EcoStruxure™
Innovation At Every Level

Power quality

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Product Manager

Life Is On Schneider Electric

Why address power quality?

Because

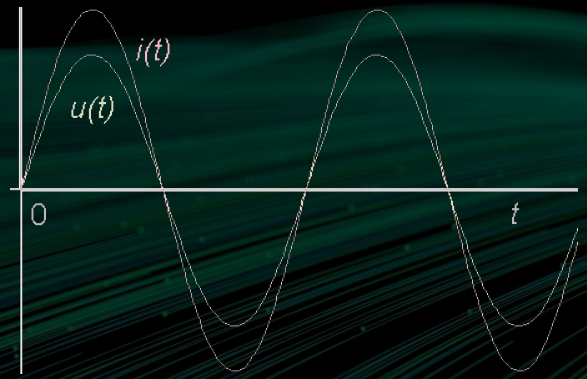
1. Ensuring the safe operation of equipment or entire production

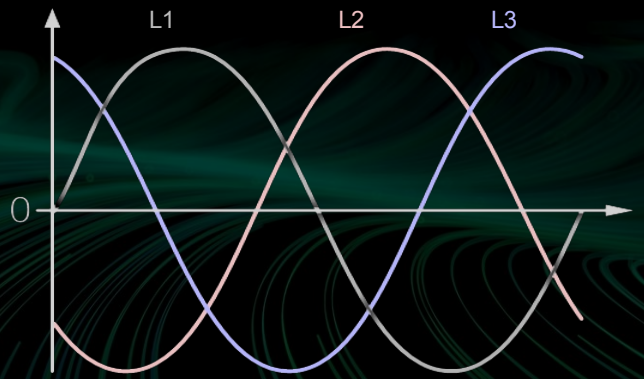
2. Ensuring the reliability of equipment/operation/producti

3. Ensuring economic efficiency

Why address power quality?

What would it look like in an ideal world?

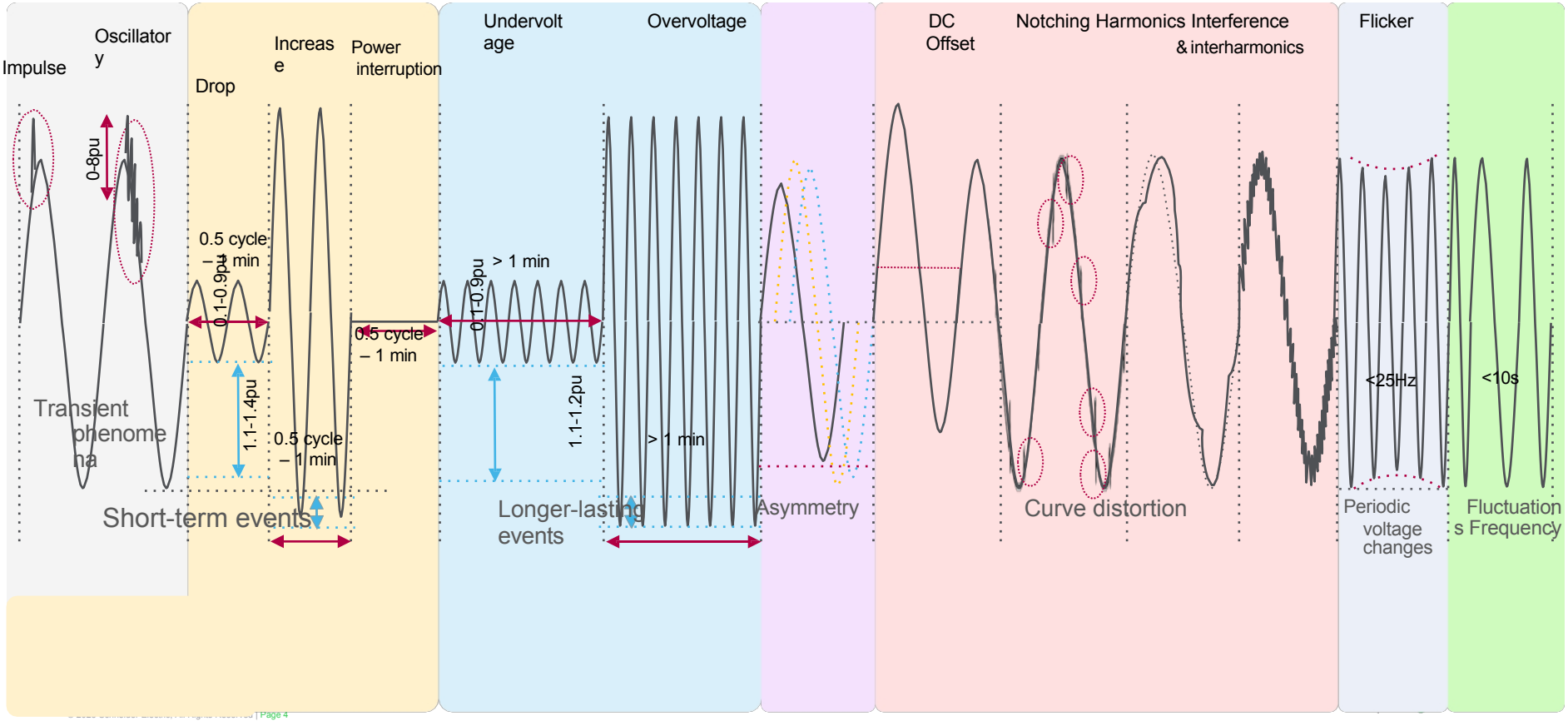




- ✓ Nominal voltage and frequency
- ✓ Sinusoidal (harmonic) voltage and current waveform
- ✓ Zero phase shift of voltage and current
- ✓ Symmetry and balance of three-phase system

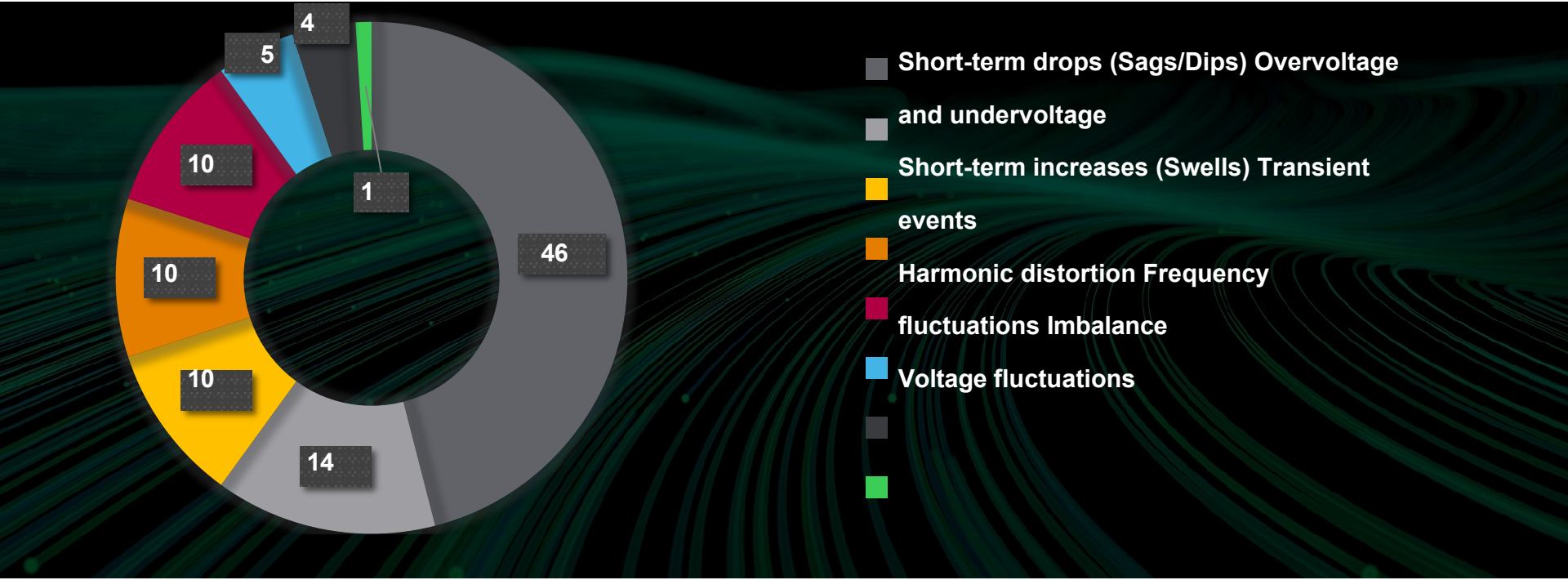
Why address power quality?

What does it look like in the real world?



Why address power quality?

What does it look like in the real world?



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Why address power quality?

What can indicate a problem with grid quality?

- Flashing lights
- **Random tripping of circuit breakers**
- Malfunctioning regulators
- **Transformer humming**
- Overheating of electrical cables
- **Reduced motor life**

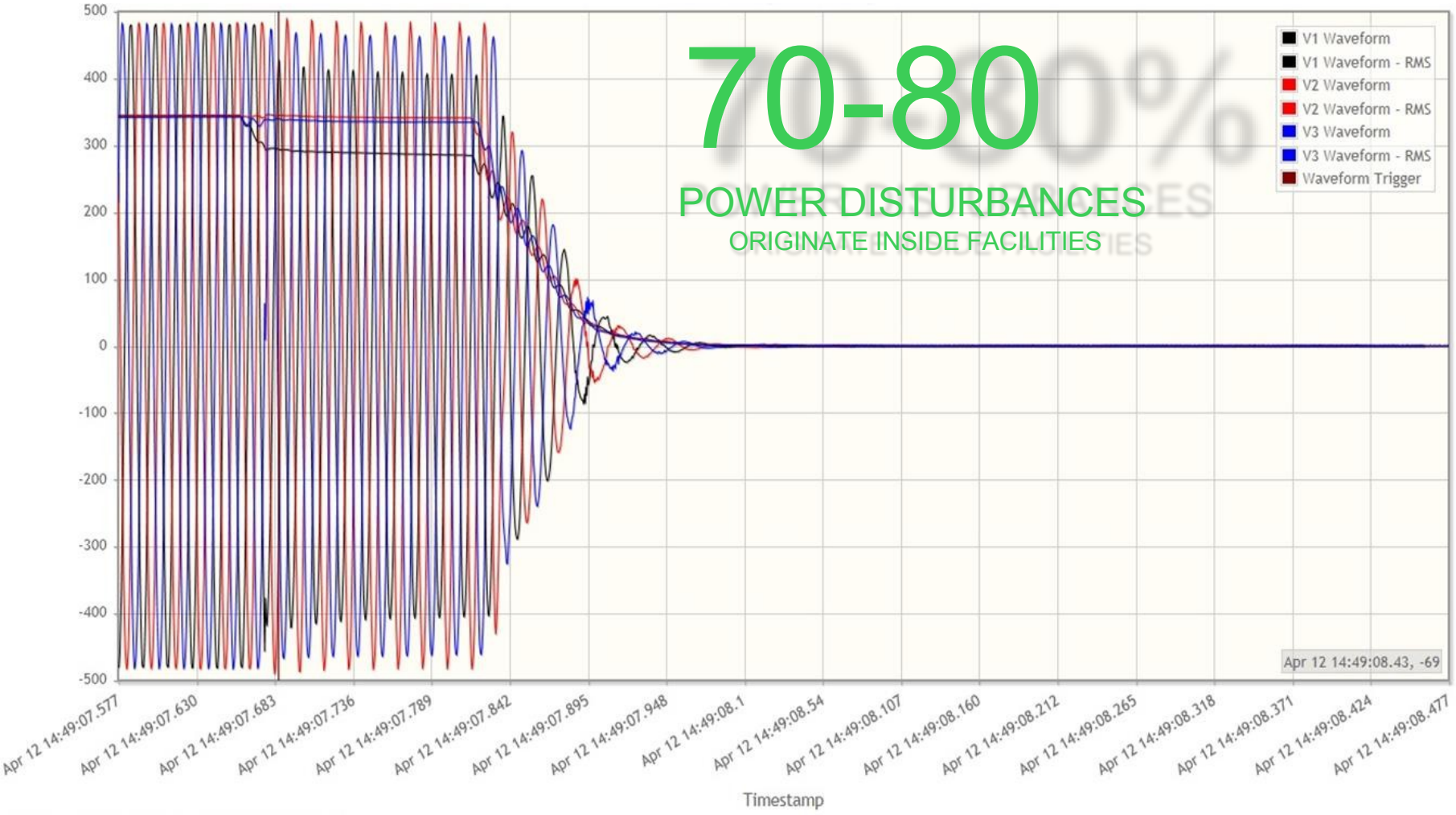
- Unexpected shutdown of equipment
- **Data loss**
- Circuit board faults
- **Reduced capacity of electrical system distribution**
- **Contactor failure**
- Network communication problems

Why address power quality?

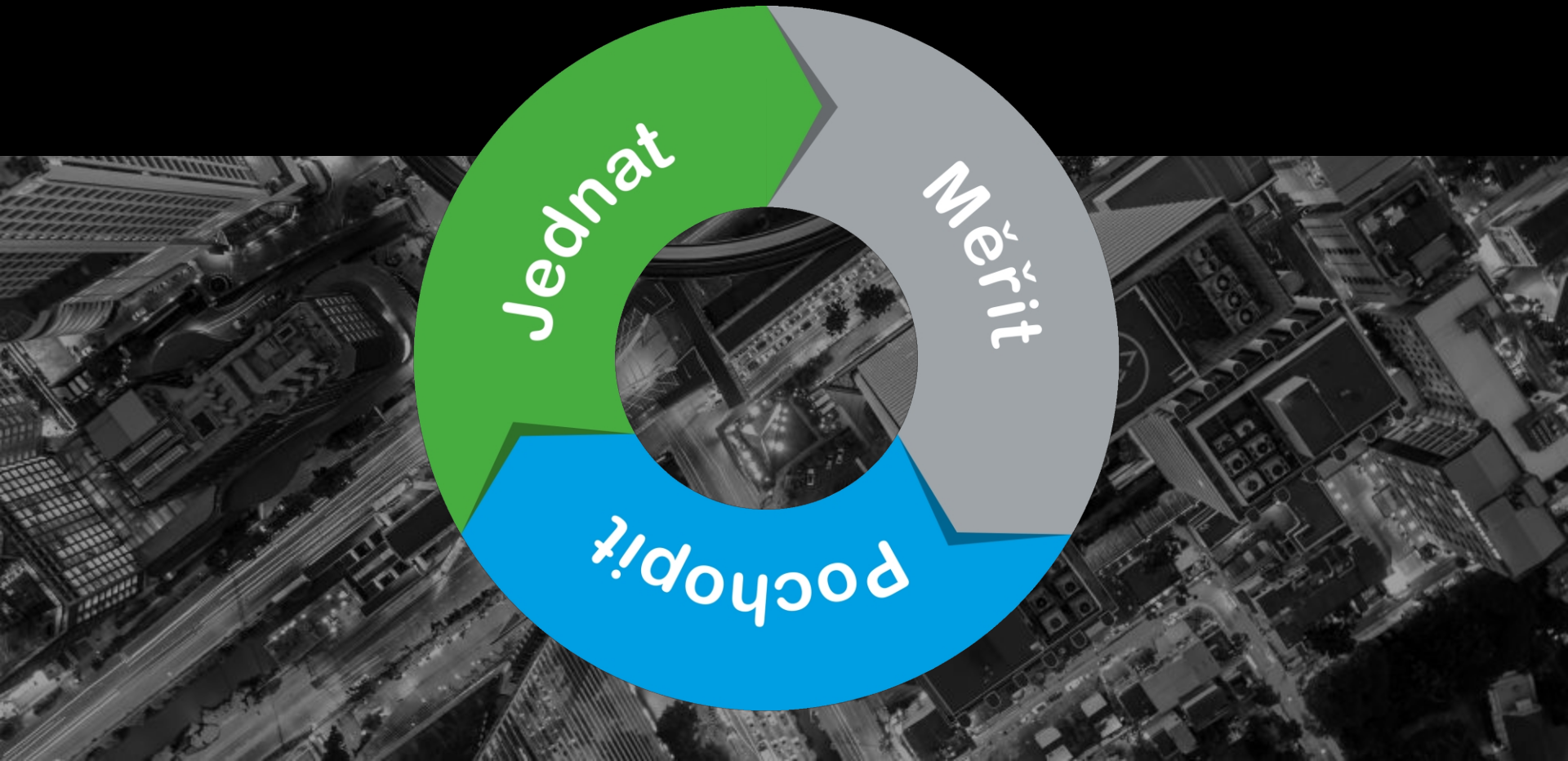
Can we afford to lose power?

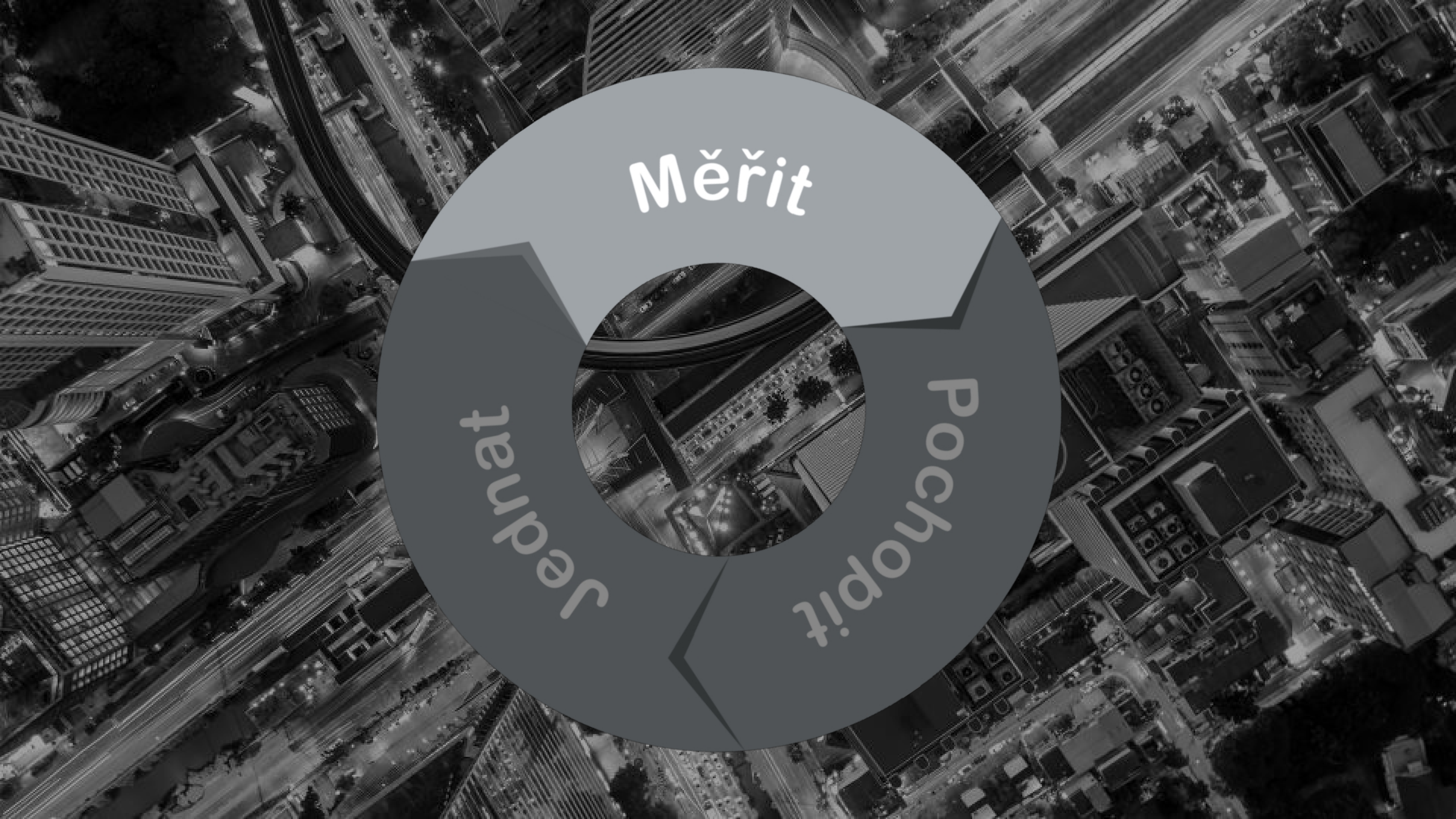
Average damage:

Semiconductor manufacturing	3.8	M€/unit
Hospitals	85	k€/employee
Stock exchange	6	M€/h
Data center	750	k€/year
Telecommunications	30	k€/min.
Heavy industry	35	k€/unit
Glass industry	250	k€/unit


70-80
POWER DISTURBANCES
ORIGINATE INSIDE FACILITIES
V1 Waveform
V1 Waveform - RMS
V2 Waveform
V2 Waveform - RMS
V3 Waveform
V3 Waveform - RMS
Waveform Trigger
Apr 12 14:49:08.43, -69
500
400
300
200
100
0
-100
-200
-300
-400
-500
Apr 12 14:49:07.577
Apr 12 14:49:07.630
Apr 12 14:49:07.683
Apr 12 14:49:07.736
Apr 12 14:49:07.789
Apr 12 14:49:07.842
Apr 12 14:49:07.895
Apr 12 14:49:07.948
Apr 12 14:49:08.1
Apr 12 14:49:08.54
Apr 12 14:49:08.107
Apr 12 14:49:08.160
Apr 12 14:49:08.212
Apr 12 14:49:08.265
Apr 12 14:49:08.318
Apr 12 14:49:08.371
Apr 12 14:49:08.424
Apr 12 14:49:08.477
Timestamp

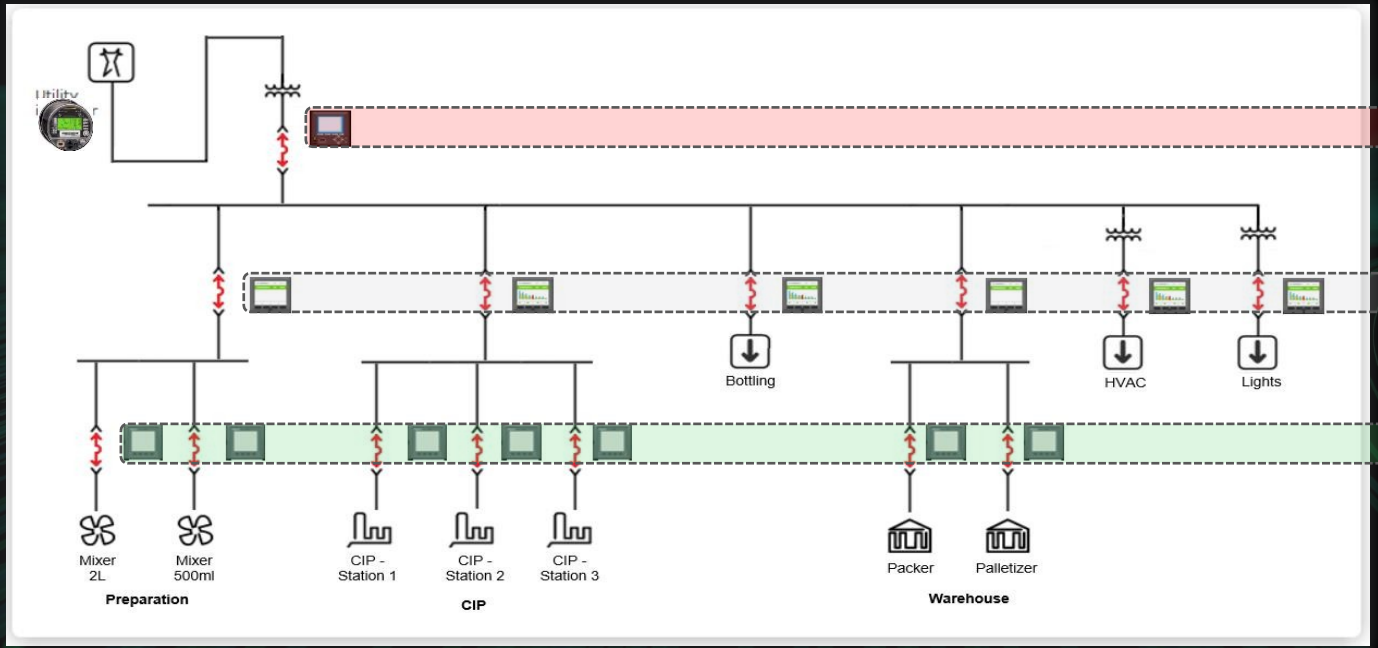
How to improve power quality?




Měřit
Pochopit
Jednat

Continuous energy quality monitoring

→ for immediate detection and correction You won't miss a fault.



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Audit and temporary measurement of electrical energy

Flexible, strategic for identifying specific problems on specific devices or locations.

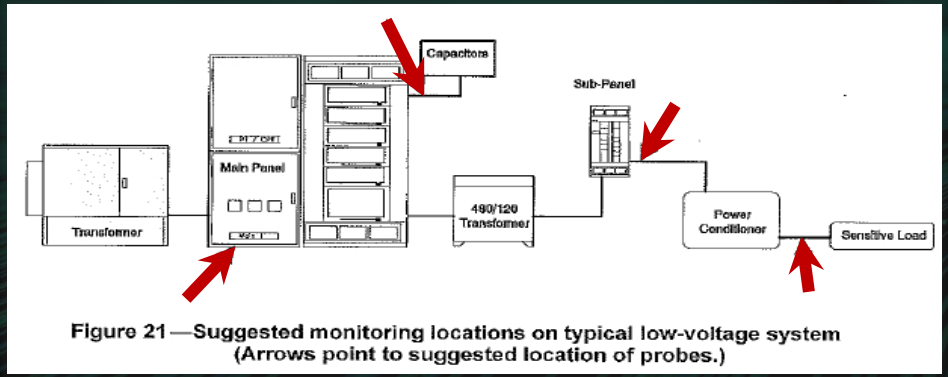

Figure 21—Suggested monitoring locations on typical low-voltage system (Arrows point to suggested location of probes.)

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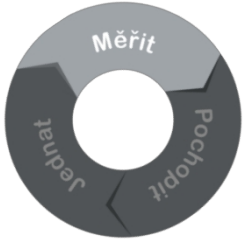
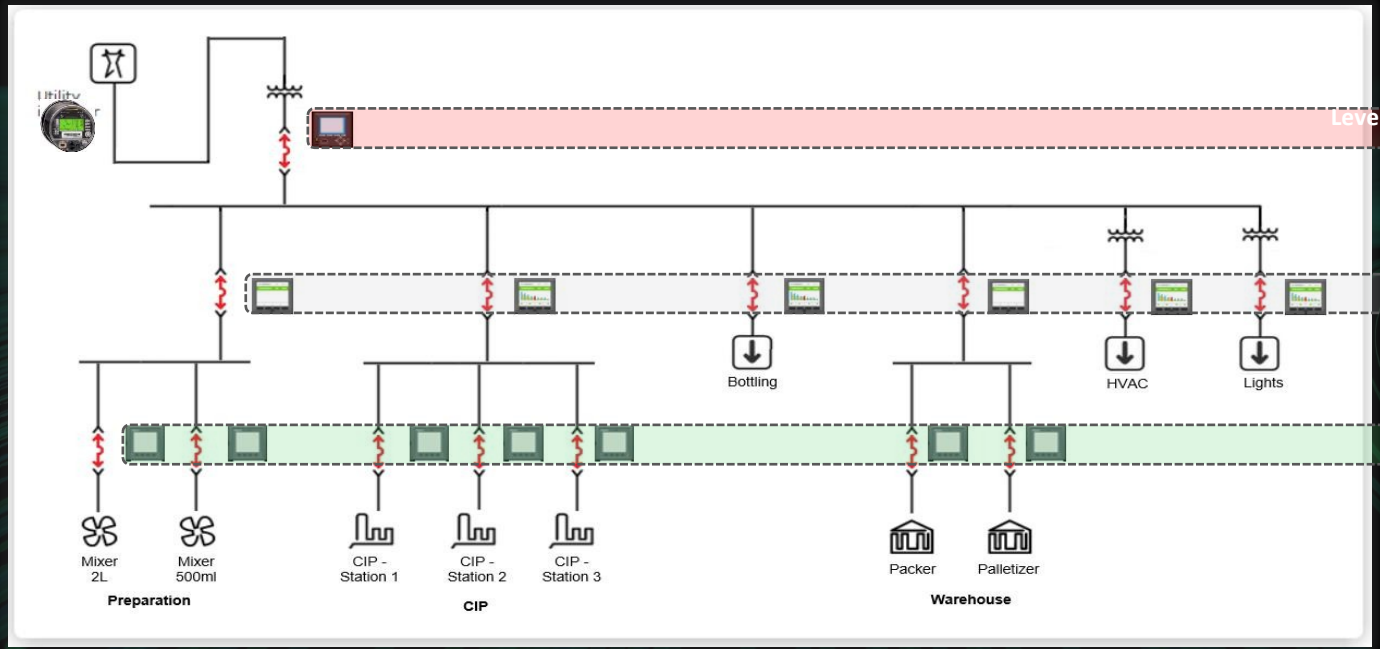
What, where, and how to measure?





Level 1 - Interface with the distribution network

Level 2 - Supply lines

Level 3 - Machines, loads

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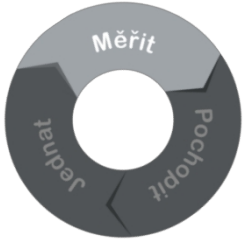
What, where, and how to measure?



Phenomena and faults	Level 1	Level 2	Level 3
Transient phenomena	✓	✗	✗
Flicker	✓	✗	✗
Disturbance Direction Detection	✓	✓	✗
Outages, wave capture	✓	✓	✗
Sudden voltage drops and surges, wave capture	✓	✓	✗
Overvoltage/undervoltage, wave capture	✓	✓	✗
Frequency fluctuations	✓	✓	✗
Imbalance (voltage & current)	✓	✓	✓
Harmonics (voltage & current)	✓	✓	✓

Level 1

ION9000

Level 2

PM8000

Level 3

PM5000

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Síťové analyzátory

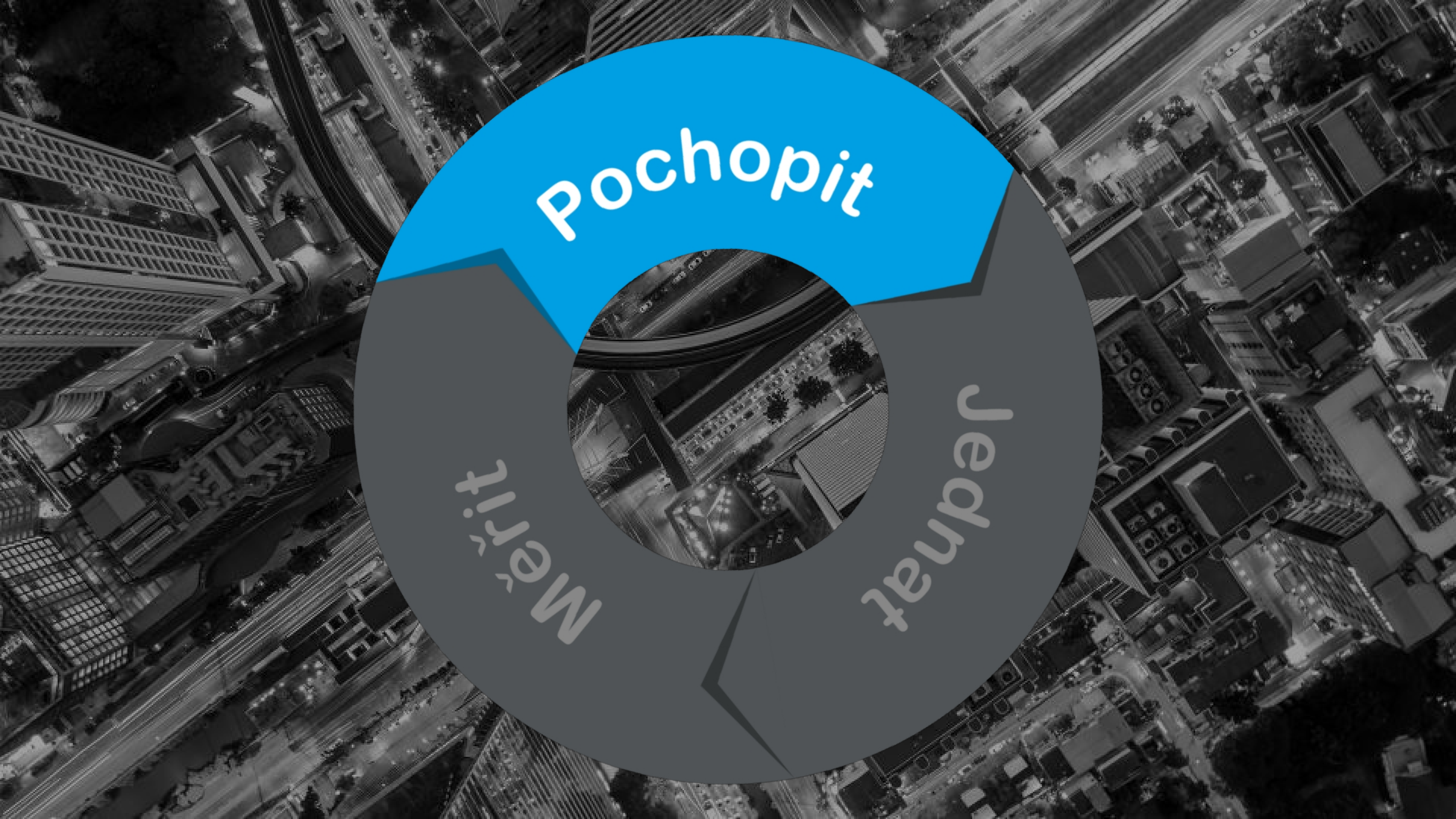
Zapuštěná montáž do panelu a/nebo montáž na DIN lištu

PM5500

PM8000 (3)

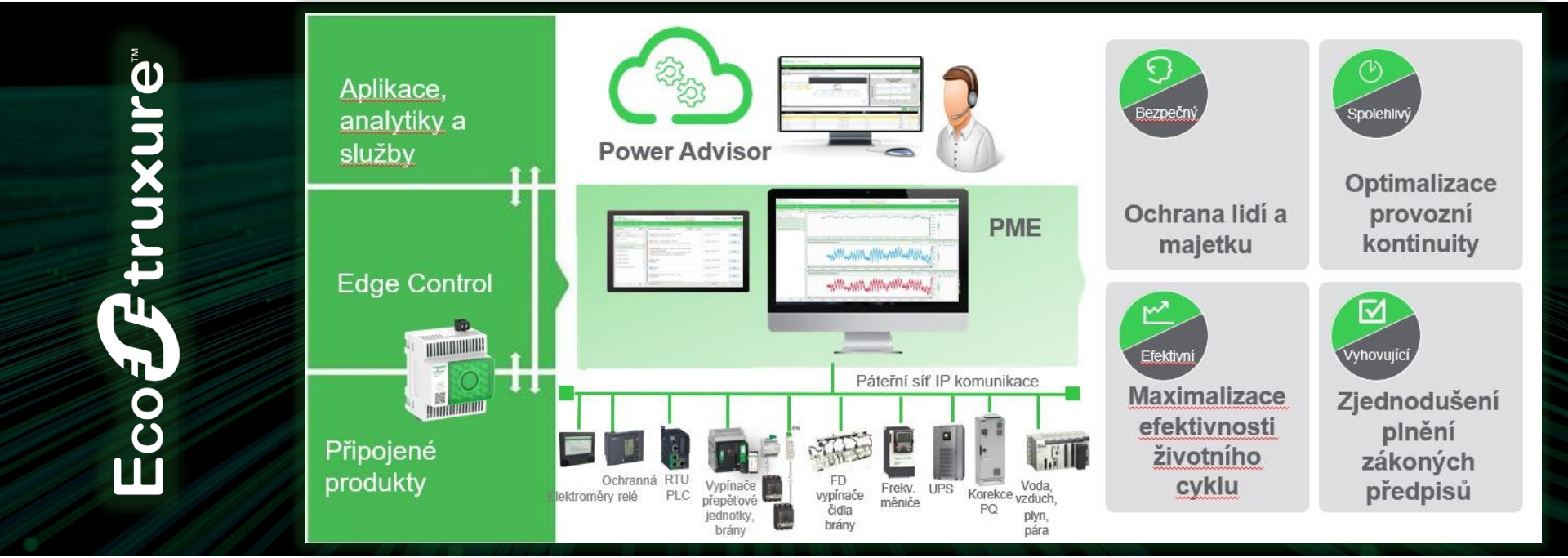
ION9000

				METSEPM - - - -								METSEPM - - - -			METSEION - - - -			
	5320	5330 5331	5340 5341	5560 5561	5563 na DIN lištu nebo do panelu, lze vybavit displejem (není v balení) (5)	5563RD na DIN lištu, lze vybavit displejem (v balení) (5)	5570	5580	5650	5660 5661	5760 5761	8240 8241 8210 20-60 V DC montáž do panelu	8243 8213 20-60 V DC na DIN lištu, lze vybavit displejem (není v balení) (5)	8244 8214 20-60 V DC na DIN lištu, lze vybavit displejem (je v balení) (5)	92030 na DIN lištu nebo do panelu, lze vybavit displejem (není v balení) (5)	92040 na DIN lištu nebo do panelu, lze vybavit displejem (je v balení) (5)	95030 na DIN lištu nebo do panelu, lze vybavit displejem (není v balení) (5)	95040 na DIN lištu nebo do panelu, lze vybavit displejem (je v balení) (5)
				CT se vstupem 1 A nebo 5 A				CT se vstupem 1 A a 5 A				CT se vstupem 1 A nebo 5 A			CT se vstupem 1 A a 5 A			
	-	jen 5331	jen 5341	jen 5561	-	-				jen 5661	jen 5761	jen 82401	-	-	-	-	-	-
				Třída 0.2S			Třída 0.2S					Třída 0.2S			Třída 0.1S			
	4	4	4	8	8	8	8	8	8	8	8	standardně 4 s možností nastavení více			standardně 4 s možností nastavení více			
	31.	31.	31.	63.	63.	63.	63.	63.	63.	63.	63.	63. / 127. s PME a PSO sw			63. / 511. s PME a PSO sw			
	35	35	35	52	52	52	52	52	52	52	52	255			255			
		2 reléové	2 reléové									až 8 (kombinace)			až 8 (kombinace)			
	1 port		1 port	2 porty	2 porty	2 porty	2 porty	2 porty	2 porty	2 porty	2 porty	2 porty	2 porty	2 porty	2 porty	2 porty	2 porty	2 porty


Pochopit
Jednat
Měřit

EcoStruxure™ unified platform

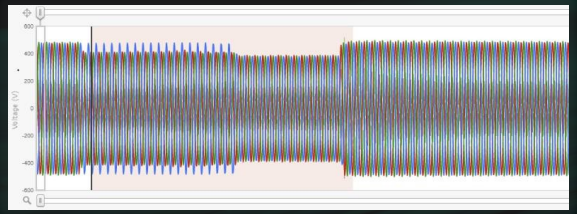
Get the most out of your data



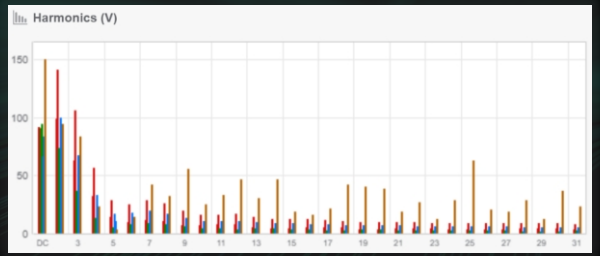
EcoStruxure™ Power Monitoring Expert

Get the most out of your data

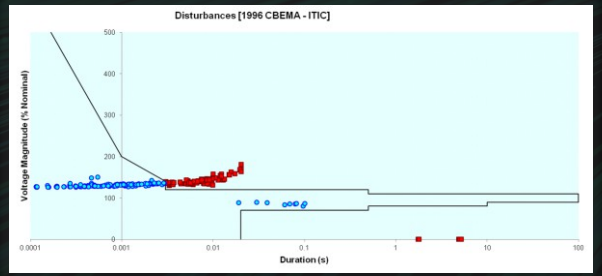
Detailed waveform display



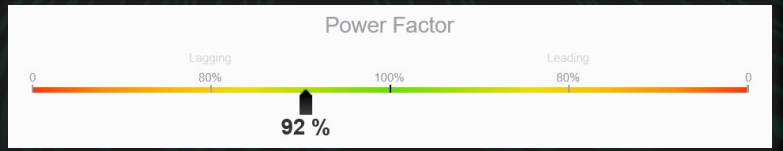
Spectral display of harmonics



Phasor diagrams



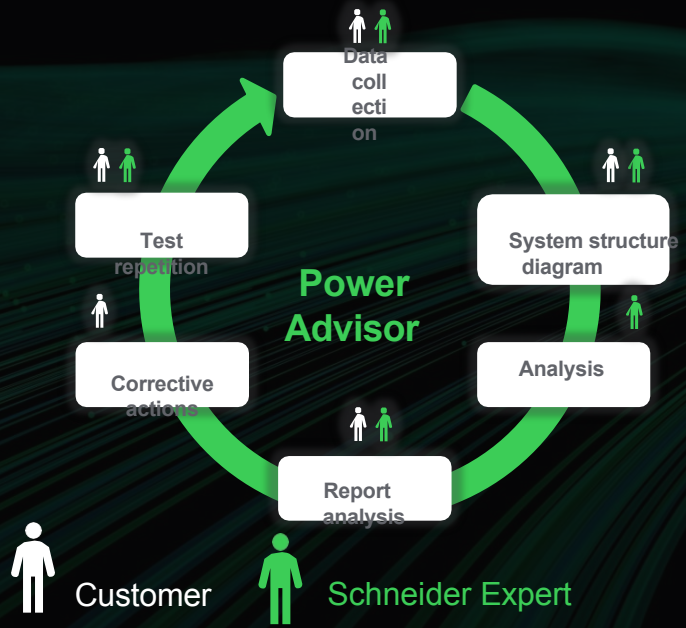
CBEMA – ITIC plots



Lagging and leading power factor

EcoStruxure™ Power Advisor

Get the most out of your data




Analytické poznatky

Celkové skóre (pokračování)

Níže uvedená tabulka ukazuje vaše celkové skóre ve srovnání s mediánem všech ostatních systémů:

82 % Váš celkový výsledek: 82 % - dobré
Medián všech ostatních systémů: 92 % - dobré

Níže uvedená tabulka uvádí rozpis problémů, které měly největší negativní dopad na celkové skóre:

18 %

6/31 Schneider Electric CZ, s.r.o. • Období analýzy: od 01.04.2022 do 31.05.2022
Report elektrické sítě

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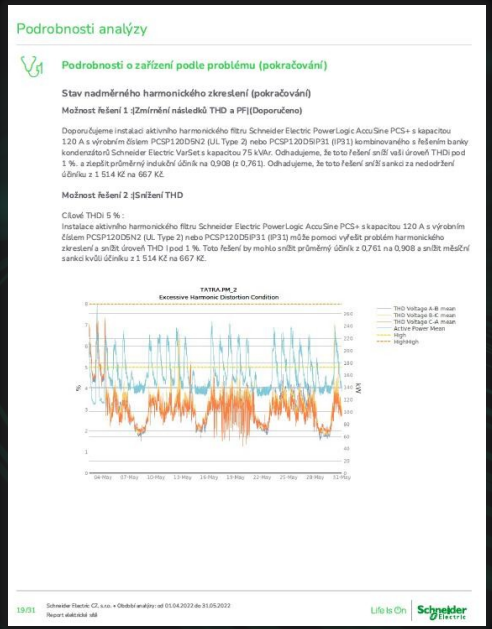
Podrobnosti analýzy

Podrobnosti o zařízení podle problému (pokračování)

Stav nadměrného harmonického zkreslení (pokračování)

Možnost řešení 1 ¡Zmírnění následků THD a PF¡(Doporučeno)

Doporučujeme instalaci aktivního harmonického filtru Schneider Electric PowerLogic AccuSine PCS+ s kapacitou 120 A s výrobním číslem PCSP120D5N2 (UL Type 2) nebo PCSP120D5IP31 (IP31) kombinovaného s řešením banky kondenzátorů Schneider Electric VarSet s kapacitou 75 kVAr. Odhadujeme, že toto řešení sníží vaši úroveň THDi pod 1 %. a zlepší průměrný indukční účiník na 0,908 (z 0,761). Odhadujeme, že toto řešení sníží sankci za nedodržení účiníku z 1 514 Kč na 667 Kč.

Možnost řešení 2 ¡Snížení THD

Cílové THDi 5 % :
Instalace aktivního harmonického filtru Schneider Electric PowerLogic AccuSine PCS+ s kapacitou 120 A s výrobním číslem PCSP120D5N2 (UL Type 2) nebo PCSP120D5IP31 (IP31) může pomoci vyřešit problém harmonického zkreslení a snížit úroveň THD I pod 1 %. Toto řešení by mohlo snížit průměrný účiník z 0,761 na 0,908 a snížit měsíční sankci kvůli účiníku z 1 514 Kč na 667 Kč.

TATRA PM_2
Excessive Harmonic Distortion Condition

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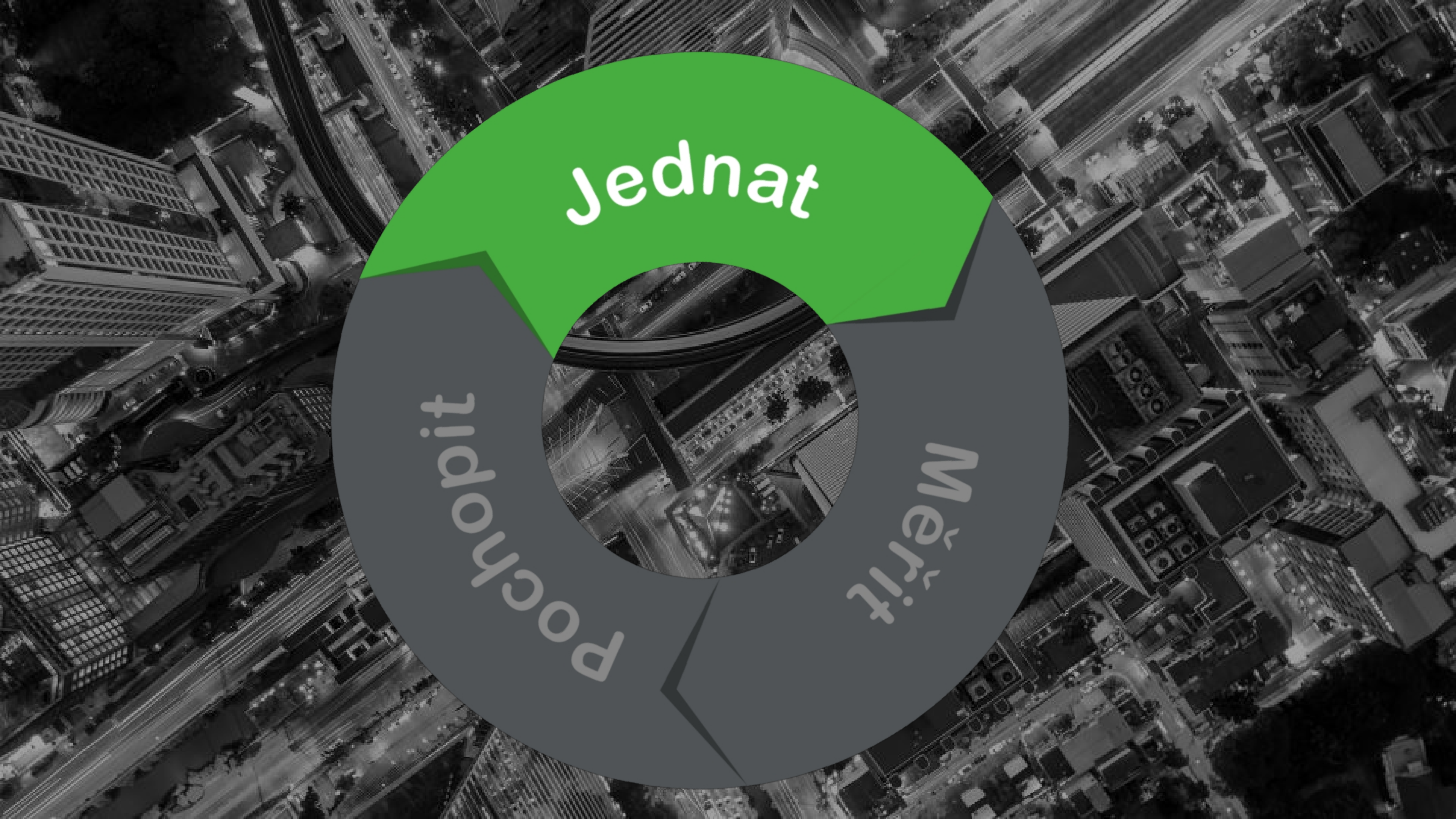


Jednat
Měřit
pochopit

Power factor compensation

Basic concepts – active, reactive, and apparent power

Active power P [W]

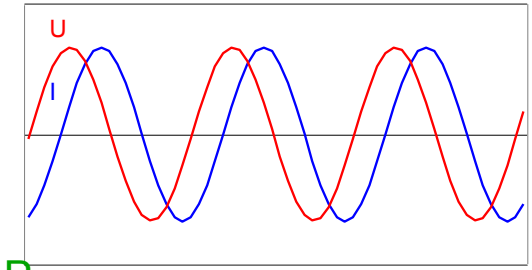
- Part of the power transformed into actual **mechanical** power, **heat,** or **light**

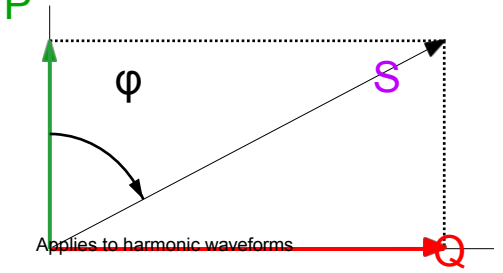
Reactive power Q [var]

- Part of the power **required for the operation of electrical machines and equipment**, e.g., powering magnetic circuits (does not perform work but enables it)

Apparent power S [VA]

- **Total** power supplied from the grid required for the operation of the equipment (used to dimension transformers, conductors, etc.)





Power factor compensation

Why is it advantageous to deal with power factor correction, i.e., reactive power?

1 Economic savings

- ✓ Elimination of penalties for reactive power (cosφ>0.95)
- ✓ Reduction of losses in transformers and conductors = reduction of operating costs by up to 10%

Example:
Reduction of losses on a 630 kVA transformer with losses PW= 6,500 W at an actual power factor of 0.7. With correction, we achieve an actual power factor of 0.98. Losses are reduced by 3,316 W, which is almost 50%.

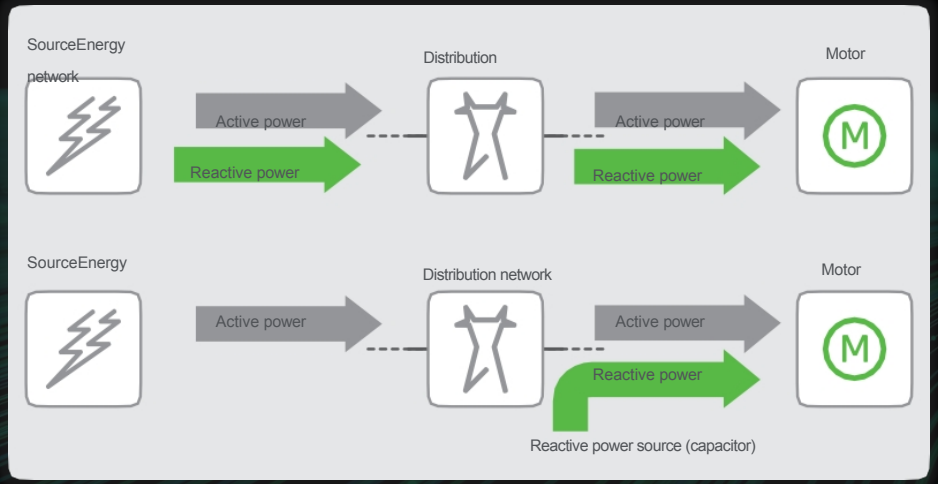
2 Increase in available power in the installation

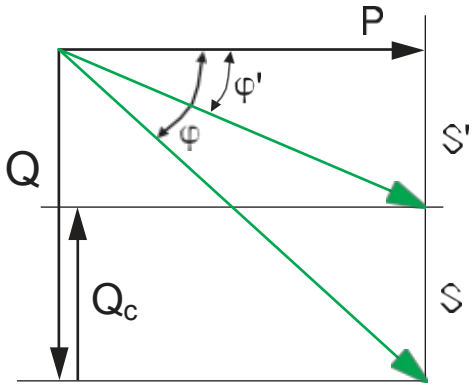
Power factor	Increase in available power
0.70	0
0.80	+14%
0.85	+21
0.90	+28%
0.95	+36%
1.00	+43

Power factor	Cable cross-section factor
1.0	1.0
0.80	1.25
0.6	1.67
0.40	2.50

Power factor compensation

What is the technical solution for improving efficiency?





Reactive power **can be "generated"** on the side of the electricity consumer

Power factor compensation

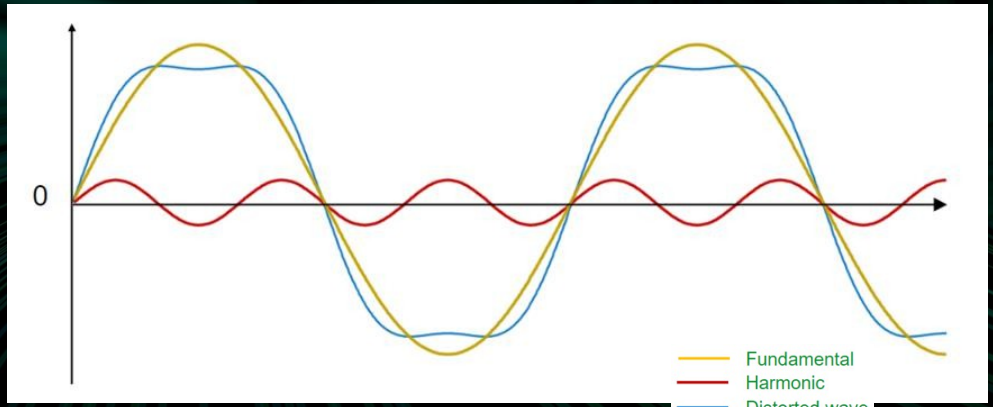
When is it appropriate to consider an active filter for compensation?

1. If there are "high" harmonics in the network THDu > 7%
2. → □□ dynamic and precise compensation for **rapid** load **changes**
   Cranes, lifts
3. When **resonance** problems are imminent
4. If **the capacitive nature of** the load is a problem
   E.g., server farms or UPS outputs

Harmonic components of current and voltage

What are harmonics?

- Voltage or current sinusoidal (harmonic) waves
- **Multiples of the** fundamental **frequency**
- They are caused by **non-linear loads** consuming **non-harmonic current**
- This results in current/voltage distortion and so-called **deformation power**.



Harmonic components of current and voltage

Total harmonic distortion THD

Ratio of the effective value of **the sum of** all harmonic components up to a specified order (50 recommended) and effective values of **the basic component**.

$$THD = \sqrt{\sum_{h=2}^{h=H} \left(\frac{Q_H}{Q_1} \right)^2}$$

Table 1—Voltage distortion limits

Bus voltage V at PCC	Individual harmonic (%) $h \leq 50$	Total harmonic distortion THD (%)
$V \leq 1.0$ kV	5.0	8.0
1 kV $< V \leq$ 69 kV	3.0	5.0
69 kV $< V \leq$ 161 kV	1.5	2.5
161 kV $< V$	1.0	1.5[a]

[a]High-voltage systems are allowed to have up to 2.0% THD where the cause is an HVDC terminal whose effects are found to be attenuated at points in the network where future users may be connected.

IEEE 519 source

Harmonic components of current and voltage

Examples of non-linear appliances

Residential sector

- Television
- Microwave oven
- LED lights, fluorescent lights, dimmers

Office buildings

- Laptops, PCs
- Printers, servers, etc.
- Battery chargers, UPS

Industry

- Welding machines
- Arc and induction furnaces
- **Frequency converters**

Harmonic components of current and voltage

Electrical installation "problems"

Additional heat

- Reduces load capacity
- Unwanted tripping of circuit breakers

Damage to equipment

- Electrical machines, electronics, computer technology, etc.

Interaction with compensation

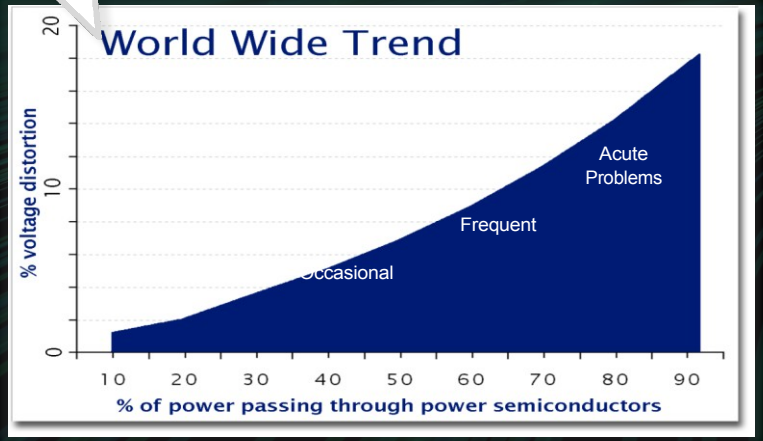
- Compensation capacitors respond to all frequencies
- Capacitor overheating
  →Activation of protective elements in capacitor stages
- Causes resonance
  →Harmonic amplification

Harmonic components of current and voltage

Development of power electronics

"Currently, 30% of all electrical energy passes through power electronics between production and consumption. **In 2030, this share will increase to 80%**."

- U.S. Department of Energy



Impact on voltage and current

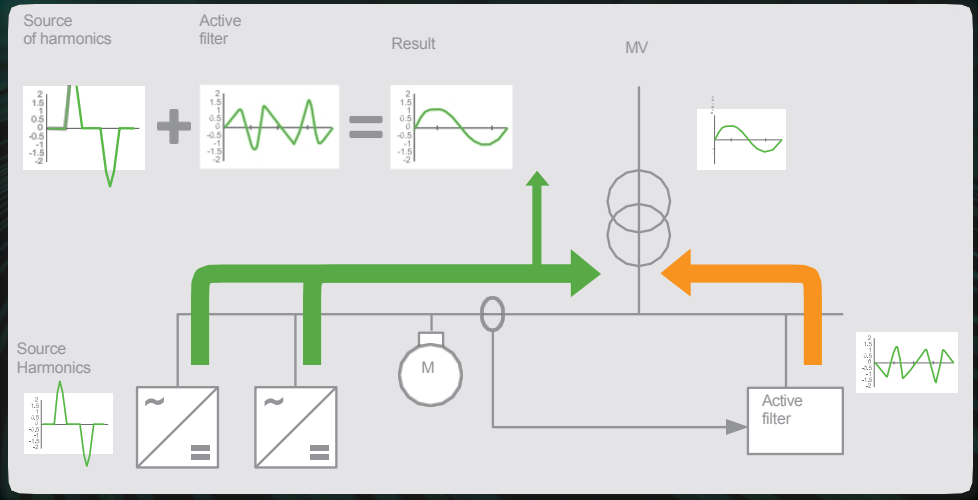
Harmonic Elimination

Fortunately, this can be remedied by addressing the cause→ Active filter

An active filter is a device that uses power electronics to limit or eliminate harmonic distortion of current (voltage) in a given electrical installation.

Principle of operation

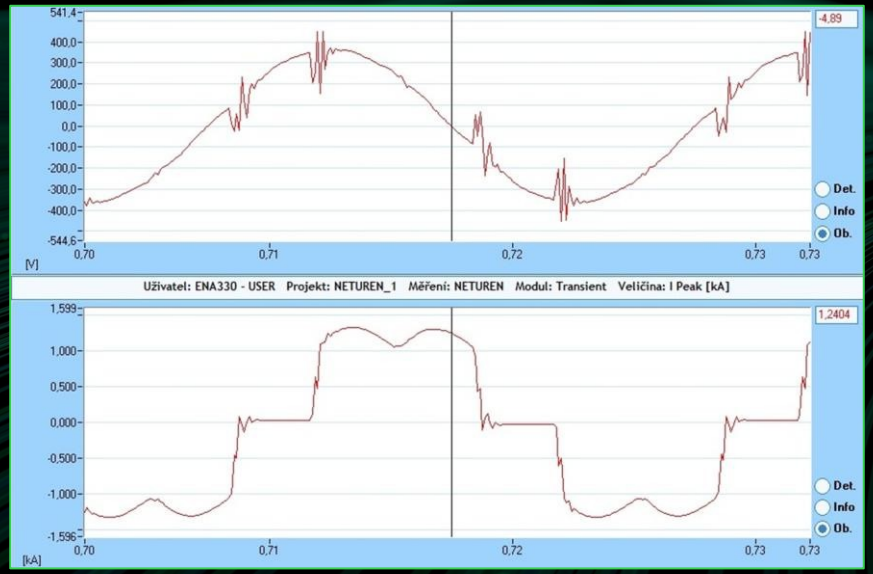
- Measures harmonics drawn from the load
- Generates the same waveform in real time but with the opposite polarity.
- Thanks to its principle, it can also solve power factor correction.



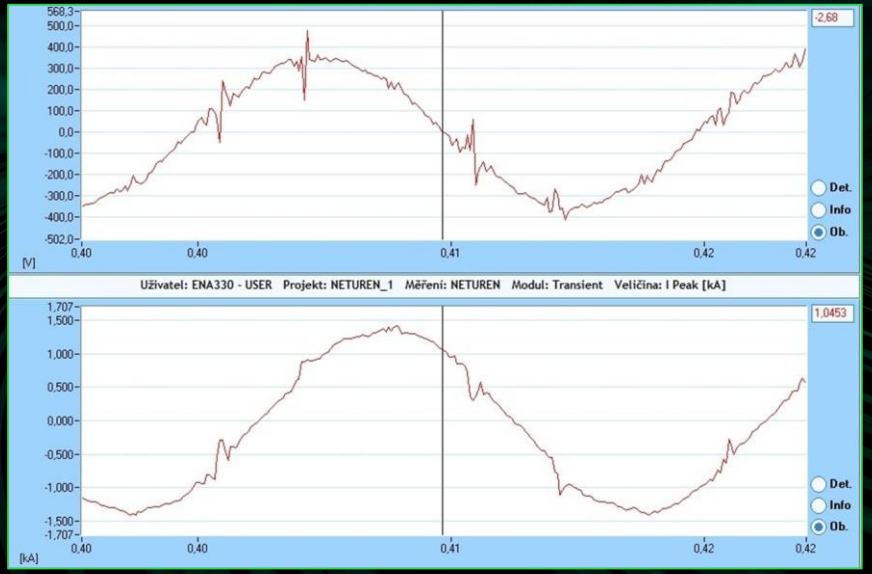
Harmonic elimination

Fortunately, this can be remedied by addressing the cause→ Active filter

Measurements before filter installation and compensation

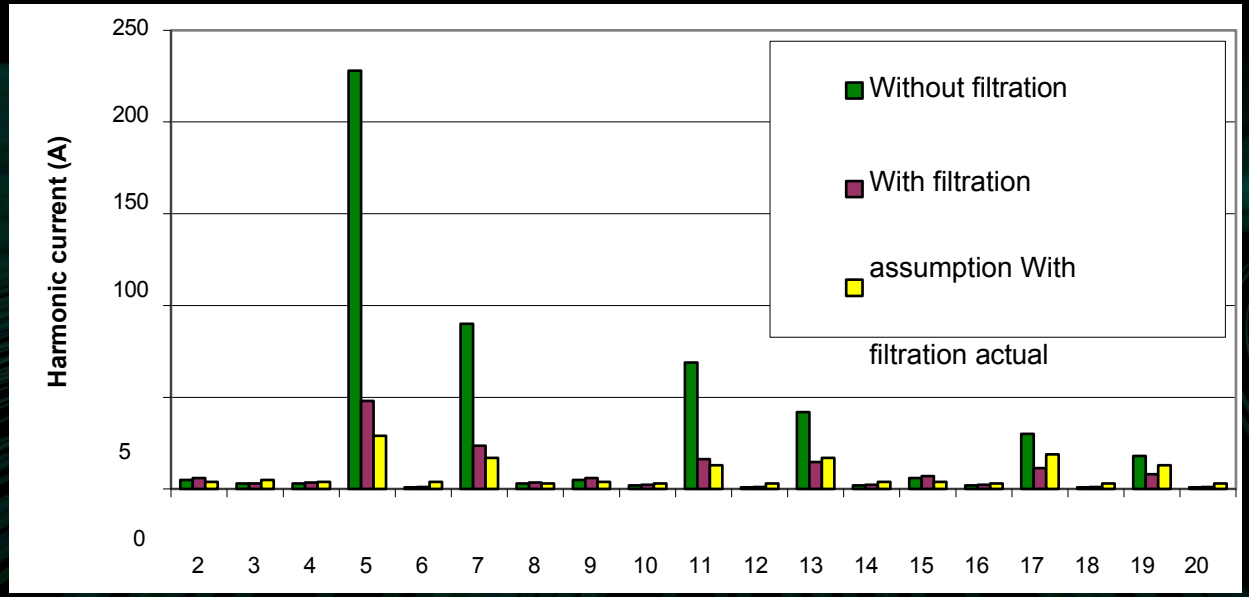


Measurements after filtration without compensation



Harmonic elimination

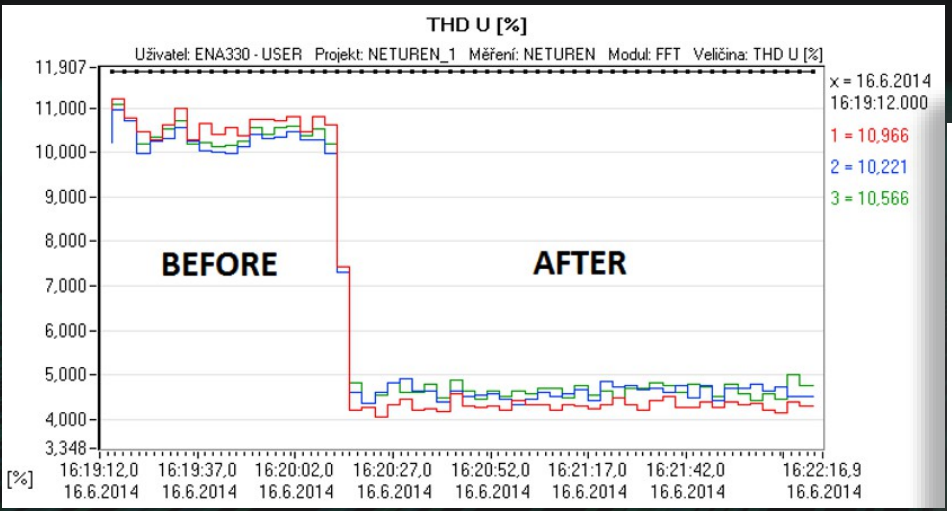
Fortunately, this can be remedied by addressing the cause→ Active filter

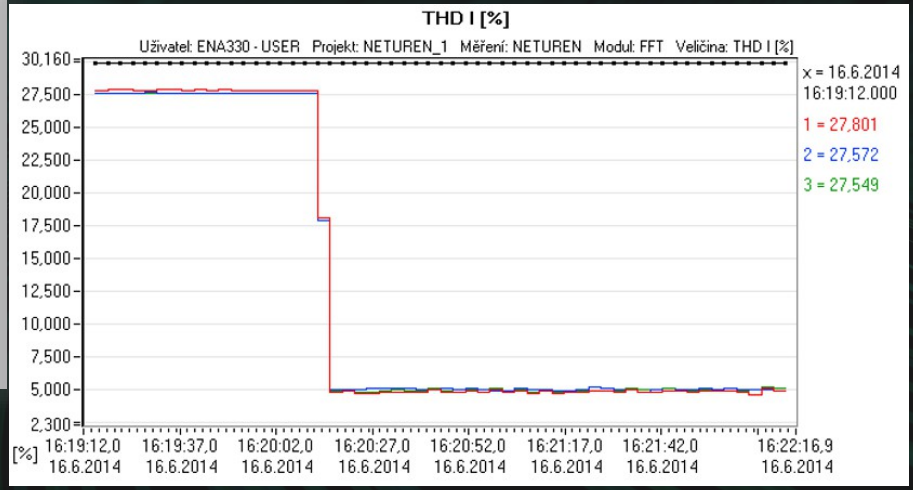


$$h = kp \pm 1$$

Harmonic elimination

Fortunately, this can be remedied by addressing the cause→ Active filter





Introducing Schneider Electric's offering

EcoStruxure Power

Initial investment

Communication performance

Device performance

Pow erLogic PFC

PFC k distrib ution ompon děče & enty

Fowerl ogi c AccuSine

EVC+ and PFV+

PowerLogic AccuSine

PC Sn

PowerLogic AccuSine

PCS+

PowerLogic DVR

Power factor correction (PFC)

VarSet for passive power factor correction

(stepwise)

Active power factor correction (EVC and PFV+)

Active PFC for sensitive loads.
Dynamic and stepless PFC

Active filter

Harmonic correction for small and medium-sized buildings with neutral correction

Active correction

Harmonic correction
PFC, Imbalance, Flicker

Voltage regulator Chronic overvoltage/undervoltage
Short-term voltage drops
Voltage

Passive Compensation

Active compensation

Compensation components

Products for your compensation switchboard

VarPlus Can capacitors

Chokes for protected compensation

Contactors for compensation

Controllers VarPlus Logic

Life Is On Schneider Electric

PowerLogic PFC (VarSet)

Compensation switchboard

From 6 kvar to 1150 kvar

Mounting type

- ✓ Wall
- ✓ Free-standing

Design

- ✓ Protected (covered)
- ✓ Unprotected

Compensation type

- ✓ Fixed
- ✓ Automatic

AccuSine+ (PCS+/PFV+)

Heavy industry and critical applications

PFV+ is only for active compensation and cannot eliminate harmonic currents

Wall mounting

IP00

208 – 480Vac
60, 120, 200, 300A

IP20

208 – 480Vac
60, 120, 200, 300A

Free-standing

IP31

208 – 480Vac
60, 120, 200, 300A

IP54

208 – 480V
60, 120, 200, 300A

IP31

690V
40, 80, 133, 200A

IP54

690V
40, 80, 133, 200A

Life Is On Schneider Electric

AccuSine+ (PCSn)

Commercial buildings, data centers, etc.

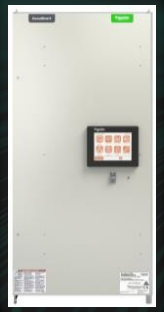
For switchboards

IP00

208 – 415Vac

20, 30, 50, 60A

Wall mounting



IP20

208 – 415Vac

20, 30, 50, 60A

19” rack mounting

19” rack module

208 – 415Vac

20, 30, 50, 60A

Life Is On Schneider Electric

AccuSine (EVC+) Active compensation

Commercial buildings, light industry

Wall mounting

IP00

208 – 480Vac
75kVar, 100kVar

IP20

208 – 480Vac
75kVar, 100kVar

IP31

208 – 480Vac
75kVar, 100kVar

Our offer

for PQ Challenges in Modern Electrical Networks

	Power factor correction												
Power Solution	Power factor correctio	Power factor = 1	Capacitive power compensation reactive power	Power factor correction one in	Fast correctio n <20ms	Stepless() compensation	Phase harmonics	Harmonics in neutral conductor	Network symmetry	Short-term undervoltage	Sudden overvoltage	Flicker	Long-term undervoltage and overvoltage
 PowerLogic PFC	✓												
 AccuSine PFV+/EVC*	✓	✓	✓	✓	✓	✓			✓			✓	
 AccuSine PCSn	✓	✓	✓	✓	✓	✓	✓	✓	✓				
 DVR										✓		✓	✓
 AccuSine PCS+	✓	✓	✓	✓	✓	✓	✓		✓			✓	

Green cells represent 60% of problems encountered

**EVC+ can eliminate harmonics up to the 15th order*

Dynamic Voltage Restorer (DVR)

Basic definition of DVR

What is a DVR?

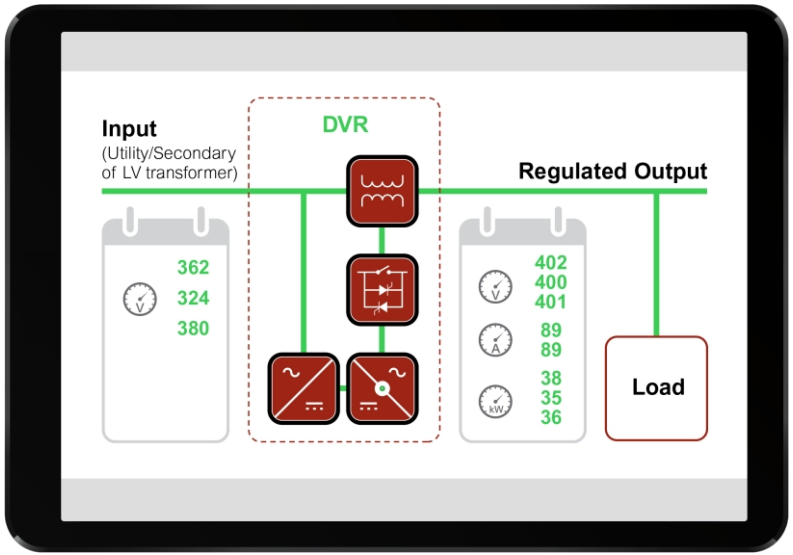
- A voltage regulator that allows short-term voltage drops and chronic problems
  with undervoltage/overvoltage.

Where to install a DVR?

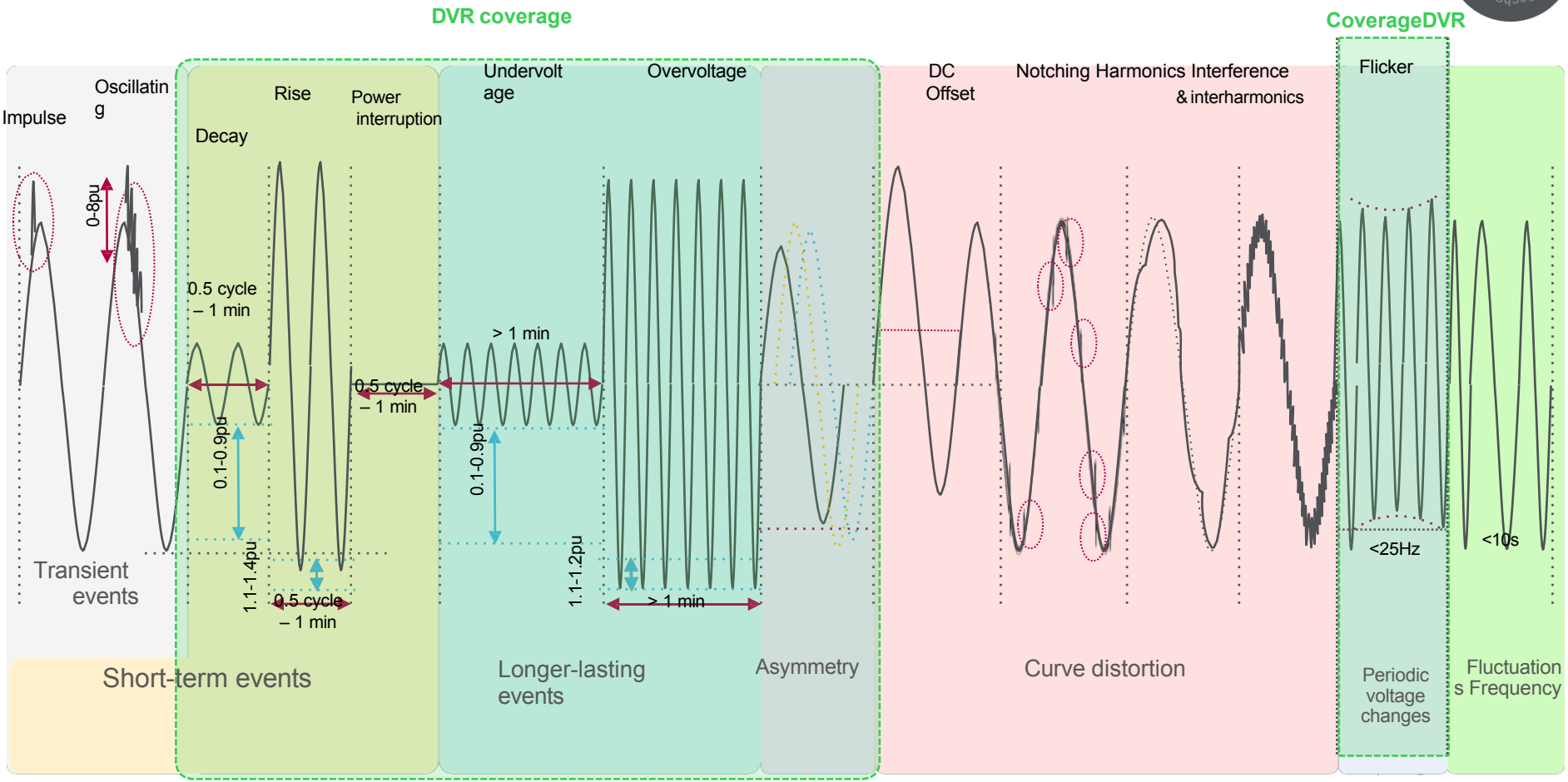
- A voltage regulator needs to be installed either at a critical load or at the input of the distribution system to the premises.

What does a DVR do if there is no problem (voltage fluctuations)?

- During normal operation, the DVR remains connected to the network and provides minimum voltage to compensate for drops caused by device and transformer losses.

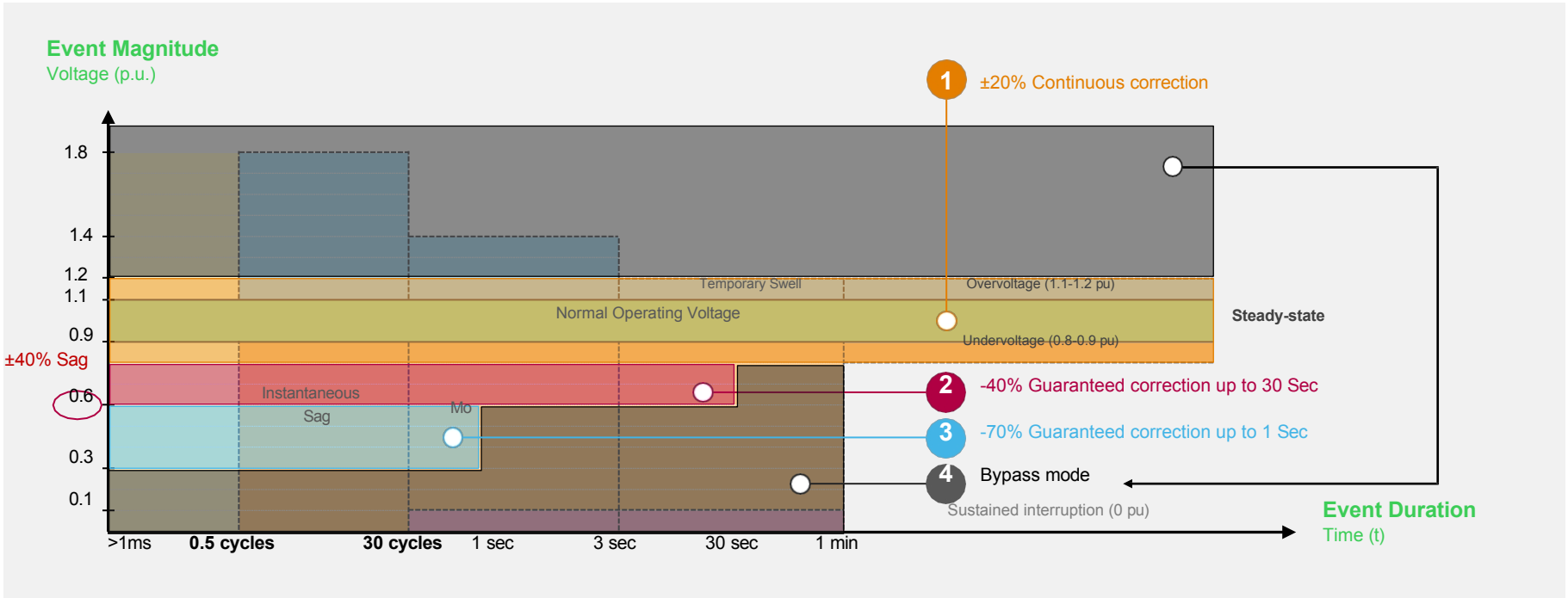


Where can DVR help us?

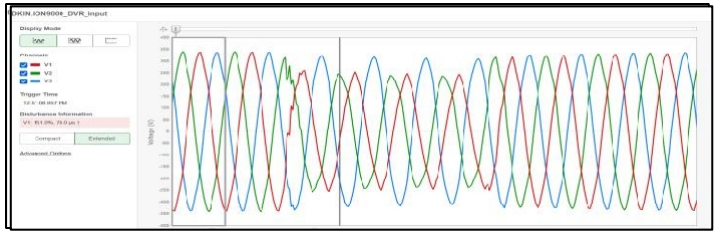


Working range

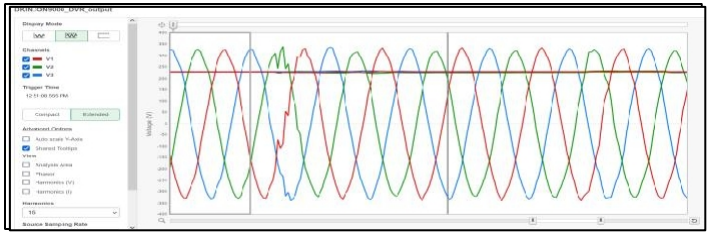
- 40% voltage drop



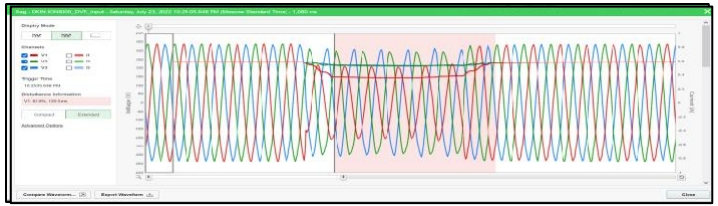
DVR Input: Sag: 70.8% of Nominal Voltage



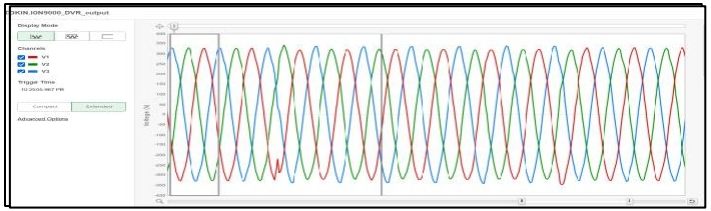
>>>> DVR Output



DVR Input: Sag: 62.8% of Nominal Voltage

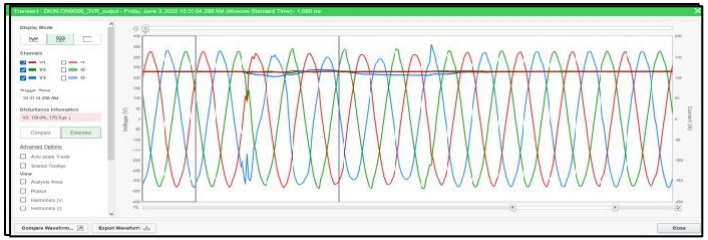


>>>> DVR Output



DVR Input: Sag: 52.2% of Nominal Voltage

>>>> DVR Output



PowerLogic DVR

Scope and structure of the offer

Master unit

Slave unit

Dynamic Voltage Restorer (DVR)

Quick recap

- **Always ready - no recharging or resetting required**
- **Low investment costs and very low operating costs - High efficiency up to 98%**
- **No batteries or energy storage required**
- **Continuously monitors input voltage for voltage changes**
- **Only activates in the event of power quality incidents, otherwise remains inactive**
- **Corrects voltage drops until the rated voltage reaches 95%.**
- **Provides balanced sine wave output and corrects phase shift during fluctuations.**

Further information and documentation?

Application description: power quality monitoring

Try the Power Monitoring Expert demo here
(Login name: demo Password: demo)

ČSN 33 2000-8-1 ed. 2, ČSN EN 50160, IEE519, ČSN IEC 61000-4-30

How to improve power quality?