# Ovation$^{TM}$ Digital Twin Smart Grid Extensions

## Features

- Simulation of unbalanced, polyphase electrical distribution systems
- Trains operators for efficient responses to unit operations including recognizing and avoiding incidents that could result in blackouts or brownouts
- Tests and validates new or changed control strategies prior to live operation
- Fine-tunes and verifies control system design prior to plant startup to minimize commissioning time
- Assists in the development of best-practice operating procedures for optimized grid operation
- Transfers operational knowledge from experienced staff to new employees
- Enhances operator confidence for quick response to dynamic operating conditions
- Provides redundancy through an engineering test bed for distribution network contingency and “what if” analysis

## Introduction

The Ovation$^{TM}$ Smart Grid Extensions simulation package provides quasi-steady-state simulation of the effect that changing weather, loading conditions, and equipment malfunctions have on the electrical grid. Quasi-steady-state simulations means that transients due to changes in weather, loads, and mechanical equipment, are captured, but electromagnetic transients are not. There are three modes of simulation which duplicate the behavior of electrical network during normal and abnormal operating conditions. These modes are load flow simulation, fault study simulation, and harmonic analysis simulation.

Ovation Smart Grid Extensions simulator models are created from a suite of graphic-based software tools especially designed for electric power distribution system modeling. These tools use power flow and fault equations in a complex matrix solver to provide fast and stable responses for power flows.

## Equipment

- Substation feeders
- Power transformers
- Voltage regulators
- Overhead transmission lines
- Underground transmission lines
- Capacitor banks
- Photovoltaic systems
- Battery storage systems
- Distribution transformers
- Advanced loads
- Induction motors
- Emergency generators

# Load Flow

Load flow simulation produces the bus voltages, network currents, and power flows for a given operating condition. Time-varying data inputs provide a quasi-steady-state simulation solution, meaning that transient effects that are captured are due to changes in load, weather, and connected mechanical equipment. The solution time step for this mode of simulation can be as small as six cycles for 60 Hz systems and five cycles for 50 Hz systems. Time-varying weather data can be input to the Smart Grid Extensions simulator, which varies the operating point for distributed energy generation, such as solar and varies the operating point of loads. In addition, loads have their own time-varying data, which is based on the behavioral characteristics of the load.

# Fault Studies

Fault simulation produces the effect of a rapid change in the electrical network due to common electrical faults. All common electrical faults including single line-to-ground, double line-to-ground, and line-to-line, can be simulated for a single bus in the network to study the effects. In addition, a Monte Carlo fault study mode produces random faults about the network, which can be used to determine voltage sag weaknesses in the connected grid.

# Harmonic Analysis

The influx of power electronic devices in electrical systems comes with harmonic effects due to electronic switching. Harmonic simulation produces the effect that higher than nominal electrical frequencies have on the grid. Harmonic spectra of interest can be defined, and the load flow can be calculated.

# Digital Twin

The Smart Grid Extensions simulator has the capability of digital twin connection. This digital twin provides a live digital representation of a physical electrical system. Digital twin capabilities allow for safe testing of modifications to the existing electrical networks, which would not be possible on an actual physical system. This in turn increases reliability, grid cybersecurity, and equipment lifecycle management. Digital twins can also be used to train grid prognostic algorithms creating a self-healing grid.

# Equipment Models

| Equipment | Model Description |
|---|---|
| Substation Feeder | A substation feeder is a multi-phase, Thevenin equivalent device, which applies an electromotive force (EMF) causing alternating current to flow throughout an electrical circuit. The feeder is modeled as an EMF and impedance. |
| Power Transformer | A transformer is a multiterminal power delivery device, which transforms voltage and current levels to reduced transmission losses. |
| Voltage Regulator | A voltage regulator controls voltage levels at a grid load center. The load center is typically located at a different location than the voltage regulator; therefore, a compensator is used to correct for this. |
| Transmission Lines | Overhead and underground transmission line models are multi-phase, two-port lines or cables. The purpose of the transmission is to transmit electric power from one location to another. Transmission lines are often connected to transformers, loads, shunt capacitors, shunt reactors, and other transmission lines. |
| Capacitor Banks | A capacitor is a power delivery element which supplies reactive power to the connected electrical network. Capacitors are used to correct power factor from |



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| Equipment | Model Description |
| --- | --- |
| | being too inductive and can also be used to boost voltage at buses where the voltage is not sufficient. |
| Photovoltaic Systems | A photovoltaic system is a power conversion element consisting of a photovoltaic (PV) system and an inverter. The PV system generates DC power through the photovoltaic effect and transforms it into AC power through its attached inverter. |
| Distribution Transformers | Distribution transformers are usually single-phase transformers that step distribution voltages down from the primary level to the secondary level for end use power consumption. |
| Battery Storage Systems | A storage device stores energy for a later time instance. The battery storage system is capable of either consuming or dispatching power in response to the attached system. |
| Advanced Loads | An advanced 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. |
| Induction Motors | An induction motor, otherwise called an asynchronous motor, is a device which converts electrical energy to rotational mechanical energy through the principal of magnetic induction. Induction motors are the most common industrial load and are used to drive fans, pumps, and other rotating equipment. |
| Emergency Generators | Emergency generators supply power to the grid during emergency conditions. |





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