RH MARINE

The advantages of transformers

EMC-ESD in de praktijk 09-11-2016

Jan-Kees van der Ven

Introduction

- RH Marine
- Additional benefits
  - Common mode reduction LF
  - Harmonic reduction
  - Common mode reduction HF
  - Fault current reduction
  - Reduction of Short circuit power
- Points of attention
  - Transients
  - Temperature

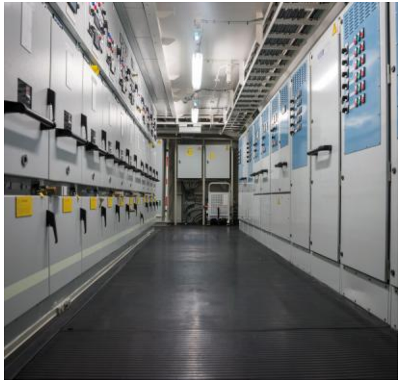
RH Marine Segments

RH Marine Rhodium family

RHODIUM • BRIDGE

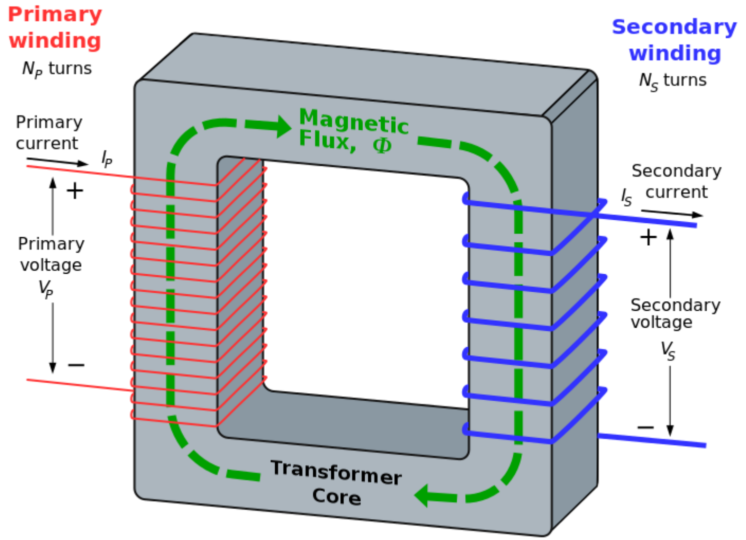
RHODIUM • HYBRID

RHODIUM • AUTOMATION



RHODIUM • POWER

The transformer



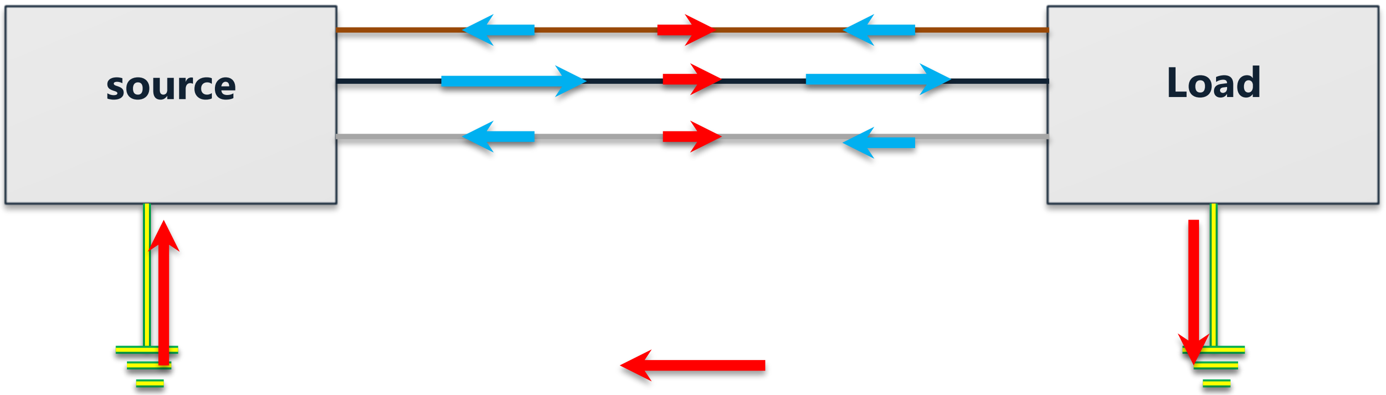
https://en.wikipedia.org/wiki/Transformer#/media/File:Transformer3d_col3.svg

$$\frac{V_P}{V_S} = \frac{I_S}{I_P} = \frac{N_P}{N_S}$$

COMMON MODE REDUCTION LF

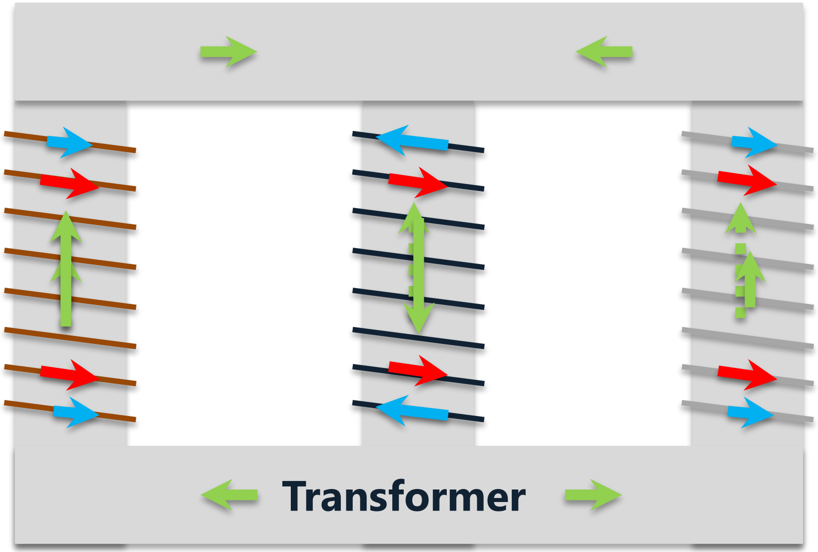
Common mode attenuation

- Differential mode and common mode currents



Common mode attenuation

- Common mode attenuation at low frequencies



Differential mode current

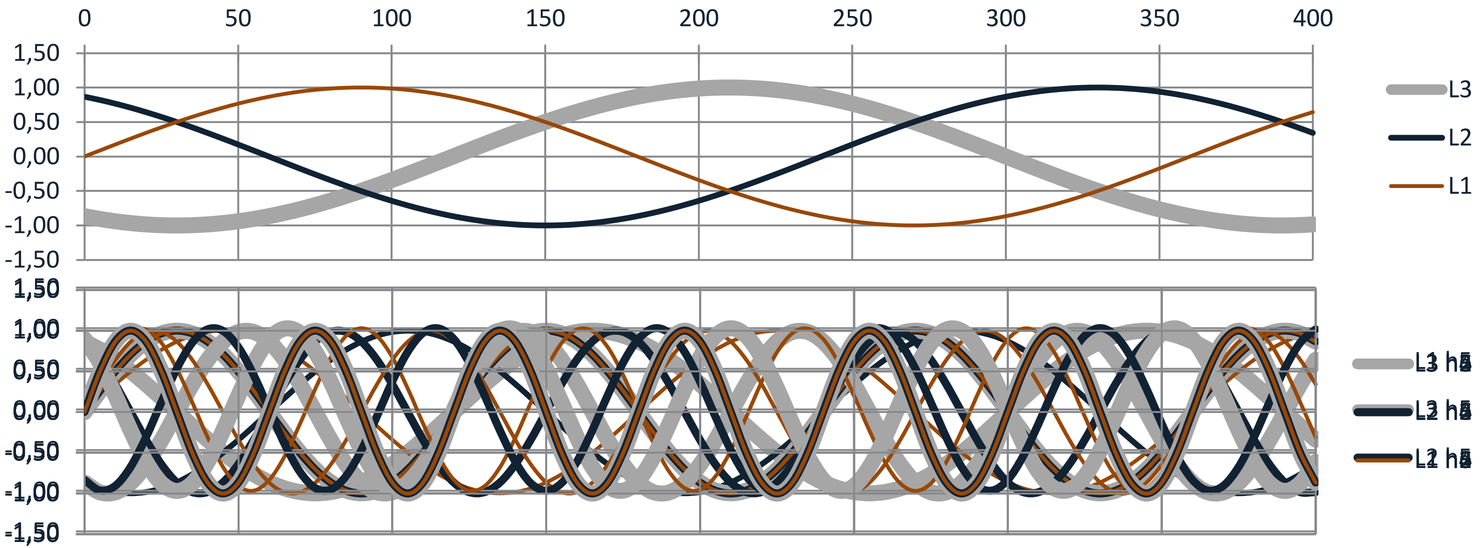
Common mode current

Magnetic flux

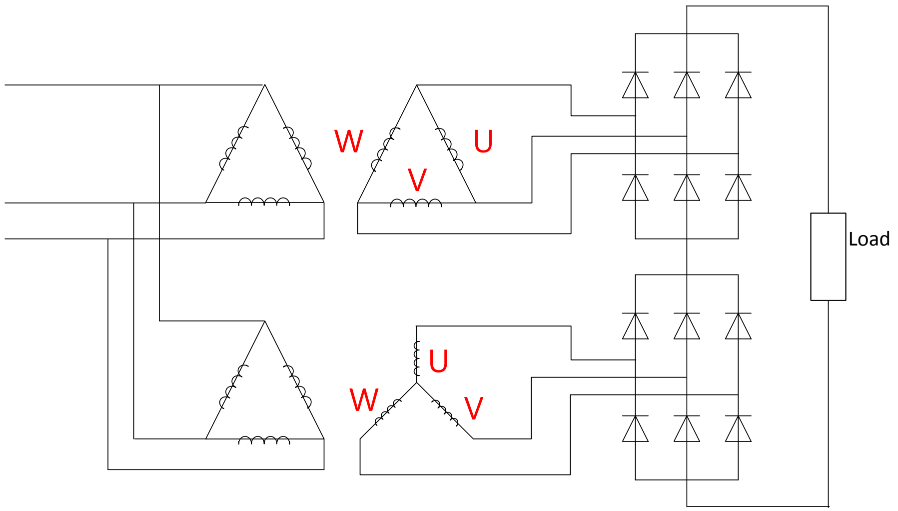
As long as proper shape transformer core is chosen!!!

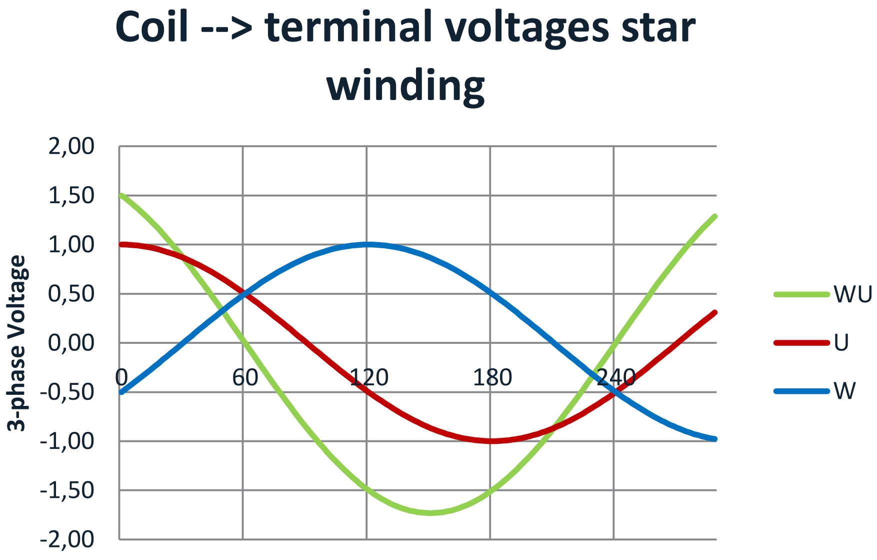
HARMONIC REDUCTION

Reduction of harmonics, multiples of three



Reduction of harmonics ≠ n*3





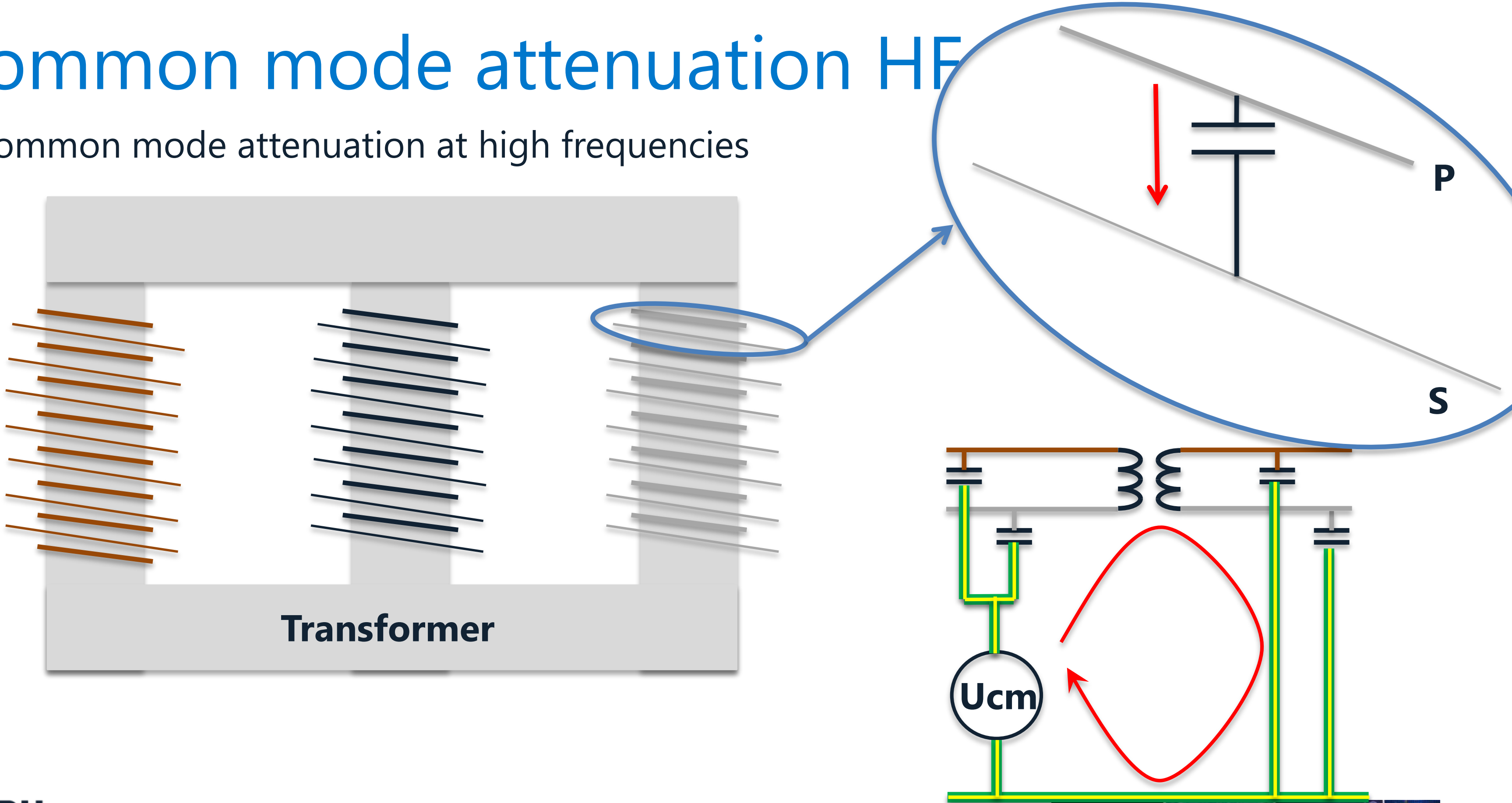
Reduction of harmonics ≠ n*3

Rectifier	Generated harmonics	5	7	11	13	17	19	23	25	29	31	35	37	41	43	47	49
6 pulse	6*n ± 1:	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
12 pulse	12*n ± 1			X	X			X	X			X	X			X	X
18 pulse	18*n ± 1					X	X					X	X				
24 pulse	24*n ± 1							X	X							X	X
48 pulse	48*n ± 1															X	X

COMMON MODE REDUCTION HF

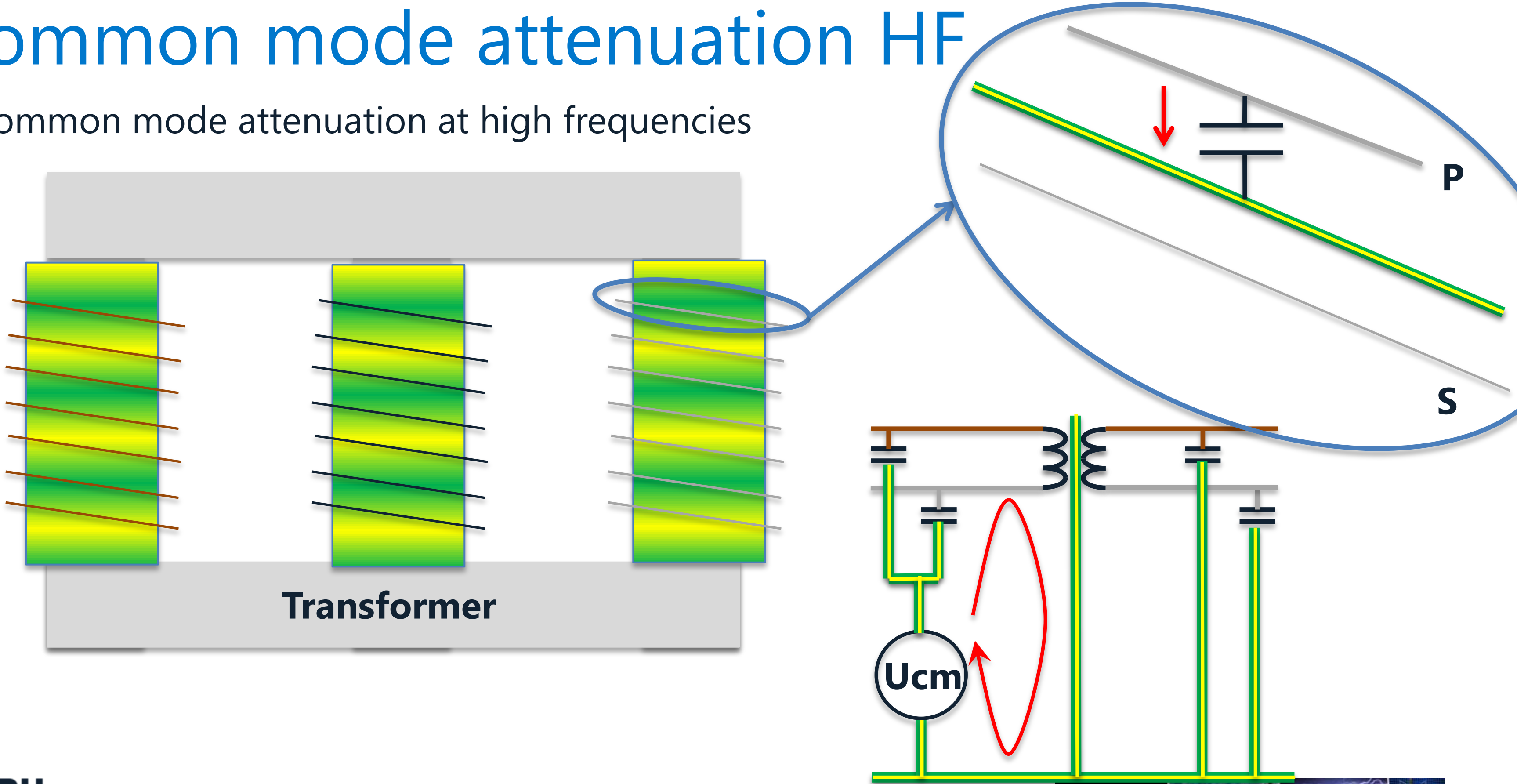
Common mode attenuation HF

- Common mode attenuation at high frequencies



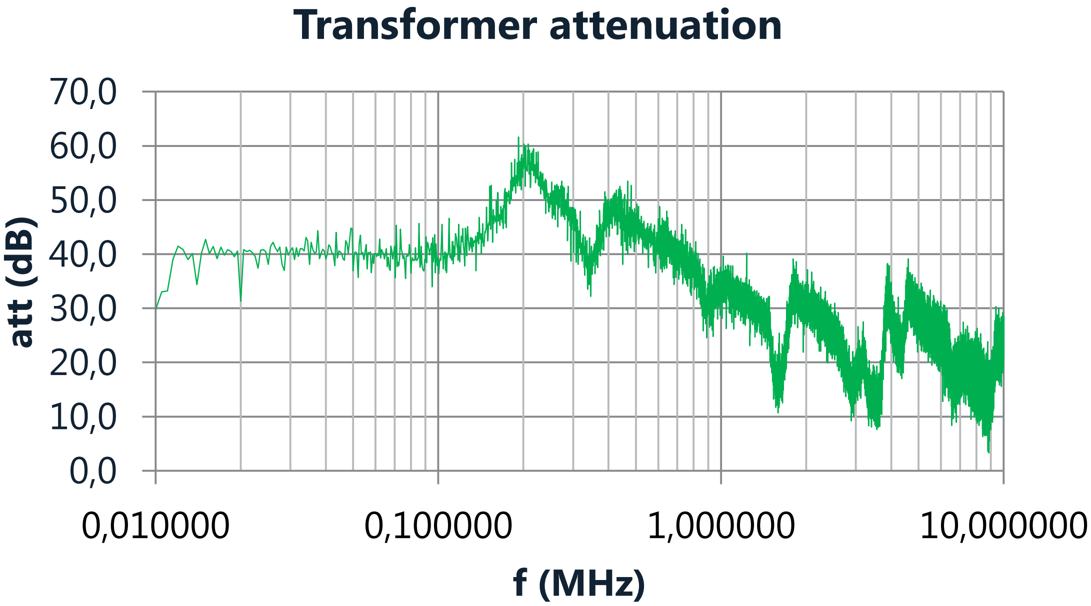
Common mode attenuation HF

- Common mode attenuation at high frequencies

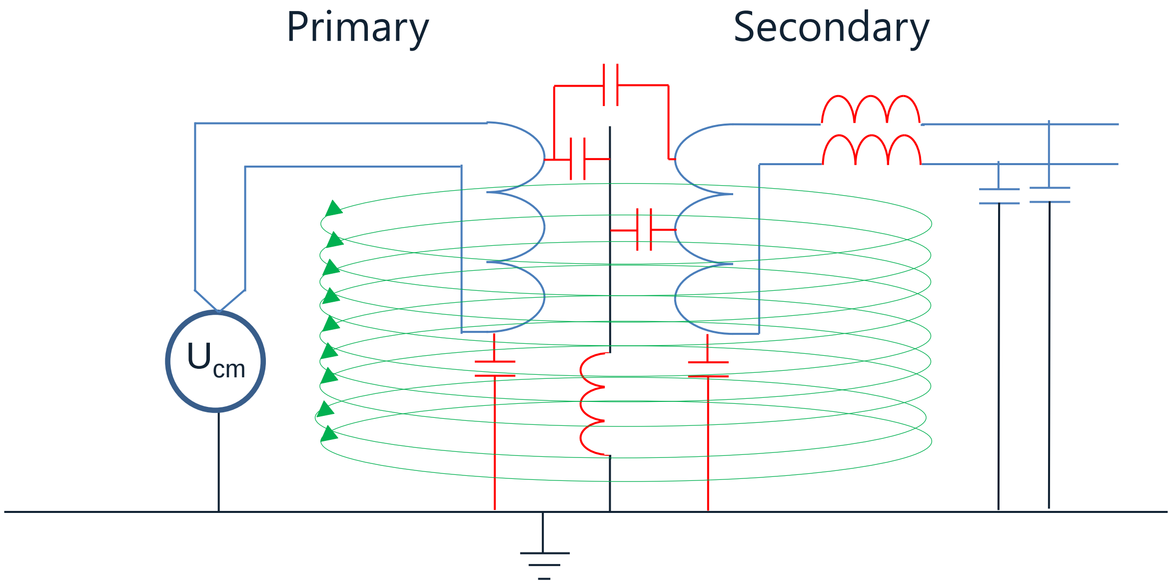


Common mode attenuation example

Common mode attenuation



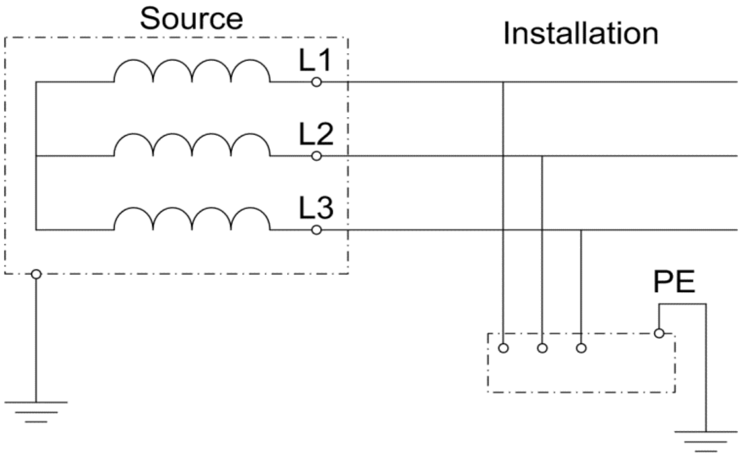
Common mode attenuation



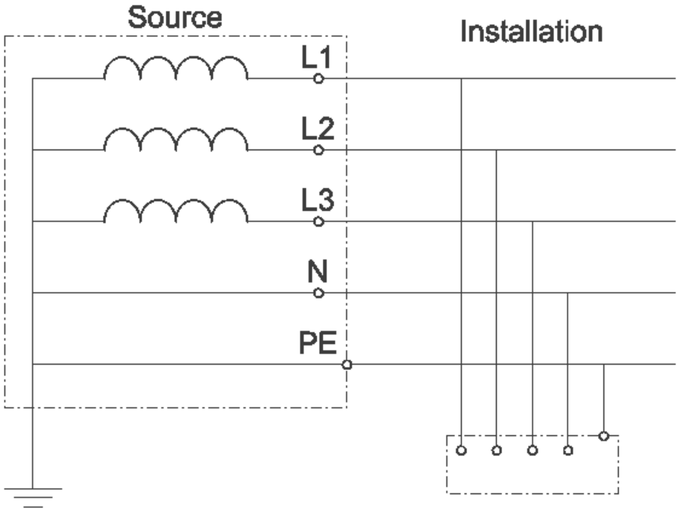
FAULT CURRENT REDUCTION

Reduction of fault currents in IT power grids

- IT power grid

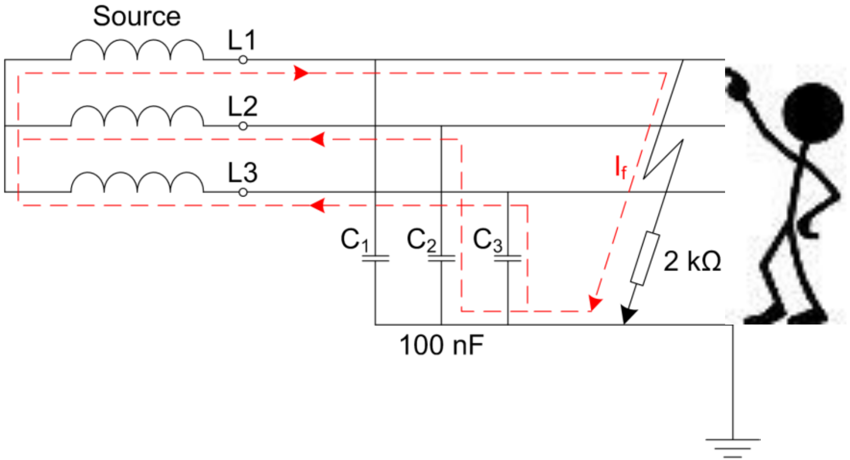


- TN power grid



- “Protection against electrocution”
- Continuity of supply

Reduction of fault currents in IT power grids



System: 440 V, 60 Hz, IT

(parasitic) capacitance to earth	I_earth fault	Consequence
100 nF	30 mA	Electrocution
1 → 16.7 µF	0.3 → 5 A	Fire risk

(Parasitic) Capacitances to earth in an installation:

- Cables 0.1 … 0.2 µF per km
- Motors 0.1 … 0.3 µF, depending on size
- Generators 0.1 … 0.3 µF, depending on size
- EMI filters 0.05 … 3 µF (!), depending on rating

REDUCTION OF SHORT CIRCUIT POWER

Reduction of short circuit powers

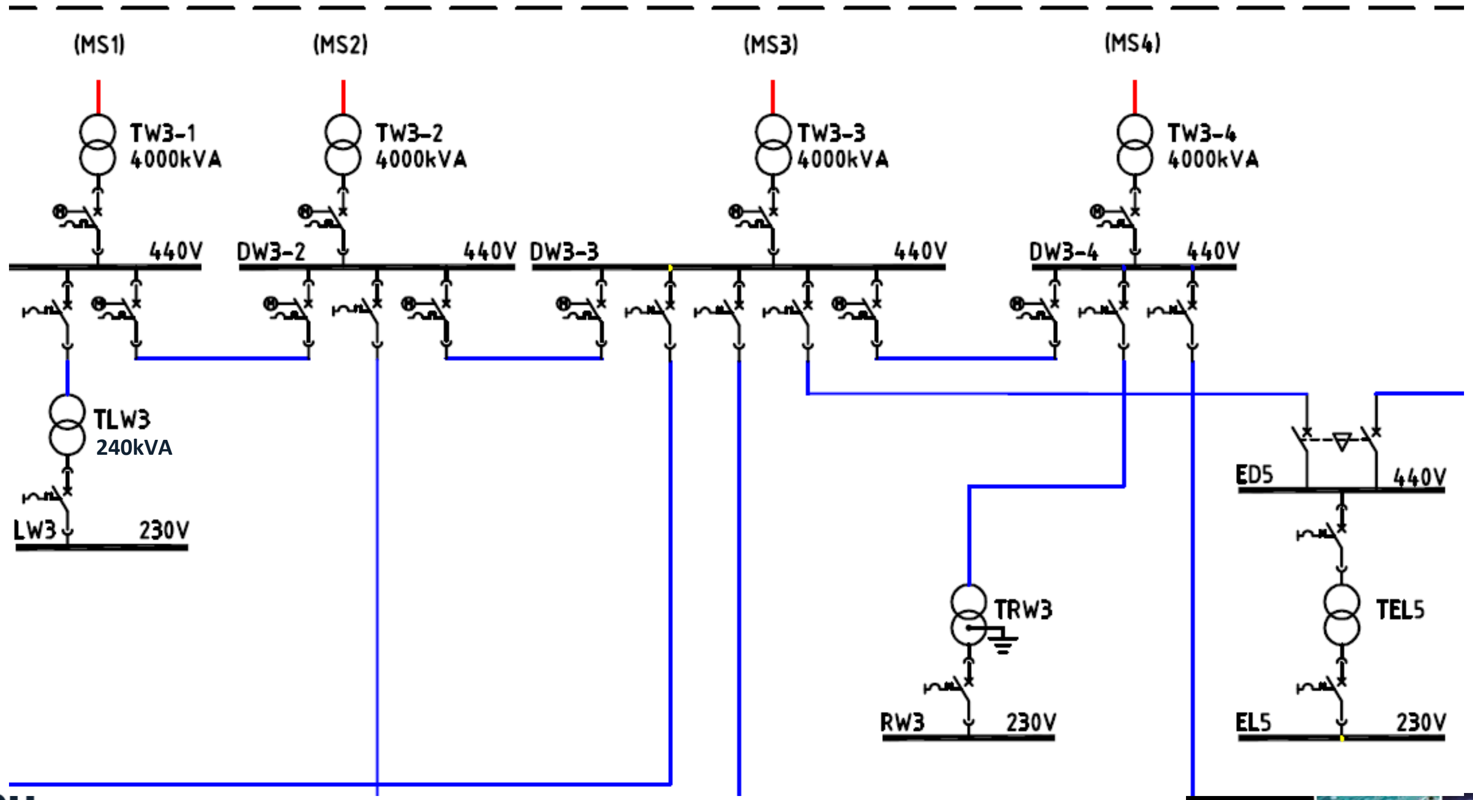
- Total installed power:
  95,000 kW

- Thrusters:
  12 x 6050 kW
  non-retractable, fixed pitch,
  variable speed

RH MARINE

EMC-ESD IN DE PRAKTIJK
ELEKTRUM | ARNHEM
9 NOVEMBER 2016

Reduction of short circuit powers



Reduction of short circuit powers

- $I_{FL\_sec} = \frac{S_{rated/phase}}{U_{sec}/\sqrt{3}} = \frac{4.000.000/3}{440/\sqrt{3}} = 5.2\ kA$
- $I_{SC\_sec} = I_{FL\_sec}/Z\ _{tr}\ (Z_{tr}[\%]) = 5248/0.06 = 87\ kA$

	4 MVA (6%)	240 kVA (4%)
Isc	87 kA	15 kA

Reduction of short circuit powers

- National Fire Protection Association
- NFPA 70E® Standard for Electrical Safety in the Workplace
- Table 130.7(C)(15)(A)(b) Arc-Flash Hazard PPE Categories for Alternating Current (ac) Systems
- The arc flash boundary shall be the distance at which the incident energy equals 5 J/cm2 (1.2 cal/cm2).

Reduction of short circuit powers

Equipment	Arc Flash PPE Category	Arc-Flash Boundary
Panelboards or other equipment rated 240 V and below Parameters: Maximum of 25 kA short-circuit current available; maximum of 0.03 sec (2 cycles) fault clearing time; working distance 455 mm (18 in.)	1	485 mm
Panelboards or other equipment rated >240 V and up to 600 V Parameters: Maximum of 25 kA short-circuit current available; maximum of 0.03 sec (2 cycles) fault clearing time; working distance 455 mm (18 in.)	2	900 mm
600-V class motor control centers (MCCs) Parameters: Maximum of 65 kA short-circuit current available; maximum of 0.03 sec (2 cycles) fault clearing time; working distance 455 mm (18 in.)	2	1.5 m
600-V class motor control centers (MCCs) Parameters: Maximum of 42 kA short-circuit current available; maximum of 0.33 sec (20 cycles) fault clearing time; working distance 455 mm (18 in.)	4	4.3 m

Reduction of short circuit powers

ABB 2CDS253001R0325 Zekeringautomaat 3-polig 32 A

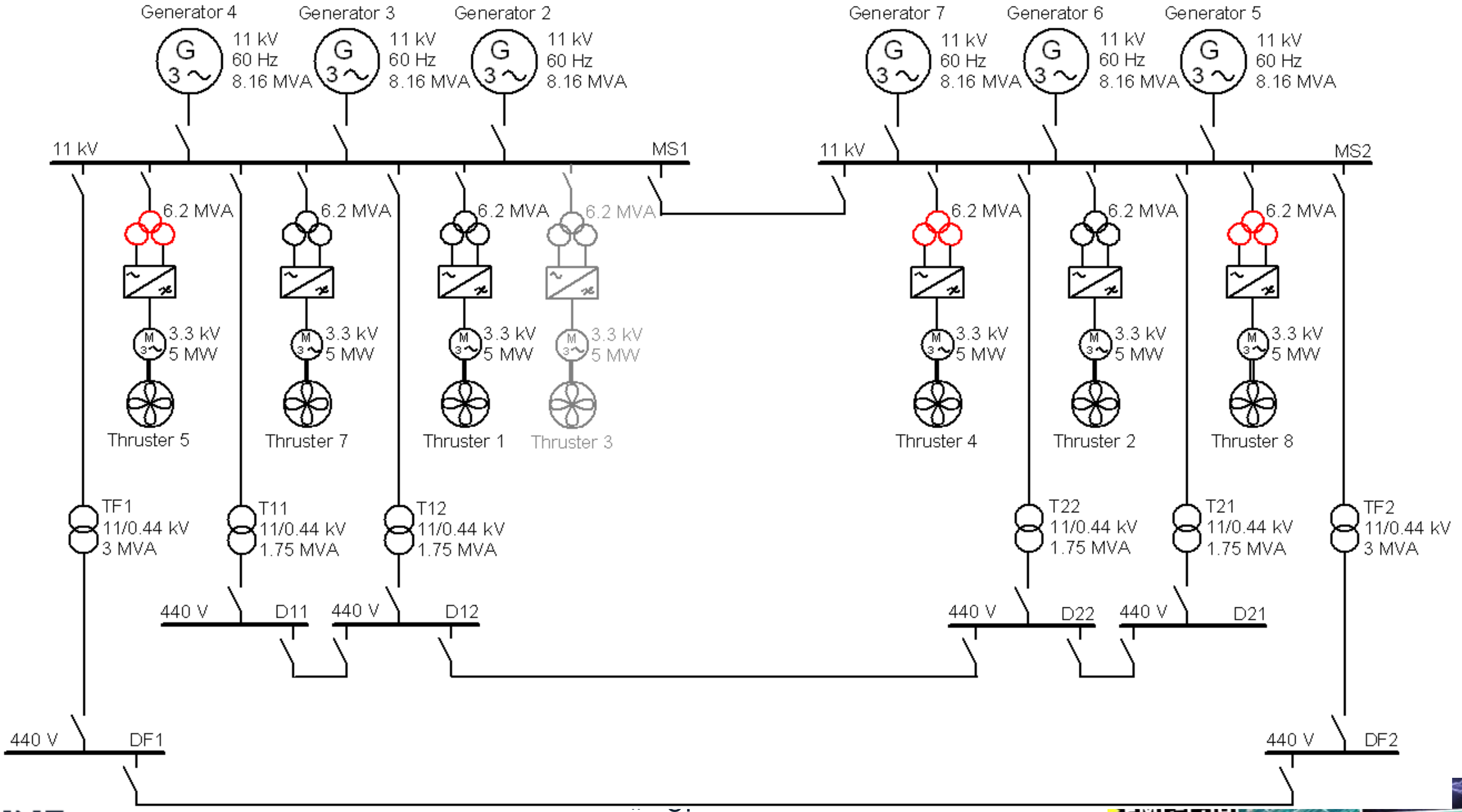
ABB ★★★★☆ 1 review

Direct naar: Beschrijving › Reviews › Accessoires › Download ›

6 kA Automaat 3-polig B kar 32A

RISKS
TRANSIENTS

Damage caused by transients



Damage caused by transients

Transformer 4

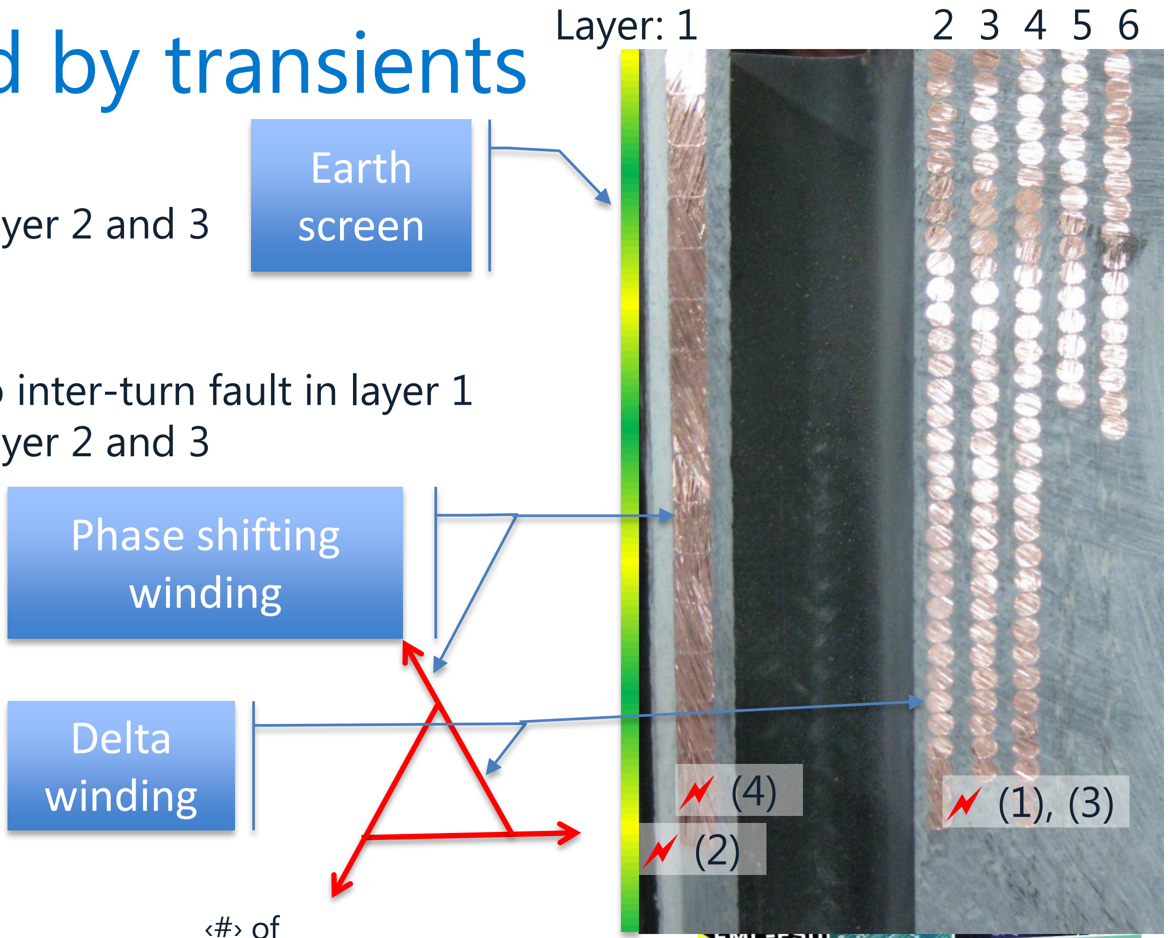
1. Inter-layer fault between layer 2 and 3

Transformer 8

2. Earth fault, developing into inter-turn fault in layer 1
3. Inter-layer fault between layer 2 and 3

Transformer 5

4. Inter-turn fault in layer 1



RH MARINE

Damage caused by transients

High voltage peaks?

No:

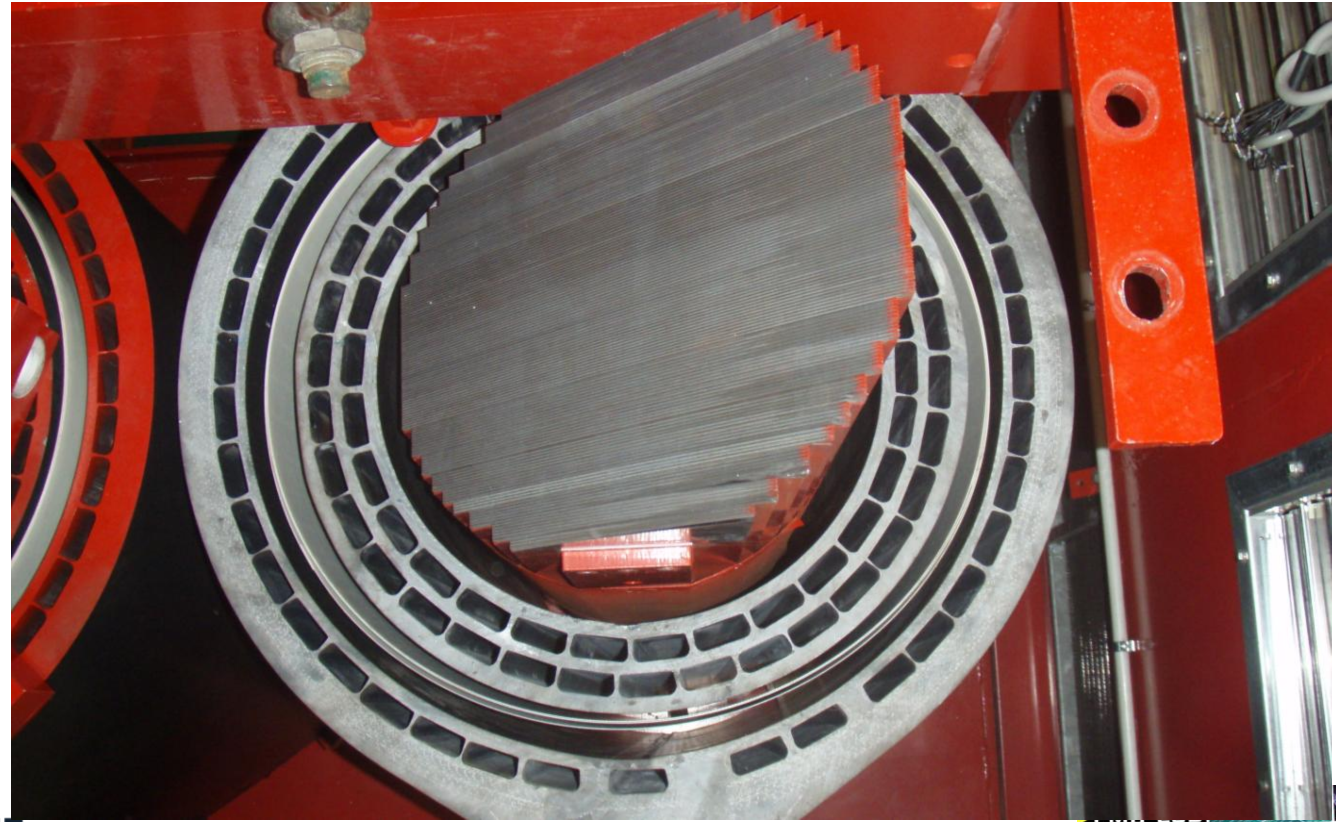
Highest peak measured was 17 kV. For a 11 kV transformer winding this is not high at all.

High rate of rise (dU/dt)?

Yes:

dU/dt measured as high as 130 kV/µs. This is extremely high.

Damage caused by transients



Damage caused by transients

Damage caused by transients

RISKS
TEMPERATURE

Cooling aspects

Cooling aspects

Cooling aspects

- Space requirements
- Heating by harmonics
- Internal circulating currents

THANK YOU FOR YOU ATTENTION