CIGRE Study committe A3

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

JWG A3/A2/B3/B4/C4.53

NAME OF THE CONVENOR
Heinrich Christian (GERMANY)

TITLE
Inductive load Switching in transmission and distribution systems

THE WG APPLIES TO DISTRIBUTION NETWORKS: **YES**

ENERGY TRANSITION
5 / Grids and Flexibility

POTENTIAL BENEFIT OF WG WORK
5 / Guide or survey on techniques, or updates on past work or brochures

STRATEGIC DIRECTION
1 / The electrical power system of the future reinforcing the End-to-End nature of CIGRE: respond to speed of changes in the industry by preparing and disseminating state-ofthe-art technological advances
2 / Making the best use of the existing systems

SUSTAINABLE DEVELOPMENT GOAL
9 / Industry, innovation and infrastructure

BACKGROUND :

The switching of small inductive currents has become a relevant point in power systems since the 1960s, particularly through various research and development initiatives aimed at understanding electric arc behaviour in high-voltage circuit breakers. Initial investigations concentrated on the arc instability during the interruption of small inductive currents, including arc modelling and determining the chopping current based on the electrical parameters of the network, inductive loads, and circuit breaker characteristics. Early applications primarily involved switching large motors connected to high-voltage networks. However, post-1980, the rapid expansion of transmission grids — especially in regions where generation resources are far from consumption centres — highlighted the expansion of longer transmission lines and the need for reactive shunt compensation.

The rapid growth of renewable energies requires for additional voltage control within electrical systems. One solution that has gained traction is the use of switchable shunt reactors, even in electrical systems with relatively short transmission lines length, traditionally not requiring this type of resource.

CIGRE has provided extensive technical support through its publications to optimize the operations associated with shunt reactors. Despite these efforts, a persistent challenge remains: high transient overvoltages that occur during circuit breaker reignitions when reactors are de-energized. These overvoltages raise significant concerns regarding the wear and degradation of the oil-paper insulation used in the reactors and can compromise the performance of circuit breakers due to the stresses of the resulting transient recovery voltage (TRV).

There are several solutions to protect shunt reactors and circuit breakers against this kind of transient overvoltages: Surge arresters (MOSA, ZnO) are quite effective but have been proven to be insufficient in some cases. RC filters are very efficient but have to be calculated for each project separately. The introduction of controlled switching in high voltage (transmission) circuit breakers has emerged as an effective response to mitigate these undesirable phenomena.

The growing population of air-core reactors having significant lower stray capacitance leading to a higher natural frequency should be investigated to proof if today’s testing procedure is still appropriate. The same is valid for the growing use of neutral grounding reactors. Their application, mainly for line reactors in EHV systems, leads to a neutral shift, causing pole-to-clear factors other than 1 p.u. This is not considered in current testing schemes.

We see that lines or cables for connections of renewables are very often fully compensated which might lead to issues when closing or re-closing and causing missing zero crossings.

While this issue is mostly related to reactor switching in high voltage / transmission systems, it has the same physics in medium voltage / distribution and industrial system when switching reactors or motors.

Another effect seen often in distribution networks is the so called virtual current chopping, i.e. interruption of inductive currents due to coupling transients after a (multiple) re-ignition in a neighbouring phase resulting in switching overvoltage. This effect shall be discussed with respect to various switching media including vacuum, SF_6, and CO_2 based breakers.

Recent experience with shunt reactor switching has led to unsatisfactory operational performance in some cases, given an increasing number of reactor circuit breaker failures. This fact indicates the need for better understanding and to investigate the reasons for such events and propose improvements to application guides and relevant standards.

PURPOSE / OBJECTIVE / BENEFIT OF THIS WORK :

The main purposes of this WG are:

- Complement existing CIGRE publication on inductive switching in medium voltage (distribution and industrial) and high voltage (transmission) systems
- Taking into account the operational experience with reactor circuit-breakers, with and without application of controlled switching.
- Considering different switching media, especially SF_6 as most relevant for HV equipment but also $C_4FN/CO_2/O_2$, CO_2/O_2 gas mixtures, and vacuum as the dominant media in MV and one of the future technologies for HV.
- Provide analysis of the existing circuit-breakers standards dealing with reactor switching with the aim of improving them.
- Provide clear guidance to the user for the specification of inductive load circuits (including reactors, motors, transformers, etc.), especially in view of the change in switching technology based on SF_6 ban in increasing parts of the world.

The benefits of this work will be comprehensive guide for inductive switching in HV and MV, the proposal of improvements on the existing application guides, testing procedures and standards for shunt reactor and other inductive load switching.

SCOPE :

1. Analyse the existing guidance on inductive switching based on CIGRE reports, IEC and IEEE documentation, manufacturers recommendation and other publications
2. Correlate known issues with these guidelines by considering various switching media, taking into account extensive use of SF_6 circuit breakers in the past being replaced by vacuum and CO_2-based circuit breakers in future in HV, while vacuum was already dominant in MV
3. Propose improvements on existing specification criteria and engineering guidelines

Review and propose changes to testing procedures and standards (e.g. IEC 62271-110) for inductive switching with the purpose of giving guidance to utilities, industrial users and manufacturers on how to improve performance of these circuits.

Remarks:

Relevant documents so far selected:

- IEC 62271-110, Inductive Load Switching.
- IEC/TR 62271-306, Guide to IEC standards related to HV circuit-breakers.
- IEEE Std C37.015™-2017 - IEEE GUIDE FOR THE APPLICATION OF SHUNT REACTOR SWITCHING
- CIGRE TB 262 CONTROLLED SWITCHING OF HVAC CIRCUIT BREAKERS – BENEFITS & ECONOMIC ASPECTS - - WG A3.07 – December 2004
- CIGRE TB 757, Guidelines and best practices for the commissioning and operation of controlled switching Projects, Feb. 2019.
- CIGRE TB 947, Fourth CIGRE international reliability survey on equipment operated in 2014-17, November 2024.

DELIVERABLES AND EVENTS

Deliverables Types

Annual progress and activity report to Study Committee
Technical Brochure and Executive Summary in Electra
Tutorial

Webinar

Deliverables schedule

Annual progress and activity report | Q4 | 2025 | Annual Reporting

Tutorial | Q1 | 2029 | Tutorial

Technical Brochure | Q2 | 2029 | TB and Electra article ready

Webinar | Q3 | 2029 | Webinar

Time schedule

Q4 | 2025 | Recruit members (National Committees, WiE, NGN)

Q1 | 2026 | Develop final work plan

Q4 | 2028 | Draft TB for Study Committee Review

Q2 | 2029 | Final TB

APPROVAL BY TECHNICAL COUNCIL CHAIRMAN:
Rannveig S. J. Løken
October 13th, 2025