

DISCUSSION MEETING

Study Committee C4

(Power System Technical Performance)

Date: Thursday, 1st September, 2022

SUMMARY

Chairman: Dr. Zia EMIN

Secretary: Dr. Genevieve LIETZ

Special Reporters: Professor Sarath PERERA, Kostas VELITSIKAKIS, Dr. Babak BADRZADEH

1. INTRODUCTION

The 2022 Group Discussion Meeting (GDM) of Study Committee C4 was held on Thursday, September 1st 2022 in the Bordeaux Amphitheatre at the Palais des Congrès as an all-day event. Over 120 participants were in attendance during the morning session; averaged more than 80 participants throughout. All preferential subjects stimulated very active discussions. There was a total of 59 papers and 21 questions.

The GDM covered the following preferential subjects:

Preferential Subject 1 (PS1) – Challenges and advances in power quality (PQ) and electromagnetic compatibility (EMC)

Preferential Subject 2 (PS2) – Challenges and advances in insulation coordination and lightning research

Preferential Subject 3 (PS3) – Challenges and advances in power system dynamics

Next Generation Network (NGN) Presentations:

NGN presentations from Spain (PS1) and France (PS2) were given. There were spontaneous contributions in response to both NGN presentations.

PS1:

19 papers, 6 questions.

11 contributions with presentations to 6 questions. There was a total of 7 spontaneous contributions with discussions.

PS2:

11 papers, 4 questions.

5 contributions with presentations to 3 questions; 1 question had no contribution. There was a total of 10 spontaneous contributions with discussions.

PS3:

29 papers, 11 questions

24 contributions with presentations to 9 questions; 2 questions did not have a contribution. There was a total of 29 spontaneous contributions with discussions.

2. RUNNING OF THE MEETING

The Group Discussion Meeting was chaired by the Study Committee Chairman, *Dr. Zia EMIN*, with *Kostas VELITSIKAKIS (NL)* and *Dr. Babak BADRZADEH (AU)* as Special Reporters and *Dr. Genevieve LIETZ* as SC C4 Secretary. The incoming Study Committee Chair *Marta VAL ESCUDERO* was also present. PS1 Special Reporter *Professor Sarath PERERA (AU)* sent his apologies.

3. CONTRIBUTIONS TO PREFERENTIAL SUBJECT 1

PS1:

19 papers (including 1 NGN), 6 questions in PS1.

11 contributions (including 1 NGN) from 6 countries (NL, BR, AU, JP, UK, ES) with presentations in response to 6 questions. There was a total of 7 spontaneous contributions with discussions.

Summary: PS1 - Challenges and advances in power quality (PQ) and electromagnetic compatibility (EMC)

Theme 1: Modelling, measurement and assessment of PQ phenomena including emerging areas such as supra-harmonics, harmonic instability, geo-magnetically induced currents and other similar phenomena

- Harmonic modelling, propagation and attenuation, their emission allocation and assessment, harmonic instability, PQ limits and trends and regulatory processes (13 papers)
- Geo-magnetically induced currents (2 papers)

Theme 2: Integration and application of advanced signal processing, artificial intelligence techniques and big data analytics for event diagnostics and system planning purposes such as hosting capacity or emission limit calculation

- Big data analytics applied in hosting capacity evaluation of solar photovoltaic systems in their planning and operation (1 paper)

Theme 3: Impacts on equipment compatibility and immunity, and emerging mitigation approaches. Power quality mitigation, compatibility and immunity in AC and DC power systems (3 papers)

Common Trends:

- Power system harmonics and their management including harmonic instability in evolving power systems with increasing IBRs are areas of significant interest.
- Power electronic solutions have the potential to control the impact of GICs
- Big data has the potential in power system planning and management
- Allocation of power quality emission levels that are immeasurable need attention

Lessons Learned:

- Utilities are finding pre-connection harmonic studies challenging, time consuming and the outcomes of such studies do not always lead to cost effective solutions.
- The data available to carry out such studies is seen to lead to overly conservative outcomes. Pre and post connection measurements are seen to be highly appropriate in reducing capital expenditure in addition to paying attention various regulatory procedures associated new connections.
- Harmonic emission allocation and assessment are still challenging where clarity is required on the actual contribution against what is allocated including overly demanding coverage of large number of low order harmonics. Measurement of very small harmonic levels allocated is difficult, so why allocate? – instead cap the minimum levels?

- IBRs connected to weak networks have the potential to lead to harmonic instability. The modelling of IBR controllers is a key part of associated studies where manufacturer provided data/models will be vital.
- Clear theoretical understandings behind reactive power is essential in relation to study and management of GICs
- Big data analytics together with a range of other tools (eg GIS data) can be used in power system planning and operation

4. CONTRIBUTIONS TO PREFERENTIAL SUBJECT 2

11 papers (1 is NGN); 4 questions.

5 contributions (including 1 NGN) from 4 countries (FR, SE, JP, DE) with presentations to 3 questions. There was a total of 10 spontaneous contributions with discussions.

Summary: PS2 - Challenges and advances in insulation coordination and lightning research

Theme 1: Insulation coordination practices for end-to-end power networks, including the effects of long lines, long cables and frequency dependent models

- Insulation coordination, harmonic resonance temporary overvoltages and switching transients of harmonic filters (3 papers)

Theme 2: Development of insulation coordination in AC systems interfaced with power electronics-based systems and devices, and the need for standardization

- Transient phenomena in power electronic based systems (2 papers)
- New approaches for the insulation coordination of HVDC systems (1 paper)

Theme 3: Lightning evaluation of transmission and distribution systems covering new asset designs and extreme meteorological events

- Utilization of available data when evaluating the impact of lightning events on the performance of overhead lines and substation equipment (5 papers)

Lessons Learned :

- TOVs are to be expected under power system restoration conditions; mitigation options include:
 - Point-on-Wave switching of power transformers
 - Gradual energization of the network
- Successful experience of HVDC systems, where conventional insulation coordination methods have been used during the design phase. However, semi-probabilistic methods might be necessary to achieve systems of reduced footprint.
- Insulation coordination of substations with respect to impinging lightning surges:
 - Statistical analysis provides flexibility over the conservative deterministic methods
 - Lower insulation withstand levels, shorter separation distances between a power transformer and surge arresters can be achieved
- Optimised OHL designs (insulation coordination and ampacity) can be achieved by considering the correlation between weather conditions and occurrence of FFOs

5. CONTRIBUTIONS TO PREFERENTIAL SUBJECT 3

29 papers, 11 questions

24 contributions from 11 countries (FR, AU, SE, IE, BE, JP, TH, FR, GR, CA, JP) with presentations to 9 questions; 2 questions did not have a written contribution. There was a total of 29 spontaneous contributions with discussions.

Summary of PS3 - Challenges and advances in power system dynamics

Theme 1: Modelling, analysis and validation of individual components and wide-area system interactions including system level protection schemes considering changing system dynamics

- Modelling tools, techniques and screening methods, and assumptions applied (8 papers)
- Model and performance validation (5 papers)
- System level protection schemes (2 papers)

Theme 2: Impact of emerging technologies such as hydrogen and other storage devices, grid forming inverters and demand side management

- Grid-forming inverters (6 papers)

Theme 3: Analysis of security and resilience of power systems having high share of grid-connected or distributed inverter-based resources including feasibility of providing system support such as black start, islanding, system strength and inertia

- System inertia, frequency and voltage control (4 papers)
- Power system planning and flexibility considerations (4 papers)

Common Trends:

- Initiatives for faster off-line EMT simulation
- Increasing occurrences of unknown/unexplained dynamic phenomena
- More complex and fast acting special protection schemes
- The use of battery energy storage systems for grid support services (grid-following and grid-forming)
- Several grid-forming inverters in practice and under studies
- Increasing impact of the DER on bulk system dynamic performance
- More detailed modelling for long-term system planning

Lessons Learned:

- Offline and real-time EMT simulation may need to be considered complementarily.
- Model validation is not a one-off exercise.
- Whole system dynamic modelling and model validation accounting for the dynamic response of loads and DER is becoming necessary.
- Special protection schemes are being increasingly used for HILP and non-HILP events as the IBR share increases.
- It is not always a good idea for the grid-forming inverters to emulate the response of a synchronous generator.
- Case-by-case prioritisation of the services and better definition of system technical needs is important to facilitate increased deployment of grid-forming inverters.
- Modelling methodologies for long-term system planning are expected to evolve including forward-looking EMT network models and the use of relevant screening methods.
- The need for more industry efforts to better understand the inter-relationship between system stability, power quality and protection as the IBR share increases.

6. CONCLUSION

A total of 86 contributions including written contributions, spontaneous contributions and suggestions provided many interesting ideas and stimulated useful discussions. The session was of interest to all participants from a technical viewpoint. The peak number of participants was over 120 (during the morning session) and averaged more than 80.