CIGRE Study Committee C4

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

WG [1]N° C4.74	**Name of Convenor:** Haoyan Xue (China) **E-mail address**: haoyan.xue@polymtl.ca
Strategic Directions #[2]: 1, 2	**Sustainable Development Goal #[3]: 9, 13, 14**
The WG applies to distribution networks: ☒ Yes / ☐ No	
Potential Benefit of WG work #[4] : 2, 3, 4	
Title of the Group: Accurate Line and Cable Models for Steady-State and Transient Studies	

Background:

Modern electric power systems are becoming increasingly complex. The current developments are in upgrading existing systems to allow large scale penetration of renewable energy sources. Renewable energy must be delivered with flexibility, reliability and optimization. In off-shore and on-shore applications, renewable energy sources rely on AC and DC transmission systems for grid interconnection. Increasingly dense power systems pose new challenges with coupled overhead and cable systems. The number of HVDC transmission projects is increasing rapidly and posing new challenges for line and cable modelling.

The transmission and distribution systems are generally characterized by overhead lines and cables. Recent research on transmission line and cable models for simulating power system transients has demonstrated new accuracy levels and new capabilities. Both analytical and numerical verifications have been established.

Cable usage is becoming increasingly important for point-to-point and multi-terminal HVDC transmission systems. The advanced HVDC systems are capable of transmitting energy from offshore wind farms to onshore grids over long distances with new submarine cable systems.

The implementation of underground and/or submarine cables interconnected with existing overhead transmission systems is becoming more and more common. Recently, a practical 500 kV mixed transmission system which includes overhead lines and buried cables has been adopted into the reinforcement of island power delivery in south-eastern coast of China. As a result, it is predicted that mixed systems consisting of overhead lines and buried cables will be dominant in future power grids.

The environmental and visual impacts of overhead power lines raise public concerns, and one possible solution is to use underground cables even over long distances.

The gas-insulated substations and/or lines (GIS/GIL) are important in transmission and distribution of electrical power in dense locations due to reduced space requirements, high reliability and low maintenance costs.

The performance of new systems heavily depends on simulation and analysis capabilities with theoretical foundations. Significant contributions are needed to work on transmission line and cable systems with support from numerical and experimental validations.

To address this challenge, this Working Group will deliver a set of publicly generalized electromagnetic transient (EMT) simulation models which could be used to compare various

results in steady-state and EMT studies. The developed models will be validated and benchmarked based on EMT simulation software, numerical electromagnetic analysis methods (FEM, MoM and FDTD) and field measurements. The developed models and methods will establish the most recent capabilities in this field.

The series and shunt parameters used in line and cable models will be evaluated using the recently developed methods for Line/Cable Data (LCD) calculation. The new methods are capable of accounting for overhead lines, underground cables, mutual couplings between overhead and underground conductors together with a consideration of multi-layer earth, stranded conductors, proximity effect, high frequency transient, complete expression of earth-return parameters, discharge times, etc. The new LCD provides a new tool to researchers and engineers for accurate simulation of cables and lines in power grids.

The novel features discussed in this Working Group can be used to fundamentally replace existing parameters calculation methods in EMT-type simulation tools. This is an important new information in practices for the simulation of EMTs with lines and cables.

Scope:

The scope and expected outcome of the proposed working group is summarized as follows:

I. Perform a review of parameter calculations and models

1. Concept of calculation for per-unit-length (pul) series and shunt parameters in frequency domain
2. Present a survey on new challenges and new configurations in modern power systems
3. Analytical methods
    a) Classical transmission line approach (Line and Cable Constants)
    b) Extended transmission line approach
4. Numerical electromagnetic analysis
    a) FEM based technique
    b) MoM based technique
5. Wideband modelling: fitting techniques, limitations

II. Deliver standard calculation examples of pul parameters in frequency domain

1. Overhead cables or lines
    a) HVAC, HVDC or HVAC-HVDC (same tower) overhead lines
    b) Bridge installed cable
    c) Tunnel installed cable
    d) GIS and/or GIL
2. Underground and/or submarine cables (HVAC and/or HVDC)
    a) Single core cable
    b) Pipe-type cable
3. Significant characteristics, demonstration of effects
    a) Multi-layer earth
    b) Generalized earth-return parameters
    c) Proximity effect
    d) Stranded conductor
    e) Frequency-dependent soil model
    f) Corona effect
    g) Cross-bonded effect
    h) Discharge times

4. Validations
    a) FEM based technique
    b) MoM based technique
    c) Field measurement

III. Deliver simulation examples in time-domain for covering the various aspects outlined above

1. Wideband model in EMT-type simulation tool
    a) Fitting techniques
    b) Passivity violation problems
2. Steady-state and EMT (energization, lightning, fault etc.) simulations
    a) Overhead lines and cables in Section II-1
    b) Underground and/or submarine cables in Section II-2
    c) Influences of II-3 in simulations
3. Validations
    a) FDTD based technique
    b) FEM based technique
    c) Field measurement

IV. Benchmark the examples in Sections II and III in different EMT-type simulation tools and share with industry members. Show limitations in existing models.

Remarks:

Liaison experts from SC B1 and B2 will be invited.

Deliverables:

☒ Technical Brochure and Executive Summary in Electra
☒ Electra Report
☐ Future Connections
☐ CSE
☒ Tutorial
☐ Webinar

Time Schedule: start: January 1st 2023 **Final Report**: January 1st, 2027

Approval by Technical Council Chairman:

Date: November 14th, 2022

Notes: [1] Working Group (WG) or Joint WG (JWG), [2] See attached Table 1, [3] See attached Table 2 and CIGRE reference Paper: Sustainability – at the heart of CIGRE's work. [4] See attached Table 3

Table 1: Strategic directions of the Technical Council

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-of-the-art technological advances
2	Making the best use of the existing systems
3	Focus on the environment and sustainability (in case the WG shows a direct contribution to at least one SDG)
4	Preparation of material readable for non-technical audience

Table 2: Environmental requirements and sustainable development goals

	CIGRE selected the 7 SDGs that are the most relevant to CIGRE. In case the WG work refers to other SDGs or do not address any specific SDG, it will be quoted 0.
0	Other SDGs or not applied
7	**SDG 7: Affordable and clean energy** Increase share of renewable energy; e.g. expand infrastructure for supplying sustainable energy services; ensure universal access to affordable, reliable, and modern energy services; energy efficiency; facilitate access to clean energy research and technology
9	**SDG 9: Industry, innovation and infrastructure** Facilitate sustainable infrastructure development; facilitate technological and technical support
11	**SDG 11: Sustainable cities and communities** Increase attention on sustainable and resilient buildings utilizing local (raw) materials, power for electric vehicles, strengthening long-line transmission and distribution systems to import necessary power to cities, developing micro-grids to reinforce the sustainable nature of cities; protect and safeguard the world's cultural and natural heritage; reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and waste management
12	**SDG 12: Responsible consumption and production** E.g. Promote public procurement practices that are sustainable; address reducing use of SF6 and promote alternatives, encourage companies to adopt sustainable practices and to integrate sustainability information into their reporting cycle, address inefficient fossil-fuel subsidies that encourage wasteful consumption
13	**SDG 13: Climate action** E.g. Increase share of renewable or other CO_2-free energy; energy efficiency; expand infrastructure for supplying sustainable energy; strengthen resilience and adaptive capacity to climate-related hazards and natural disasters; integrate climate change measures into national policies, strategies and planning; improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning
14	**SDG 14: Life below water** E.g. Effects of offshore windfarms; effects of submarine cables on sea-life
15	**SDG 15: Life on land** E.g. Attention for vegetation management; bird collisions; integration of substations and lines into the landscape

Table 3: Potential benefit of work

1	Commercial, business, social and economic benefits for industry or the community can be identified as a direct result of this work
2	Existing or future high interest in the work from a wide range of stakeholders
3	Work is likely to contribute to new or revised industry standards or with other long term interest for the Electric Power Industry
4	State-of-the-art or innovative solutions or new technical directions
5	Guide or survey related to existing techniques; or an update on past work or previous Technical Brochures
6	Work likely to contribute to improved safety.

Comments:

1) CIGRE Official Study Committee Rules: WG Membership

https://www.cigre.org/GB/about/official-documents

a. Only one member per country (by exception of SC Chair)

b. WG nominees must first be supported by their National Committee (or local SC Member) as an appropriate representative of their country.

c. Acceptance of the nomination is granted by the SC Chair and advised to the WG Convener

2) Collaboration Space

https://www.cigre.org/article/GB/collaborative-tools-2

CIGRE will provision the WG with a dedicated Knowledge Management System Space.

The WG will use the KMS for drafting collaboration, capture and retention of discussion and meeting records.

Official country WG Members will be sent registration instructions by the Convener.

Official country WG Members may request the WG Convener to allow additional access for an extra national subject matter specialist to aid in the work at the national level, including NGN members.