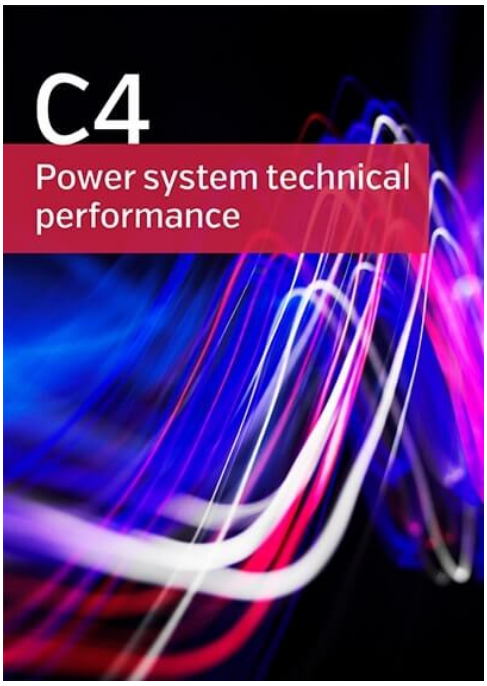
C4 - Power system technical performance



Mission

To facilitate and promote the progress of engineering and the international exchange of information and knowledge in the field of end-to-end power system technical performance. To add value to this information and knowledge by means of synthesizing state-of-the-art practices and developing recommendations supporting the energy transition.

Scope

Study Committee C4 is responsible for advanced methods and tools for analysis related to end-to-end power systems, with particular reference to dynamic and transient conditions and to the interaction between the power system and its apparatus/sub-systems (including external causes of stress, other installations and non-standardised waveforms). This scope includes the development of tools, models and methods of analysis for identification of power system needs, scarcities, technical envelope and design requirements, and new power system phenomena caused or accelerated by the energy transition. Key drivers, from the system perspective, include increased penetration of non-synchronous generation technologies such as wind, solar and storage into the power system, and the resultant changes in transmission and distribution networks. Accurate modelling of the controls of new (IBR based) technologies has become increasingly important for power system studies in both, steady state and transient, as well as inter-stability issues and harmonics. The Study Committee also addresses modelling and performance issues related to demand, and in particular, integration into bulk power systems. Demand types considered include but not limited to traditional industry plants (e.g., arc furnace, traction systems, etc) and their decarbonisation efforts, and new energy consumers (e.g., Data Centres, electrolysers, crypto mining farms).

Specific issues related to the design and manufacturing of components and apparatus are not in the scope of SC C4, as well as those specifically related to planning, operation and control, apart from those cases in which a component, apparatus, or subsystem behaviour depends on, or significantly interacts with, the performance of the nearby power system. However, as many design studies depend on the tools used and developed within the scope SC C4, it is important to note that SC C4 supports and encourages working jointly with other study committees and external stakeholders.

The scope of SC C4 covers power system technical performance phenomena that range from nanoseconds to many hours. Areas of attention include:

- **Power System Dynamics**: Development of processes and best practices for performing power system dynamic studies, in particular for grid connection studies. Development of advanced tools, models and new analytical techniques for the assessment of traditional and emerging new forms of power system dynamic/transient performance, security and stability. Design of controls, modelling of existing and new equipment, real time stability evaluation and control. Modelling of transient and unsymmetrical conditions of power systems. Black-start analysis using IBR.

  Keywords: *Steady-State, Power System Dynamics, RMS, EMT, PDT, Voltage Stability, Frequency Stability, Transient Stability, Rotor Angle Stability, Resonance Stability, Converter-driven Stability, Control Interactions, Small Signal Stability, Sub-Synchronous Oscillations, Super-Synchronous Oscillations, Low Inertia, RoCoF, Grid Following, Grid Forming, IBR, IBL, Storage, Wind and Solar, SPS, System Strength, PMU, Model Development, Model Validation, Power System Resilience.*

- **Power Quality**: Continuity of end-to-end electric power supply and voltage waveform quality (magnitude, frequency, symmetry). Analysis covers emission assessments from contributing installations (e.g. HVDC, FACTS controllers, inverter-based resources, inverter-based loads, arc furnaces) in radial and meshed networks, measurement and simulation methods, identification of quality indices, monitoring techniques, immunity of sensitive installations, and mitigation techniques taking into account a co-ordinated approach across all voltage levels.

Keywords: *Power Quality,* Voltage *fluctuation, Voltage Dip, Flicker, Voltage Imbalance, Frequency Variation, Waveform Distortion, Harmonics, Sub-harmonics, Inter-harmonics, Emissions, PQ Compliance, PQ Monitoring, PQ mitigation.*

- **Electromagnetic Compatibility and Interference (EMC/EMI)**: High frequency disturbances on the end-to-end electricity supply and all disturbances (HF or LF) reaching equipment other than through the electricity supply. Studies include measurement and simulation methods including EM vulnerability, immunity of sensitive installations, EMC in the vicinity of power systems, effects of intentional EMI and HEMP on the power system, understanding geomagnetic phenomena and their impacts on the power system. SC C4 will support the evaluation of health effects related to low-frequency EMF with measurements, calculations, mitigation, etc.

Keywords: *EMC, EMI, HEMP, GMD, Supra-harmonics, Radiated Interference, Conducted Interference, Radio Interference, Communications Interference, Impulsive Transient, Oscillatory Transient, Digitalization.*

- **Lightning:** Analysis and modelling of lightning characteristics and interactions of lightning with electric power systems and equipment, including the evaluation of the lightning performance of power systems as well as lightning detection technologies. Design of protection measures against lightning effects and their standardisation in power transmission and distribution networks, power stations, sensitive infrastructures, industrial sites and tall structures.

Keywords: *Back-Flashover, EMT analysis, FDTD, Ground Flash Density, Grounding, Induced overvoltages, Lightning, Lightning characteristics, Lightning data analysis, Lightning detection systems, Lightning induced overvoltages, Lightning measurements, Lightning monitoring, Lightning performance, Lightning protection, Shield wire, Surge arresters.*

- **Insulation Co-ordination**: Methods and tools for insulation co-ordination and electromagnetic transient analysis (e.g. harmonic instability, ferroresonance, lightning, switching, transformer energization, IBR driven transients) in electric power systems and equipment, contributing to optimisation of their cost and reliability. Development of accurate models for network components and equipment, appropriate for the phenomena of interest, as well as modern sources for LF, HF, and VHF transients.

Keywords: *Insulation Co-Ordination, BIL, BSL, Low Frequency Oscillation, Temporary Overvoltage, Slow-Front Surges, Fast-Front Surges, Very-Fast-Front Surges, Harmonic Instability, Ferroresonance, Resonance, Inrush current, Transformer Energisation, EMT, Switching Transient, Black-start.*

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