EGSTON POWER

WHITEPAPER

# EGSTON PowerLoop

Accelerating the Development of Solid State Power Systems and Next-Generation DC Power Networks

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## EXECUTIVE SUMMARY

Solid state transformers, solid state power substations and emerging DC distribution architectures require realistic, high-power validation long before field deployment. The EGSTON PowerLoop Product Platform combines bidirectional power conversion, Power Hardware-in-the-Loop integration and configurable internal energy circulation to create scalable test environments from laboratory scale to multi-megawatt capability from a 100 kW grid supply in suitable regenerative configurations.

**Core value proposition**

In a suitable back-to-back test configuration, most of the required test energy circulates between the test system and the Hardware Under Test. The grid connection only needs to supply the net losses and auxiliary energy demand, instead of the full circulating test power.

## 1. Why Conventional Test Infrastructure Is Reaching Its Limits

Electrification, renewable integration, Artificial Intelligence (AI) data centers, and power-electronics-dominated grids are increasing the complexity and performance demands of modern energy systems. To ensure reliability and interoperability, developers must validate converters, controls, protection functions, and system behavior across AC, DC, and hybrid architectures.

Conventional high-power test facilities often depend on grid connections sized for the full rated test power, creating substantial infrastructure and operational costs at megawatt scale.

## 2. Designed for SST, SSPS and MVAC Validation

Solid State Transformers and Solid State Power Substations combine power conversion, control, protection and communication functions. Their validation therefore requires more than a conventional source or load. Engineers need programmable grid conditions, bidirectional power flow, dynamic events, and closed-loop interaction with real-time models.

- Solid State Transformer (SST) and Solid State Power Substations (SSPS) converter validation
- Medium-voltage AC input testing with optional transformers, up to 34.5 kV depending on configuration
- 800V DC data center and AI architecture validation
- Grid-forming and grid-following converter studies
- Protection, fault-management and black-start testing
- Battery energy storage and renewable integration
- Dynamic interaction, like data center load curve studies in AC/DC networks

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## 3. The PowerLoop Approach: Circulate power but only supply the Losses

PowerLoop uses regenerative, four-quadrant power amplifiers to exchange energy bidirectionally. When the hardware under test and the test system are arranged as a closed power loop, energy is circulated internally. The external grid then covers conversion losses and auxiliary loads.

This architecture decouples circulating test power from the required grid connection, subject to the selected configuration, operating point, device efficiency and site-specific losses. It enables realistic high-power operation without requiring the facility to continuously source the full test power.

- Lower grid-connection demand for suitable regenerative test scenarios
- Reduced facility investment and operating losses
- High-power steady-state and dynamic testing in existing laboratories
- Bidirectional source and load emulation within one platform
- A scalable path from early-stage research to full-power validation

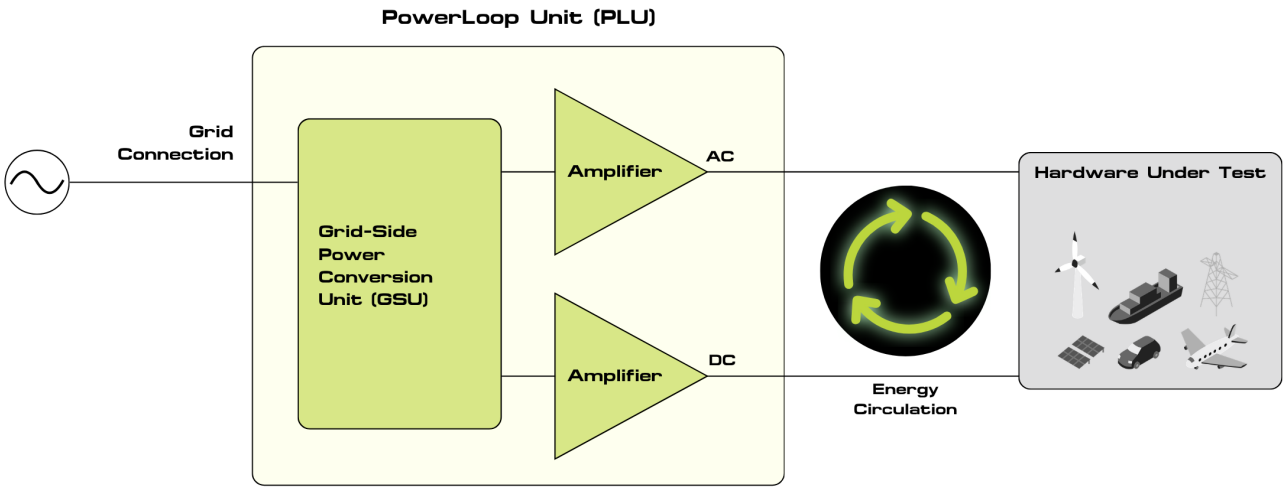


Fig. Topology of EGSTON PLU



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## 4. PHIL Integration as a Development Accelerator

Power Hardware-in-the-Loop (PHIL) connects a real hardware under test to a real-time simulation through a digital interface. This allows physical hardware, embedded control, and simulated networks to interact under repeatable and configurable conditions.

PowerLoop can be integrated with commonly used real-time simulation environments via the applicable EGSTON interface configuration.

**From model to megawatts**

The same platform concept supports controller development, subsystem integration, protection verification and full-power validation, reducing the gap between simulation results and field behavior.

## 5. Application Example: Power for AI and High-Performance Computing

AI and high-performance computing are accelerating interest in high-power DC distribution, battery-supported power paths and solid-state conversion. These systems must withstand rapid load changes while maintaining voltage quality, stability and protection coordination.

PowerLoop provides a configurable environment for reproducing source, load, storage and grid interactions. Engineers can investigate converter stability, transient response, power reversal, protection behavior and system-level controls before deployment.

## 6. Engineering and Commercial Benefits

- Validate realistic operating conditions before field deployment
- Identify instability, control interaction and protection issues earlier
- Less grid power for more test power
- Reuse one platform across AC, DC, source, load and PHIL scenarios
- Scale test capability as programs progress from prototype to system level
- Improve test repeatability and support faster design decisions



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## 7. A Scalable Platform

The EGSTON PowerLoop platform uses a common control, software and PHIL integration concept. Configurations can be selected according to grid availability, amplifier topology and required AC or DC test power.

| | PLU 100-4G4 | PLU 200-4G6 | PLU 800-8G6 | PLU 800-16G4 | PLU800-16G6 |
|---|---|---|---|---|---|
| **Grid Connection** | 100 kW | 200 kW | 800 kW | 800 kW | 800 kW |
| **AC Circulation Capability** | 400 kW | 600 kVA | 1200 kVA | 1600 kVA | 2400 kVA |
| **DC Circulation Capability** | 400 kW | 600 kVA | 1200 kVA | 1600 kVA | 2400 kVA |
| **Max. DC Voltage** | | | 820 V | | |
| **Max. AC Voltage *** | | | 555 V / 34.5 kV | | |

* AC Voltage up to 480 V / 555 V AC default, up to 34.5 kV optional transformer configuration

Configuration values are platform ratings and indicative dimensions. Final capability depends on the selected system topology, transformers, switchgear, cooling, operating mode and Hardware Under Test requirements.

## 8. Conclusion

The transition to solid state and DC-centric power systems requires test infrastructure that is dynamic, regenerative, scalable, and economically practical. The EGSTON PowerLoop Platform addresses this need by combining high-performance power amplification with PHIL integration and energy-circulating test architectures.

For Solid State Transformer developers, data-center power teams, utilities, OEMs and research institutions, PowerLoop provides a structured path from simulation to realistic high-power validation, with configurations providing a multi-megawatt test capability from a 100 kW grid connection.

## Discuss Your Test Architecture

Define the required AC and DC voltages, power levels, current limits, dynamic bandwidth, fault cases, real-time simulator and available grid connection. EGSTON Power Electronics can then develop a PowerLoop configuration and single-line concept tailored to the application.



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