SUBMISSION OF RESEARCH OBJECTIVE

Research Topic-1

1. Research Objective (Topic): *Exploration and Investigation of Wide-Area Simulation Frameworks including Renewable Energy and HVDC Systems to accurately capture their Dynamic Behaviour*

2. Lead of project-GM and above: (Name, Designation, & Department):

   Sh. S. S. Raghuwanshi
   GM (SO)

3. Co-Ordinator of Project (Name, Designation, & Department):

   Sh. Madhukar Goodelli
   DGM (SO)

4. **Key Problem Areas**: [Briefly Outline the current Challenges to address with Research]:

   - *Two primary simulation tools are employed for analyzing power system transients:*
     - *Transient Stability (TS) Programs: These programs focus on lower-frequency phenomena, such as power swings (typically below 2 Hz), loss of synchronism, and the response of voltage regulators and governors. TS models utilize simplified representations of system components.*
     - *Electromagnetic Transient (EMT) Programs: Designed to capture fast transient events, EMT simulations require detailed high-frequency models of system components and employ very small time steps (typically less than 50 microseconds).*
   - *Evolving Challenges:*
     - *The integration of power electronic converter-interfaced systems like wind farms, High-Voltage Direct Current (HVDC) links, Voltage Sourced Converters (VSC), Variable Frequency Drives (VFD), and Photovoltaic (PV) inverters into the grid has blurred the traditional distinction between fast and slow time-scale transients. The dynamics introduced by these technologies often exhibit characteristics that span both time domains.*
   - *Computational Challenges:*
     - *Simulating the entire grid with detailed EMT models for all components would be computationally excessive. This has led to the development of more efficient simulation techniques:*
     - *Limited Study Zone with Equivalents: Modeling the system of interest in detail with simplified representations (equivalents) for the external grid.*
     - *Hybrid TS-EMT Simulations: Combining TS and EMT simulations, where the core study area is modeled with EMT, while the broader system is represented by a TSS model.*
     - *Full-Scale EMT Simulations: Despite the computational demands, advancements in computing power are enabling more comprehensive full-scale EMT simulations for certain applications.*

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5. **Briefly outline the detail of methodology used for research:** [Provide a concise overview of your research write-up and methodology. Include key aspects like the research approach, data collection methods, and analytical techniques.]

   Considerations for conducting large-scale studies

   - *Accuracy, Simulation speed and hardware requirements.*
   - *Power System Model Guidelines. Average versus Switching Models?*
   - *Screening methods for determining when RMS and EMT simulations are required.*
   - *The extent of the system that needs to be modeled in EMT domain if hybrid simulation is to be done*

   Based on above considerations outline of the methodology for the proposed project is as below.

   - *Methodology for hybrid simulations and simplified representations, characterize the accuracy of simulations in terms of spatial and temporal parameters (e.g., what is the bandwidth of the transients that can be accurately captured as a function of the "distance" from the disturbance).*
   - *Accuracy of hybrid simulations with different relative sizes of EMT and TS simulations.*
   - *Explore different open-source tools/commercially available tools and co-simulation methodologies for computational efficiency and speed.*
   - *The hybrid simulation studies will be initially carried out on simple benchmark systems. Thereafter, larger systems will be explored. Source tools/Hardware will be transferred.*
   - *Carve out one part of the TS system and model it in EMT domain. Carry out a hybrid simulation using open source/commercially developed TS and EMT program.*
   - *Successively embrace larger parts of the TS simulation in the EMT domain to assess the impact on accuracy and speed. Explore High-performance computing (HPC) that be used to accelerate electromagnetic transient (EMT) simulations of large-scale power systems.*
   - *Sharing the outcomes through workshops/sessions, reports and other documentations.*

6. Citation/References (Relevant Literature/Technical Papers):

   - L. Gérin-Lajoie and J. Mahseredjian, "Simulation of an extra-large network in EMTP: From electromagnetic to electromechanical transients," in Proc. Int. Conf. Power Syst. Transients (IPST), Kyoto, Japan, Jun. 2–6, 2009
   - B. Badrzadeh et al, The Need for Enhanced Power System Modelling Techniques and Simulation Tools. CIGRE Scince and Engineering, Volume No.17, February 2020
   - V. Jalili-Marandi, V. Dinavahi, K. Strunz, J. A. Martinez, A. Ramirez,"Interfacing Techniques for Transient Stability and Electromagnetic Transient Programs",IEEE Trans. on Power Del., Vol. 24, No. 4, pp. 2385-2395, Oct. 2009.
   - H. T. Su, K. W. Chan, L. A. Snider, "Parallel Interaction Protocol for Electromagnetic and Electromechanical Hybrid Simulation", Proc. Inst. Elect. Eng., vol. 152, no. 3, pp. 406-414, May 2005.
   - https://www.dsatools.com/wp-content/uploads/2019/05/TPI-A-New-TSAT-PSCAD-InterfaceLaunched-Final.pdf Available online July 2024

SUBMISSION OF RESEARCH OBJECTIVE

- https://assets.new.siemens.com/siemens/assetsapiuuid:81673bb4cff16dd38809d3960f59063342003c0b/psse-pscad-cosimulation-moduleflyer.pdf Available online July 2024.
- G. D. Irwin, C. Amarasinghe, N. Kroeker and D. Woodford, "Parallel processing and hybrid simulation for HVDC/VSC PSCAD studies," 10th IET International Conference on AC and DC
- Power Transmission (AC-DC 2012), Birmingham, 2012, pp. 1-6, doi: 10.1049/cp.2012.1977.
- https://www.electranix.com/software/e-tran-plus/ Available online July 2024
- S. Panda, A.M.Kulkarni, “Waveform relaxation based hybrid simulation of power systems,” 19th National Power Systems Conference (NPSC), India, December 2016