TECHNICAL PRESENTATION

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SCIENTIFIC ENERGY MANAGEMENT

THE COMMON PROBLEMS

TECHNICAL PRESENTATION

THE COMMON PROBLEMS

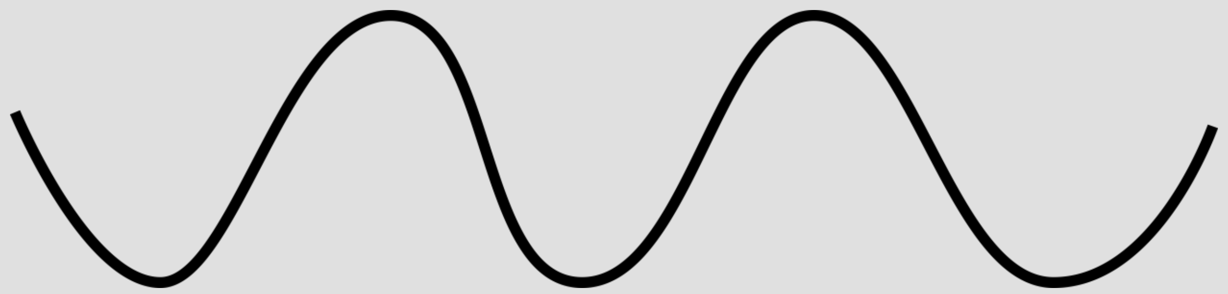
Low voltage and current quality is very common to all electrical installations worldwide due to:

- The non-linear nature of modern electric loads, Power electronics line inverters, dc converters, soft starters etc., are used for motor control and soft starting, but they “Pollute” the electrical installations with harmonics.
- The incompatibility between electrical motors and mechanical load demands that motors supply.
- The system-wide reactive currents that inductive loads (motors) should be supplied with in order to operate.

Electrical pollution

The negative impact

Modern power electronics

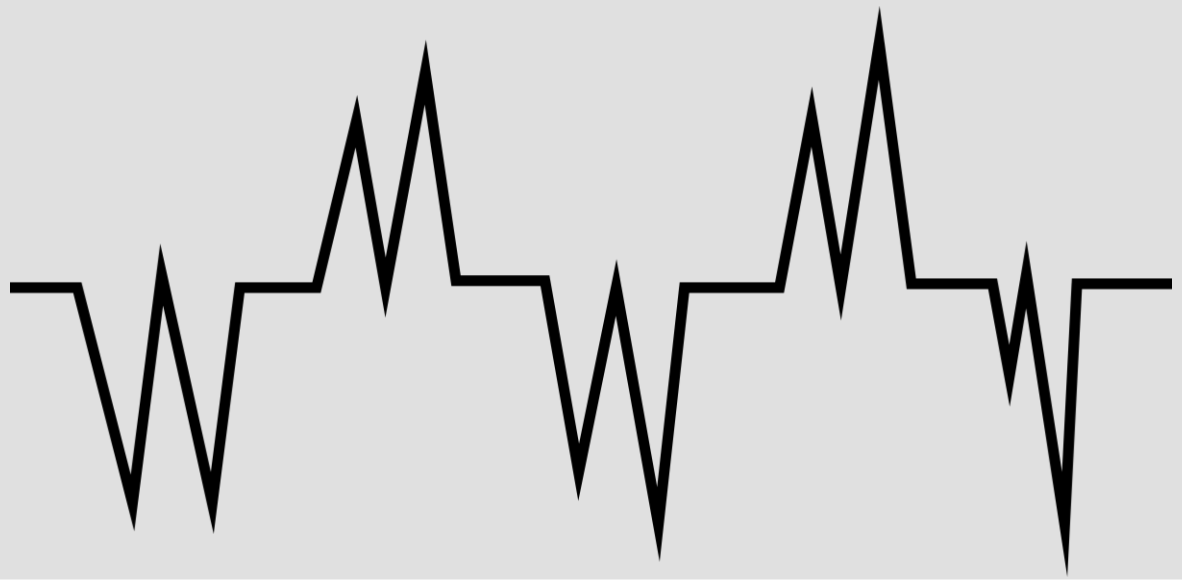


DC Converters

VFDs

...electrical pollution...

...that negatively impact facility performance



UPSs

Soft starters

Rectifiers

- Unplanned shutdowns
- Premature failure and wear of electrical equipment and safety hazards
- Higher maintenance costs
- Reduced efficiency in electrical motors, transformers, and other electrical components
- Reduced capacity of electrical installation
- Increased energy consumption and increase in power demand

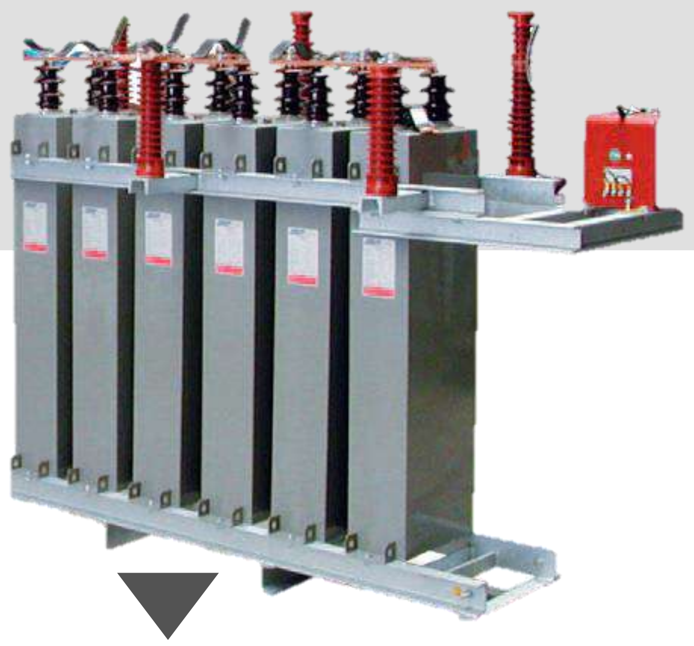
Electrical pollution

impairs facility performance

- Reduced efficiency (7-10%) of electrical loads
- Thermal losses, breaking torque
- Premature wear and failure
- Voltage drops and surges

- Thermal losses in cables can be up to 0.5 – 1.5% of total power (skin effect, proximity effect)
- Eddy currents in adjacent metallic structures

- Reduced efficiency (1-2%) of transformers
- Copper losses
- Iron losses



- Resonances and failure in existing capacitor banks

- Faulty activation of power switches
- Grounding issues
- Safety hazards
- Reduced electrical grid usage capacity

// Refer to IEEE 519 Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems

The problem

of **low voltage** and **current quality** finally leads to:

- **Additional energy consumption** [kWh]
- **Increased electromagnetic field losses within installations & distributions lines**
- **Premature wear of the electrical equipment and higher maintenance cost**
- **Existing capacitor banks suffer resonances**
- **Reduction of electrical motors and power transformers efficiency**
- **Reduced usage capabilities of electrical installations and distributions lines**
- **Neutral current increase**
- **Unreasonable activations of thermal or thermo-magnetic switches**

Measurements and Recordings

Real time measurements and recordings involve:

- Power transformers
- Low and medium voltage general panels
- Various distributions sub-panels
- Inverters, large motors and soft starters

Measurements concern:

Basic electric values, current and voltage harmonics up to the 35th order, and transient phenomena solution

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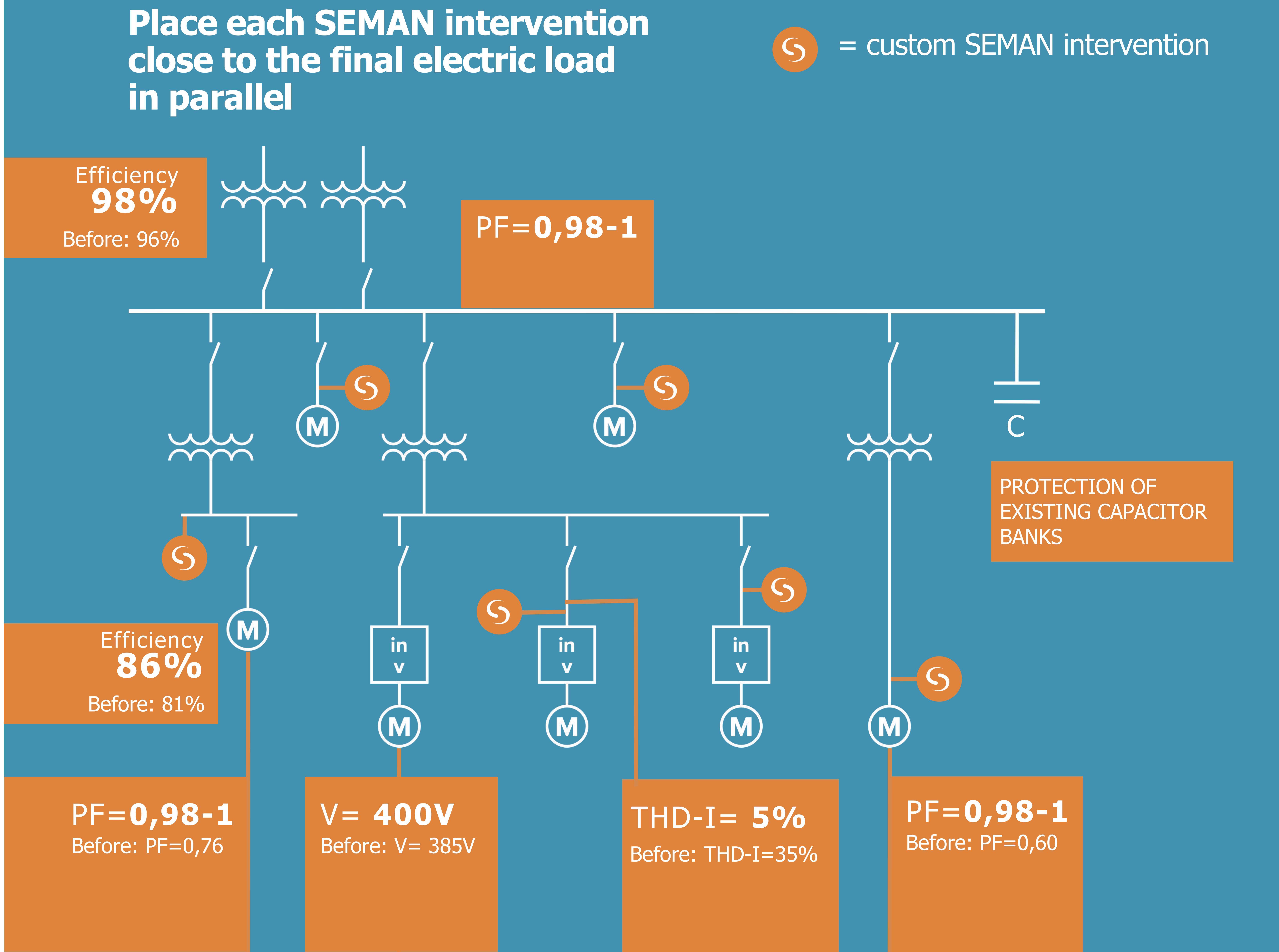
COMPLETELY ADDRESS POWER QUALITY

across
the entire facility

SEMAN project technical objectives:

- Stable voltage levels (e.g. 400V) throughout
- Power Factor = 0.98 – 1 next to all the loads
- Harmonic currents and voltages eliminated
- Cut all interactions between the loads for all harmonic's resonance scenarios
- Transform useless energy of harmonics to reactive energy at the electric loads
- Reduce apparent power by 15% – 35% throughout the electrical installation
- Increase efficiency of motors by 5% – 9%
- Increase efficiency of transformers by 1% – 2%
- Protection of existing capacitor banks



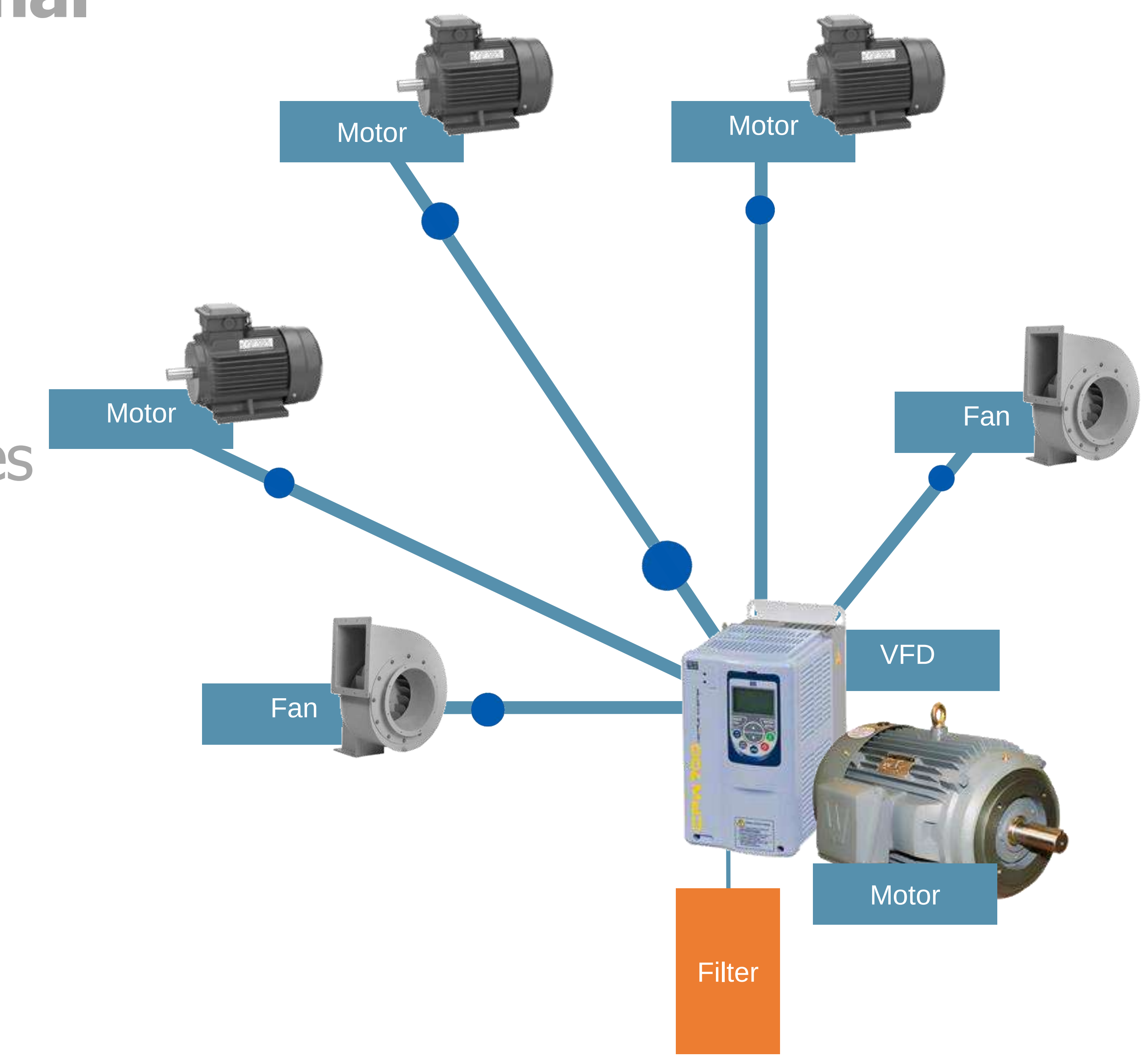
THE SEMAN GROUP DIFFERENCE

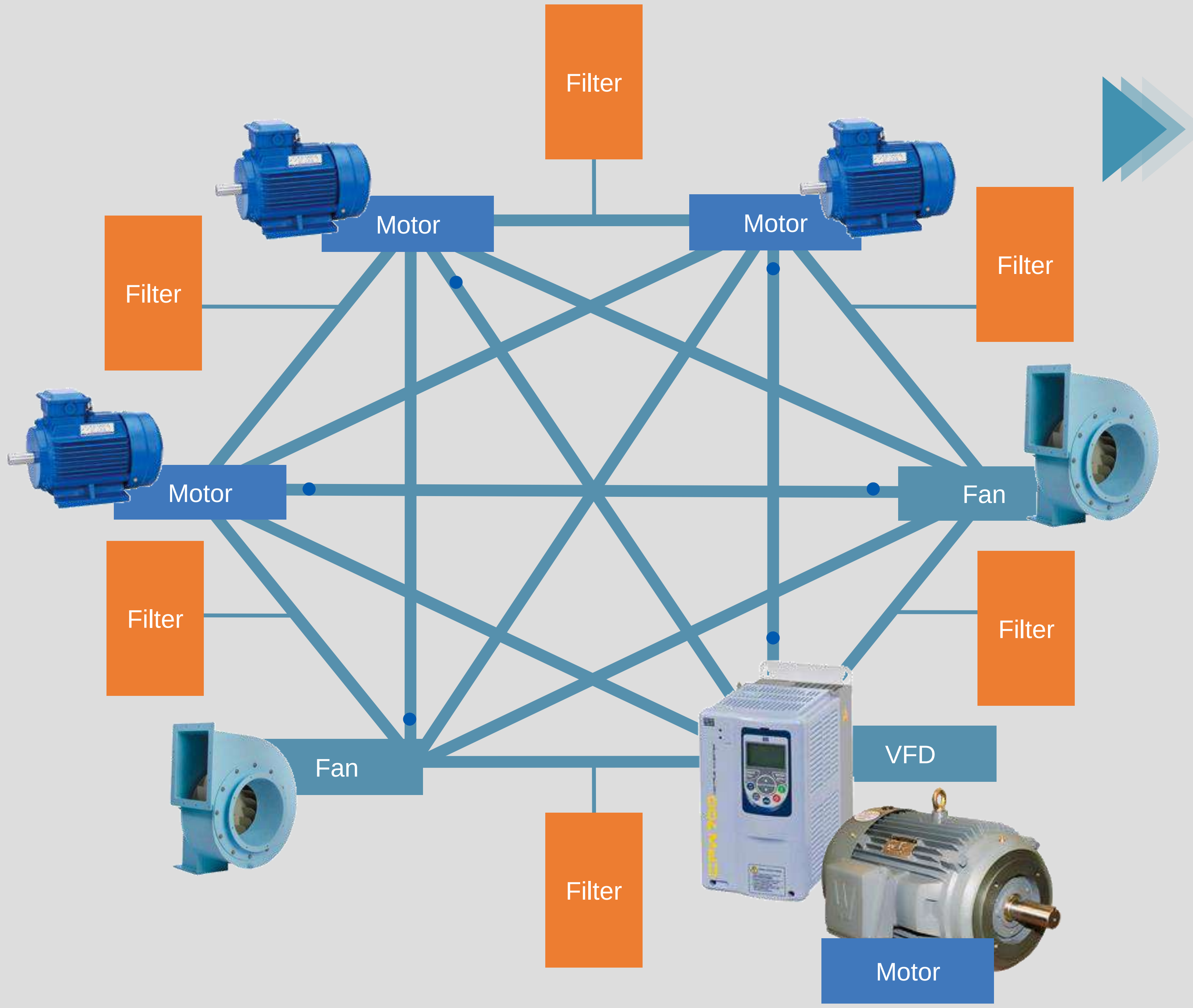
Cut harmonics interactions

Conventional approach

(cutting harmonics from point sources)

- Cut harmonics only from point sources
- Limited harmonics reduction
- No power reduction





SEMAN Group approach

(cutting all harmonics interactions and resonances)

- Cut harmonics interactions with electric loads
- Nearly total harmonics elimination
- Significant power reduction

CONSTRUCTION AND INSTALLATION OF THE PROJECT

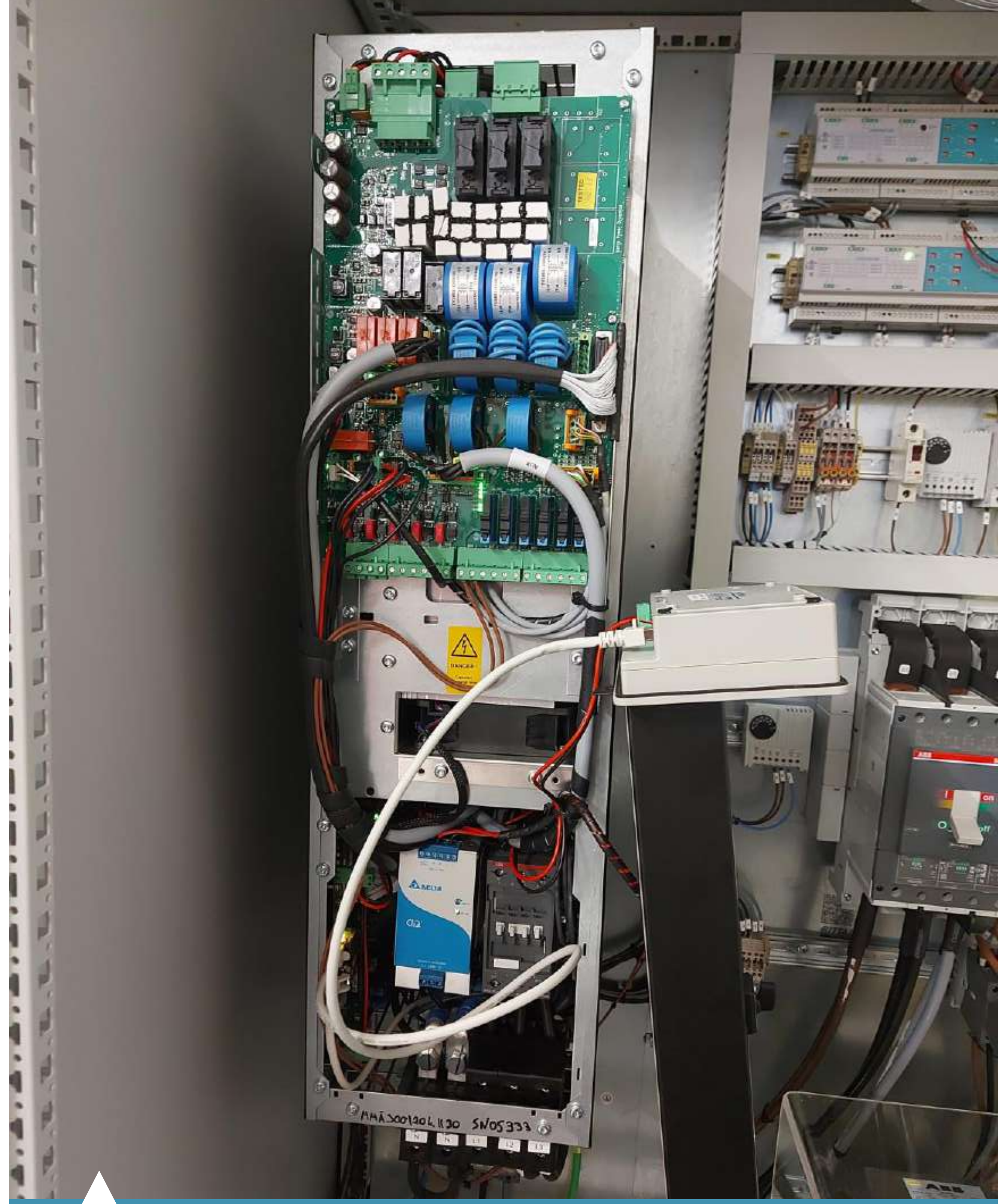
Construction of unique interventions by using customised materials from recognised international companies

SEMAN Group's scientific staff installs all energy saving interventions without affecting the existent plant operation conditions or impeding the production process

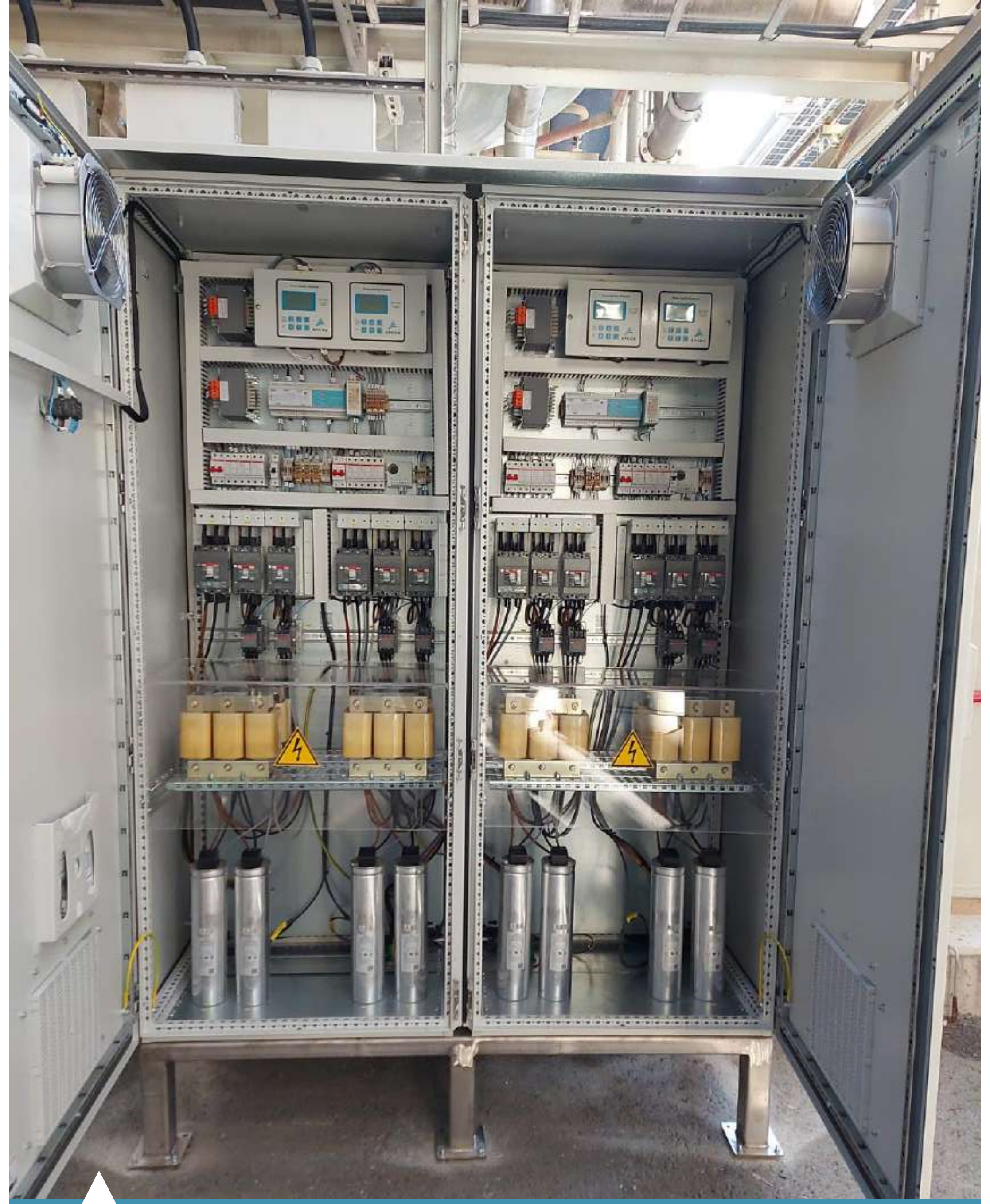
SEMAN

customised interventions

Hybrid System, Active and Passive Harmonic filters built in the same enclosures



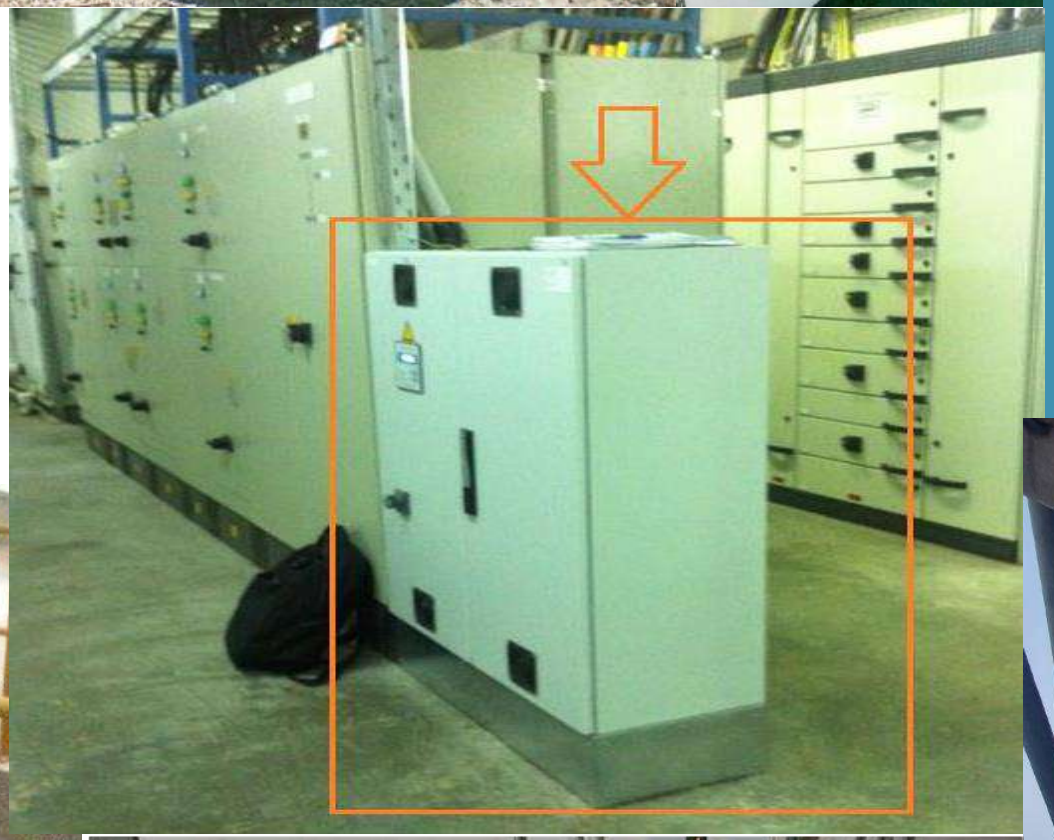
Active Harmonic Filter, mitigates current and voltage harmonics



Passive Harmonic Filter, mitigates reactive power and current harmonics (lower levels of harmonics)

SEMAN customised interventions

DESIGNED FOR EXTREME OPERATING ENVIRONMENTS



- Dust exposure
- Water exposure
- Explosive gas hazards
- Tight spaces
- Factory conditions
- Meet all applicable UL, CSA, EN standards

THANK YOU FOR YOUR ATTENTION

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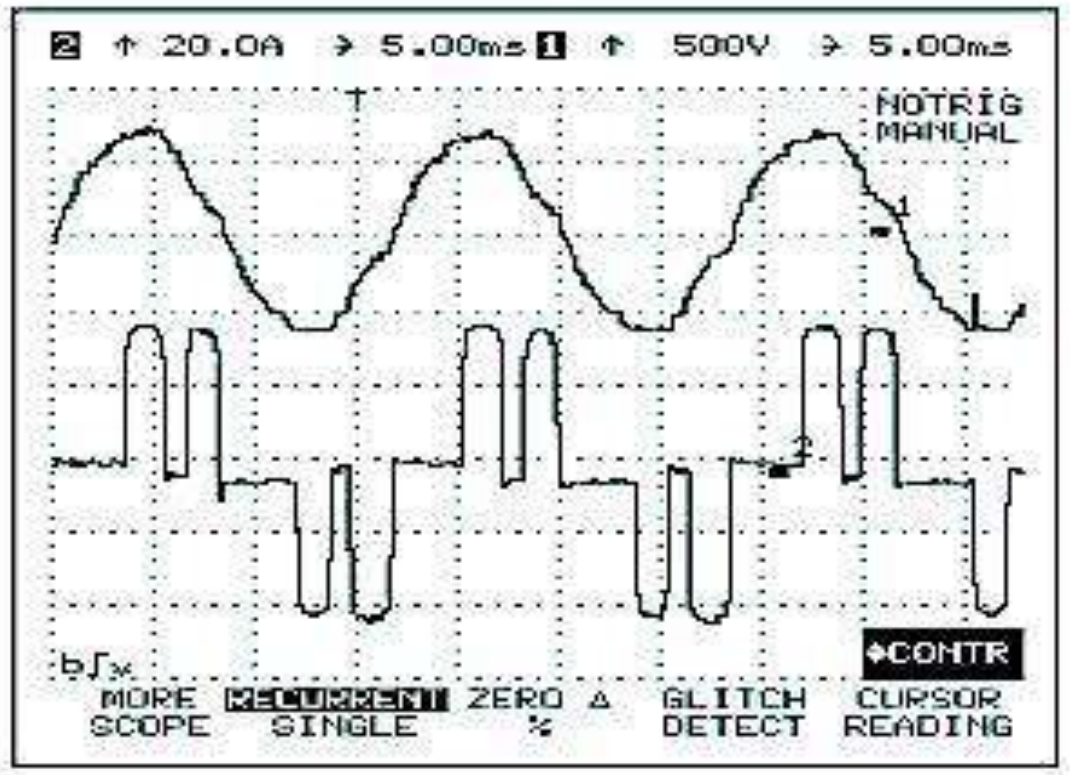
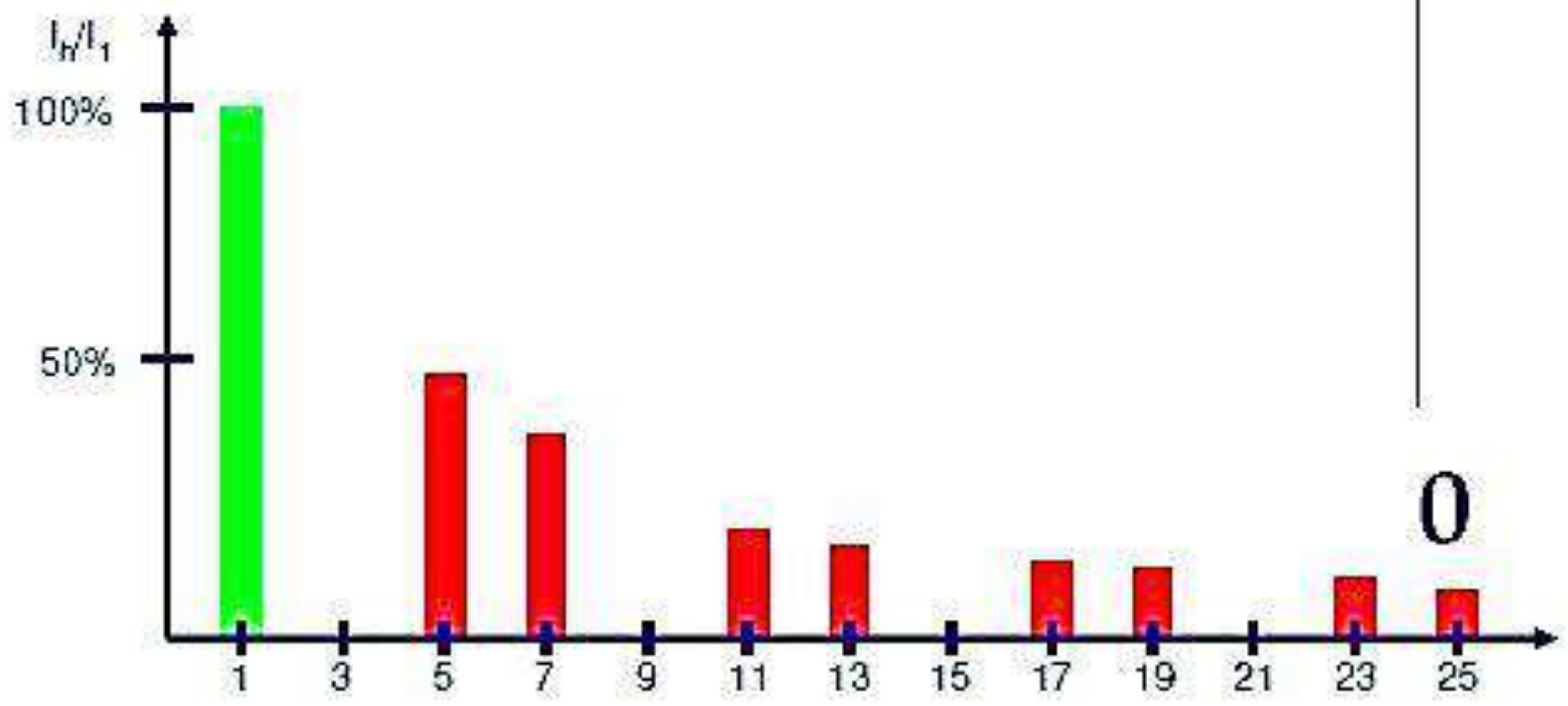
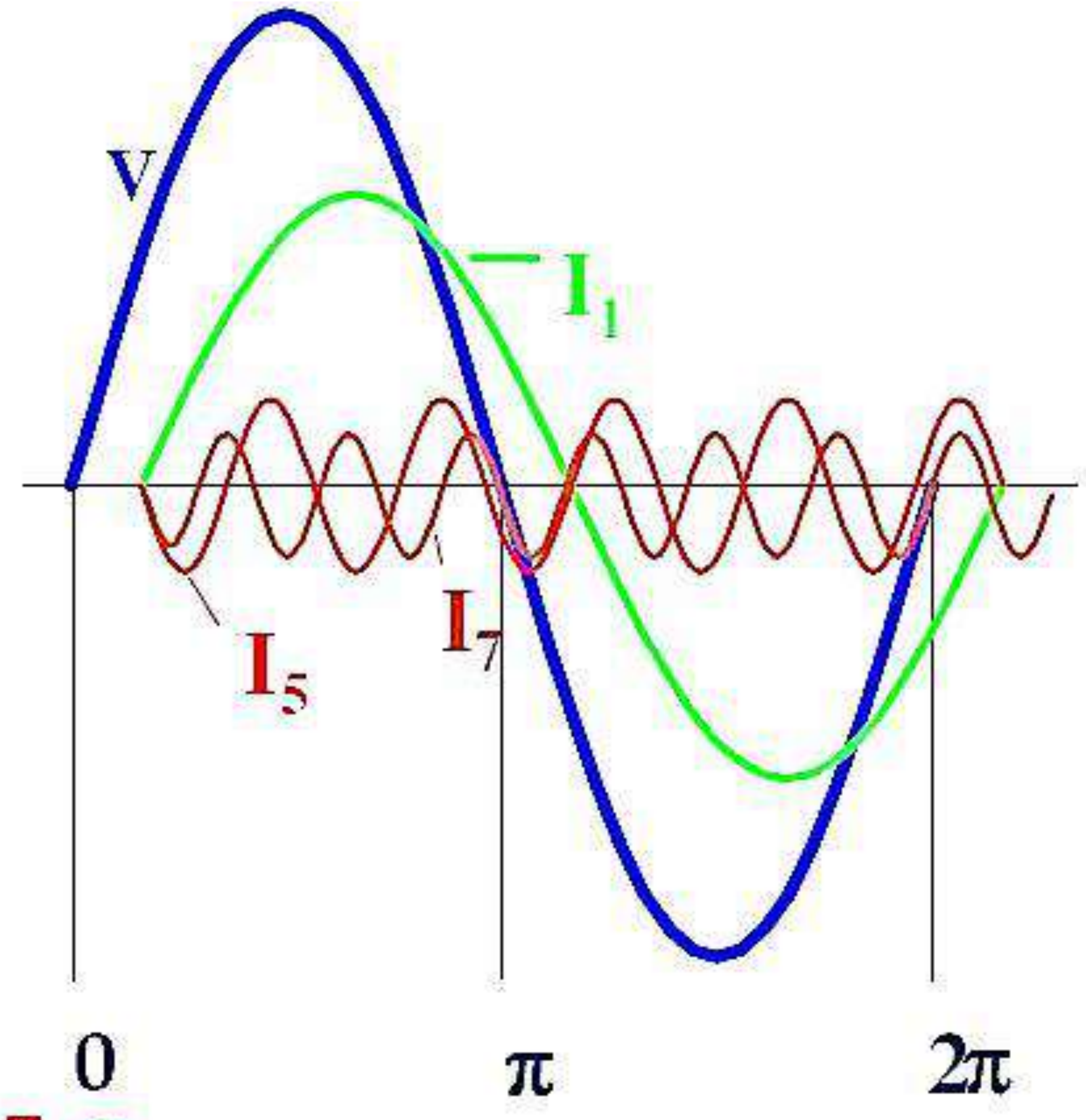
APPENDIX

The problem of low voltage and current quality

Typical Measurement Results

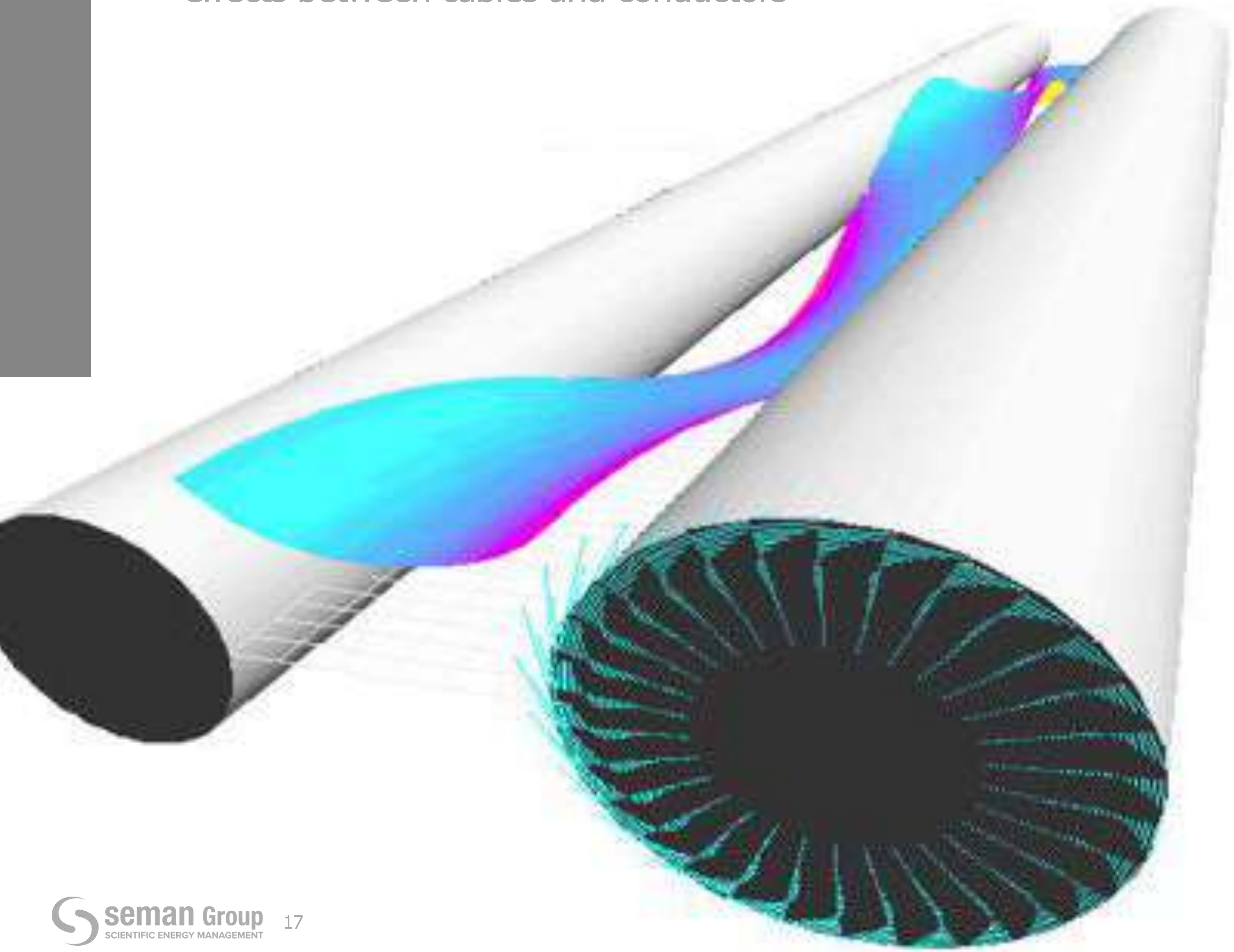






Proximity Effects

Thermal losses increase due to proximity effects between cables and conductors



Propagated Electromagnetic Waves

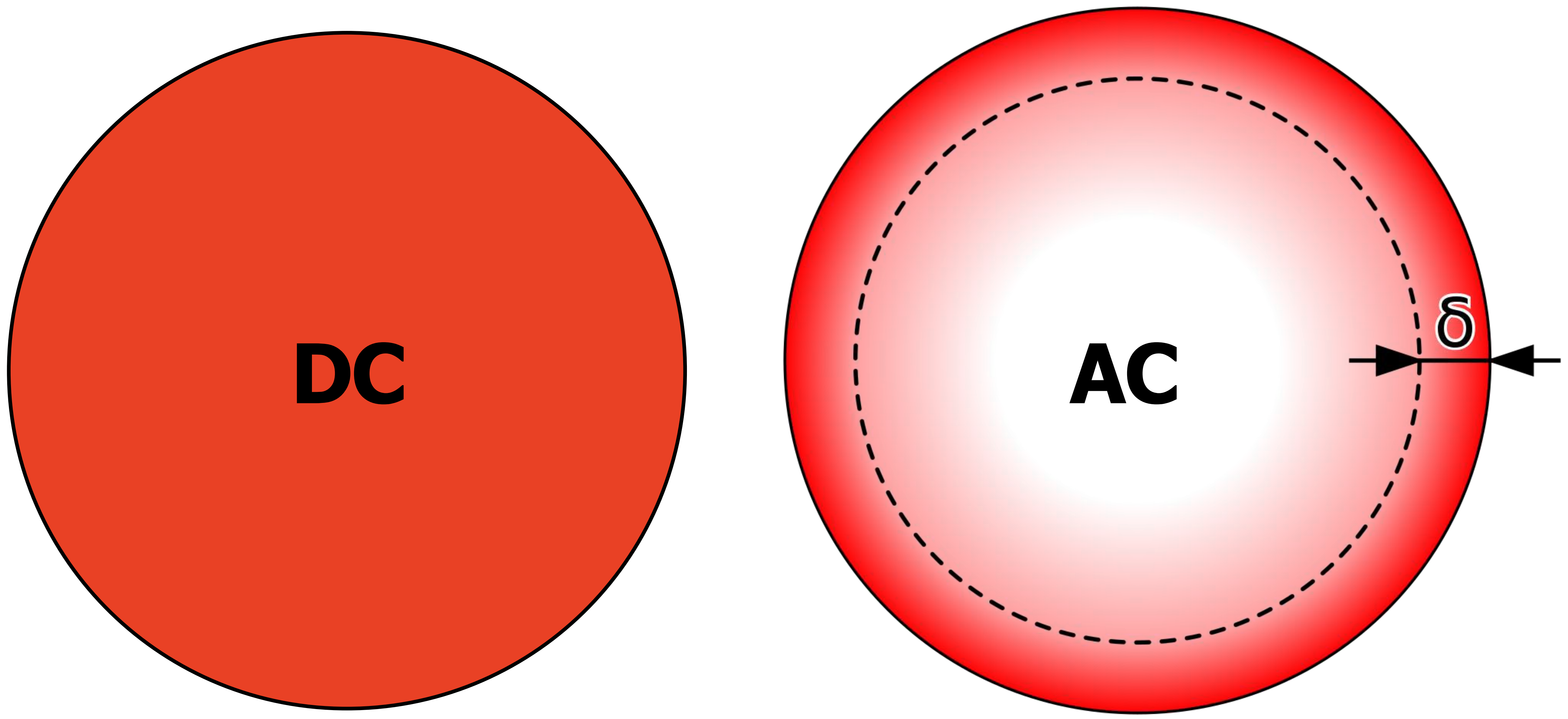
Typical losses due to proximity effect of an electrical installation as a percentage of the total power demand may vary from:

0.5% to 1.5%

Skin Effect

Thermal losses increase due to
the **skin effect problem**

For alternating current, the current density decreases exponentially from the surface towards the inside.

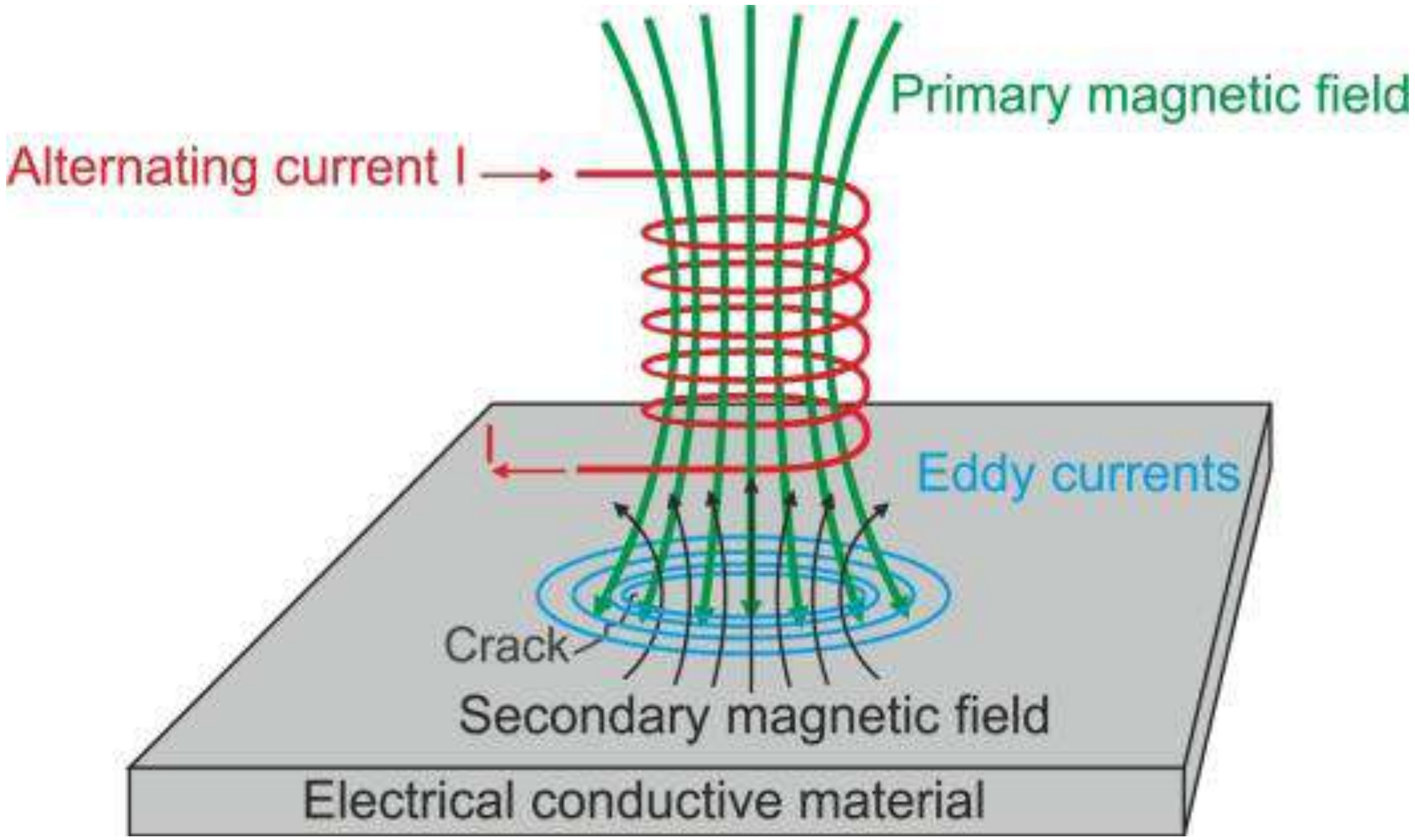


Typical losses due to skin effect of an electrical installation as a percentage of the total power demand may vary from:

0.5% to 1%

Eddy Currents

Thermal losses increase due to the increase in eddy currents, which are inducted to neighbouring metallic equipment
(i.e. Cable Tray)



Typical losses due to eddy current effect of an electrical installation as a percentage of the total power demand may vary from:

0.5% to 1.5%

Breaking Torque and Vibration due to the influence of harmonics

Breaking torque occurrence (torque that work as a brake) in motors all-around the electrical installation, that leads to an efficiency reduction

Motor Rotation due to Fundamental Current

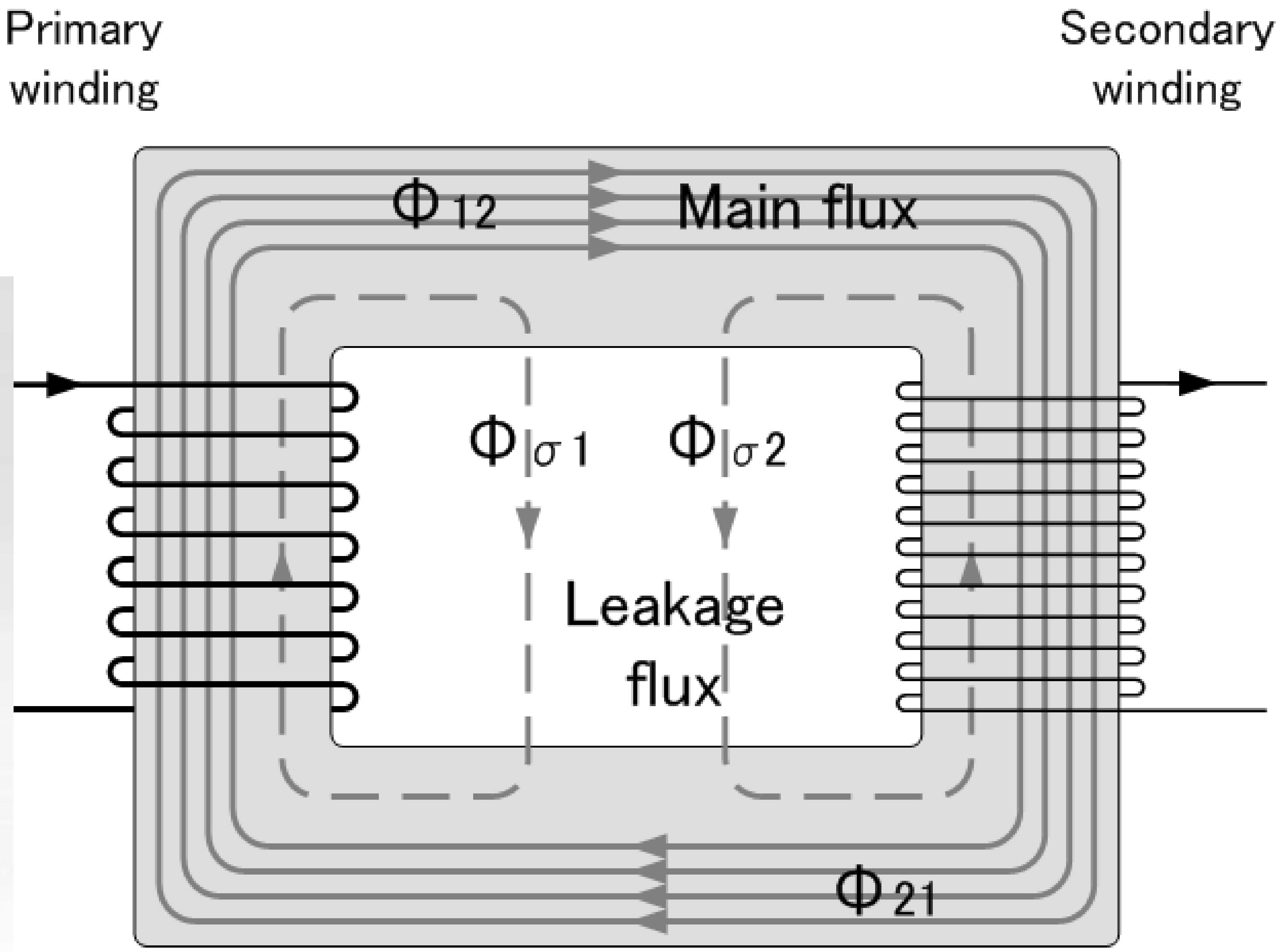
Motor Rotation due to Harmonic Currents (ubnormal condition)

Typical drops in motor efficiency due to harmonic braking torque range from:

5% to 8%

Transformer Losses due to the influence of harmonics

Overload of power transformers and increase of copper and iron losses that lead to low efficiency

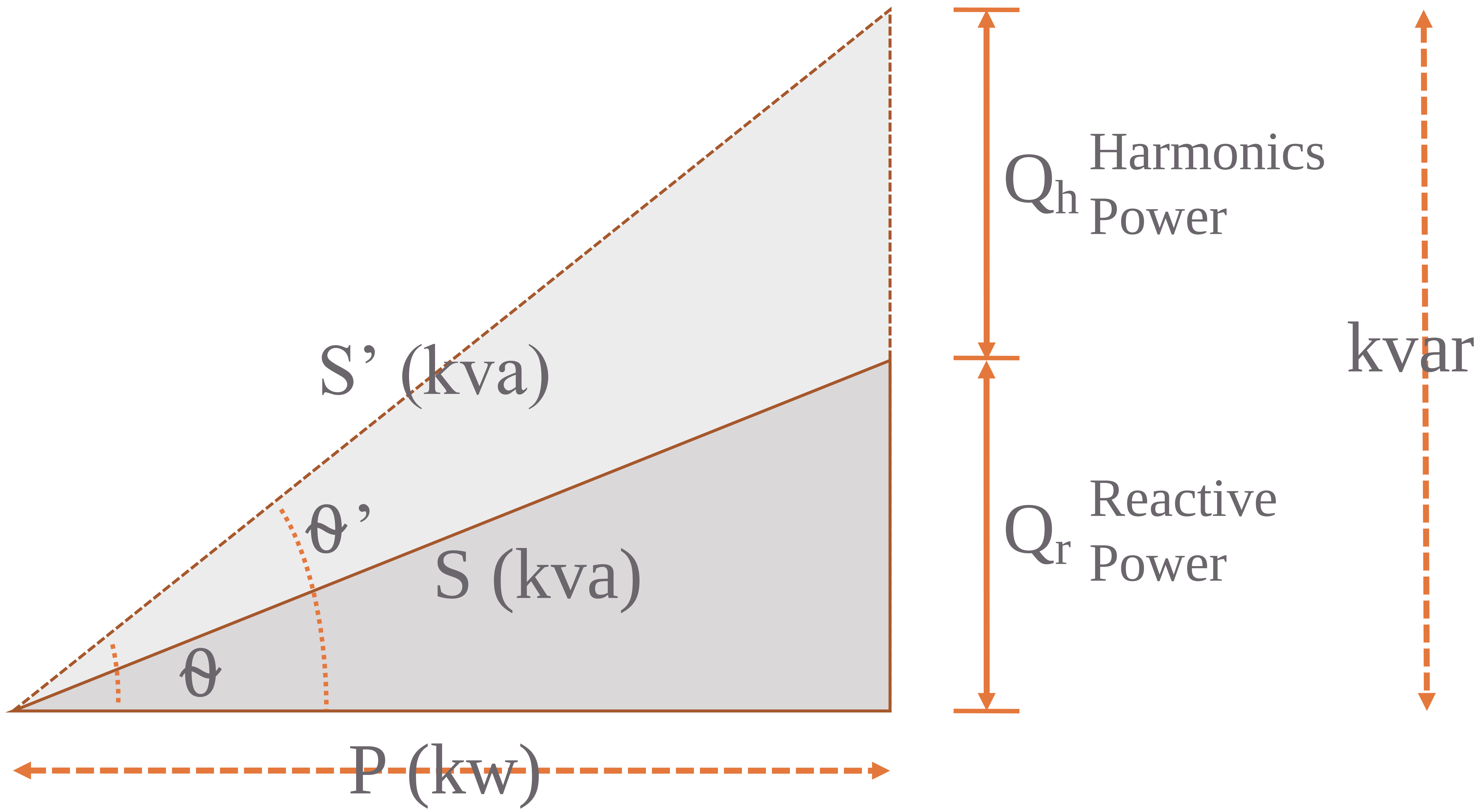


Typical losses due to transformer losses as a percentage of the total power demand may vary from:

1% to 2%

Eliminate harmonics

Improve power factor,
reduce apparent current



Reducing harmonics:

- Improves power factor (PF)
- Reduces apparent power (kva)
- Improves power availability (aka power reserve)

$PF = \cos(\vartheta)$ This power factor only considers reactive current
$PF' = \cos(\vartheta')$ This power factor is the total power factor including both harmonics and reactive current
$S = sqrt(P + Qr)$ This apparent power only considers reactive current
$S' = sqrt(P + (Qr + Qh))$ Total apparent power includes both harmonics power and reactive power

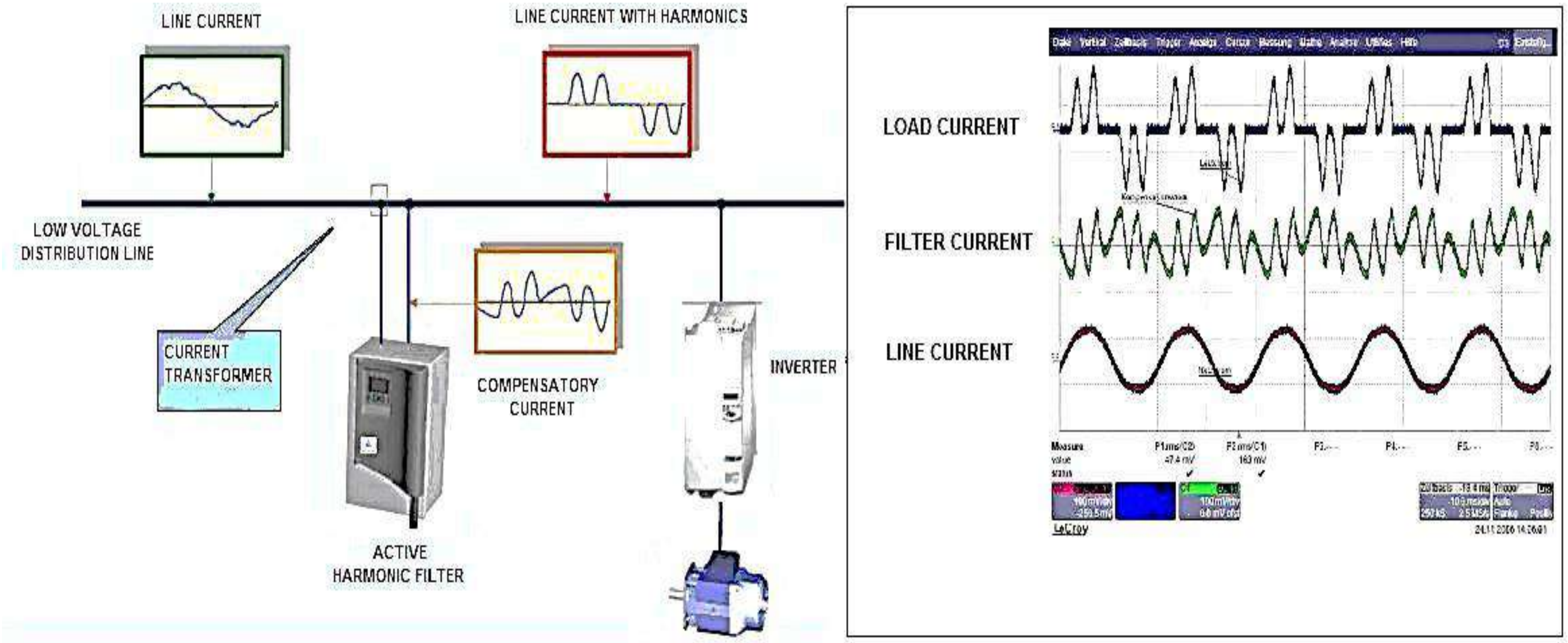
Customised Energy Saving Interventions

Examples

Customised interventions banks and reactors designed for groups of smaller electric loads
Dynamic filter behaviour based on operating conditions (i.e. combinations of loads)

Customised Energy Saving Interventions

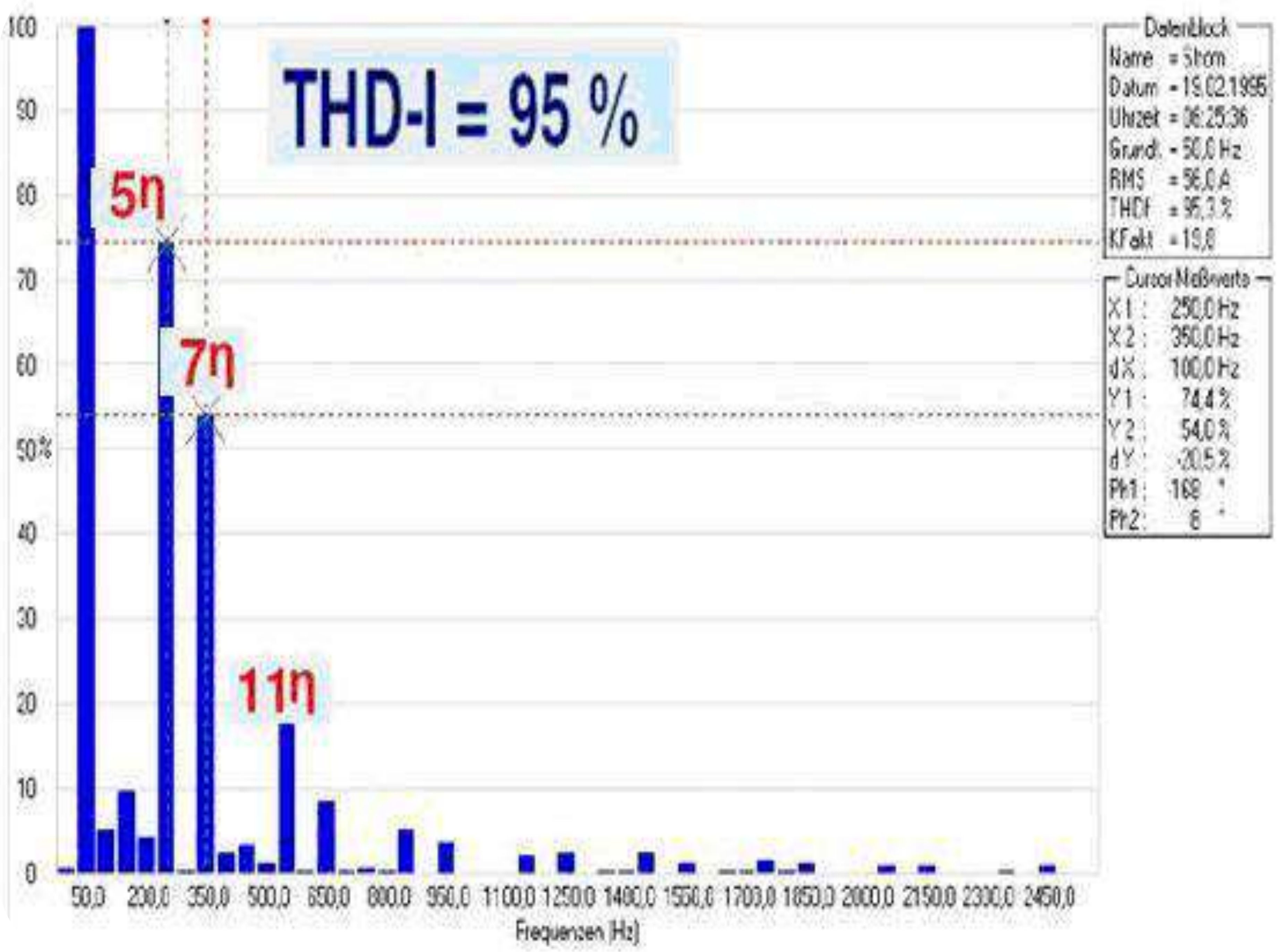
Examples

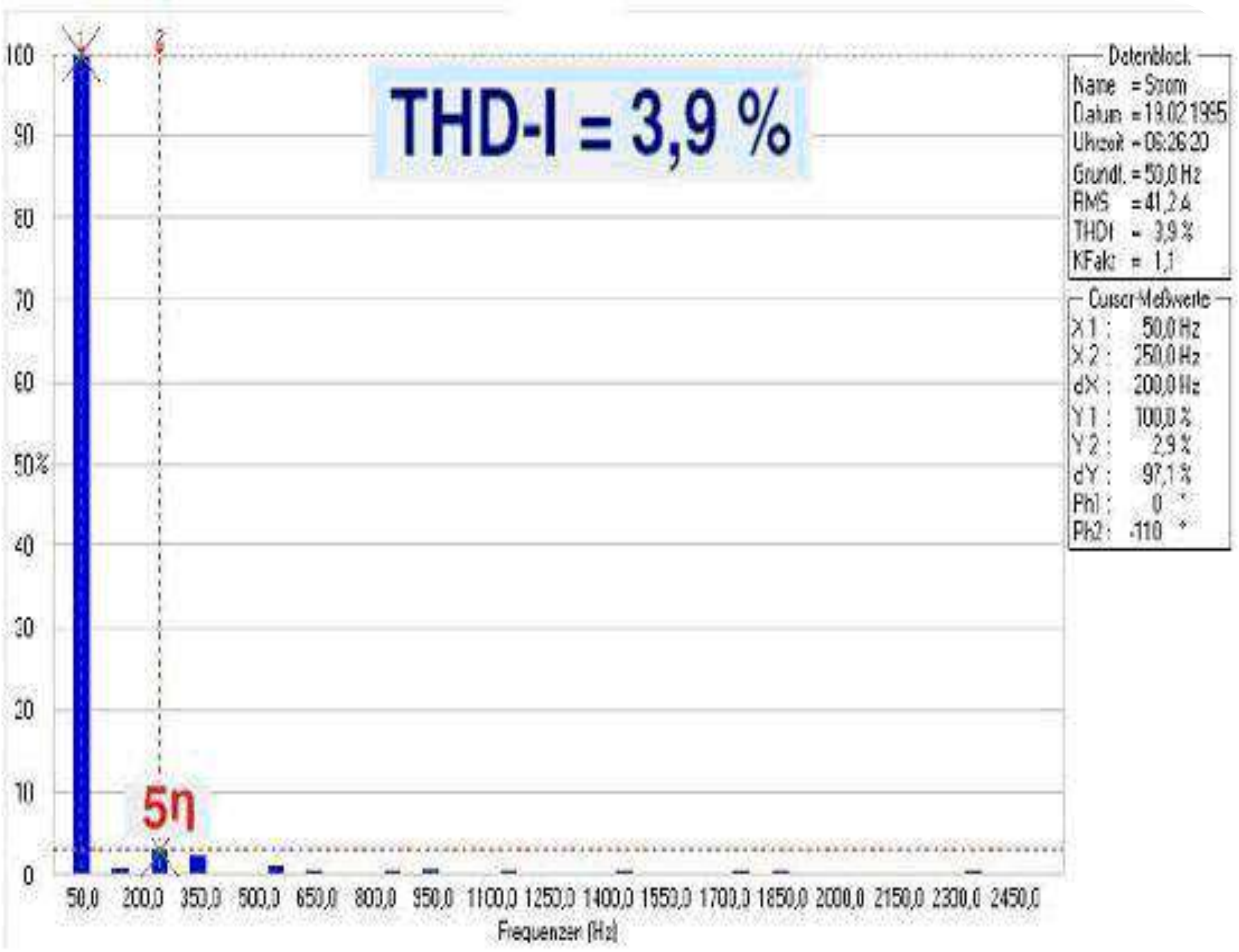


Schematic description of an active **harmonic filter** and its basic principle of operation

Customised Energy Saving Interventions

Examples





Example of **reducing** the Total Current Harmonics Distortion (THD-I %)

appendix

Customised Energy Saving Interventions

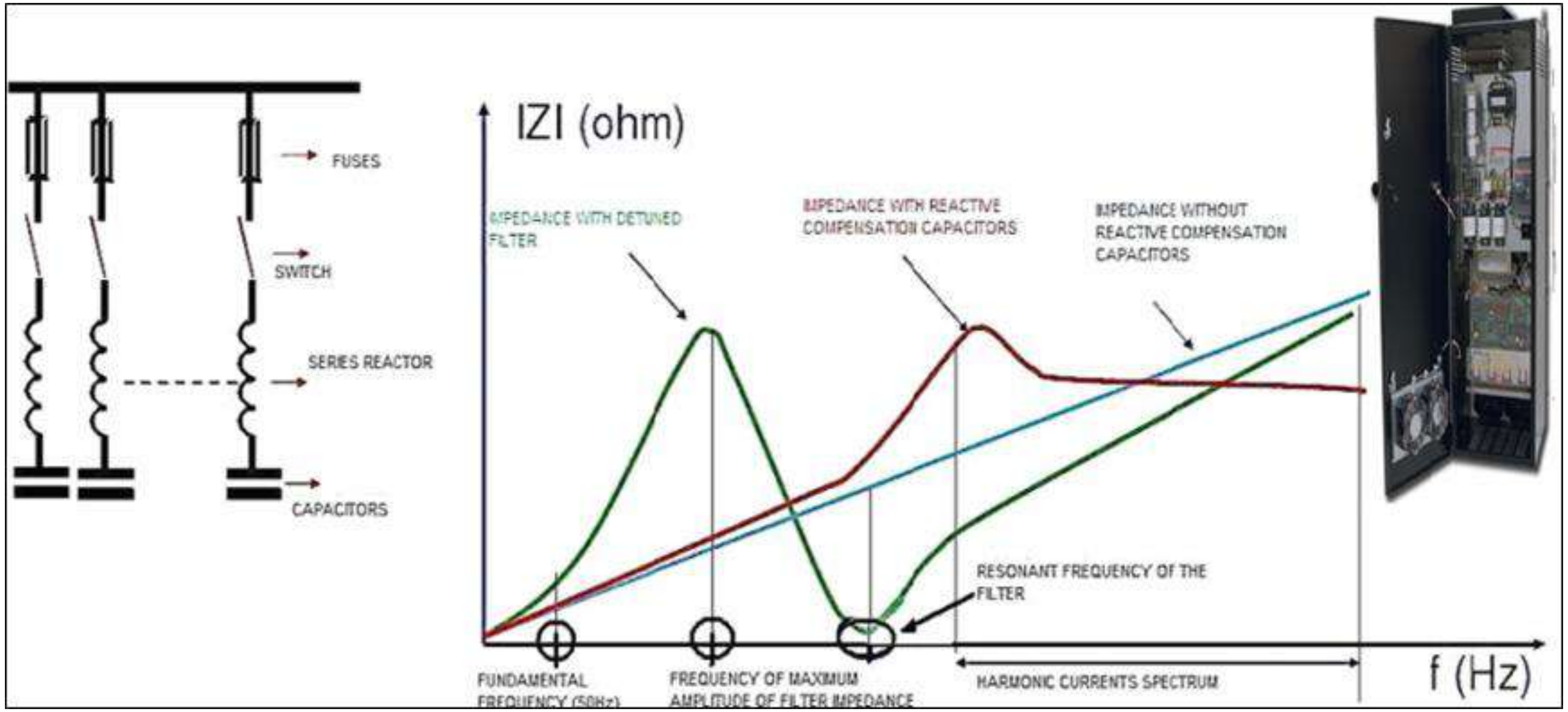
Examples

Active harmonic filter

Advanced electronics and embedded software dynamically adapt the filter behaviour based on operating conditions appendix

Customised Energy Saving Interventions

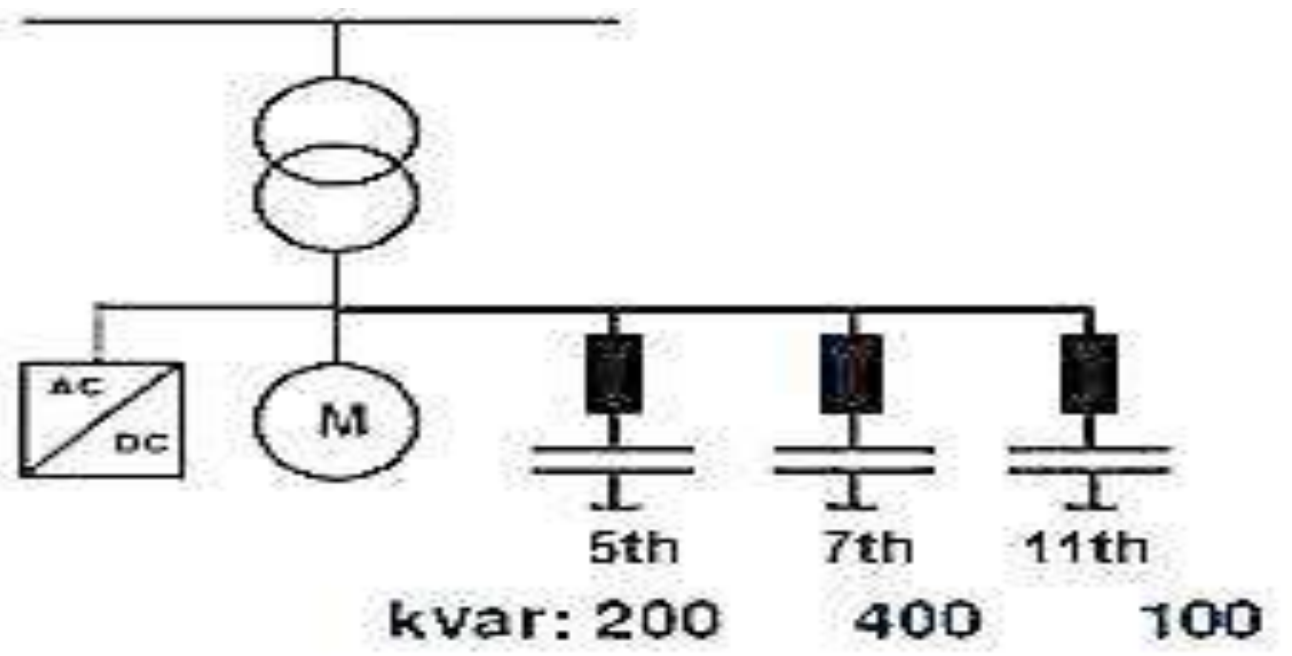
Examples

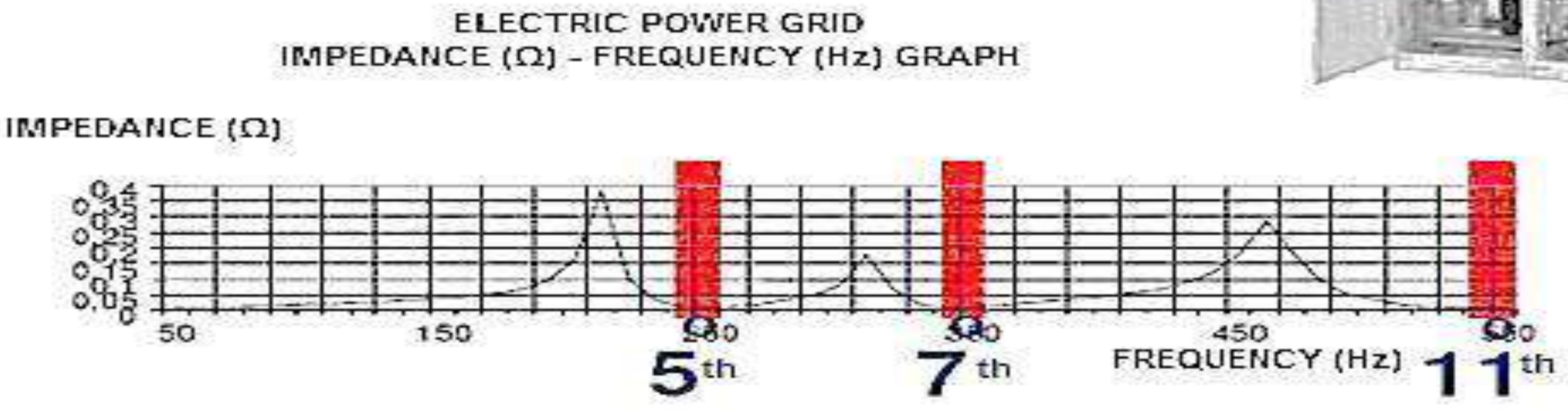


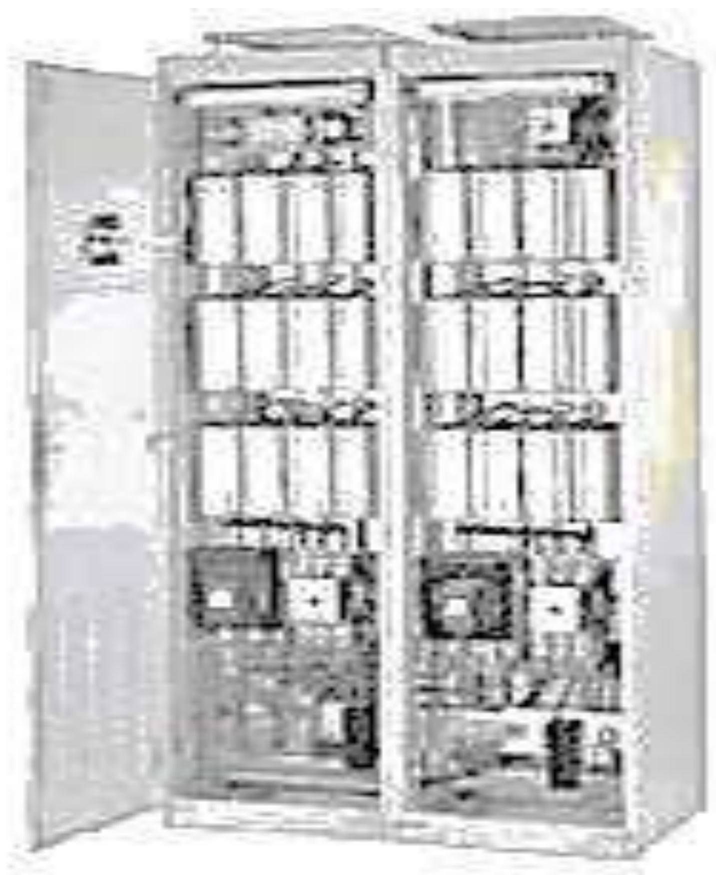
Schematic display of a detuned harmonic filter and its basic principle of operation

Customised Energy Saving Interventions

Examples



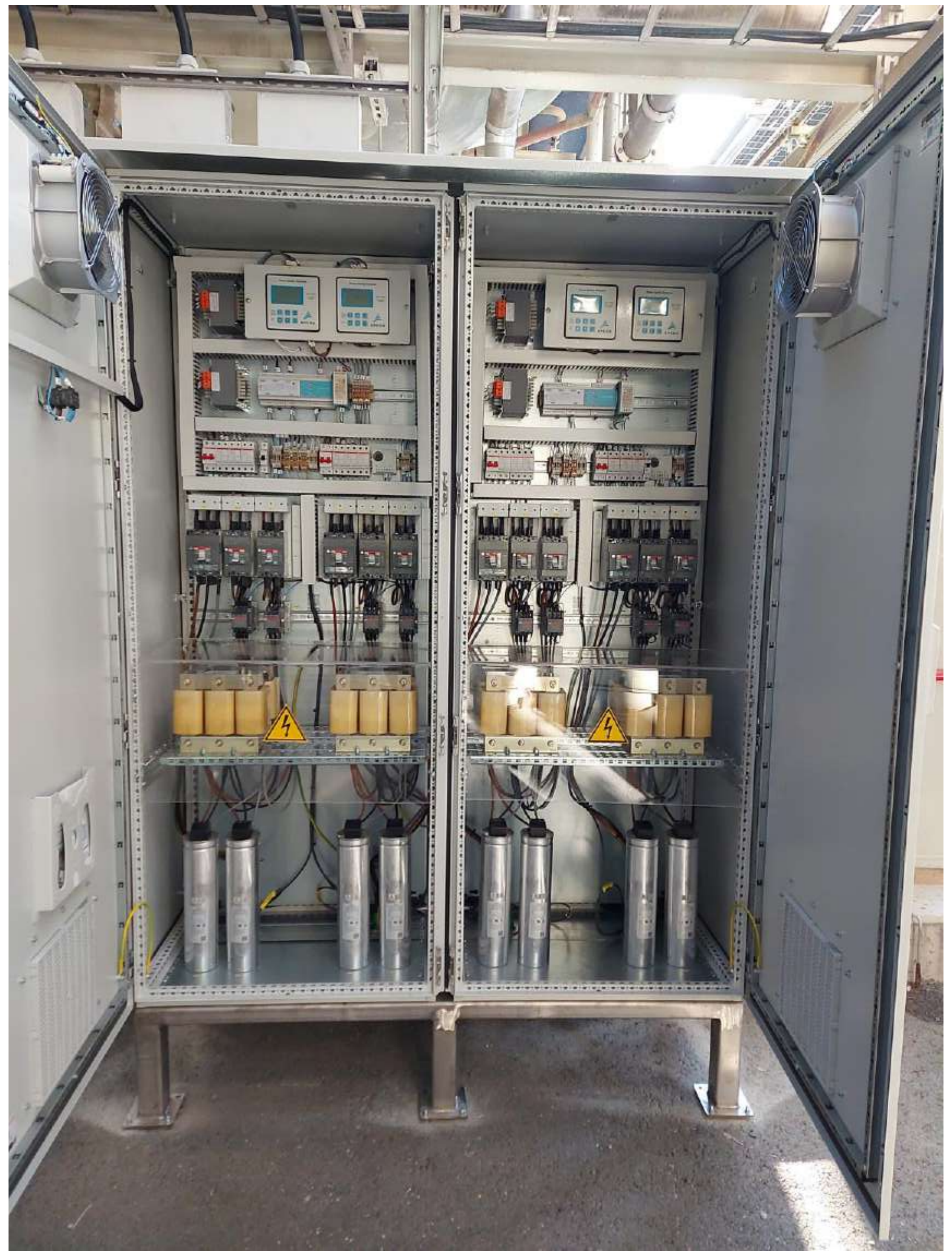




Schematic description of a tuned harmonic filter and its basic principle of operation

Customised Energy Saving Interventions

Examples



- Detuned harmonic filter with very high-speed variability for fast changing load conditions
- Monitors and adjusts behavior every millisecond with advanced power electronics
- 1.5MW motor at 690V
- Decreases vibrations in motor operation, significantly improving production quality

Customised Energy Saving Interventions

Examples

Low voltage detuned harmonic filter

480V circuit tuned to collect 5th and 7th order harmonics and convert to reactive power

Medium voltage detuned harmonic filter

6.6kV circuit for a 500kW electric load