KoCoS America

IEEE Switchgear Committee

Testing Breakers with Both Sides Grounded

- Breaker Analysis
- Relay Testing
- Digital Fault Recording
- Meter Testing
- Power Quality Analysis
- Optical Measurement

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KoCoS Presentation outline

- **Background**
  - Main Contact Timing
  - Both Side Grounded
- **Measuring Methods**
  - Conventional
  - Dynamic Timing
  - New Method
- **Tested sample**
- **Comparison**

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KOCOS AMERICA LLC

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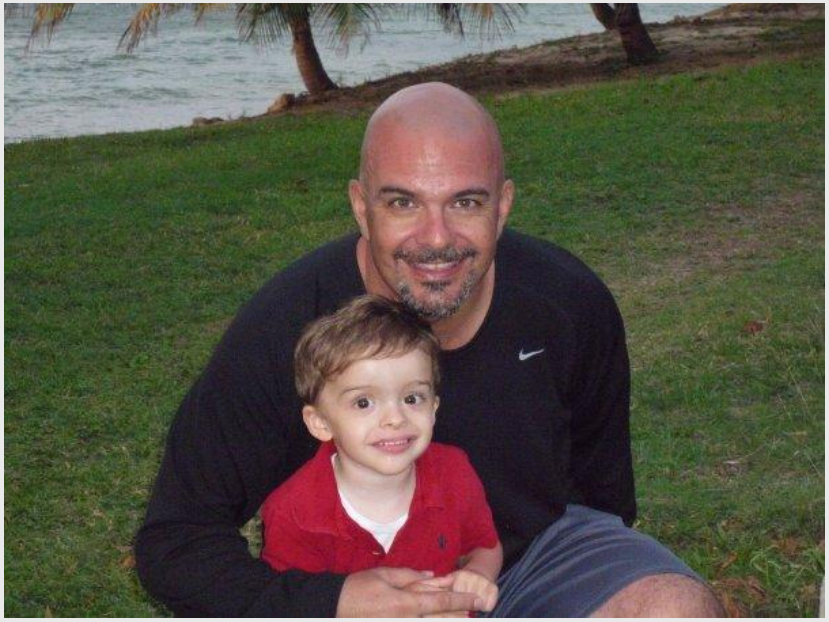
Jean-Guy Wasfy



43 years old

Born in Montreal.

Guy Wasfy received his BSEE from University of Rhode Island, graduating in 1990.

First job was for Doble Engineering, performed many roles, such as as a client service engineer, a product manager, and an International Sales manager.

In 2001, formed a subsidiary along with KoCoS AG, for all of North American Operations.

Context / Background

- Switching devices are essential equipment in a substation.
- The current must be interrupted if a failure occurs.
- To guarantee the operation the circuit breaker need maintenance.
- Reasons:
  - Wear of the moving parts
  - leak on valves and seals
  - Failures in control circuits
  - Deterioration of contact parts
  - Problems with compressors, springs, and other “speed” parts

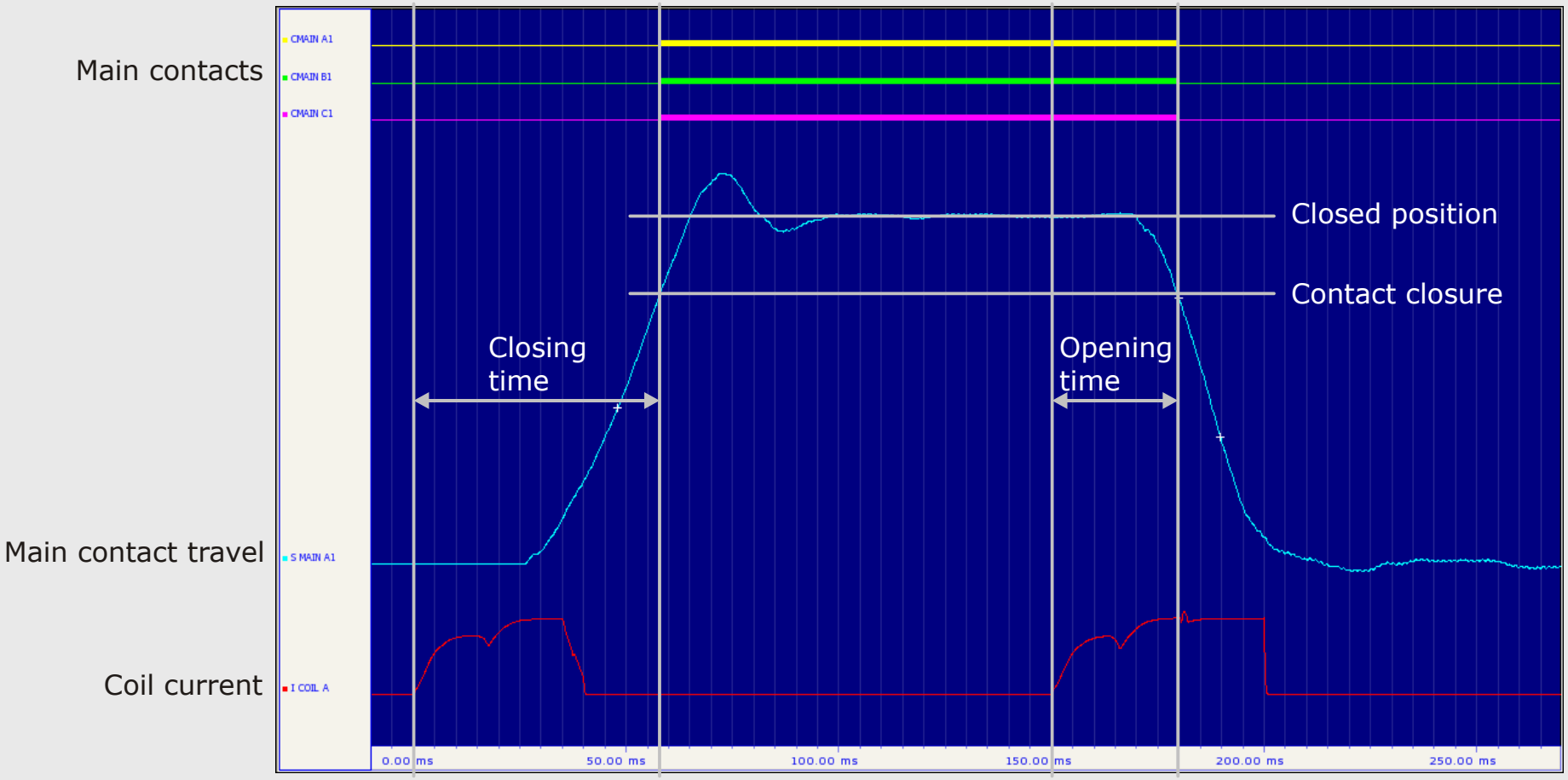
Why is a determination of the main contact timing important?

- Fundamental and important test for testing circuit breakers:
  ➔ *Determination of main contact timing*
- Determination of timing from command until execution.
- ➔ *Circuit breaker need maintenance*
- Determination of:
  1) Synchronisation between poles
  2) Synchronisation of contacts within one pole

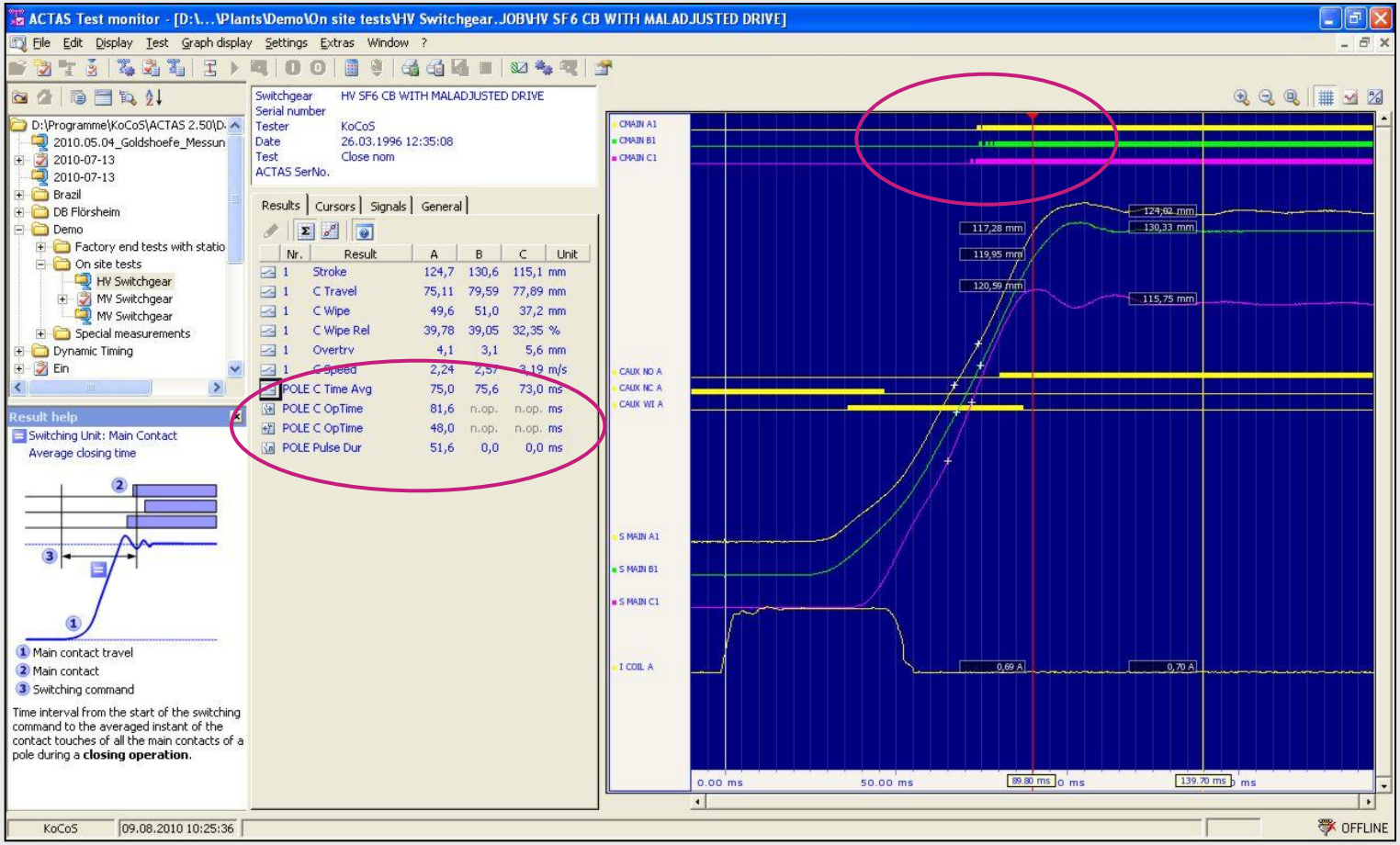
Parameters measured

- main contact velocity,
- main contact travel and
- the operating times of all switching contacts.
- Coil operating currents,
- the operating currents of spring-tensioning or pump motors,
- valve pressures,
- valve travel and mechanical main contact travel,
- in addition main and auxiliary contact state,
- Main contact resistance.

Typical Close-Open-Operation



Example: main contact timing



Conventional Method

- Decommission of circuit breaker - danger through:
  - undesirable electrical potential
  - capacitive or inductively coupled voltages
- Safety through connection of the circuit breaker to ground.
- Exception: measurement of main contact timing
- Practice: the ground must be removed on one side of the breaker pole for test
- Used for the conventional measurement method.

Conventional Method

- Ground both sides of the breaker with grounding cables
- Connect timing set to breaker
- Remove ground from one side of breaker
- Perform tests
- Ground the one side that is not connected
- Remove leads

- IEEE and OSHA Require that the breaker be grounded at both sides during maintenance
- Accepted exception to laws and standards that call for both sides to be grounded at all times, but not recommended.

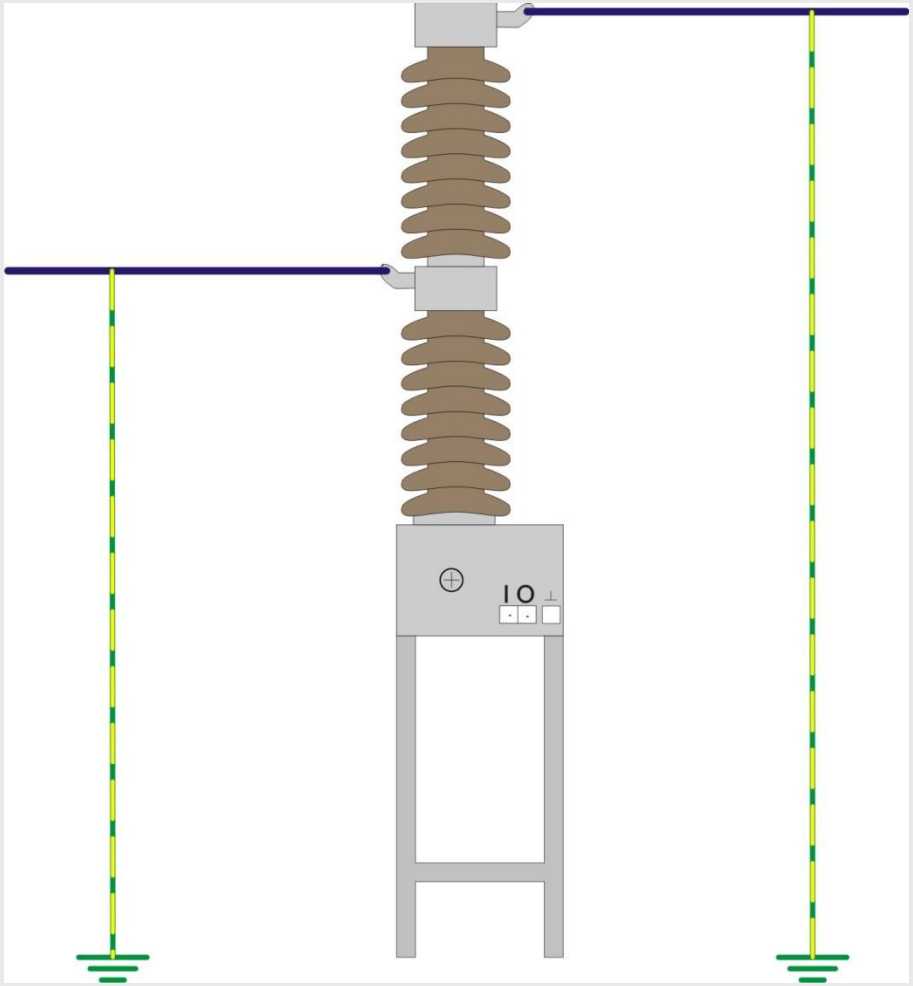
Conventional Method

- **Electrical Risk!**
  - Fault
  - Lightning
  - Electrical coupling
    - IEC ® EN 61010 considers any current above 3.5 mA dangerous

Why test with Both Sides Grounded?

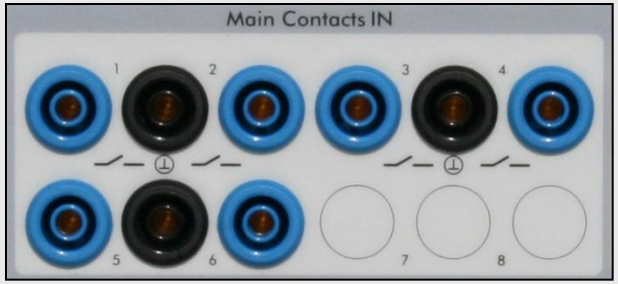
- Financial – the cost of removing the ground from one side of the breaker can be costly – utility studies have shown the cost could reach $6,000 or higher.
  - Overtime
  - Bucket truck
  - Harness
  - Supervisor
  - GCB, big conductors
- Safety through connection of the circuit breaker to ground.
  - Testing and operations can be done inside the ground circuit of the breaker
- Ease of use
- Reduced switching time
- Less paperwork

Example: Earthed on both sides



Conventional measuring method

- Binary measurement inputs for main contact timing
  ➔ by comparator method

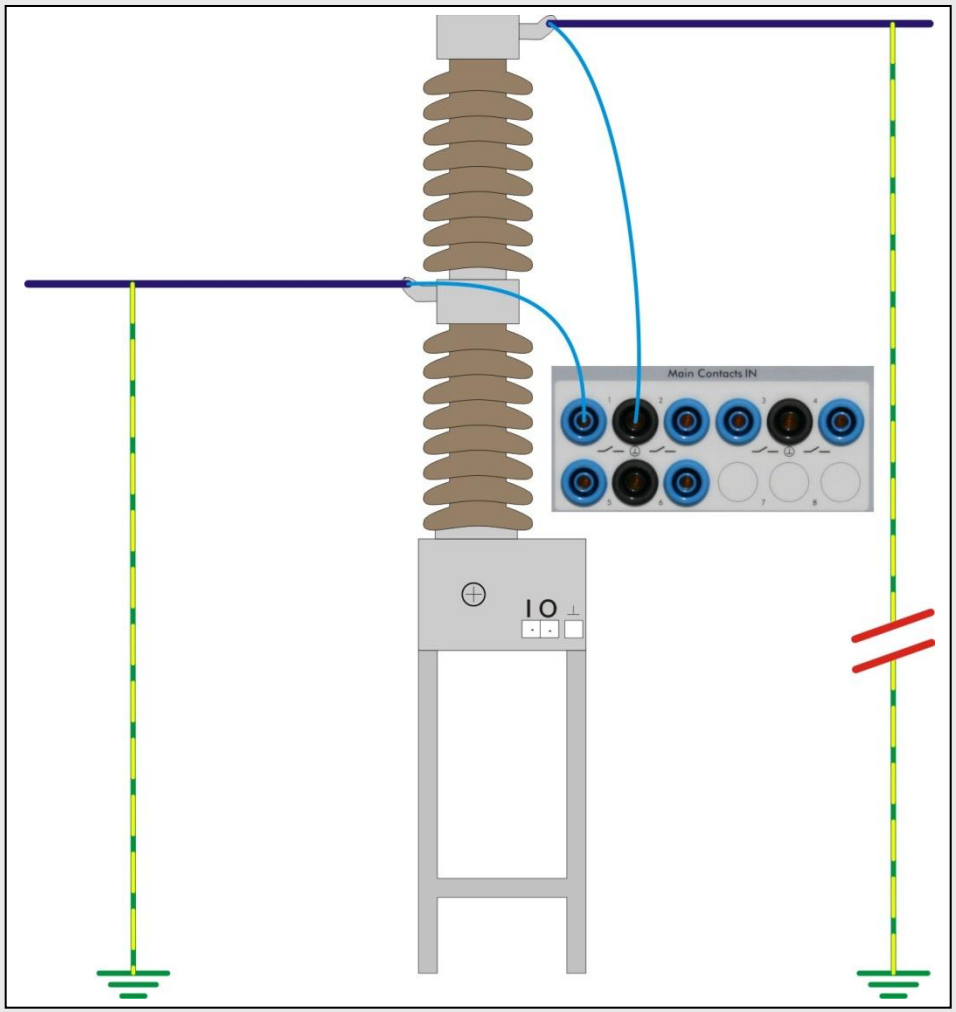


- Signal threshold:
  - R < 30 Ω *Main and resistive contact closed*
  - 30 Ω < R < 30 kΩ *Resistive contact closed*
  - R > 30 kΩ *Main and resistive contact open*

- Earthing: main contact status CLOSED
  - total resistance of the earth loop < 30 Ω

- The earth must be removed on one side of the breaker!

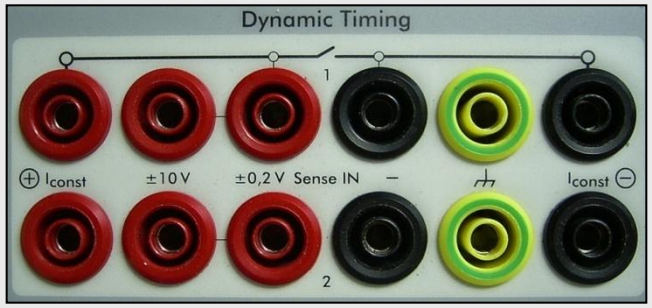
Connection diagram with Main Contacts IN



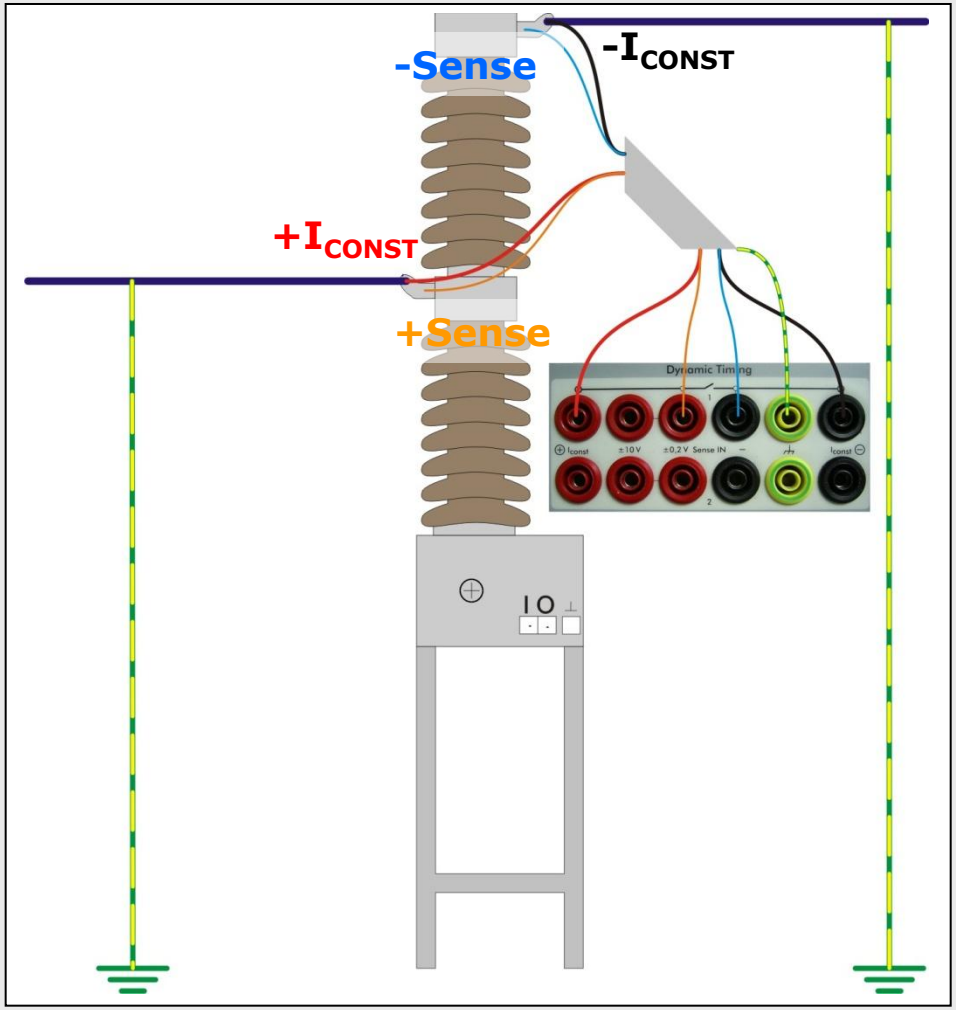
- Circuit breaker must be grounded on both sides when the measuring leads are being attached.
- The ground must be removed on one side of the breaker for the test.
- The ground connection should always remain in place on the side on which there is the greatest danger of capacitive or inductively coupled voltages.

Analog main contact measurement inputs

- Hardware option **Dynamic Timing**
- Voltage drop measurement with test current 10 A
- Determination of operating instants → special algorithm
- ACTAS P22: 6 analog voltage measurement inputs
  - per Pole: 2 measurement inputs
  - Range: 200 mV / 10 V
  - 10 A constant-current source per pole



Connection diagram for voltage drop measurement

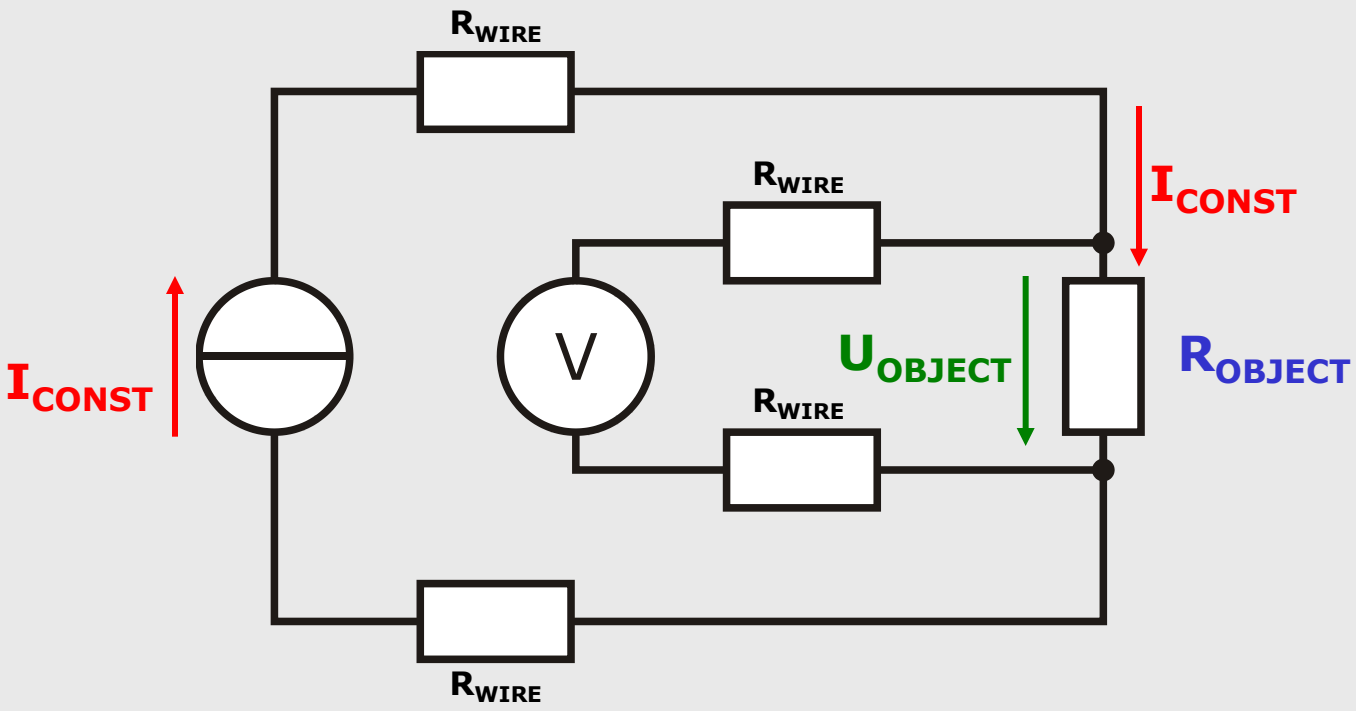


- Leads for the electricity supply and the voltage drop measurement are not attached at the same place.
- The measuring leads should be attached close to the test object.
- The earth connections may remain connected on both sides of the breaker pole during tests!

Kelvin (4-wire) resistance measurement

- Measurement of electrical resistance
- Known current through test object (resistance)
- Measurement of voltage drop
- Measuring faults through voltage drop on current lead are avoided
- Calculation of the resistance is based on Ohm’s Law:
  R=V/I

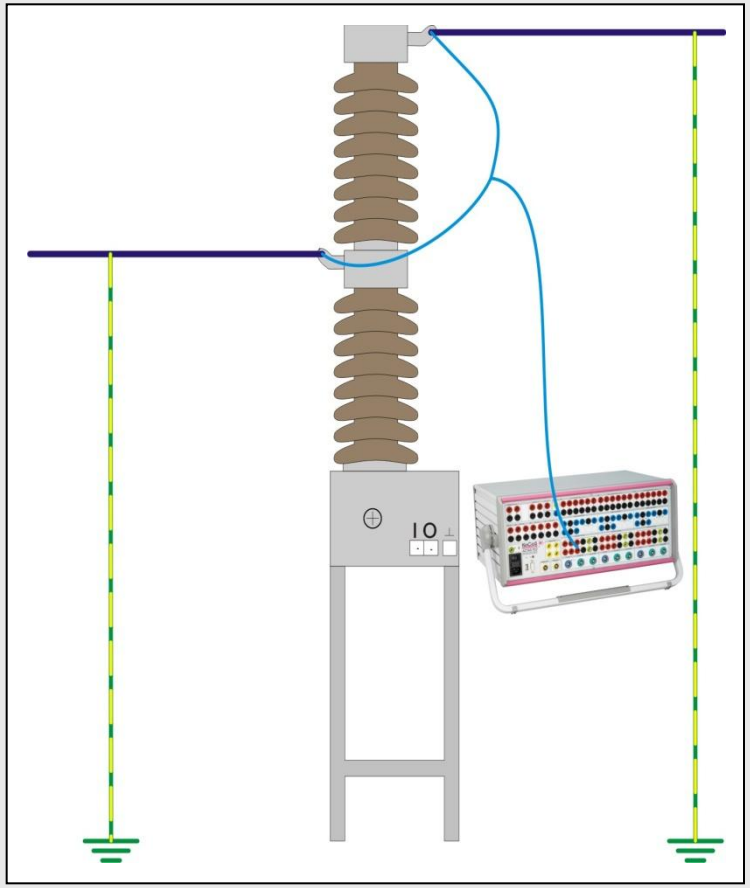
Diagram: Kelvin (4-wire) resistance measurement

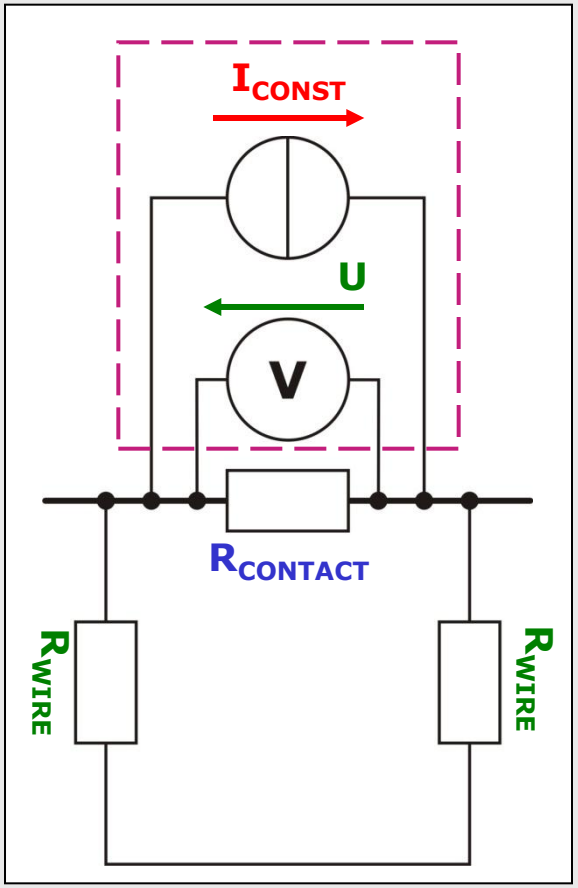


Basic information: Earthing

- For grounded long connection leads: ~ 20 mΩ
- Contact resistance of the circuit breaker: ~ 20 µΩ
- Target: reliable detection of contact state
- Resistance of ground has no affect of the test.

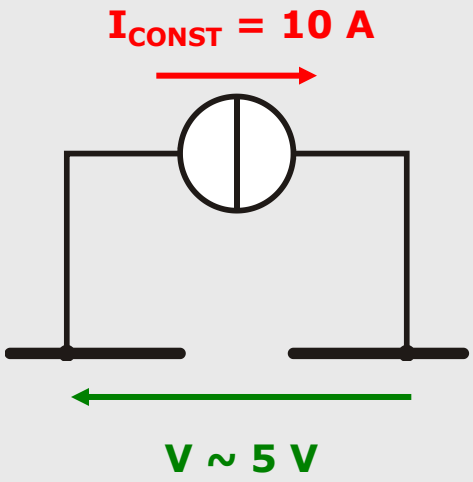
Basic information



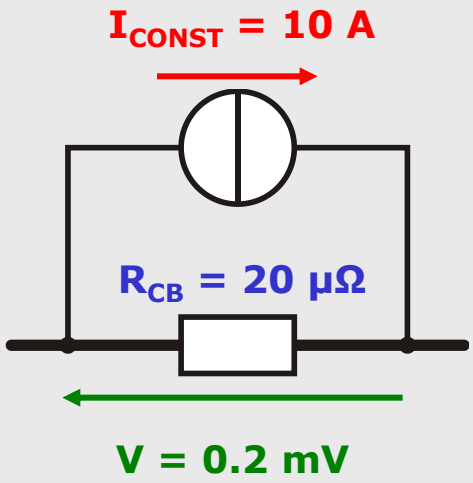


Worked sample: Without Earthing

Circuit breaker: OPEN

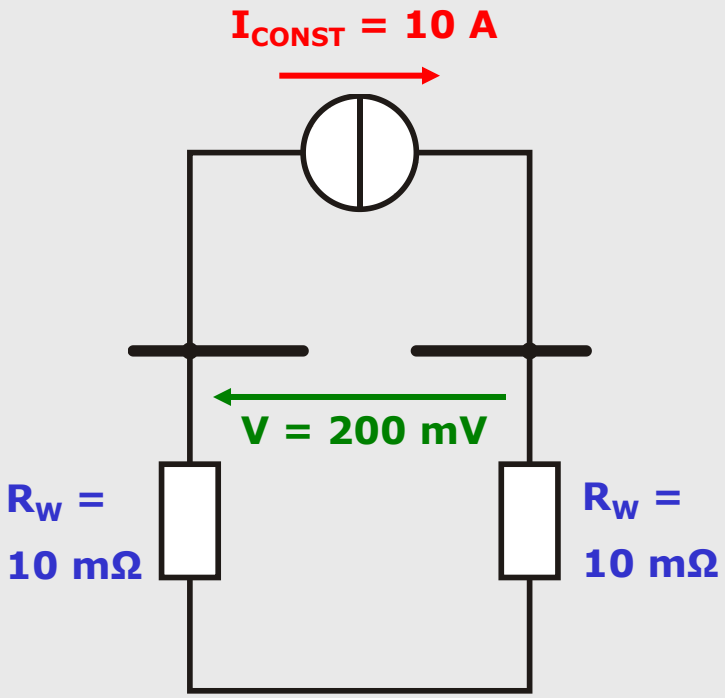


Circuit breaker: CLOSED

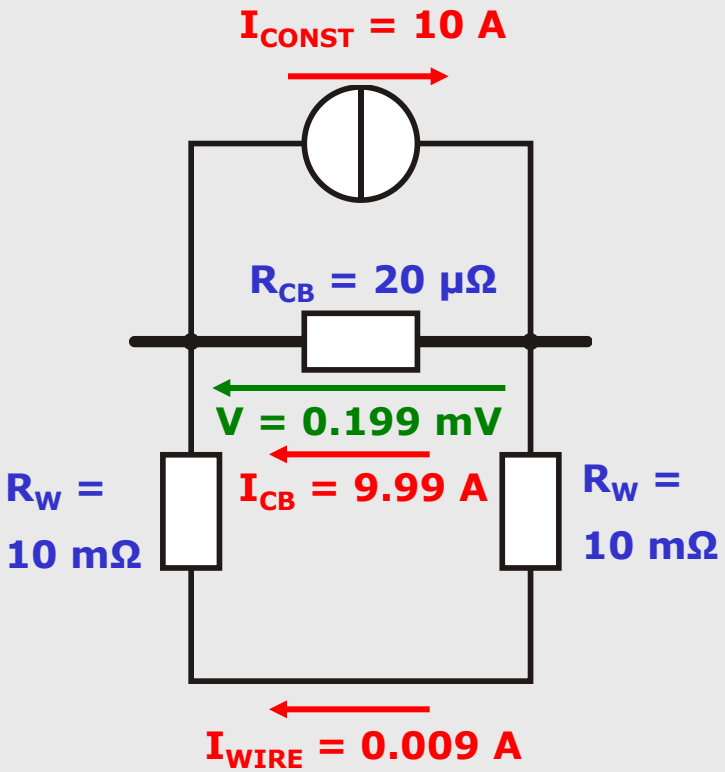


Worked sample: With Earthing

Circuit breaker: OPEN



Circuit breaker: CLOSED



▪Measurement of the Earth Current (new development)

▪Another method to determine the times at both side grounded breaker is to capture a current change in the ground lines during a switching operation.

▪The grounding at both ends of the switching device results in a parallel connection of the contact and the earth.

▪A constant current is connected to the contact, and is divided in the parallel circuit to a ground current and current to the contact.

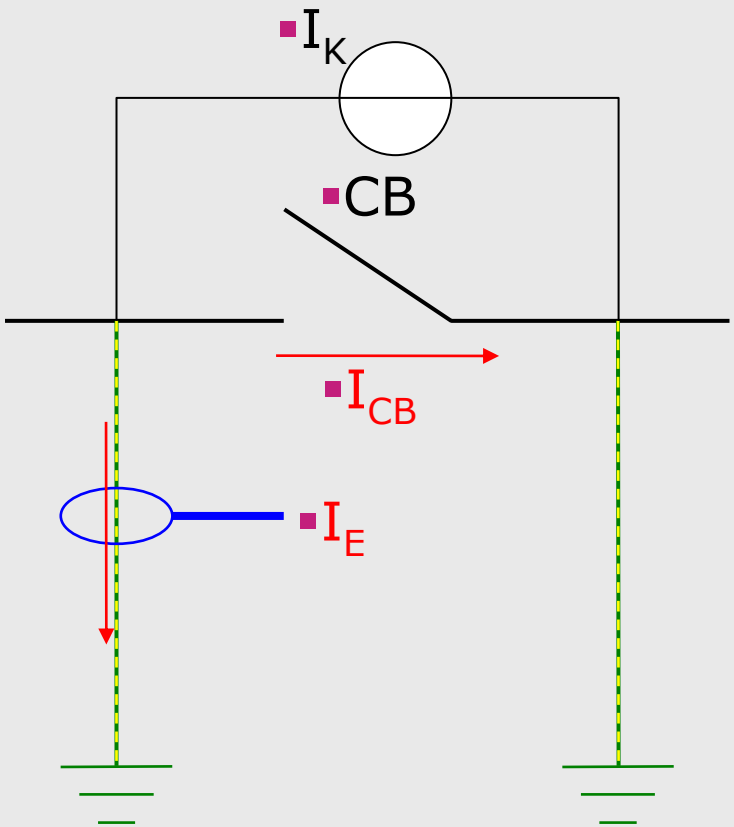
▪If the contact is open the constant current flows through the earth, with closed contact to inform on the current.

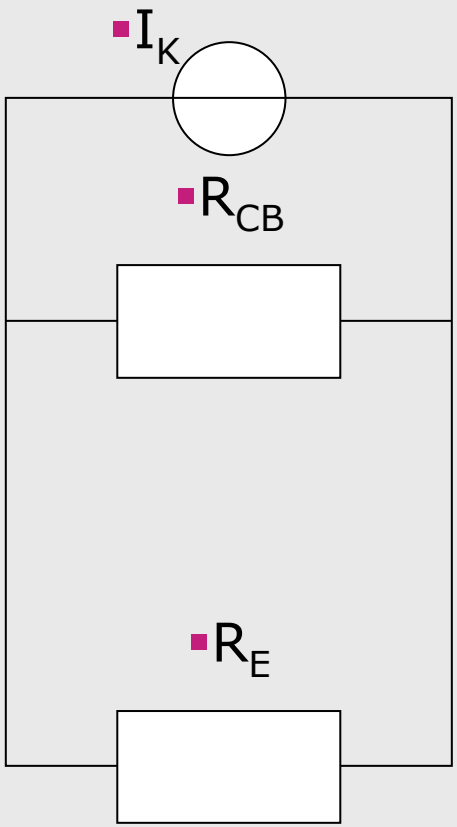
▪Measurement of the Earth Current (new development)

▪These current changes the switching times of the contact can be determined For feeding the constant current sources are the dynamic timing function (ICON = 10 A) connected to the switching unit. The current probes detect the current IE in the ground wire and connected to the 200mV/10V-measurement inputs.

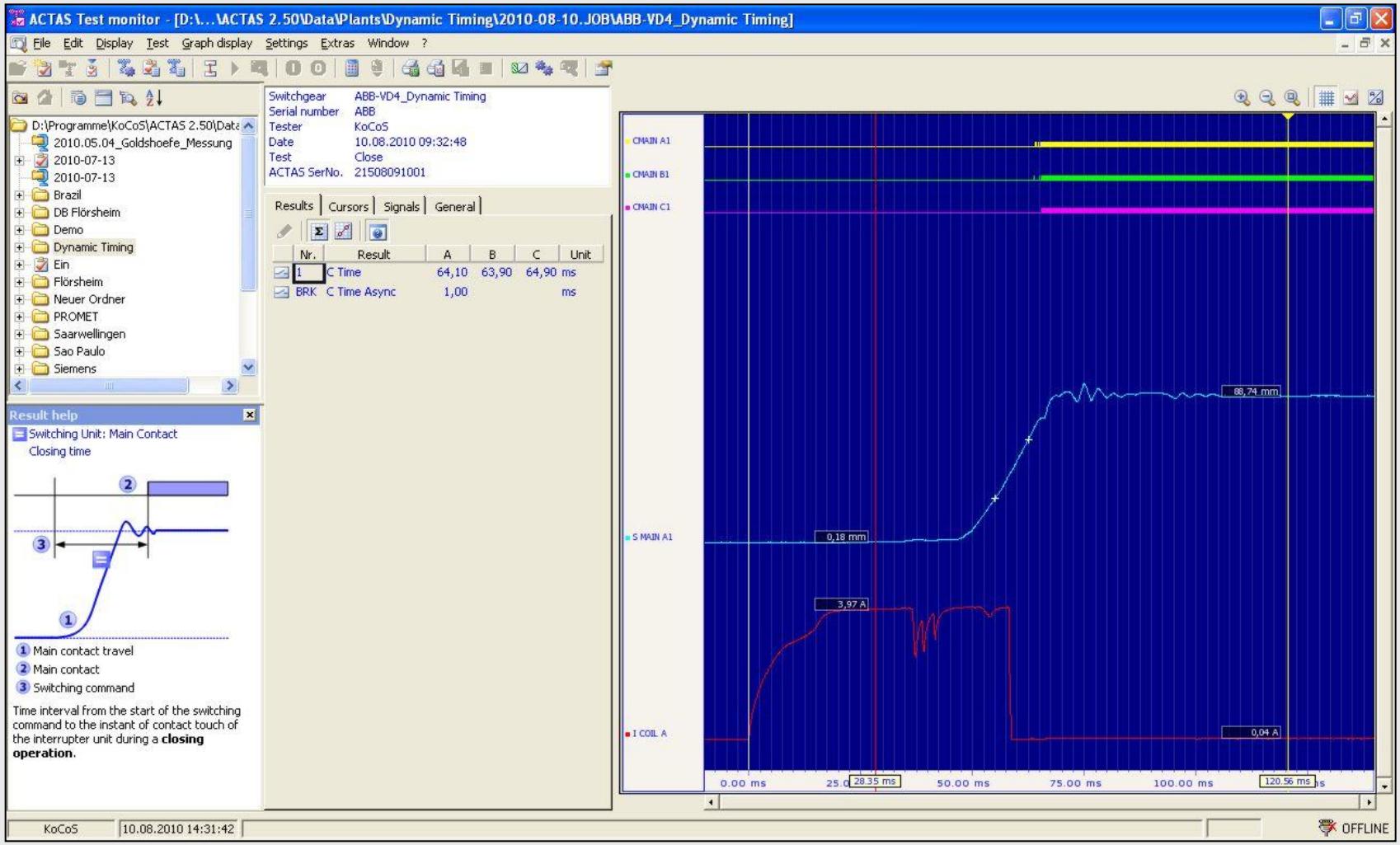
▪Both methods for determining the switching times, the above-described 4-wire method, and the earth current measurement are selectable in the software.

New method

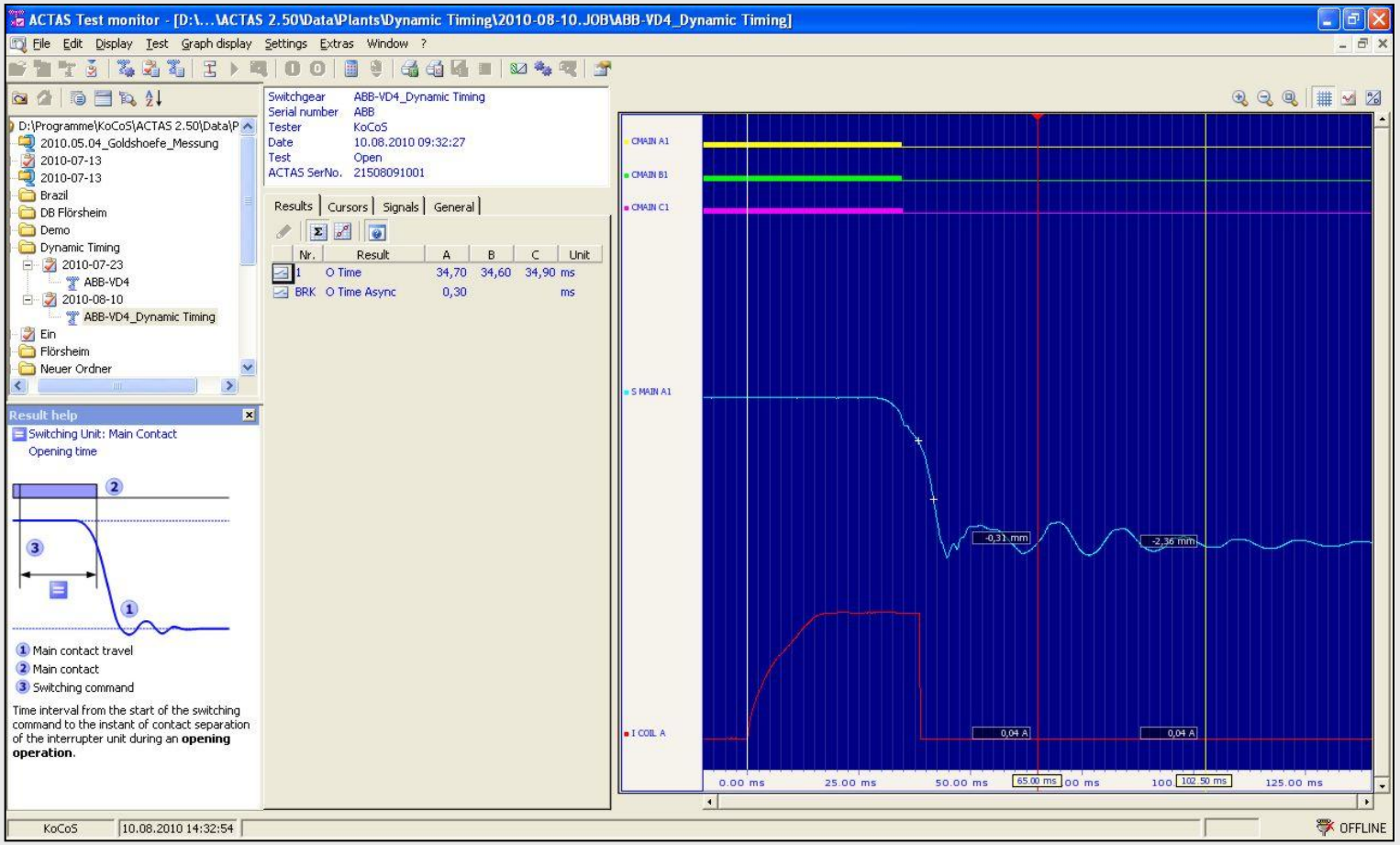




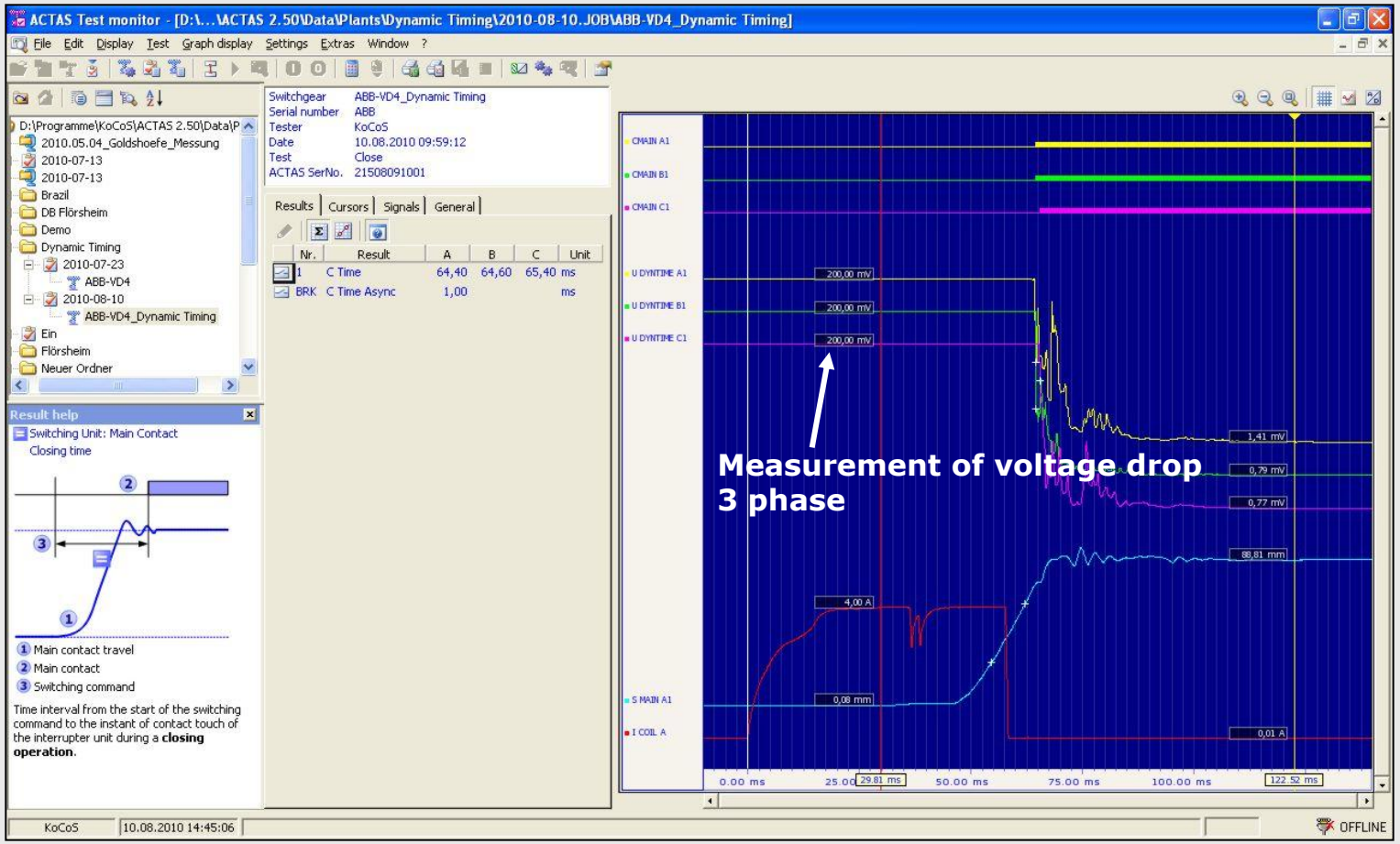
Test with Main Contact IN - CLOSE



Test with Main Contact IN - OPEN

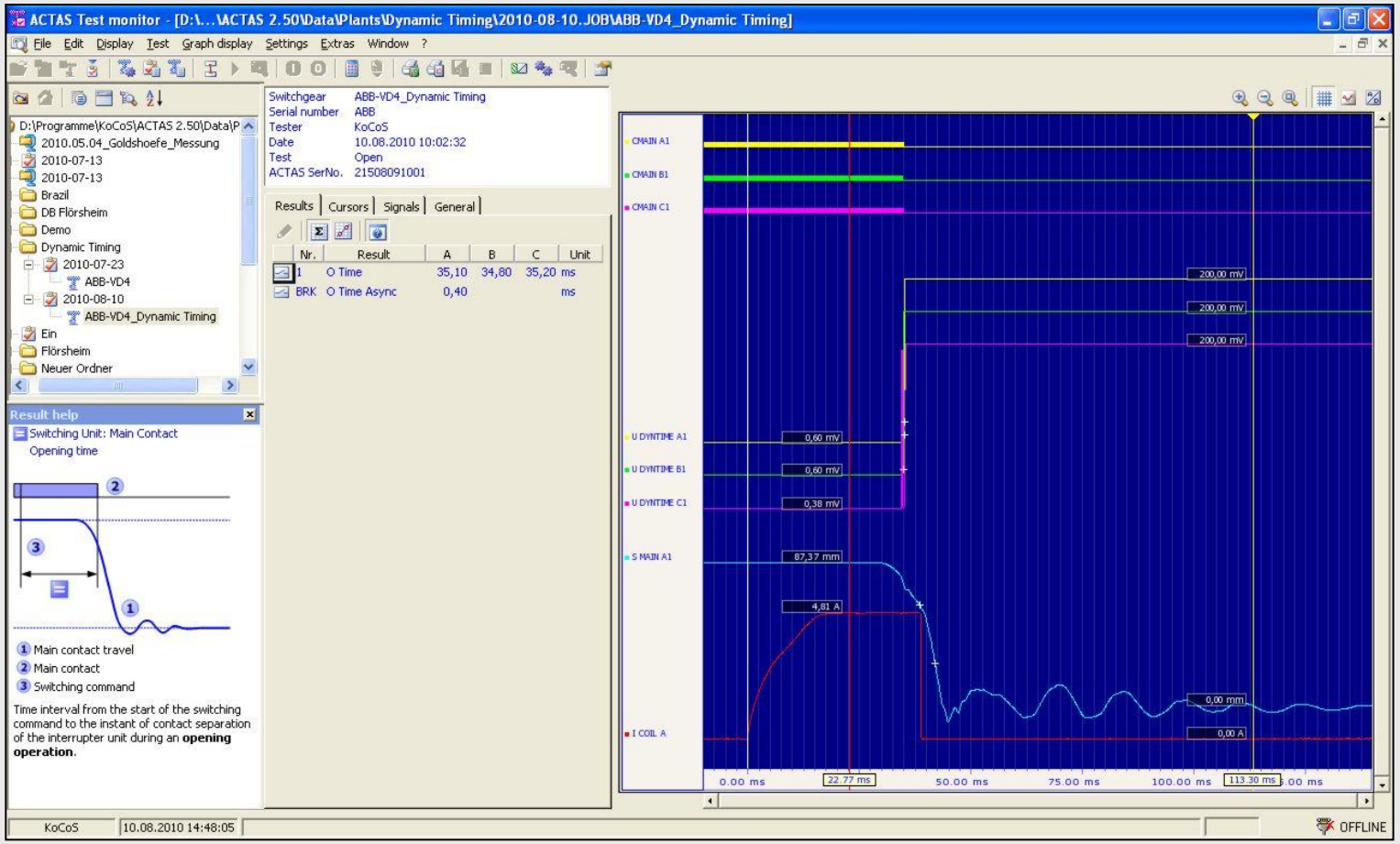


Test with Dynamic Timing – CLOSE without Earthing (Short Circuit)



- Short circuit: ~ 3 mΩ (~ 32 mV, 10 A)

Test with Dynamic Timing – OPEN without Earthing (Short Circuit)



Comparison

CLOSE – Operation

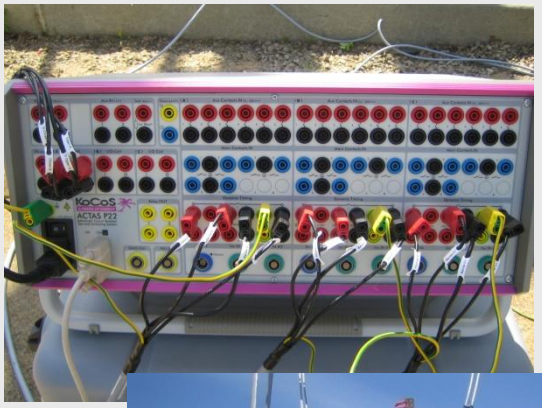
C Time	A	B	C	
Main Contact IN	64.10	63.90	64.90	ms
Dynamic Timing (without)	64.40	64.60	65.40	ms
Dynamic Timing (with)	64.10	63.80	65.20	ms

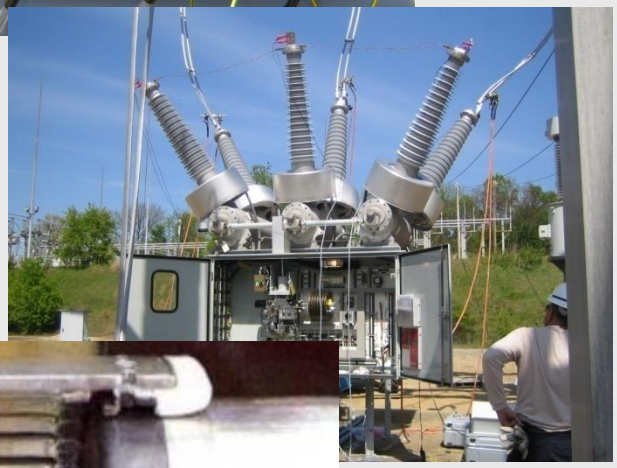
OPEN - Operation

O Time	A	B	C	
Main Contact IN	34.70	34.60	34.90	ms
Dynamic Timing (without)	35.10	34.80	35.20	ms
Dynamic Timing (with)	35.50	35.00	35.40	ms

Advantages

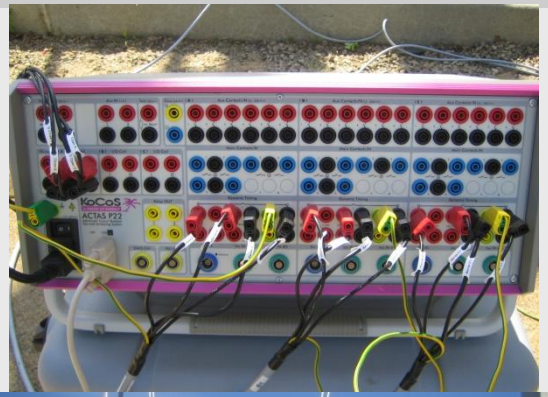
- Test with both sides earthing possible.
- No additional equipment required
- Safety of the operator is secured
- Determination of Graphite Contacts





Advantages

- Additional external measuring devices are not required.
- No special measuring cables are necessary.
- Connect directly to a device. The workload is therefore low.
- No calibration or adjustment to the electrical conditions of the apparatus.
- No triggering of external devices and the associated distortion of the switching times needed.
- The measuring current may be permanently made available. A waiting time until the next circuit is not required.
- A dynamic analysis is the recorded traces. This allows for precise analysis of contact systems with material transitions, such as Graphite-metal.



Method used on any breaker

KoCoS America

- Breaker Analysis
- Relay Testing
- Digital Fault Recording
- Meter Testing
- Power Quality Analysis
- Optical Measurement

Thank you for your interest.

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