

Study Committee A3 Transmission and Distribution Equipment

Paper 10439_2022

Improving Human Safety & Environment by Innovative Circuit Breaker Testing

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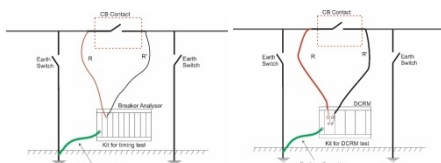
SCOPE T&M Pvt Ltd, India.

Motivation

- Traditional CB testing method involves frequent connection & disconnection of earthing and need to follow the correct sequence of the same could lead to human error having grave consequences.
- To ensure safety, there is a need to develop technology to test CB by keeping it earthed from both ends.
- The Paper describes the technology developed to dynamically measure & compensate the current flowing through the earth loop during testing and get the correct results.

Traditional CB Test Method

- CB tested with both side's earth open



- After making test cable connections, before actual test, both side's earth is removed. Again after test, both side's earth is connected to remove test cable connections.

Objective of investigation

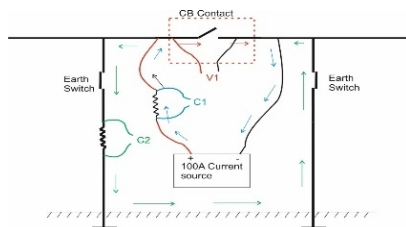
- To measure following parameters of CB, by keeping earth switch on both sides in closed condition.
 - Closing time, Opening time, C-O time and no. of bounces & bounce duration during closing.
 - DCRM signature & measurement of static contact resistance from DCRM graph
- Both sides earthing creates a permanent short circuit across the contact. Hence it is not possible to measure Opening and Closing time.
- New method : Use high current source and find out contact status by compensating current in earth loop.

TIME Measurement

- CB in Open state. Pass current through circuit. Current flows through earth path.
- This current is sampled and stored for compensation.
- Close command given, During operation, total current, current through earth and voltage drop across contact is sampled.
- A special software algorithm is developed to compensate current through earth and find out bounce duration and Closing time
- Same way Opening time is calculated.

DCRM test

- Similar method is used in DCRM with 100A or 200A current.
- Resistance v/s Time and Current v/s Time graph is derived by compensating current through earth.



Prototype Development

- Hardware prototype module using signal conditioning amplifiers, ADCs and microcontroller is developed.
- Carried out studies : Nature of variation in current signal in earth path and it's behavior during operation.
- Influence of 50/60Hz system voltage noise and its effect when DC current gets mixed in earth path of CB.
- Proper current compensation algorithm is developed
- The only current passing through contact is derived and with voltage drop across it, required parameters are calculated.

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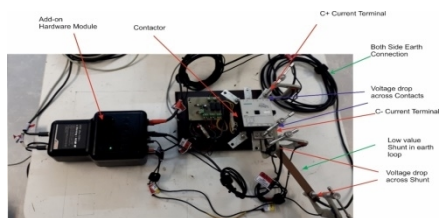
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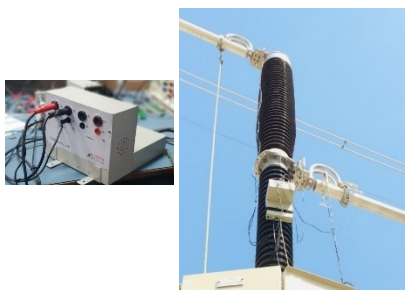
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LAB Simulation

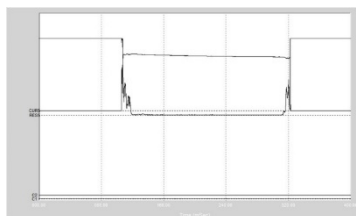
- Simulated test set-up using Contactor in Lab
- Existing CB Analyzer and software is used to sample data and derive test results



Field Trial With Prototype

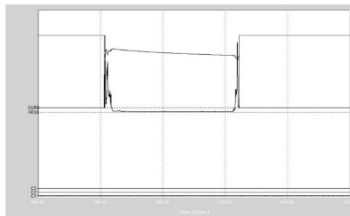


DCRM GRAPH WITHOUT EARTH



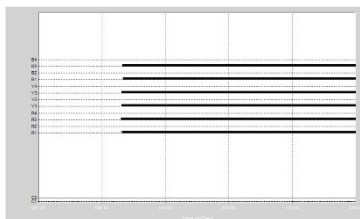
DCRM test without both sides earthed
Contact resistance – 53 micro-ohms

DCRM GRAPH WITH EARTH



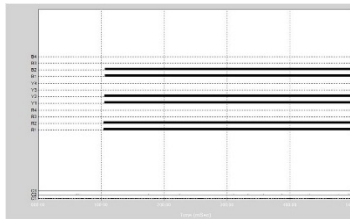
DCRM test with both sides earthed
Contact resistance – 56 micro-ohms

CLOSE TIME TEST WITHOUT EARTH



| | R1 | R2 | Y1 | Y2 | B1 | B2 |
|-------------------|-------|-------|-------|-------|-----|-------|
| Closing Time (mS) | 104.4 | 104.0 | 104.8 | 105.0 | 106 | 106.0 |
| Total Bounce (mS) | 1 | 1.1 | 0.8 | 0.9 | 0.9 | 0.8 |
| No Of Bounce | 2 | 3 | 1 | 1 | 3 | 2 |

CLOSE TIME TEST WITH EARTH



| | R1 | R2 | Y1 | Y2 | B1 | B2 |
|-------------------|-------|-------|-------|-------|-------|-------|
| Closing Time (mS) | 104.2 | 104.3 | 105.3 | 105.3 | 106.4 | 106.4 |
| Total Bounce (mS) | 1.2 | 1.4 | 1 | 1.3 | 1.4 | 1.3 |
| No Of Bounce | 2 | 3 | 1 | 2 | 2 | 2 |

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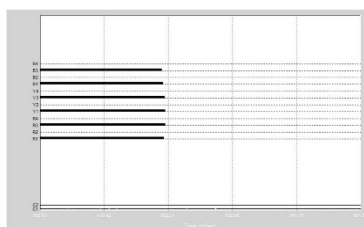
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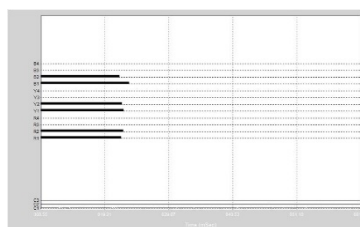
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OPEN TIME TEST WITHOUT EARTH



| | R1 | R2 | Y1 | Y2 | B1 | B2 |
|----------------|------|------|------|------|------|------|
| Open Time (mS) | 21.6 | 21.8 | 21.8 | 21.8 | 21.4 | 21.2 |

OPEN TIME TEST WITH EARTH



| | R1 | R2 | Y1 | Y2 | B1 | B2 |
|----------------|------|------|------|------|------|------|
| Open Time (mS) | 22.0 | 22.2 | 22.2 | 22.0 | 23.0 | 21.7 |

Analysis of Result

- It has been proven that, it is possible to test the circuit breaker with both side's earth switches connected.
- The difference in timing results was generally found to be within 1 to 1.5 mS, with both methods.
- As closed loop doesn't form in testing without earth form both sides, it is possible to achieve the difference of 0.5mS.
- The 'with earthing' method is analog measurement and as 50/60Hz noise is filtered through digital filter and special algorithm, still 1.5mS difference is good achievement.
- Further work is needs to be carried out to keep this difference below 0.5mS.
- The nature of DCRM graph is same in both the cases.
- Also the contact resistance is almost same in both cases.

Conclusion

- Testing Circuit Breaker with both sides earthed is must as it meets the crucial need of safety during testing.
- The new technique provides facility to test CB timings and DCRM with both sides earthed.
- Possible to test all breaks in one operation. Reduced down time.
- The reduction in size, usage of lesser & environment friendly materials makes new solution sustainable, compact, easy for handling & transportation.
- Test results are in digital form, Asset management and health assessment possible.
- All above contributes in decarbonisation by reducing carbon footprint of the activity of diagnostic testing of CBs.
- Overall, it is expected to make testing safer, faster, leaner & environment friendly.