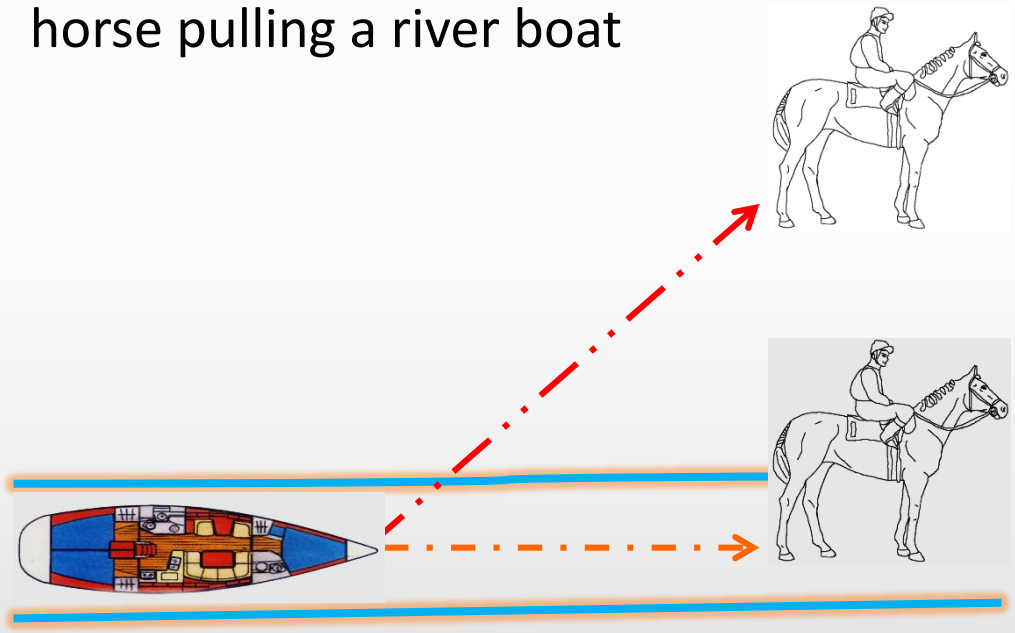
Power Factor Correction systems

What is power factor – NON technical explantion

Power factor analogy with horse pulling a river boat



Consider a river boat being pulled by a horse. If the horse could walk on water the angle (phi) would be zero and cos ϕ=1 – mean the all the horse power is being used to pull load.

The position of the horse influences the power.

The horse would ideally pull the boat directly down the river, so the apparent power equals the real power .

As the horse gets far from the river, angle increases as apparent power to.

Total active, apparent and reactive components

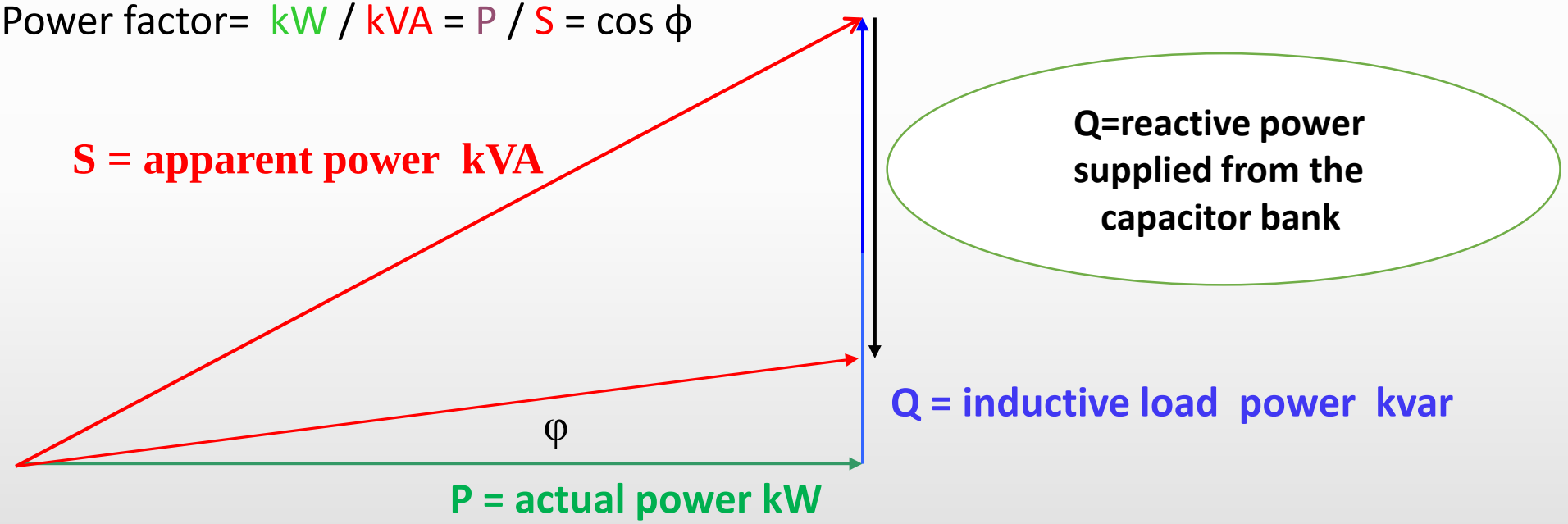
Relations between actual, apparent and reactive power

Power factor= kW / kVA = P / S = cos ϕ

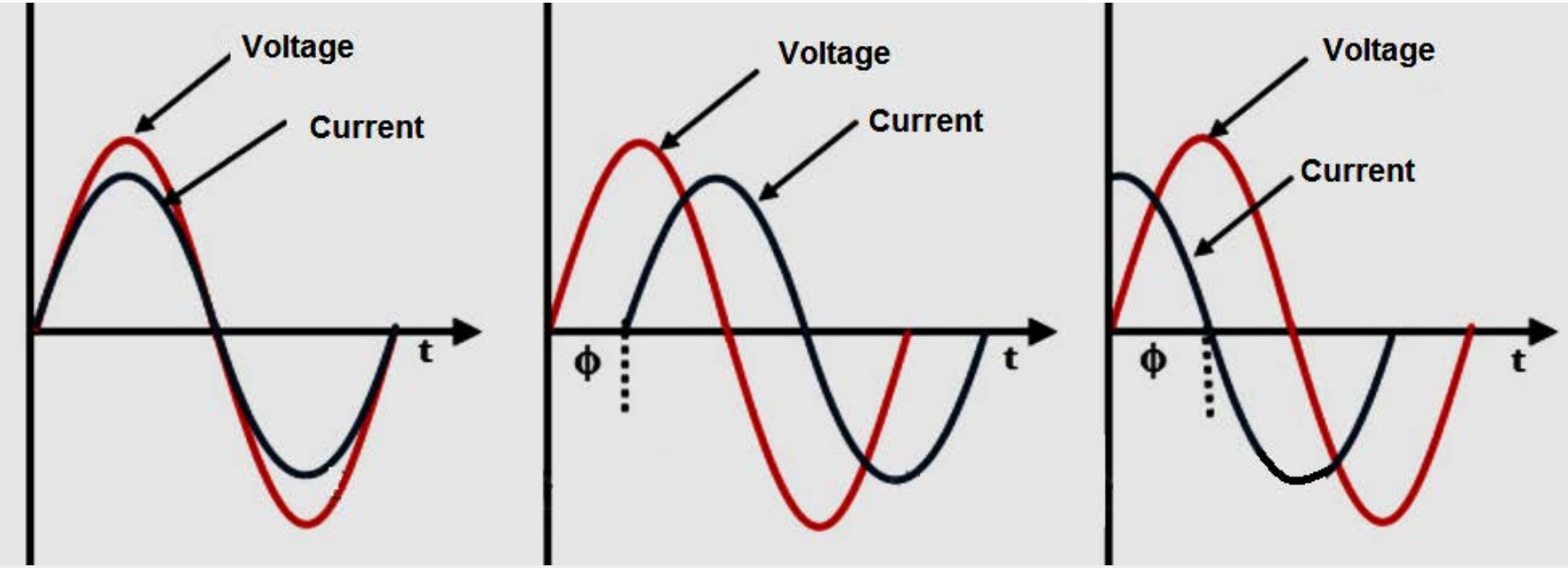
$$\cos \varphi = \frac{P}{S}$$

$$\sin \varphi = \frac{Q}{S}$$

$$\cos \varphi = \frac{Q}{S}$$



Current and voltage sinusoidal explanation



resistive load
cos fi 1

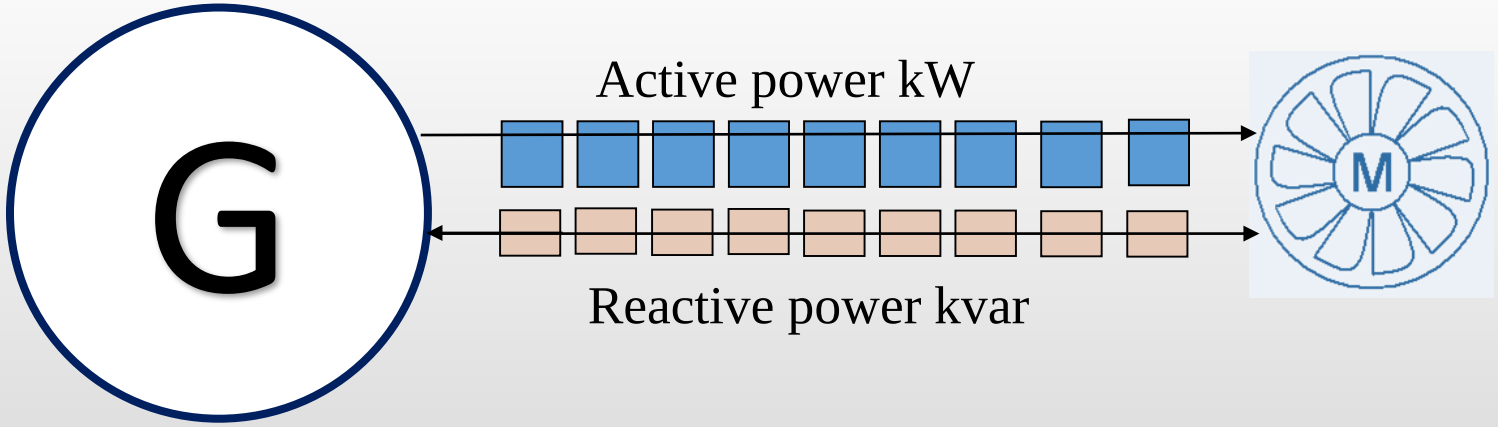
capacitive load
current leading voltage

inductive load
current lagging voltage

Electrical systems are mainly inductive. With adding the capacitors in parallel connection we decrease the angle between the current and voltage.

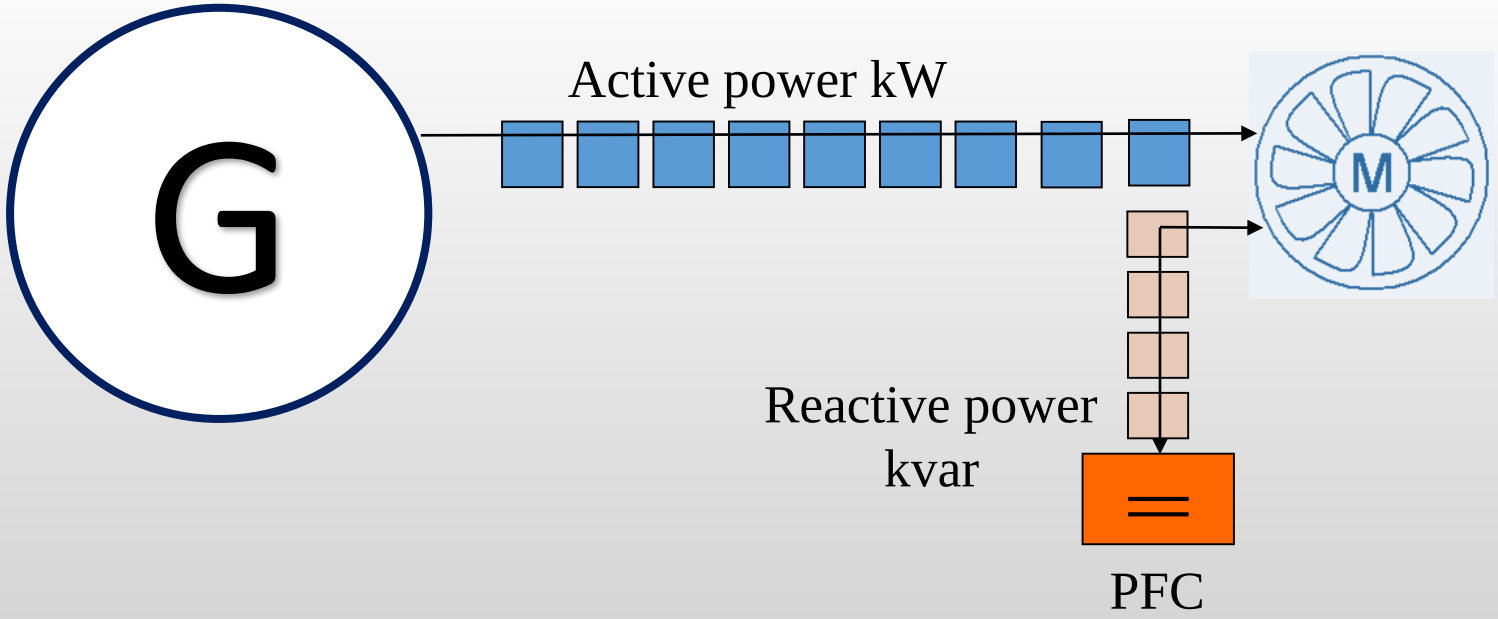
Motor operation – without PFC

- motor without the capacitor
- generator must supply both powers: active and reactive
- reactive power is needed to create magnetic field in the motor

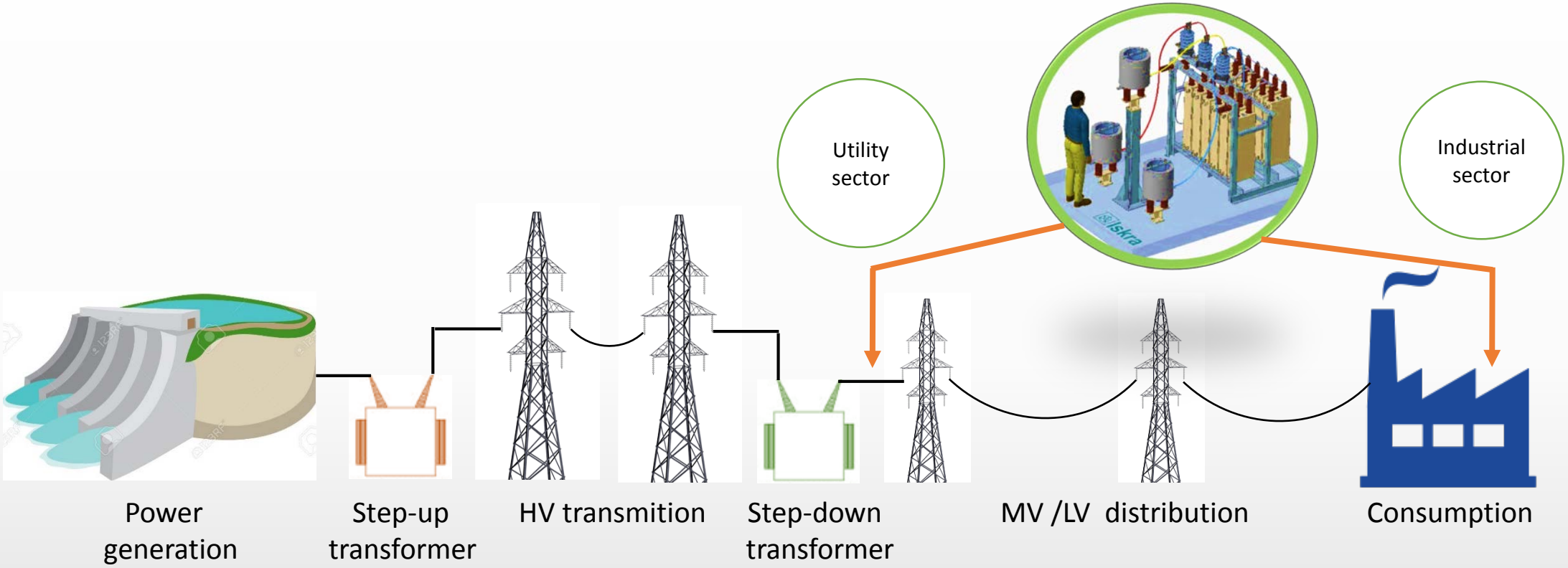


Motor operation – with PFC

- motor with the capacitor
- generator supply mainly active power
- reactive power is produced by a capacitor



Typical power generation and distribution schema



Economical benefits: money saving, prolong the life time of all system parts, prevent overloads, saves cost of new installation

Technical benefits: increases system voltage & capacity, relief the system components, improve sytem power factor, reduce harmonics

Scope of supply

- knowledge about the switchgear, measuring, protection, control equipment, installations, implementation of integrated turnkey solutions
- PQM measurement and collection of site condition data
- system data analysing and design calculation
- manufacture of equipment
- logistic, site works : installation, testing, commissioning >TURNKEY
- after sales support

Applicable standards

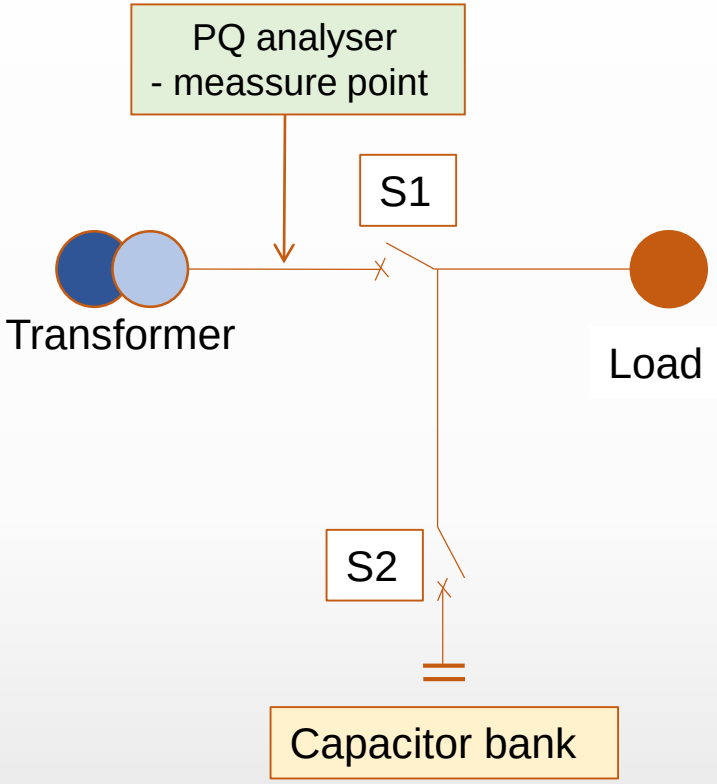
HV Power capacitors	IEC60871-1 2014
PFC Controllers	IEC60664-1
MV Protection relay	IEC60664-1
MV Instrumental C.T and V.T.	IEC60044 -1
MV Reactors	IEC60076-6
MV Fuses	IEC60549
MV Contactors	IEC60470
MV Disconnectors	IEC62271-1 / 102
MV Circuit breakers	IEC62271-100

LV Power capacitors	IEC60831-1/2
LV Capacitor duty contactors	IEC60947-4-1
LV Filter reactors –iron core	IEC60076-6
LV Fuses	IEC60269-1
LV Automatic capacitor banks	IEC60439 Part 1, IEC 60831, IEC61921

Enclosures and assembly	IEC60529
Letter symbols	IEC60027-1

PQ measurements

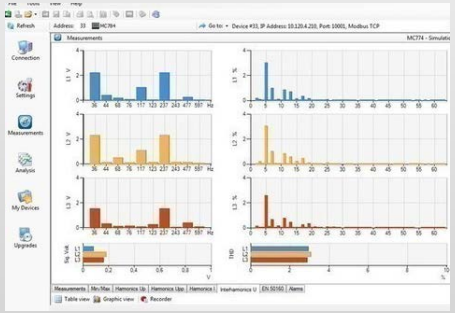
a) get needed system data prior design of capacitor banks
b) verify the design and installation of capacitor banks
c) verify compliance with THD (I,U) conditions
d) investigate suspected resonances and other problems
e) realised simulations for more sophisticated projects….



The measurement results are used to make a calculations, verifications in comparison with standards and system designing.

First measurements must be realized, after all calculations must be made to put the results into a useful form.

In case of very sophisticated solutions simulations are sugested.



Project information and design

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Fax: +386 (0) 1 51 11 532
www.iskrasistemi.si
Tax number: SI13278088
ID number: 5185726
Share capital: 28.065.567,31 EUR

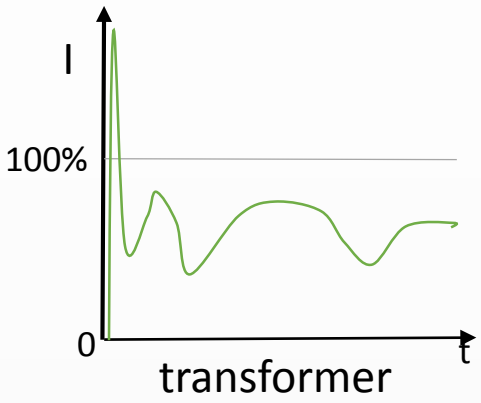
Sequence Number/ *Sequenz Number*.....

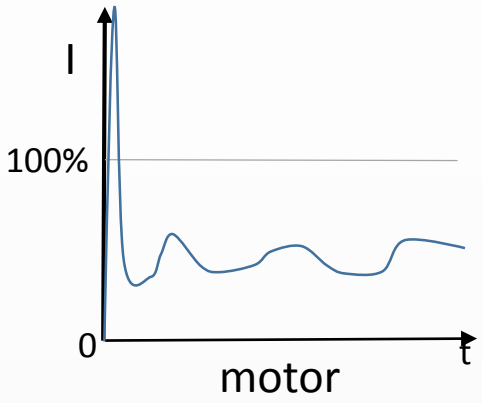
SELECTION FORM FOR POWER FACTOR CAPACITOR BANK
AUSWAHL FORM FÜR BLINDLEISTUNGS-KOMPENSATIONSANLAGEN

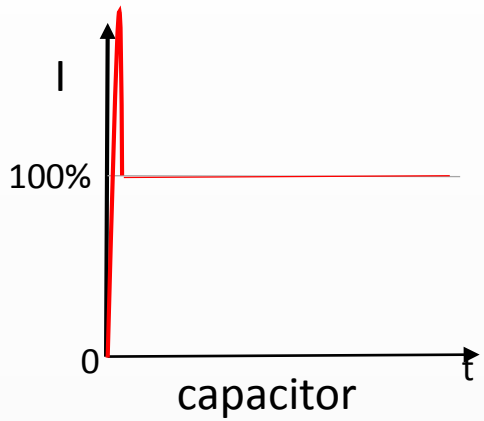
Customer details *Kundendaten*	
Date / *Datum*	
Project / *Projekt*	
Company / *Firma*	
Address / *Adresse*	
Name / *Name*	
Telephone / *Telefon*	
E-mail / *E-Mail*	

Technical information				
Technische Daten				
Power distribution transformer *Leistungstransformator*	kVA			
Short circuit voltage U_k *Kurzschlussspannung U_k*	%			
Nominal system voltage *Netznennspannung*	kV			
Maximum system voltage	kV			

Important design recommendation







It is important to understand the operation of the three most typical power loads:

- the transformer almost never works with a 100% nominal load and current
- the motor almost never works with a 100% rated load and current
- the capacitor always works with a 100% rated load and current.

By understanding the current & operation conditions of the capacitors, few considerations need to be respected during design and production of the capacitor banks:

- sufficient conductors and bus bars cross section
- proper connections, terminations assembly elements
- satisfactory distance between the elements due to cooling
- proper switching and protection elements

LV and HV power capacitors

Capacitors type **KNK****** for low voltage systems

Single phase 230...550 V, 1,67...5 kvar
Three phase 220...690 V, 5...100 kvar

Capacitors type **KLV****** for MV systems

Single phase unit	up to 20kV/50Hz	600kvar
Three phase unit	up to 13,86kV/50Hz	450kvar
Unit with two outputs	up to 12kV/50Hz	400kvar

LV and MV switch gear

LV capacitor duty contactors , nominal power **KC 12 up to 75kvar,** voltage up to 690V 50/60Hz

MV and HV capacitor banks – back to back systems – vacuum contactors, disconectors, circuit breakers

Control and protection relays

Power factor controller types PFC6max and PFC12max for automatic LV systems:

-6 or 12 relay outputs

Power factor controller types PFC-CX/CM for automatic LV and MV systems:

-up to 14 outputs (relay or thyristor)

-RS485 MODBUS

-fully automatic settings

Protection relay KSR-V-Z for MV systems:

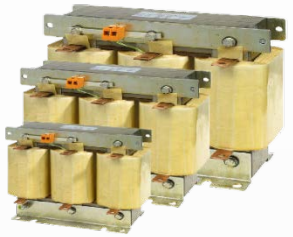
-differential protection YY

-line current and voltage protection

-RS485 MODBUS

LV and MV reactors

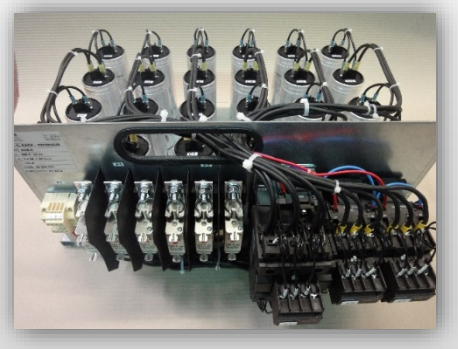
LV detuned filter reactors
- -400, 440, 525V 50Hz
- -5-120kvar
- -detuning factors p=5,67%, 7%, 14%
- -3-6W/kvar power loss
- -iron core , Al or Cu winding



MV detuned filter reactors
- -indoor, outdoor
- -air / iron core
- -single/three phase

MV damping inrush current reactors
- -indoor, outdoor
- -air core
- -single/three phase

LV capacitor banks



MV capacitor banks

References


Estonia
Macedonia
Slovenia
Croatia
Bosnia and Hercegovina
Serbia
Germany
USA
Iran
Pakistan
KSA
UAE
Bangladesh
DR Congo
Algeria
Lebanon
Tunisia
Cambodia
Chile
Ecuador
Panama

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