

Elevator Issue Resolved Through Power Quality Analysis

CASE STUDY

Reported Issue

Multiple, frequent instances of elevator interruptions in a Senior Care facility in the southwestern U.S. As a result, elderly residents have been trapped for approximately 1.5 hours per event.

Summary of Observed Behavior

- The elevator intermittently stopped functioning during normal operation.
- Passengers inside the elevator were unable to exit until service personnel arrived.
- The system logs and onsite observations indicated that the elevator entered safe mode due to irregularities detected by the elevator control system.
- These events occurred repeatedly.

Investigation of Problem Behavior

A key observation was that the voltage feeding the elevator controls appeared to fluctuate. When this occurred, the elevator control system responded by entering a protective safety mode. This behavior is consistent with the way in which modern elevator controllers operate - any perceived electrical instability can trigger a shutdown to prevent the following dangerous situations:

- Uncontrolled movement
- Door malfunction
- Equipment damage
- Passenger safety risks



Potential Root Causes

1. **Elevator Control System Sensitivity**

   The elevator controls may have been overly sensitive to minor voltage deviations. This could have caused nuisance trips, where the system entered safe mode even when there was no immediate operational hazard. Sensitivity issues may have been related to controller settings, age of equipment, or internal component degradation.

2. **Utility Voltage Fluctuations**

   Incoming power from the electrical utility may have been experiencing voltage instability (sags, swells, or momentary drops). Such fluctuations could have directly impacted elevator electronics, triggering protective lockout sequences. This is consistent with the observed timing and pattern of interruptions.

Power Quality (PQ) Monitoring Setup

To identify the root cause of the elevator interruptions, two Nexus® 1500+ power quality meters were deployed onsite. Each meter was installed at a different electrical point to determine whether the disturbance originated from the utility power or from the elevator control system.

Meter #1 – Monitoring Elevator Controls

The first Nexus® 1500+ meter was mounted adjacent to the elevator's UPS/control equipment.

- Below the enclosure, a black UPS, or power supply component, fed power to the elevator controls.
- The meter was connected to the elevator control circuit so that it would capture voltage, current, and event data directly at the elevator's point of electricity use.
- This location allowed monitoring of:
  - Voltage dips or sags caused by the internal building equipment
  - Control level sensitivity issues
  - Any disturbances that might not originate from the utility, but that affected the elevator controls



Nexus® 1500+ Power Quality Meter Installed at the Elevator Controls Board on the Roof



Meter #2 – Monitoring the Utility Supply

The second Nexus® 1500+ meter was installed next to the main electrical switchgear that receives incoming power from the utility. As seen in the image below:

- The meter was installed adjacent to a large switchboard panel, which is the building's main service entrance or main distribution point.
- The meter was placed there to monitor the point of common coupling (PCC) - the customer side connection point where the building interfaces with the utility.
- This location provided visibility into:
  - Utility voltage fluctuations
  - Sags or swells coming from the grid
  - Harmonic distortion or disturbances arriving at the building from the grid



Nexus® 1500+ Power Quality Meter Monitoring the Mains Service at 480V, 3000 Breaker

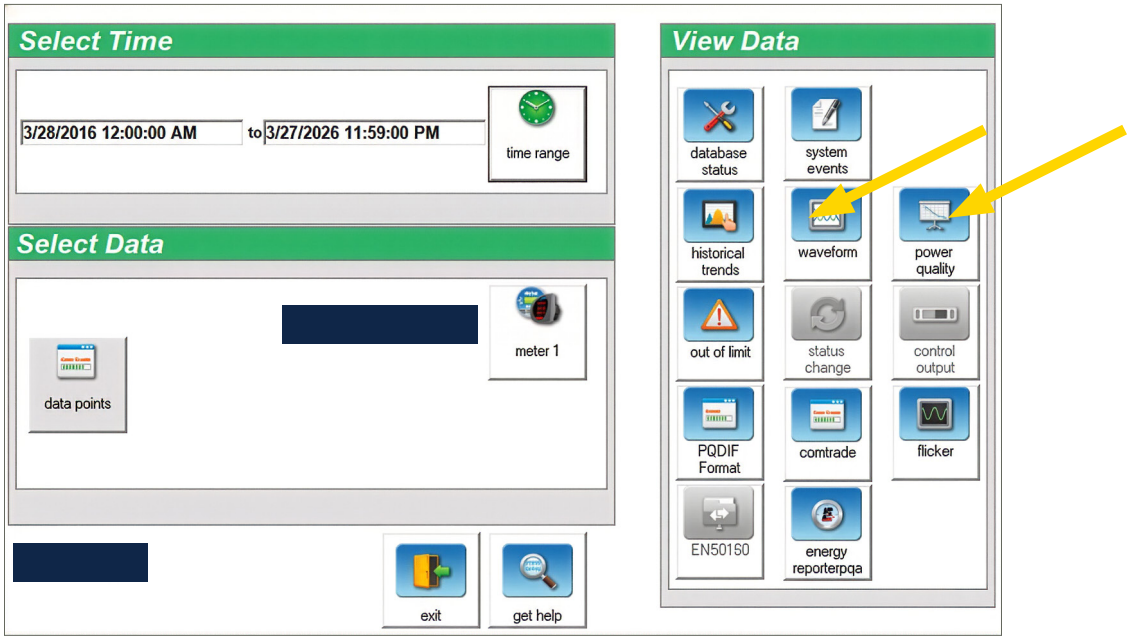
The meters' placement allowed for direct comparison between utility level power and elevator level power, as shown in the following table.

Meter	Location	Purpose
Nexus® 1500+ Meter (Elevator Controls)	On the elevator UPS/ control panel	Check if control voltage or internal disturbances were causing safe mode activations.
Nexus® 1500+ Meter (PCC Feed)	On main service switchgear	Determine if voltage disturbances originated with the utility.

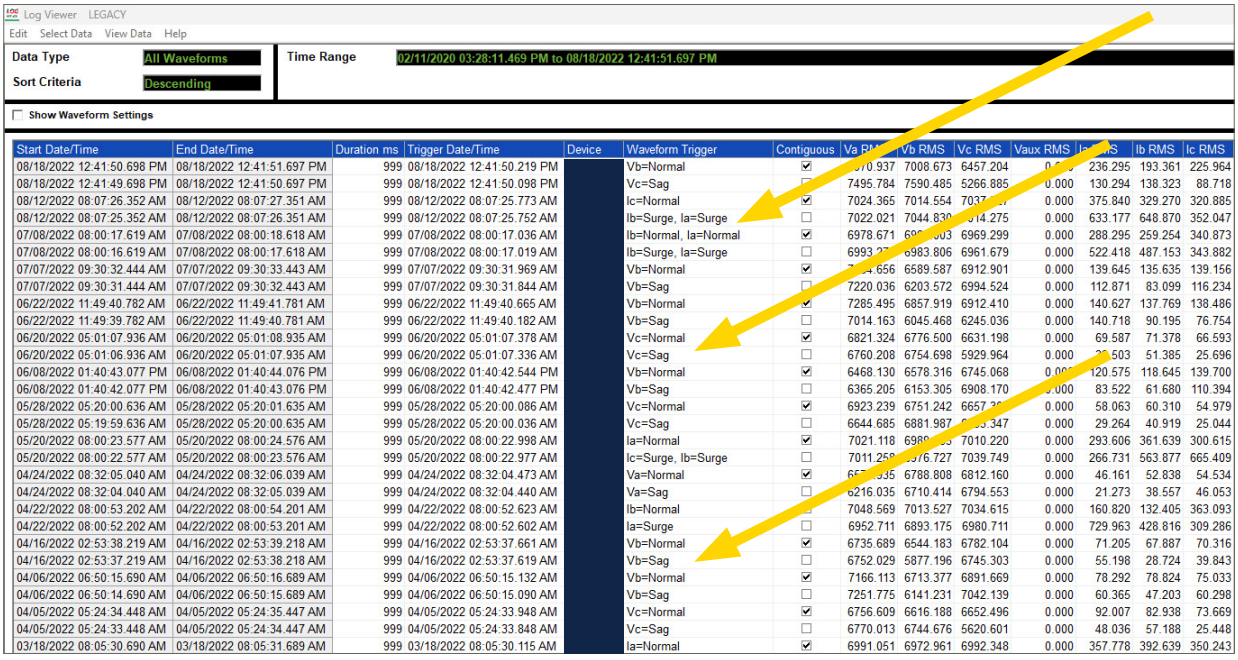
Nexus® 1500+ Meters' Power Quality Data

Over several months, the two Nexus® 1500+ meters recorded the PQ information from their locations. They captured multiple voltage disturbances, including sags, swells, and irregular waveforms. The analysis of PQ events and waveforms provided clear insight into the root cause of the elevator safe mode events.

The data was analyzed by Electro Industries/GaugeTech (EIG)'s CommunicatorPQA® application and displayed via its Log Viewer.



Log Viewer Screen, Allowing Selection of Power Quality and Waveform Logs

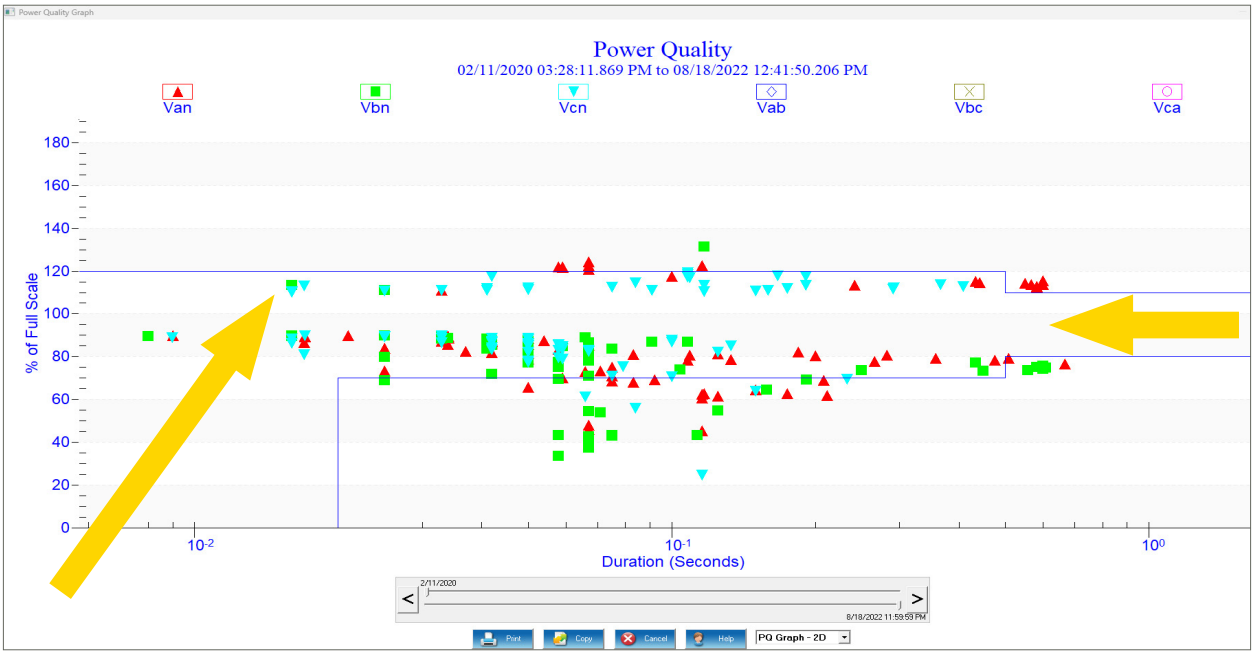


Start Date/Time	End Date/Time	Duration ms	Trigger Date/Time	Device	Waveform Trigger	Contiguous	Va RMS	Vb RMS	Vc RMS	Vaux RMS	Ia RMS	Ib RMS	Ic RMS
08/18/2022 12:41:50.698 PM	08/18/2022 12:41:51.697 PM	999	08/18/2022 12:41:50.219 PM		Vb=Normal	☑	970.937	7008.673	6457.204	0.000	236.295	193.361	225.964
08/18/2022 12:41:49.698 PM	08/18/2022 12:41:50.697 PM	999	08/18/2022 12:41:50.098 PM		Vc=Sag	☐	7495.784	7590.485	5266.885	0.000	130.294	138.323	88.718
08/12/2022 08:07:26.352 AM	08/12/2022 08:07:27.351 AM	999	08/12/2022 08:07:25.773 AM		Ic=Normal	☑	7024.365	7014.554	7037.[illegible]	0.000	375.840	329.270	320.885
08/12/2022 08:07:25.352 AM	08/12/2022 08:07:26.351 AM	999	08/12/2022 08:07:25.752 AM		Ib=Surge, Ia=Surge	☐	7022.021	7044.830	[illegible]14.275	0.000	633.177	648.870	352.047
07/08/2022 08:00:17.619 AM	07/08/2022 08:00:18.618 AM	999	07/08/2022 08:00:17.036 AM		Ib=Normal, Ia=Normal	☑	6978.671	69[illegible]03	6969.299	0.000	288.295	259.254	340.873
07/08/2022 08:00:16.619 AM	07/08/2022 08:00:17.618 AM	999	07/08/2022 08:00:17.019 AM		Ib=Surge, Ia=Surge	☐	6993.[illegible]	6983.806	6961.679	0.000	522.418	487.153	343.882
07/07/2022 09:30:32.444 AM	07/07/2022 09:30:33.443 AM	999	07/07/2022 09:30:31.969 AM		Vb=Normal	☑	7[illegible].656	6589.587	6912.901	0.000	139.645	135.635	139.156
07/07/2022 09:30:31.444 AM	07/07/2022 09:30:32.443 AM	999	07/07/2022 09:30:31.844 AM		Vb=Sag	☐	7220.036	6203.572	6994.524	0.000	112.871	83.099	116.234
06/22/2022 11:49:40.782 AM	06/22/2022 11:49:41.781 AM	999	06/22/2022 11:49:40.665 AM		Vb=Normal	☑	7285.495	6857.919	6912.410	0.000	140.627	137.769	138.486
06/22/2022 11:49:39.782 AM	06/22/2022 11:49:40.781 AM	999	06/22/2022 11:49:40.182 AM		Vb=Sag	☐	7014.163	6045.468	6245.036	0.000	140.718	90.195	76.754
06/20/2022 05:01:07.936 AM	06/20/2022 05:01:08.935 AM	999	06/20/2022 05:01:07.378 AM		Vc=Normal	☑	6821.324	6776.500	6631.198	0.000	69.587	71.378	66.593
06/20/2022 05:01:06.936 AM	06/20/2022 05:01:07.935 AM	999	06/20/2022 05:01:07.336 AM		Vc=Sag	☐	6760.208	6754.698	5929.964	0.000	[illegible]503	51.385	25.696
06/08/2022 01:40:43.077 PM	06/08/2022 01:40:44.076 PM	999	06/08/2022 01:40:42.544 PM		Vb=Normal	☑	6468.130	6578.316	6745.068	0.000	[illegible]20.575	118.645	139.700
06/08/2022 01:40:42.077 PM	06/08/2022 01:40:43.076 PM	999	06/08/2022 01:40:42.477 PM		Vb=Sag	☐	6365.205	6153.305	6908.170	0.000	83.522	61.680	110.394
05/28/2022 05:20:00.636 AM	05/28/2022 05:20:01.635 AM	999	05/28/2022 05:20:00.086 AM		Vc=Normal	☑	6923.239	6751.242	6657.[illegible]	0.000	58.063	60.310	54.979
05/28/2022 05:19:59.636 AM	05/28/2022 05:20:00.635 AM	999	05/28/2022 05:20:00.036 AM		Vc=Sag	☐	6644.685	6881.987	[illegible]347	0.000	29.264	40.919	25.044
05/20/2022 08:00:23.577 AM	05/20/2022 08:00:24.576 AM	999	05/20/2022 08:00:22.998 AM		Ia=Normal	☑	7021.118	6989.[illegible]	7010.220	0.000	293.606	361.639	300.615
05/20/2022 08:00:22.577 AM	05/20/2022 08:00:23.576 AM	999	05/20/2022 08:00:22.977 AM		Ic=Surge, Ib=Surge	☐	7011.258	6976.727	7039.749	0.000	266.731	563.877	665.409
04/24/2022 08:32:05.040 AM	04/24/2022 08:32:06.039 AM	999	04/24/2022 08:32:04.473 AM		Va=Normal	☑	6[illegible]935	6788.808	6812.160	0.000	46.161	52.838	54.534
04/24/2022 08:32:04.040 AM	04/24/2022 08:32:05.039 AM	999	04/24/2022 08:32:04.440 AM		Va=Sag	☐	6216.035	6710.414	6794.553	0.000	21.273	38.557	46.053
04/22/2022 08:00:53.202 AM	04/22/2022 08:00:54.201 AM	999	04/22/2022 08:00:52.623 AM		Ib=Normal	☑	7048.569	7013.527	7034.615	0.000	160.820	132.405	363.093
04/22/2022 08:00:52.202 AM	04/22/2022 08:00:53.201 AM	999	04/22/2022 08:00:52.602 AM		Ia=Surge	☐	6952.711	6893.175	6980.711	0.000	729.963	428.816	309.286
04/16/2022 02:53:38.219 AM	04/16/2022 02:53:39.218 AM	999	04/16/2022 02:53:37.661 AM		Vb=Normal	☑	6735.689	6544.183	6782.104	0.000	71.205	67.887	70.316
04/16/2022 02:53:37.219 AM	04/16/2022 02:53:38.218 AM	999	04/16/2022 02:53:37.619 AM		Vb=Sag	☐	6752.029	5877.196	6745.303	0.000	55.198	28.724	39.843
04/06/2022 06:50:15.690 AM	04/06/2022 06:50:16.689 AM	999	04/06/2022 06:50:15.132 AM		Vb=Normal	☑	7166.113	6713.377	6891.669	0.000	78.292	78.824	75.033
04/06/2022 06:50:14.690 AM	04/06/2022 06:50:15.689 AM	999	04/06/2022 06:50:15.090 AM		Vb=Sag	☐	7251.775	6141.231	7042.139	0.000	60.365	47.203	60.298
04/05/2022 05:24:34.448 AM	04/05/2022 05:24:35.447 AM	999	04/05/2022 05:24:33.948 AM		Vc=Normal	☑	6756.609	6616.188	6652.496	0.000	92.007	82.938	73.669
04/05/2022 05:24:33.448 AM	04/05/2022 05:24:34.447 AM	999	04/05/2022 05:24:33.848 AM		Vc=Sag	☐	6770.013	6744.676	5620.601	0.000	48.036	57.188	25.448
03/18/2022 08:05:30.690 AM	03/18/2022 08:05:31.689 AM	999	03/18/2022 08:05:30.115 AM		Ia=Normal	☑	6991.051	6972.961	6992.348	0.000	357.778	392.639	350.243

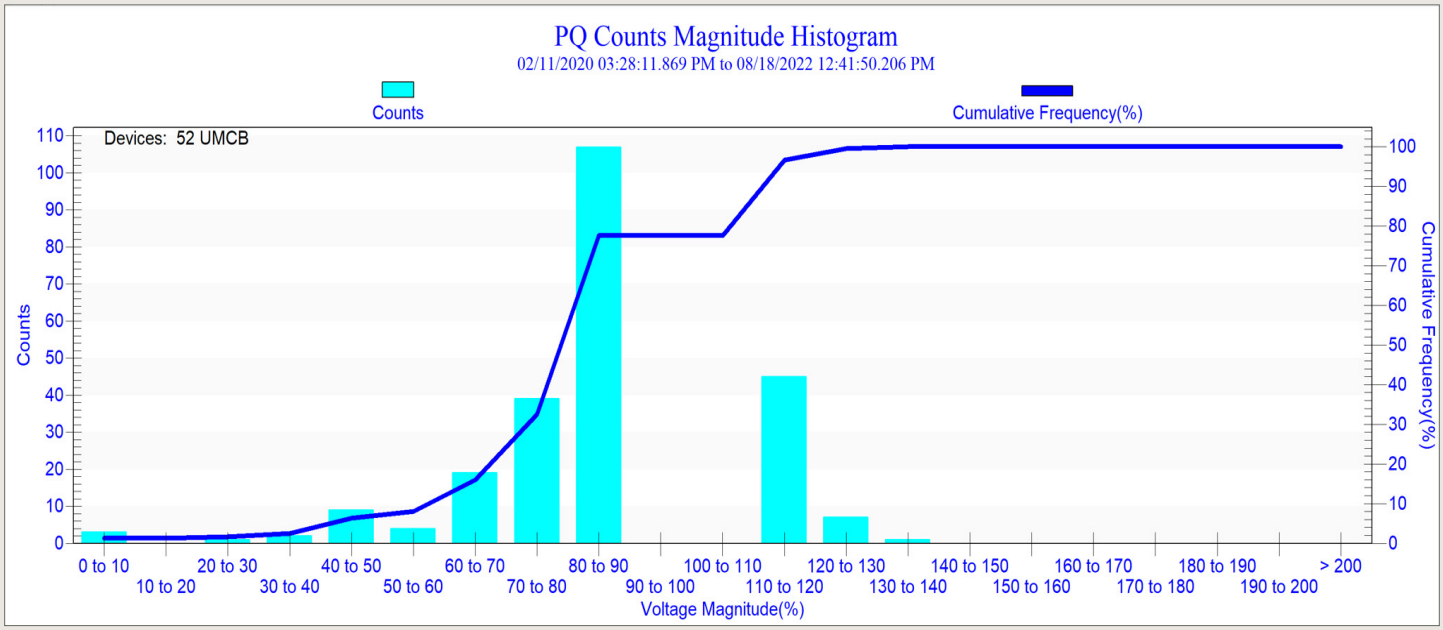
Log Viewer PQ Log Records Showing Surge and Sag Events

Start Date/Time	End Date/Time	Duration ms	Device	Condition	Channel	Value	% of Full Scale	Waveforms
08/18/2022 12:41:50.106 PM	08/18/2022 12:41:50.206 PM	99.9994575977325	52 UMCB	Surge	Van	8,159.01	117.63	☑
08/18/2022 12:41:50.102 PM	08/18/2022 12:41:50.219 PM	116.994185373187	52 UMCB	Surge	Vbn	9,121.53	131.51	☑
08/18/2022 12:41:50.098 PM	08/18/2022 12:41:50.214 PM	116.00092984736	52 UMCB	Sag	Vcn	1,706.58	24.60	☑
08/12/2022 08:07:25.756 AM	08/12/2022 08:07:25.773 AM	17.0035287737846	52 UMCB	Surge	Ic	580.51	145.13	☑
08/12/2022 08:07:25.752 AM	08/12/2022 08:07:25.769 AM	17.0035287737846	52 UMCB	Surge	Ia	633.18	158.29	☑
08/12/2022 08:07:25.752 AM	08/12/2022 08:07:25.769 AM	17.0035287737846	52 UMCB	Surge	Ib	648.87	162.22	☑
07/08/2022 08:00:17.023 AM	07/08/2022 08:00:17.031 AM	8.00010748207569	52 UMCB	Surge	Ic	464.55	116.14	☑
07/08/2022 08:00:17.019 AM	07/08/2022 08:00:17.035 AM	16.0014722496271	52 UMCB	Surge	Ib	487.15	121.79	☑
07/08/2022 08:00:17.019 AM	07/08/2022 08:00:17.035 AM	16.0014722496271	52 UMCB	Surge	Ia	522.42	130.60	☑
07/07/2022 09:30:31.848 AM	07/07/2022 09:30:31.964 AM	116.000301204622	52 UMCB	Surge	Van	8,494.65	122.47	☑
07/07/2022 09:30:31.844 AM	07/07/2022 09:30:31.969 AM	125.003722496331	52 UMCB	Sag	Vbn	3,793.53	54.69	☑
06/22/2022 11:49:40.231 AM	06/22/2022 11:49:40.664 AM	433.002202771604	52 UMCB	Sag	Vbn	5,356.28	77.22	☑
06/22/2022 11:49:40.227 AM	06/22/2022 11:49:40.660 AM	433.002831414342	52 UMCB	Surge	Van	7,994.77	115.26	☑
06/22/2022 11:49:40.189 AM	06/22/2022 11:49:40.198 AM	8.99399165064096	52 UMCB	Sag	Vcn	6,167.02	88.91	☑
06/22/2022 11:49:40.181 AM	06/22/2022 11:49:40.206 AM	24.9954639002681	52 UMCB	Sag	Vbn	5,536.71	79.83	☑
06/20/2022 05:01:07.335 AM	06/20/2022 05:01:07.377 AM	41.9989926740527	52 UMCB	Sag	Vcn	5,834.12	84.11	☑
06/08/2022 01:40:42.489 PM	06/08/2022 01:40:42.539 PM	49.9997287988663	52 UMCB	Sag	Van	6,146.43	88.62	☑
06/08/2022 01:40:42.477 PM	06/08/2022 01:40:42.544 PM	67.0032575726509	52 UMCB	Sag	Vbn	5,997.95	86.48	☑
05/28/2022 05:20:00.035 AM	05/28/2022 05:20:00.085 AM	49.9997287988663	52 UMCB	Sag	Vcn	5,687.72	82.00	☑
05/20/2022 08:00:22.981 AM	05/20/2022 08:00:22.998 AM	17.0035287737846	52 UMCB	Surge	Ia	591.71	147.93	☑
05/20/2022 08:00:22.977 AM	05/20/2022 08:00:22.994 AM	17.0035287737846	52 UMCB	Surge	Ic	665.41	166.35	☑
05/20/2022 08:00:22.977 AM	05/20/2022 08:00:22.994 AM	17.0035287737846	52 UMCB	Surge	Ib	598.17	149.54	☑
04/24/2022 08:32:04.439 AM	04/24/2022 08:32:04.473 AM	33.9982565492392	52 UMCB	Sag	Van	6,206.81	89.49	☑
04/22/2022 08:00:52.610 AM	04/22/2022 08:00:52.619 AM	8.99399165064096	52 UMCB	Surge	Ic	623.70	155.93	☑
04/22/2022 08:00:52.606 AM	04/22/2022 08:00:52.623 AM	16.9953564181924	52 UMCB	Surge	Ib	715.18	178.79	☑
04/22/2022 08:00:52.602 AM	04/22/2022 08:00:52.619 AM	16.9947277754545	52 UMCB	Surge	Ia	729.96	182.49	☑
04/16/2022 02:53:37.619 AM	04/16/2022 02:53:37.660 AM	40.9969361498952	52 UMCB	Sag	Vbn	5,791.15	83.49	☑
04/06/2022 06:50:15.094 AM	04/06/2022 06:50:15.127 AM	32.9962000250816	52 UMCB	Surge	Van	7,700.33	111.02	☑
04/06/2022 06:50:15.089 AM	04/06/2022 06:50:15.131 AM	41.9989926740527	52 UMCB	Sag	Vbn	4,981.03	71.81	☑
04/05/2022 05:24:33.848 AM	04/05/2022 05:24:33.948 AM	99.9994575977325	52 UMCB	Sag	Vcn	4,903.60	70.70	☑

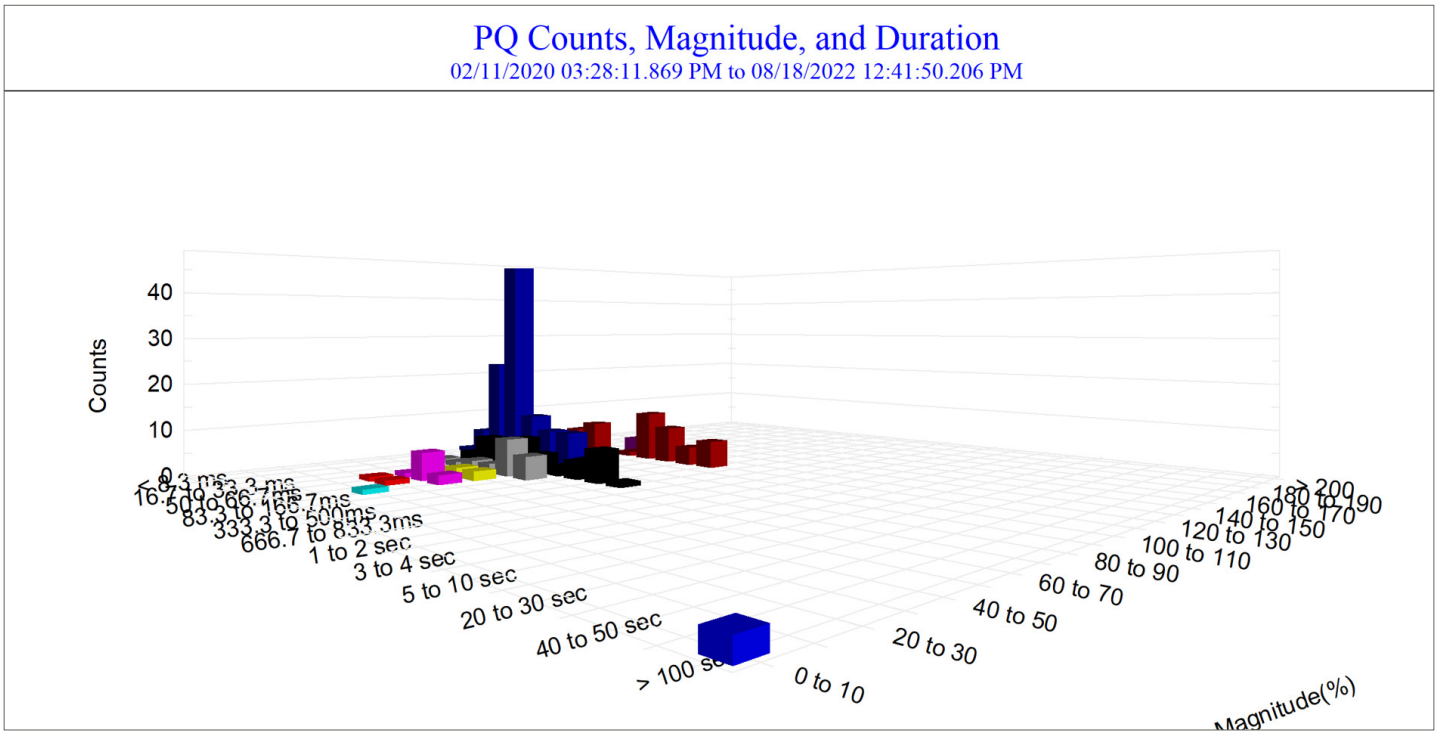
Log Viewer Detailed View of Surge and Sag Events and Available Waveform Records



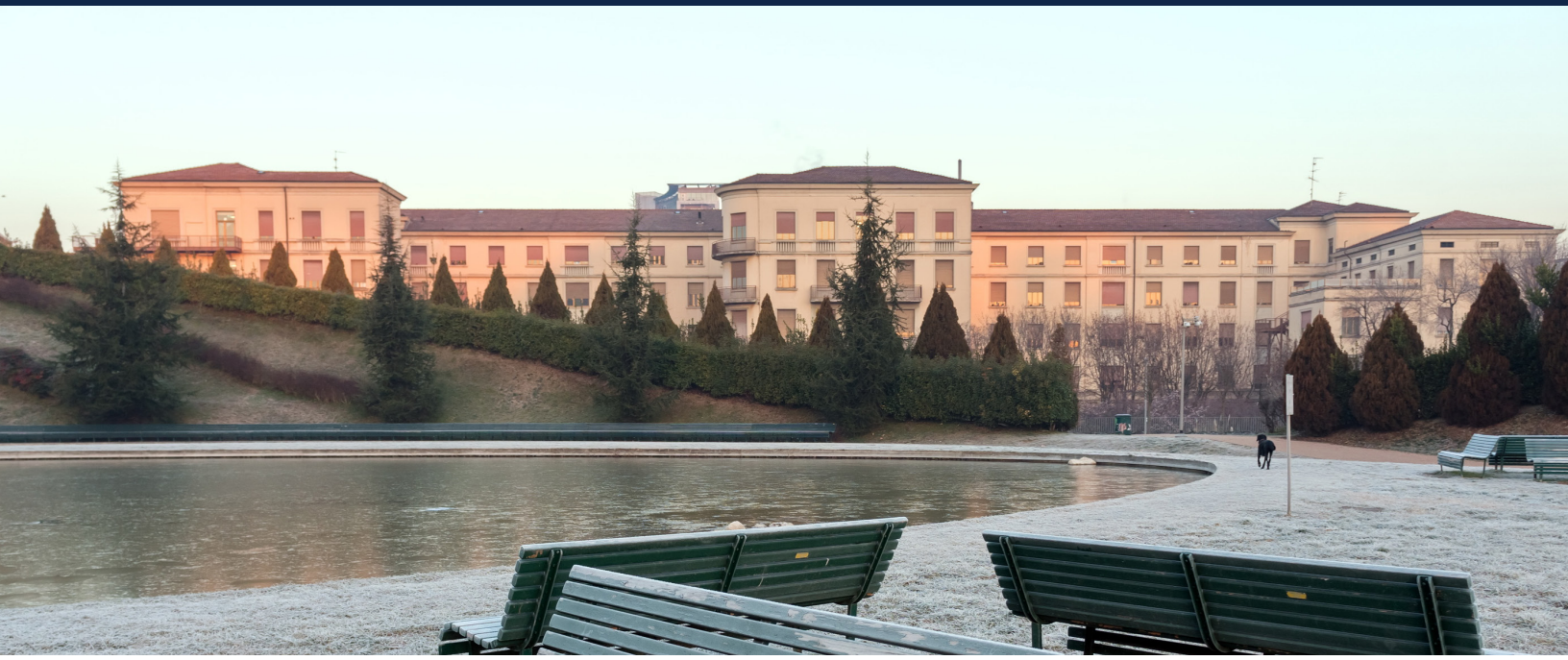
Log Viewer CBEMA Power Quality Graph Showing PQ events



Log Viewer Power Quality Counts Magnitude Histogram



Log Viewer PQ Graph in 3D



The PQ records contained the following information:

- Voltage events ranged widely from ~40% to ~120% of nominal, showing both sags and occasional overvoltage conditions (swells).
- Numerous points below nominal voltage indicated frequent significant voltage sags.
- Some points slightly above nominal voltage showed occasional short-duration swell events.
- Most disturbances occurred between 0.01–0.1 seconds, typical of momentary voltage instability. These durations matched known patterns of utility recloser activity, feeder switching, or fault clearing.
    - Short-duration events do not trip breakers but can disrupt sensitive control electronics, including elevator controls.
- Disturbances appeared across all three phases, suggesting the issue was not internal to the elevator.
    - Multi-phase voltage deviations are commonly associated with external or upstream electrical disturbances.
- The cluster of points between 60–95% reflected voltage sags capable of triggering safe mode undervoltage protection in elevator controllers.
- The large number of events indicated a persistent pattern of short-duration voltage instability - not a single fault or an elevator equipment issue.

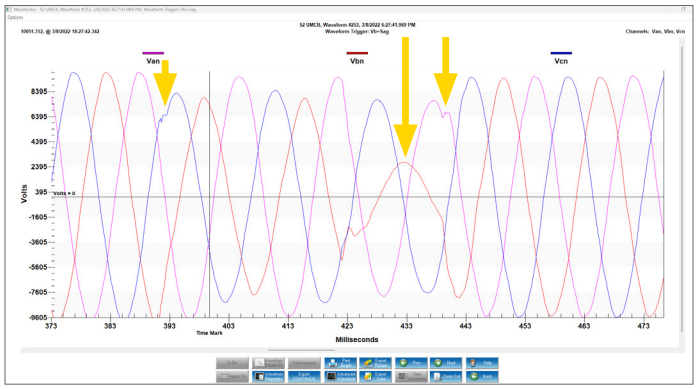
In summary, the PQ logs showed dozens of incidents recorded over the monitored period. Most events were classified as:

- Voltage Sags (V-Sag)
- Voltage Swells (V-Surge)
- V-Normal entries (automatic recovery back to normal levels)
- Some Irregular / Interrupted waveform patterns

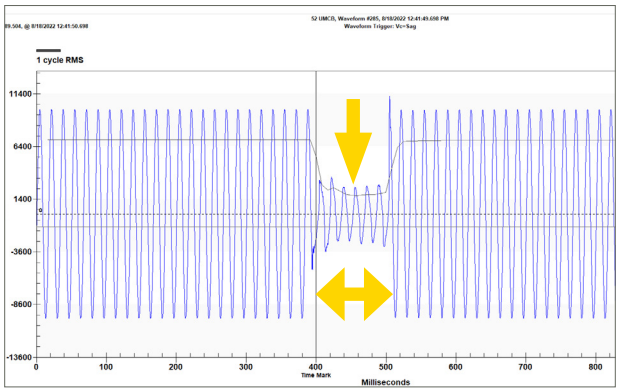
The duration of many events was a few ms, indicating 1 second disturbance windows, which are typical for short duration utility voltage irregularities. These events occurred repeatedly across several dates, confirming the issue was not random and not internal to the elevator.

Analysis of Recorded Waveforms

Log Viewer was used to analyze the waveforms recorded by the meters. Two recorded waveforms are shown below.



Log Viewer Waveform Screen 1



Log Viewer Waveform Screen 2

Waveform 1 – Multi-Phase Voltage Disturbance

The first waveform screenshot displays:

- Multiple three-phase voltage channels: Van, Vbn, Vcn
- Disturbance occurring mid-cycle
- A noticeable drop in amplitude on at least one phase
- Irregular distortion visible on the disturbed phase waveform

This pattern is consistent with utility voltage sags, not internal building issues. Internal electrical faults usually affect one circuit; utility sags often affect all phases simultaneously, but unevenly — exactly as shown by the waveform.



Waveform 2 – 1 Cycle RMS Sag Event

The single-channel waveform above shows:

- A clear sag event around the 400–500 ms window
- RMS values dropping significantly during the disturbance
- Multiple cycles of voltage collapse followed by recovery
- Asymmetrical waveform distortion consists of upstream disturbances

This pattern is typical of:

- Utility recloser operations
- Switching on the distribution network
- Faults elsewhere on the local feeder
- Short duration load drops affecting the entire area

The sag profile matches the most likely known signature of upstream utility events - not equipment malfunction.

PQ Analysis Correlated with Elevator Safe Mode Behavior

Based on the analysis of the meters' PQ data and knowledge of the elevator's controls, the elevator system entered safe mode repeatedly because of the following:

- Elevator controls rely on stable voltage to operate safely.
- During each sag event, the control circuit experienced voltage well below acceptable thresholds.
- The controller's protective logic shut down the system to prevent electrical or mechanical hazards.

After a sag, the elevator remained locked out until manually reset, causing the passenger entrapment.

Key Technical Conclusion

Based on the PQ data and waveform captures:

- The elevator controller most likely was responding appropriately to external electrical disturbances.
- The root cause of the elevator shutdowns was most likely an incoming voltage fluctuation from upstream source, not an internal elevator fault.
- Elevator control power is sensitive by design, and voltage sags below the allowable threshold will trigger safety shutdowns.

The Nexus® 1500+ meters confirmed that the disturbances at the elevator controls matched the disturbances at the utility PCC, ruling out internal wiring or equipment issues. Because both meters showed disturbances at the same timestamps, this confirmed that **the voltage disturbances most likely originated from the utility side, not the elevator equipment.**

Recommended Corrective Paths

1. **Contact with utility provider:**
   - The provider was given the Nexus® 1500+ meters' RMS sag/swell waveforms.
   - The provider was asked to perform investigation into feeder switching, faults, or recloser activity.
   - The provider was asked for mitigation or voltage stabilization support.
2. **Internal mitigation options to prevent elevator shutdowns during external disturbances:**
   - The end user is in the process of installing a constant voltage transformer (CVT), or voltage regulator, on the elevator control feed.
   - The end user is considering a double conversion UPS to isolate the controller from voltage sags.

For more information on the meter:
https://www.electroind.com/products/nexus-1500-power-quality-meter-with-phasor-measurement-unit/

Any questions? Please contact:

1800 Shames Drive
Westbury, NY, 11590

1-877-EIMETER
(1-877-346-3837)

Email: EIG_sales@hubbell.com
Website: www.electroind.com

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