BEST PRACTICES FOR CREATING DYNAMIC NETWORK MODELS BASED ON LOAD FLOW MODELS FOR DSA APPLICATIONS

Johannis PORST [1], Ilya BURLAKIN [1], Elisabeth SCHEINER [1], Matthias LUTHER[1], Stefanie SAMAAN [2], Markus KNITTEL [2], Mojtaba MOMENI [2], Albert MOSER [2], Hendrik JUST [3] and Stefan HORN [4]

[1] Institute of Electrical Energy Systems, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), 91058 Erlangen, Germany, johannis.porst@fau.de, https://www.ees.tf.fau.de/

[2] Institute for High Voltage Equipment and Grids, Digitalization and Energy Economics (IAEW), RWTH Aachen University, 52062 Aachen, Germany

[3] 50Hertz Transmission GmbH, Berlin, Germany

[4] TenneT TSO GmbH, Bayreuth, Germany

Introduction

Due to increasing share of converter-based components and the ongoing shutdown of conventional power plants in Germany, Dynamic Security Assessment (DSA) becomes more important in order to secure safe system operation. The German transmission system operators are currently evaluating enhancements of their system operation strategies with a curative system operation [1]. To further increase the utilization of the current state of the German power system, curative actions (i.e. fast reacting power sources and sinks) shall be used to solve possible grid congestions [2]. The higher utilization causes rising reactive power demands and shifts the operating points closer to the stability limits. Thus, efficient DSA processes in order to analyze and assess the system stability as proposed in [3] are required. However, especially for an automated DSA process, as presented in [3], the availability and creation of dynamic network models is essential.

Therefore, in the research project "Innovations in system operation until 2030" ("InnoSys2030"), a new development process is evolved and applied to a load flow model using to two different simulation tools, DIgSILENT PowerFactory and MatPAT [4] , respectively. This paper presents best practices and a Python toolbox for creating a dynamic network model based on load flow models. This will include typical drawbacks of load flow network models, standard controllers for generators and converter-based components such as HVDC links, STATCOMs and wind parks. Additional, a best practice for modeling of a grid interface for converter is presented to ensure RMS solver convergence in network models with a high share of converter-based units.

Method

Creating a dynamic network model starts with an initial load flow model representing one or multiple load flow scenarios. Dynamic network studies are usually only one part of a research project. In many cases, the initial load flow model is created in previous studies to serve a specific (load flow) study purpose and only contains relevant information for load flow studies. Relevant information for dynamic system studies are frequently missing. Common drawbacks of such load flow models are:

- Insufficient modelling of topology (especially transformers for power generating units)
- Missing or false data of generators, such as nominal power, power limits or dynamic parameters
- Existence of extended ward equivalents to balance additional active power (e.g. system losses) and reactive power demands
- Insufficient modelling of the voltage control situation leading to non-realistic conditions with regard to voltage-reactive power balance
- Missing models of dynamic controls for generators and converter assets (e.g. HVDC-Links, STATCOMs)

In order to solve those drawbacks, a new development process is applied. The process starts with an adaption of the voltage-reactive power balance. For the next steps, a Python toolbox for the dynamization process is designed, utilizing the Python API of DIgSILENT PowerFactory. First studies using the tool box were done in [5] by implementing dynamic controls into forecast data sets. The process from [5] is enhanced by implementing methods in order to solve load flow modeling issues like the ones listed above. Additional, standard controls for different types of synchronous generators and additional controls for power electronics, such as HVDC links, STATCOMs and wind parks are integrated in the toolbox. For network models containing a high amount of converter-based units, a dedicated grid interface is used to guarantee RMS solver convergence.

Validation and Results

The new development process including the adaption of the voltage-reactive power balance will be presented by applying it on one exemplary network model: a load flow model that was initially used for the German Grid Development Plan [6] by the German transmission system operators. In order to create a dynamic network model suitable for RMS simulations, the load flow model was reworked in DIgSILENT PowerFactory by FAU Erlangen-Nürnberg and in MatPAT by RWTH Aachen University, respectively, during the research project "Innovations in system operation until 2030" ("InnoSys2030"). For validation, commonly used network quantities, such as short circuit power, load flow analysis and voltage trajectories in case of short circuits have been compared to each other in both tools.

The simulations show sufficient results to investigate contingencies and their impact on system stability. Further work will focus on dynamic studies, e.g. impact of curative actions on system stability, variation of control time constants in FACTS elements to enhance system stability and the development of DSA methodologies in hybrid AC/DC grids.

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