Fuji Electric

Innovating Energy Technology

Power System Simulator

Real-time simulation for “power flow” and “data flow”

Objectives

- ☑ Analysis of grid faults and impact to the grid with a high penetration of renewable energy
- ☑ Verification and assessment of grid control systems and grid stabilization systems
- ☑ Verification when introducing into the grid development products such as IEDs for protection relays or smart-inverters that conform to the IEC 61850 / 61588 standards

10D4-E-0043

Real-time simulation for

Our power system simulator can simulate the power flow and data flow by supplying electricity to the miniaturized power grid.

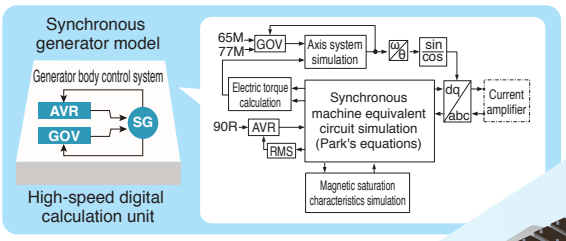
Power Flow

Data Flow

① Synchronous generator model (e.g., thermal power plants)

Features
- 1 µs high-speed calculation cycle
- Users can install calculation blocks by Simulink® to controller of the model
- Changing to other models such as a solar power system model, wind turbine generator model or battery model is possible

Mechanism

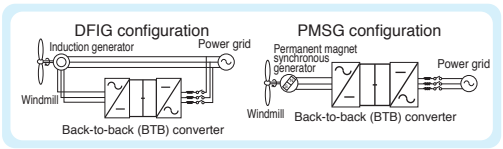


③ Wind turbine generator model

Features
- Two types of generator models : doubly fed induction generator (DFIG) and permanent magnet synchronous generator (PMSG)
- Implemented digital wind power generator model can be combined with the analog section.

Mechanism

Inductive generator and permanent magnet synchronous generator are instantaneous value models based on Park's equations

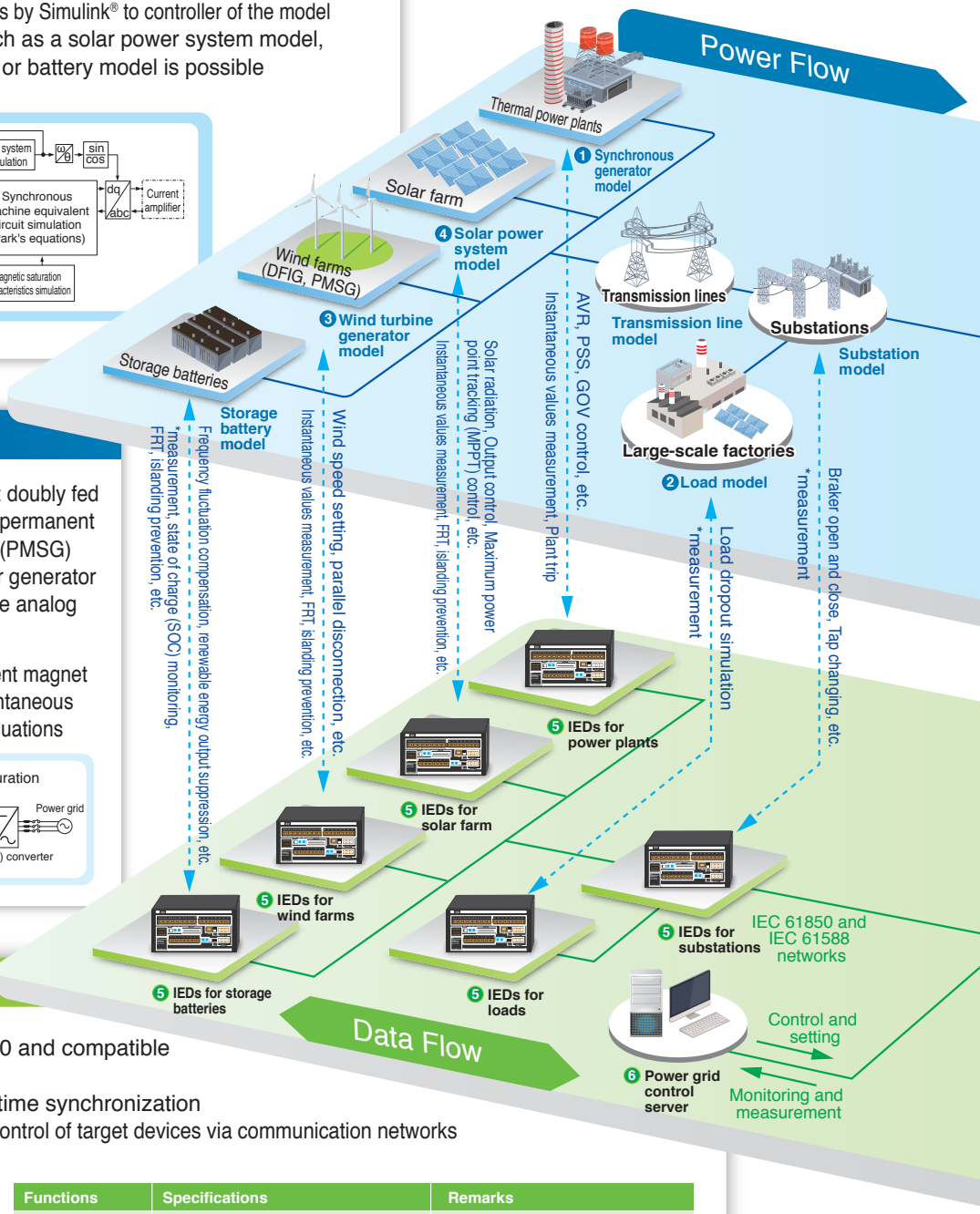


⑤ IEDs

Features
- IEDs applicable to IEC 61850 and compatible with various interfaces
- Compatible with IEC 61588 time synchronization
- Measurement, monitoring and control of target devices via communication networks

IED appearance

Functions	Specifications	Remarks
Measurement input	Analog, 12 points (±10 Vp-p)	Voltage and current (external converter required) Sensor input
Measurement sampling	60 Hz system: 7,680 Hz or less Analog-to-digital converter (ADC) resolution: 16 bits	128-point sampling per cycle (variable) Interchannel synchronization
Ethernet communication	10 BASE-T, 100 BASE-TX TCP-IP, UDP, IEC 61850, IEC 61588	1 port (Precision Time Protocol (PTP) V2 compatible) Web, FTP, IEC 61850-8-1 server device
Input and output, serial interface	Digital input: 16 points, Digital output: 8 points, RS-485 3 ports	



“power flow” and “data flow”

Power equipments in the grid, which are power plants, substations, transmission lines and loads, are simulated by some models of miniature power equipments. Users can flexibly create a ”miniaturized power grid” by connecting the several models following the target power gird, and re-create an actual power grid by flowing a small electric current in the miniaturized power grid. These simulations make it possible to analyze grid faults in real-time and the impact to the power grid as well as countermeasures with a high penetration of renewable energy.

With a data network that conforms to the IEC 61850 and IEC 61588 international standards, and using intelligent electronic devices (IEDs) and merging units (MUs) that installed in each model, it is possible to measure, monitor and control the entire miniature grid just like an actual grid.

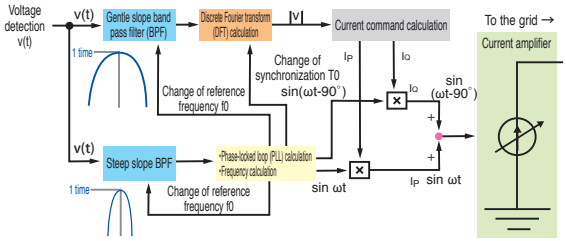
② Load model

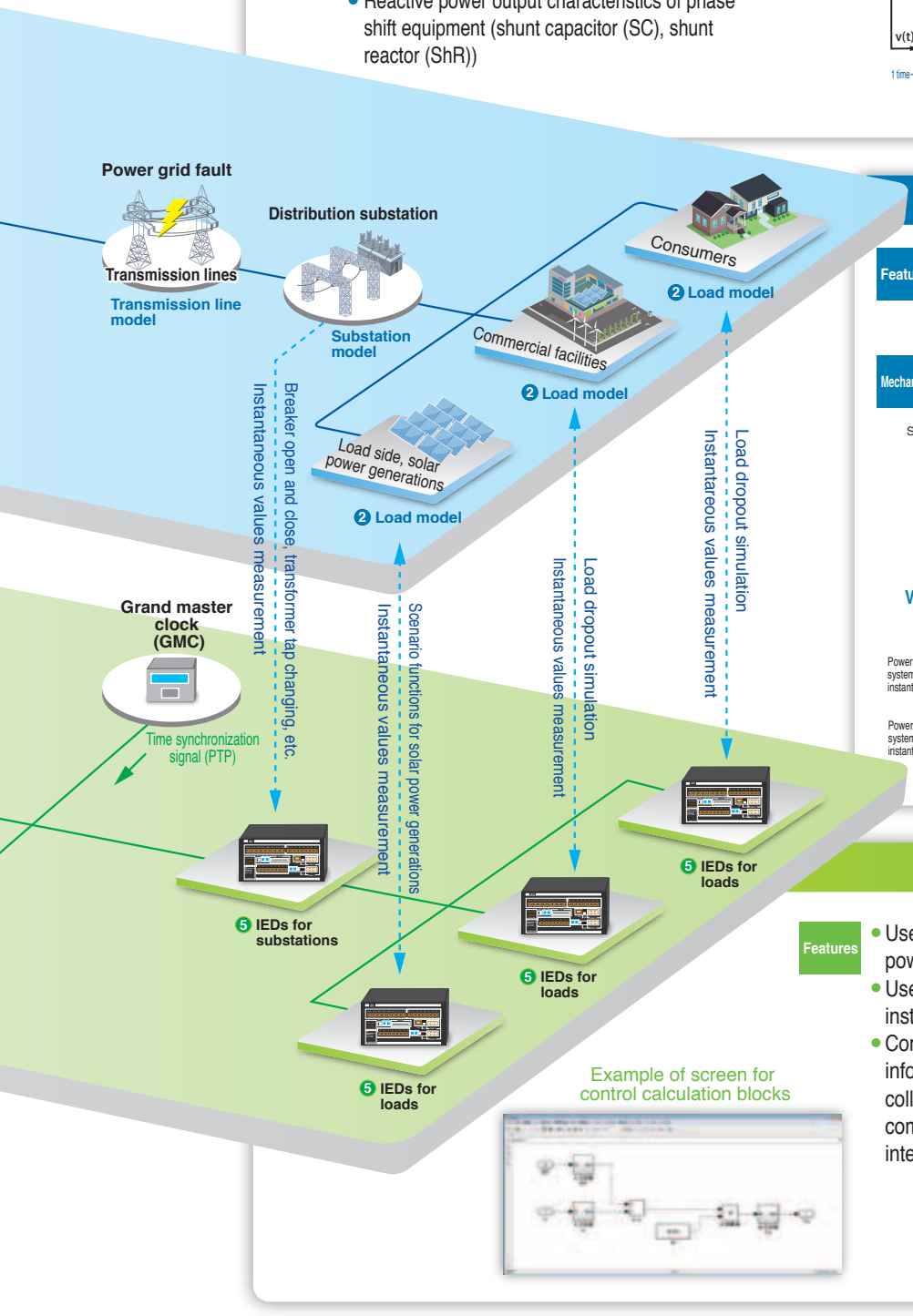
Features

- Load characteristics (ZIP load model) simulation
- Load characteristics with grid voltage frequency fluctuation
- Aggregate output characteristics of residential solar system
- Reactive power output characteristics of phase shift equipment (shunt capacitor (SC), shunt reactor (ShR))

Mechanism

Structure of the main computing unit of the load model





Example of screen for control calculation blocks

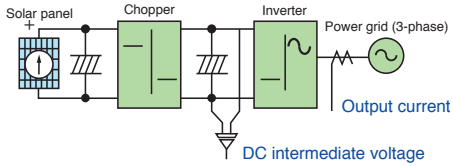
④ Solar power system model

Features

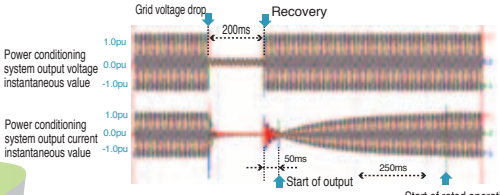
- 1 µs calculation cycle
- FRT*1 function, islanding prevention function, Voltage rise suppression control, MPPT*2 control simulation

Mechanism

Configuration of solar power generation system



Verification result of FRT function at three-phase short circuit



*1:Fault Ride Through *2:Maximum Power Point Tracking

⑥ Power grid control server

Features

- Used to simulate the automatic control system of the power grid such as power flow control
- Users can freely create control calculation blocks and install them on each model
- Control calculation block inputs can use measurement information (P, Q, V, I, f, phase differences, etc.) collected from each IED, and outputs can use control commands (such as for circuit breakers and grid interconnection) to each IED.

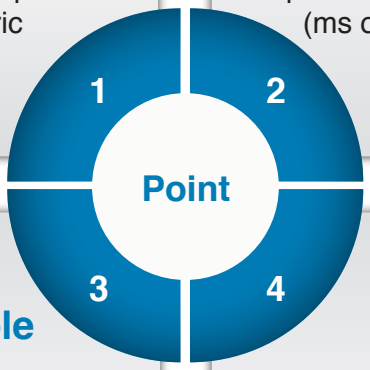
Features

High reproducibility for grid phenomena

Compared with digital simulators, reliable simulation results to be acquired by simulating as actual electric phenomena.

High-resolution and long-time analysis

High-resolution analysis of grid phenomena is possible from an instant (ms order) to a long time (24 hours).



Renewable energy resources compatible

Real-time simulation of grid phenomena with a high penetration of renewable energy. Can also be used as equipment for education and research.

HILS* compatible

Actual devices such as control equipment and protective equipment can be connected to this simulator and the verification of actual devices operation and impact to the grid can be analyzed.

* Hardware In the Loop Simulation

Comparison with other company

Model	Comparison item	Fuji Electric	Company R
Synchronous generator model	Calculation speed	○	△
	IEC 61850 compatible	○	△
	HILS compatible	○	○
Solar power system model	Calculation speed	○	△
	FRT functions	○	×
	Islanding prevention	○	×
Wind turbine generator model	Calculation speed	○	△
	Two generator types implemented	○	○
	Binding with analog part	○	×
Load model	Calculation speed	○	△
	Aggregate simulation of solar power	○	×
	FRT functions	○	×

○: Supported △: Partially supported ×: Not supported

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