POWERINSIGHT BY ADVANCED ENERGY

TURN TOTAL POWER SYSTEM DATA INTO ACTIONABLE INSIGHTS FOR EFFICIENT OPERATIONS

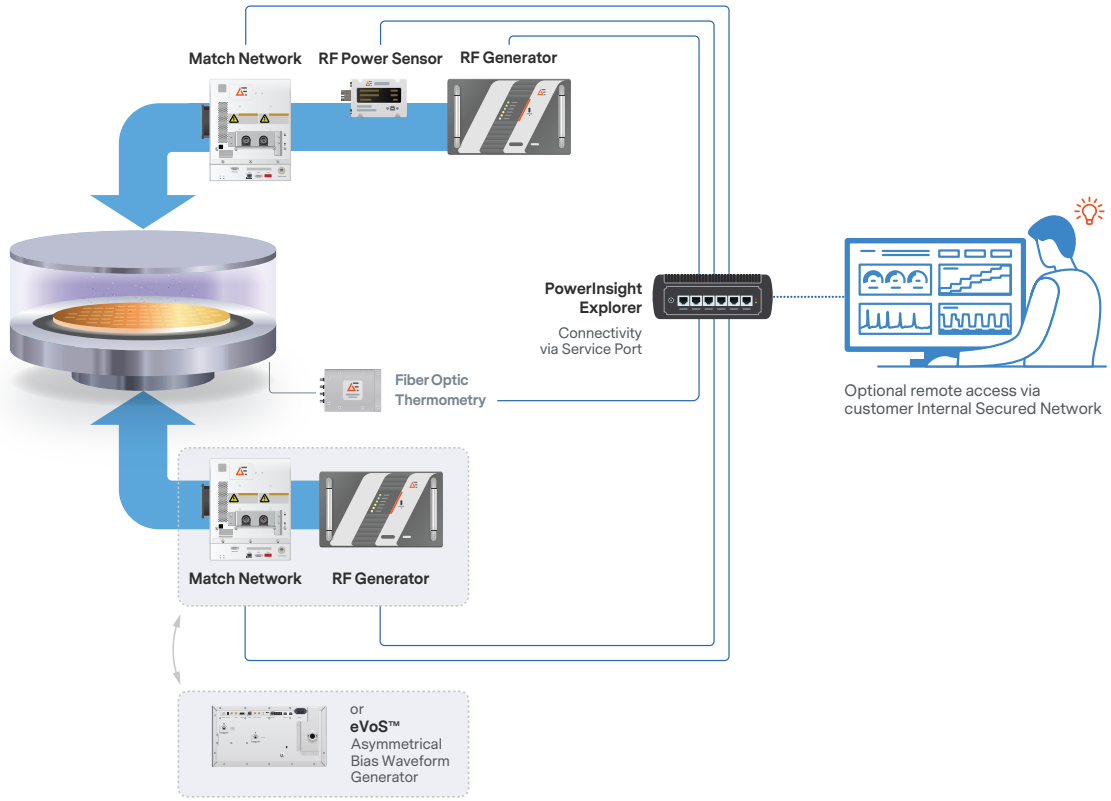
In today's competitive manufacturing environment, the pressure to reduce operational costs while maintaining efficiency and uptime is greater than ever. Challenges like unplanned downtime, costly spare unit inventory, delayed troubleshooting, and the ripple effects of NPO (no problem observed) returns on production, labor, and logistics continue to weigh heavily on businesses.

What if you could turn these challenges into opportunities?

At the heart of modern manufacturing, plasma power products play a critical role, yet they often hold untapped potential to transform operations. Every plasma power unit generates a wealth of operational data, and it is crucial to leverage the full potential of this data to drive measurable improvements.

POWERINSIGHT
by Advanced Energy™

Designed for manufacturers looking to streamline troubleshooting, minimize downtime, and optimize operational costs.



"With the flight recorder capturing comprehensive data, I can troubleshoot more efficiently – no more waiting to schedule an on-site visit just to replicate a problem. The enhanced visualization tools and remote access make root cause analysis faster and more convenient than ever."
– Senior Field Engineer

"Tool downtime has dropped because we can now access detailed performance data that our system alone doesn't provide. This really speeds up root cause analysis."
– RF/DC Engineer

"The rich data logs have opened the door for smarter diagnostics. They're laying the foundation for predictive maintenance strategies that could help us avoid unnecessary returns and reduce operational costs."
– Data Scientist

- **Plug-and-play deployment** with total power system monitoring and in-depth diagnostics.
- **Complementary data insights**, including oscilloscope-level FastDAQ™ event captures, time-stamped history of faults and warnings, unit statistics, and unit internal sensor data.
- **Web-based data visualization** with access to months of historical data, plus configurable raw data export and backup options.
- **Independent operations** on dedicated hardware—no software installation required on customer system and no risk of interfering with existing monitoring and control systems.
- **Optional remote access** and configurable notifications within the customer's internal secured network.
- **Scalable infrastructure** designed to support future predictive maintenance capabilities.

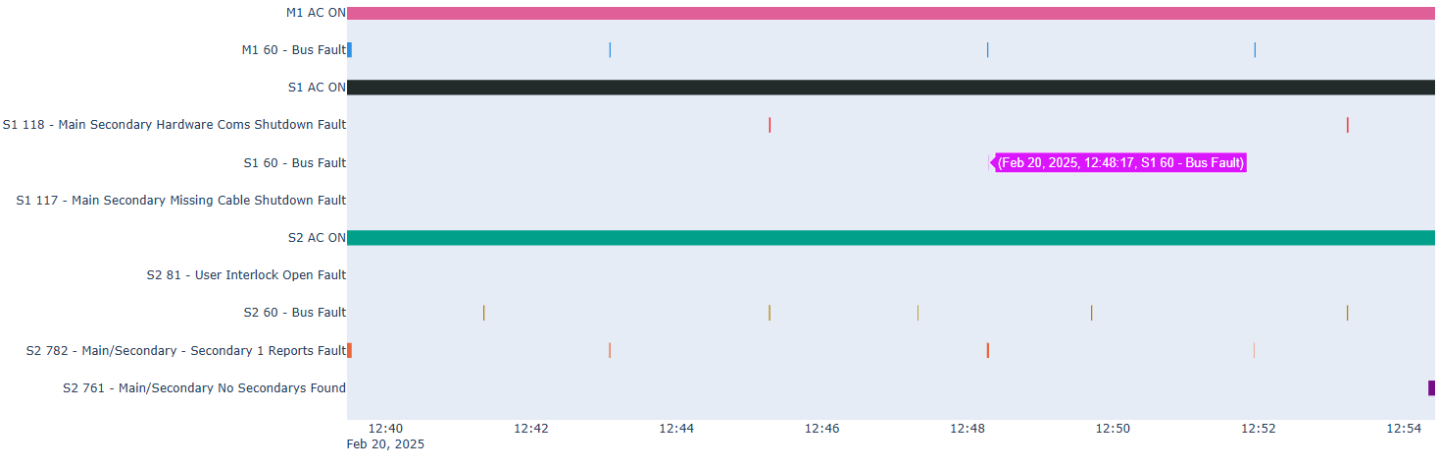
COMPLEMENTARY DATA COLLECTION

Enhancing Health Monitoring

We understand that customers often log data that is critical for process monitoring and control through EtherCAT or DeviceNet. However, when it comes to in-depth **generator and match health monitoring**, these data streams often fall short. This gap becomes evident during troubleshooting activities and can pose significant risks when critical faults and warnings—sometimes deemed less relevant for process control—are not logged. These **overlooked data points**, however, are essential for maintaining unit health. This is where **PowerInsight** steps in to complement existing systems. By logging a **comprehensive dataset** through the service port, PowerInsight fills critical gaps, enabling the creation of a robust database for **health diagnostics** and **predictive maintenance**.

Target Unit	RF Generator	Match Network	DC Generator	RPS
OEM Tool (For process control & monitoring)	✓ Setpoint	✓ Cap Position	✓ Setpoint	✓ Output Power
	✓ Forward/Reflected Power	✓ Input Impedance	✓ Voltage/Current	✓ Setpoint
	✓ Frequency	✓ Output Sensor Readings (optional)	✓ Power	✓ Voltage
	✓ Arc Counts (optional)		✓ Arc Counts	✓ Current
PowerInsight (Complementary data fields for unit health monitoring & troubleshooting)	✓ FastDAQ	✓ Fault & Warning Details	✓ FastDAQ	✓ Fault & Warning Details
	✓ Arc Parameters	✓ Internal Match Sensors	✓ Arc Parameters	✓ Firmware Verification
	✓ Fault & Warning Details	✓ Match Configuration	✓ Fault & Warning Details	✓ Generator Statistic Data
	✓ Generator Statistic Data	✓ Match Statistics Data	✓ Generator Statistic data	✓ Frequency
	✓ Firmware Verification	✓ Firmware Verification	✓ Firmware Verification	✓ Temperature
	✓ Generator Configuration	✓ Process Status (e.g. tune status)	✓ Generator Configuration	✓ Process Status Data
	✓ Internal Generator Sensors		✓ Internal Generator Sensors	
	✓ Impedance			
	✓ Pulse Parameter			

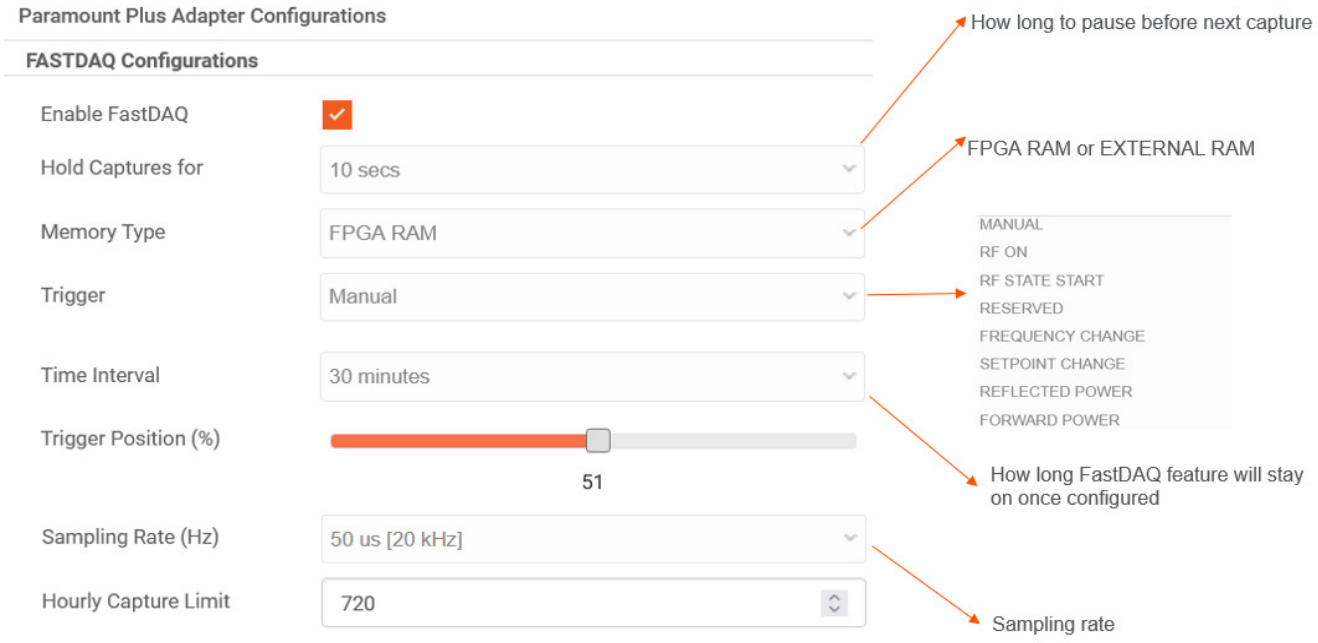
PowerInsight timestamps the data and save it for historical review. For example, users can monitor arc density trends and Faults & Warnings sequences from multiple units to visualize when each fault occurred and how they may have influenced one another.



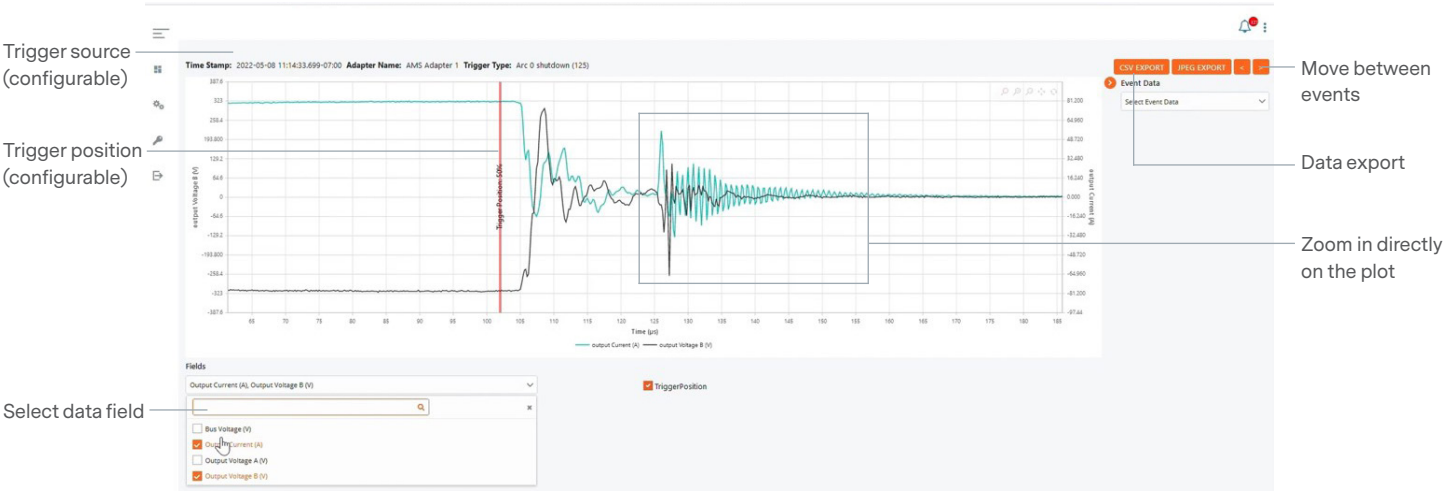
Sample dashboard displaying the fault sequence across Master DC (M1) and Satellite DC (S1 and S2) units.

ONBOARD OSCILLOSCOPE CAPTURES AND RECORDS FASTDAQ (FAST DATA ACQUISITION) EVENTS

High-resolution event capture is critical for diagnosing complex system behaviors, especially when conventional tools like oscilloscopes cannot be safely used during semiconductor production. When deployed on products with FastDAQ capability, such as the eVerest® RF generator, PowerInsight allows users to configure trigger sources and sampling rates for event-driven data capture up to 40 MHz.



Sample FastDAQ event capturer configuration.



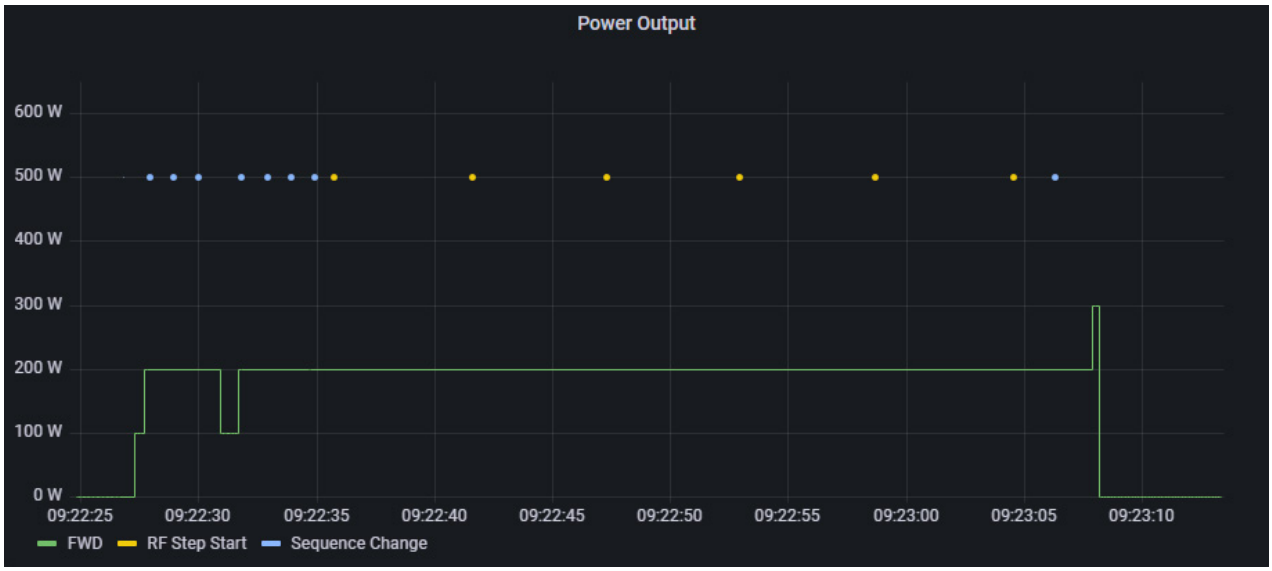
Review FastDAQ events on a web browser.

SMART FASTDAQ

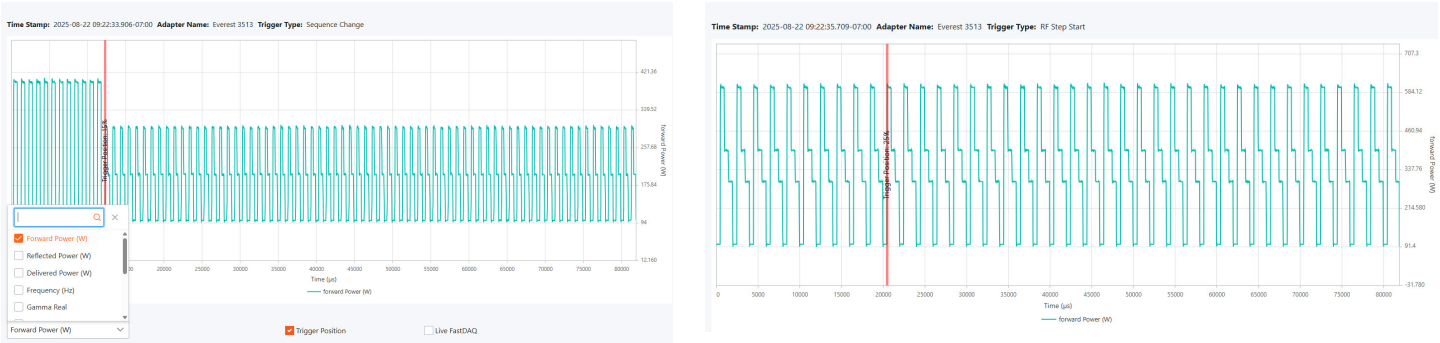
Building on our existing FastDAQ integration, we developed Smart FastDAQ. This advanced event capture feature enables users to define a state machine that dynamically adapts trigger sources and other configuration parameters to the power condition changes, hunting for all critical moments in process while minimizing irrelevant data from idle periods.

For example, capturing multi-level pulsing FastDAQ signals on an eVerest® RF Generator, PowerInsight Smart FastDAQ was configured to automatically set different trigger types as follows.

- At startup, set the trigger type to '[On] Sequence Change',
- When the unit reaches "steady state", reset the trigger type to 'RF Step Start',
- Reset the trigger type to '[On] Sequence Change' when the forward power begins to ramp down,
- Then 'powered off' reverts to xyz trigger, avoiding unnecessary data collection.



FastDAQ™ events appear as clickable dots on PowerInsight dashboard - click a dot to view detailed event information.



Sample FastDAQ™ events captured by dynamic triggers that automatically adjust based on changing power conditions.

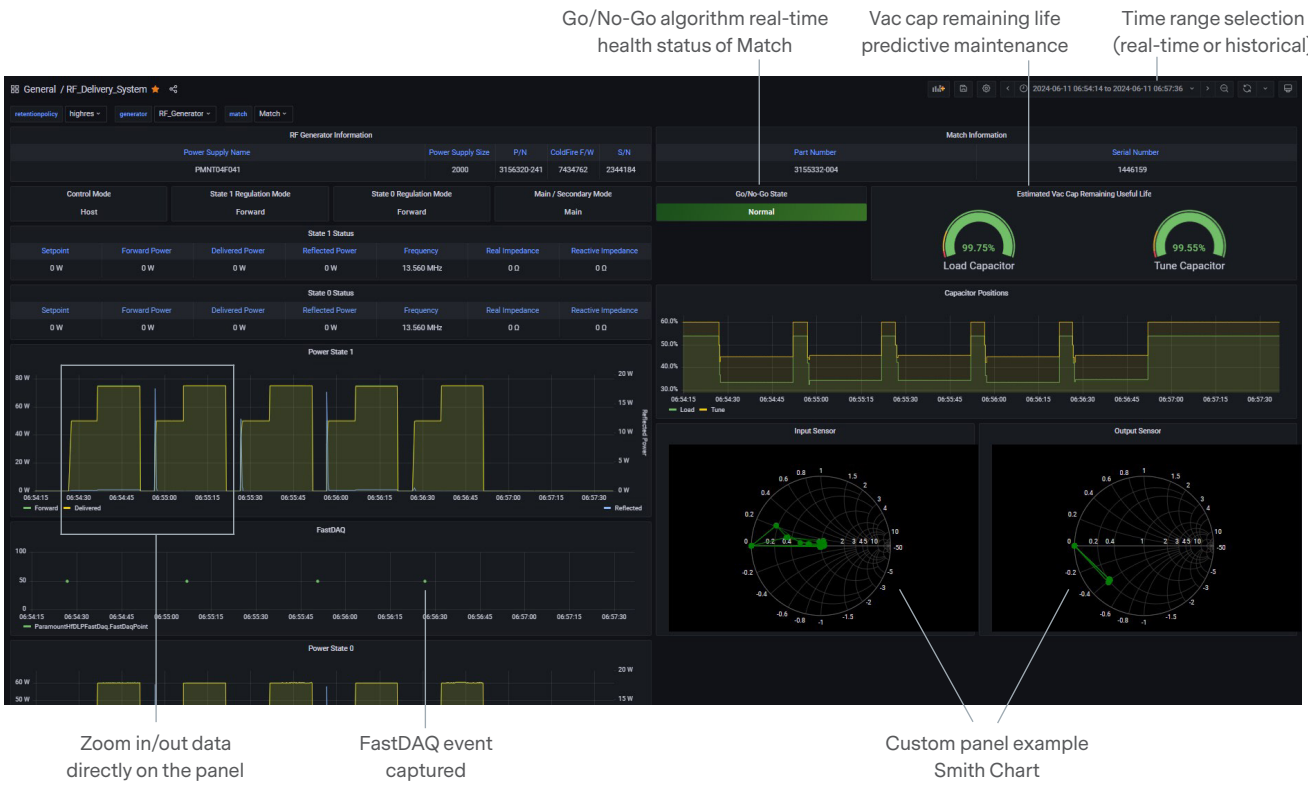
These capabilities enable customers to capture all critical moments in process while filtering out irrelevant idle-time data. In the example with eVerest, it allows users to monitor pulse timing under different power conditions and potentially leverage the data to optimize process performance at the wafer level.

CUSTOM DASHBOARD AND NOTIFICATIONS

Custom dashboard can put everything together – displaying data, notifications such as FastDAQ events, faults & warnings, and health monitoring algorithm results. The dashboard is also the primary tool for our data scientist team during **Exploratory Data Analysis** (EDA). With its interactive and highly customizable data visualization capabilities, PowerInsight empowers users to:

- **Plot and Overlay Data:** Either plot different parameters from the same unit on the same panel or overlay data from different units for immediate comparison.
- **Apply Mathematical Methods:** Perform advanced calculations directly on raw data for deeper analysis.
- **Zoom and Navigate Freely:** Smooth zoom in and out by simply dragging the mouse on the plot, enabling focused examination of specific data points.
- **Adjust Time Span:** Easily choose time spans ranging from recent days to weeks or even months.

The ability to tailor user's own way to visualize the data streamlines the process of identifying anomalies and patterns, as well as establishing and testing hypotheses and assumptions.



Stay Ahead of Issues with Real-Time Notifications

PowerInsight notification feature allows users to configure real-time alerts for a variety of critical events and thresholds, such as Faults and Warnings, arc events, custom threshold like load and tune positions, input/output sensor for current and voltage on the match, or power profiles of the generator.

UNLOCK THE FUTURE OF PREDICTIVE MAINTENANCE

The rich data logs captured by PowerInsight also lay the foundation for advanced monitoring methods combining domain expertise and/or data science to assess unit health in the field.

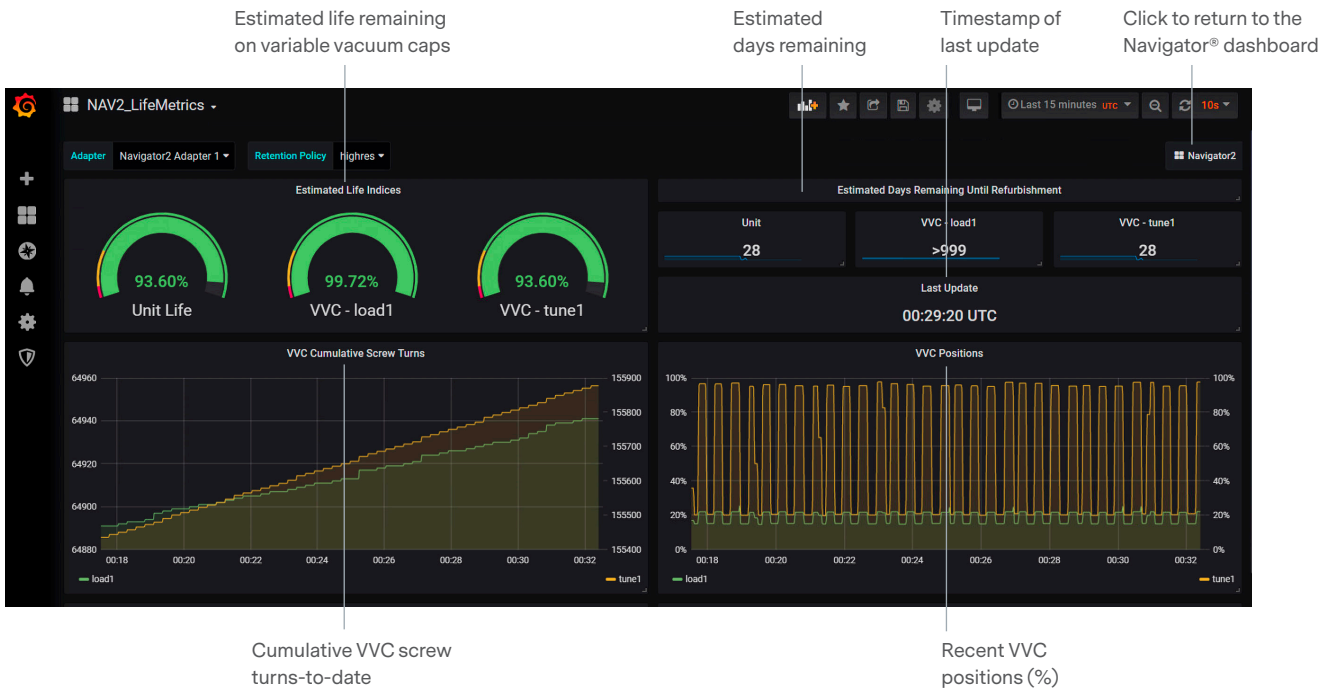
Go/No-Go Algorithm

To prove what's possible, our data science team developed a preliminary “Go / No-Go” model using machine learning techniques and years of AE Global Service RMA data. The model categorizes the match unit under test as either a probable NPO, as in “Go” status; or in need of service, as in “No-Go” status. This exemplifies our broader strategy to develop comprehensive health monitoring and predictive models across all plasma power products.

To reach its full potential, the final model requires both real-time and historical data on plasma power products for continuous monitoring and accurate health assessments. PowerInsight offers a turn-key solution to begin building this high-quality dataset today accelerating the path toward predictive maintenance and more efficient operations. No other system in the field captures all the necessary data from the unit as comprehensive as ours.

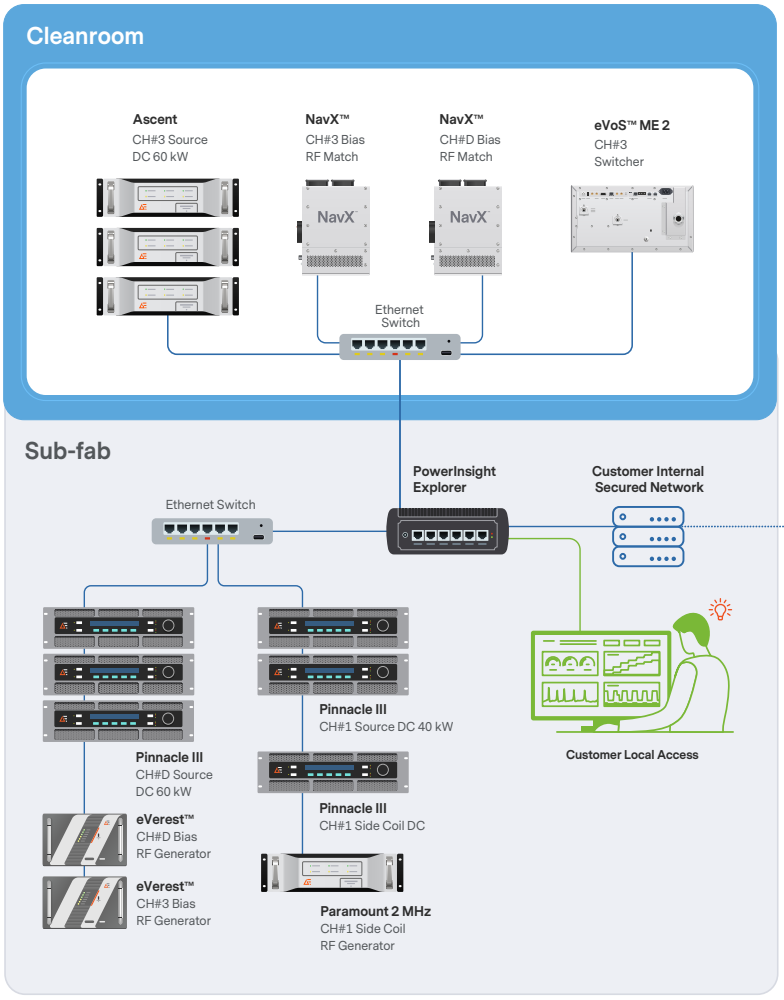
Vacuum Capacitor Remaining Lifetime Prediction

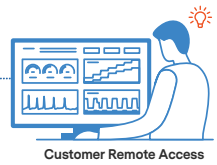
Variable Vacuum capacitors are the highest wear mechanical components in RF matching networks. They have a manufacturer-defined life span, but it is based off a consistent use pattern. In a semiconductor fab environment, vacuum capacitors are subject to inconsistent use and wear patterns, even across multiple capacitors in the same matching network. This makes it a challenge to estimate capacitor health and predict time schedules for regular maintenance. By combining manufacturer recommended life spans with actual wear patterns, PowerInsight data scientists developed a proprietary algorithm to observe details of capacitor movements and accurately estimated the “consumed life” of the capacitor. This estimation was also verified through in-house highly accelerated life testing. On the PowerInsight dashboards, users can easily understand the estimated remaining useful life, displaying as a percentage or unit of time. This insight allows the customers to selectively replace capacitor at the end of their life before they fail and cause unplanned downtimes.



DEPLOYMENT LAYOUT

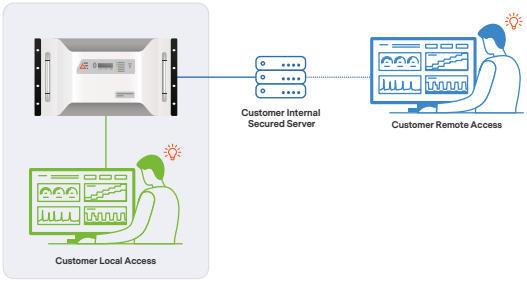
PowerInsight seamlessly integrates with the total power system on the OEM tool, providing a plug-and-play installation experience. All software runs on a preconfigured industrial computer (the PowerInsight Explorer), tailored to the specific tool type and device scope to ensure a streamlined setup. Connectivity between the Explorer and the target devices is through service ports. The Explorer can be optionally connected to the customer's internal secured network, allowing users to access the system interface via a web browser either locally or remotely. Once installed, users gain deep visibility into the performance of individual units as well as their interactions with one another, enabling enhanced monitoring, diagnostics, and maintenance.





Digital Twin: mirrors the total power system in real time for insights, troubleshooting, and predictive actions.

Some of the newer Plasma products, such as Ascent® AMSII and Ascent SMS AP10 include an embedded module with the same PowerInsight application, allowing out-of-the-box monitoring with no need for any external HW devices. Either access locally by simply plugging in the service port of the unit, or access remotely through the customer's internal secured network.



COMPATIBILITY OVERVIEW

The table below highlights the product lines from AE that are fully compatible with PowerInsight. Different combinations of these products can be flexibly configured to match the specific architecture and operational scope of customer systems.

PowerInsight Compatible		Sample Rate	FastDAQ***	Algorithms
DC Power Source Systems	eVoS®	10 Hz	✓	
	Pinnacle® III Plus		✓	Arc Monitoring
	Pinnacle® III	10 Hz	✓	
	Pinnacle® II	4 Hz		
	Ascent® SMS AP10	10 Hz	✓	
	Ascent® AMS II		✓	
	Ascent® AMS	10 Hz	✓	
	Ascent® DMS	10 Hz	✓	
	Ascent® AP	10 Hz	✓	
	Ascent® AMS/DC	10 Hz	✓	
	Ascent® MS	10 Hz		
	Crystal	4 Hz		
RF Plasma Generator	eVerest™	10 Hz	✓	
	Paramount®	10 Hz	✓	Reflected Power Events Monitoring RF Generator Health Monitoring
	Paramount® Plus	10 Hz	✓	
	Apex® Refresh	10 Hz		
RF Match Network	Navigator® I Refresh	4 Hz		Vacuum Capacitor Predictive Maintenance Go/No-Go Health Monitoring
	Navigator® X	10 Hz		
	Navigator® II	10 Hz		
Plasma Abatement	MAXstream™	10 Hz		
	Aeris-G	4 Hz		RPS Chamber Clean
Other Devices	Optical Temperature Sensor (FOT)	20 Hz		
	Analog Input Modbus® TCP Module	10 Hz		
	TEGAM® RF Power Sensor	1 Hz		
Integration Capabilities	Third-Party Systems*			
	Data Sources**			

*Can be made API-ready for integration with customer software, database, and analytics platforms.

**Integration with PLCs through OPC-UA for industrial applications.

***FastDAQ availability depends on model number of the target unit.

CASE STUDY

One example showed how PowerInsight can help reduce root-cause analysis time from days to hours across different tools, platforms, and customer sites.

A customer reported an issue where their eVoS® HVDC unit displayed an unrecognizable fault code during regular recipe operation.

To keep operations running, engineers have historically relied on the following workarounds:

- **Power cycling or swapping out the generator**—this is a temporary fix that may clear the system fault symptomatically but leave the root cause unresolved or risk unnecessary NPO returns.
- **Calling in field engineers to determine the root cause**—this requires scheduling chamber time to attempt to manually reproduce the issue before collecting and analyzing the fault data. Unfortunately, this method often misses historical context and key indicators and wastes valuable tool time.

In this case where PowerInsight was already deployed on the tool, AE's subject matter experts were able to remotely access intuitive historical plots and determine that the given fault code and other key process data indicated a performance issue while switching between low voltage and high voltage that needed to be addressed via a firmware update. AE was able to confirm the required firmware to install on the eVoS supply within hours of the initial notification. This eliminated the need to schedule chamber time and attempt to piece together all the relevant information to determine the root-case and provide a solution. Later, once the firmware update was ready, AE deployed a local field application engineer to install at the customer's location.

This example is not unique. Similar troubleshooting challenges occur frequently across various tools, where customers often lack either complete datasets or the expertise to interpret the available logs. By making sufficient and intuitive data readily available, PowerInsight empowers experts with the know-how to troubleshoot efficiently. This seamless combination of data and expertise has reduced root-cause analysis time by 70-90% based on recent deployments, preventing unnecessary returns, and minimizing mean time to recovery (MTTR).

READY TO SAVE OPERATIONAL COSTS?

Reduce your troubleshooting time and eliminate costly NPO returns. PowerInsight has helped customers save millions by enabling faster root cause analysis and smarter maintenance decisions.

The first step is simple—identify the tools where unlocking data capabilities will bring the most value to you.

Reach out to our PowerInsight team if you have questions or want to explore next steps.

Email: PowerInsightTeam@aei.com

ABOUT ADVANCED ENERGY

Advanced Energy (AE) has devoted more than three decades to perfecting power for its global customers. AE designs and manufactures highly engineered, precision power conversion, measurement and control solutions for mission-critical applications and processes.

AE's power solutions enable customer innovation in complex semiconductor and industrial thin film plasma manufacturing processes, demanding high and low voltage applications, and temperature-critical thermal processes.

With deep applications know-how and responsive service and support across the globe, AE builds collaborative partnerships to meet rapid technological developments, propel growth for its customers and power the future of technology.

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