
ADF
Power
Tuning
The shape of power to come
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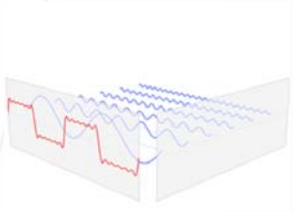
A brief history of active harmonic filter



1822,
Joseph Fourier

$$K_C = \sqrt{\frac{2}{3}} \cdot \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{bmatrix}$$

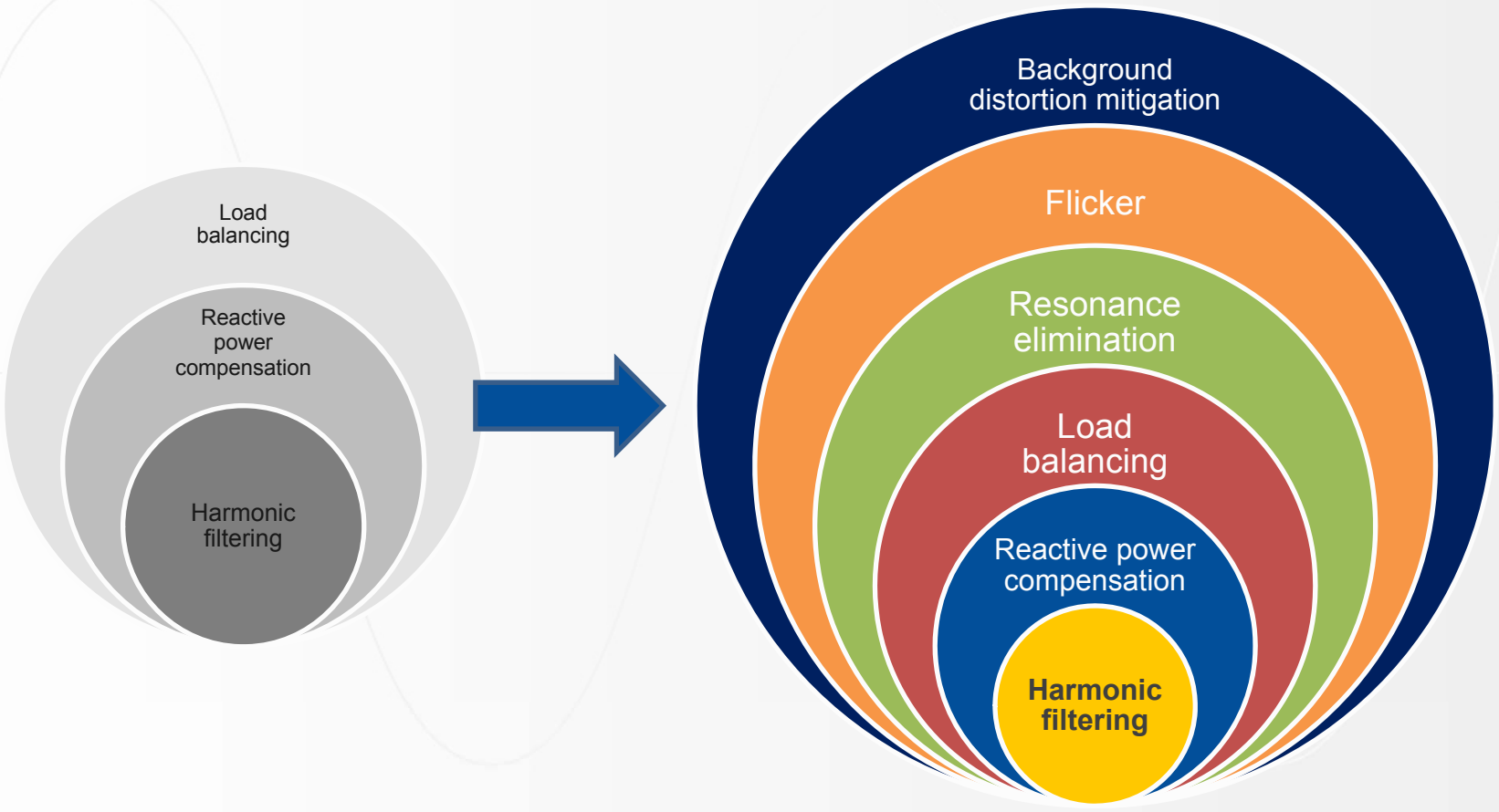
1925,
Edith Clarke & Robert Park

1990s,
High performance DSP
+
High power IGBT

1996 - 2000,
Born about
20 years ago

2000 – today,
400V → 690V, 3W → 4W
Response time：cycles→ uS
Air cooling→ water cooling
Current control → Voltage control
High power → Low power
Active filter→ ADF power tuning

Evolution of active filter functions



Traditional active filters

Trend: **ADF Power Tuning**

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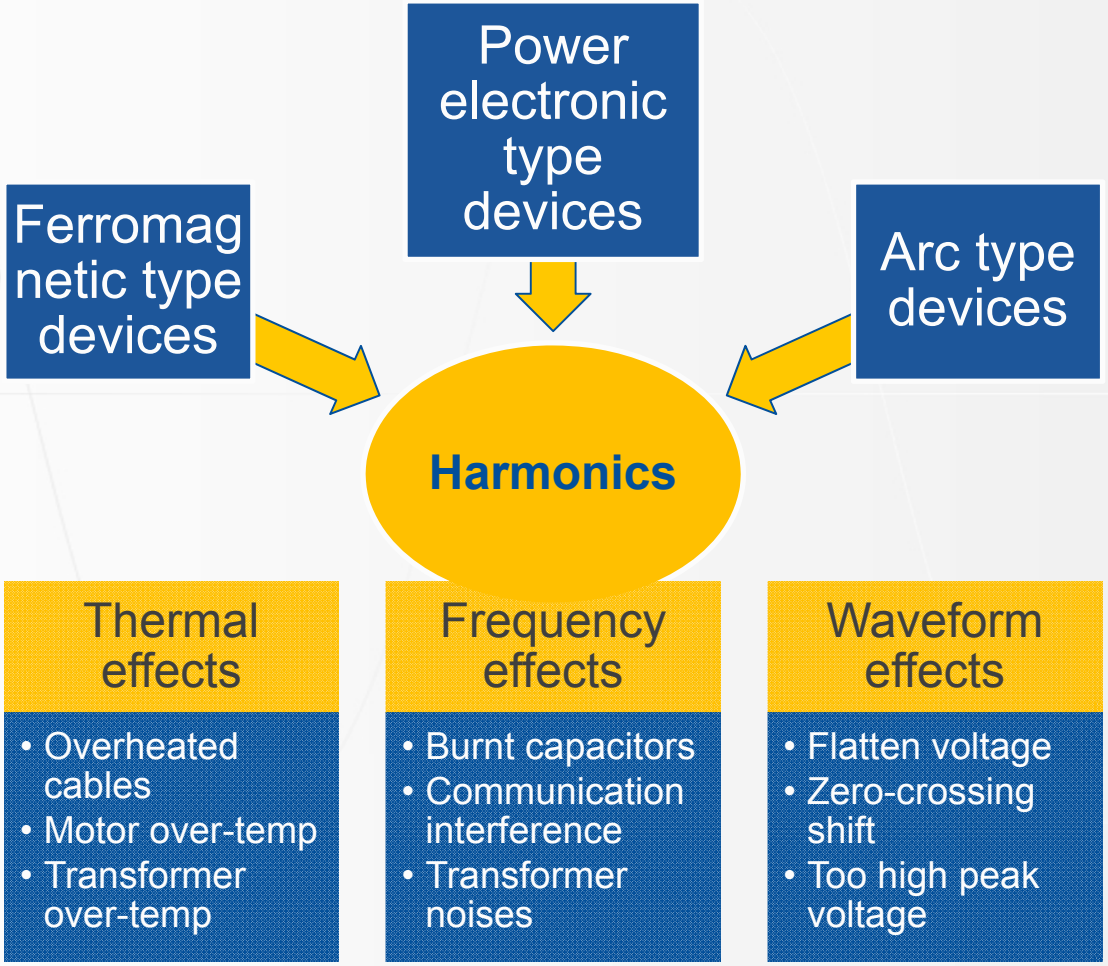
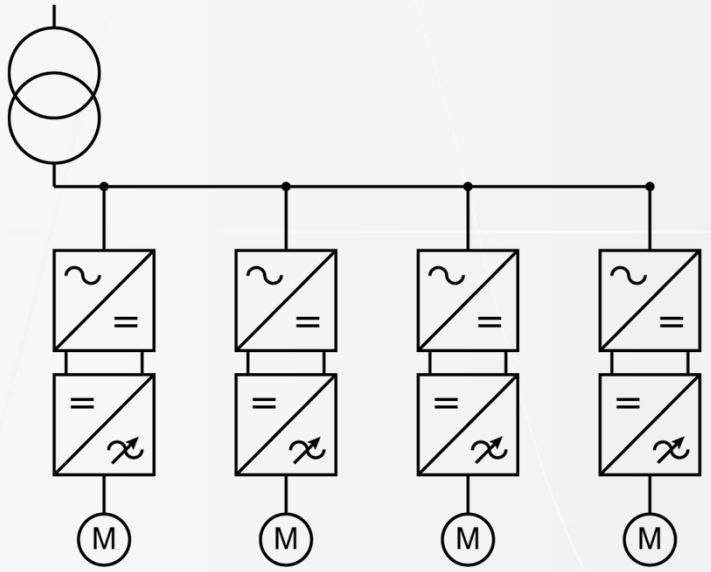
Harmonic sources and effects



Major harmonic polluter 6-Pulse drives

Energy efficient, but:

- High harmonic content, 35-80%, can cause problems and does not meet regulations



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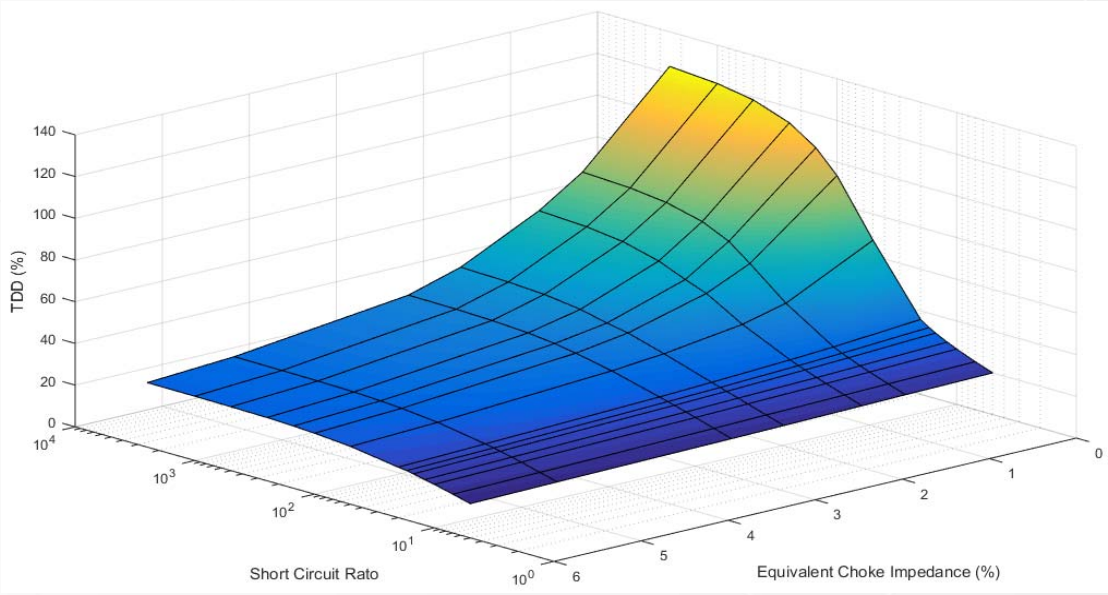
Effects of line impedance and Short Circuit Ratio on THDI

- Higher SCR always increases the THDI
- Increase of THDI on low AC/DC impedance is stronger
- 6% AC impedance has nearly flat curve



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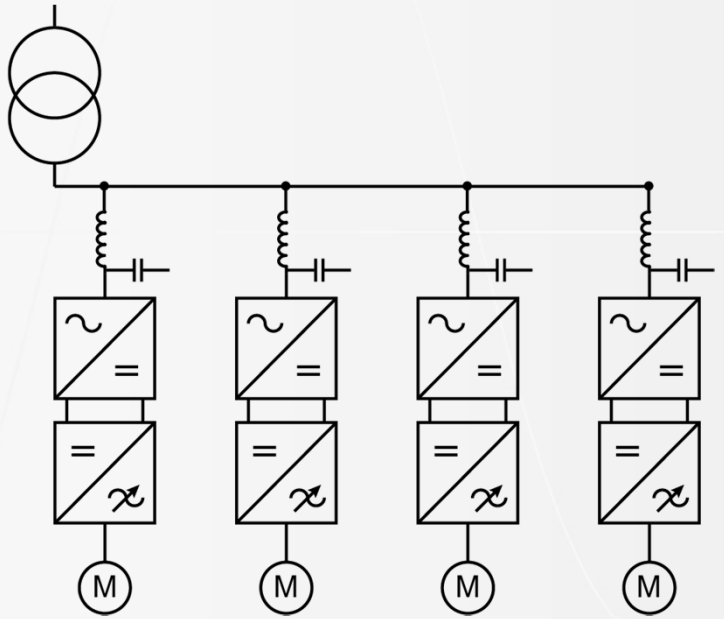
Harmonic solution 1:

6-Pulse drives + series passive harmonic filters

Low cost solution, but:

- Filter in line with load, requires a lot of space
- Can be overloaded, with damage as result
- Several passive components in a grid will cause resonance problems
- Non-flexible, installation upgrade = replace filter
- Redundancy, If filter fails, drive stops



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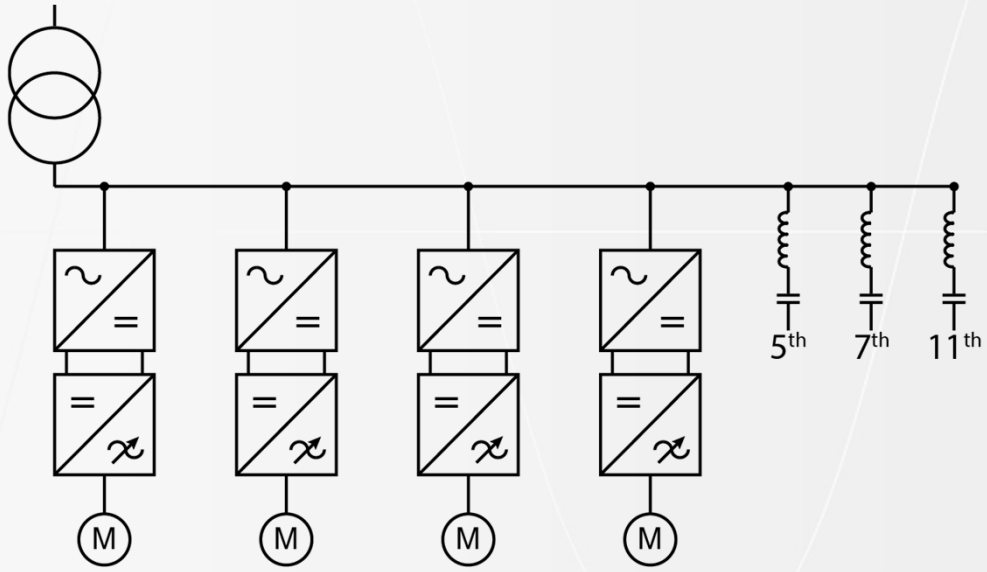
Harmonic solution 2:

6-Pulse drives + shunt passive harmonic filters

Low cost solution, but:

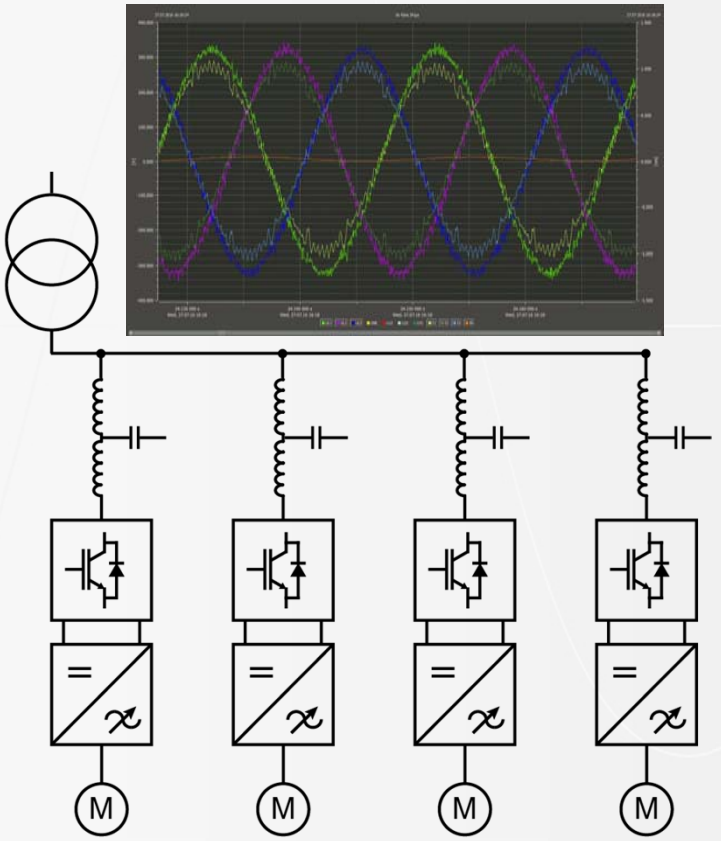
- Filter in shunt with load, requires a lot of engineering
- Can be overloaded, with damage as result
- Several passive components in a grid will cause resonance problems
- Non-flexible, installation upgrade = replace filter
- No redundancy design possible



Harmonic solution 3: Active Front End drives

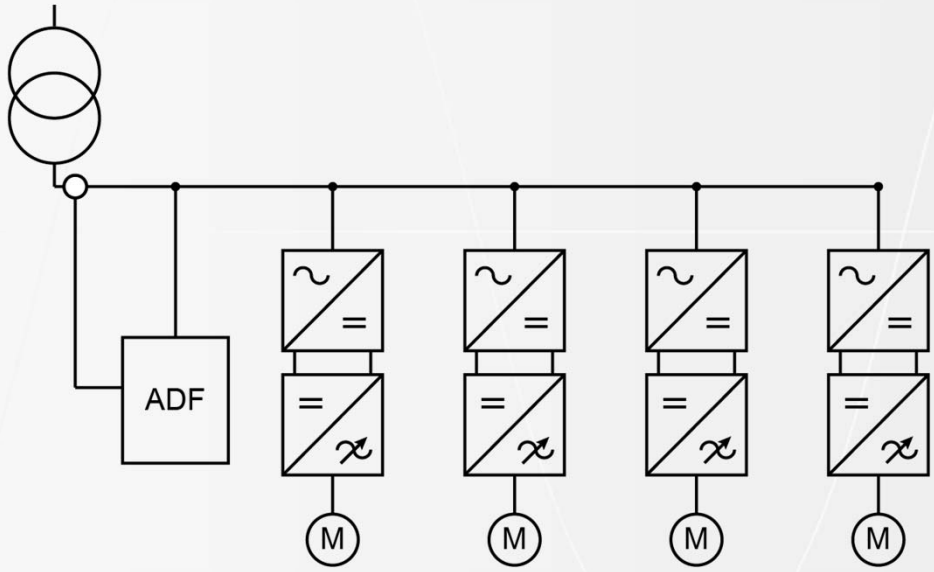
Easy to size solution but:

- Filter in line with load, requires a lot of space
- Front end in line with load results in high losses
- Redundancy, if front end fails, drive stops
- High order harmonics



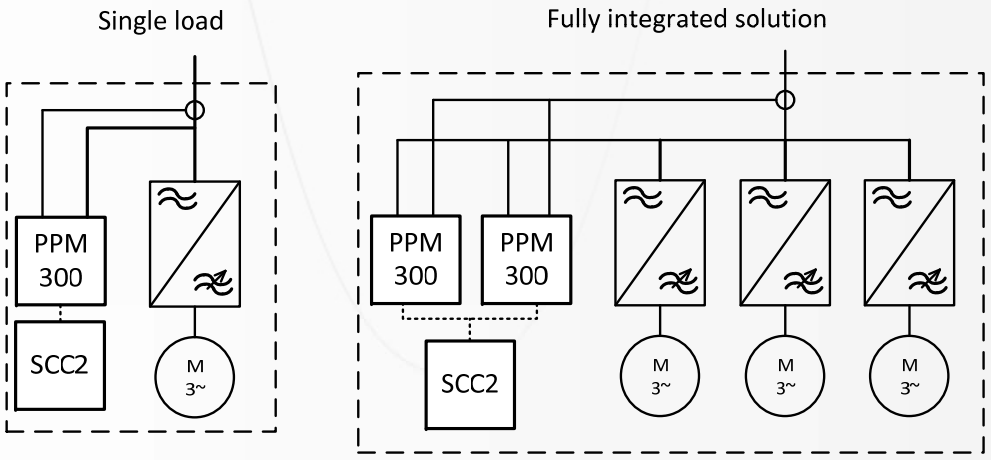
Harmonic solution 4: 6-Pulse drives + ADF

- ADF is installed in parallel with load, compact installation
- Can easily be scaled up at later stage
- ADF can be sized for worst case total load
- Redundancy, If ADF fails, drives still run



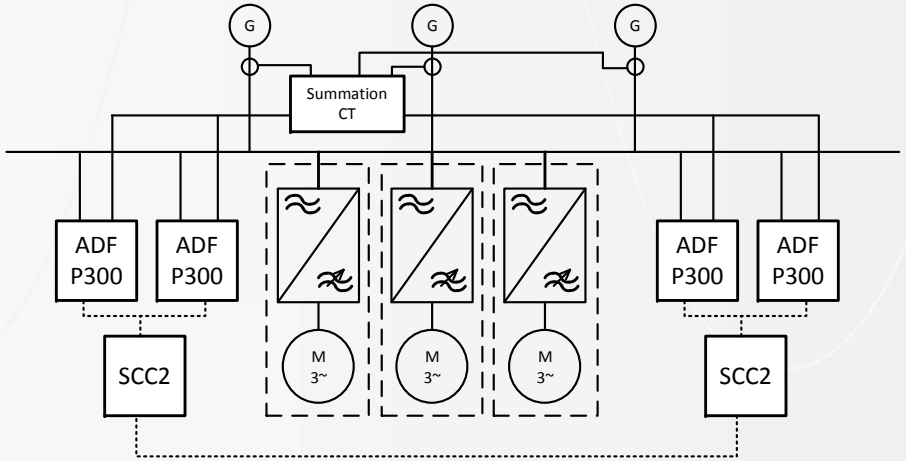
Handle all applications with basic building blocks

- Solution scales from single load…
- … to fully integrated solution



Handle all applications with basic building blocks

- Very complex setups can be handled
- Parallel systems with multi-master capability
- Design redundancy schemes according to need



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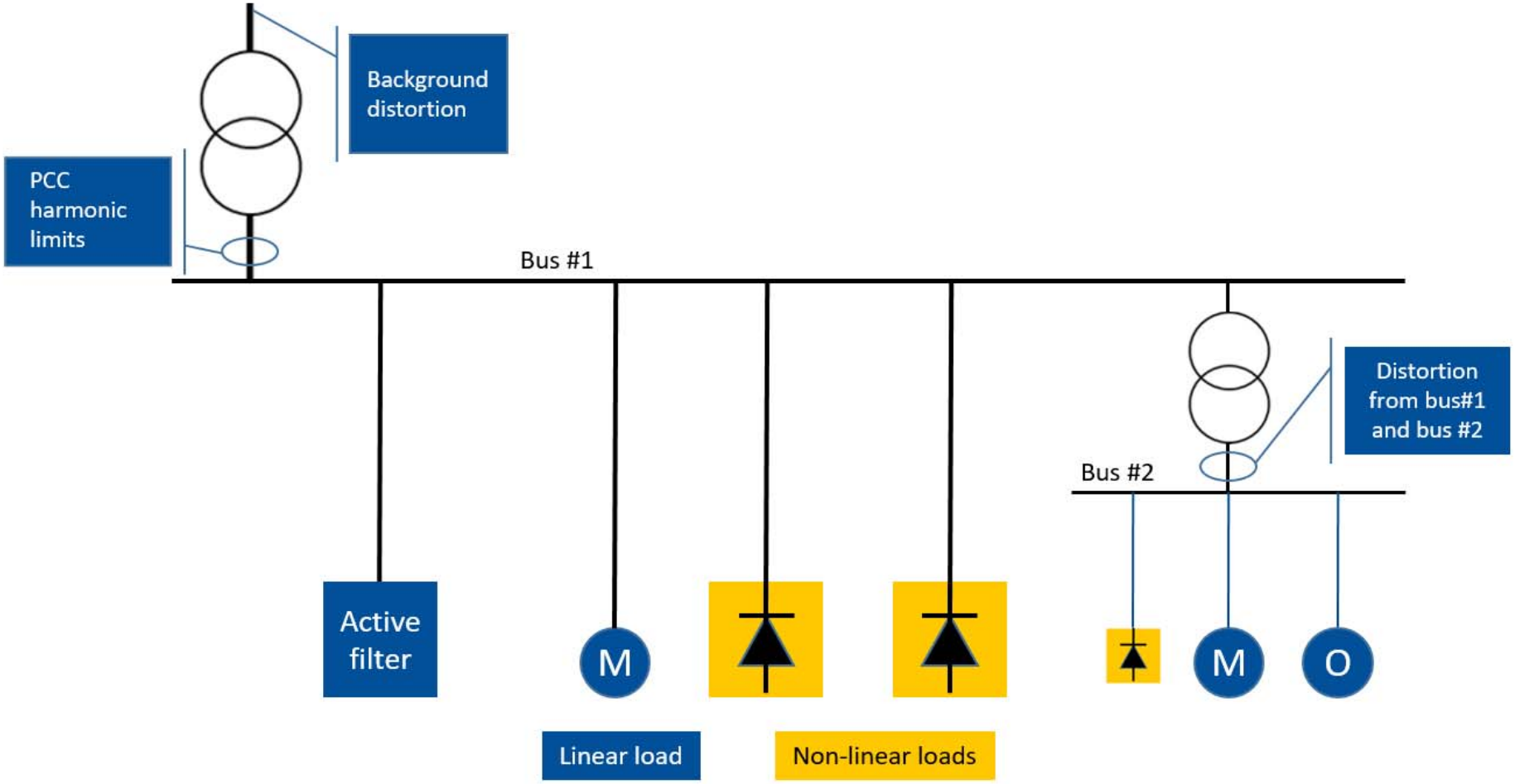
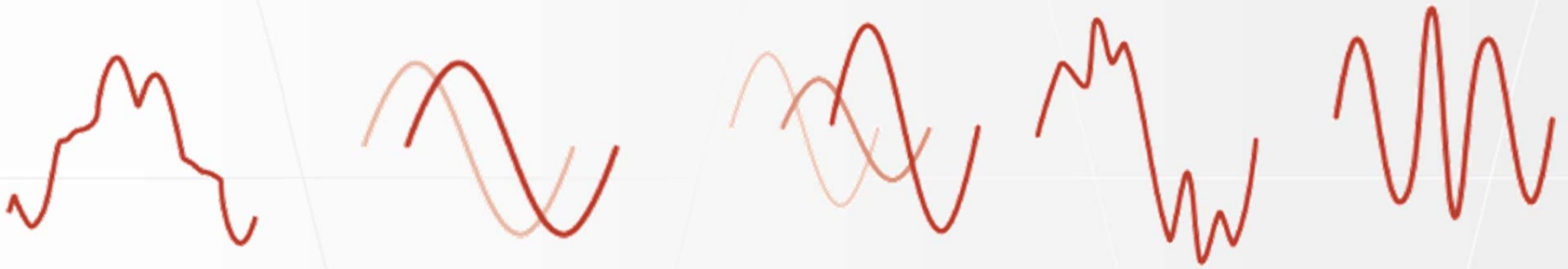
Typical installation with harmonic issues



Common power quality issues



Harmonics

Reactive power

Load unbalance

Flicker

Resonance

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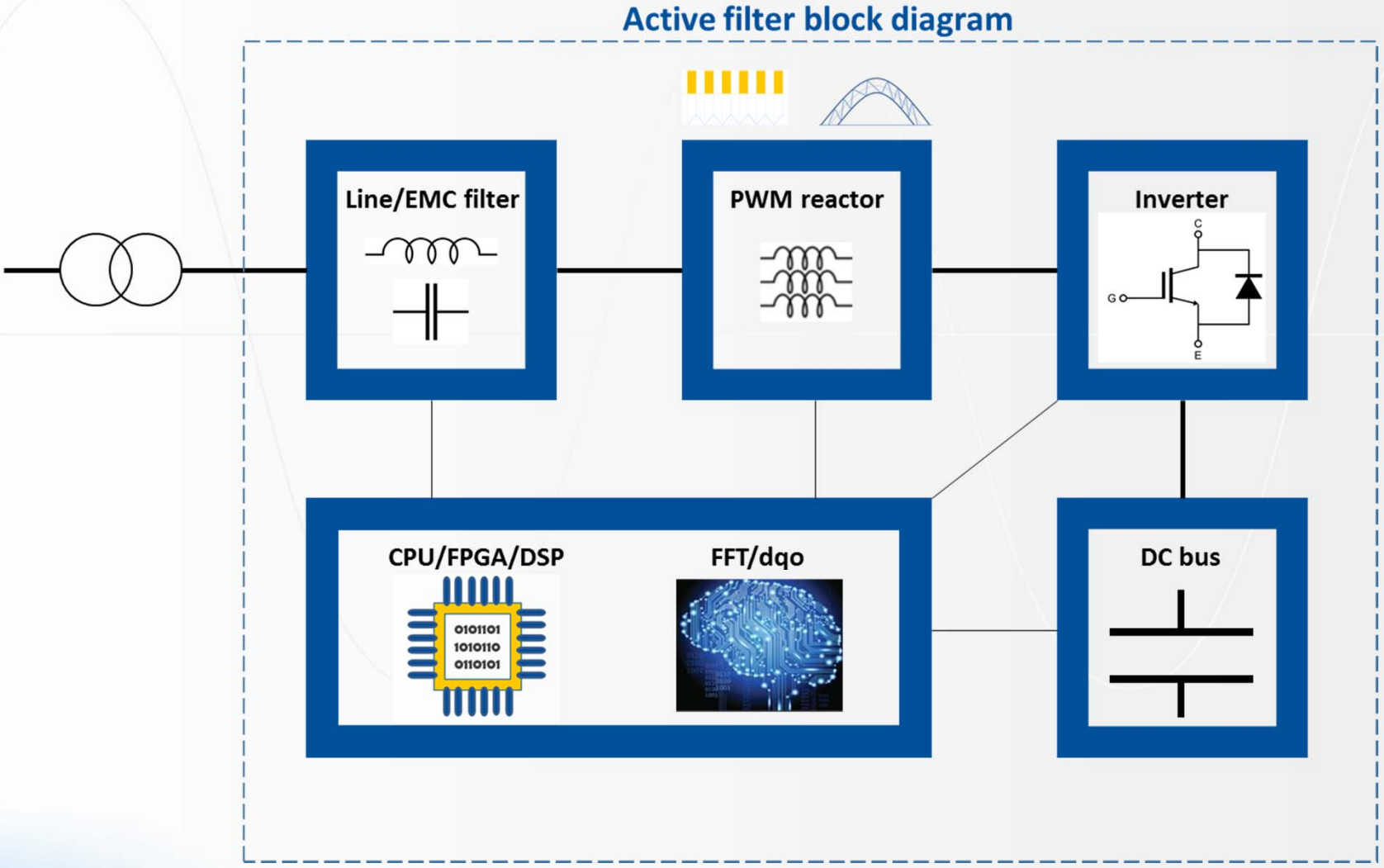
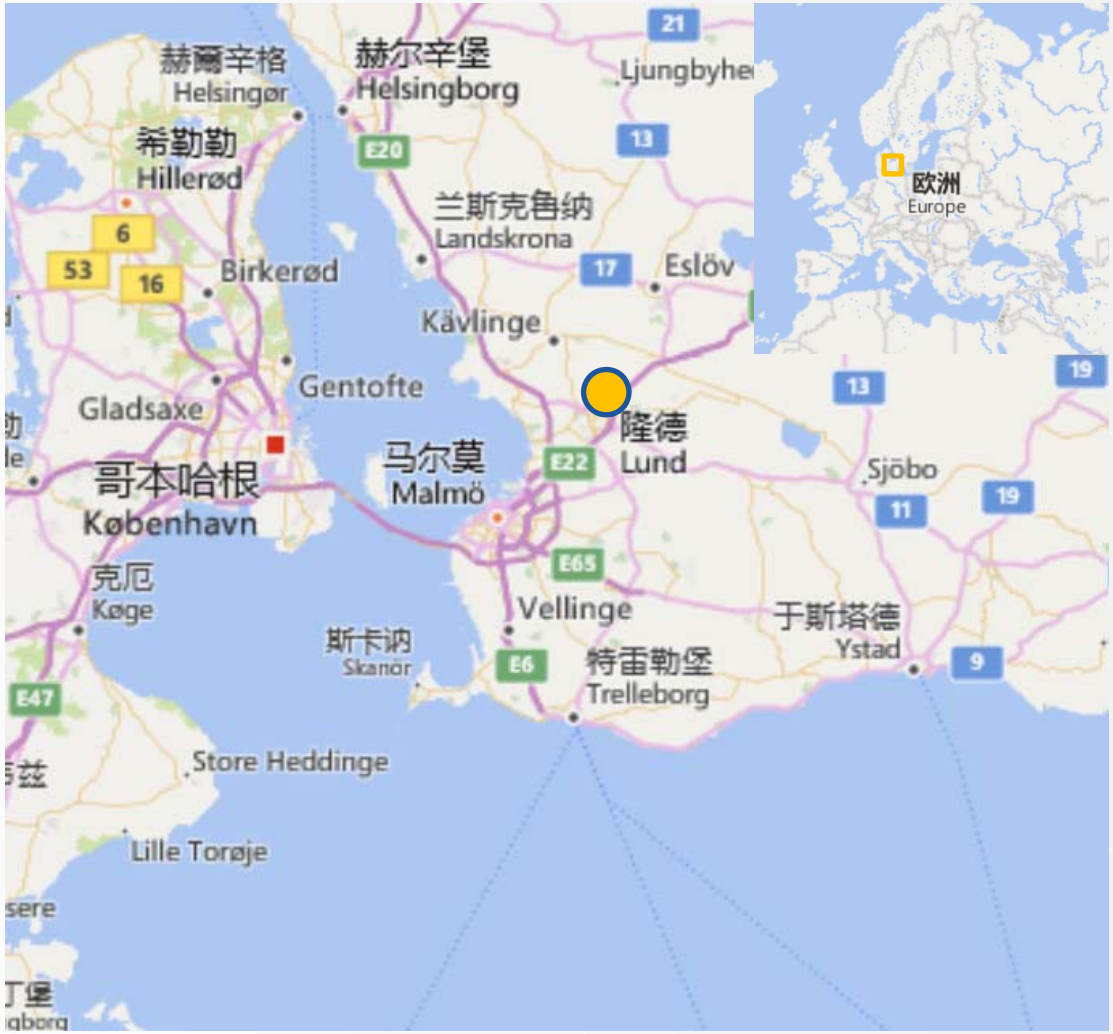
How an active filter works



Company profile

- 1992，found as Comsys AB in Sweden.
- One of the few original active filter developers in the world.
- 100% dedicated to active filter research and innovations.
- The first company on vertical modular design.
- The only brand capable of voltage control worldwide.
- The only filter in market mitigates background distortion.
- Address harmonic issues without CT.

Company profile



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Our customers

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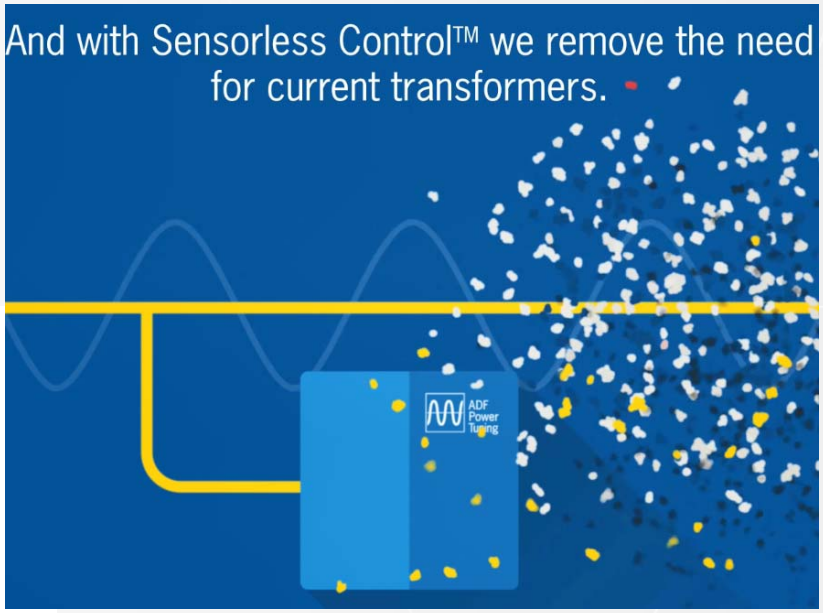
Power of innovation

Unique voltage control: no need CT



Top innovator

Recent patent families / employee

Maschinenfabrik Reinhausen	0,047
Siemens	0,067
Schneider Electric	0,041
Schaffner	0,037
ABB	0,045
COMSYS	0,47

Source: PatBase

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Product range

ADF P100

ADF P100N

ADF P300

ADF P200

ADF PPM300

Web User Interface

ADF P700 STATCOM

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ADF P100/P100N

- Wall mounted
- Very space efficient for retrofit
- Cost effective
- 480/690 V, 3ph-3w
- 415 V, 3ph-4w
- Current capability: 70 - 130 A_{RMS}

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ADF P300

- Modular design (PPM)
- Air and liquid cooling
- 3 wire
- Simple installation
- Simple operation through WUI, Smart grid ready
- Current **and** Sensorless control
- Is able to compensate with high efficiency
  - Harmonics (up to 49th harmonic)
  - Reactive power
  - Unbalance
  - Voltage variations (flicker)
- Available in 480 V Air, 120 A – 360 A
- Available in 480 V liquid, 150 A – 450 A
- Available in 690 V Air, 90 A – 270 A
- Available in 690 V liquid, 140 A – 420 A
- UL/cUL certified

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ADF P700

- Modular design for high availability
- Air and liquid cooling
- 3 wire
- Simple installation
- With or without housing
- 2 – 20 MVA compensation power
- 690 V – 130 kV connectivity

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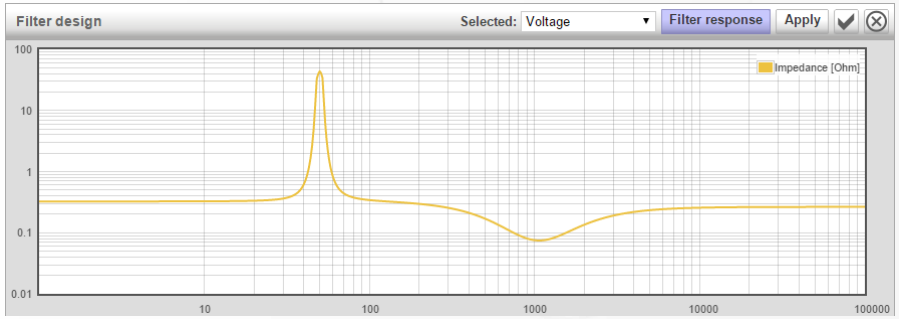
ADF P200

- Air cooling
- 480 V 3ph–3w 120 A_{RMS}
- Sensorless control
- Wideband curve compensation
- Compensation up to 6 kHz!
- World's fastest active filter!



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PPM300 – Integrator friendly

- ADF OEM Concept is the ultimate low harmonic alternative for OEM's and System Integrators on the market
- Virtually plug & play for drives
- Combination of modules gives highest possible flexibility 90 A and upwards
- Compensation powers from 80 kVA to 15 MVA can be built with simple building blocks
- Allows system integrators to be flexible and competitive with a small standardized tool set. 100% Drive supplier independent

Voltage	208 – 480 V	480 – 690 V
Air Cooling	PPM300-3-A-120/480	PPM300-3-A-90/690
Liquid Cooling	PPM300-3-W-150/480	PPM300-3-W-140/690

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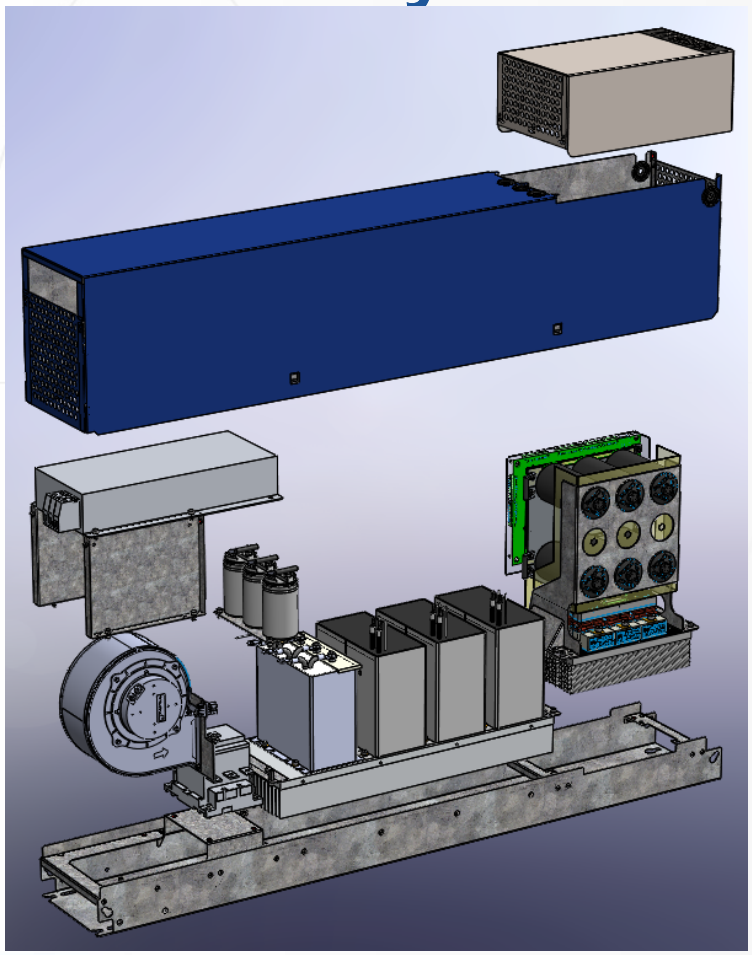
Modular design
Reliability and Serviceability



- All module type components can be exchanged when inverter is mounted in cabinet
- Cover hood easily detachable
- Modules slide out towards front of cabinet
- Converter, fan and capacitor exchanges are especially convenient to service
- Heaviest component (line filter) is the one rarely serviced!

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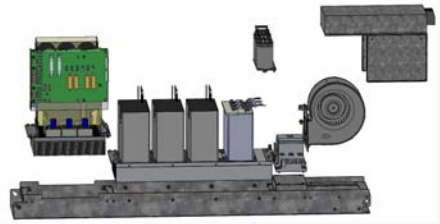
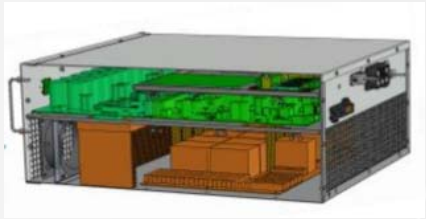
Modular design
Vertical module vs rack-mounted



Comparing criteria:
- o Heat dissipation
- o Component temp
- o Component lifetime
- o Early failure
- o Noise level
- o Performance
- o Reliability

Vertical module design has significant better performance than rack-mounted on module or cabinet temp rise, noise level and reliability.



Commissioning - Web user interface

- ADF Dashboard Web User Interface (WUI) allows control of system via web browser
- Only use your laptop for commissioning!
- Ease of use – easy to support – lower cost of training – lower cost of ownership
- Leverages the remote support capabilities
- Easy to connect to overall system incl. remote access, logging and analysis functions

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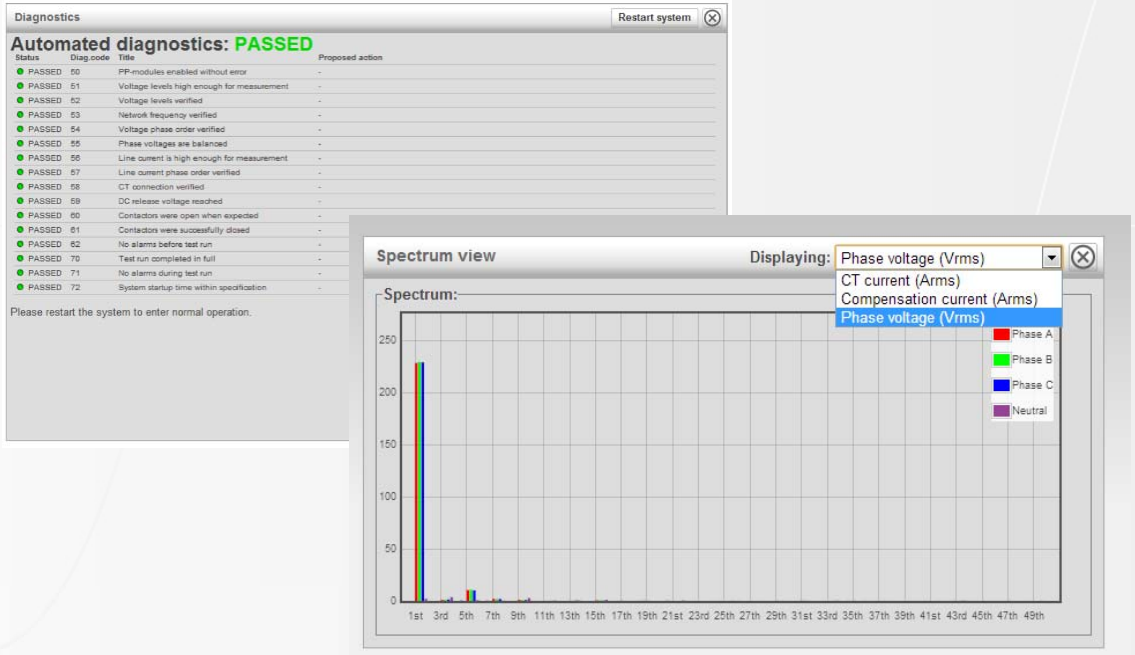
Commissioning
Automatic diagnostics

- Automated diagnostics with human-readable error messages simplifies commissioning process
- ADF performs self-test on startup
- Error in connection will quickly be detected
- FFT in Web User Interface
- Commission process is fast and simple – results seen immediately



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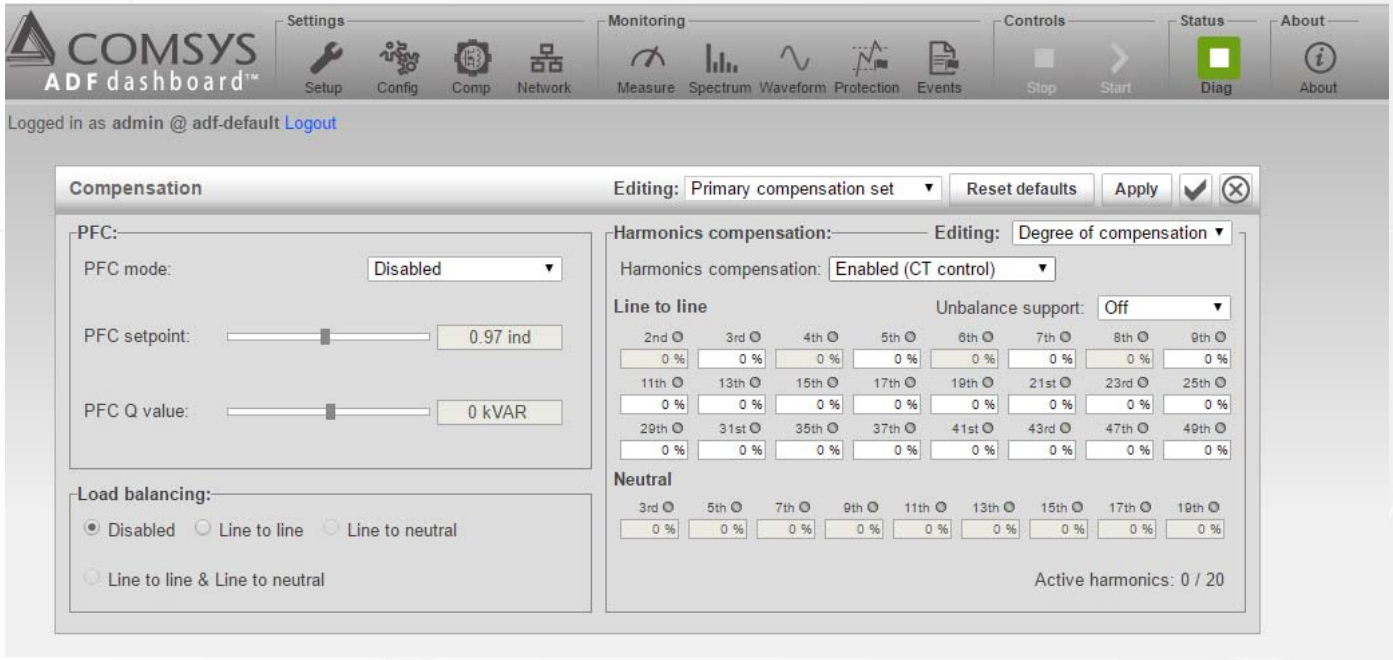
Commissioning



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Sensorless Control:

- Active Filters inject a counter-current to compensate for a grid/PQ issue
- Typically, active filters are current control
- **Voltage control = sensorless** control (in our case; elimination of CT)
- Calculates compensation current based on load current

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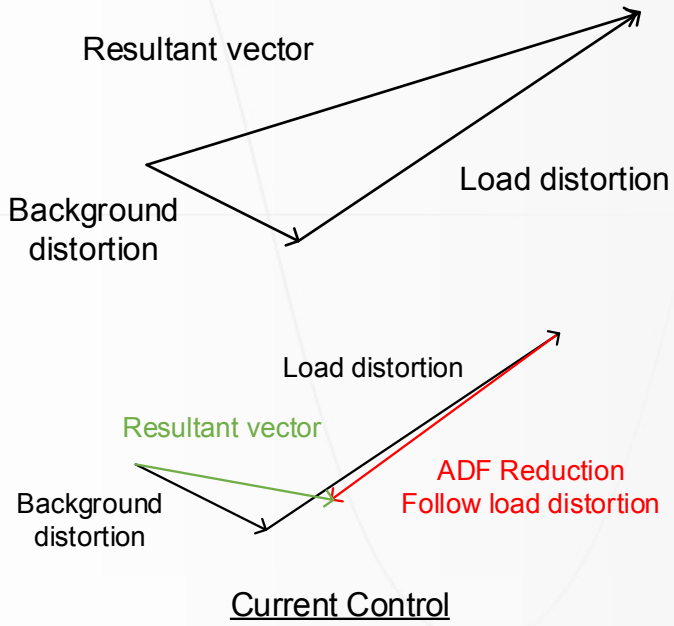
Sensorless Control:

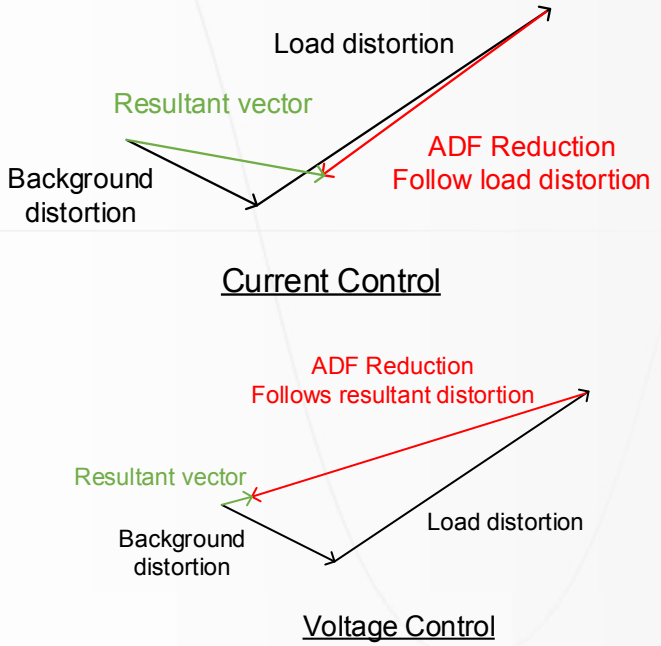
- Most common goal of ADF:
  Lower the **VOLTAGE** harmonics!
- So, we measure current to kill current harmonics, and "hope" that the voltage improves
- This works, but the idea is flawed

Sensorless Control: How it works



- Voltage control is more efficient when the goal is to achieve a certain voltage level
- Due to mixing of background distortion and load distortion, current control never works in correct phase angle
- In current control, ADF is bound to follow load current only
- This limits ultimate results, and may be a waste of power (depending on phase angles)

Sensorless Control: How it works



- Voltage control enables filter to work in exactly correct phase angle, minimizing current used
- The compensation current “follows the resultant” in voltage control
- This results in more being done with less current, or a bigger reduction with the same amount of current

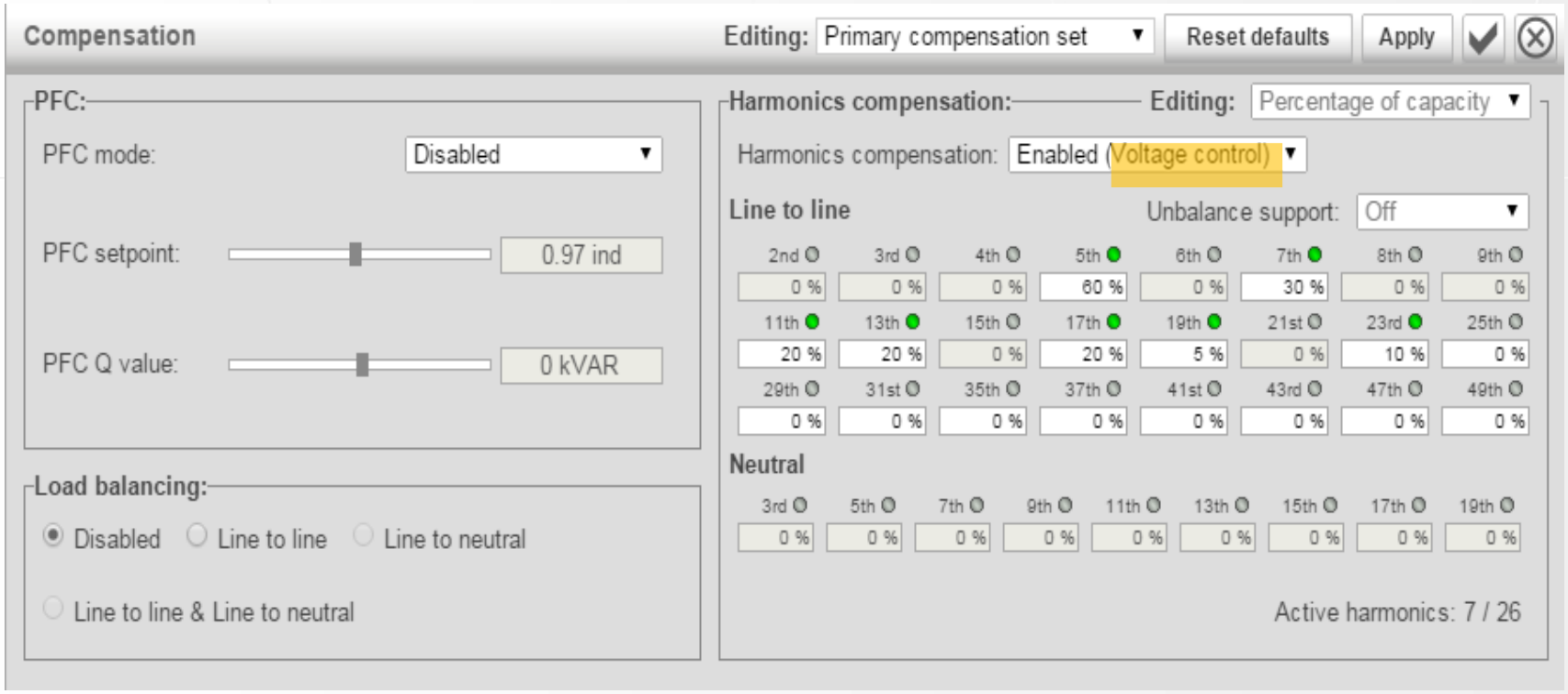
Voltage control：case study

- Customer: Netherlands HHNK, Wavershoof plant
- Sector: wastewater treatment
- Load: 6-p VFD
- ADF first commissioned as current control, changed to voltage control after some years of successful performance.

hoogheemraadschap Hollands Noorderkwartier

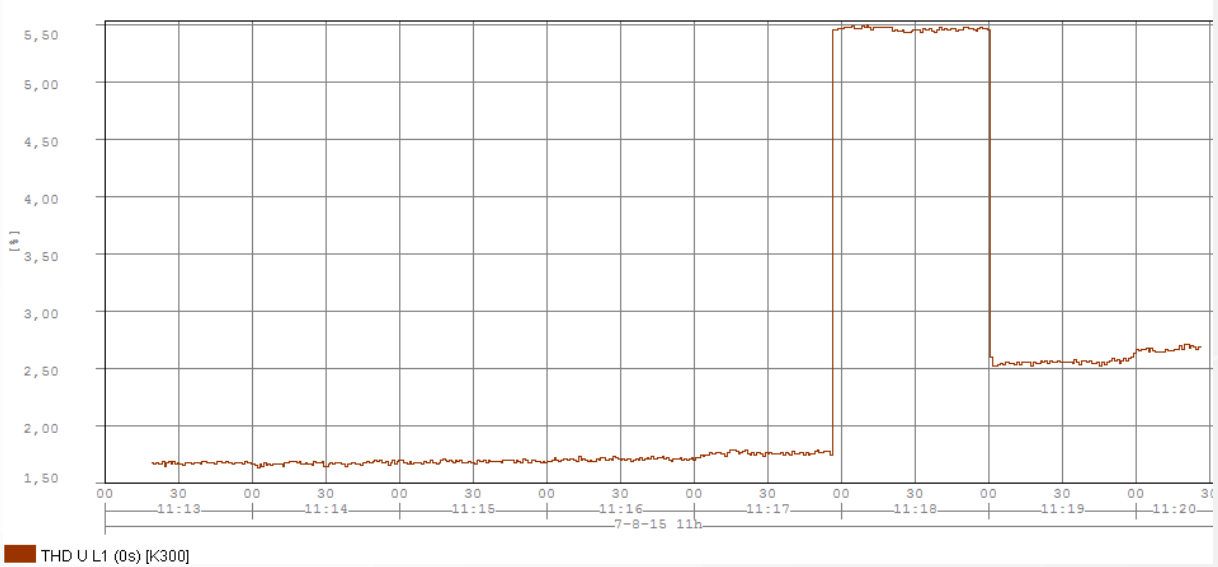
Voltage control：case study

Commissioning:



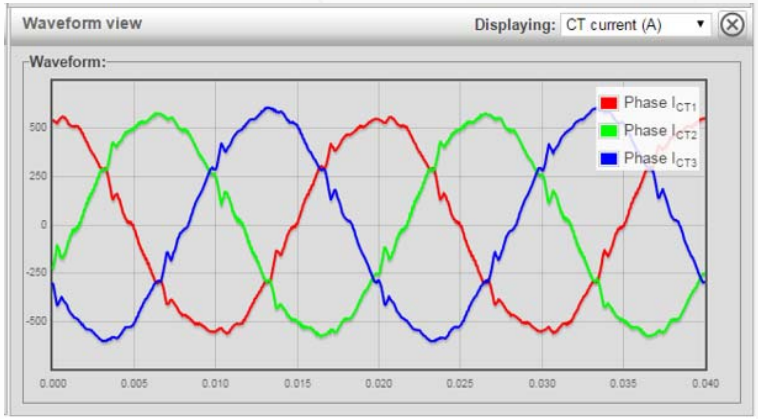
Voltage control：case study

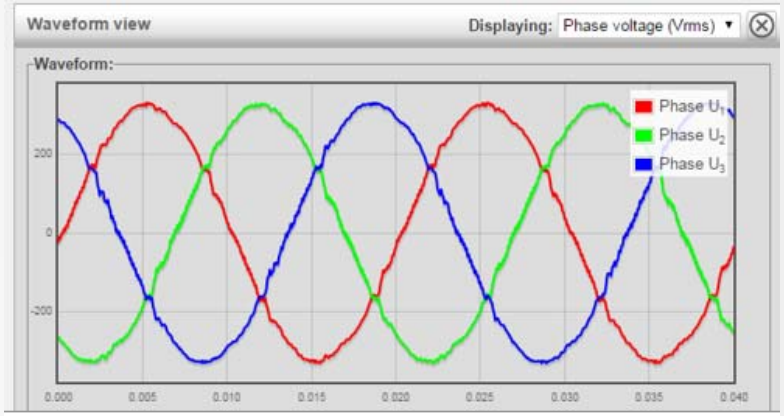
- Left: voltage control (VTHD 1.75%)
- Middle: ADF is not working (VTHD 5.5%)
- Right: Current control (VTHD 2.5%)



Voltage control：case study

- Left： Current control
- Right： Voltage control





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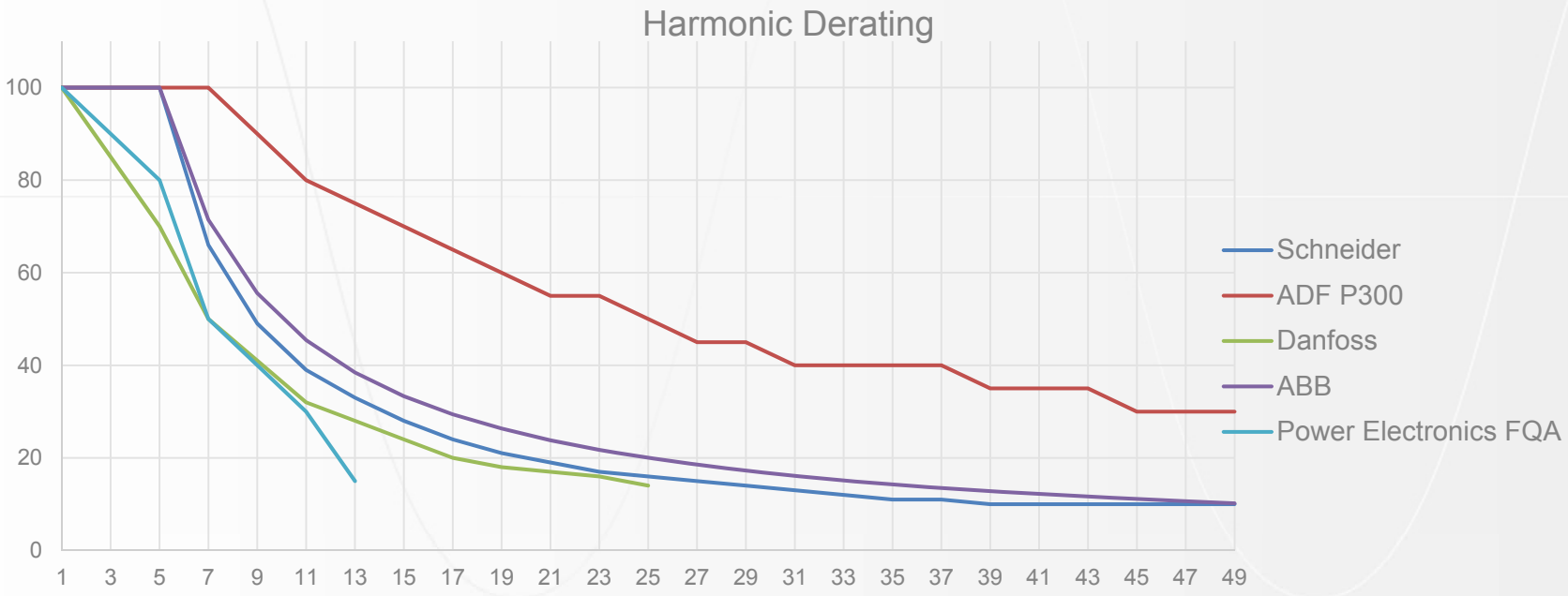
De-rating as a function of frequency



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Effects of derating in sizing

- Total harmonics are 104 A
- ABB would need 135 A (129%) filter to compensate
- ADF would need 106 A (102%) filter to compensate
- Power Electronics would need 216 A (208%) filter to compensate
- Derating can have a big effect on the sizing

Harmonic	Current		ABB With Derating	ADF With Derating	PE With Derating
5	80 A		80 A	80 A	100 A
7	60 A		84 A	60 A	120 A
11	20 A		44 A	25 A	67 A
13	20 A		52 A	24 A	133 A
Total:	104 A		135 A	106 A	216 A
			129%	**102%**	**208%**

Success stories

Tizir Norway (Steel)

Seacor Namibia (Marine, PSV)

VCCC in Australia (Hospital)

Vacon LHD in France (Water & Wastewater)

Global Casting Sweden (Steel)

Nonghyup Korea (Data Center)

Zhongyeda China (Charging station)

Vacon Singapore (LHD)

Oasys USA (Oil & Gas)

Flemming Germany (Marine, LNG)


Thank you!