DPQ Event: Overbuilt Transmission Line Downed on Distribution System

Keywords:
Momentary Interruption
Monthly Event
Other Faults
Outage
Sag/Swell

Overbuilt Transmission Line Downed on Distribution System
In Figure 1 we see the steady-state rms voltage and current for a 24 hour period from a feeder being monitored as part of the EPRI Distribution Power Quality Project. The voltage plot has a noticeable gap during a seven hour outage which was the result of a transmission line fault. Due to strong winds, a transmission line was blown into the EPRI DPQ distribution feeder. A series of resulting circuit breaker operations ended in a lockout. After seven hours, the circuit was partially restored by resetting the breaker, followed by a complete restoration after another three hours.

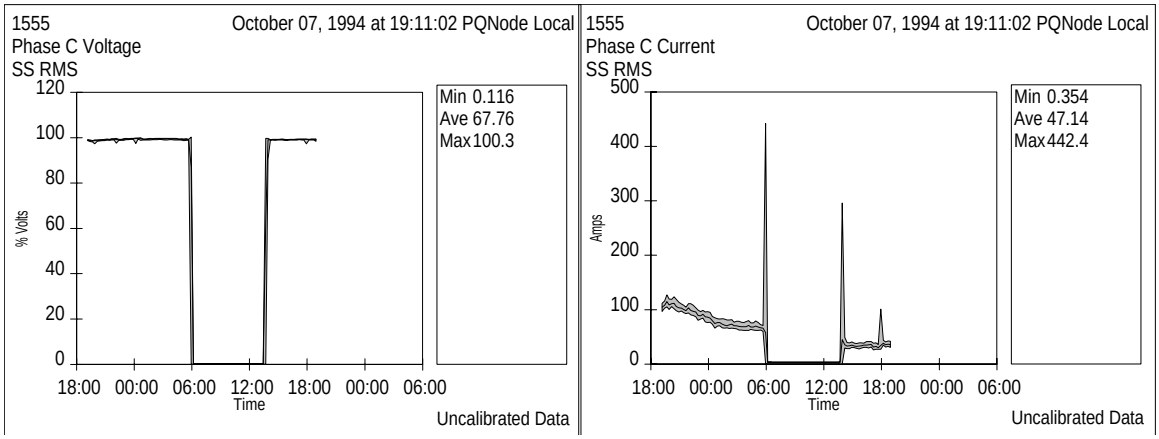


Figure 1: Steady-State RMS Voltage and Current

This event occurred on a wye grounded radial feeder (Figure 2) with 12 miles of three-phase circuit and 25 miles of single-phase. The substation transformer's rating is 3.75MVA, and it steps 69 kV down to the feeder's nominal voltage of 13.2kV. It only supplies this feeder; there are no other feeders in parallel. There is a 900 kVAr bank located on one of the feeder's branches.

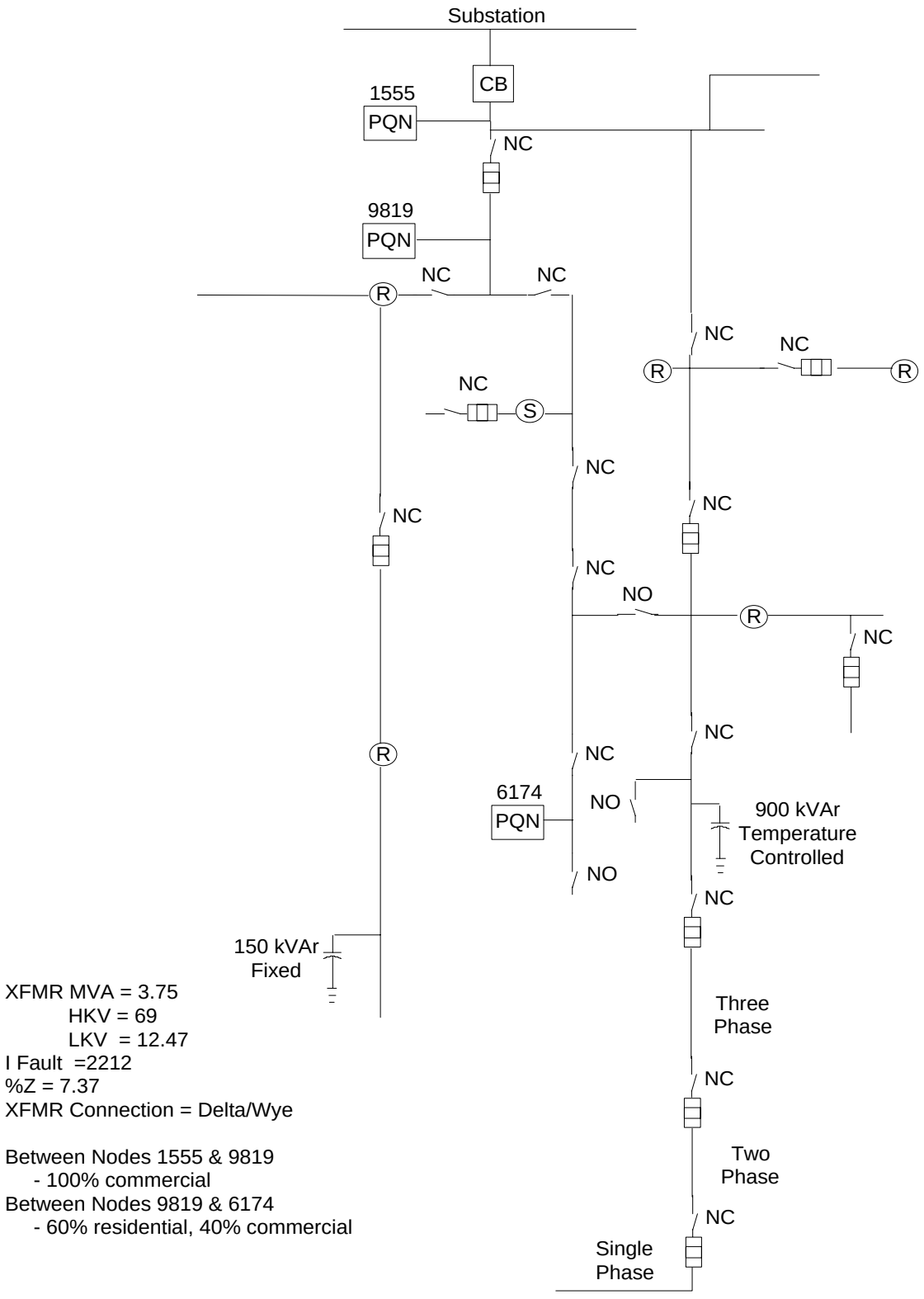


Figure 2: Feeder Diagram

First Fault (Figure 3):
This first fault results in three operations of the substation circuit breaker. The breaker reclosed after 2, 10, and finally 25 seconds, with the third operation clearing the initial fault. The cause of the event was wind blowing an overbuilt transmission line onto the distribution somewhere down-line of nodes 1555 and 9819. Node 6174, a good candidate to have seen more of the event, was out of service at the time of the incident.

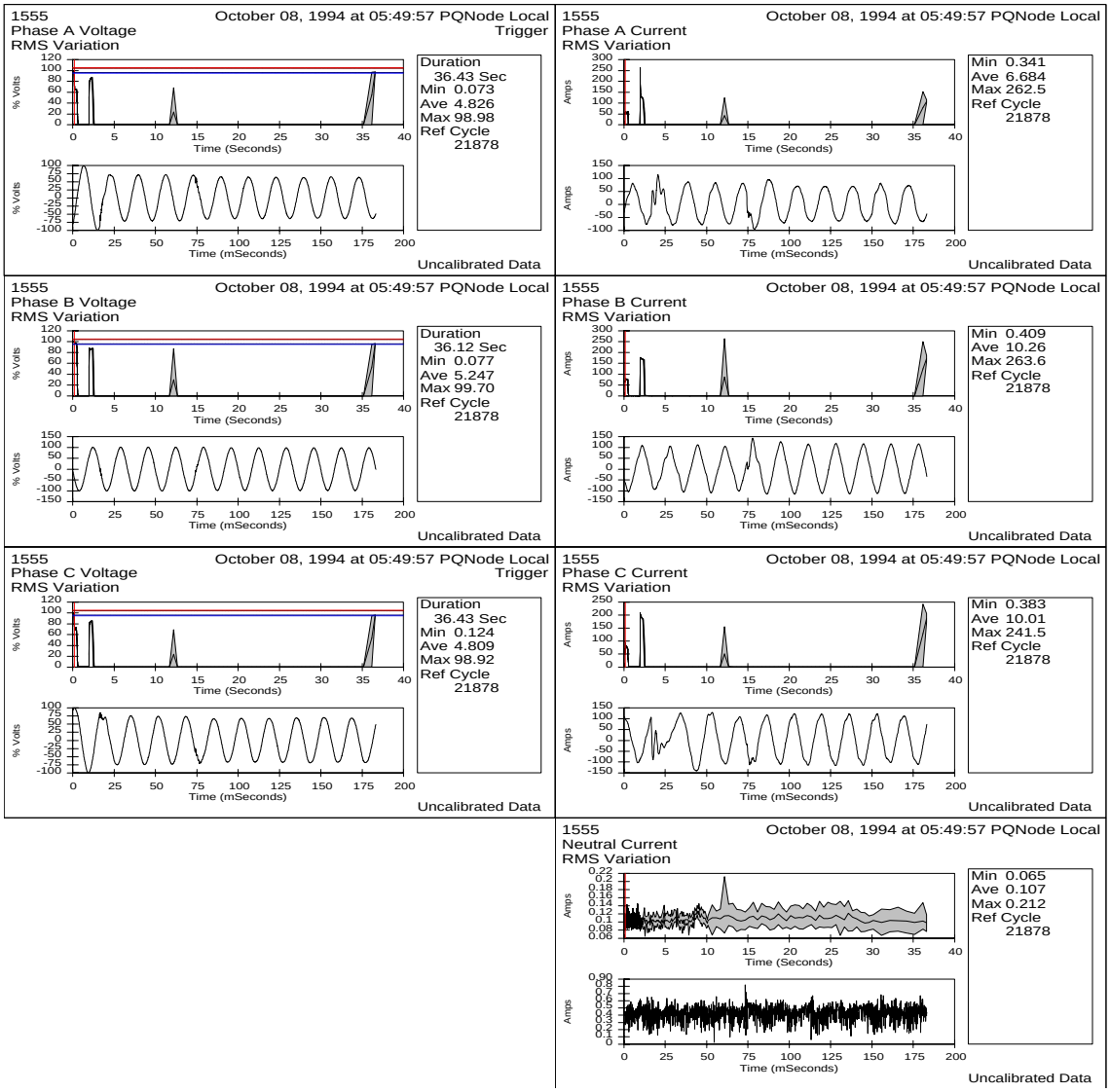


Figure 3: First Fault

Interesting Waveform (Figure 4):
This waveform was measured just prior to the breaker lockout. Its high frequency characteristic suggests that it is some type of discharge from an energy storing element. Its frequency is about 5 kHz, which is most probably not accurate since that is around the upper end of frequency which the monitor can measure properly and beyond the

frequency response of the node's PT. The current is at noise level, suggesting that the transient is occurring far away from the monitors. Figure 5 shows all phases of voltage and current for this waveform.

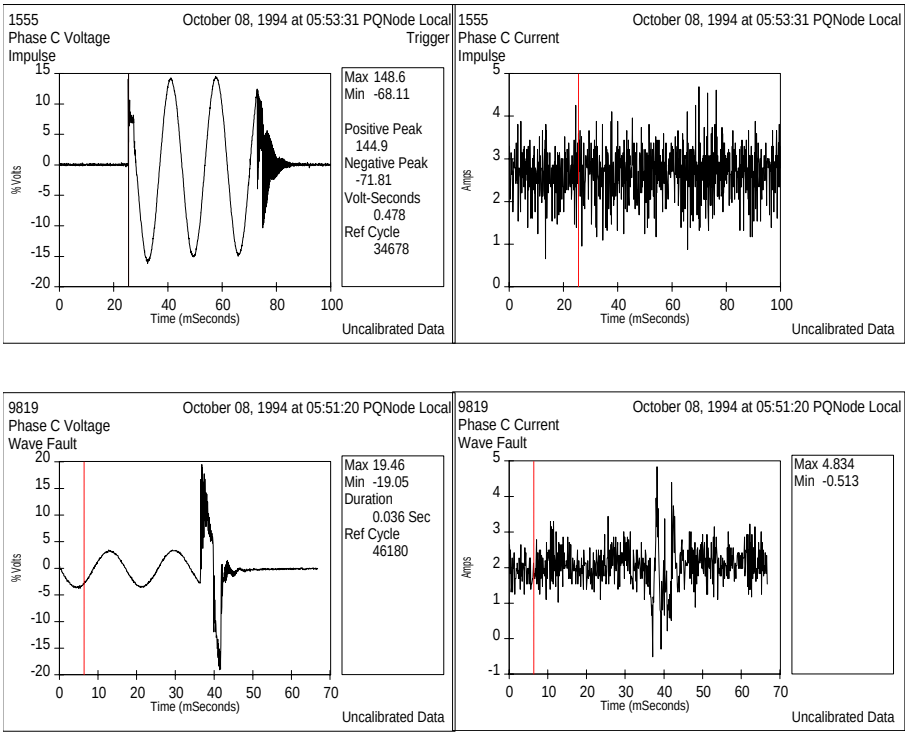


Figure 4: Interesting Waveforms at Node 1555 and Node 9819

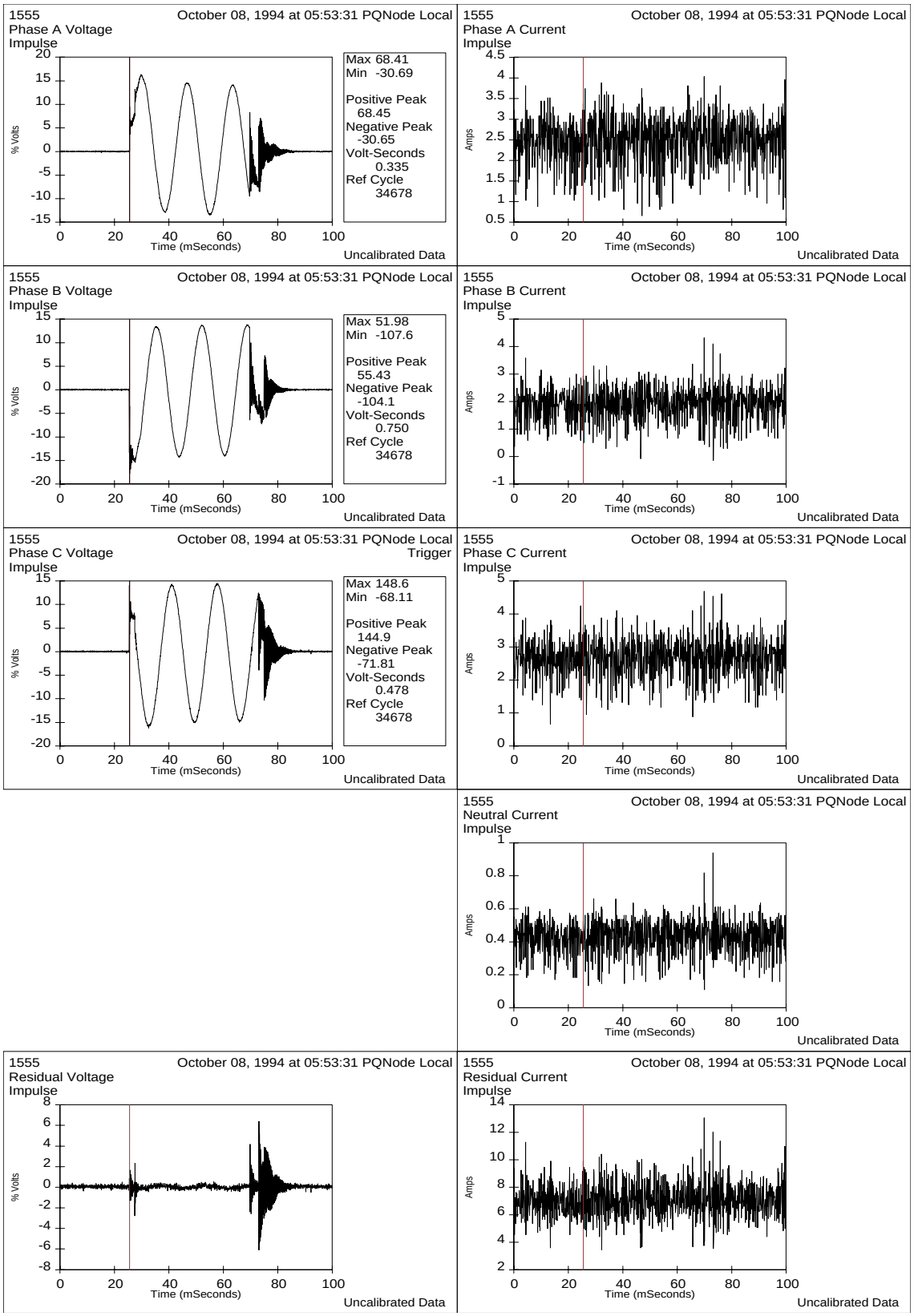


Figure 5: Voltage and Current (All Phases at Node 1555)

Outage Reports (Figure 6):
The outage report for node 1555 differs slightly from 9819. The substation reported an outage with a 7:41:10 duration, while just downline 9819 gave a 7:53:33 duration. The difference of twelve minutes can be explained by the next few figures. Voltage was restored to the monitoring location several minutes before a manual switch was operated, allowing the main feeder to energize.

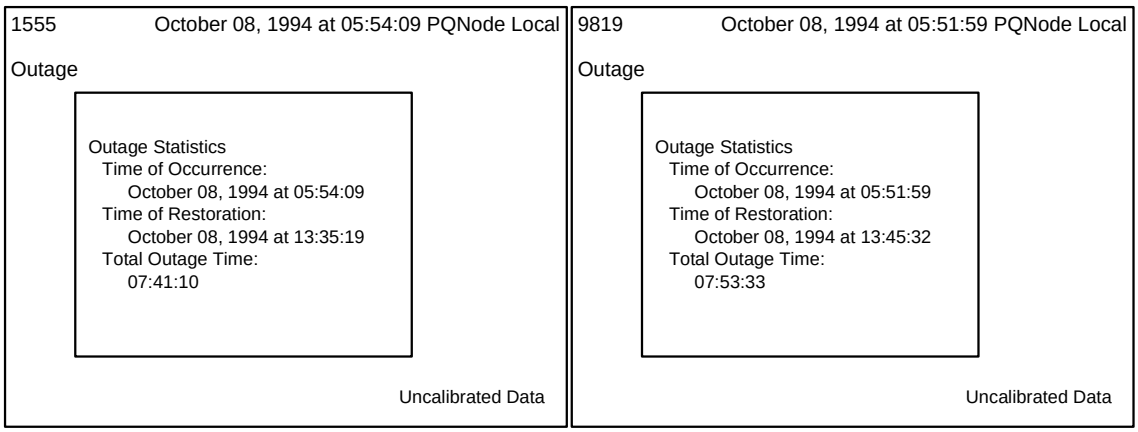


Figure 6: Outage Reports

First Inrush (Figure 7):
The node recorded a "Cold Load Pickup" event at the restoration of voltage. Note how the voltage waveforms for all three phases are showing sinusoids, while the corresponding current waveforms are still noise. This is because the voltage that the node measured was restored minutes before the main feeder was energized. The measurement also shows the inrush current magnitude during the re-energizing period.

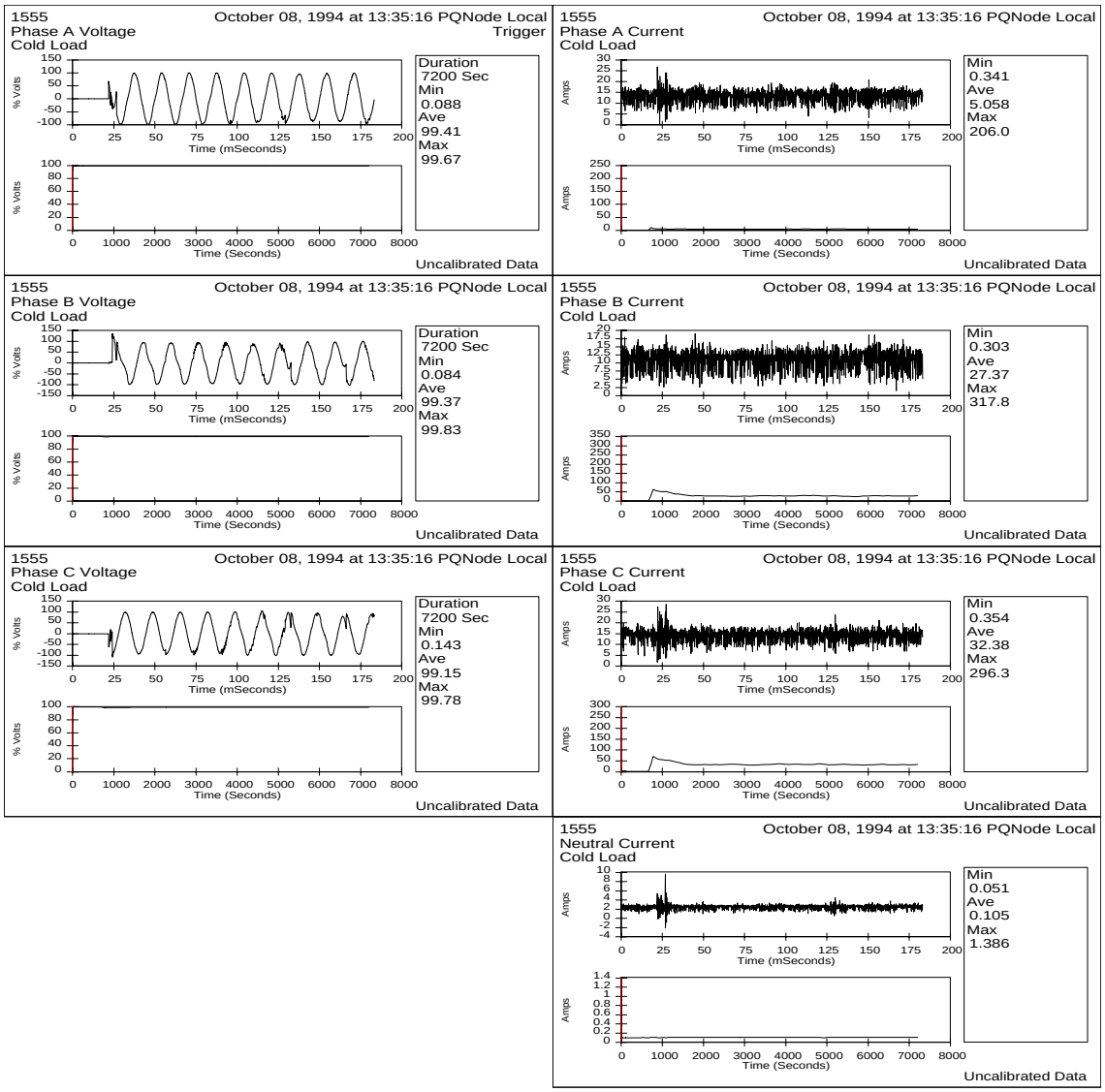


Figure 7: First Inrush

Noise Level Current (Figure 8):
This measurement confirms that there was still no measurable current eight seconds after the node first detected voltage.

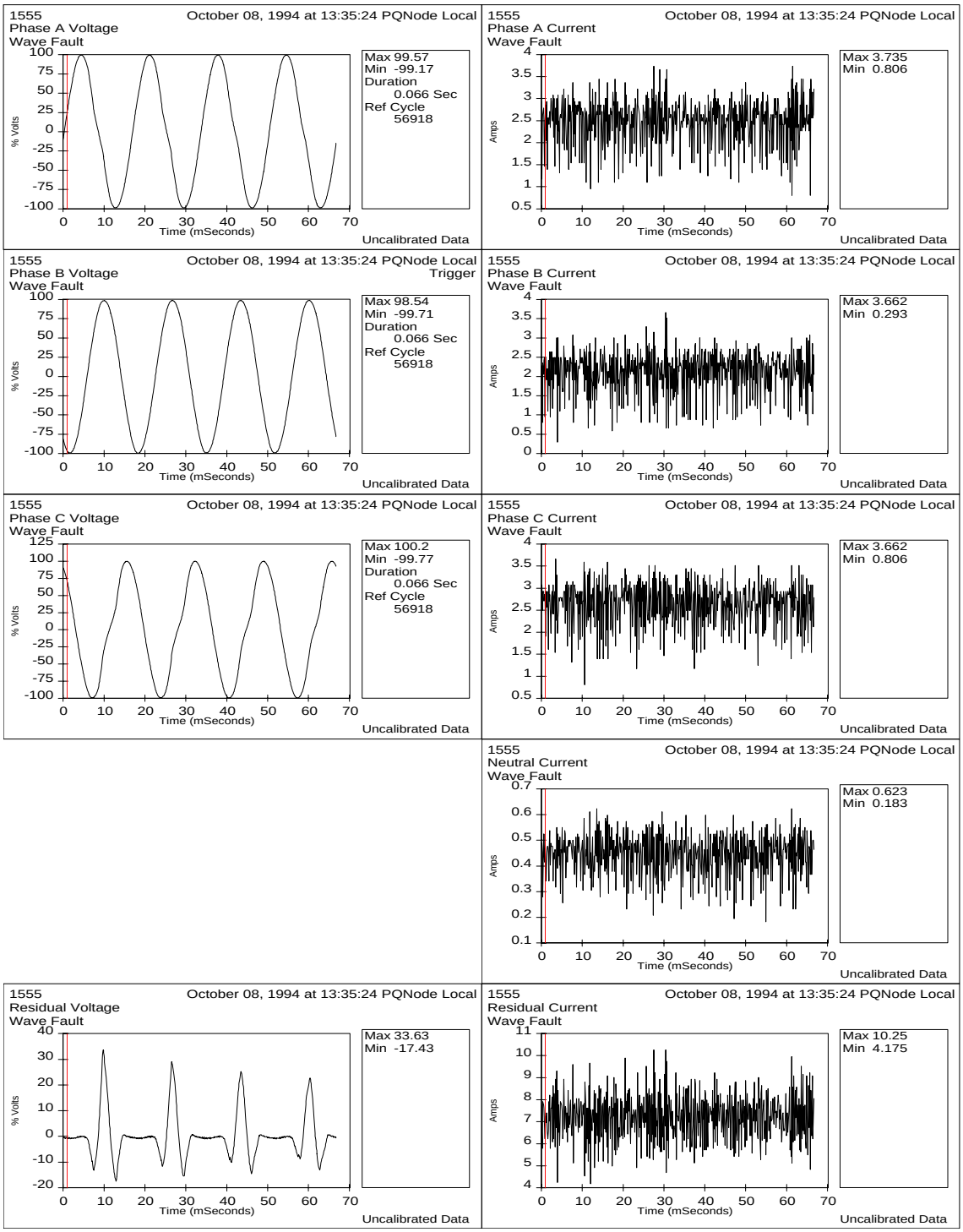


Figure 8: Noise Level Current

Second Inrush (Figure 9):
This voltage sag was recorded by the substation node when a downline single-phase recloser was reset to restore power to a remote section of the feeder, presumably where the transmission fault had occurred.

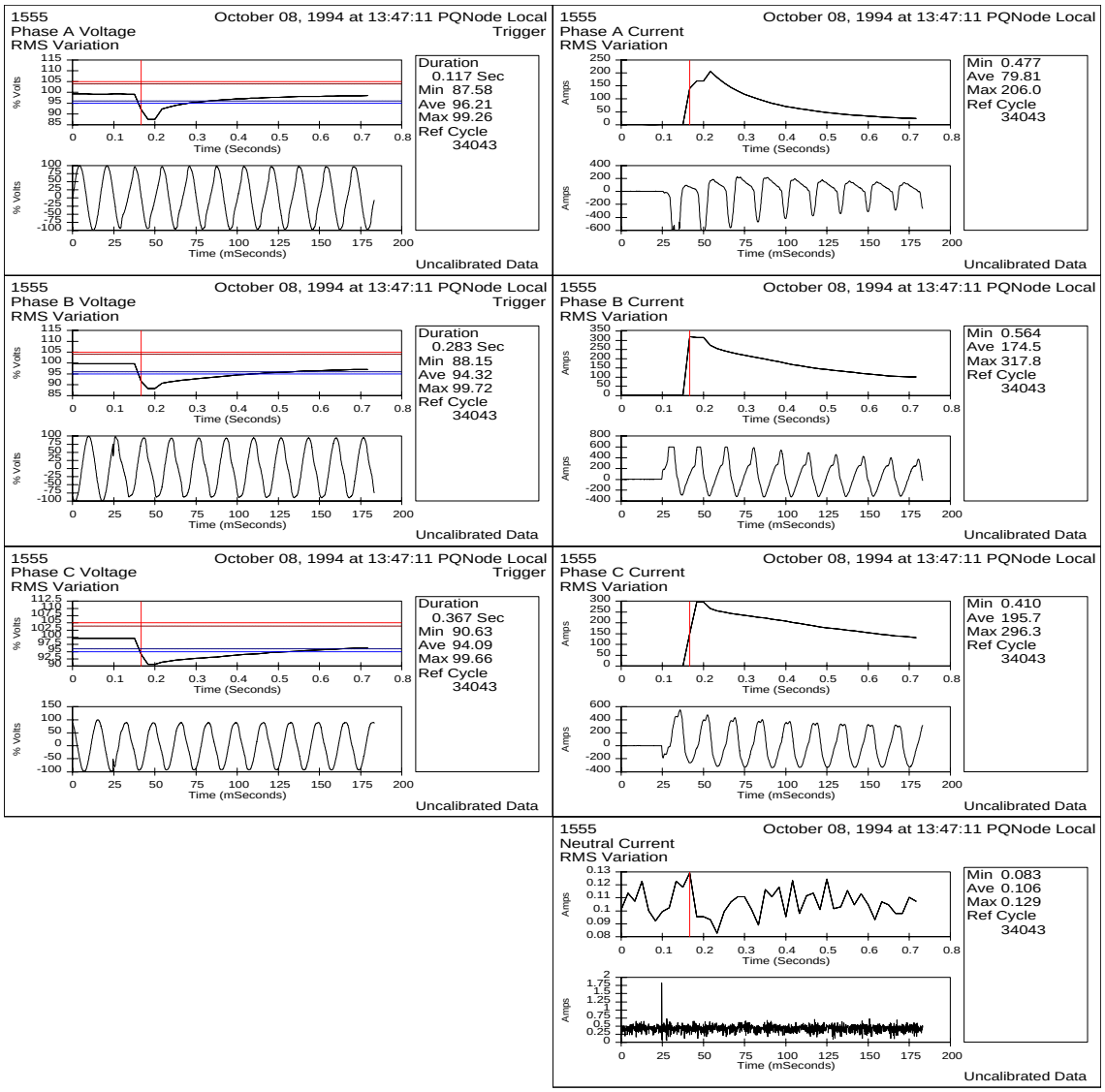


Figure 9: Second Inrush

24 Hour Summary (Figure 10):
A summary of the fault, outage, and two inrush periods for all phases of voltage and current.

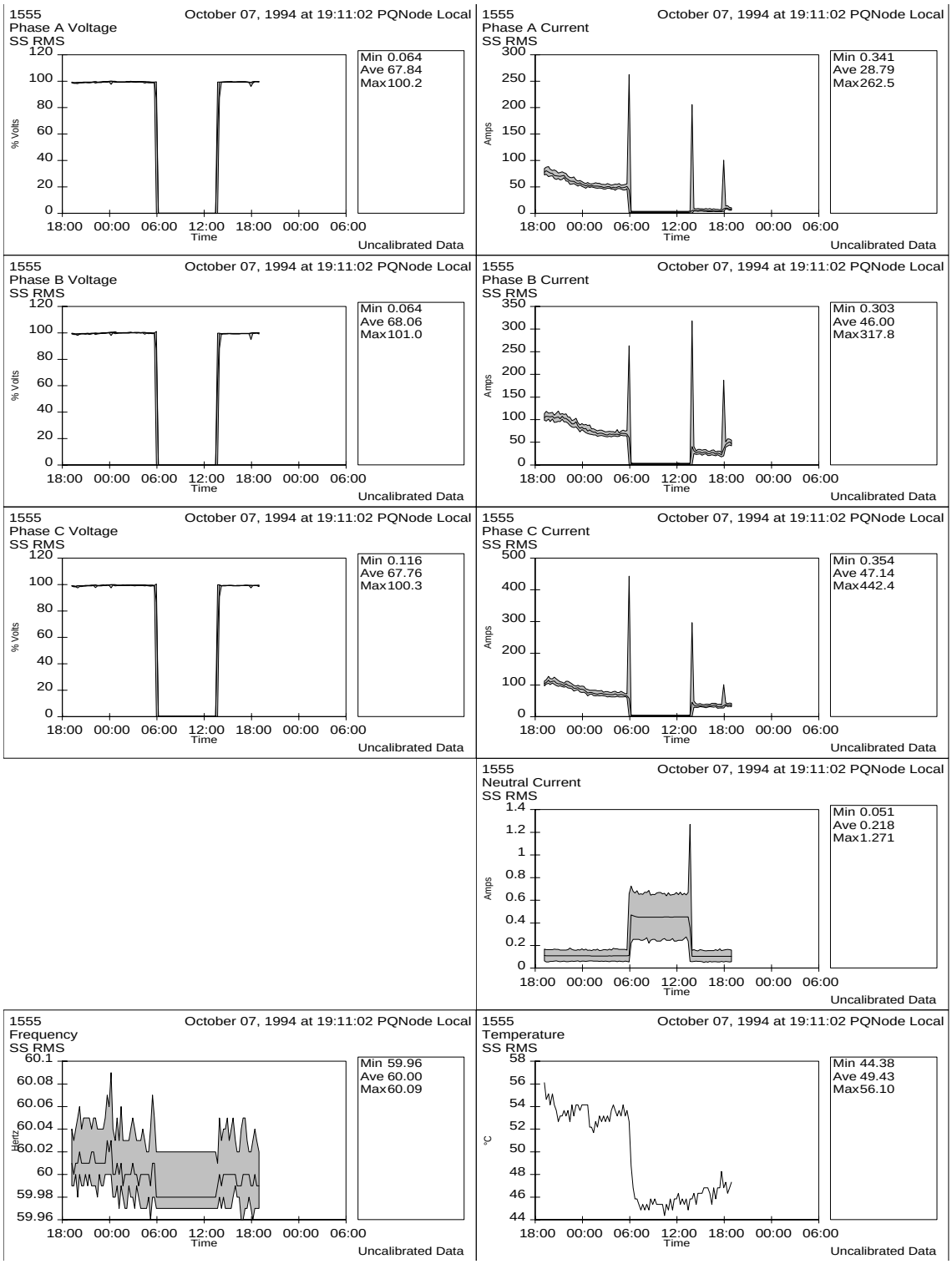


Figure 10: 24 Hour Summary