



INNOVATIVE SOLUTIONS FOR THE POWER INDUSTRY

BESSTI™

Battery Energy Storage Systems Tester

Testing and Simulation of Basic/Advanced Applications

The BESSTI is a hardware- or software-based platform specifically designed for testing of commercial Energy Storage System (ESS).

The tester streamlines testing and evaluation of ESS controls and communication systems for various grid support, Non-Wires Alternatives (NWA) applications, or market services. In the simulation mode, it acts as a site controller or an Energy Management System (EMS) for verifying new applications or independently driving an ESS as a SCADA simulator.

Combination of application simulation and data measurements from real-time operation will be used to evaluate the ESS' performance and dynamic response.

Applications

BESSTI can be used in a laboratory environment and/or in the field to facilitate a:

- Factory Acceptance Test (FAT)
- Site Acceptance Test (SAT)
- Commissioning Test and Performance Evaluation.

Test Scenarios and Standards

Operating Modes

The device can operate in testing or simulation modes:

- **Test Mode:** To perform pre-specified test procedures as defined by available BESS test standards or any customer- specified procedure.
- **Simulation Mode:** To evaluate BESS performance with custom-designed applications or alternative control schemes.

Type Testing Options

Type testing options from Standards include:

- Charge and discharge (dispatch)
- Reactive power-compensation
- Target SOC
- Minimum and maximum SOC
- Capacity
- Response time
- Roundtrip efficiency
- Offline and real-time P or Q profiling.



PICTURED: Portable BESSTI dedicated hardware-based platform

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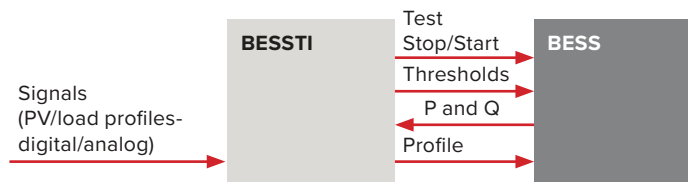
Standards for Testing BESS:

- IEEE 2030.3-2016: Standard Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications
- IEEE 2030.2-2015: IEEE Guide for the interoperability of Energy Storage Systems Integrated with the Electric Power Infrastructure
- IEC TS 62933-3-1:2018: Planning and performance assessment of electrical energy storage systems - General specification
- IEEE 1679-2010: IEEE Recommended Practice for the Characterization and Evaluation of Emerging Energy Storage Technologies in Stationary Applications
- PNNL: Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems.

Application Testing Options (Customized)

Customized application testing options can include:

- Peak shaving
- Demand management
- Renewable firming and smoothing
- Generation shifting
- Frequency regulation
- Real-time profiling
- Islanding.

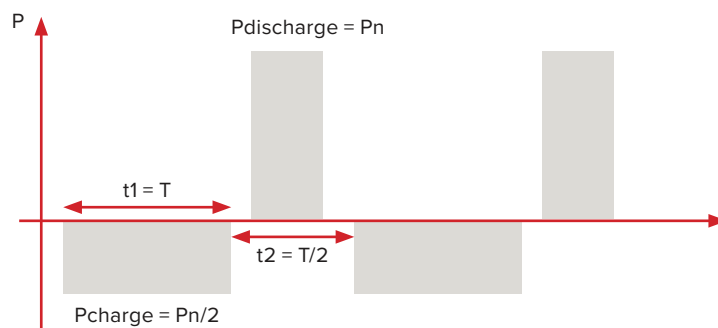


PICTURED: Block diagram of application testing

Interconnection Testing Options (Customized)

Customized interconnection testing options can include:

- Rate of change of P and of Q
- Voltage droop
- Harmonics
- Outage detection and Islanding
- Resynchronization.



PICTURED: Sample profile of capacity test

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Device Interfaces

BESSTI hardware is designed as a rack-mounted or portable device. A touchscreen display provides the user interface to navigate pages to confirm test setup and select pre-defined test applications. The device has the following ports/modules:

Communication Ports

- USB, Ethernet, and Serial ports (RS-485 and RS-232).
- Ports may be used to exchange data and commands with external devices, as well as transfer test profiles or points to BESS.

PQM Ports

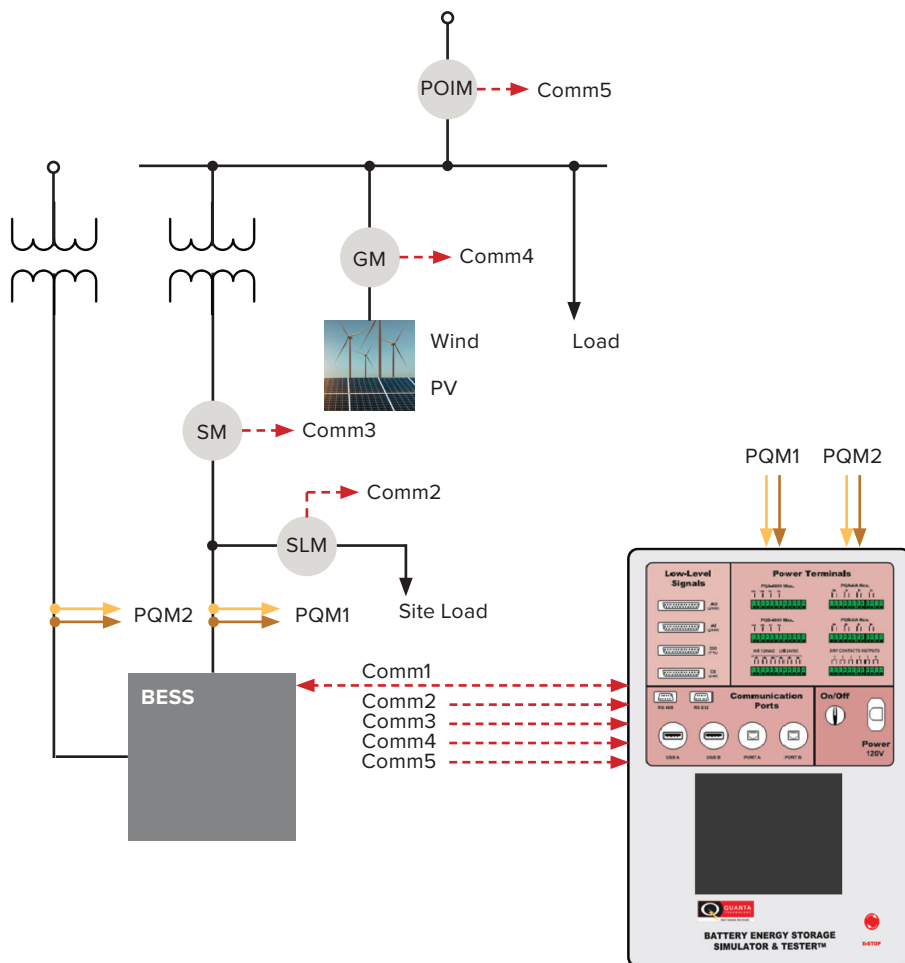
- Direct measurement of actual power exchange with the rest of the system at the BESS' terminal (up to 480 V and 5 A).

Input/Output Modules

- Provide physical digital and analog I/O connections for signals and data exchange with the test device.
- Analog I/Os are used for low-level signal exchange (± 10 V) and power quality grade measurement for connecting the unit to BESS or a real-time simulator.



PICTURED: Typical BESSTI test setup



Key:

- POIM: Point of Interconnection Meter
 - SM: Site Meter
 - GM: Generation Meter
 - SLM: Site Load Meter
 - Comm1: Communications with BESS
 - Comm2: Communications with SLM
 - Comm3: Communications with SM
 - Comm4: Communications with GM
 - PQM1: Power Quality Measurement at BESS Terminal
 - PQM2: Power Quality Measurement for BESS Auxiliary Power
- Communication Path
 — Electric Path

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Hardware Specifications Overview

Power Supply:

- Nominal input voltage 120 VAC single-phase (60 Hz)
- Power consumption <200 W.

Protocols

- Modbus
- IEC 61850 GOOSE
- DNP3
- Non-standard protocols (optional).

Power Supply:

- Nominal input voltage 120 VAC single-phase (60 Hz)
- Power consumption <200 W.

Connection Terminals and Communication Ports:

- Low-level signal connection terminals, type DB25
- Communication ports (two Ethernet ports, DB9 (one RS-232 and one RS-485) and two USB ports).

Low-level Interface Signal (Hardwire):

- Analog input (± 10 V): eight pairs
- Analog output (± 10 V): eight pairs
- Digital Input (DI) signals (24 VDC): six (12 with DC25)
- Digital Output (DO) signals (TTL): six (12 with DC25)
- Power terminals: Power Quality Measurement (PQM) terminals (480 V three-phase voltage, 5 A three-phase current).

Human-Machine Interface (HMI):

- Touchscreen interface: 7"
- Operating system: Virtual Network Connection (VNC) server using a VNC viewer.

Security Features:

- Account management: user accounts, user rules, central authentication, strong password
- Encrypted communication SSL/TLS, SSH HTTPS.

Compliance:

- Developed and manufactured under an ISO 9001 registered system
- NERC/CIP user authentication, logging, and port-control requirements.

Dimensions and Weight:

- Without handle 23" x 17" x 12"
(584 mm x 432 mm x 305 mm)
- 46.0 lbs (20.9 kg).

Environmental Conditions:

- Operation temperature +32 to +122 °F (0 to +50 °C)
- Storage temperature -13 to +158 °F (-25 to +70 °C)
- Overvoltage category II
- Insulation class I equipment
- Relative humidity range 5-95% non-condensing.

Processing and Memory:

- Processor speed: 333 MHz.
- Memory: 512 MB DDR2 ECC RAM
- Storage: 2 GB.

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