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CONFERENCE

## Fleet Management – spending your service budget on the right assets

### Dan Keller, Highvolt Germany



Dan Keller studied and graduated from University of Cooperative Education (Bautzen) with a Dipl.-Ing. (BA) in electrical engineering.

He joined the HIGHVOLT Prüftechnik Dresden GmbH control department in 2009 as a design engineer. Since 2011 he works as Area Sales Manager and is responsible for U.A.E., Kuwait, Qatar, Bahrain, Egypt, Poland, Czech Republic and Italy.





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## Fleet Management – spending your service budget on the right assets

**HIGH  
VOLT**  
Test with the best.

### A NEW GENERATION OF A LOSS MEASURING SYSTEM FOR POWER TRANSFORMERS

**Dan Keller**  
HIGHVOLT Prüftechnik Dresden GmbH



# Fleet Management – spending your service budget on the right assets

## Content



- Information about HIGHVOLT
- Introduction to loss measurements
- Test set-up of loss measurement devices
- Comparison of different solutions
- Mobile Loss Measurement Calibration
- Summary

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## Test Systems for HV Transformers



Factory test systems



On-site test systems



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## Introduction to Loss Measurements



- Tests are carried out to show that equipment under test meets customer requirements and specifications
- Tests are part of quality assurance
- Routine tests are carried out with every individual product, type test are carried out with a representative sample
- IEC and IEEE standards for transformer test require the determination of load loss and no-load loss as routine tests
- Test equipment for loss measurements is established and well known
- There is a new device for loss measurements by HIGHVOLT

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## No-Load Loss Measurement of Transformer



- **Purpose:**
  - during life-time a transformer consumes a considerable amount of energy due to losses in iron and in windings
  - the losses have to be guaranteed by the manufacturer, a correct value is very important
- **Standards:**
  - IEC 60076-1:2011, clause: 10.1: “General requirement for routine, type and special tests”, clause 10.5: “Measurement of no-load loss and current”
  - IEC 60076-8:1997, clause: 10: “Guide to the measurement of losses in power transformers”
  - IEEE Std C57.12.90-1999, clause: 8: “No-load losses and excitation current”

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## Load Loss Measurement of Transformer



- **Purpose:**
  - during life-time a transformer consumes a considerable amount of energy due to losses in windings and in iron
  - information about losses is important for safe operation and lost resources
  - the losses have to be guaranteed by the manufacturer, a correct value is very important
- **Standards:**
  - IEC 60076-1:2011, clause 10.1: “General requirement for routine, type and special tests”, clause 10.4: “Measurement of short-circuit impedance and load loss”
  - IEC 60076-8:1997, clause: 10: “Guide to the measurement of losses in power transformers”
  - IEEE Std C57.12.90-1999, clause 9: “Load losses and impedance voltage”

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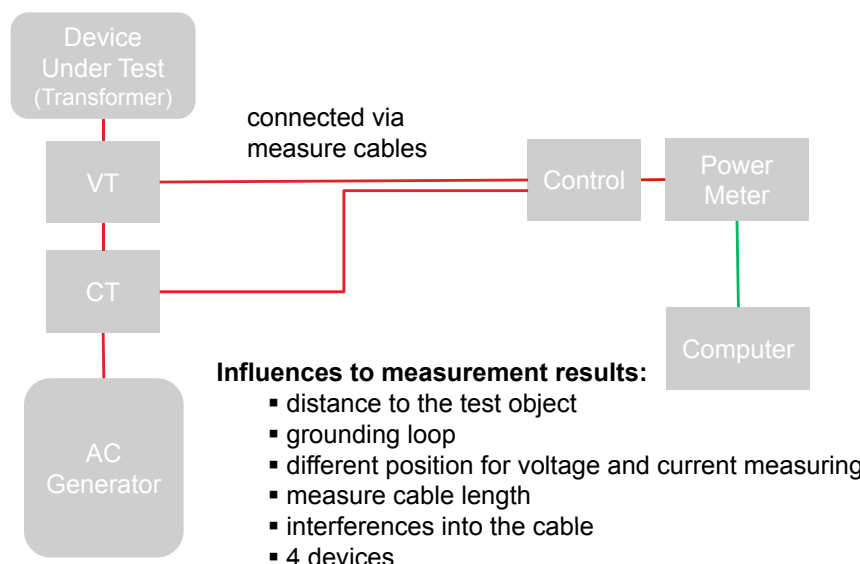


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## Typical Test Set-up of Loss Measurement Devices (Single Phase)



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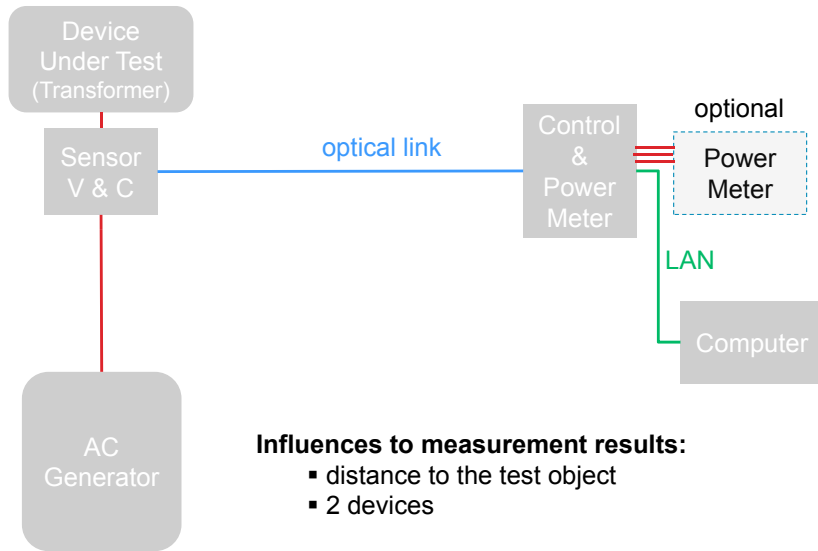
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## Test Set-up of **New** Loss Measurement Devices (Single Phase)

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### Influences to measurement results:

- distance to the test object
- 2 devices

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## LiMOS 2000/100 or 4000/200 by HIGHVOLT Loss Measurement Device

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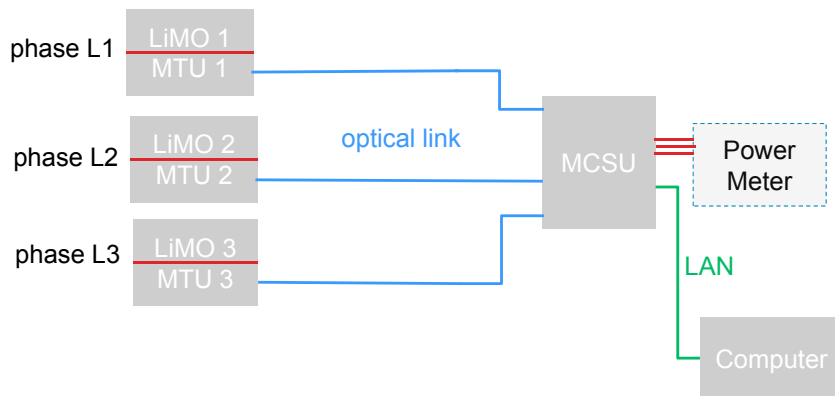
## 3 Phase Loss Measurement Device - LiMOS

**HIGH  
VOLT**

### SIMPLIFIED SKETCH

sensors + electronic  
(current /voltage)

control & power meter



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## LiMO - Sensor Principle

Loss Measurement Device

**HIGH  
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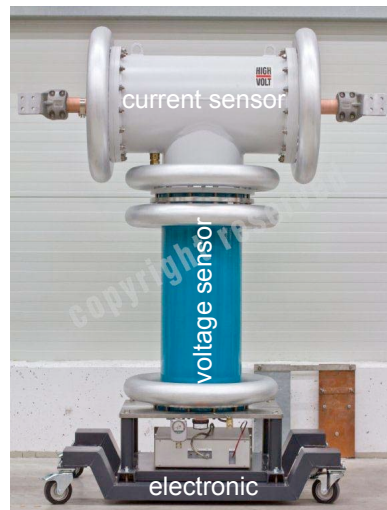
LiMO (sensors)

- inductive current sensor
- capacitive voltage sensor

LiMO-MTU (electronic)

- amplifier
- analog digital converter
- reference voltage
- controller
- interface
- self test

MTU = Measuring and  
Transmission Unit



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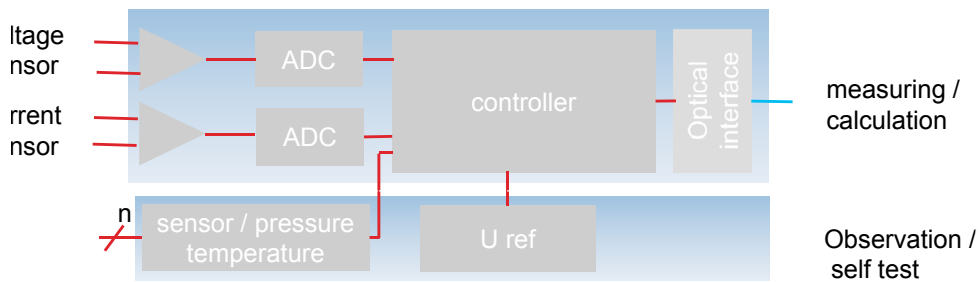
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## LiMO – MTU Sensor Electronic

Loss Measurement Device

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### SIMPLIFIED SKETCH



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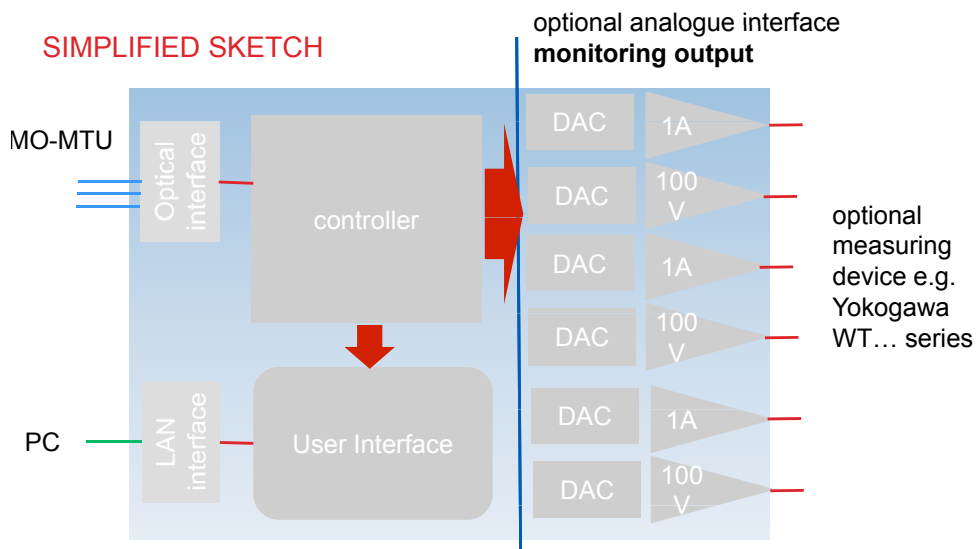
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## LiMO – MCSU Evaluation Electronic

Loss Measurement Device

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VOLT**

### SIMPLIFIED SKETCH



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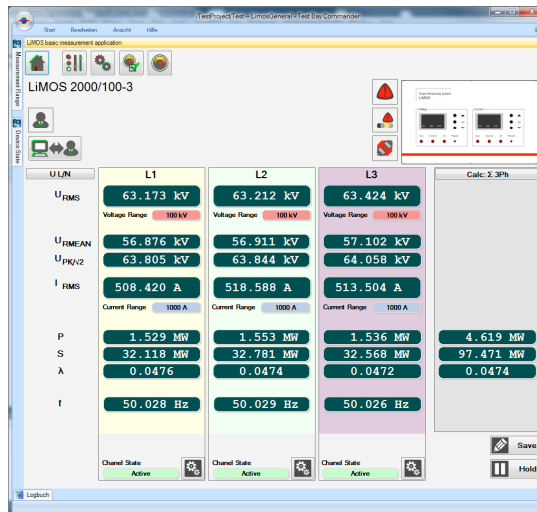
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## iMOS - Software Loss Measurement Device

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**Features:**

- device operation control incl. measurement range control and status messages
- processing and visualization of measured values
- capable of multi channel data processing if used with multi phase systems



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## LiMOS 2000/100 Technical Data and Accuracy Loss Measurement Device

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**Voltage Measurement:**

Primary voltage kV 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100  
Accuracy class % 0.08

**Current Measurement:**

Primary current A 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000  
Accuracy class % 0.08

**Power Measurement:**

Power factor	Accuracy
cos φ = 1	0.11 %
cos φ = 0.1	0.13 %
cos φ = 0.05	0.19 %
cos φ = 0.01	0.87 %
cos φ = 0.008	1.10 %

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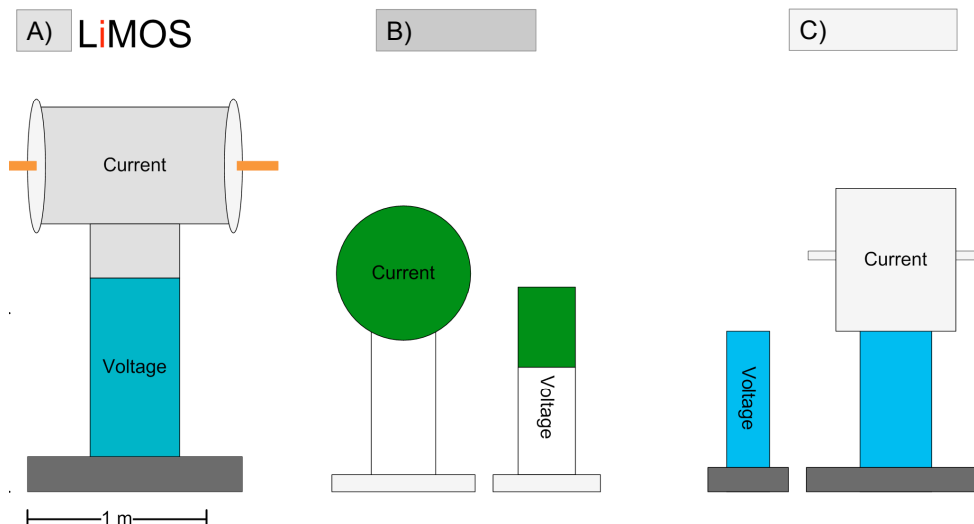
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## Comparison of Different Solutions HV Components - Size per Phase

**HIGH  
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### SIMPLIFIED SKETCH



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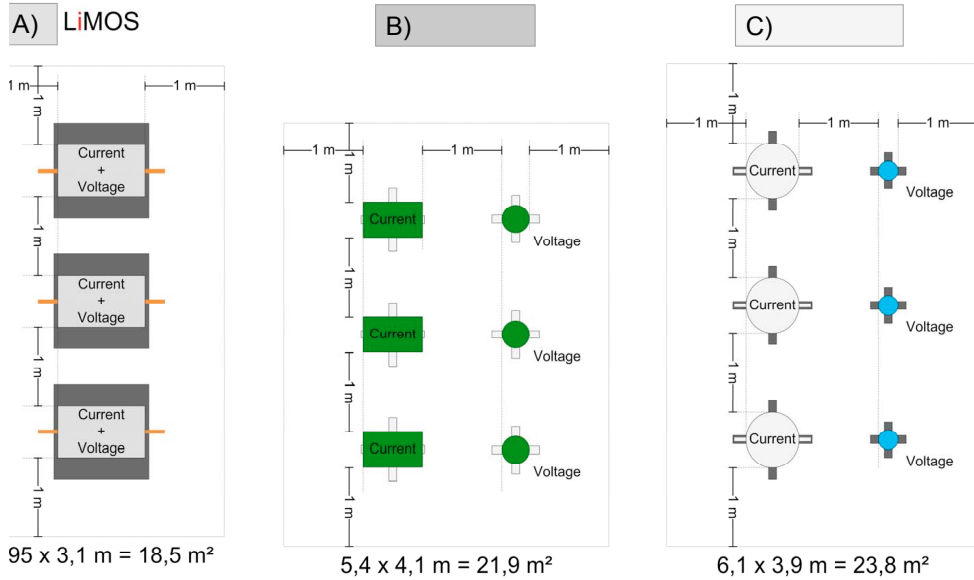
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## Comparison of Different Solutions HV Components - Layout

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VOLT**

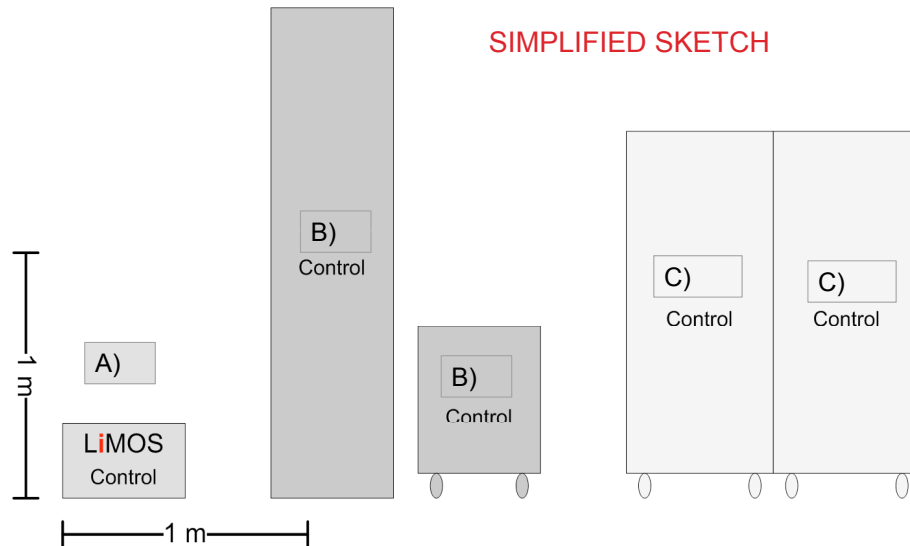


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## Comparison of Different Solutions Sizes of Control Units for 3 Phases

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## Comparison of Different Solutions Control and Measurement

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A) HIGHVOLT LiMOS 2000-100	B) 2000A/100kV Competitor	C) 2000A/100kV Competitor
0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100 kV manual or auto-range	0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100 kV	1, 2, 5, 10, 20, 50, 100 kV
1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000 A manual or auto-range	1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000 A	one CT range 2000 : 1 current measurement ranges of the wattmeter's: 5, 2, 1, 0.5, 0.2, 0.1, 0.05, 0.02, 0.01, 0.005 A
<b>Included</b> iMOS Software (optional additional Yokogawa WT3000)	Fluke Norma 5000 or Yokogawa WT3000	3 wattmeters by MI

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## LiMOS 2000/100 by HIGHVOLT

At a glance

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- Ethernet optical link to connect the measuring system to a HIGHVOLT test system
  - supports automatic control
  - is easy to handle
  - allows automatic safety procedures, e.g. emergency off in case of over temperature or over pressure
  - reduces influences of cable impedances, interferences or noise on measured values substantially
  
- One HV device for current and voltage
  - saves space
  - is easy to connect
  - is easy to calibrate



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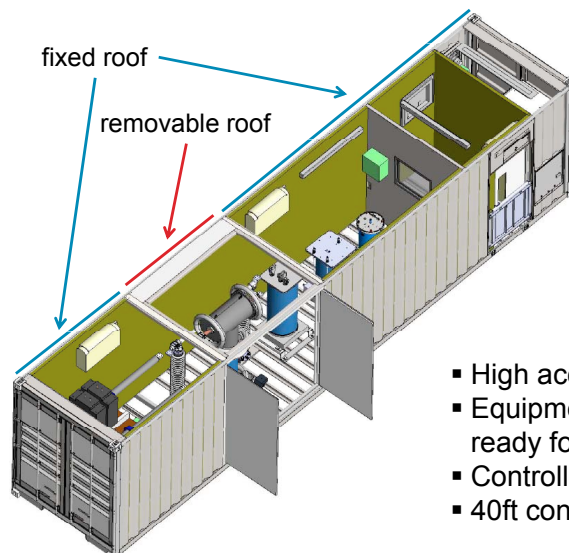


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## LiMOS – calibration (Service from HIGHVOLT)



- High accuracy
- Equipment completely installed and ready for operation within 2h
- Controlled environmental conditions
- 40ft container for road transport

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## SUMMARY



- Common standards require the determination of losses
- HIGHVOLT introduced a new device that can measure power, voltage and current with high accuracy and little space requirements
- Physical quantities are measured close to the sensor and transmitted via optical link
- Measured values can be handed out digital or analog
- The device can be traceably calibrated against national standards for power directly in addition to voltage and current
- Procedures in test bays can be considerably simplified due to remote measurement range control of sensors
- Appropriate software for automatic device control and test
- If designed as multi channel device with relevant data processing it can be used in multi-phase systems

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## YOUR COMMENTS AND QUESTIONS

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## APPENDIX

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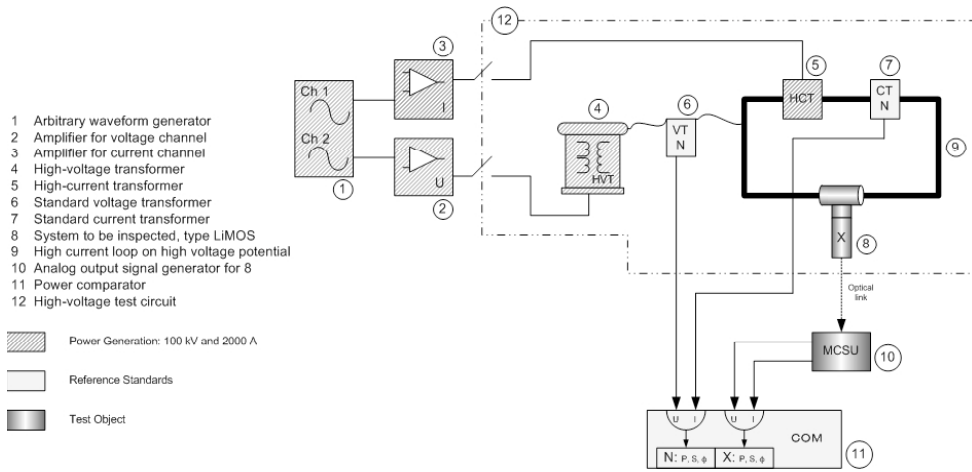
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## Mobile Loss Measurement Calibration Laboratory

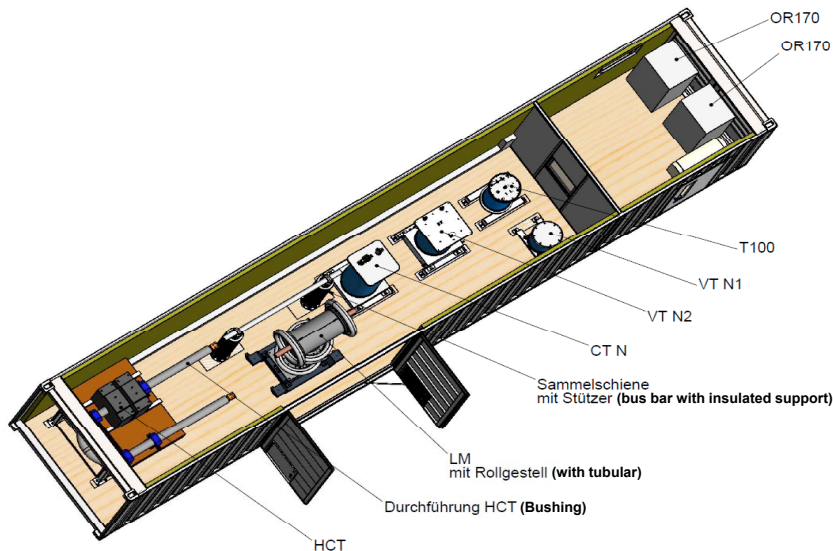
**HIGH  
VOLT**

### LOSS MEASUREMENT



## Mobile Loss Measurement Calibration Test Field

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## Results from the calibration of the mobile loss calibration test field

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VOLT**

PERFORMED BY SP (SWEDISH NATIONAL LABORATORY)



**KALIBRERINGSBEVIS**

utfärdad av RIM001025 01  
CALIBRATION CERTIFICATE issued by a Swedish National Laboratory  
Client person: Allan Bergman  
Microservices Technology  
+46 10 516 54 98  
allan.bergman@sp.se  
Date: 2013-01-09  
revision: MTePX28712-K01 Rev.1

RMP  
01

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Quantity	Expanded uncertainty range	
	from	to
active power at 50 Hz	± 0.011 %	± 0.03 %
active power at 60 Hz	± 0.011 %	± 0.019 %
voltage at 50 Hz	± 0.011 %	± 0.014 %
voltage at 60 Hz	± 0.011 %	± 0.013 %
current at 50 Hz	± 0.021 %	± 0.03 %
current at 60 Hz	± 0.021 %	± 0.03 %

for active power **0.036 %**

for RMS-value of voltage **0.023 %**

for RMS-value of current **0.033 %**

## LiMOS Calibration

**HIGH  
VOLT**

Calibration Certificate K 1255

**HIGH  
VOLT**

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Calibration object:	Channel 1 of the power measurement system Type: LIMOS 2000/100-3 Serial no.: 909613 consisting of - LIMO Type: 2000/100 Serial no.: P0181000-7 - LIMO-MTU Type: 2000/100 Serial no.: MTU12-52476242-1 - LIMO-MCSU Type: A 2000/100-3 Serial no.: MCSU12-52476242 Channel: 1
Manufacturer:	HIGHVOLT Prüftechnik Dresden GmbH
Customer:	[REDACTED]
HIGHVOLT oder no.:	[REDACTED]
Place of calibration:	Hightvolt Prüftechnik Dresden GmbH
Date of calibration:	2012-10-29
Issue date of calibration certificate:	2012-12-04
Atmospheric conditions:	Temperature: 24.3 °C, rel. humidity: 50.2 %
Register No.:	K 1255

