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.

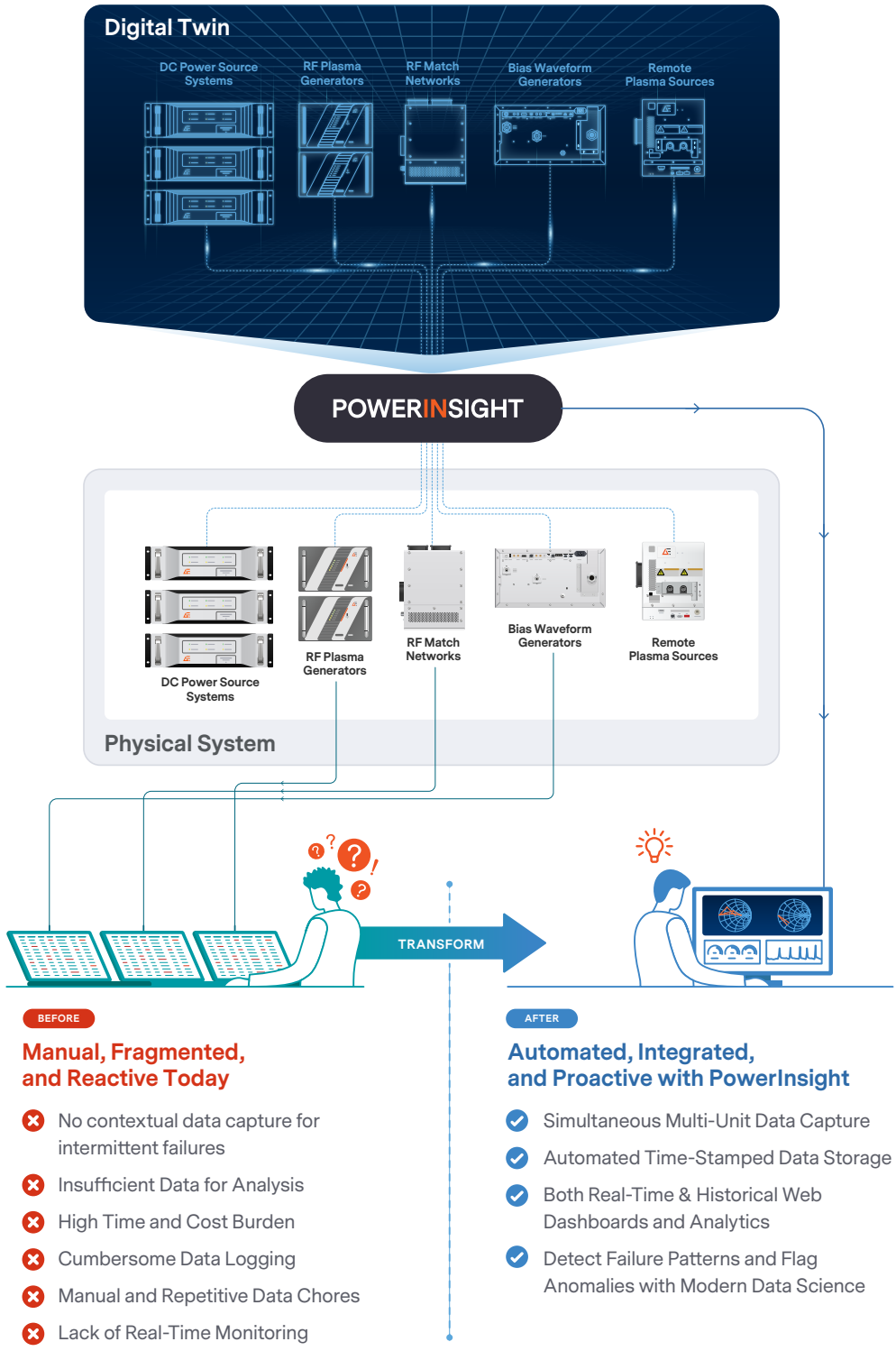
What if you could turn these challenges into opportunities?

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®

PowerInsight unlocks proprietary and complementary high-resolution data that has historically been inaccessible or uncorrelated – bringing critical unit diagnostics into context.

Combined with Advanced Energy's application expertise, this dataset accelerates troubleshooting, enables finer tuning of parameters for better yield, and supports predictive maintenance over time.



BEFORE

Manual, Fragmented, and Reactive Today

- No contextual data capture for intermittent failures
- Insufficient Data for Analysis
- High Time and Cost Burden
- Cumbersome Data Logging
- Manual and Repetitive Data Chores
- Lack of Real-Time Monitoring

AFTER

Automated, Integrated, and Proactive with PowerInsight

- Simultaneous Multi-Unit Data Capture
- Automated Time-Stamped Data Storage
- Both Real-Time & Historical Web Dashboards and Analytics
- Detect Failure Patterns and Flag Anomalies with Modern Data Science

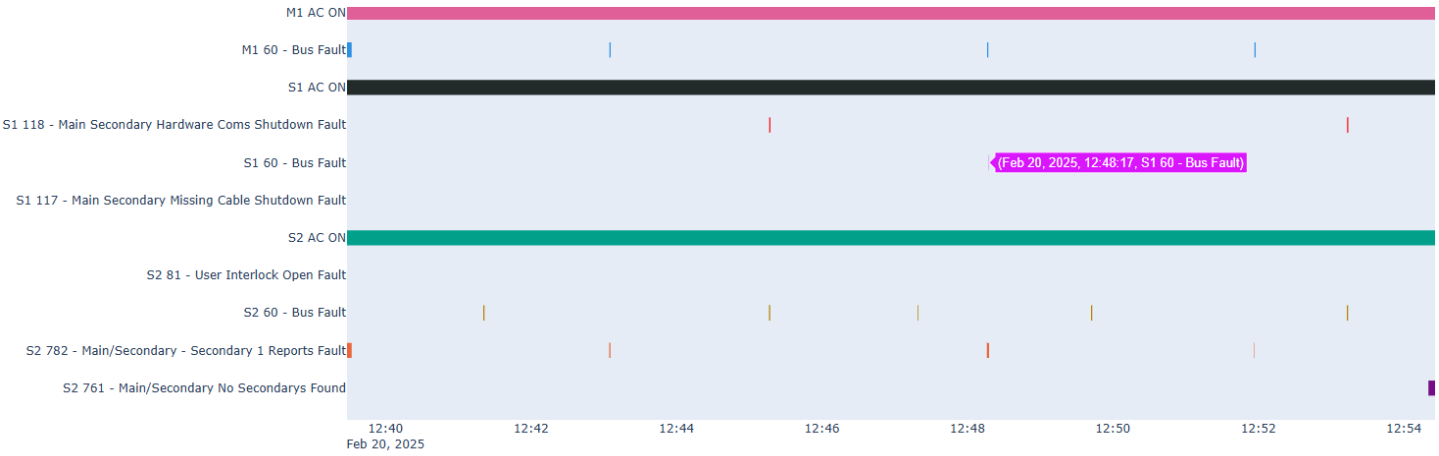
COMPLEMENTARY DATA COLLECTION

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			

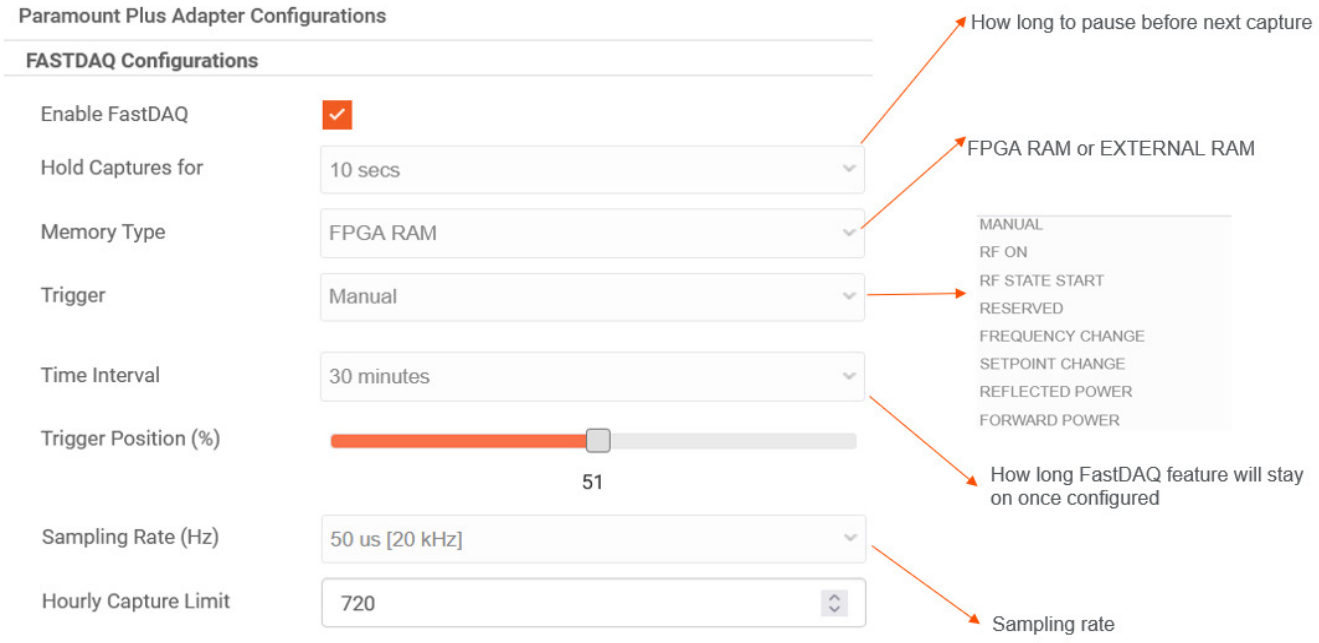
PowerInsight timestamps the data and save it for historical review. For example, users can monitor arc density trends and Faults & Warnings sequences from multiple units to visualize when each fault occurred and how they may have influenced one another.



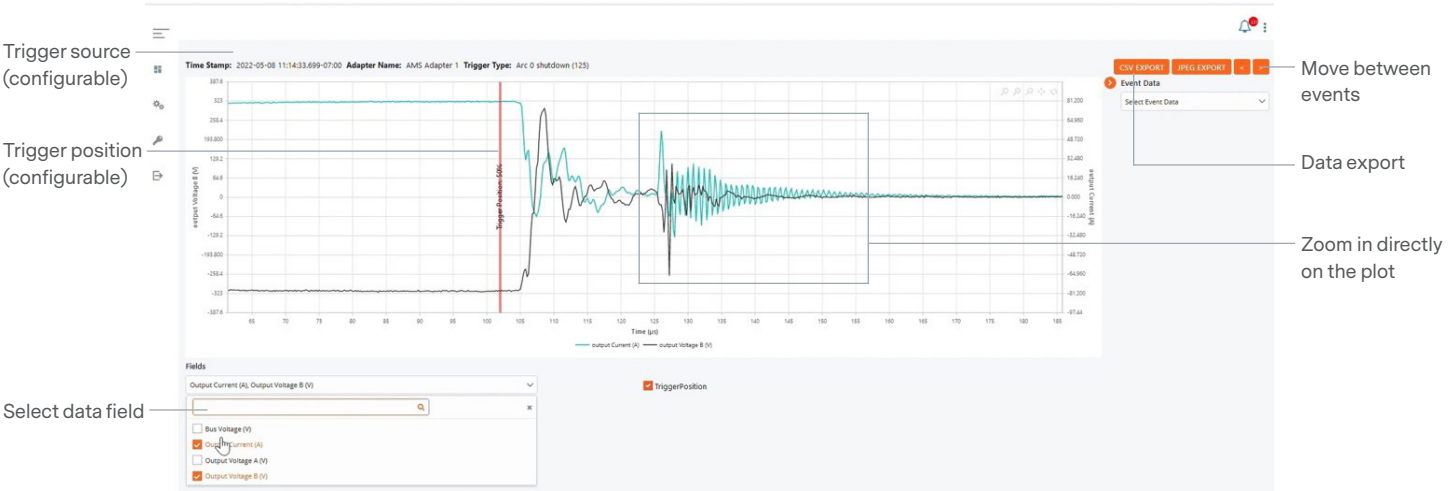
Sample dashboard displaying the fault sequence across Master DC (M1) and Satellite DC (S1 and S2) units.

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.



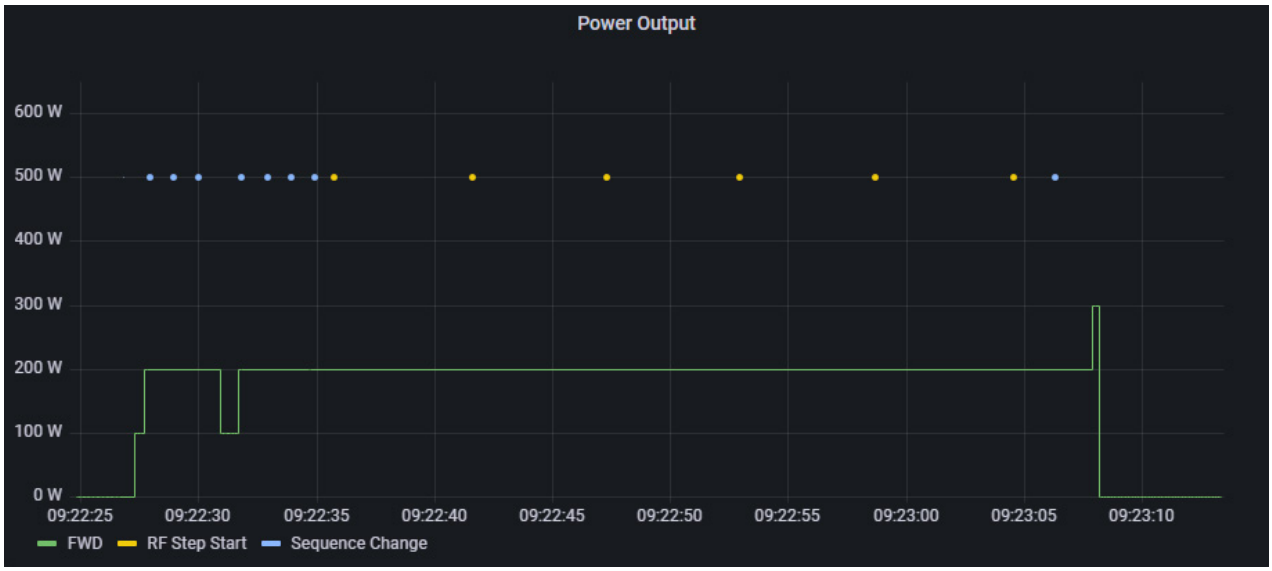
Review FastDAQ events on a web browser.

SMART FASTDAQ

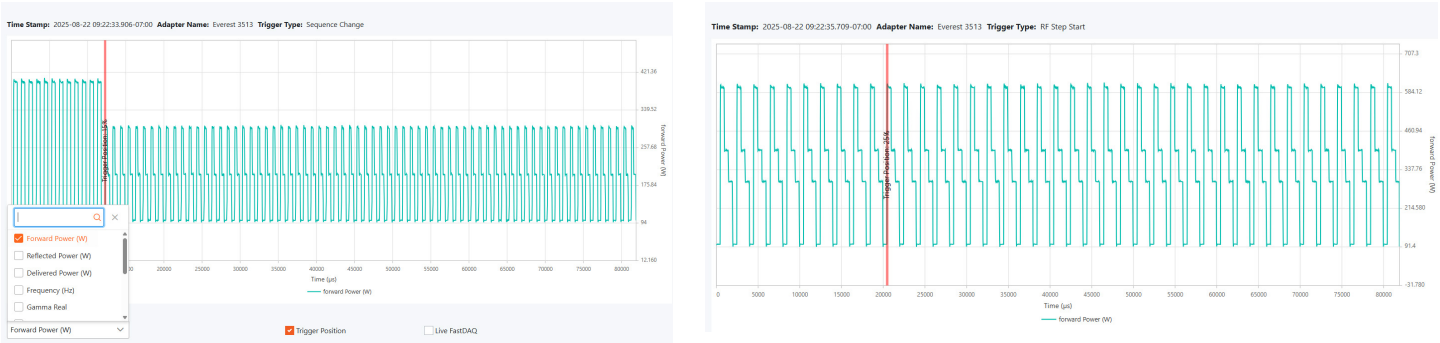
Building on our existing FastDAQ integration, we developed Smart FastDAQ. This advanced event capture feature enables users to define a state machine that dynamically adapts trigger sources and other configuration parameters to the power condition changes, hunting for all critical moments in process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

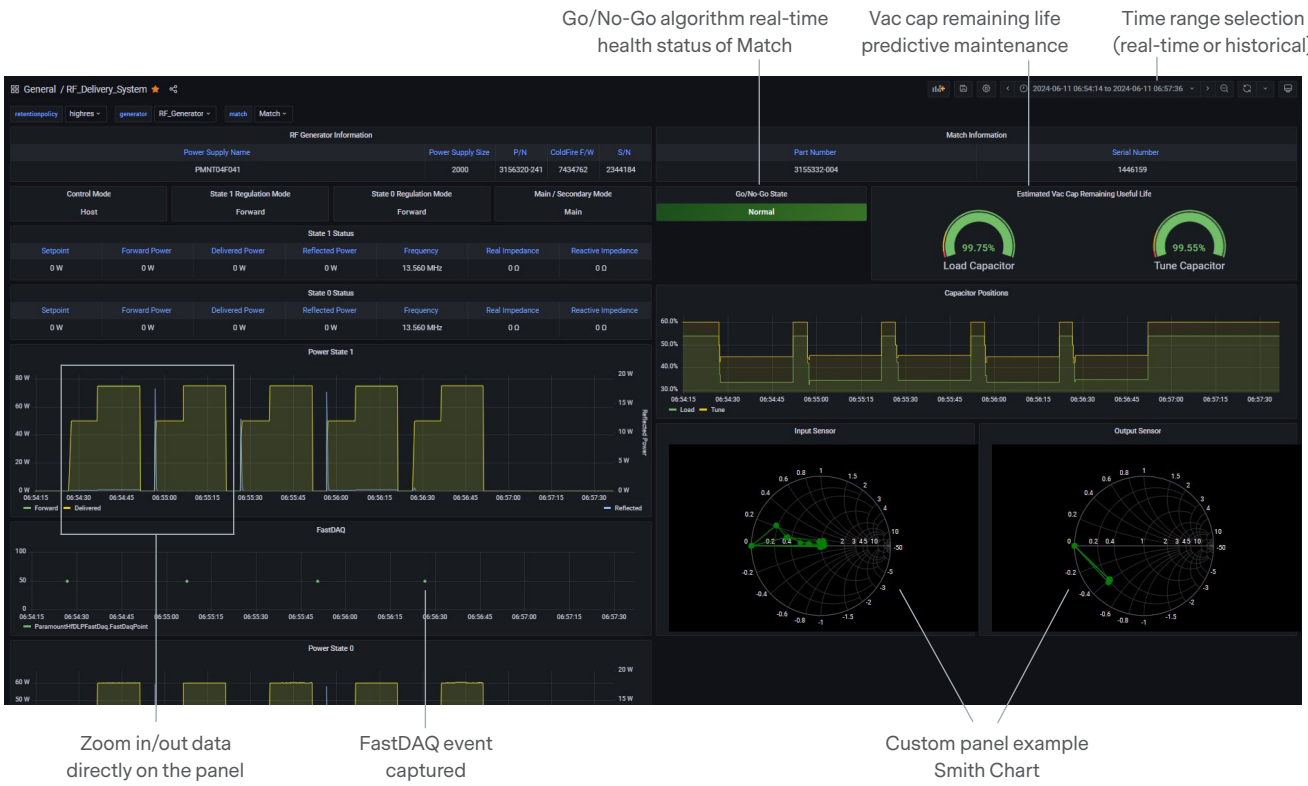
These capabilities enable customers to capture all critical moments in process while filtering out irrelevant idle-time data. In the example with eVerest, it allows users to monitor pulse timing under different power conditions and potentially leverage the data to optimize process performance at the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

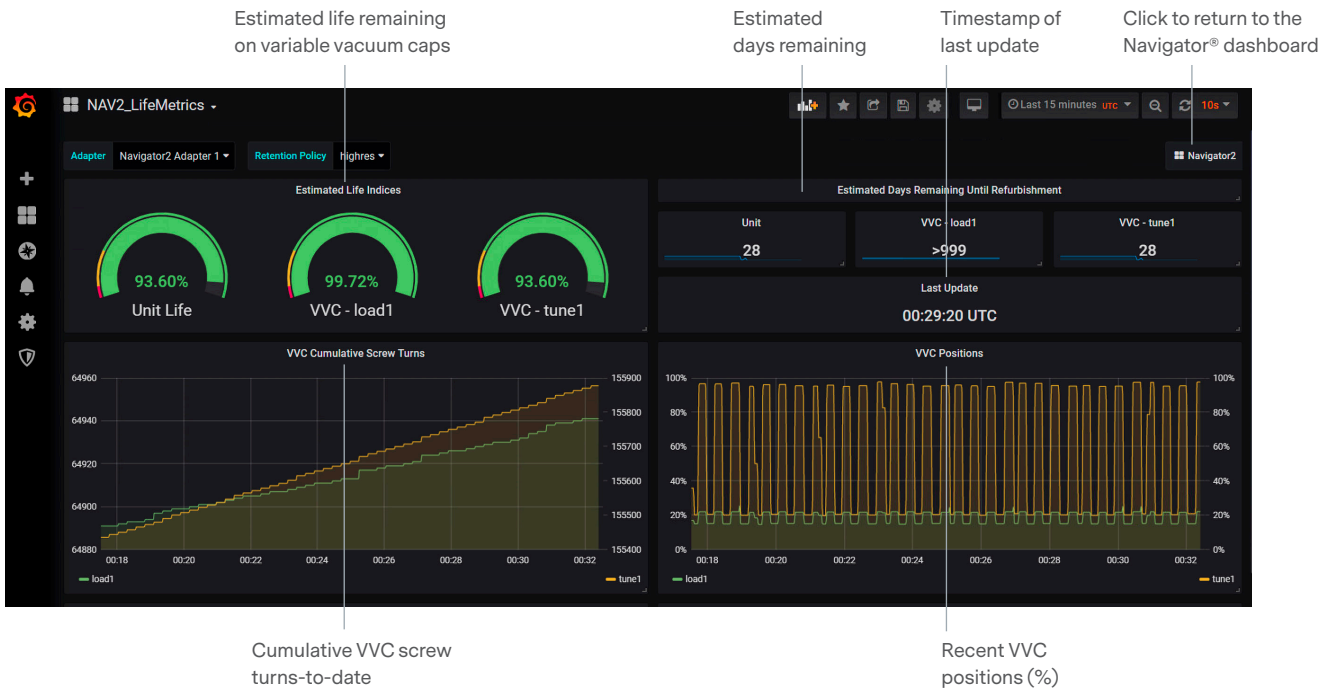
Go/No-Go Algorithm

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.



COMPATIBILITY OVERVIEW

PowerInsight is available as either an external module or embedded directly within AE's plasma power products. The table below highlights the product lines from AE that are fully compatible with PowerInsight.

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
	Nav 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.

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: Jing.Li@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.

PRECISION | POWER | PERFORMANCE | TRUST

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