

## Data Center Connectivity & Grid Monitoring



### Enhancing Data center performance and grid reliability

Applying high-resolution sampling to a data center's output connection shifts the focus from grid generation to mission-critical load management. At high-resolution, the monitoring moves beyond standard power quality into the realm of electromagnetic compatibility (EMC) and high-frequency phenomena, which is precisely where modern data centers operate.

Here's how ultra-high-resolution (2 MHz) waveform sampling at a data center's output connection provides critical insights:

For a data center, uptime is paramount, and its power infrastructure is a complex ecosystem of uninterruptible power supplies (UPS), server power supply units (PSUs), and variable-speed cooling systems. High-resolution 2 MHz sampling at the point of utility connection acts as a forensic microscope, revealing ultra-fast electrical events that are invisible to standard monitors but can be catastrophic for sensitive IT equipment.

### How 2 MHz Sampling Assists in Monitoring:

1. **Capturing High-Frequency Noise and EMI:** Modern server PSUs and UPS systems use high-frequency switching (in the tens to hundreds of kHz range) to efficiently convert AC to DC power. The aggregation of thousands of these devices creates significant high-frequency "noise" that is injected back into the facility's electrical system. A 2 MHz sampling rate can directly capture the waveform distortion caused by this switching, identifying the precise

signature of Electromagnetic Interference (EMI) that can cause logic errors, data corruption, and network jitter in sensitive equipment.

- 2. Forensic Analysis of UPS and Power Transfers:** The transition from utility power to UPS battery or generator backup is a sub-cycle event fraught with risk. 2 MHz sampling provides a near-instantaneous, high-definition replay of this transfer. It can precisely measure voltage notching, high-frequency transients, and ringing that occur during the switchover. This data is invaluable for validating that the UPS is performing to specification and for diagnosing the root cause of IT equipment crashes that mysteriously coincide with power transfers.
- 3. Identifying Supra-Harmonic Emissions (2-150 kHz):** Data centers are a primary source of supra-harmonics, a range of frequencies above traditional harmonics but below radio frequencies. These emissions can cause overheating in transformers and neutral conductors, interfere with communication and control signals (including Power Line Communication), and prematurely age electrical components. 2 MHz sampling is essential for accurately measuring these emissions, helping to ensure compliance with emerging standards and preventing long-term, stealthy damage to infrastructure.
- 4. Differentiating Internal vs. External Disturbances:** When a server rack fails, the immediate question is "why?" Was it a momentary voltage sag from the utility, or was it a transient caused by a large cooling unit (VFD) starting up inside the facility? By capturing the exact shape, frequency, and timing of the disturbance at the main output, operators can definitively determine its origin. This provides irrefutable evidence for service-level agreement (SLA) discussions with the utility and helps engineers focus troubleshooting efforts internally.

### Benefits to the Data Center Operator

- Maximizing Uptime and Reliability:** By proactively identifying and mitigating high-frequency threats that cause "unexplained" IT faults, operators can significantly increase the reliability of their core business operations.
- Reduced Mean Time to Repair (MTTR):** The forensic-level data eliminates guesswork in fault diagnosis, allowing engineers to pinpoint the exact cause of an event in minutes rather than days.
- Proactive Asset Management:** Monitoring the high-frequency signature of critical equipment like UPS systems can reveal signs of degradation (e.g., failing capacitors) long before a catastrophic failure occurs.

- **Improved Vendor and Utility Accountability:** The precise, high-resolution data provides objective proof when dealing with equipment vendors for warranty claims or with utilities regarding power quality SLAs.
- **Risk Mitigation during Commissioning:** It validates that the entire power chain, from the utility connection to the server rack, performs as designed under real-world, dynamic load conditions before the facility goes live.

While the primary beneficiary of such detailed monitoring is the data center operator, the data gathered is incredibly valuable to the utility and the Independent System Operator (ISO)/Regional Transmission Organization (RTO).

For these entities, a massive data center is no longer just a large, passive load; it's a dynamic, electronically-coupled system that directly interacts with the grid. High-resolution (2 MHz) sampling transforms this "black box" into a known quantity, providing critical data for grid stability and reliability.

### Benefits to the Utility

The utility manages the local distribution network and is responsible for power quality and asset health on its feeders.

- **Isolating Power Quality Issues:** When a neighboring industrial or commercial customer complains about power quality, the utility can use the high-resolution data from the data center's connection point to definitively determine if the data center's high-frequency emissions (supra-harmonics) are the root cause. This prevents costly, speculative investigations and facilitates enforcement of interconnection agreements.
- **Protecting Grid Assets and Infrastructure:** The high-frequency currents injected by data centers can cause additional heating and accelerated aging of utility assets like distribution transformers, capacitor banks, and metering equipment. 2 MHz sampling quantifies this stress, allowing the utility to plan for proactive maintenance, specify more robust equipment for data center feeders, and potentially adjust billing to account for the added wear and tear.
- **Improving Fault Analysis and Grid Resilience:** During a fault on the distribution feeder (e.g., a tree branch hitting a line), the high-speed data captures the data center's precise reaction. It shows exactly how the UPS systems and other loads contributed to or were affected by the event. This forensic insight helps the utility understand complex fault dynamics and improve the coordination of its protective devices (fuses, reclosers).

- **De-risking Interconnection of Large Loads:** Before a new data center is connected, the utility can mandate high-resolution monitoring as part of the commissioning process. This provides empirical proof that the facility's power systems will not destabilize the local grid, validating pre-connection models and reducing risk for all customers on the circuit.

### Benefits to the ISO/RTO

The ISO/RTO is responsible for the stability and reliability of the entire bulk power system, balancing generation and load in real-time.

- **Enhancing Grid Modeling and Stability Studies:** Current grid models often approximate large loads. 2 MHz data from a major data center provides a highly accurate, real-world model of how these new types of loads behave dynamically. This is crucial for studying and preventing system-wide instabilities, especially sub-synchronous oscillations that can be excited by the complex control systems in modern electronics.
- **Enabling and Verifying Participation in Ancillary Services:** Data centers are being explored as resources for grid services like fast frequency response (FFR). If a data center is contracted to curtail load or inject power within milliseconds of a frequency deviation, the ISO needs a way to verify this performance. High-resolution sampling is the only way to accurately measure and validate such a rapid response, ensuring the ISO can rely on these new resources to maintain grid stability.
- **Improving Real-Time Situational Awareness:** Aggregated high-resolution data from multiple large loads can be fed into Wide-Area Monitoring Systems (WAMS). Anomalous high-frequency signatures appearing simultaneously across several data centers could provide an early warning of emerging grid stress or instability long before it becomes visible in traditional 50/60 Hz measurements. This gives operators precious time to take preventative action against potential blackouts.

Please email us at: [sales@nexbe.us](mailto:sales@nexbe.us) for further information or to organise a trial.