GE’s eLumina™ HVDC Control System

Leandro Vacirca
Product Manager for HVDC Control Systems
Utilizing nearly 60 years of HVDC expertise along with a powerful Model-Based Design methodology, GE has combined cutting-edge computing technology with standardized application software to deliver a reliable, high-performance system.
GE Makes Major Investment in HVDC

New HVDC COE Building 2017

- World class office space for over 500 employees
- High capacity VSC and LCC valve manufacturing facility

New HVDC Simulation Lab 2017

- Contract system validation
- Multi-project test capacity, >45 RTDS™ racks
- Multiple fully equipped customer FAT test suites

New Valve Test Facility 2018

- Completely programmable voltage and current test waveforms
- 6000A test capability for VSC and LCC valves
- Accelerates production and development type tests

GE investing in HVDC technology to WIN!!
GE Introduces eLumina™ Control System

HVDC Control System for the New Grid

eLumina™

- Controls Platform
- Digital Substation

- eLumina™ Suite
  - HVDC Software
  - Single Source of Truth Model
  - Brilliant SW Factory

- eLumina™ Explorer
  - Real-time monitoring
  - Data visualization
  - Events logging

- eLumina™ Analytics
  - (Digital Ready)
  - Insights via analytic engines
  - Advanced visualization
Customer Outcomes

Rapid Project Delivery

+150 Configurable SW modules
30% faster cycle

Maximized Performance

+10x computing platform power

Robust & Resilient Design

80% fewer wires
100% automatic testing

Compact Footprint

50% smaller footprint
40% fewer cabinets

Digital Analytics

Built with operational analytics, Cyber-secured

Designed to address today’s and tomorrow’s grid challenges

(*) Disclaimer: all values shown above are “up-to” numbers that vary depending on HVDC scheme configuration
GE Introduces **eLumina™** Control System

**HVDC Control System for the New Grid**

**Maximized System Availability & Reliability**

- Improved system resilience through simplified, fully redundant system architecture that maximizes system availability
- IEC61850-compliant for ultimate interoperability
- Dual-redundant converter control with seamless changeover
- Triple-redundant converter protection
- Modular, Secure, Simple
- Maximized availability and increased reliability
- Cyber-resilient compliant with utility practices and regulations like NERC-CIP

**High Performance**

First HVDC solution to implement a world-class digital measurement system fully in accordance with IEC 61850
- Full digital integration of all voltage and current sensors via new fast merging units (NMUs)
- High-speed process bus technology, compliant with IEC61850 and IEC61869 standards
- Robust, ultra-fast and low-latency sensor data gathered via redundant Ethernet and fiber optic communication networks
- Fastest core computing unit (CCU) in the industry, enabling a more flexible and adaptive HVDC solution

**Compact Footprint**

Using a modular approach to our control platform combined with cutting-edge computing technology, GE's latest generation of control system reduces the form factor and footprint.
- 40% reduction in total cabinets count
- 30% reduction in weight
- Reduced complexity
- Lower power usage
- Significant reduction in audible noise

**Proven Software and Optimized Delivery**

-eLumina™ Suite provides a proven HVDC application software and industry-best tool chain to enable >30% reduction in delivery cycle
- eLumina™ HVDC Software
  - 90% standard and configurable HVDC applications built from 350 proven software components
- Single Source of Truth process
  - Allows to validate system performance across multiple simulation tools from the very same source
- eLumina™ Brilliant Software Factory
  - Automatic regression test engine ensures improved quality of as-delivered software

**Introducing eLumina™ Explorer**

- Modern HTML5 web interface
- Real-time visualization
- Configuration and commissioning
- Analyze transient fault records
- Signal historian

**Examples:**
- Real-time status
- Live debugging capability

**eLumina™ Analytics**

An analytics platform enabled by the HVDC control system
- Data connectivity
- Advanced computing power
- Analytic engines that generate insights
- Intuitive visualization
- Outcomes
  - Reduced maintenance
  - Reliability and Availability improved
  - Predict & diagnose assets to avoid unplanned outages
- Asset life-cycle optimization
# eLumina™ - Product Qualification

## Type Tests Plan

- **EN 61000-4-2** - Electrostatic Discharge Immunity
- **EN 61000-4-3** - Radiated RF Immunity
- **EN 61000-4-4** - Electrical Fast Transients Immunity
- **EN 61000-4-5** - Voltage Surge Immunity
- **EN 61000-4-6** - Conducted RF Immunity
- **EN 61000-4-8** - Power Frequency Magnetic Field Immunity
- **EN 61000-4-11** and EN61000-4-29 - Voltage Dips and Short Interruptions Immunity
- **EN 61000-4-16** - Power frequency
- **EN 61000-4-17** - A.C. component in d.c. (ripple)
- **EN 61000-4-18** - Slow damped oscillatory wave
- **EN 60255-26:2013 clause 7.2.13** - Gradual shutdown/start-up
- **EN 55011** - Radiated Emissions (30 – 1000 MHz)
- **EN 55032** - Radiated Emissions (1 – 6 GHz)
- **EN 55011** - Conducted Emissions
- **EN 60068-2-1:2007** - Test Ad: Cold : -20C / -10 C 16 hours (*)
- **EN 60068-2-2:2007** - Test Bd: Dry Heat : +55 Deg C, 16 hours
- **EN 60068-2-7:2013** - Test Cab: Damp Heat, Steady State: 10 days at 40deg C and 96 % humidity
- **EN 60068-2-30:2005** - Test Db: Damp Heat variant 2: 90 to 96 RH @ 40 deg C ramped to 95 - 100 RH @ 25 deg C 24 H + 6 * 24 hour cycles
- **BS EN 60255-21-1:1996 (IEC 255-21-1:1998)** - Vibration (Class 1)
- **EN60068-3-3 AG5, EN60068-3-3 Perf level III, EN60255-21-3 Class 1, IEE693-2005 Perf level high** - Seismic

Ingress Protection: **IP42**

## Type Tests Status

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<thead>
<tr>
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<th>Result</th>
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<tr>
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eLumina™ - Type Tests (Lab Photographs)
HVDC Application Software Demonstrated

1. End to End Power Transfer (using DW3 App SW)
2. Power Flow Reversal
3. Reaction to Voltage Depression on AC network

- Scheme type: VSC Symmetrical Monopole
- RTDS Novacor™ simulating:
  - AC & DC Networks
  - VBE
- Interfaces:
  - GT AO & MU640 (Fast Measurements)
  - Xilinx Aurora (Firing Words)
Maximized System Availability & Reliability

Improved system resiliency through simplified, fully-redundant system architecture that **maximizes system availability**

- IEC61850 compliant for ultimate interoperability
- Dual-redundant converter control with seamless changeover
- Triple-redundant converter protection
- Modular, Secure, Simple
- Maximized availability and increased reliability
- Cyber-secure compliant with utility practice and regulations (ex. NERC/CIP)

System Architecture

Maximized System Availability & Reliability

Designed for >99.9% availability
Pole and Bipole Control Architecture

**Duplicated Control and triplicated Protection systems** for each pole end

- Complete electrical and mechanical segregation between Control and Protection
- Any one cabinet can be switched off/on during power transmission
- All plant I/O is connected via IEC61850 compliant, high speed, fiber optic communication links
- Bipole functionally hosted by control core computing units (CCUs)
- Copper wiring is virtually eliminated -80%
- Footprint reduced by -50%
Core Computing Unit - **CCU** for Control and Protection

Provides the **high performance, real time computing platform needed** to execute HVDC control and protection applications to meet today’s and tomorrow’s demands

- Designed as Line Replaceable Units (LRU) for simplified maintenance and spares management
- Complies with OpenVPX Standard (ANSI/VITA 65-2017) used in long life and high availability applications such as Avionics
- Type-tested for harsh EMC, environmental and mechanical environments mandated by IEC61850-3
- Optimized for executing industry-leading Simulink® Model-Based HVDC applications
- Fast and simplified installation with as few as 3 fibers connections
- Duplicated power supply for high reliability

Powerful, Robust, Reliable – Ease of Maintenance
Compact Footprint

Using a modular approach to our controls platform combined with cutting-edge computing technology, GE’s latest generation of control system reduces the form factor and footprint.

- ~40% Reduction in total cabinets count
- ~30% Reduction in weight

- Reduced complexity
- Lower power usage
- Significant reduction in audible noise

ELECTRICALLY AND MECHANICALLY SIMPLIFIED
HVDC DIGITAL SUBSTATION
First HVDC solution to implement a world-class digital measurement system fully based on **IEC61850**

- Full digital integration of all voltage and current sensors via new fast merging units (MU640)
- High-speed process bus technology compliant with IEC61850 and IEC61869 standards
- Robust, ultra-fast and low-latency sensor data gathered over redundant Ethernet and fiber optic communication networks
- Fastest core computing unit (CCU) in the industry, enabling a more flexible and adaptive HVDC solution
Network Interface Cabinet - **NIC**

The digital hub coordinating all communications between the HVDC system elements. Interconnects control and protection racks and digital substation via duplicated optical networks

- Two NICs are required for a Pole or a Bipole
- Proven and ruggedized gigabit optical ethernet network switches (GE S20 family)
- All network paths are duplicated via PRP or from source
- IEEE1158 v2 PTP is used to provide an accurate (1us) time system
- Type-tested for compliance with HVDC substation level requirements dictated by IEC61850-3
- Low power, thermally efficient and reliable design
- High reliability, full optical interconnections, no media converters

1. GE Reason RT430 Precision Time Clock
2. GE Reason S20 Industrial Ethernet Switches
3. IEC61850-compliant industrial servers
4. Optical Communication Patch Panel

Fully optical ruggedized digital communication Hub
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QUESTIONS