New Methods for Non-intrusive On-site Testing of Gas-insulated Switchgear

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New Methods for Non-intrusive On-site Testing of GIS

- Voltage withstand testing with portable resonance test system
- Current transformer demagnetization from primary side
- Timing test with both sides grounded

Requirements according IEC62271-203

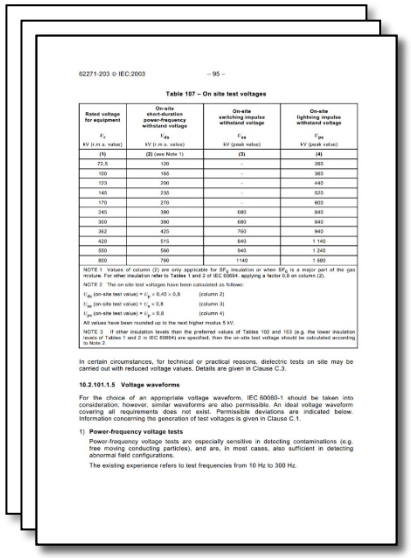
Voltage withstand test

> The GIS shall be installed completely and gas filled at its rated filling density.

> Every newly installed part of the GIS shall be subjected to a dielectric test on site.

Partial discharge test

> Dielectric test performed as type test shall be followed by a partial discharge measurement



62271-203 © IEC:2003 – 95 –

Table 107 – On site test voltages

Rated voltage for equipment U_r kV (r.m.s. value)	On-site short-duration power-frequency withstand voltage U_{ps} kV (r.m.s. value)	On-site switching impulse withstand voltage U_{ps} kV (peak value)	On-site lightning impulse withstand voltage U_{pl} kV (peak value)
(1)	(2) (see Note 1)	(3)	(4)
72,5	120	–	360
100	165	–	360
123	200	–	440
145	235	–	520
170	270	–	600
245	380	680	840
300	380	680	840
362	425	760	940
420	510	840	1 140
550	590	940	1 240
800	790	1 140	1 550

NOTE 1 Values of column (2) are only applicable for SF_6 insulation or when SF_6 is a major part of the gas mixture. For other insulation refer to Tables 1 and 2 of IEC 60694, applying a factor 0,8 on column (2).

NOTE 2 The on-site test voltages have been calculated as follows:

U_{ps} (on-site test value) = $U_r \times 0,45 + 0,5$ (column 3)

U_{ps} (on-site test value) = $U_r \times 0,8$ (column 3)

U_{pl} (on-site test value) = $U_r \times 0,8$ (column 4)

All values have been rounded up to the next higher modus 5 kV.

NOTE 3 If other insulation levels than the preferred values of Tables 100 and 103 (e.g. the lower insulation levels of Tables 1 and 2 in IEC 60694) are specified, then the on-site test voltage should be calculated according to Note 2.

In certain circumstances, for technical or practical reasons, dielectric tests on site may be carried out with reduced voltage values. Details are given in Clause C.3.

10.2.101.1.5 Voltage waveforms

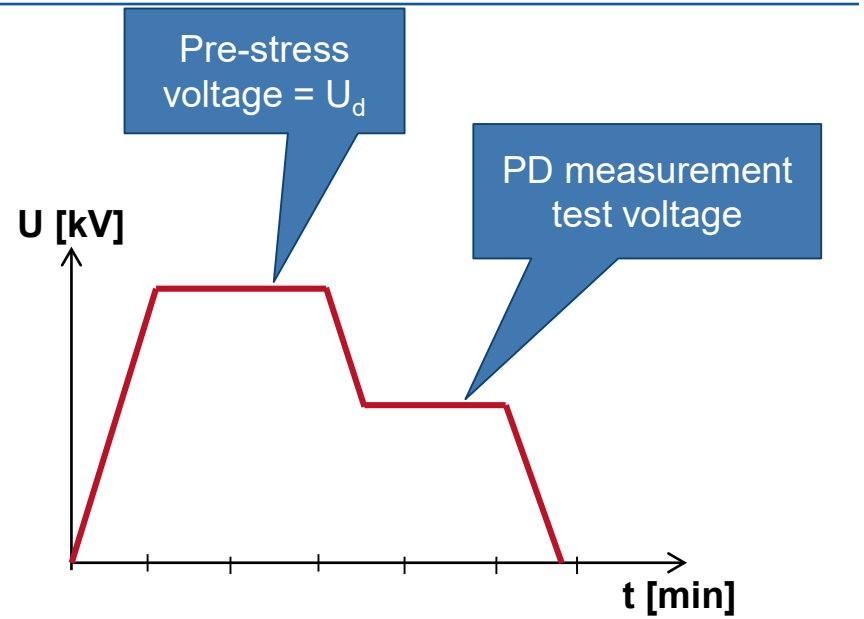
For the choice of an appropriate voltage waveform, IEC 60060-1 should be taken into consideration; however, similar waveforms are also permissible. An ideal voltage waveform covering all requirements does not exist. Permissible deviations are indicated below. Information concerning the generation of test voltages is given in Clause C.1.

1) **Power-frequency voltage tests**

Power-frequency voltage tests are especially sensitive in detecting contaminations (e.g. free moving conducting particles), and are, in most cases, also sufficient in detecting abnormal field configurations.

The existing experience refers to test frequencies from 16 Hz to 300 Hz.

Rated voltage GIS [kVrms]	On-Site withstand voltage (U_d)	PD measurement test voltage
72,5	120	87
100	165	120
123	200	148
145	235	174



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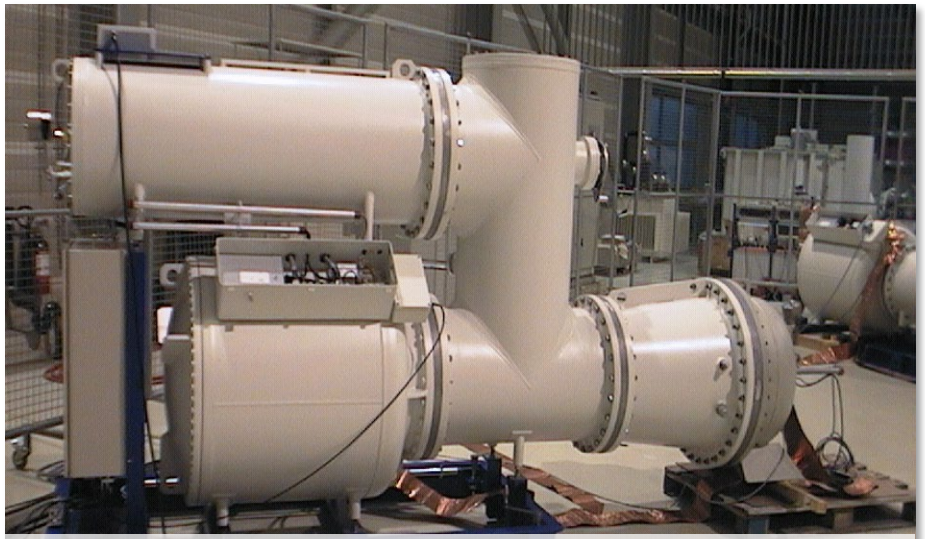
Conventional testing up to now

- High purchase cost
- Heavy and huge components
- High effort for transport and handling
- Expensive
- Time consuming venting and refilling necessary

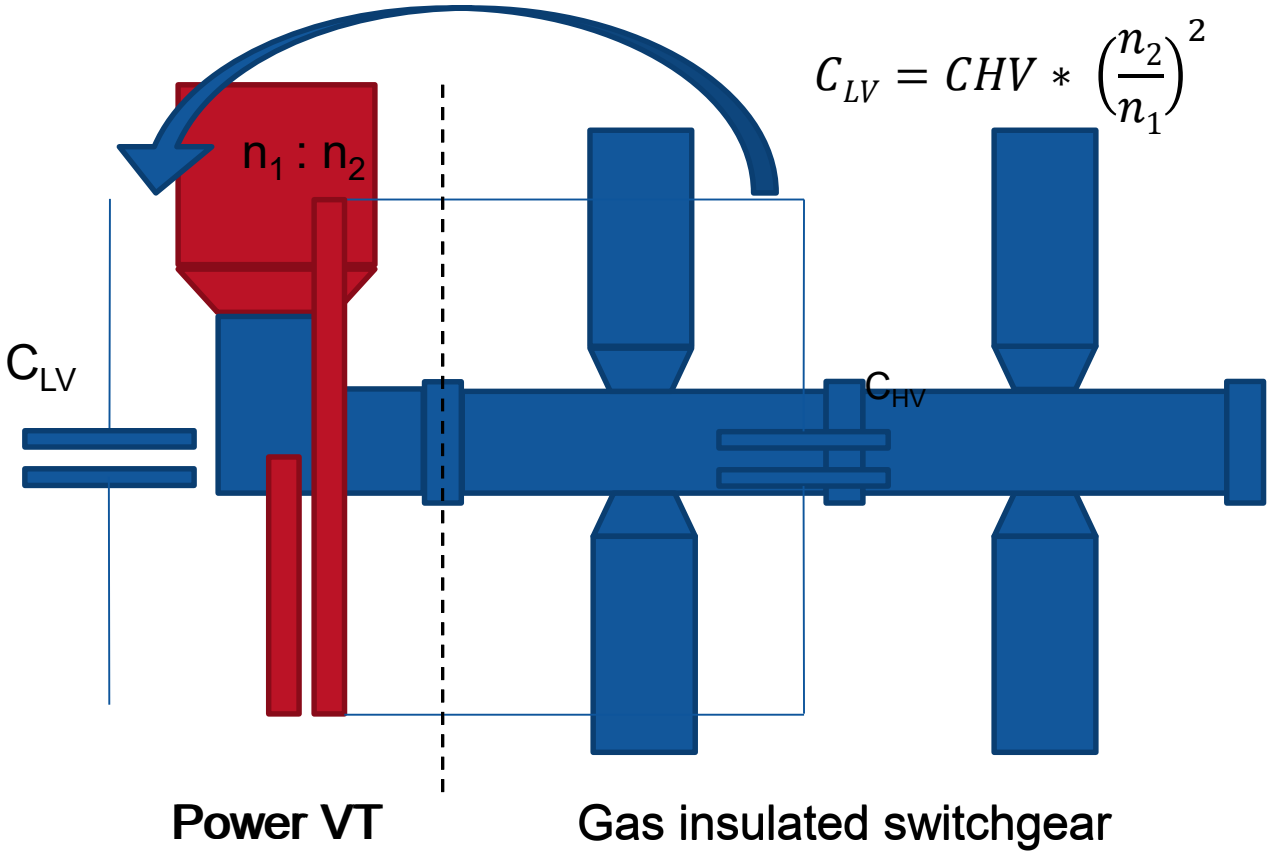
- High output power

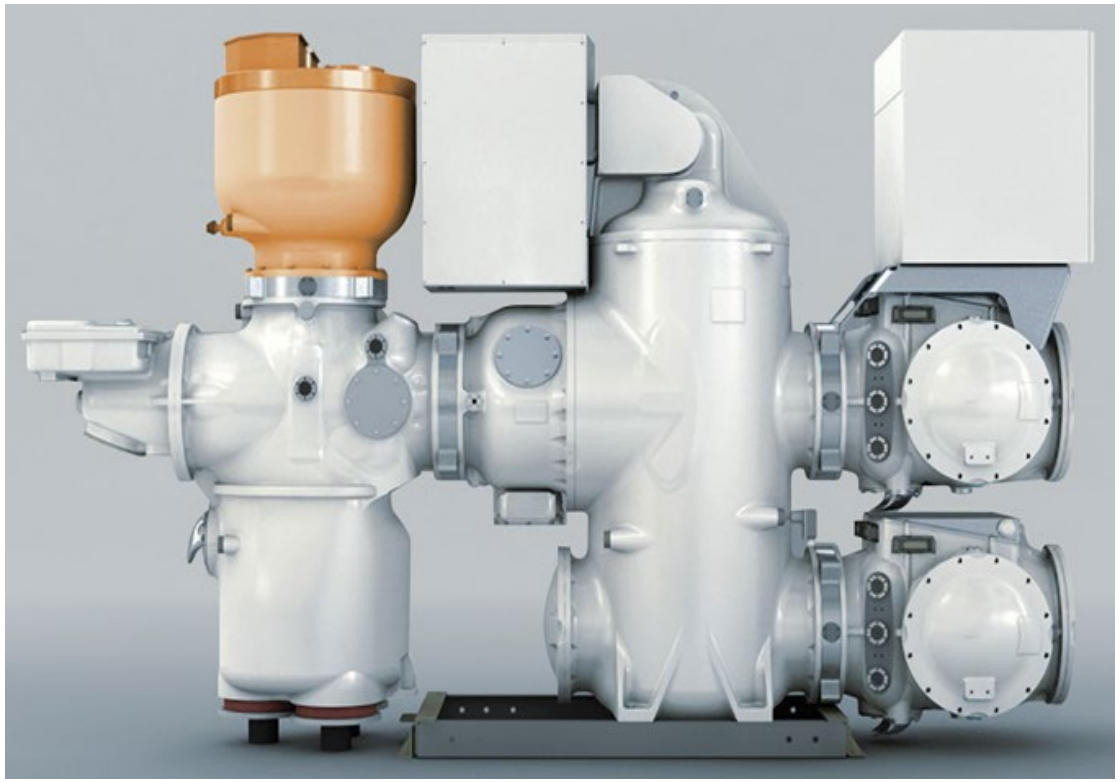


SF6 transformer with coupling capacitor

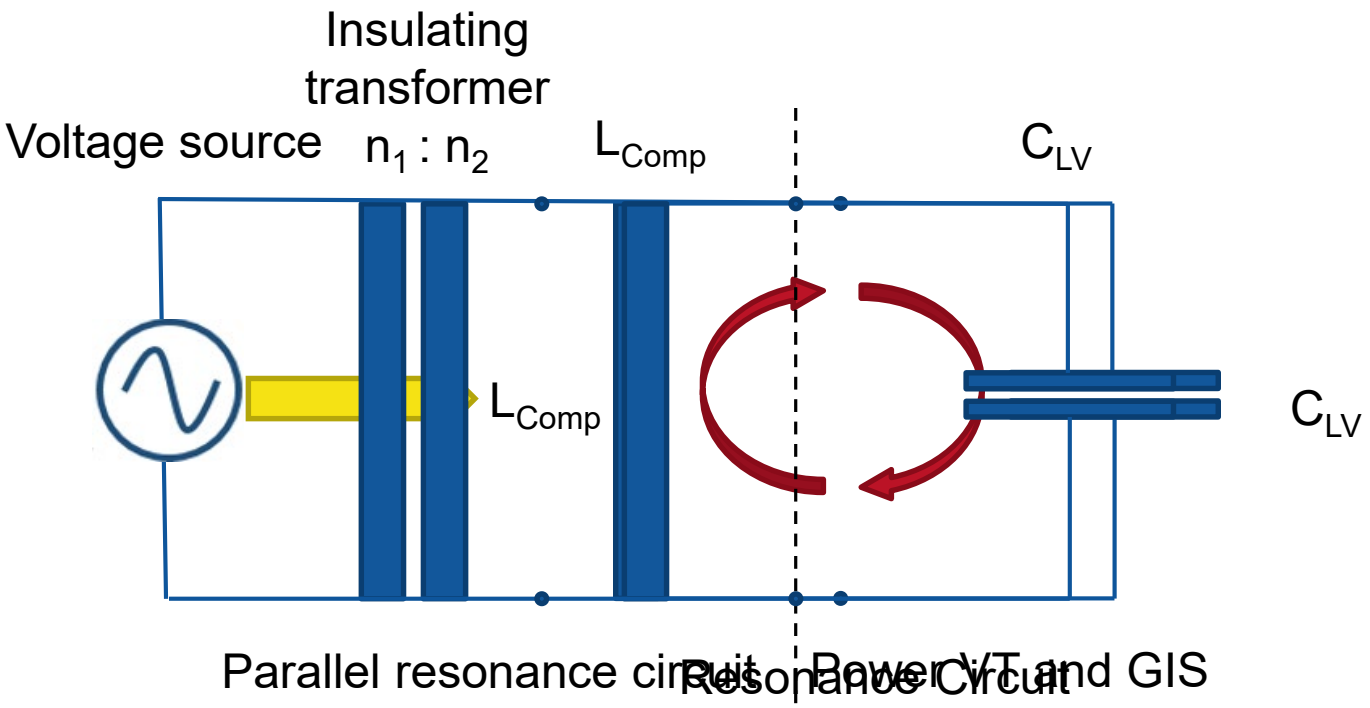
GIS and test SF6 test transformer

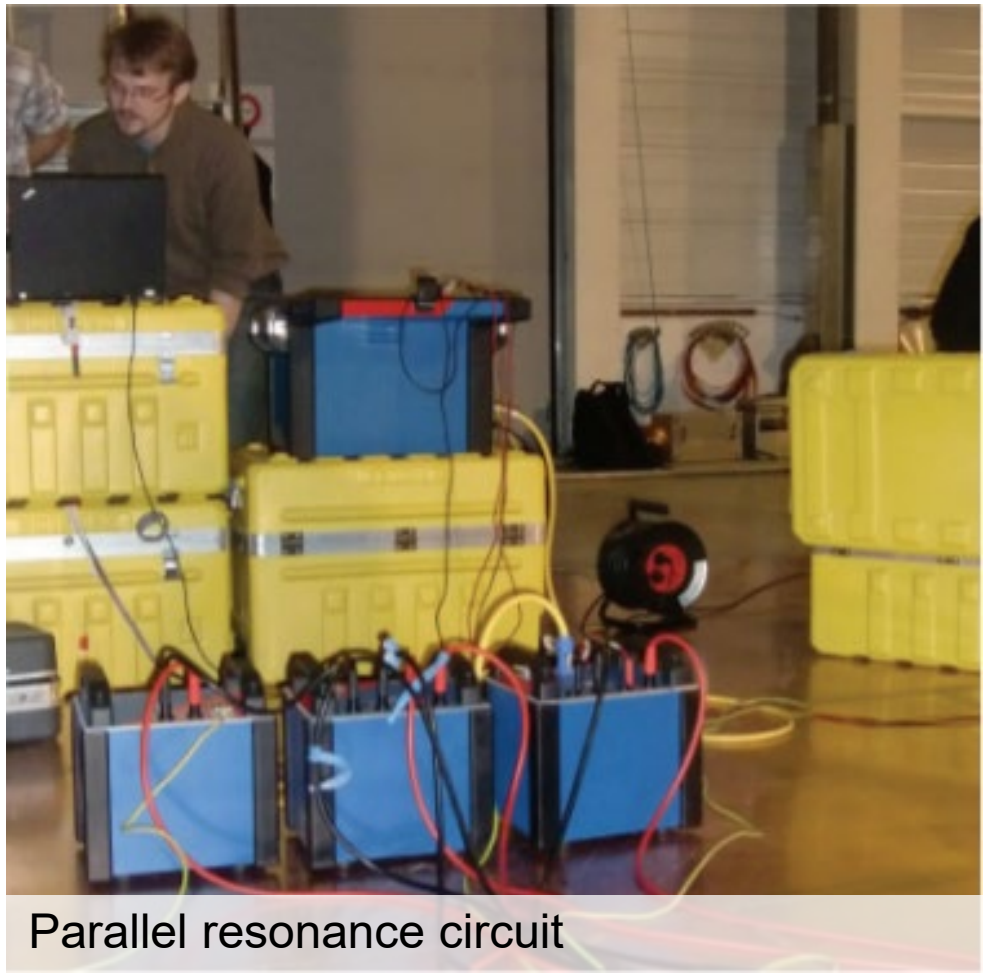
Parallel resonance circuit





Parallel resonance circuit

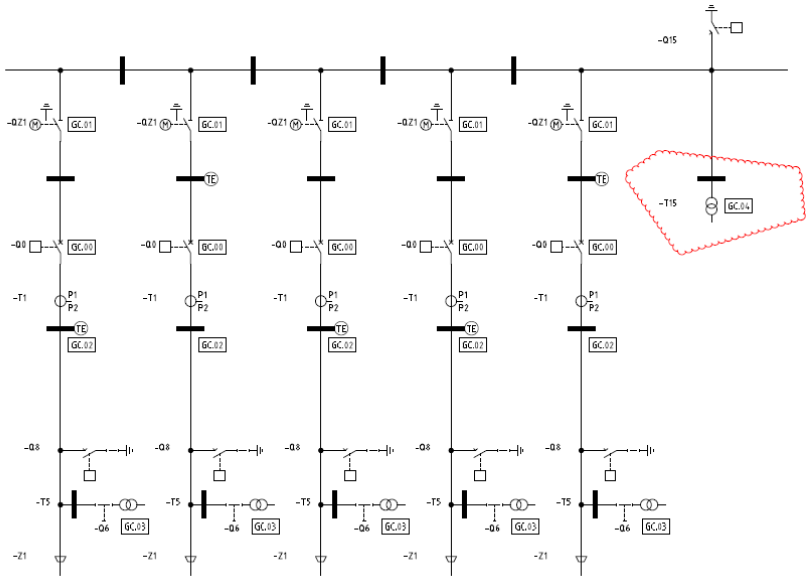




Parallel resonance circuit

Power VT

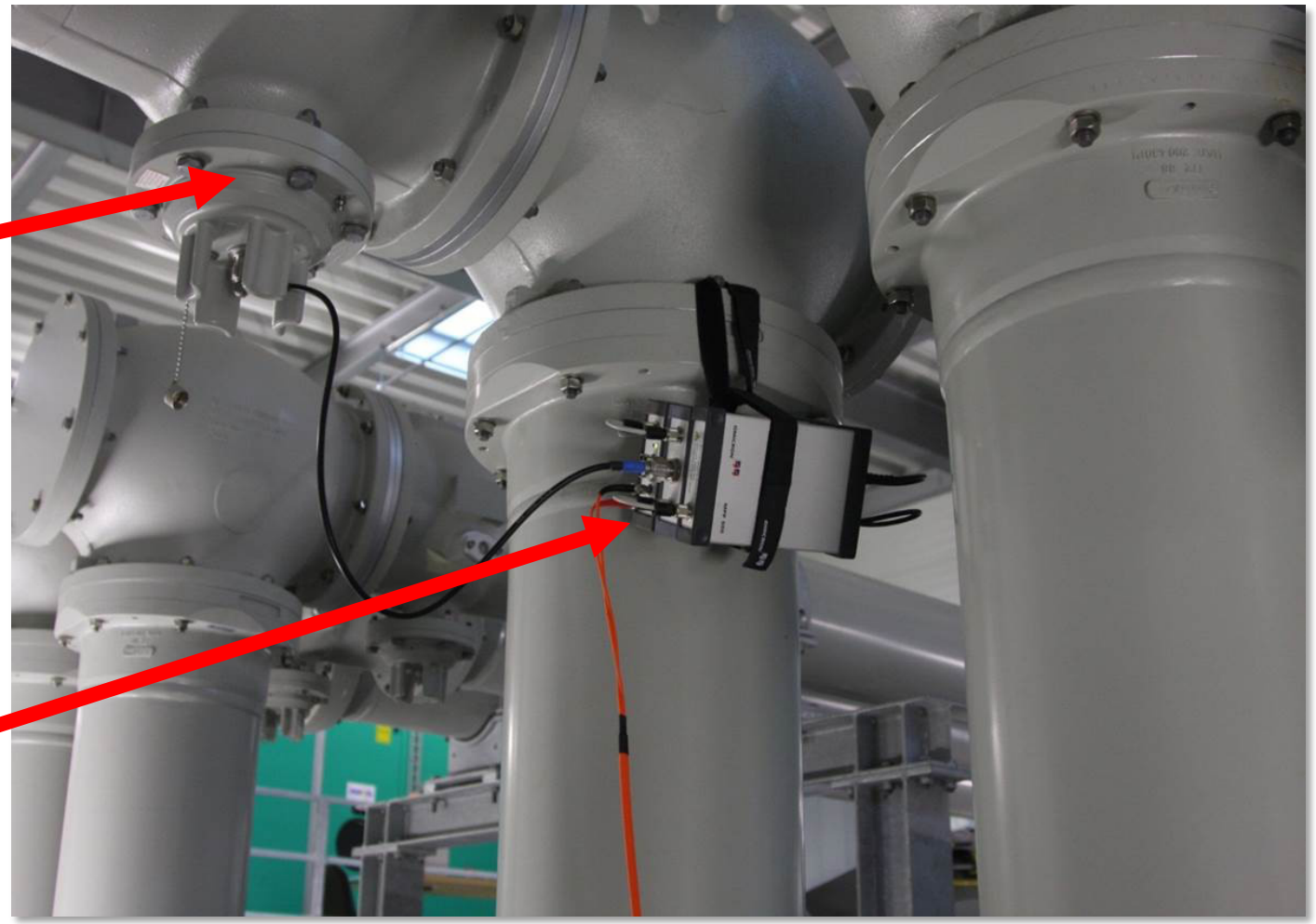
- Integrated part of the GIS
- Reinforced low voltage winding
- Measurement capabilities as usual voltage transformer
- „test transformer“ on site
- Slightly increased cost compensated through low transportation cost for test equipment
- Can be set on busbar to test a complete substation:



Power VT ready for assembling

PD measurement

> UHF measurement using built-in antenna:



New Methods for Non-intrusive On-site Testing of GIS

> Voltage withstand testing with portable resonance test system

> **Current transformer demagnetization from primary side**

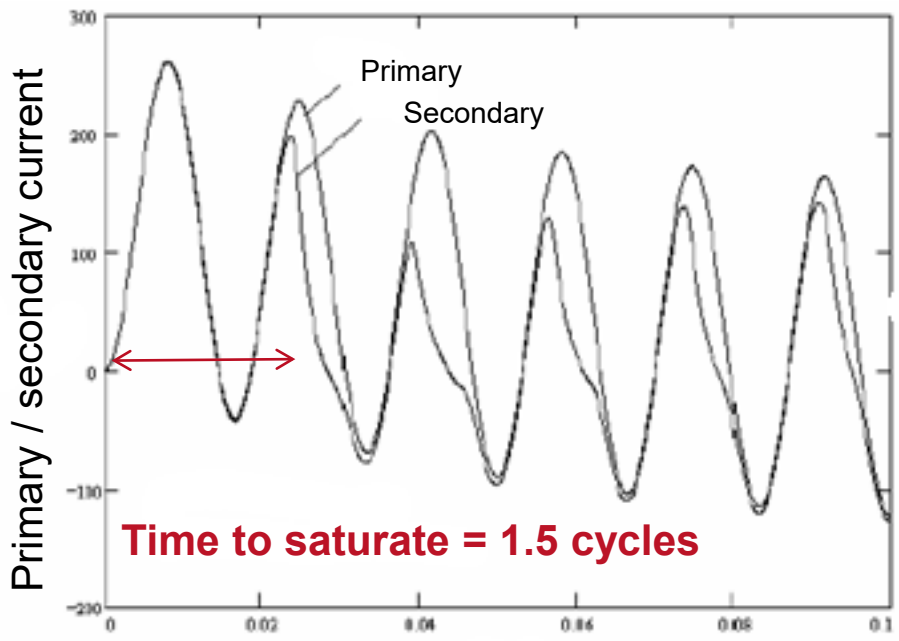
> Timing test with both sides grounded

Why to demagnetize CT after circuit breaker test?

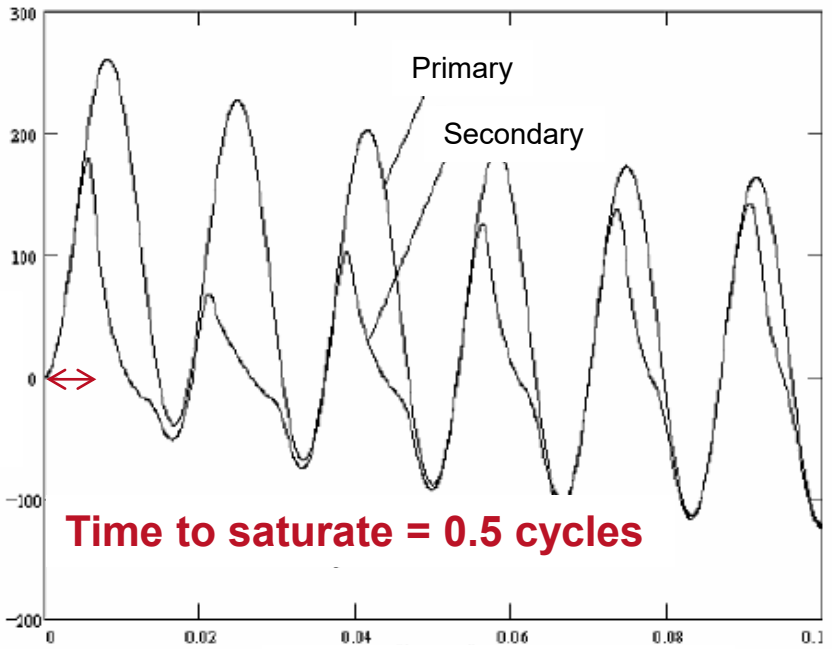
> DC current used during contact resistance test (static or dynamic) magnetizes CT mounted on dead tank breakers or GIS breakers

> Residual flux affects CT accuracy limiting factor

> The CT secondary reading is strongly affected by transient saturation when the CT core is already magnetized:



CT residual flux = 0%



CT residual flux = 75%

CT demagnetization from primary side

In order to ensure proper protective relay operations,

> CT can be demagnetized from secondary side (each core individually)...

> ...or **from the primary side** (all cores at once), same setup as for contact resistance measurement, time saving method.
  > It can be carried out with both sides grounded

> Example of remanence result after primary demag. process on 1200:5 C400 CTs of a 72.5kV dead tank circuit breaker :

CT (phase C)	C1	C2	C3	C4
Initial remanence	5%	55%	38%	9%
Remanence after contact res. test	76%	79%	81%	79%
Remanence after demag from primary side	2%	2%	3%	3%

New Methods for Non-intrusive On-site Testing of GIS

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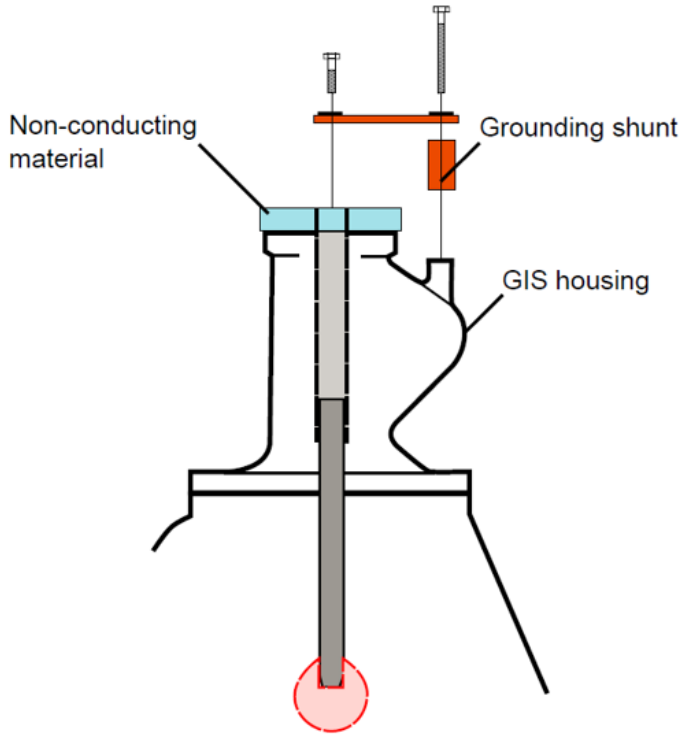
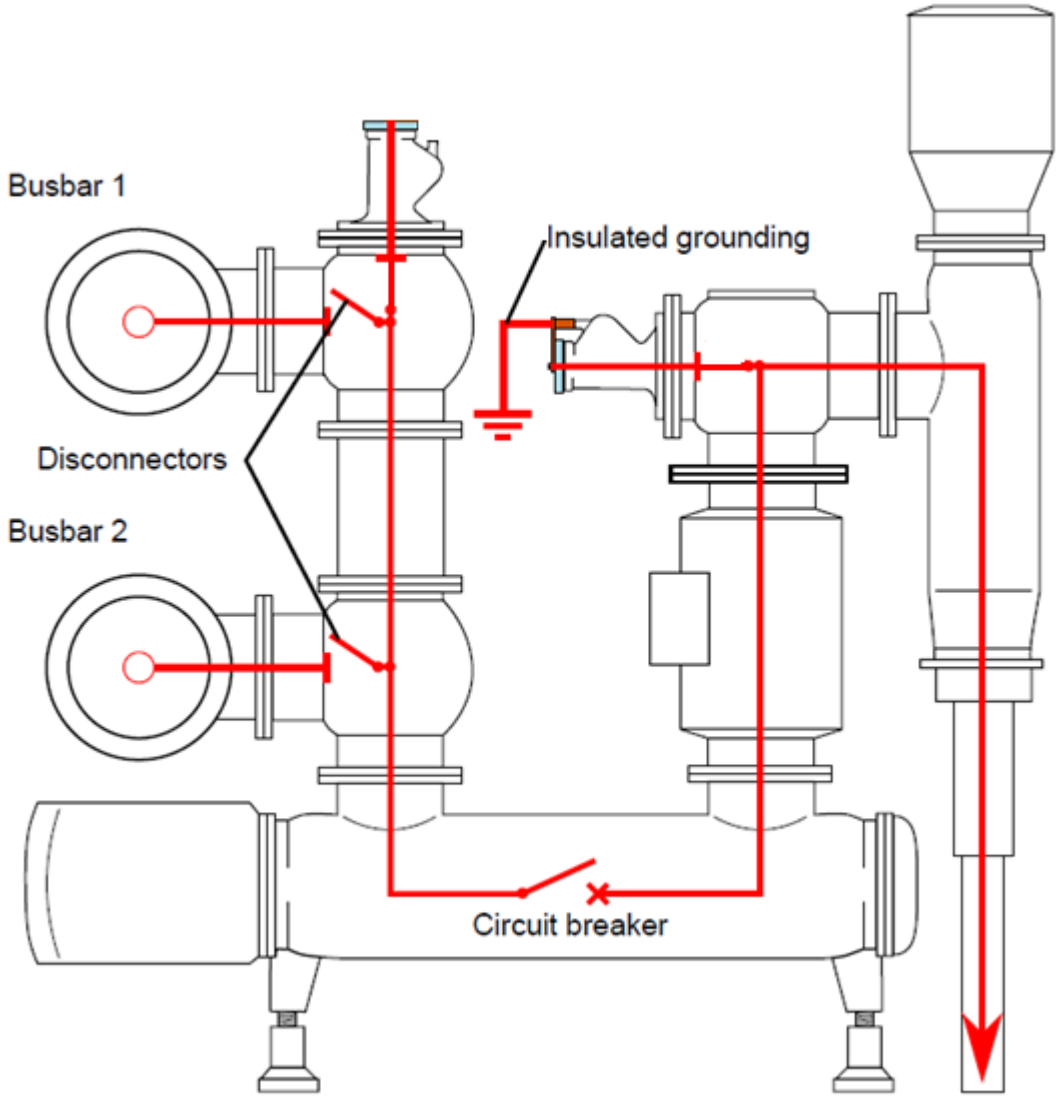
> Current transformer demagnetization from primary side

> **Timing test with both sides grounded**

Why to test timing with both sides grounded?





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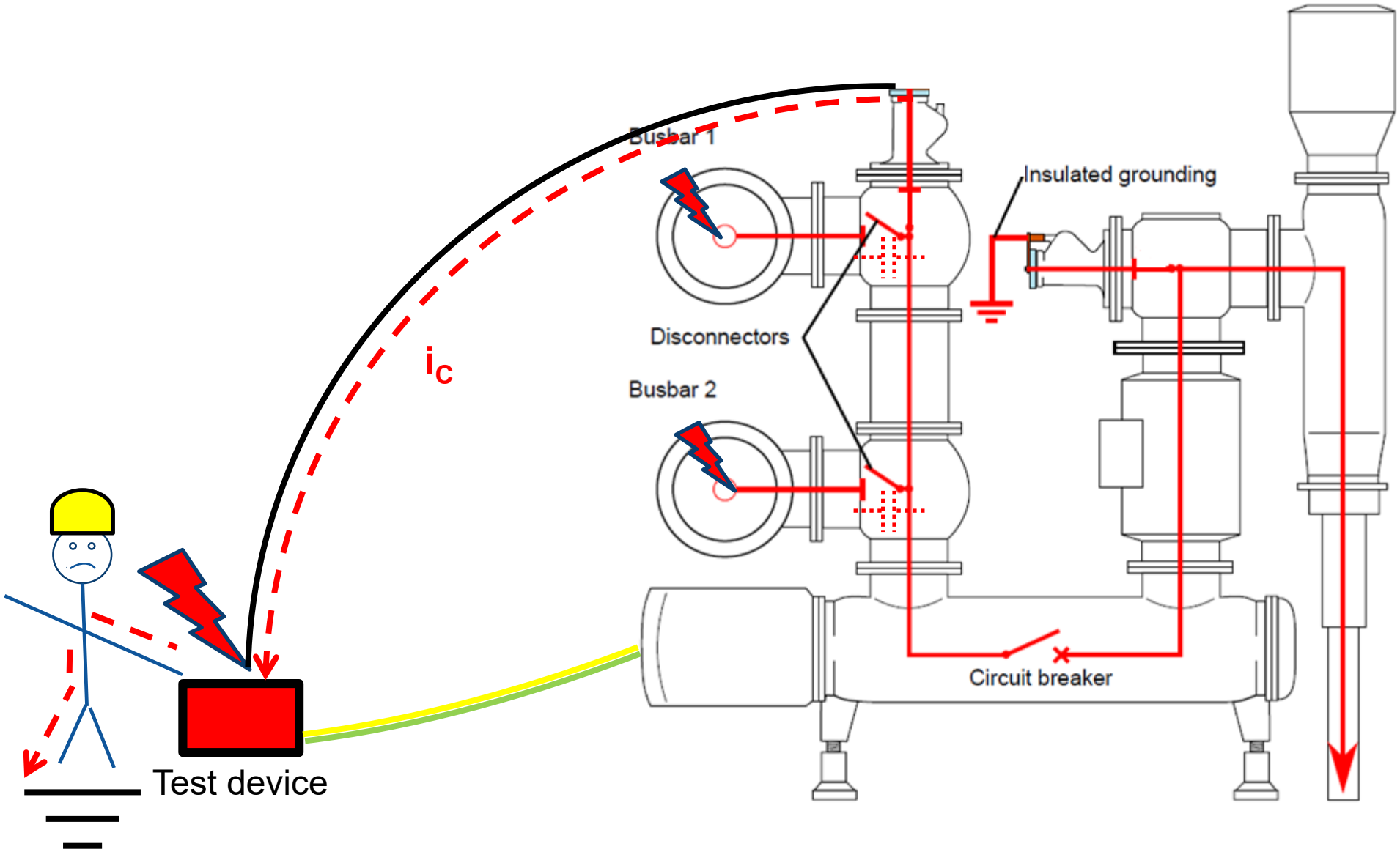

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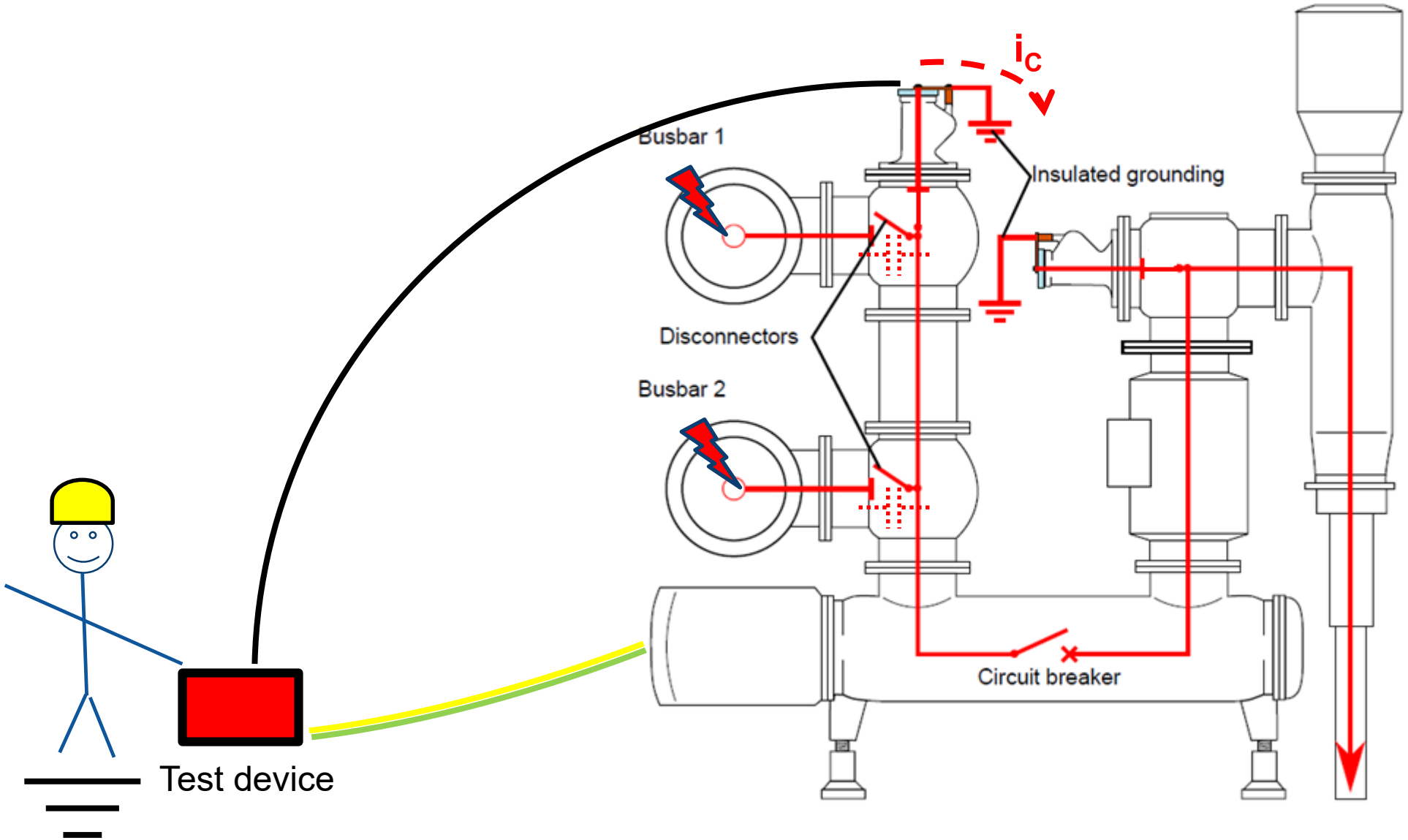


Dynamic Resistance Measurement

Due to a good ground connection of GIS

$$R_{CB} \approx R_{ground}$$

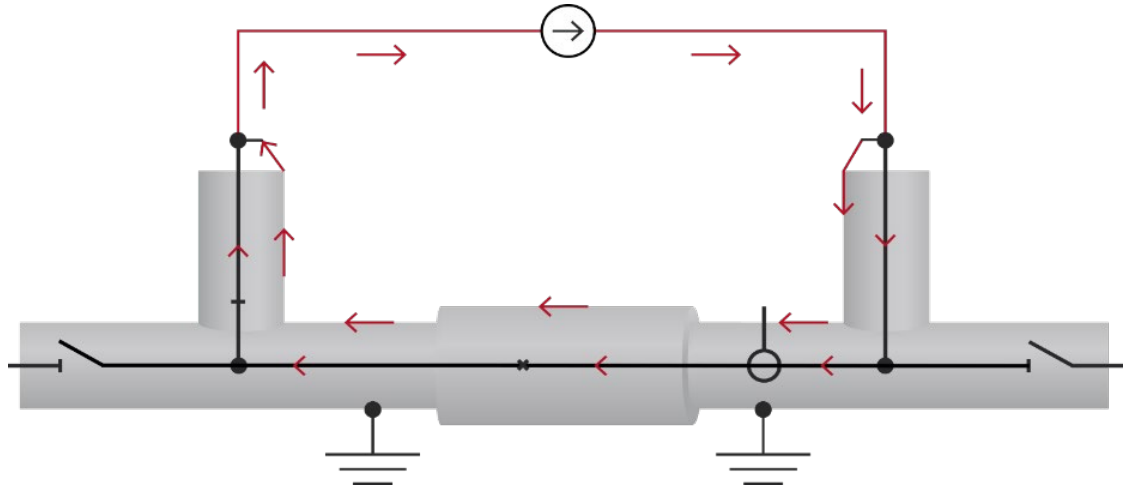
> Breaker closed, measured resistance

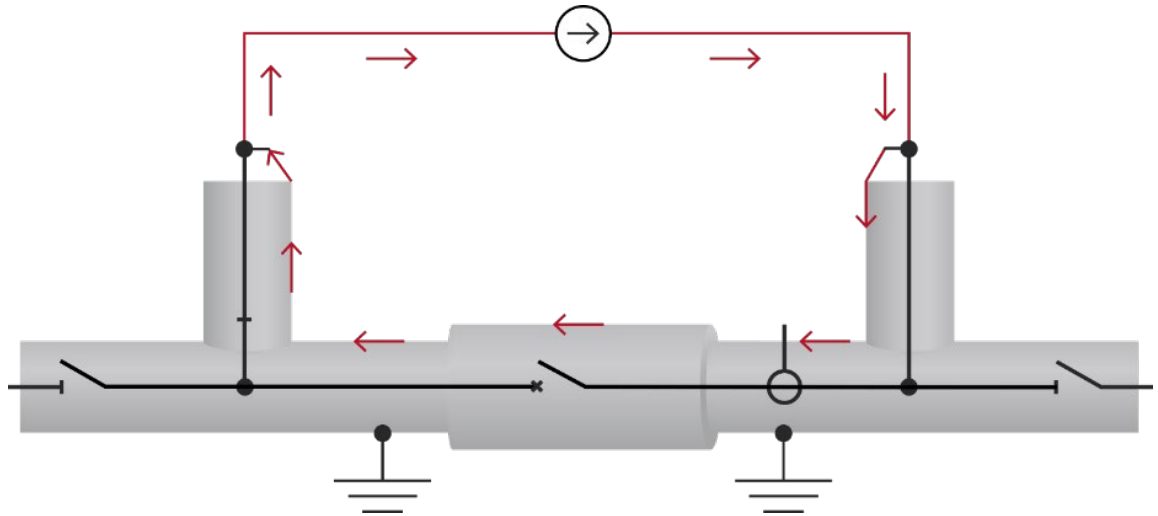
$$R_{close} = R_{CB} \,//\, R_{ground}$$

> Breaker open, measured resistance

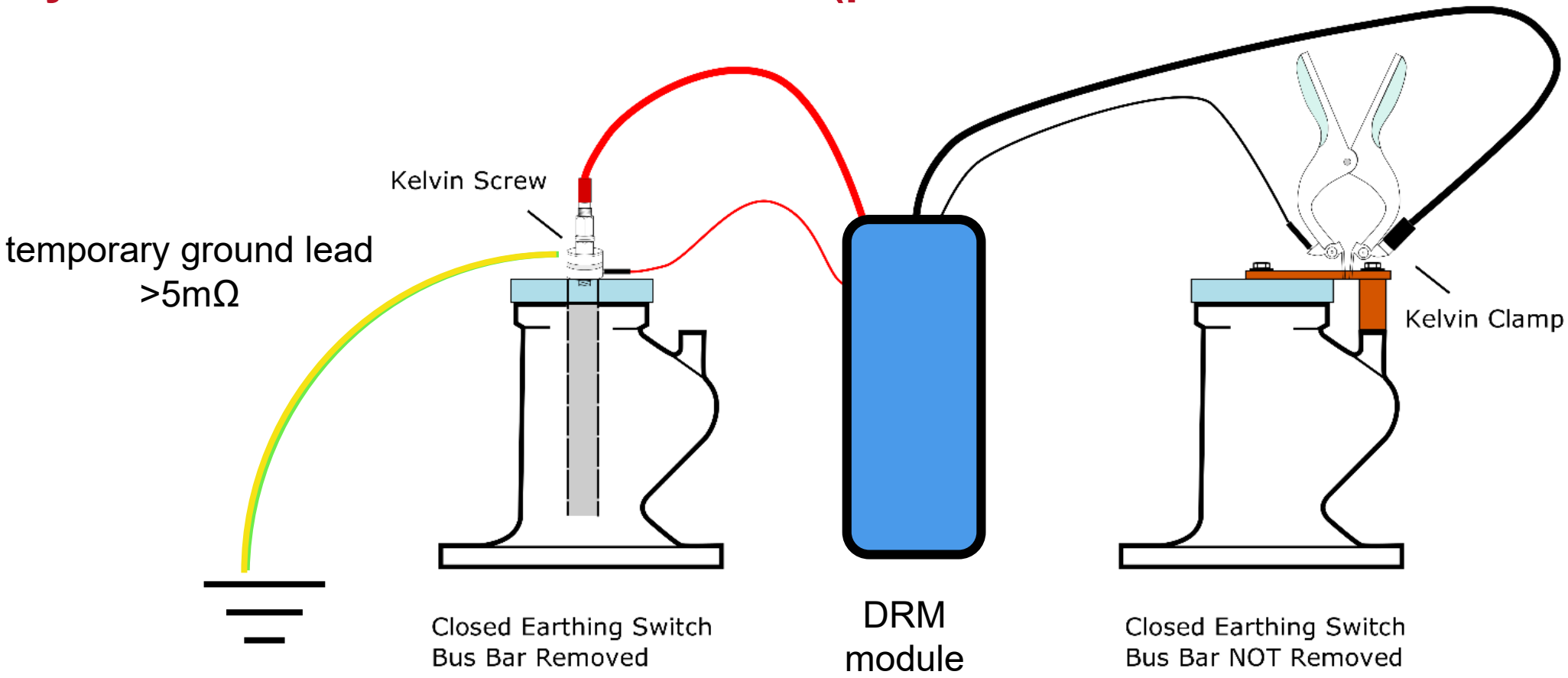
$$R_{open} = R_{ground}$$

> Dynamic resistance measurement does not show a significative resistance change during operation





Dynamic Resistance Measurement (possible safe but intrusive setup)

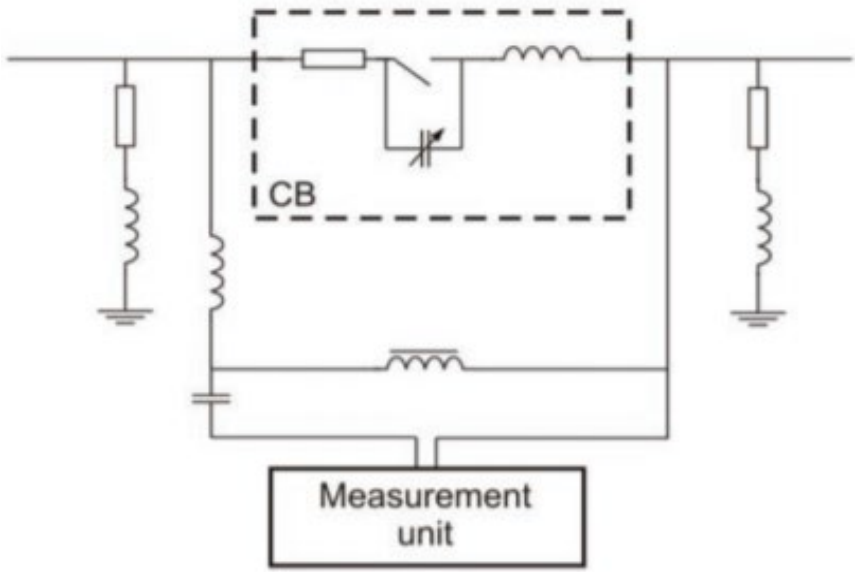


+ Same wiring for timing test and contact resistance test
+ Give additional data about contact erosion

- Ground links must be removed on earthing switches

DCM (dynamic capacitance measurement)

> Change in frequency resonance is used to detect close and open states

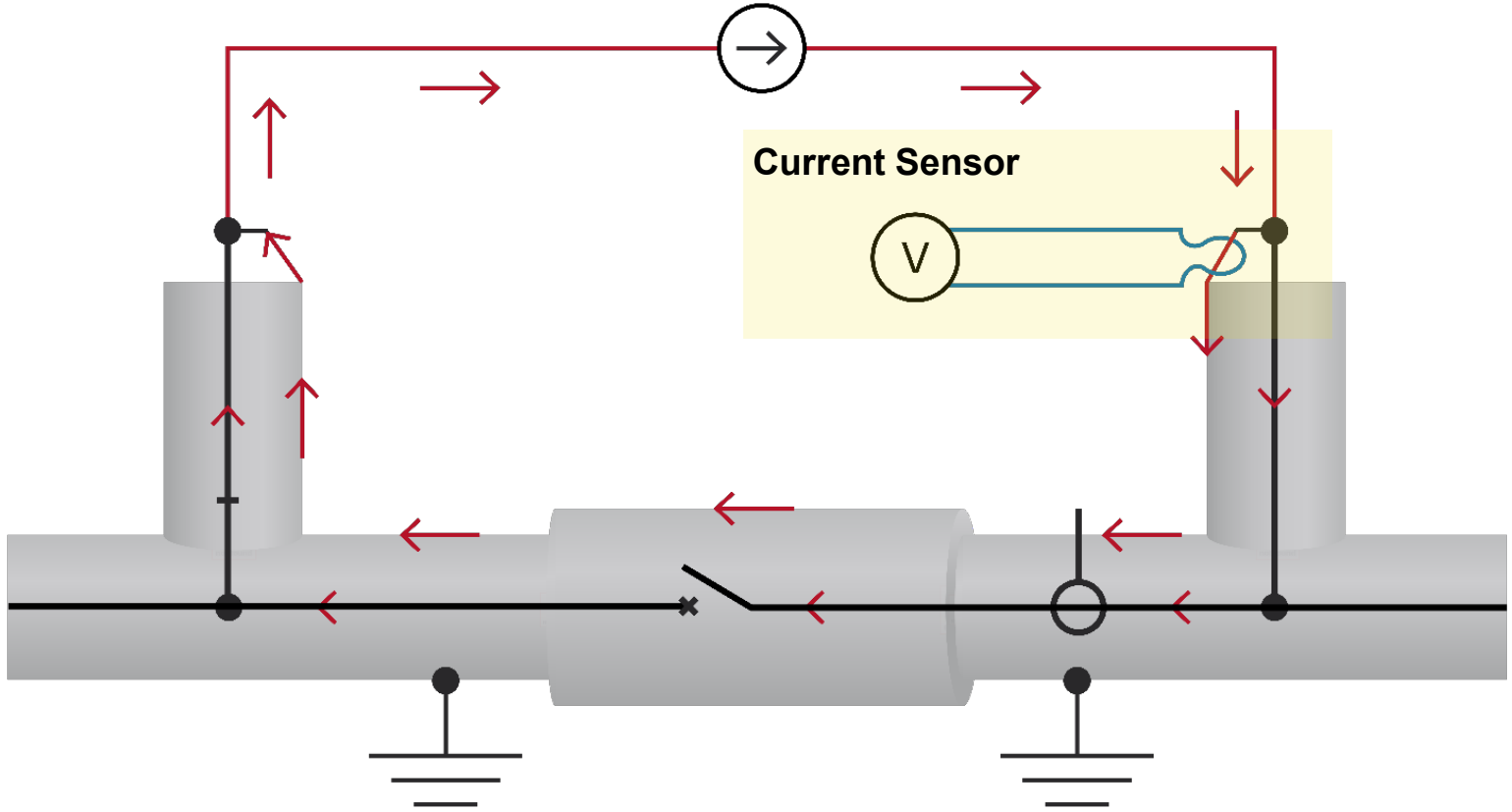


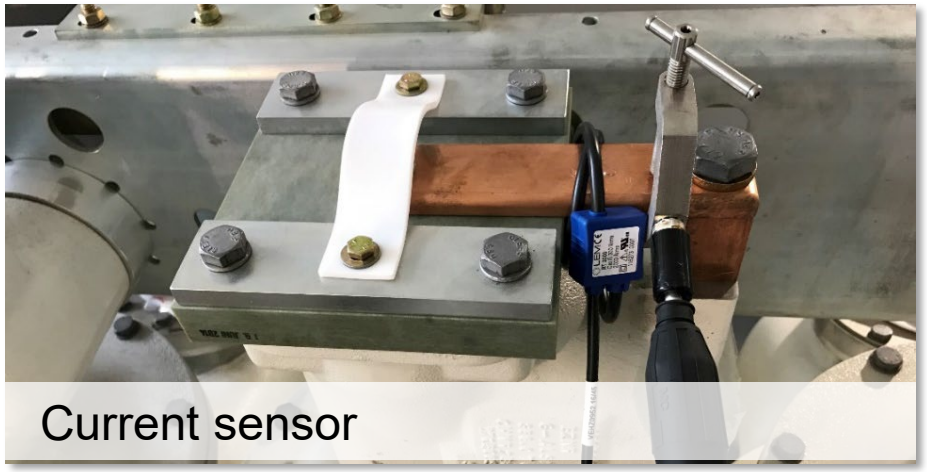
source: Programma

\+ Simple to use when compatible

\- Weak ferrites needed for GIS
\- Not compatible with GIS made in 80’s and GIS < 120kV
\- Different setups for timing test and contact resistance

Current sensor measurement (CSM) for GIS




Current sensor

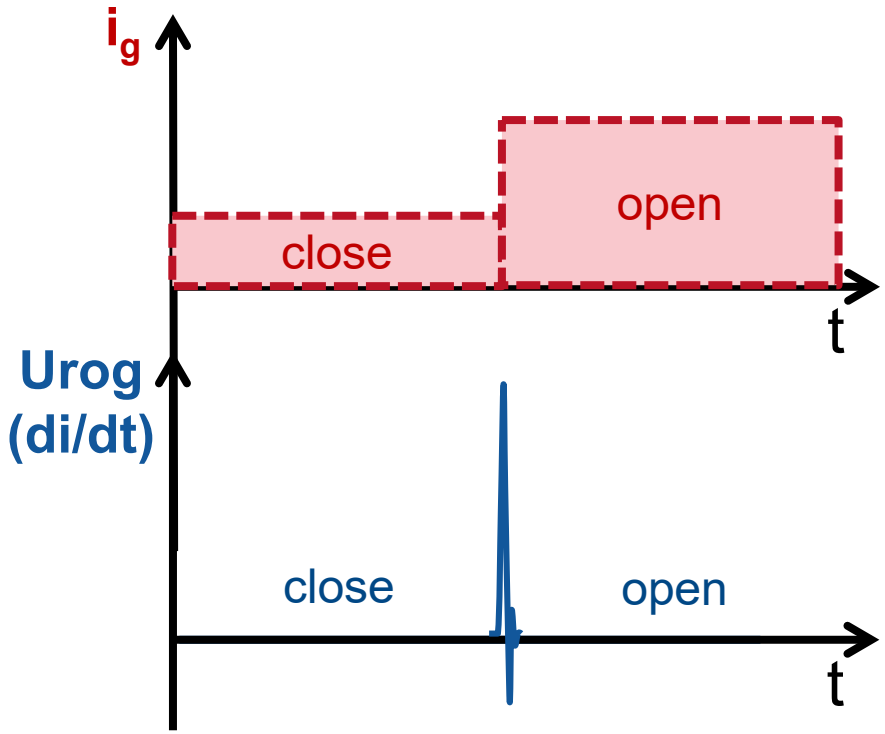
> DC current is injected in the breaker and on the grounded envelop

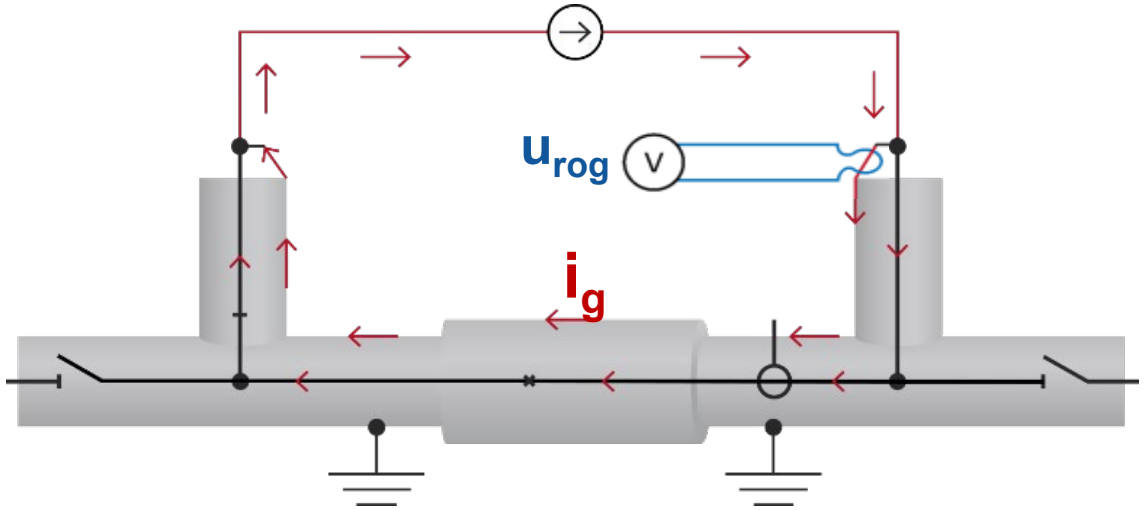
> di/dt is directly measured at earthing switch shunts

> Independent to test current amplitude

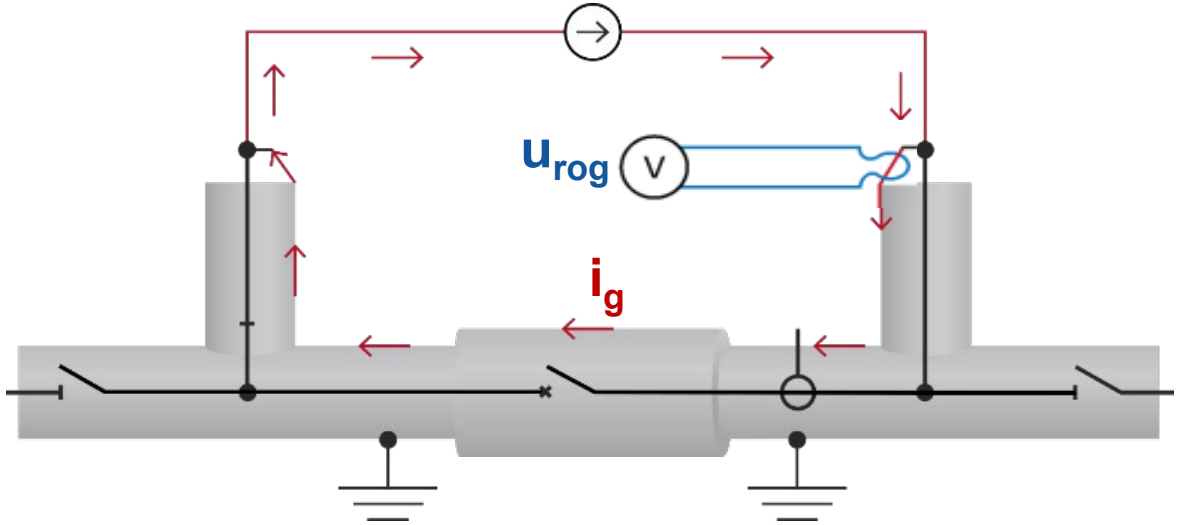
> GIS integrity is kept, no need to remove ground connections

Current sensor measurement (CSM) for GIS





1st condition: current through contact & ground



2nd condition: current through ground path only

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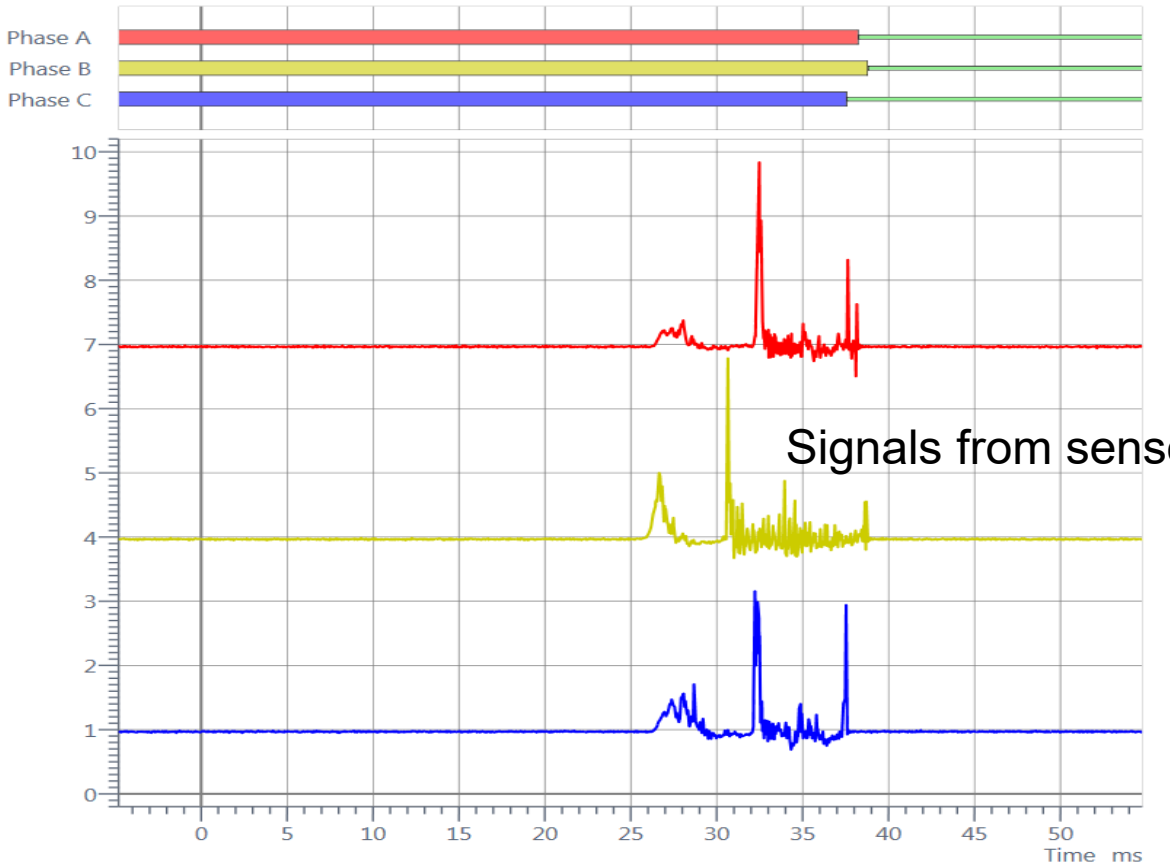
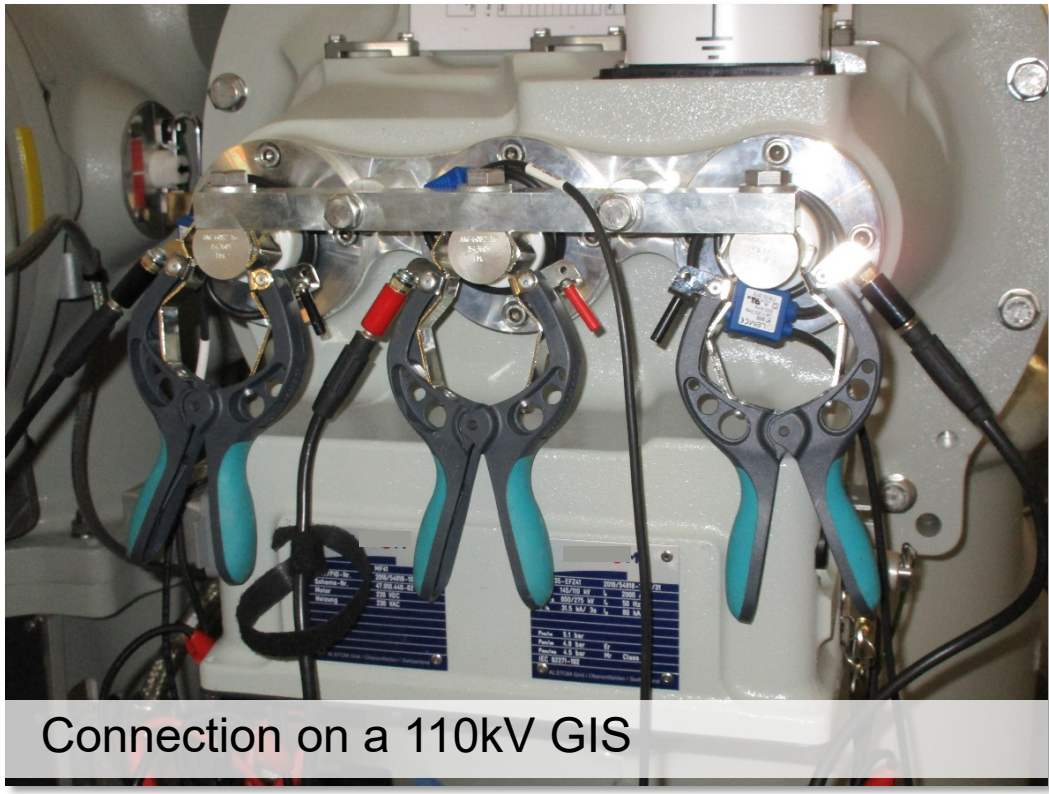
Current sensor measurement (CSM) for GIS



Signals from sensors (A/s)



Connection on a 110kV GIS

+ Small dimension and flexibility due to Rogowski coil
+ Adapted for GIS of all generations and types
+ Additional data about contact system and erosion

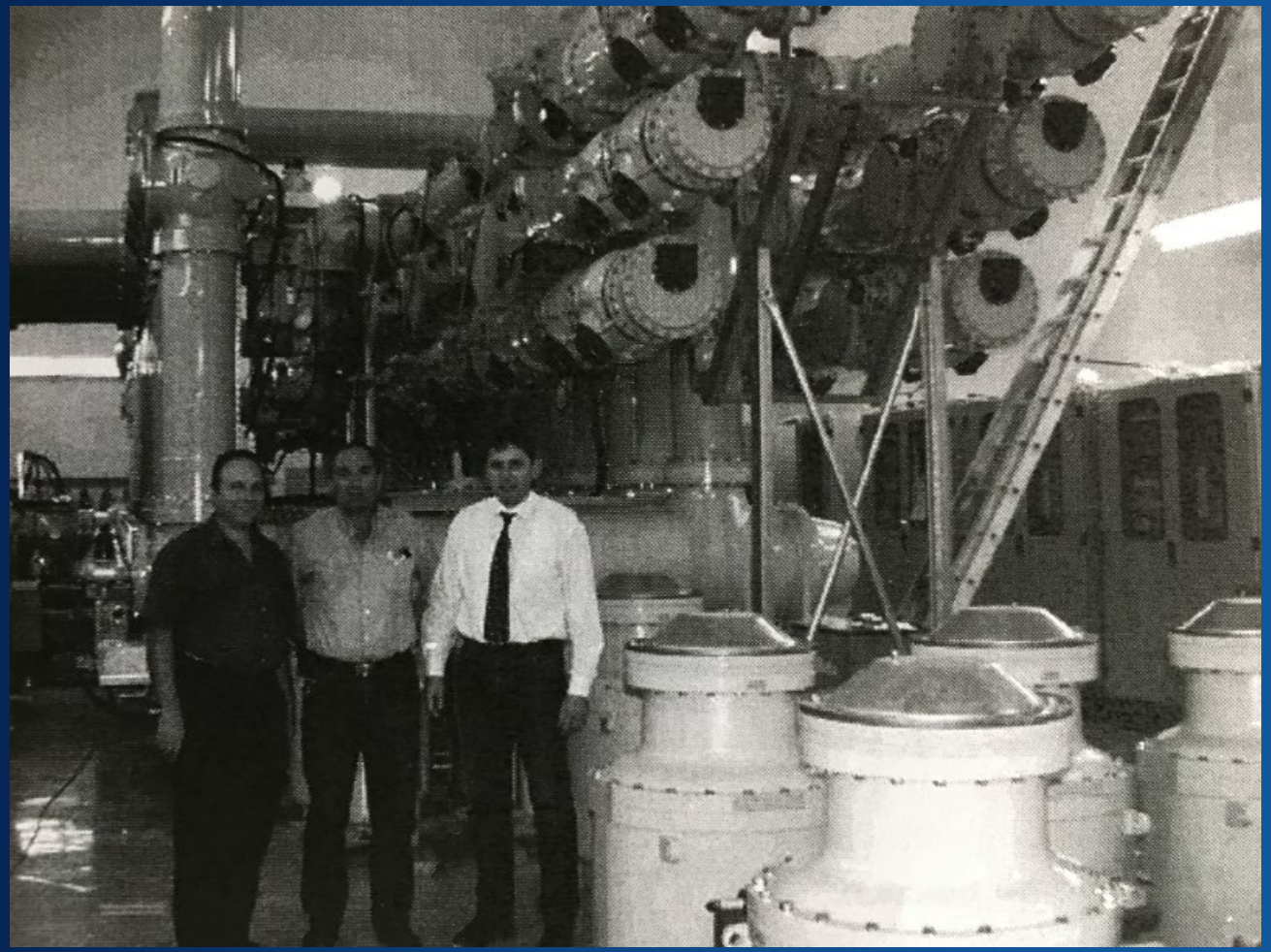
- Different setups for timing test and contact resistance test

Conclusion

> During commissioning and maintenance high voltage tests, the **integrated power VT** avoids the opening of SF6 gas compartment, and the risk of particles contamination.

> **Demagnetization from primary side** does not affect the CT secondary wiring.

> The **CSM** method represents a quick, easy and safe way to perform timing test on a both sides grounded GIS.



> Thank you for your attention