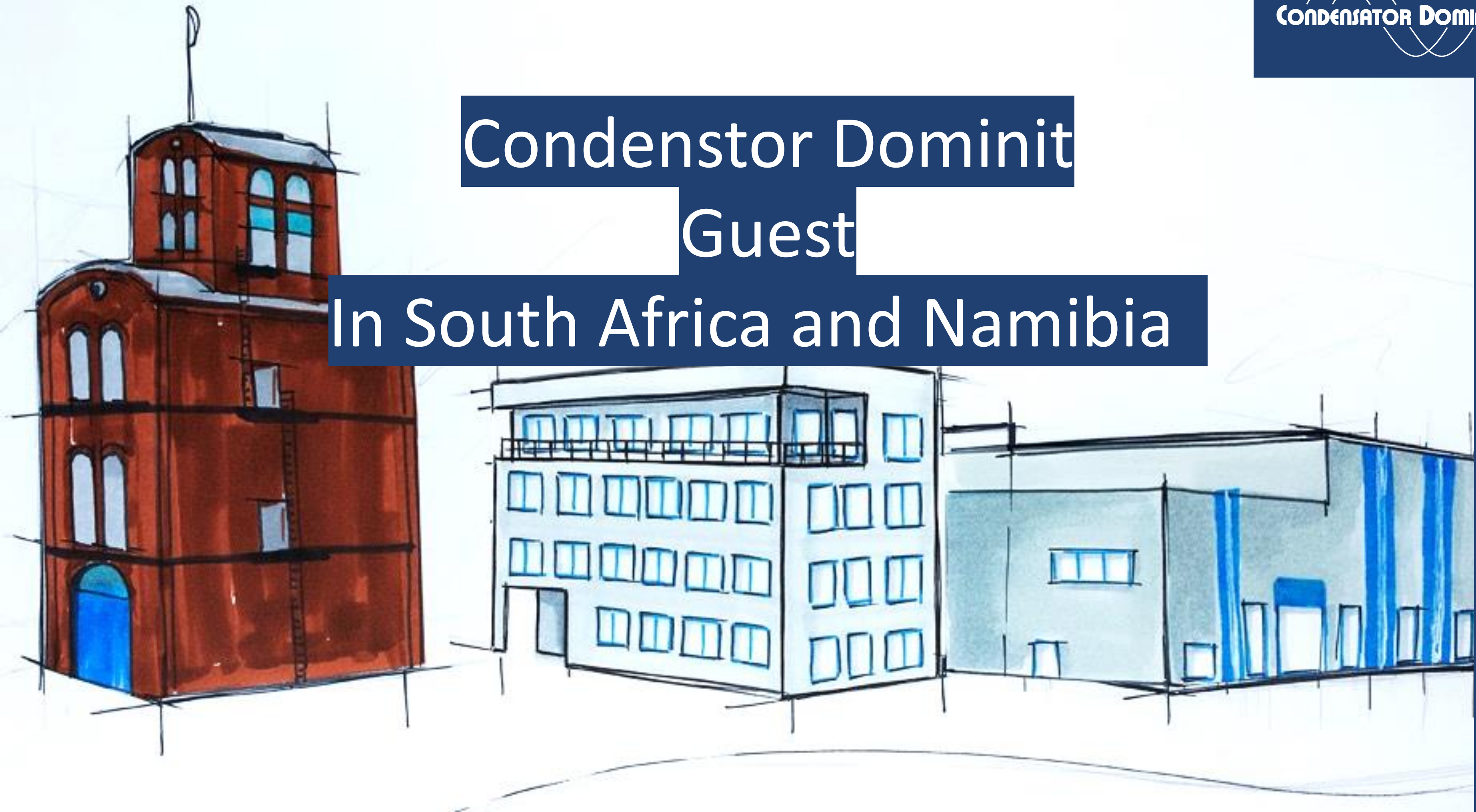
Condensator Dominit

Condenstor Dominit
Guest
In South Africa and Namibia



YOUR VOLTAGE – OUR PASSION

65 years of change

- **1950 Dominit-Werke**
- 1973 Lepper Dominit
- 1981 ASEA Lepper
- 1982 ASEA Kondensatoren
- 1988 ABB Kondensatoren
- 2002 ABB Schaltanlagentechnik
- **2005 Condensator Dominit GmbH**
- **2020 Moving into new factory building**

…the power quality company

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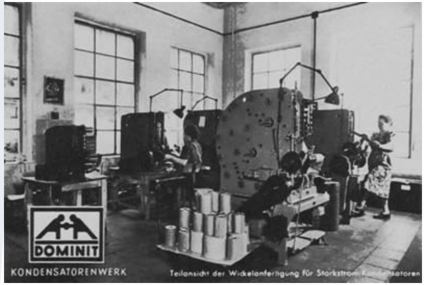
Condensator Dominit

Site Brilon – Sauerland

- 1950 founded as Dominit Plants
- ≈ 75 employee
- 40% of employees are engineers or technicians
- Own research and development
- Collaboration with national international universities
- Depth of manufacturing of over 40%
- Fulfilling of individual customer wishes
- Individual solutions for low and high voltage applications
- Worldwide references
- Owner-managed company
- ≈ 20 Mio. € turnover per year



Low voltage < 1.000 V High voltage (> 1.000 V)

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Agenda Presentation

- What is power quality
- Specific challenges to integrate PV, wind and H2 production into the grid
- Why do we believe in Namibia and South Africa
- Our contribution

Some examples

- Performance guarantee

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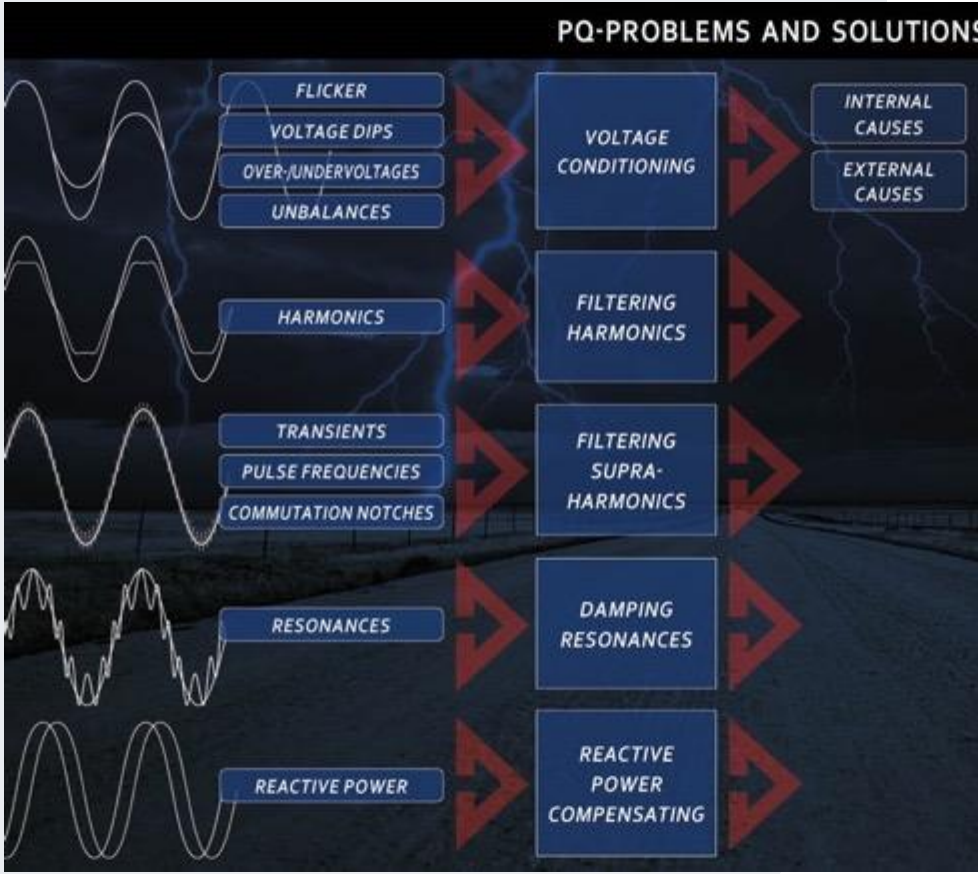
Overview: Power Quality Problems & Solutions

PQ-Problems & Solutions



Dynamic Reactive Power Compensation
Voltage Stabilizer

Active / Passive Harmonic Filter

High Pass Filter System

Resonance Damping System

Reactive Power Compensation System (Capacitive/Inductive)

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Southern Africa has a significant higher grid impedance than Europe or most parts of Asia or the American continent

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The necessary accessories for efficient hydrogen production and compliance with the normative grid connection criteria – grid code

Producing green hydrogen efficiently...

The production and processing of green hydrogen offers a future-oriented alternative to conventional natural gas. The rapidly increasing demand is a logical step to increase the self-sufficiency of all countries given over a few gas producing countries.

Regardless of political and ecological issues, the production costs of **1 kWh** of hydrogen gas from renewable energies are **going down to 7 cents per kWh** (see IHK study). Converting it back to electricity it is much more efficient than burning natural gas.

Price for H2 can be planned and calculated over years and decades, price for gas????????????

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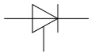
Hydrogen production technology

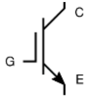
Direct current (DC) is required to produce hydrogen in an electrolysis process. The DC current required for this can be generated with the aid of powerful rectifiers. Depending on the application, three types of rectifiers can be realized:

Diode rectifier (line-controlled and uncontrolled)

Thyristor rectifier (line-commutated and controlled via phase angle control)



IGBT rectifier (self-commutated and controlled via pulse width modulation PWM)



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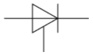
Rectifier types

Diode rectifier (line-controlled and uncontrolled)

+ robust
+ simple structure
+ low-loss

- uncontrolled, therefore no DC control possible
- therefore hardly applicable for green hydrogen

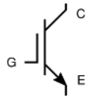
Thyristor rectifier (line-commutated and controlled via phase angle control)



+ robust
+ simple structure
+ low-loss
+ very good current regulation

- Harmonic generation by phase angle control
- Reactive power generation

IGBT rectifier (self-commutated and controlled via pulse width modulation PWM)



+ Very good DC control
+ grid stabilizing as cos phi controller

- very high losses
- hardly economically feasible for green hydrogen

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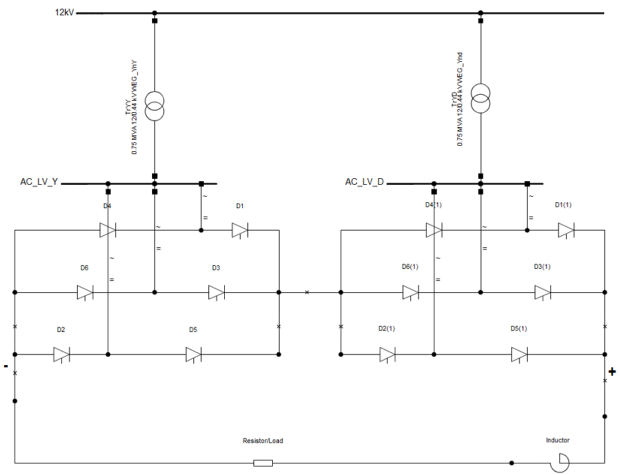
Rectification with thyristor rectifier

The fully controlled three-phase thyristor bridge circuit (B6C) has proven to be very useful in terms of production technology and economy. With this converter variant, the full control range is retained, and no compromises are made in terms of process technology. From the point of view of mains feedback and optimized process parameters, 12- or 24-pulse solutions have become established for large to very large power ratings. An example of a 12-pulse bridge circuit is shown below.



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Problem: Harmonics

For resistive(ohms)-inductive load, the harmonics can be assumed to be as follows in a first approximation:

$$I_{vi} = \frac{1}{v} I_{li} \text{ with } v = kp \pm 1, k = 1,2,3 \ldots$$

where I_{li} is the RMS value of the fundamental current and p is the pulse number of the thyristor bridge (e.g. 6, 12, 18 ...).

The harmonics of the lower order can be eliminated by a higher order, e.g. 12- or 24-pulse, but never completely prevented. Only the harmonic spectrum is shifted. Even if the absolute harmonic currents are lower with a higher order number. Due to grid and load unbalances, the harmonics to be assumed tend to be even higher than theoretically assumed.

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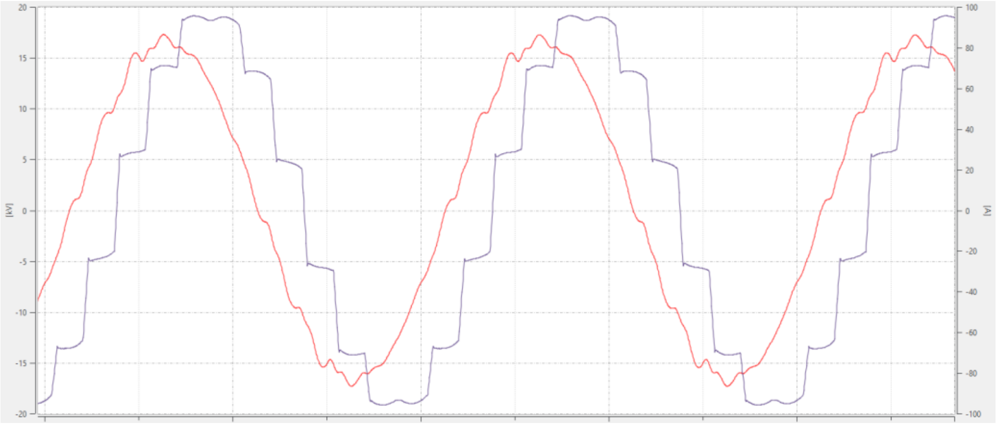
Problem: Harmonics

Due to the phase angle of the thyristors and the resulting current blocks in the rectifier, these cause a mains voltage distortion at the network impedance. According to the previous table, this can be compensated at the lower orders, but it cannot be completely avoided. A classical example for the feeding grid current and the corresponding grid voltage of a 12-pulse thyristor rectifier is shown in the figure below.

Red = Grid voltage
Purple = Phase current



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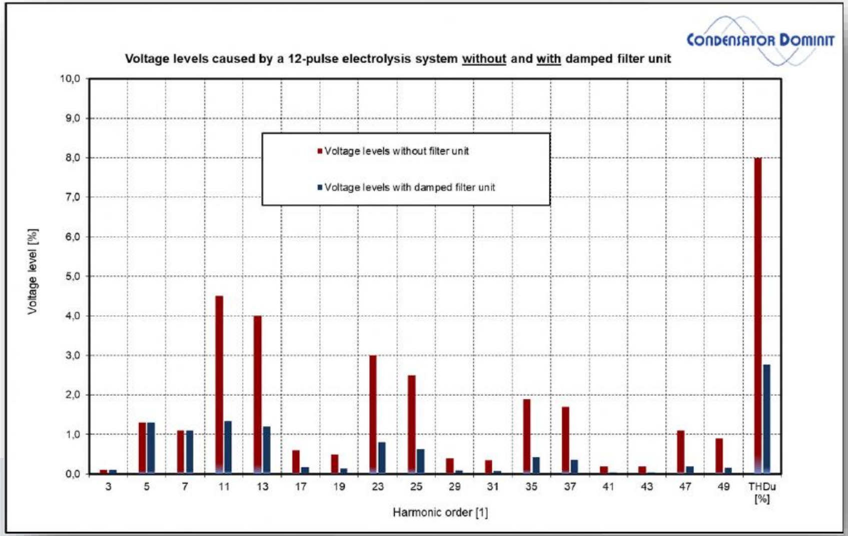
Problem: Harmonics

The mains voltage distortion as a result of a 12-pulse thyristor rectifier...
The frequency spectrum of the voltage is generated, in accordance with all theoretical expectations and practical experience...



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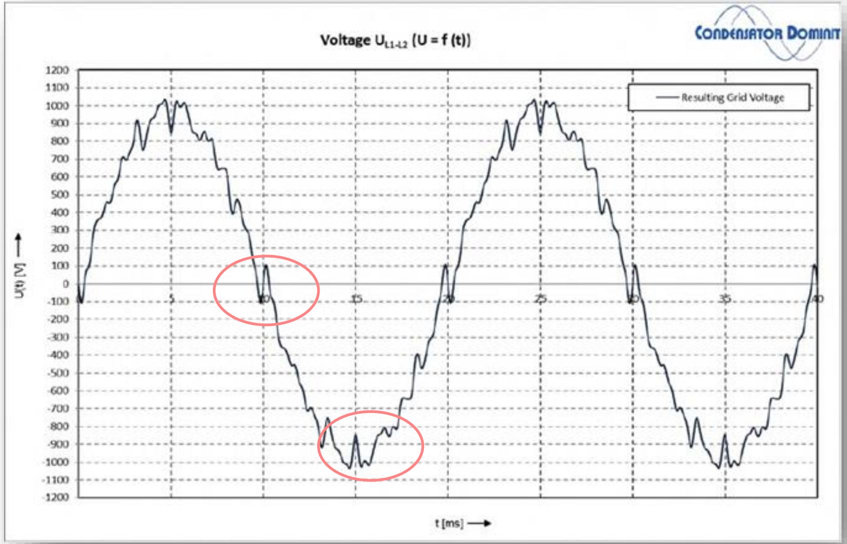
Problem: Harmonics

This results in considerable system voltage distortions, including double zero crossings.
Associated with this is a high interference potential for sensitive consumers.



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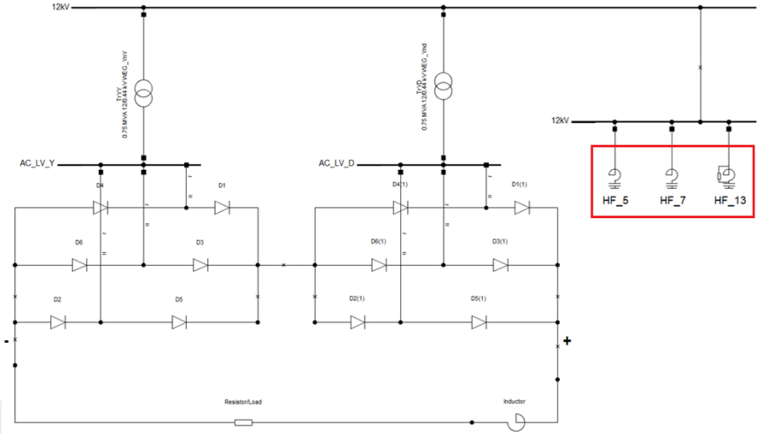
Solution approach: Harmonic filter

Tuned filters provide a remedy for this grid disturbance. As a rule, these are tuned for the 5th + 7th + 11th/13th harmonics. The 11th and 13th filter circuits are additionally provided with a resistor so that a high-pass behavior is established. This ensures that the upper orders (>13th) are additionally filtered. Regardless of the pulsatility of the bridge circuit, it is often useful to install a 5th and 7th order harmonic filter, so that any existing levels of these orders are not additionally amplified.



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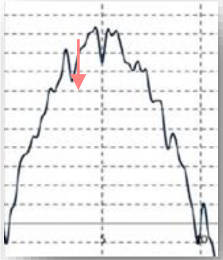
Solution approach: Commutation notches

In addition to classical harmonics, commutation notches occur during commutation in thyristors. The magnitude, steepness and level of these depend on the semiconductors used and the exact rectifier load. Regardless of the exact nature of the commutation, these can be easily reduced by a damped filter circuit stage.



The tuned filter circuit of order 5. + 7. + 13. result in a significant improvement of this voltage distortion.

Besides harmonic reduction and minimizing commutation notches, filter circuits also solve another problem...

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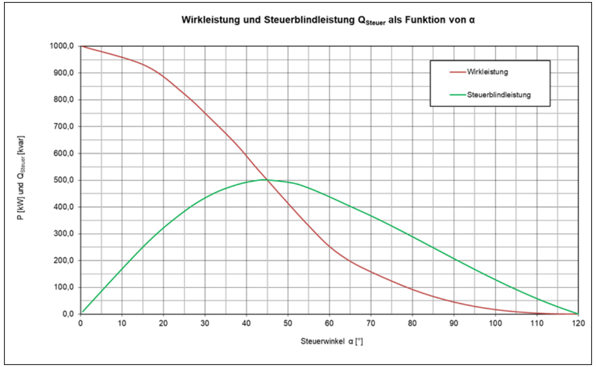
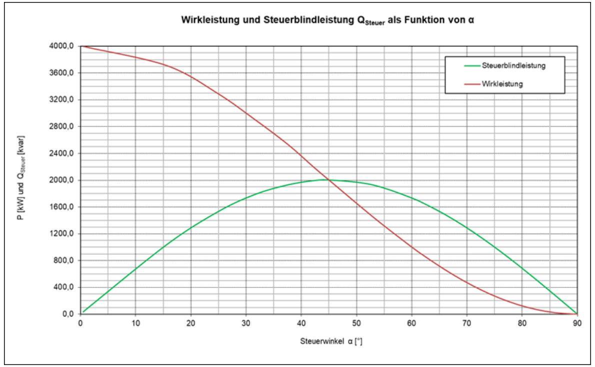
Solution approach: reactive power

Depending on the design of the electrolysis (e.g. with smoothing reactors), there is a slightly different image of the reactive power requirement as a function of the control angle a.

In the left picture a purely resistive DC load is acting, in the right picture a resistive-inductive DC load. In both cases, however, the maximum reactive power requirement can be quantified as 50 % of the nominal power of the electrolysis. Based on a usually required cos (φ) of 0.9 to a maximum of 0.95, it is necessary to provide a compensation power of 25 - 35 % of the nominal power of the electrolysis.





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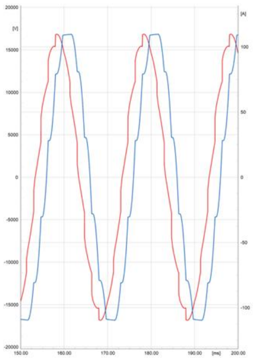
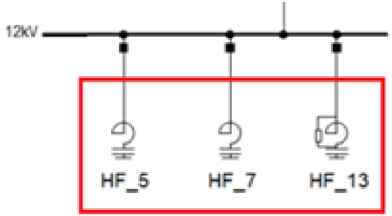
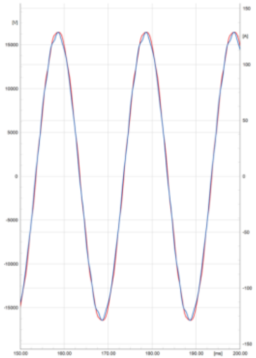
Thus, we have the perfect solution for:

+ Harmonic reduction
+ Damping of commutation notches
+ Reactive power







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Conclusion

To integrate large hydrogen electrolysis into any grid is a challenge regarding:

- Harmonics
- Commutation nodges or other hifgh frequency sgnals
- Reactive power

This challenge increases as bigger the grid impedance is

But all this can be solved:

There is no technical reason not to do it

Application sample: Plug & Play concrete station (Type BCOMP)

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Application sample: Plug & Play Container system (Type CCOMP)

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Application sample : Outdoor system (Type QBANK)

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Application sample: Outdoor system (Type FILT)

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Our preformance guarantee

- We guarantee that after installing our filter system the MV grid reaches the planning levels
- Measurement according to EN50160/ NBS 048
- If we do not perform according to guarantee we will either add filte as long as neccessary or take our equipment back
- Planning levels do not cover sing events or short term effects (See EN 50160 or NBS 048

Table A.1 — Recommended planning levels for harmonic voltages (as a percentage of the rated voltage of the power system)

1	2	3	4	5	6	7	8	9
Odd harmonics (non-multiples of 3)			**Odd harmonics (multiples of 3)**			**Even harmonics**		
Order	**Harmonic voltage %**		**Order**	**Harmonic voltage %**		**Order**	**Harmonic voltage %**	
h	MV	HV/EHV	h	MV	HV/EHV	h	MV	HV/EHV
5	5,0	2,0	3	4,0	2,0	2	1,8	1,4
7	4,0	2,0	9	1,2	1,0	4	1,0	0,8
11	3,0	1,5	15	0,3	0,3	6	0,5	0,4
13	2,5	1,5	21	0,2	0,2	8	0,5	0,4
17	1,6	1,0	> 21	0,2	0,2	10	0,4	0,4
19	1,2	1,0				12	0,2	0,2
23	1,2	0,7				> 12	0,2	0,2
25	1,2	0,7						
> 25	$0{,}2 + 0{,}5\,\frac{25}{h}$	$0{,}2 + 0{,}5\,\frac{25}{h}$						

NOTE Total harmonic distortion (THD): ≤ 6,5 % in MV networks and ≤ 3 % in HV networks.

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