Ovation™ Digital Twin Smart Grid Extensions

Features

- Simulates transmission, distribution, and generation systems, capable of handling unbalanced polyphase power.
- Supports distributed energy resource and renewable energy integration, impact studies, and deployment planning.
- Enables the application of smart grid use cases, including demand response, control strategies, and communication interfaces.
- Assists in distribution system planning and analysis, allowing the specification of network design limits and identification of areas of improvement.
- Fine-tunes and verifies control system designs before plant startup to minimize commissioning time.
- Assists in the development of best-practice operating procedures for optimized grid operation.
- Tests and validates new or modified control strategies before live operation and deployment.
- Provides training for professionals in modern power system analysis and smart grid technologies.

Introduction

The Ovation™ Smart Grid Extensions (SGE) simulation package includes a suite of algorithms available as graphic-based software tools within the Ovation Digital Twin environment. These algorithms perform complex simulations involving electric power transmission, distribution, and generation.

SGE algorithms leverage a comprehensive electric power distribution system simulator engine known as OpenDSS, which performs fast and efficient steady-state power-flow solutions based on nonlinear matrix equations. SGE algorithms omit electromagnetic transient behaviors but are capable of capturing responses produced by weather, loads, and discrete controls, and can also be used for modeling long-term power flow simulations. In addition, simulations involving SGE can be conducted faster than in real-time, allowing for rapid prototyping and extensive scenario testing of complex systems and controls.

Equipment

- Voltage sources
- Overhead transmission lines
- Underground transmission lines
- Transformers
- Capacitor banks
- Reactor banks
- Variable reactors
- Loads
- Synchronous generators

- Induction Motors
- Manual voltage regulators
- Automatic voltage regulators
- Battery storage systems
- Photovoltaic systems
- Wind turbine generators
- Sensors

Power Flow Solution

The OpenDSS engine employed in the SGE algorithm suite is designed primarily as a distributed generation power flow solver, performing a series of sequential, steady-state solutions which are time-dependent. The quasi-static nature of the simulator supports the simulation of time steps as small as 100 milliseconds, allowing a suitable representation of distributed energy resource impact and response. Discrete controls are represented as time-dependent states, while other network elements, such as loads, are included as time-varying parameters, resulting in a nodal admittance matrix formulation of a power system. Weather data may be injected into a simulation to modify the operating points for distributed energy generation, as well as to observe real-time or long-term response characteristics of a system's response.

Integration with Ovation Digital Twin

The SGE algorithm suite integrates seamlessly into the Ovation Digital Twin platform, offering live digital representations of a physical electrical system. The system can be modeled with a flexible level of fidelity, while communications through interfaces such as SCADA, MODBUS, PROFIBUS, and other industrial communication protocols can be directly integrated into the simulation environment. This combination of features enables critical monitoring and control capabilities, providing operators with a virtual platform to exercise control strategies before applying them to a live system. In addition, continuous simulation and monitoring of a power system enables constant data comparison, allowing the digital twin to detect failure modes in advance, increase operational efficiency, and identify potential areas in need of mitigation.

Tools Suite

Advanced analysis for conducting in-depth studies on an electrical network can be achieved using the SGE Tools Suite application, which offer additional functionality beyond the SGE algorithm suite. These tools include analyses such as the Hosting Capacity Study, which provides insights into the maximum amount of renewable energy generation a distribution feeder can support before incurring adverse system operating conditions. The SGE Tools Suite application runs independently from the simulation, allowing for extensive testing and evaluation without disruption to the original simulation environment.

Equipment Models

Equipment	Model Description
Voltage Source	A voltage source is a two-terminal, multi-phase, Thevenin-equivalent device, that applies an electromotive force (EMF) causing alternating current to flow throughout an electrical circuit. The voltage source algorithm is modeled as an EMF and impedance. For the infinite source mode, the source impedance and losses are assumed to be negligible.
Transmission Lines	A transmission line is used to model different (including specialized) types of multi-phase, two-port lines. The purpose of the transmission line is to transmit electric power from one location to another. The standard transmission line algorithm represents a conventional overhead line, while the concentric neutral and tape shield variations provide underground representations.
Transformers	A transformer is a power delivery device that transforms voltage and current levels. Both two-terminal and three-terminal configurations are available.
Capacitors	A capacitor is a power delivery element that supplies reactive power to the connected electrical network. Capacitors are used to correct power factors by offsetting inductive loads and can also be used to boost voltage at buses where the voltage is not sufficient. Capacitors have a wide range of uses within transmission and distribution systems, primarily focused on conditioning electrical characteristics to desired specifications. Capacitors can locally supply reactive power to a network, reducing the need for transmission lines to deliver this power over long distances.
Reactors	A reactor is a power delivery element that consumes reactive power from the connected electrical network. Reactors are used to correct power factors by offsetting capacitive loads and reducing voltage at buses where the voltage is too high. Reactors are often positioned within a shunt configuration in power transmission systems to stabilize voltage during transient conditions and are frequently used within high-voltage environments.
Loads	A load is a power conversion element that consumes real power and either consumes or supplies reactive power based on whether it is inductive or capacitive. Loads can be used to represent the end user for the electrical power grid, or they can be used to represent a larger area of the power grid.
Synchronous Generators	A generator device is a power conversion element that leverages the principle of electromagnetic induction to generate electric power.

Equipment	Model Description
Induction Motor	An induction motor, also referred to as an asynchronous motor, is a device that converts electrical energy to rotational mechanical energy through the principle of magnetic induction. Induction motors are the most common industrial load and are used to drive fans, pumps, belts, and other rotating equipment.
Voltage Regulators	A voltage regulator (automatic or manual) is an element that controls the voltage at a load center using a tap changer mechanism. The automatic voltage regulator algorithm includes smart grid connection capabilities, allowing it to regulate voltages at a user-configurable remote feeder location.
Battery Storage System	A storage system is a power conversion element that is capable of either consuming or dispatching power in response to the attached system. The storage device also contains an inverter, which functions as an interface between the system and the storage device. Power can be consumed or dispatched relative to the storage device's rating and the present amount of energy available.
Photovoltaic Systems	A photovoltaic (PV) system is a power conversion element consisting of PV panels and an inverter. The PV System generates DC power through the photovoltaic effect and transforms it into AC power through its attached inverter.
Wind Turbine Generators	A wind turbine generator (WTG) is a device that captures mechanical energy in the form of wind energy, which is supplied to a generator to convert it to electrical energy. Wind causes the blades of the WTG to rotate converting the wind energy to rotational mechanical energy.
Sensors	A sensor (ideal, no losses) collects voltage, current, real power, reactive power, power factor, and frequency data which can be displayed during simulation.

Licensing Information

The Ovation Digital Twin Smart Grid Extensions package is available as an entitlement to the digital twin software term-license subscription. Refer to the *Ovation Digital Twin Solutions Overview* data sheet for more information.