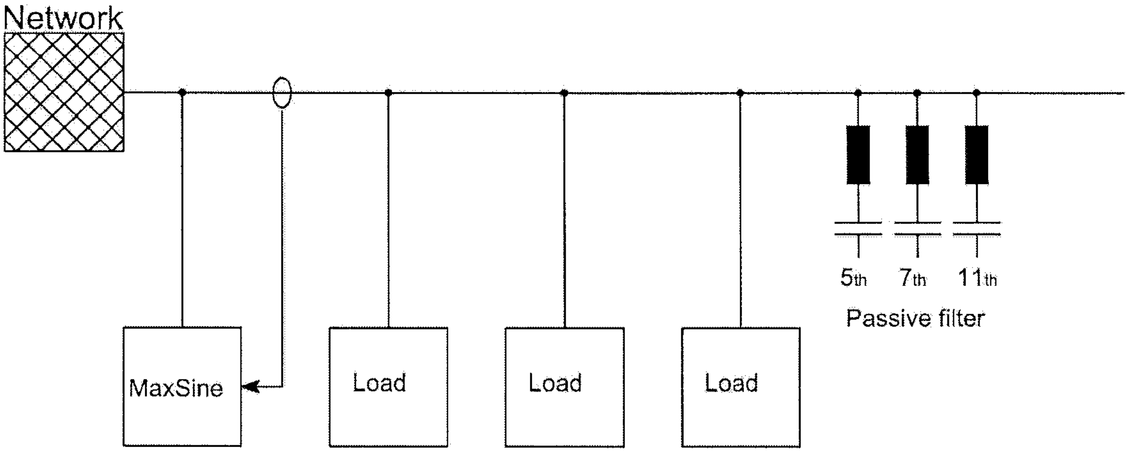
3. Passive harmonics filters included in the MaxSine's measurement circuit
   Some consumers (e.g. asynchron motors, detuned capacitor banks) also reacts like passive filters with certain resonance frequencies.
   Solution:
   - Reinstallation of the equipment out of the MaxSine measurement circuit.



Picture 31: Problem: MaxSine and capacitor banks without serial coils



Picture 32: Problem: MaxSine and consumers with input capacitances



Picture 33: Problem: MaxSine and passive harmonics filters