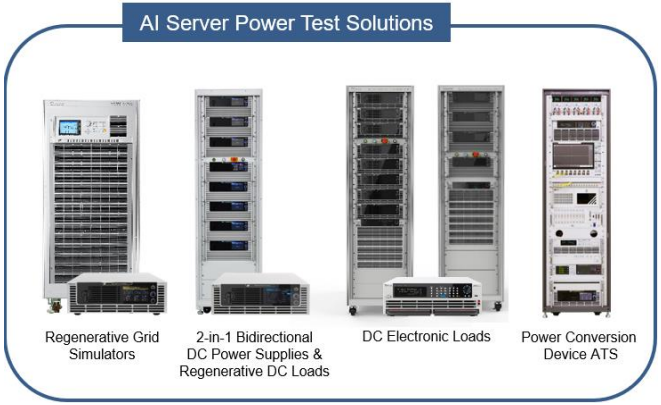
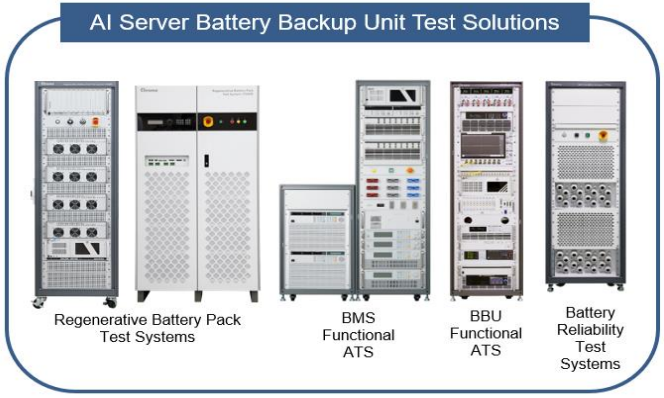

Chroma
Validation Challenges for Next-Generation
AI Power Racks:
From 100kW to MW Scale

AI Server Power and Battery Backup Unit (BBU) Test Solutions

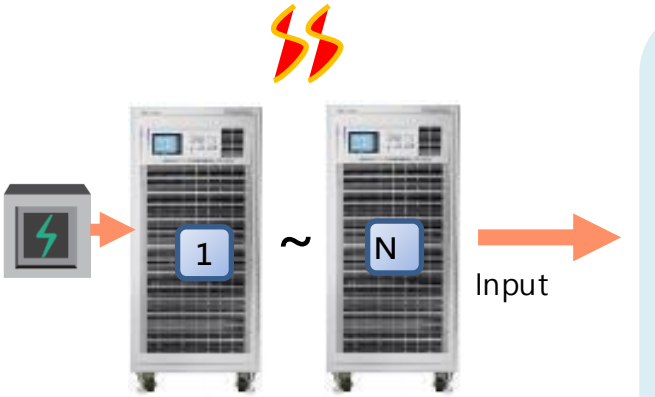
Chroma has been providing testing solutions for power supplies and batteries for 40 years. We are also committed to providing power testing solutions for AI servers.







High Power Rack Test Architecture



AC Power Source

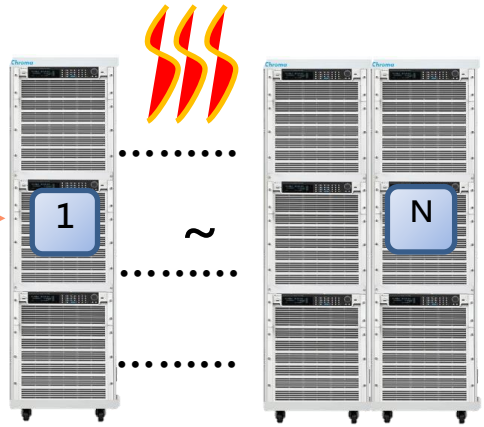
DUT Power:
Side Car
Power Rack



Power requirements are increasing, from hundreds kW to MW levels.

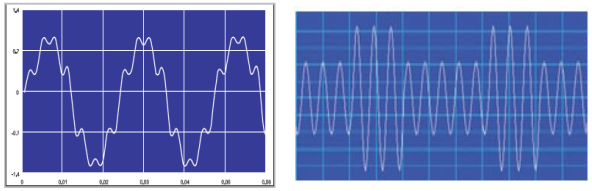
Performance Testing

Output

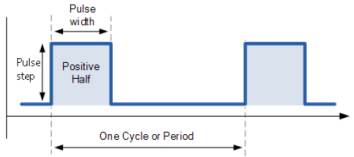


High-Speed DC Load

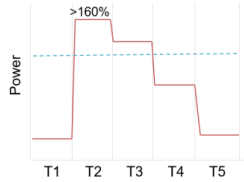
Power Line Disturbance



≥ 160% Peak Load



EDPP : 10kHz



Building an MW-Class Power Test Lab

MW Lab Overview

Purpose : As AI server power moves toward the MW class, build a test lab that can validate HVDC high power supplies

Test Scale : A single Power Rack of 900 kW-MW; megawatt-class (>1000 kW) heat output must be handled effectively

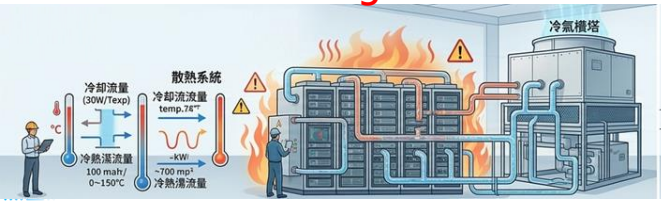
Core Equipment : DC Electronic Load, AC Source, DC Source arrangment



Power Rack

Three Key Challenges : **Cooling / Site power shortage / Megawatt-class equipment control & connection**

Cooling



Site power shortage

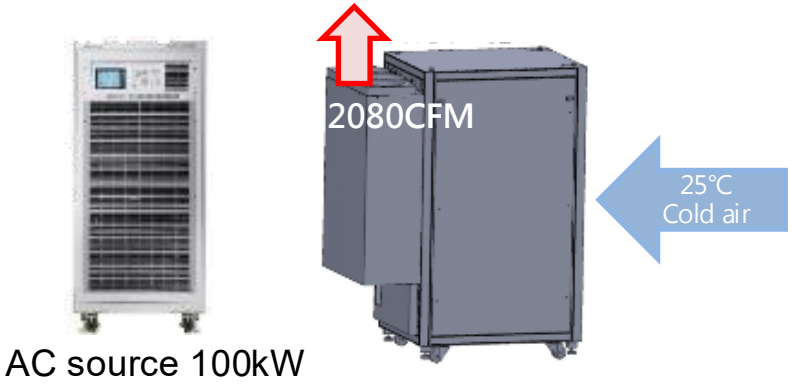


MW equipment control & connection



Challenge: Equipment Cooling

Calculating heat and airflow for equipment **air-cooling** (top exhaust)



AI-generated image for illustrative purposes only.



Thermal Management and Airflow Arrangement

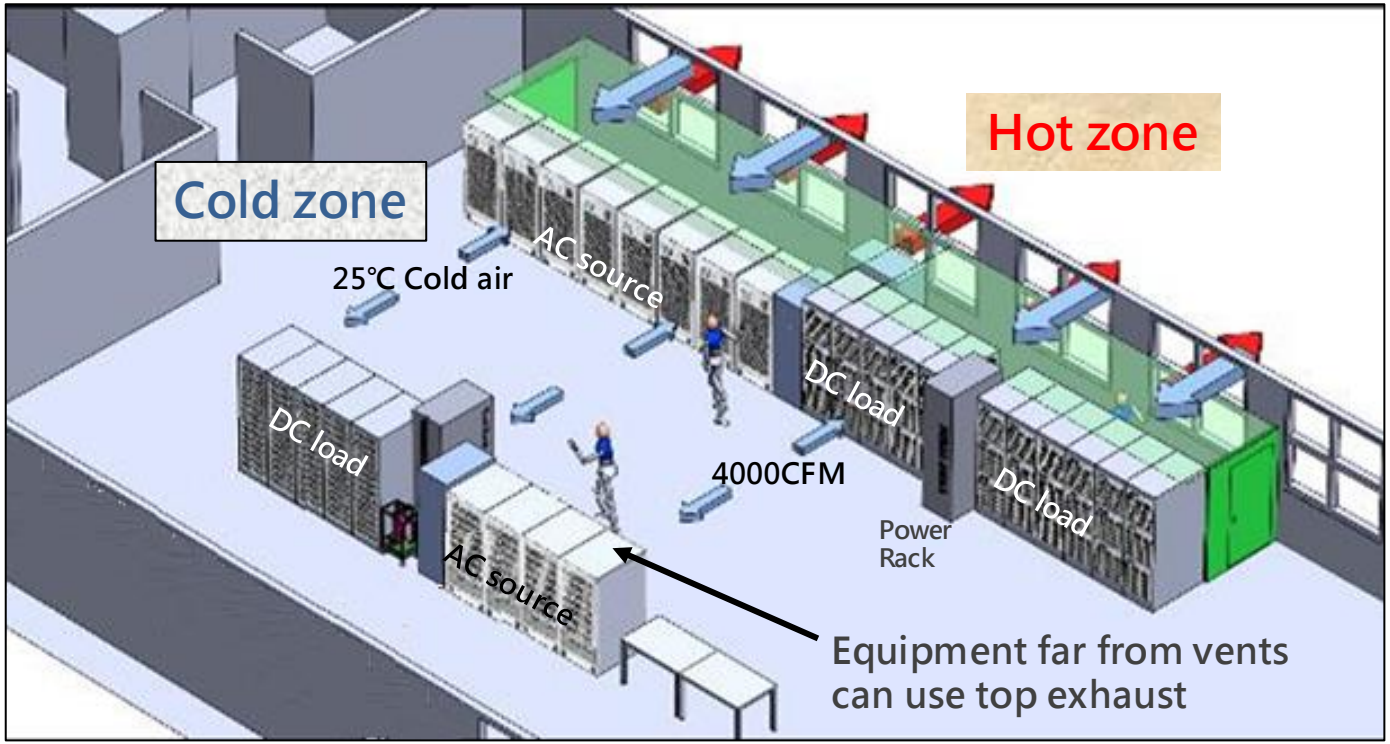
Separate hot & cold zones; exhaust hot air outside to prevent recirculation

Cold air

Hot air



Partition



Thermal-Flow Analysis

Site Equipment Operating Thermal-Flow Analysis

Megawatt-class equipment CFM requirements:

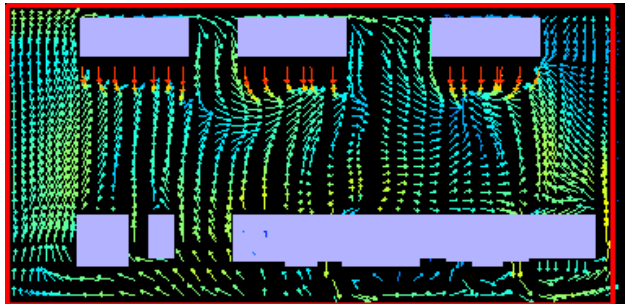
Electronic Load: >13 load cabinets x 4,000 CFM = 52,000 CFM

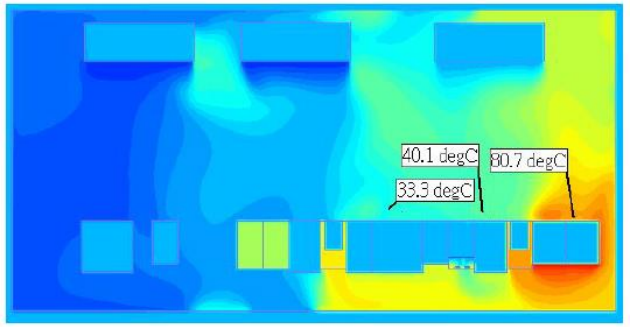
AC Source: >12 units x 2,080 CFM = 24,960 CFM



Based on the actual site's HVAC specs and test-equipment layout, Chroma can perform a complete thermal-flow simulation and analysis.

CFM / Thermal-Flow Simulation

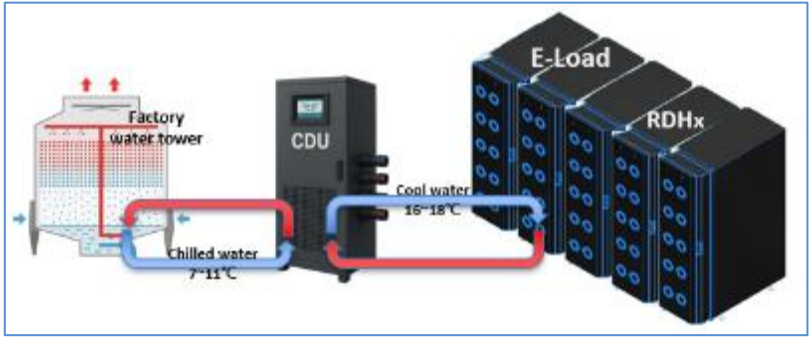


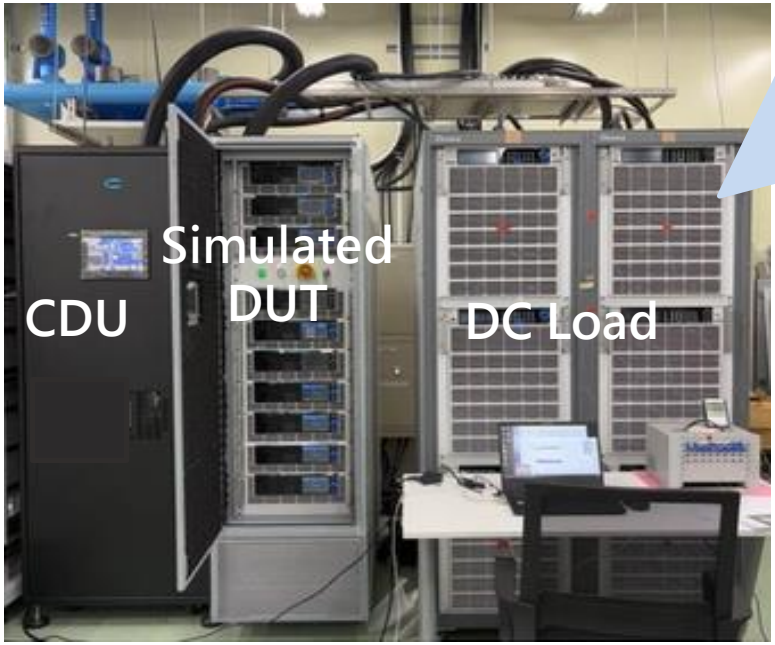


From Air to Liquid Cooling

Rear Door Heat Exchange Solution

When the laboratory cannot provide sufficient airflow and heat dissipation, this air-water exchange cooling solution can be used, utilizing the existing chilled water piping for heat removal.







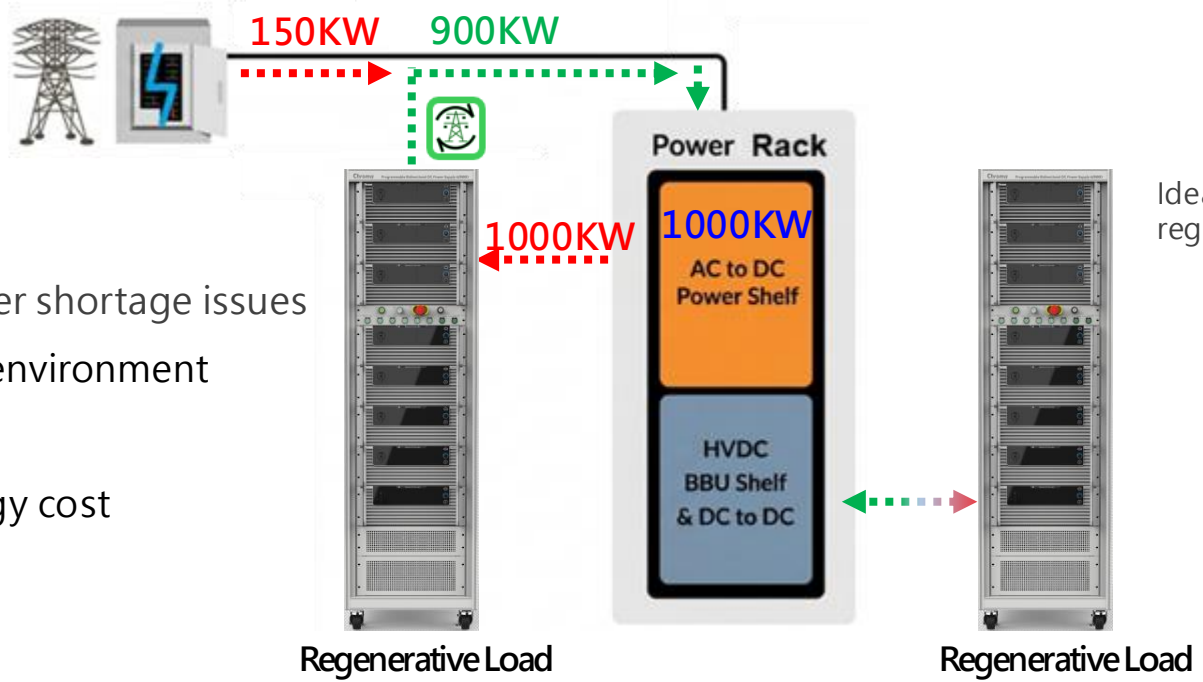
CDU + DC Load with RDHx (Rear Door Heat Exchange)

Building an MW-Class Power Test Lab (Power Shortage)

Challenge: Insufficient Building/Site Power

Regenerative DC Electronic Load

Feeds test energy back to the grid for recycle, with **efficiency above 90%**



Solves site power shortage issues

Lowers indoor environment temperature

Saves test energy cost

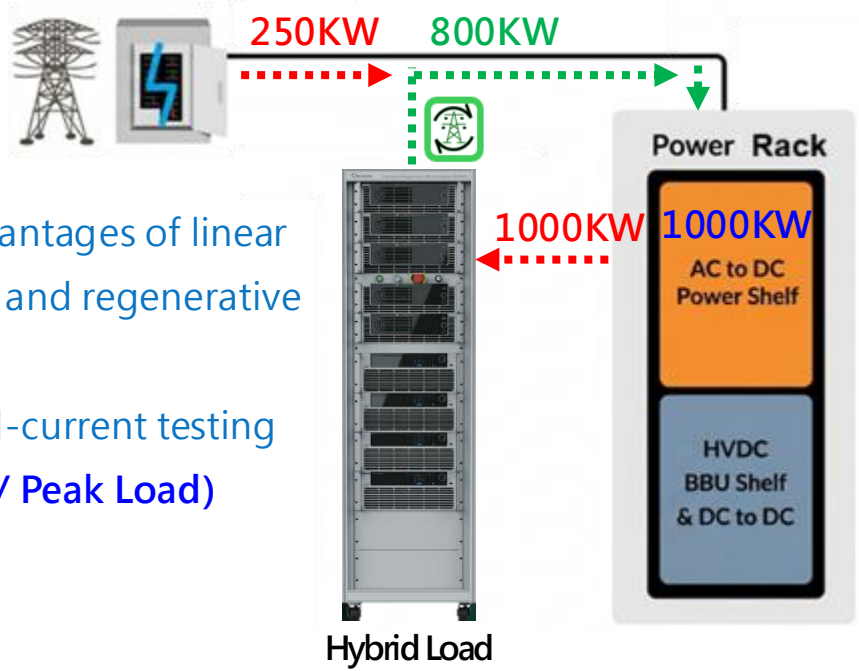
Ideal applications for regenerative loads

- Long-duration endurance testing
- Reliability testing
- Burn-in testing
- Battery discharge testing

Challenge: Insufficient Building/Site Power

Hybrid Regenerative DC Electronic Load

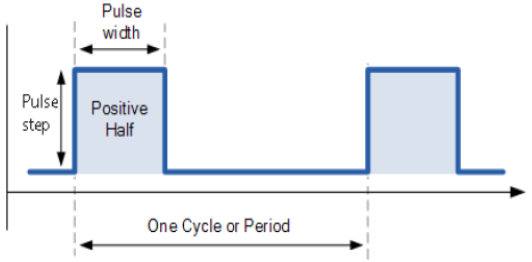
Also feeds test energy back to the grid, with steady-state **efficiency above 80%**



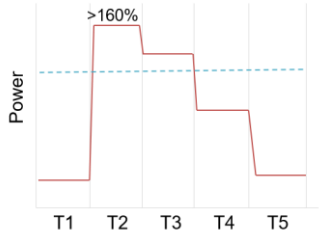
Combines the advantages of linear Load (high speed) and regenerative loads.

Meets pulsed load-current testing **(Dynamic / EDPP / Peak Load)**

≥ 160% Peak Load



EDPP : 10kHz Dynamic



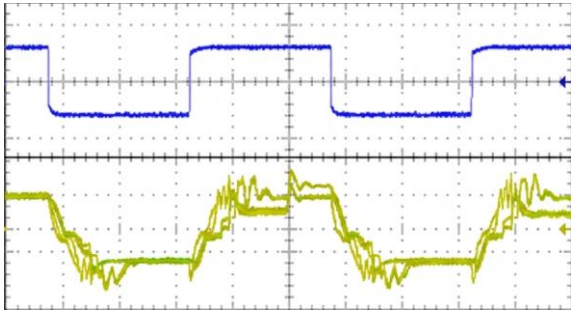
High-Speed / Regenerative / Hybrid DC Load

Chroma DC Electronic Load	 High-Speed 63200A	 Regenerative 62000D	 Hybrid 63700H
Topology	Linear	Regen (Switching)	Hybrid (Linear + Switching)
Benefits	High slew rate >20A/μs Low ripple(20mV) Peak Power function	High regen efficiency >90% High power density	High slew rate >20A/μs High regen efficiency >80% Peak Power function
Drawbacks	No energy recovery (0%) High cooling demand	Slow slew rate >30A/ms High ripple(150mV)	High ripple(150mV) No short function

Building an MW-Class Power Test Lab (Equipment Control & Connection)

Challenges of Synchronously Controlling Multi Load Units

Multiple electronic loads are connected in parallel to test high-speed dynamic current. If precise synchronous control cannot be achieved, the slew rate will slow down and fail to meet the testing requirements.



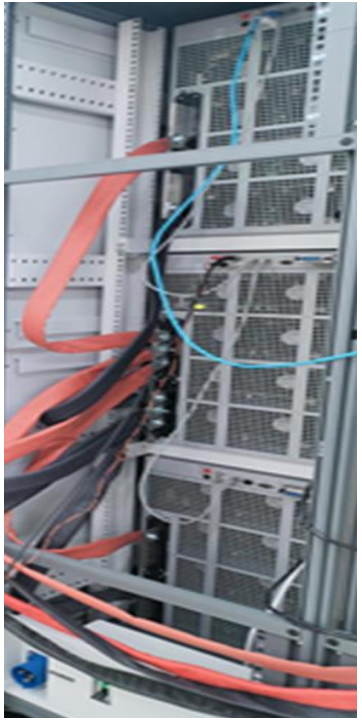
Recommend the dynamic synchronization error be under **2us.**

Supports synchronized control of 60+ load units, with total sink power up to **1.44MW** or more



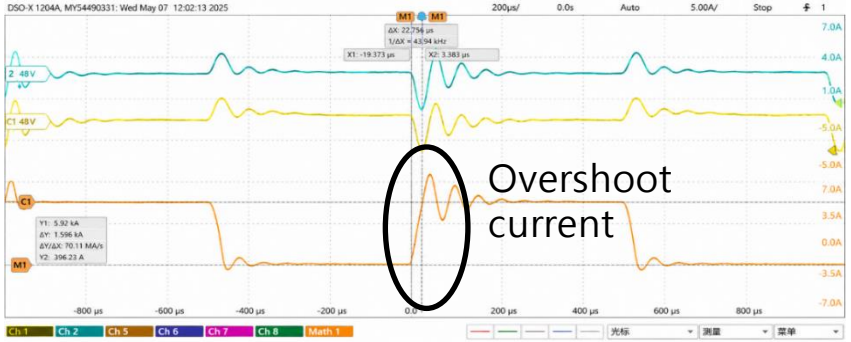
Challenge: Wiring Inductance

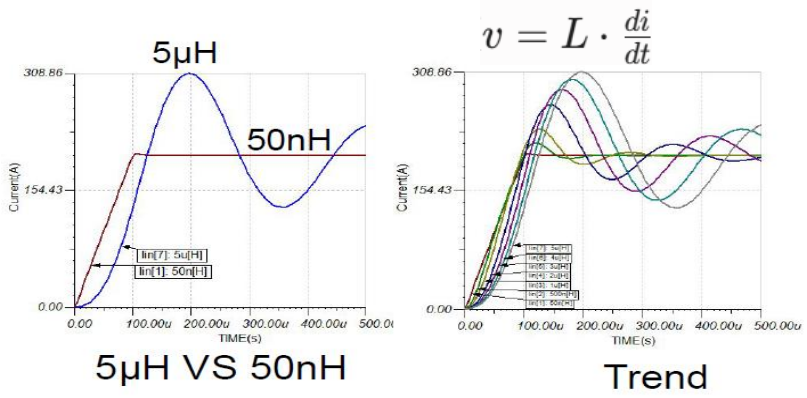
Excessive cable inductance degrades DC load dynamic capability.



It causes problems:

- Current overshoot
- Current rise time
- Settling time





Professionally Designed low-inductance Busbar

High current path, heat generation, inductance, and parasitic capacitance must be considered.

bad busbar design blocks the air outlet



Chroma Patented low-inductance busbar









NP-40191-TW

60 E-Load units, 1.44MW



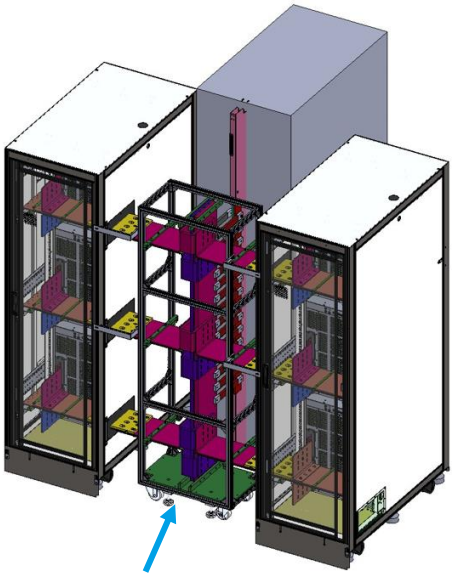
Custom-Designed Load-to-DUT Busbar

Power Rack output-interface connection challenges:

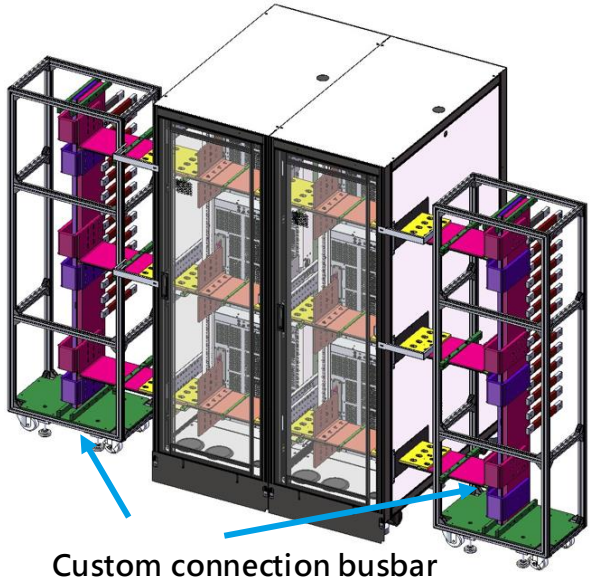
Currents of thousands of amperes

Inductive-impedance heating & meltdown

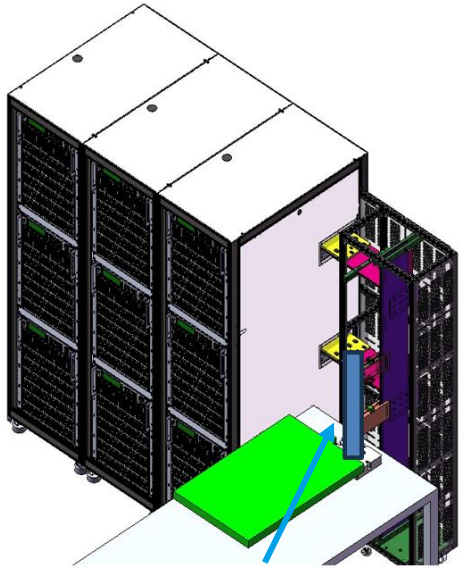
HVDC high-voltage arcing & leakage



Custom connection busbar



Custom connection busbar



Custom connection busbar

More Realistic Power Supply and Thermal Testing of AI server Racks:

Server Load Emulator

Validate the Rack Before Compute Trays Arrive

Server Load Emulator: 1U high, 15kW water-cooling, 80V/300A.

Power, distribution, control and cooling systems are often ready before the AI compute hardware.





Server Load Emulator

POWER SHELF	Ready
BUSBAR / PDU	Ready
EXTERNAL CDU	Ready
RACK CONTROL	Ready
COMPUTE TRAYS	Unavailable

RACK INFRASTRUCTURE READY

COMPUTE TRAYS NOT AVAILABLE

The validation **schedule** cannot wait.

Reproduce Real Server Power Behavior

Convert measured AI server Power profiles into a repeatable, programmable physical load model.



REAL SERVER → CAPTURE PROFILE → REPLAY WITH SLE

DYNAMIC LOAD	Fast workload transitions < 20us
PEAK EXCURSION	24kW (160%) for 200 ms
WAVEFORM REPLAY	Measured current profile
THERMAL EMULATION	Liquid + air-cooled load

Not just power consumption, Power behavior.

From One Server Model to a Complete Rack

Synchronize Server Load Emulators to validate power and cooling as one system.



VALIDATE THE COMPLETE RACK

- **Power Shelf** — Regulation, sharing, protection
- **Busbar / PDU** — Current capacity, voltage drop
- **External CDU** — Flow, temperature, heat rejection
- **Rack Control** — Sequencing, telemetry, recovery

>30 synchronized units | > 300kW @ Rack

SERVER 1 SLE › **RACK** SLE x N › **CLUSTER** Rack x N › **POWER HIL**

A scalable validation methodology for AI Power infrastructure.

From MW-Class Test Lab to Rack-Scale Validation

Four principles for validating next-generation AI power infrastructure

- **VALIDATE THE COMPLETE SYSTEM**
  Integrate power, distribution, cooling and control validation.
- **ENGINEER THE TEST LAB AS ONE PLATFORM**
  Plan cooling, site power, synchronization and connections together from the beginning.
- **SELECT THE RIGHT LOAD ARCHITECTURE**
  Balance dynamic performance, energy recovery and site constraints.
- **CLOSE THE VALIDATION GAP WITH SLE (Server Load Emulator)**
  Reproduce real server power and thermal behavior and scale from server to rack and Power HIL

SIMULATE THE SERVER. VALIDATE THE RACK. SCALE TO THE DATA CENTER.

Chroma

Advancing Excellence

Thank You

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