HIGHVOLT Prüftechnik Dresden GmbH

On site testing on high power transformers

- Introduction
- Test cases for transformer testing on-site
- Mobile transformer test system WV
  - General
  - Possible extensions
  - Technical background
- Summary

On site testing of power transformers

WHY TESTING ON SITE ?

- Routine test report of the factory may not provide sufficient information about the internal condition of the transformer after installation
- Transformer conditions after a **repair** job
- **Diagnostics** during the life time
- Possibilities for transformer manufactures to built up their **service department** to a second mainstay of their businesses

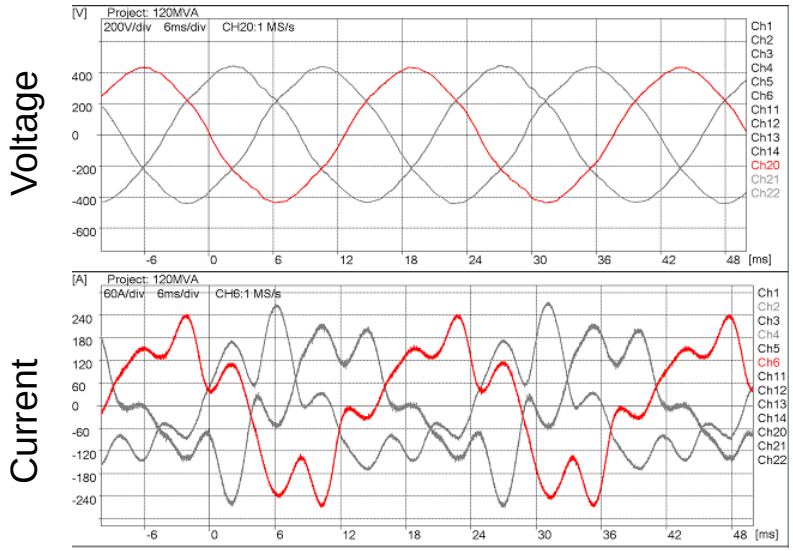
WHAT TO TEST ON SITE ?

- Load and no-load losses
- Induced voltage test
- Applied voltage tests

On site testing of power transformers

TEST OF THE NO-LOAD LOSSES

- **Check** the transformer after a **repair job or maintenance**
- According to the IEEE 57.12.90: total harmonic distortion THD ≤ 5% is acceptable



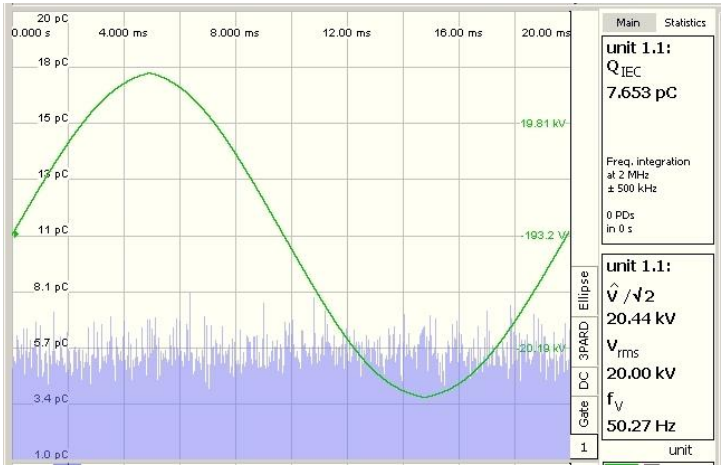
Non-linear current and sine wave test voltage during the no-load losses test of a 120 MVA transformer

On site testing of power transformers

INDUCED VOLTAGE TEST

- Test the **insulation between the coils of a winding**
- Test voltage is greater than the rated voltage of the transformer,
- Test frequency: 120 … 150 Hz

- Feeding supply of low PD noise level < 100 pC
  WV test system achieves: 30 .. 50 pC



Example of the typical PD noise level of the transformer test system

Standard

Standard IEC 60076-3 Ed. 3 (2013)

Edition 2.0 2000-03 [1]	Edition 3.0 2013-07 [2]
Repeated tests on new or in “as new” condition transformers	
100 %	100 %
Repeated tests after service / repair / refurbishment	
80 %	**80 % .. 100 %**
ACLD IVPD	
100 %	100 %
Enhancement voltages ACLD / IVPD	
1.7 Um / √3	1.8 Ur / √3 √3 Um / √3 2.0 Ur / √3

Consequently customers tend to use 100 % induced voltage test levels on-site

On site testing of power transformers

APPLIED VOLTAGE TEST

- **Verify the integrity of the main insulation** of the transformer

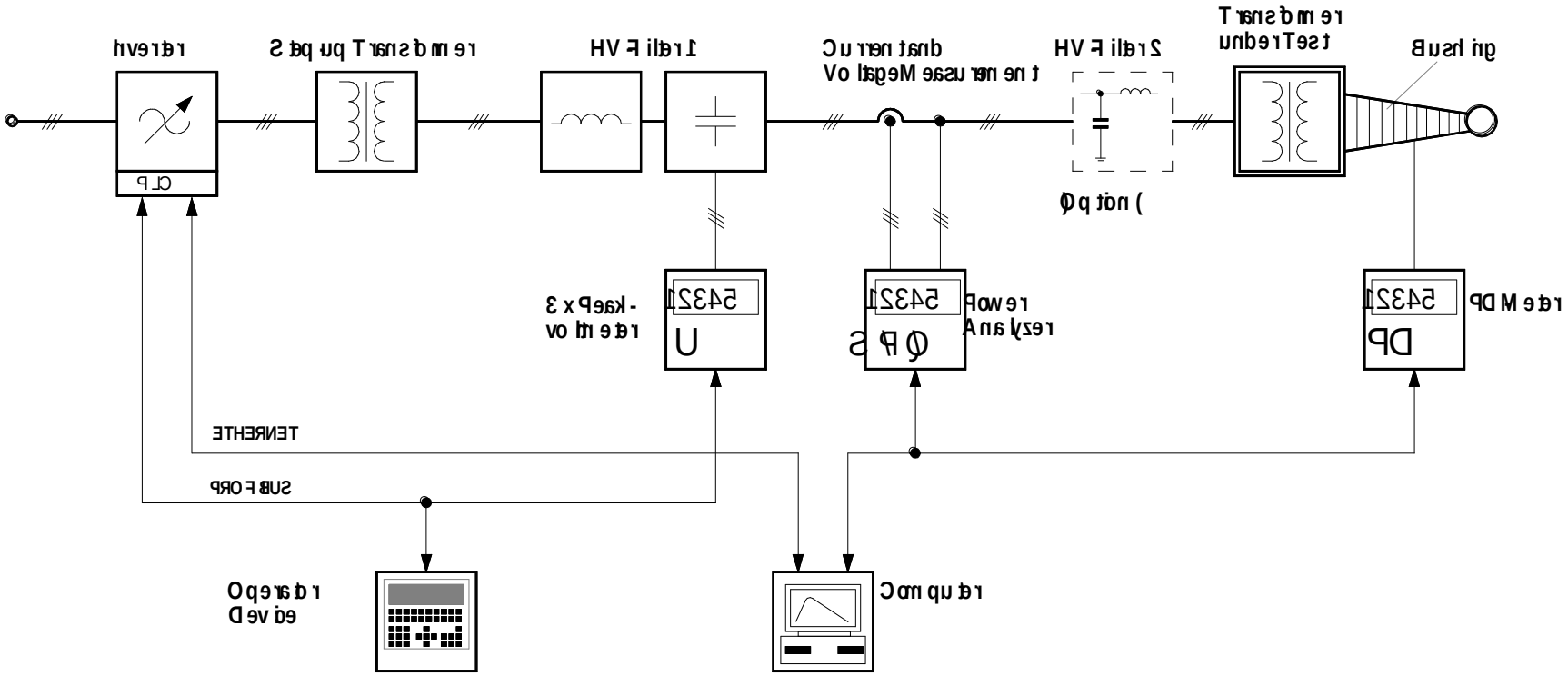
- Possibility to use a non fixed frequency for on-site testing
  IEC 60076-3 allows test frequencies at 80% of the rated frequency or higher

- The test system for the applied voltage test is an independent system which is based on the resonance effect:

$$f = \frac{1}{2\pi\sqrt{LC}}$$

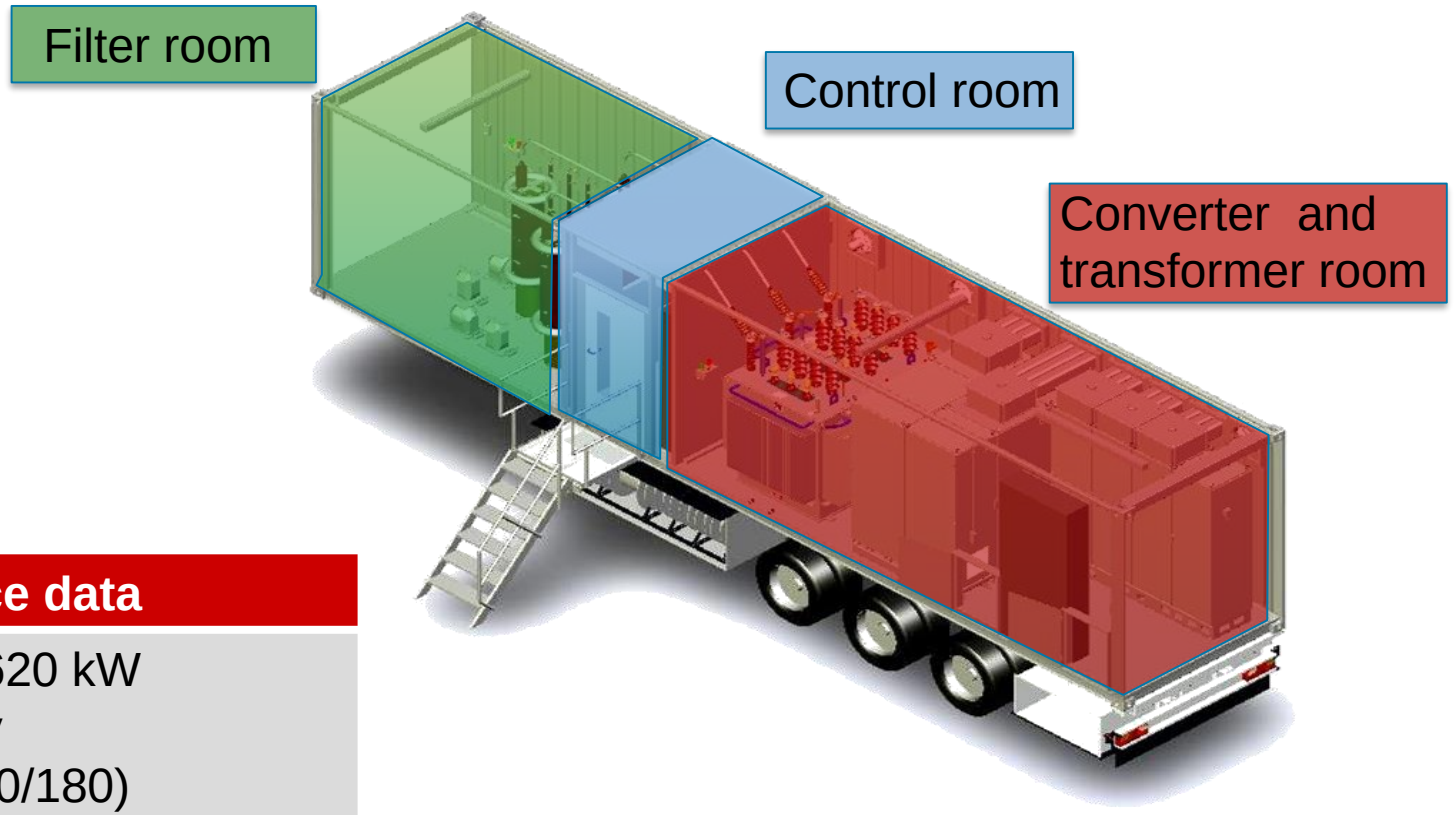
- The capacitance of the resonant circuit forms the transformer under test with its winding to winding and the winding to earth capacitances.

Mobile WV test systems



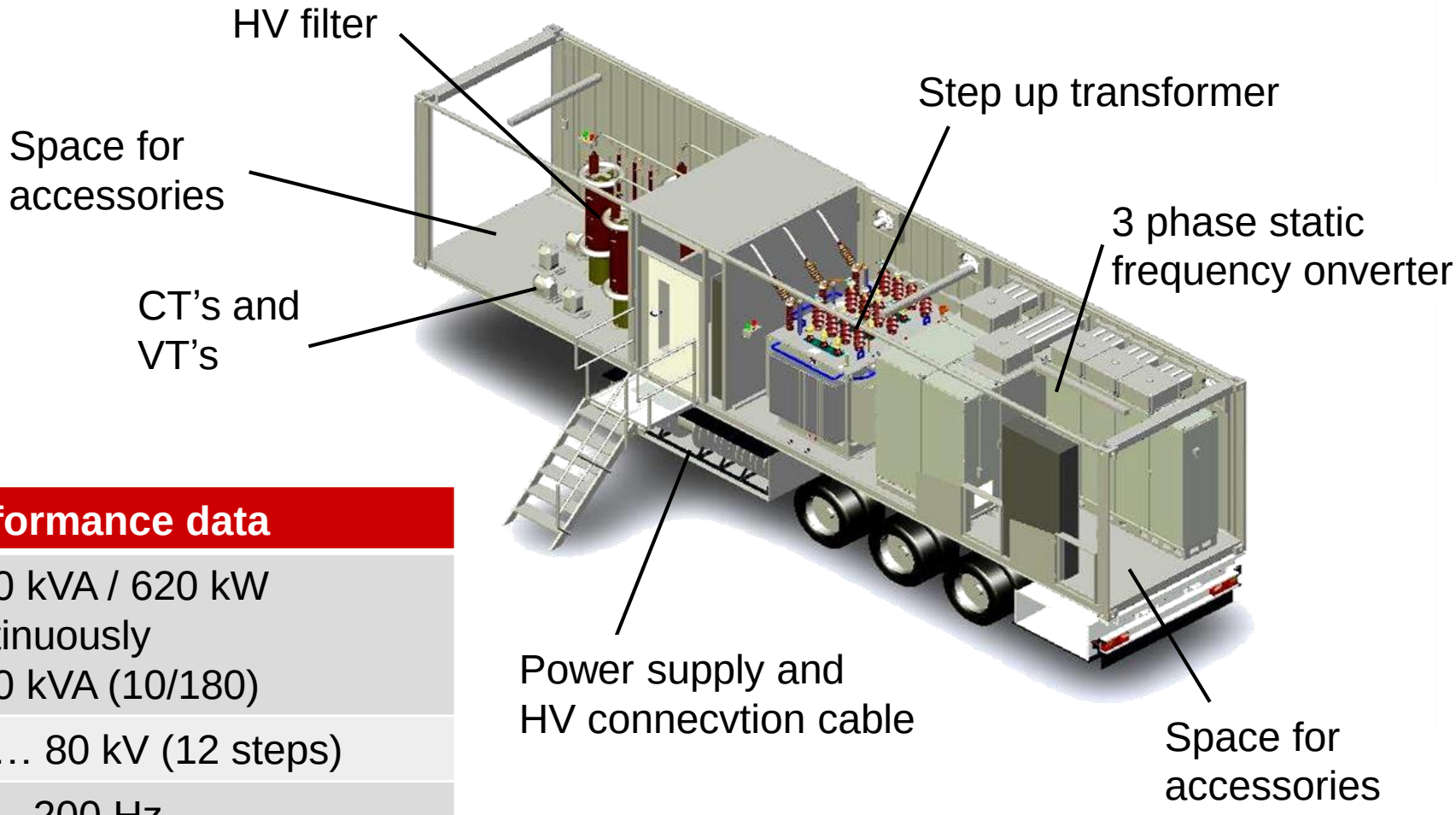
Test System Type WV 620-1000/80						
Active power	620 kW	Test	induced	no-load loss	load-loss	temp. rise
Apparent power	1000 kVA	Optional capacitive compensation	–	–	12 Mvar	12 Mvar
Max. output voltage	80 kV	Transformer to be tested	1000 MVA	500 MVA	100 MVA	80 MVA

Compact test facility in 40ft container



Performance data
1000 kVA / 620 kW continuously 1200 kVA (10/180)
8.9 … 80 kV (12 steps)
40 … 200 Hz

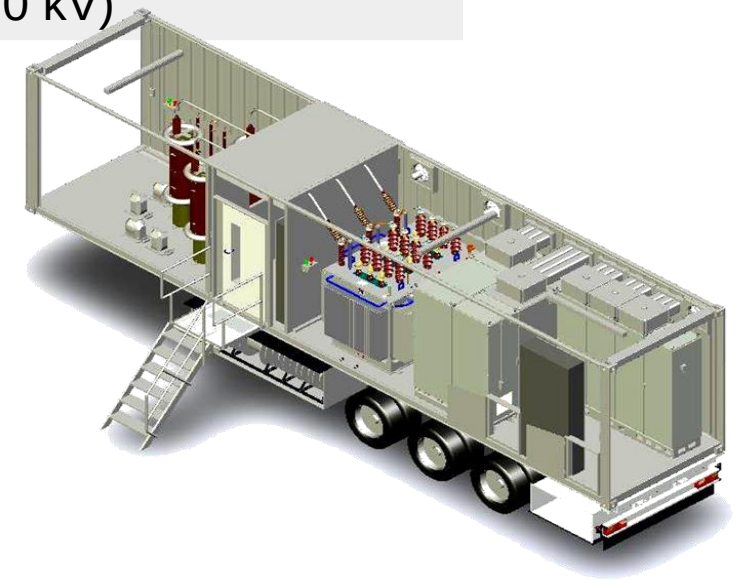
Compact test facility in 40ft container



Performance data
1000 kVA / 620 kW continuously 1200 kVA (10/180)
8.9 … 80 kV (12 steps)
40 … 200 Hz

Transformers to be tested

Test	WV 620-1000/80: Transformer data
No load losses test	350 MVA (500 MVA with THD > 5%)
Load losses / short-circuit test	30 MVA (100 MVA)
Induced voltage test	500 MVA (1200 MVA)
Applied voltage tests	360 kV (720 kV)



Transformers to be tested

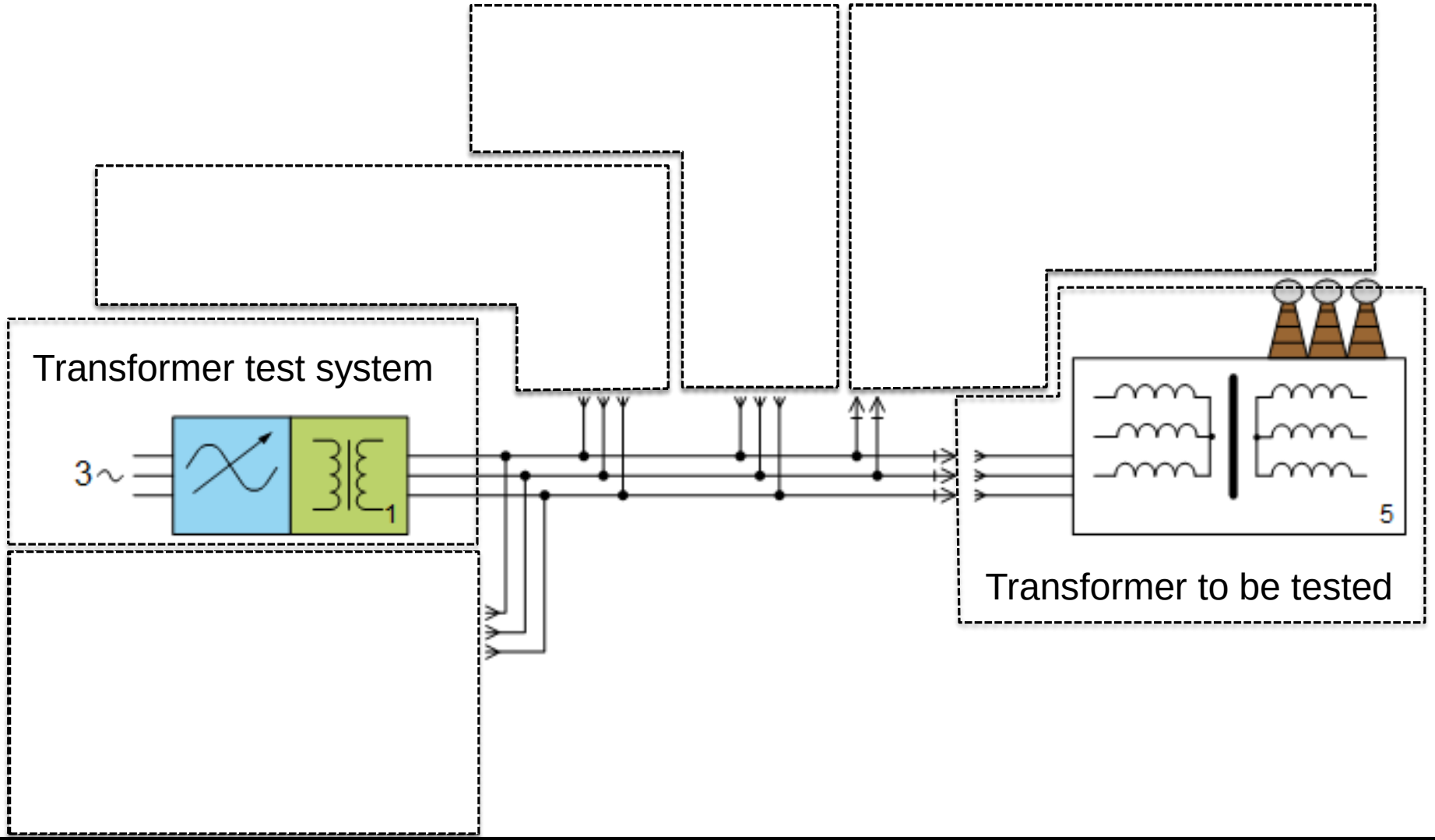
INTERNAL VIEW OF A MOBILE TRANSFORMER TEST SYSTEM

Step up transformer

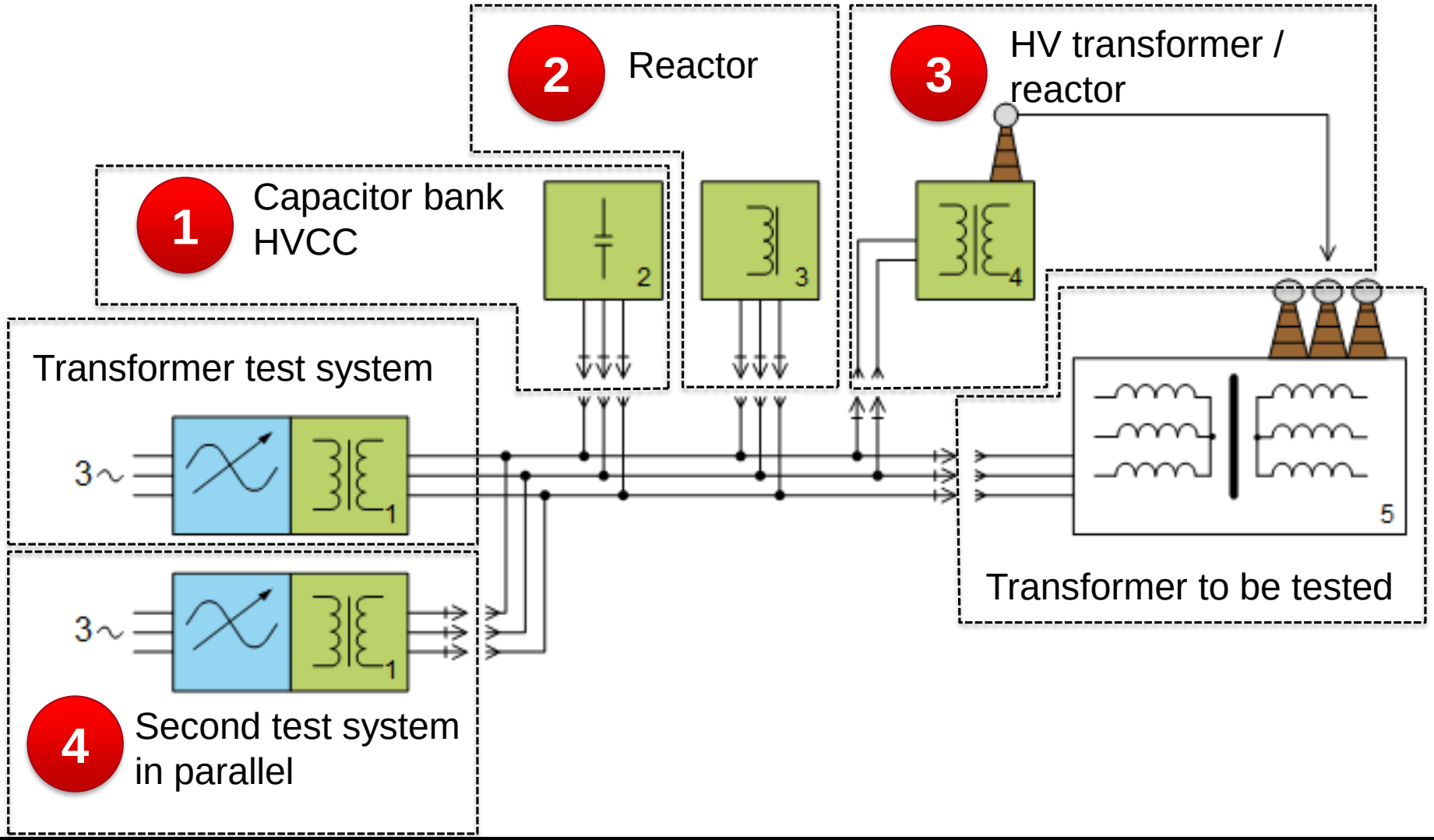
Control room

HV Filter

Possibilities for extension

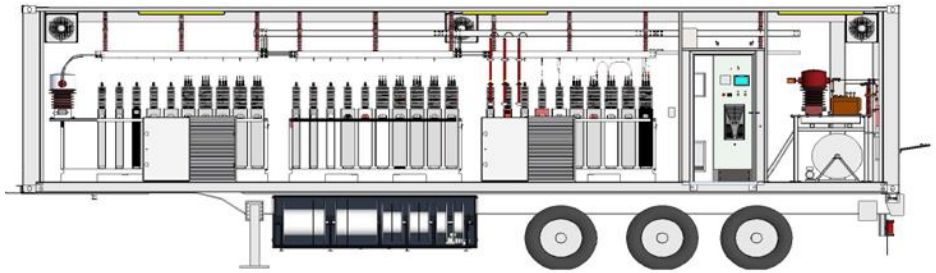


Possibilities for extension



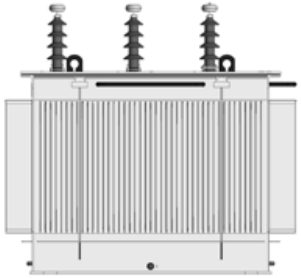
Possibilities for extension

1



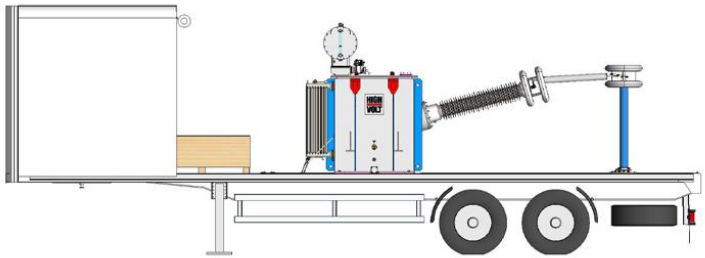
Capacitor bank
HVCC

2



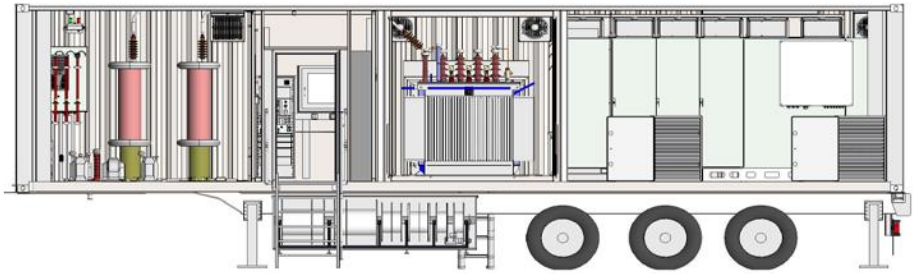
Reactor

3



HV transformer/reactor on a trailer

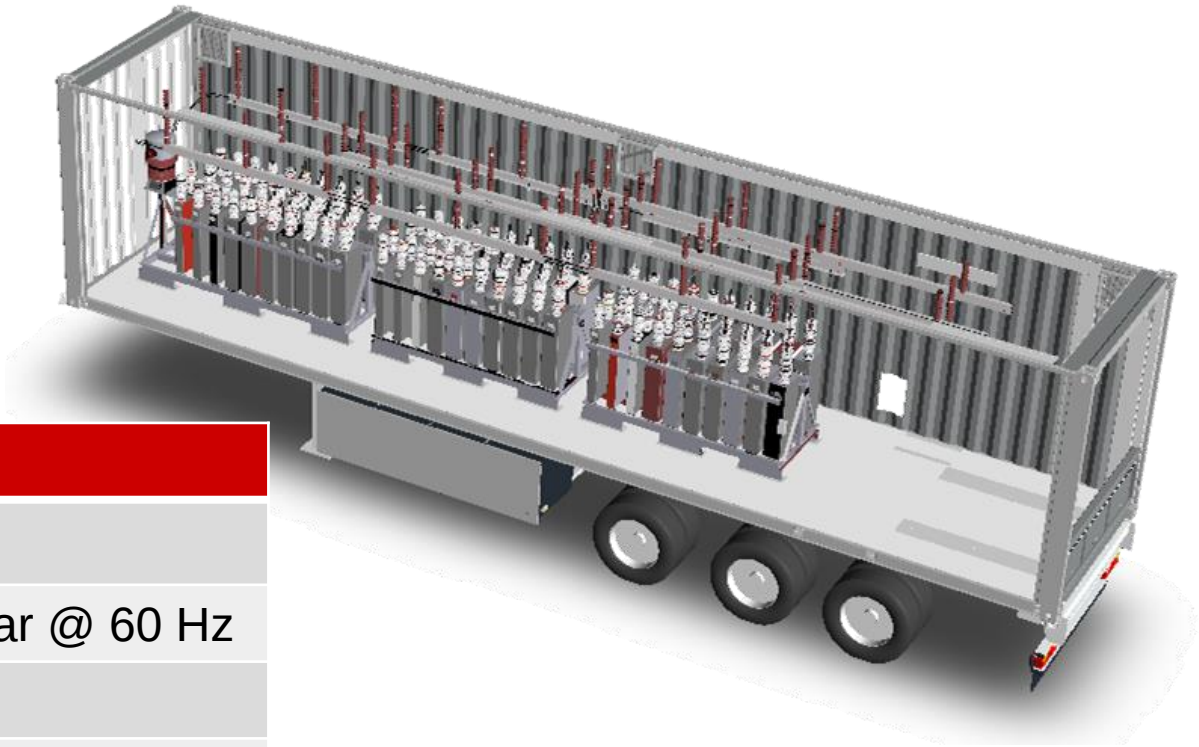
4



Second test system
in parallel

Mobile capacitor bank for load loss test

1



Parameters
Rated voltage: 36 kV
Rated Power: 24,000 kVar @ 60 Hz
3-phase
Unbalanced protection system
40 ft container
Load loss and short circuit tests up to 150 MVA

Mobile capacitor bank for load loss test

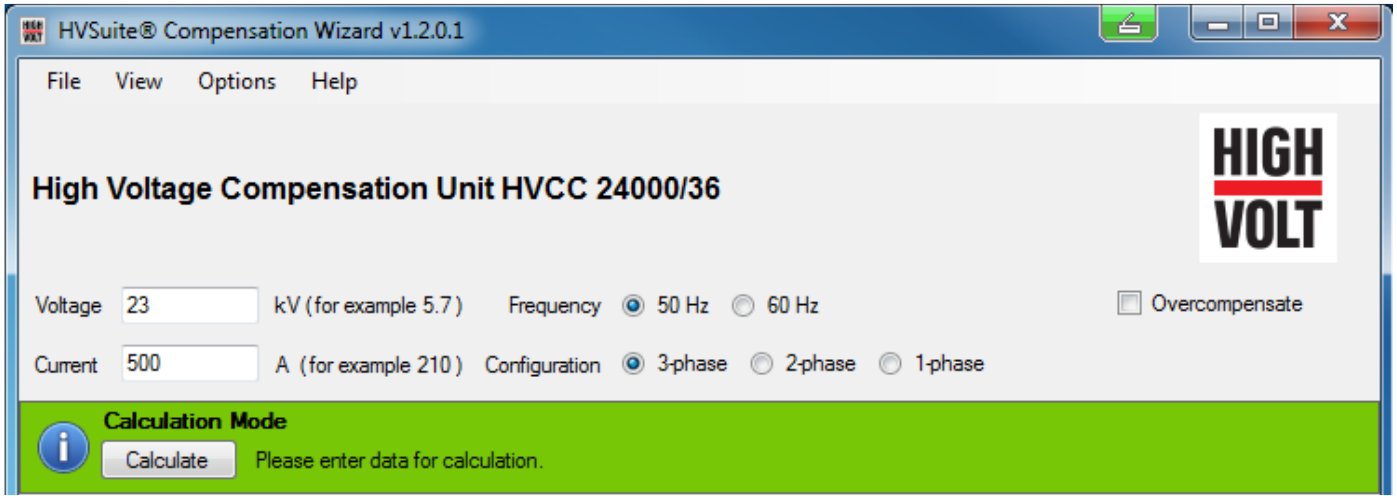
1

Interior view of
a capacitor bank

Mobile capacitor bank for load loss test

PARAMETRIZATION

- Easy manual operation (Multi-contact plug in system)
- Over 60 possible connections
- Operator has to calculate the suitable compensation power
- Parameterization tool: **HVSuite® Compensation Wizard**

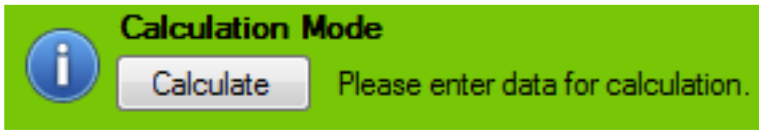


- Calculates the suitable configuration of the capacitor bank with 3 input values (voltage, current, frequency)

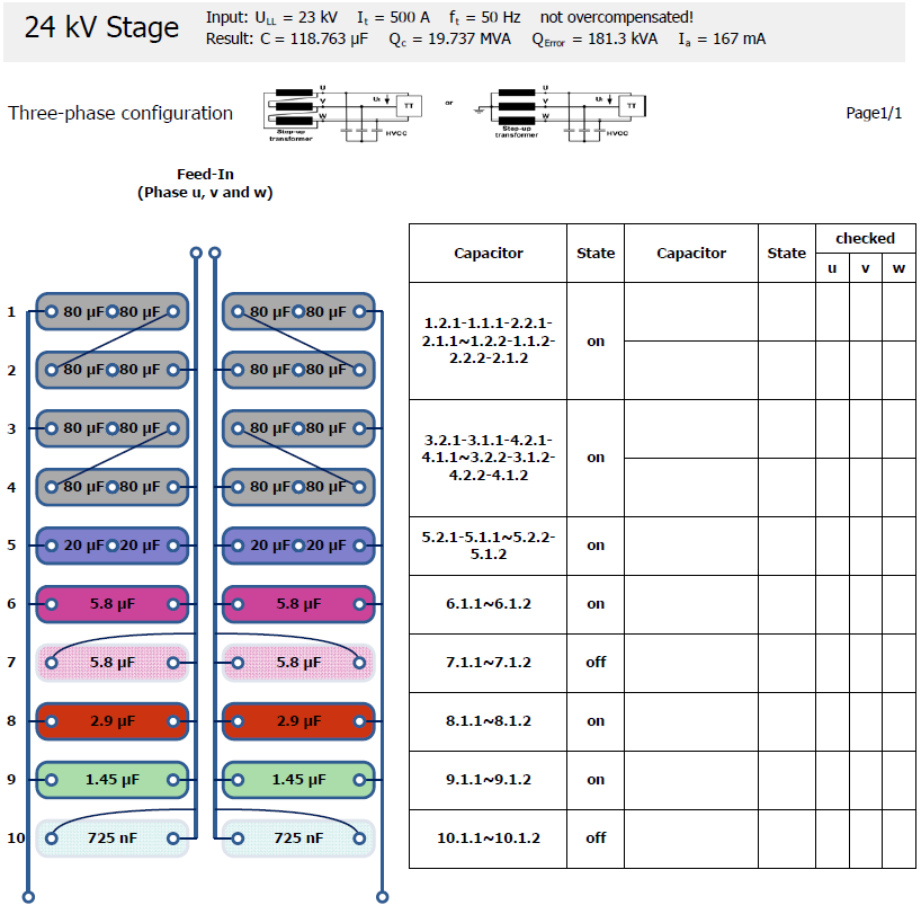
Mobile capacitor bank for load loss test

CLEAR CONFIGURATION SHEET

- HVSuite® Compensation Wizard



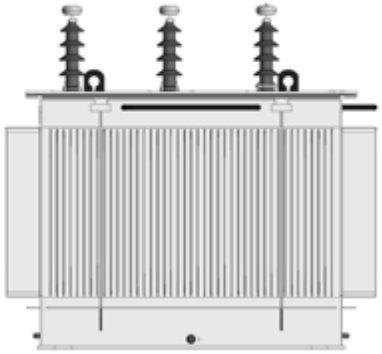
After Calculation the Software delivers a printable configuration sheet including max. compensation power, test set-up and configuration of the capacitor bank.



Capacitor	State	Capacitor	State	checked		
				u	v	w
1.2.1-1.1.1-2.2.1-2.1.1~1.2.2-1.1.2-2.2.2-2.1.2	on					
3.2.1-3.1.1-4.2.1-4.1.1~3.2.2-3.1.2-4.2.2-4.1.2	on					
5.2.1-5.1.1~5.2.2-5.1.2	on					
6.1.1~6.1.2	on					
7.1.1~7.1.2	off					
8.1.1~8.1.2	on					
9.1.1~9.1.2	on					
10.1.1~10.1.2	off					

Inductive compensating reactor

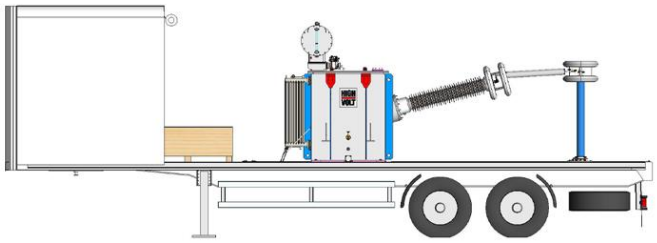
2



Parameters
Reactor 3~
Rated Power: 2 Mvar
Frequency: 120 Hz
System Power: ≤ 620 kW, ≤ **2870 kVA** ,
Continuous operation

Applied voltage test system

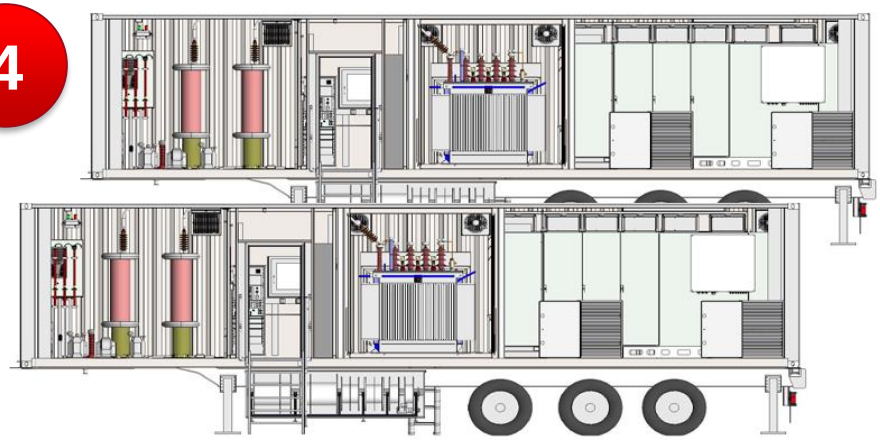
3



Parameters
Applied voltage 360 kV
With extension up to 720 kV
Load range: 5 … 40 nF
Variable test frequency: 40 … 200 Hz

Parallel connection of mobile test systems

4



Parameters
Two: 620 kW / 1 MVA test systems
Extended available test power:
≤ 1240 kW, ≤ **1760 kVA**
Continuous operation
Up to 3 in parallel operation

Case study

On-site testing of transformers

500 MVA, 1 phase

$410/\sqrt{3} - 27\text{kV}$

August 2011

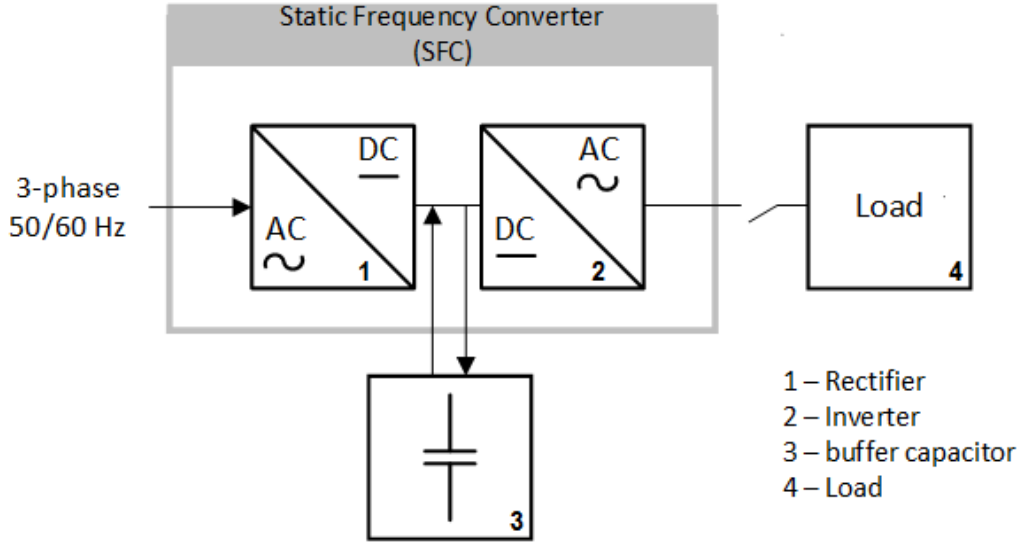
Test facility (container) and generator set

Test facility (container) with test objects and power plant

Technical background

SFC AS A POWER SOURCE

- Electronic devices as main components
- Output voltages with adjustable amplitudes and frequencies
- modular design of the power source, easily extendable

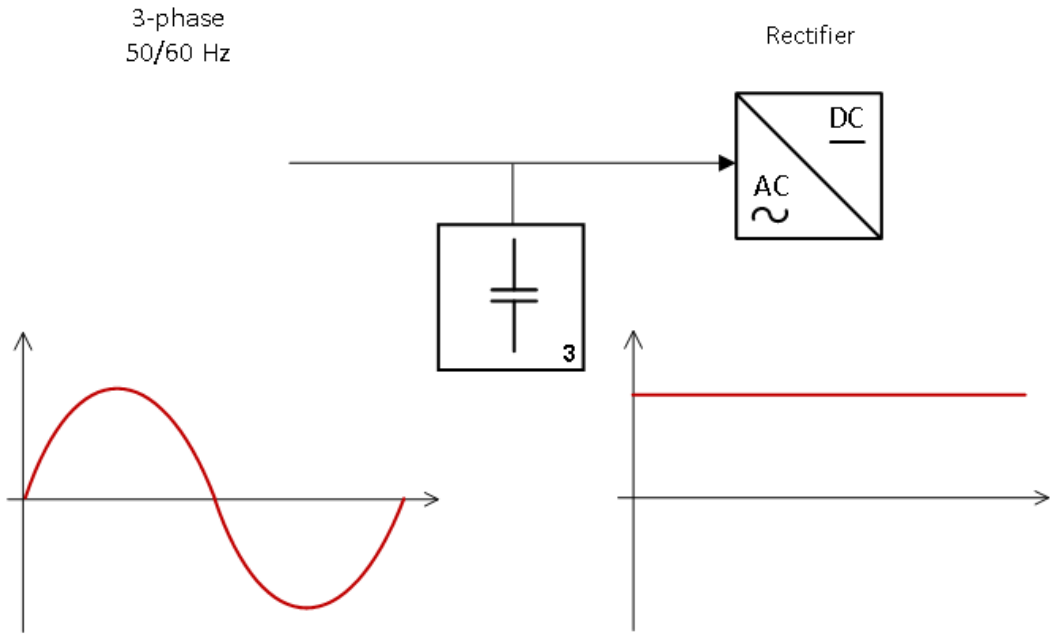


Technical background

SFC AS A POWER SOURCE

Step 1:

- Rectifying the AC-voltage

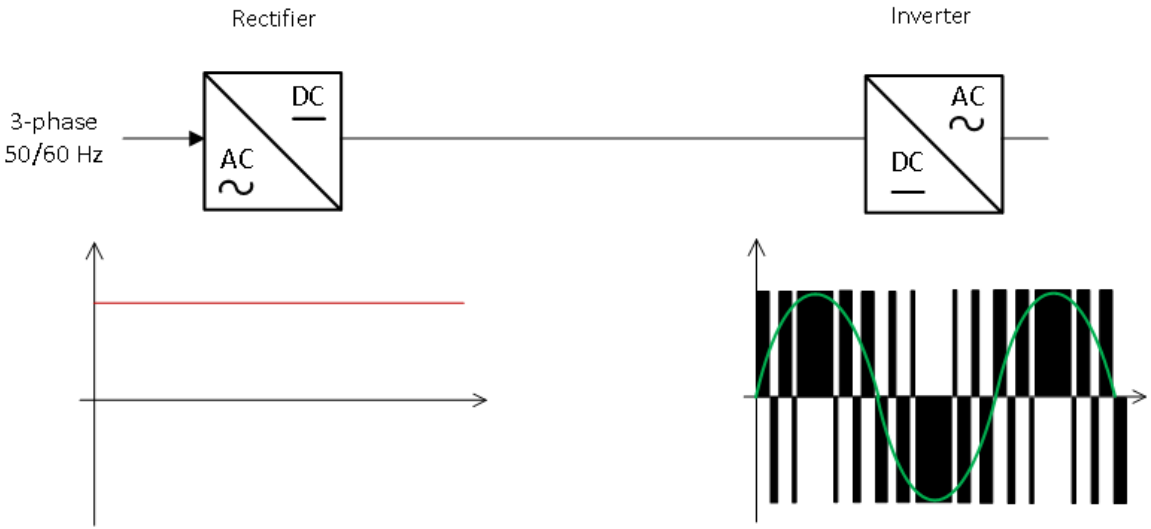


Technical background

SFC AS A POWER SOURCE

Step 2:

- Voltage conversion to a pulse-width modulated (PWM) voltage

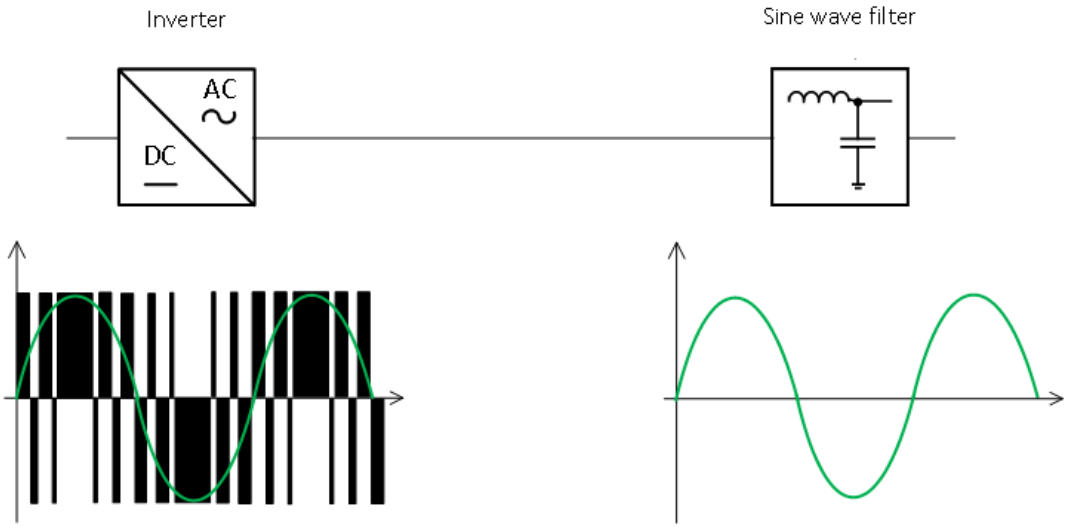


Technical background

SFC AS A POWER SOURCE

Step 3:

- Filtering the ground wave (THD ≤ 5%)

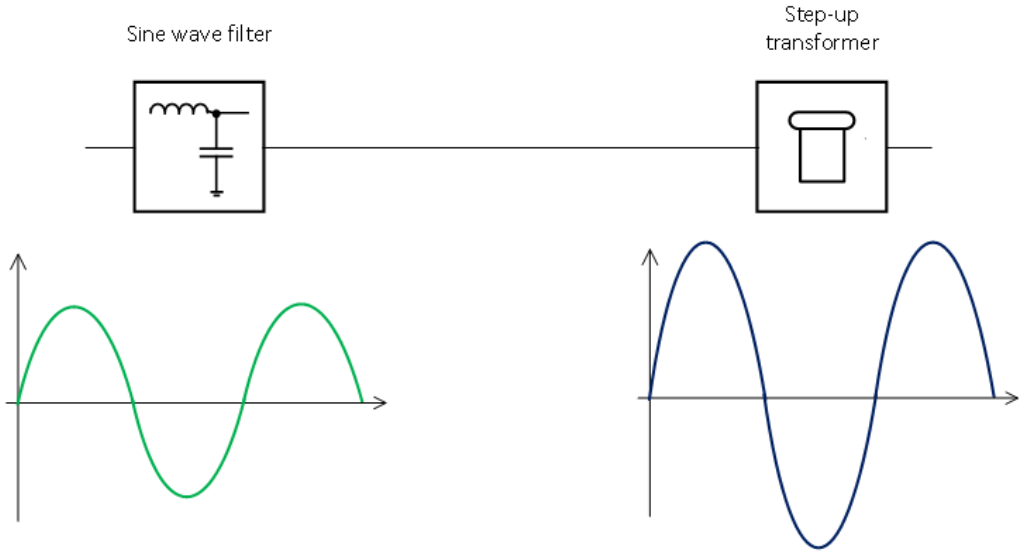


Technical background

SFC AS A POWER SOURCE

Step 4:

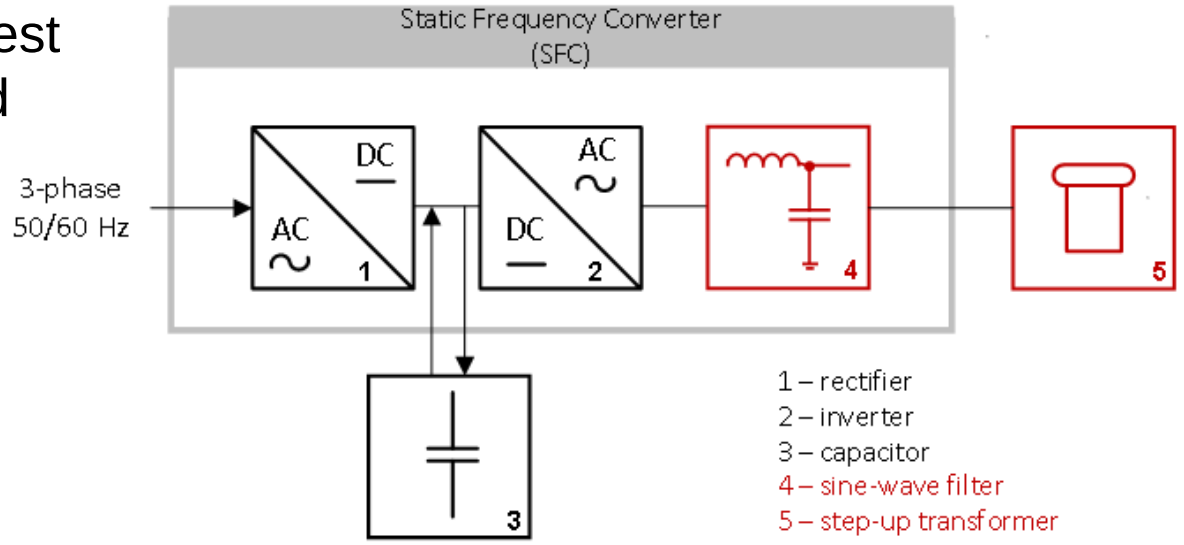
- Transforming the ground sine wave to the test voltage level



Technical background

SFC AS A POWER SOURCE

- Provision of a stable test current with minimized harmonic distortions
- Special attention on effective filtering and appropriate sampling



Summary

Quality assurance of power transformers today:

- Permanent condition monitoring (on-line monitoring)
- Off-line on-site diagnostics
- Basis to guarantee a high service security

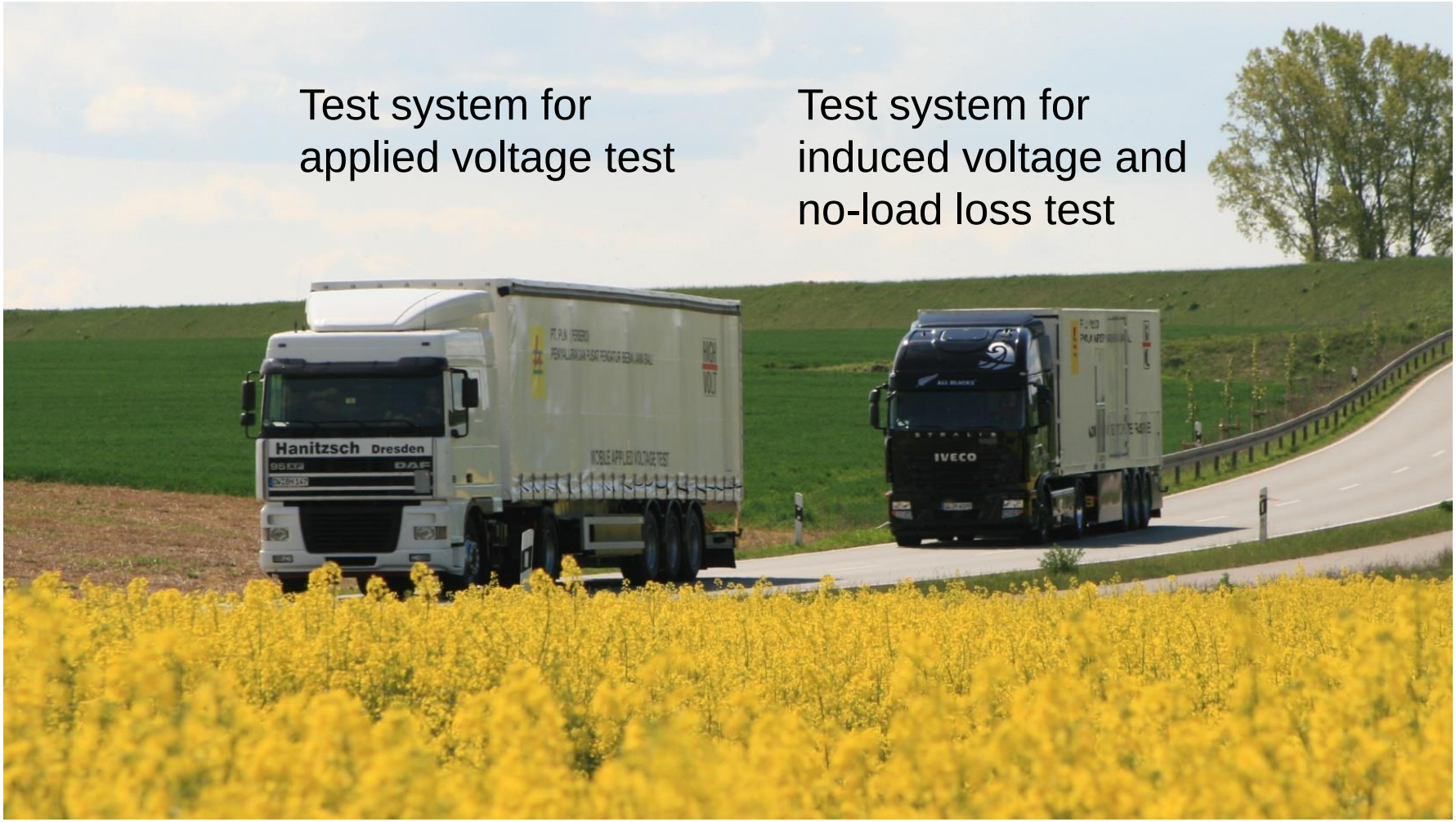
Mobile transformer test system:

- Induced voltage (with PD)
- Load and no-load tests
- Applied voltage tests

Test parameters:

- Power transformers up to 1200 MVA
- According to IEC and IEEE standards
- Waveform distortion THD < 5%
- Free adjustable frequency 40 to 200 Hz

Ready to go on-site



YOUR COMMENTS AND QUESTIONS.