GE Energy Storage
Inverter Capability Overview

Joe Heinzmann
Senior Product Manager
GE Energy Storage
April 2015

Imagination at work.
GE Energy Storage

Division of GE Renewable Power within GE Power and Water
HQ in Schenectady New York – Sales and Service worldwide
Active in energy storage for 10+ years
~50 MWH in operation or construction around the world
System integrator providing End to End ES systems worldwide
Focusing on 4 Grid Segments

Providing key applications combined with power and energy performance

**Energy Management**
- Peak Demand Reduction
- Back Up
- PV Self consumption
- Power Quality

**T&D Network**
- Load Management
- Harmonic Suppression
- Voltage Support
- Power Quality
- Capital Deferral

**Power Generation**
- Frequency regulation
- Ramp Rate Control
- Time Shifting
- Voltage Support
- Curtailment avoidance

**Microgrid**
- Grid Management
- PV integration
- Grid optimization
GE Energy Grid Projects
Expanding Global Presence and Grid Applications

- 1 MW / 2 MWh Wind Integration
- (5x) 50 kW / 100 kWh T&D Network Support
- 1 MW / 2 MWh Renewable Integration
- 1 MW / 2 MWh T&D Network Support
- 1 MW / 2 MWh Behind the Meter

- 50 kW / 100 kWh Behind the Meter
- 250 kW / 500 kWh Microgrid
- 0.1 MW / .5 MWh Behind the Meter
- 2MW / 8MWh Solar Shift
- (3x) 200 kW / 400 kWh Integrated Wind Turbine
- (2x) 10 kW / 20 kWh Behind the Meter
- 3MW / 6 Mwah PV/Storage Micro grid MAECI Solar
- 200kW/1MWh T&D Network Support Major Utility
- 4 MW / 18 MWh Behind the Meter at large Industrial
- 0.5 MW / 1 MWh Behind the Meter at industrial plant
- 100kW/200kWh Micro grid, Solar Integration

~ 50 MWh of Grid & Micro-grid projects
Leveraging GE Expertise

Storage Plant is comprised of Key GE offerings

- **Controls** – GE is a world leader in control systems for grid connected systems with years of experience in Generation, T&D, and large scale industrial systems

- **AC Hardware** – GE has a proud history of supplying AC hardware including inverter, transformer and High and Med voltage equipment to global utility and Industrial customers

- **DC Block** – As a battery manufacturer we have deep technical understanding of key battery design and safety elements such as cell design, thermal management

![Diagram of GE Expertise](image-url)
GE Brilliance IQ Plant Controls & SCADA

Voltage Regulation - example

Robust plant level control
- Integrated Ramp Rate control
- Power frequency response
- Voltage regulation
- Integrated PF/VAR control
- Power curtailment
- Plant shut-down/start-up

Integrated SCADA
- Real-time data visualization
- Remote Monitoring and Operation
- Substation & Weather station I/O
- High Speed Data capture
- Historical data analysis
- Automated reporting

Based on GE Mark Vie controls platform
- Heart of GE’s wind & thermal power plant fleet
- 250+ utility scale projects controlled
- 100+ GW renewables feasibility studies
- 40+ grid integration patents

GE’s proven grid integration expertise
GE Brilliance Inverter

GE’s Brilliance™ Inverter is the latest evolution of GE’s proven power conversion technology for grid-tie, energy storage applications. There are over 23,000 installs of the Brilliance platform on GE Wind turbines.

Inverter Features:
• 1.25 MVA 50/60Hz options
• Peak Conversion Efficiency >97.5%
• Power Factor Range +/- 0.93 / Noise < 80dBA
• Integrated 3000 A dc disconnect & 2000 A ac circuit breaker,
• NEMA 3R outdoor construction with Integral ground fault detector / interrupter
• Full to derated Power output 40/50/55°C ambient 1.25/1.00/.650MVA
• Liquid-cooled & forced ventilated with externally replaceable air filters
• Anti-condensation heaters, internally powered and automatically controlled
• GE’s Ride-Thru Technology providing LVRT, ZVRT and HVRT capability
• Targeted 100ms full power charge to discharge with < +/- 1% Voltage flicker at PCC

Codes Standards and Regulations Compliance

<table>
<thead>
<tr>
<th>Standard</th>
<th>Code/Regulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Conversion Equipment Safety</td>
<td>UL508C</td>
</tr>
<tr>
<td>Inverter, Converter, Controller &amp; Interconnection System Safety</td>
<td>UL1741</td>
</tr>
<tr>
<td>Environmental Considerations for Electrical Equipment Enclosures</td>
<td>UL50E / CSA 22.2 NO. 94.2</td>
</tr>
<tr>
<td>Industrial Control Equipment Safety</td>
<td>CSA 22.2 NO. 14</td>
</tr>
<tr>
<td>Construction &amp; Test of Rectifying Equipment</td>
<td>CSA 22.2 NO. 107-1</td>
</tr>
<tr>
<td>Harmonic Control</td>
<td>IEEE 519</td>
</tr>
<tr>
<td>Interconnection of Distributed Resources with Electric Power Systems</td>
<td>IEEE 1547</td>
</tr>
<tr>
<td>Seismic Tolerance</td>
<td>IBC / UBC Zone 4</td>
</tr>
<tr>
<td>Shock &amp; Sinusoidal Vibration</td>
<td>IEC 60721-3-3 Class 3M3</td>
</tr>
<tr>
<td>EU Conformity</td>
<td>CE Mark</td>
</tr>
</tbody>
</table>
Capability Curve - Single Inverter

GE Brilliance 1.25MVA Capability Curves

1.275MVA BESS Inverter PQ Capability - Charging

1.275MVA BESS Inverter PQ Capability - Discharging

Polarity convention:
- Power > 0 = Power to grid (discharging)
- Power < 0 = Power to battery (charging)
- Q > 0 = Inverter supplies vars to grid; capacitive PF
- Q < 0 = Inverter consumes vars from grid; inductive PF

Caveats:
- No derating applied. Results are valid up to 1000m, 40 degC.
- Internal losses not modeled. Assume -3% error when discharging, +3% error when charging
- Subject to Change

GE Proprietary
RIDE-Thru Technology
High Voltage, Low Voltage and Zero Voltage

• GE’s innovative RIDE-THRU™ technology offers ride-through capability for zero-voltage (ZVRT), Low Voltage (LVRT), and High Voltage (HVRT) applications.

• The ZVRT ride-through capability conforms to U.S. Federal Energy Regulatory Commission (FERC) requirements.
System Design Considerations

PCC Power and Energy requirements
Drives inverter and storage quantity
Affects cost and performance

20MVA -10MWh –Frequency Regulation System
Joe Heinzmann  
Senior Product manager  
GE Energy Storage  
925-586-5142