



Power Quality Monitoring: Key Component of Comprehensive Power System Monitoring

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Global Power Technology

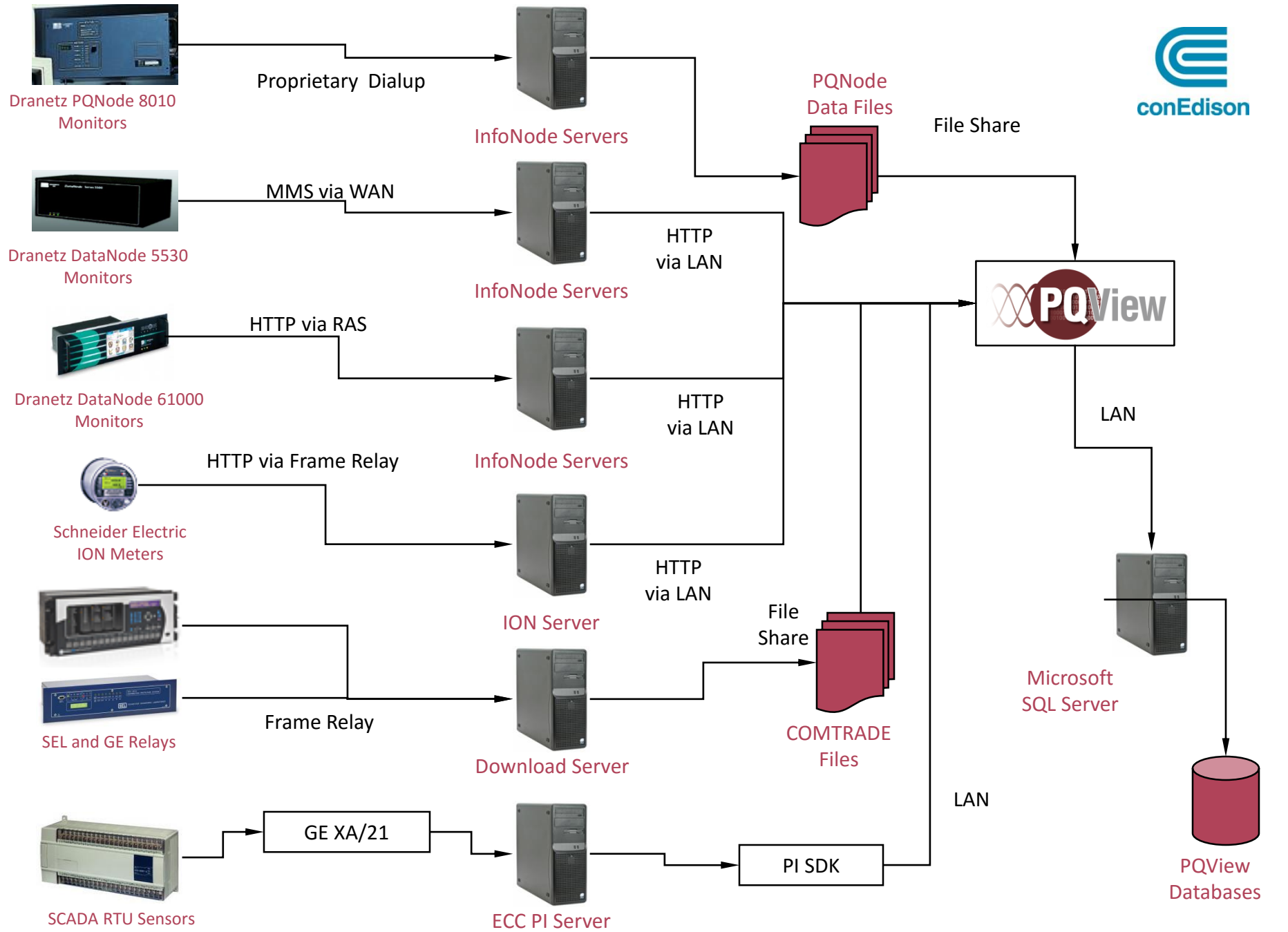


Traditional Use of Power Quality Monitoring Systems (PQMS)

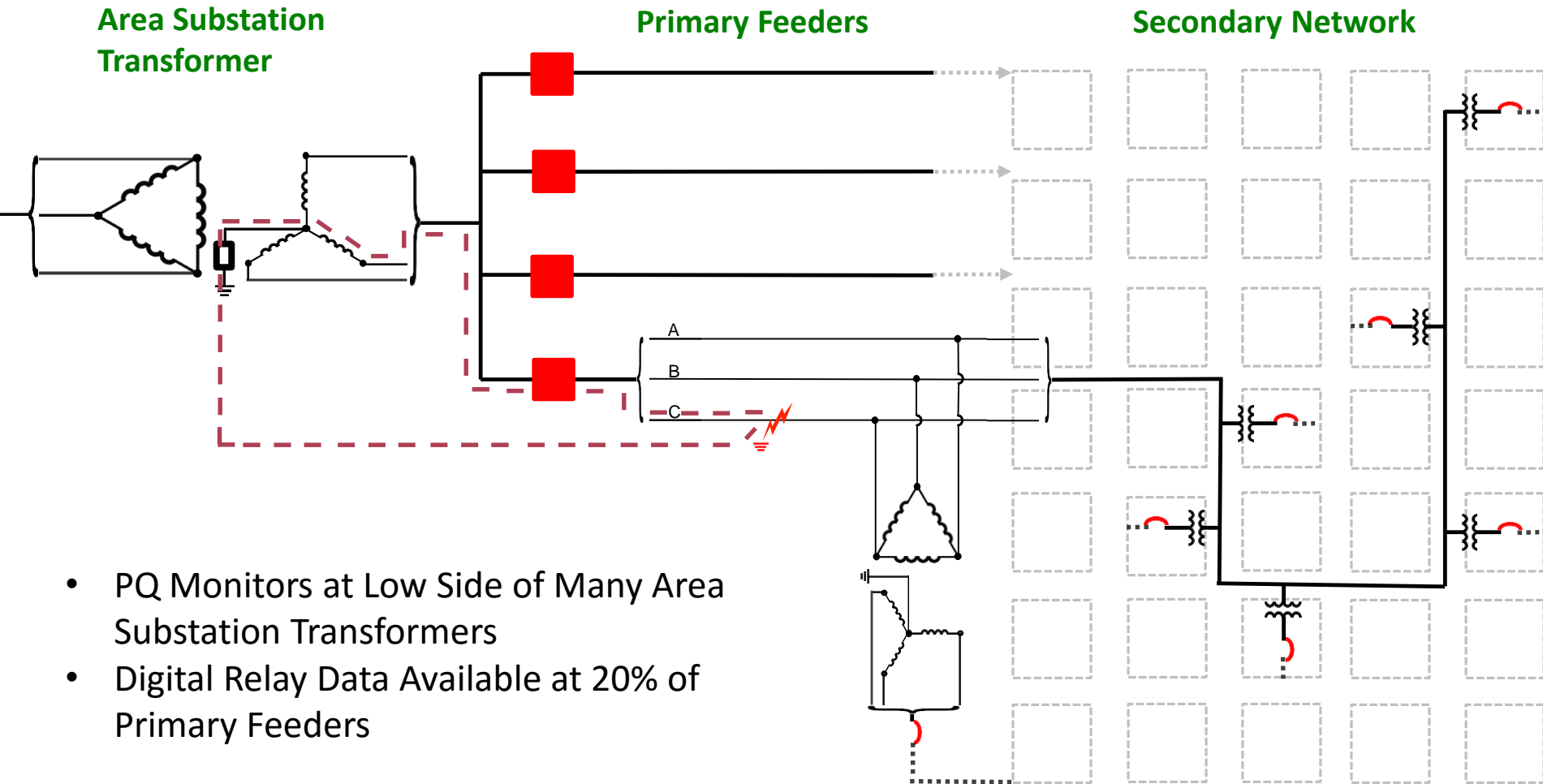
- Record/Download PQ Events and Data Logs from PQ Monitors Compliant with IEC 61000-4-30
 - Voltage Sags/Swells, Transients, Rapid Voltage Changes
 - THD, Harmonics, Imbalance, Frequency, Flicker Pst/Plt
- Analyze Single Events and Data Logs
- Build Summary Reports for Customers
- Track Voltage Sag Performance (IEEE 1564)
- Report on Compliance with Regulations (EN 50160)
- Provide Analysis of PQ Events and Data Logs

Expanded Use of Power Quality Monitoring Systems (PQMS)

- Integrated Monitoring of Power Quality Monitors, Microprocessor Relays, Digital Fault Recorders, Recloser Controllers, Capacitor Controllers, and More
- Integration with SCADA or OMS
- Fault Analysis
- Incipient Fault Detection
- Automated Fault Location for Permanent and Momentary Faults
- Automated Capacitor Analysis
- Notification and Reporting using Statistical Process Control

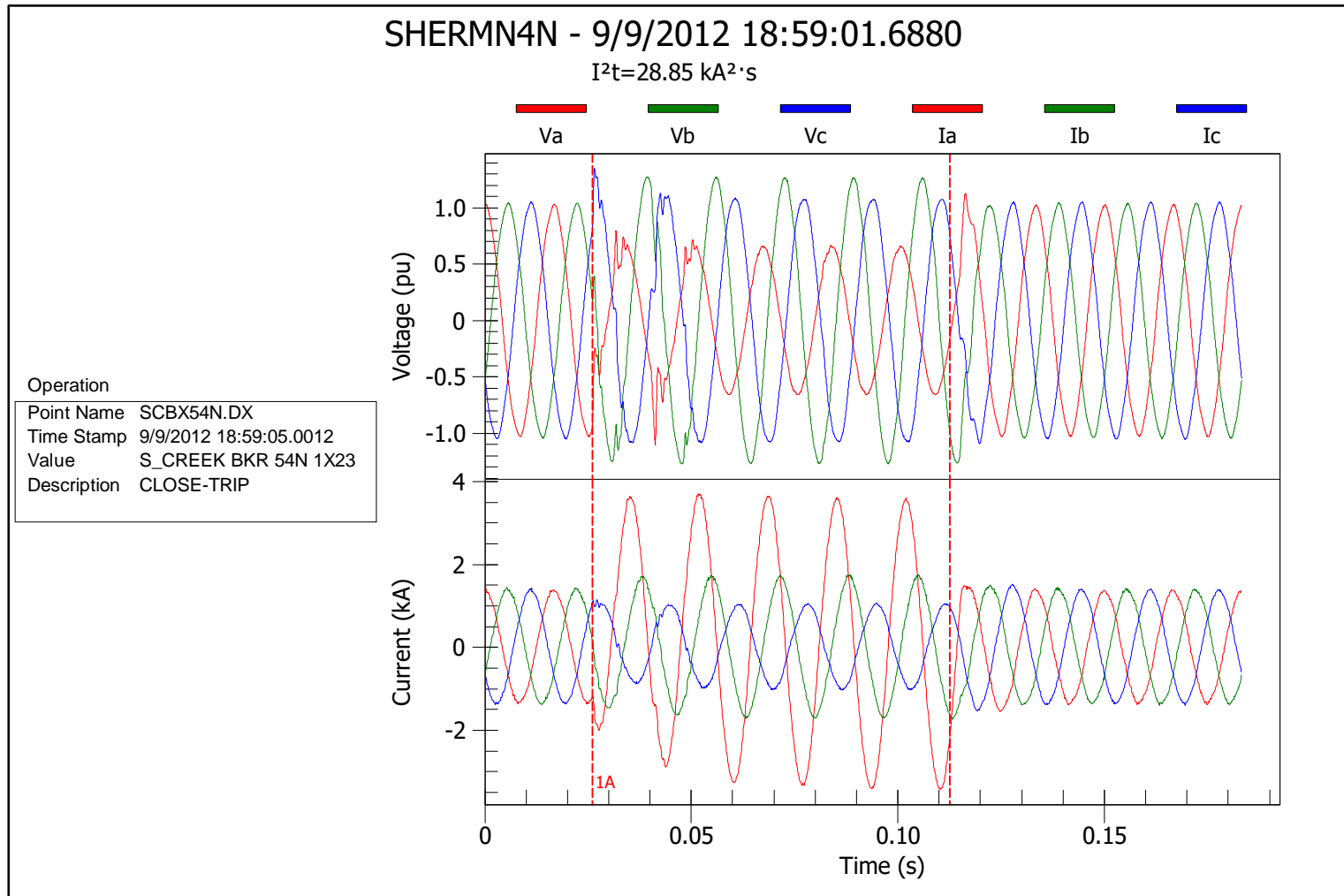


Single Line to Ground Fault

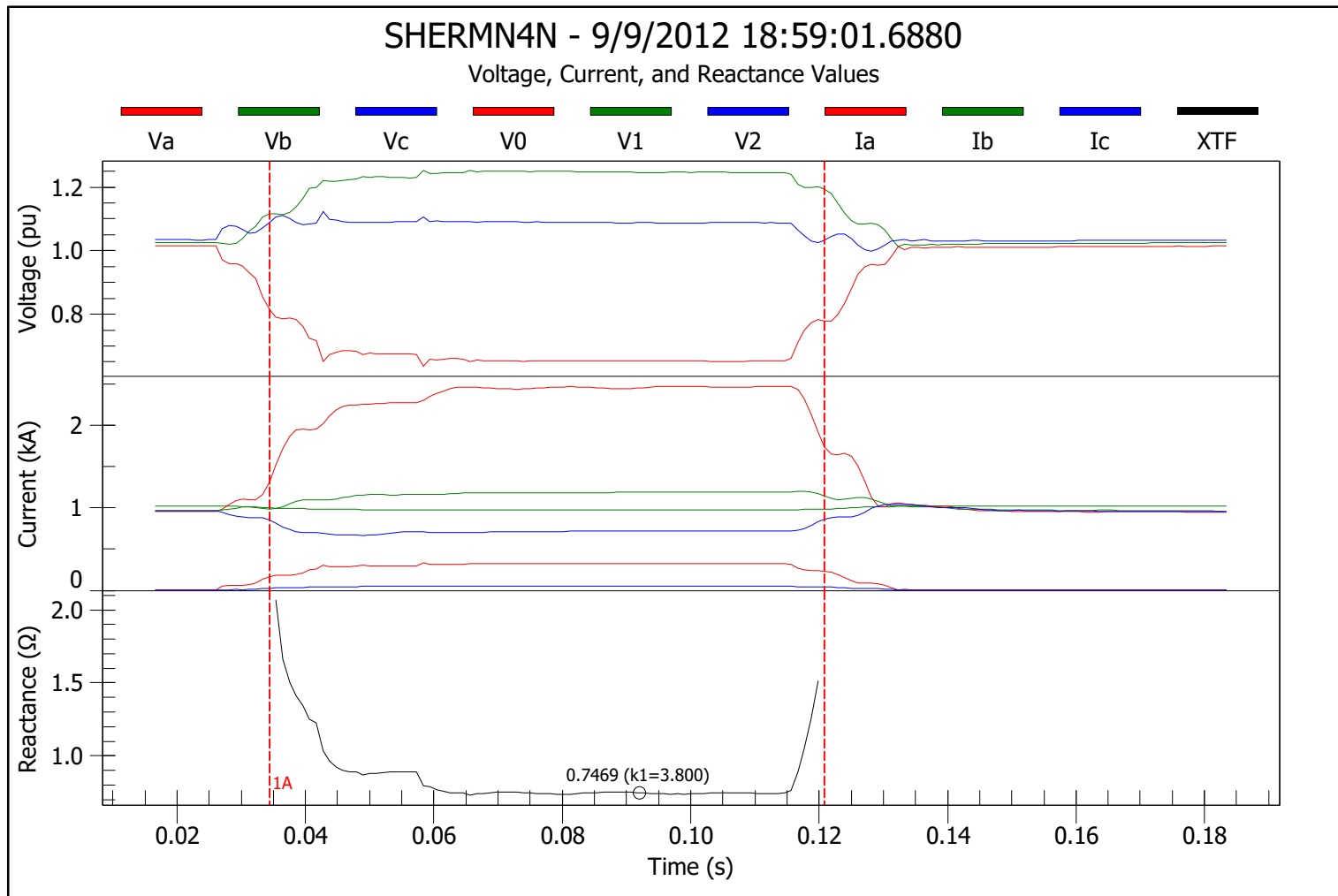


- PQ Monitors at Low Side of Many Area Substation Transformers
- Digital Relay Data Available at 20% of Primary Feeders

Example SLG Fault Recorded by PQ Monitor at Area Substation



Reactance-to-Fault Calculations for PQ Measurement at Substation



Predicted Location of Fault

RTFDetail - Windows Internet Explorer

PQ View XTF: 0.7469 Banks: 4 Feeder Factor: 1.2 XTF: 0.2241 Accuracy: 5.00 %

Buttons: Defaults Set as Default Recalculate

9/9/2012 6:59:01 PM Single-Phase Fault on Phase A SABIND, RTF User

Feeder : 01X23 Network : Riverdale Print

	Structure	Location	Resistance	Reactance
01M02	26	M23658	0.0975	0.1479
01M03	27	M23659	0.1027	0.1574
01M04	28	M11873	0.107	0.1654
01M06	29	M11874	0.1116	0.1741
01M07	30	M11877	0.1169	0.1843
01M14	31	M11889	0.1223	0.1925
01M18	32	M11891	0.126	0.1982
01M50	33	M11893	0.1299	0.2041
01M51	34	M11894	0.1316	0.207
01M54	35	M11897	0.1366	0.2165
01X22	36	M11899	0.1408	0.2244
01X23	37	M2504	0.1465	0.2352
01X26	38	M11912	0.1507	0.2416
01X28	39	M11914	0.1538	0.2476
01X29	40	M4056	0.179	0.2514
01X32	41	M11921	0.1571	0.2538
	42	M11923	0.1604	0.26
	43	M11927	0.1634	0.2658
	44	M911	0.1922	0.2659

Visualized Location of Fault

Visual Fault Locator - Windows Internet Explorer

http://intapps7.coned.com/vfl/display.aspx?dist=bx&fdr=01X23&rtf=0.2241&pct=5.00&banks=4&ft1=M1189

File Edit View Favorites Tools Help

Visual Fault Locator

EA Visual Fault Locator

RIVERDALE target feeder[01X23], RTF[0.2241], accuracy[5.00 %], banks[4]

Select feeders:

- 01X21
- 01X22
- 01X23
- 01X25
- 01X27
- 01X28
- 01X29
- 01X30
- 01X32
- 01X24
- 01X31
- 01X26

selectAll clearAll*
*target fdr always on
GO

- LandBase
- Streets
- MS-Plates
- Feeders
- FaultIDs

white bkground

Fit View
Zoom-to-Fault

Done Local intranet 100%



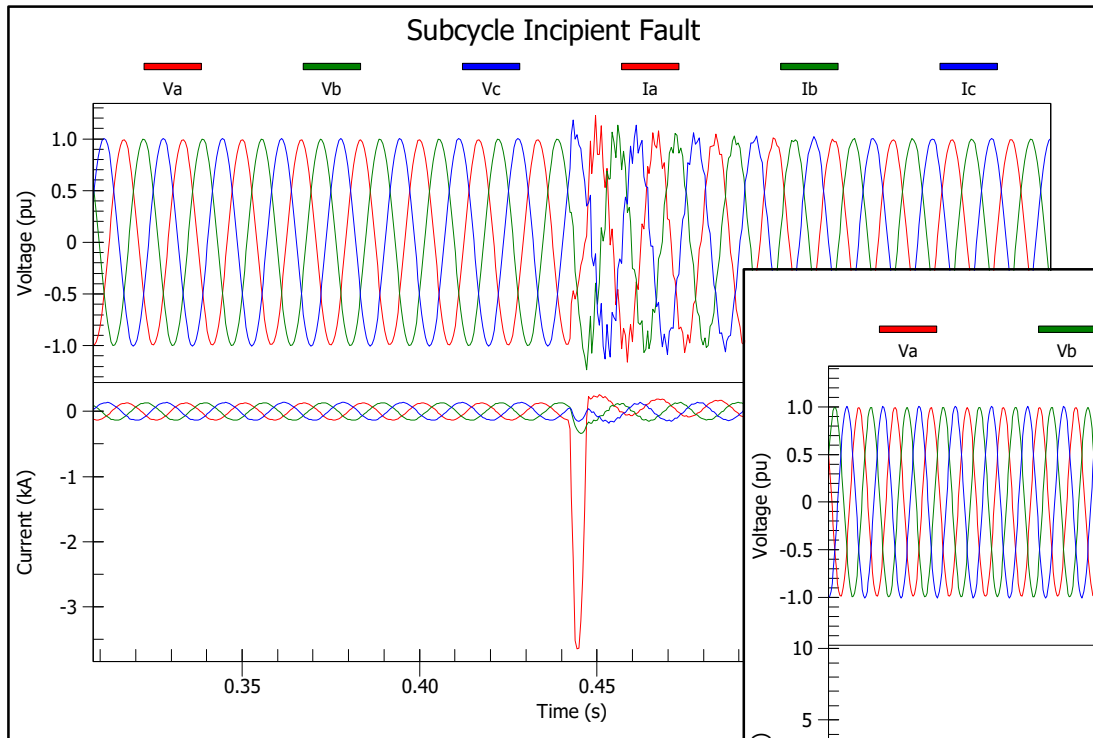
Distribution Fault Location Results at Con Edison

- On average, use of the reactance-to-fault method for fault location saves one hour per feeder restoration job
- Mitigates use of capacitive discharge thumpers and DC hi-pot



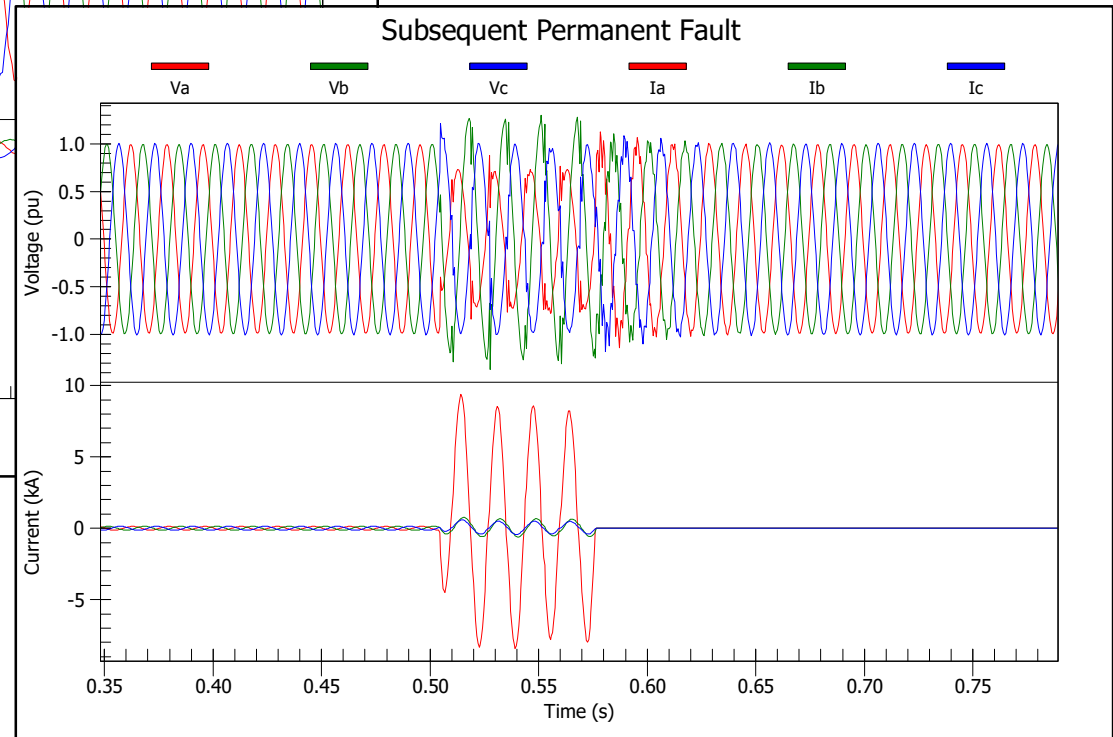
2009	64%	24%	5%	2%	6%
2010	67%	14%	5%	3%	11%
2011	64%	20%	8%	3%	5%
Summer 2012	76%	14%	4%	4%	1%

Incipient Subcycle Fault Location Using Time-Domain Estimation



Estimated XTF: 0.3235 Ω

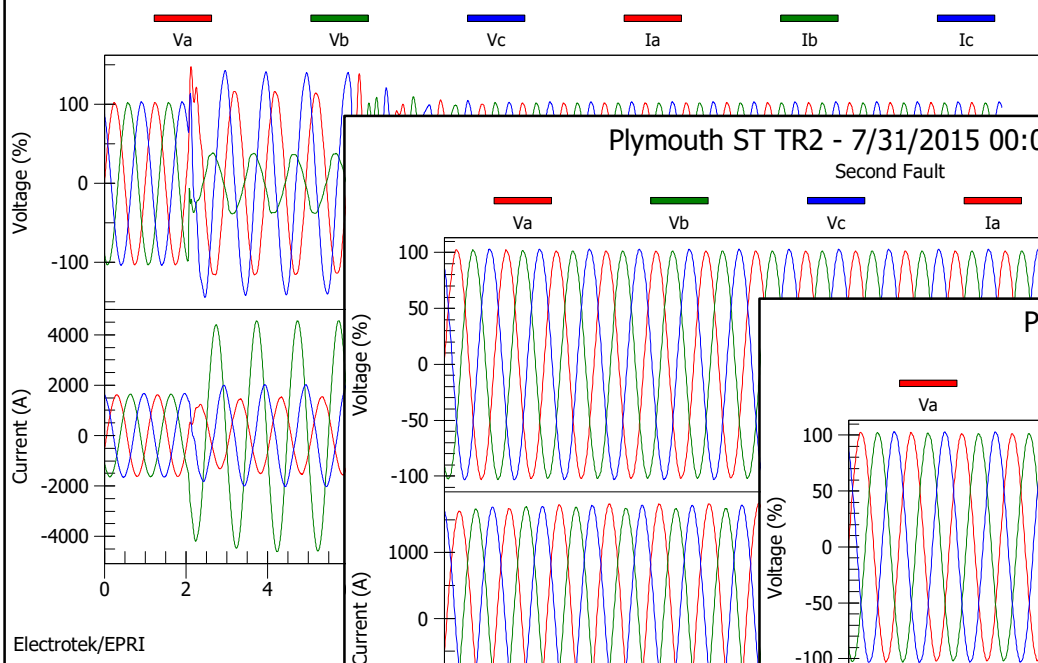
Actual XTF: 0.3221 Ω



Second Fault Detection

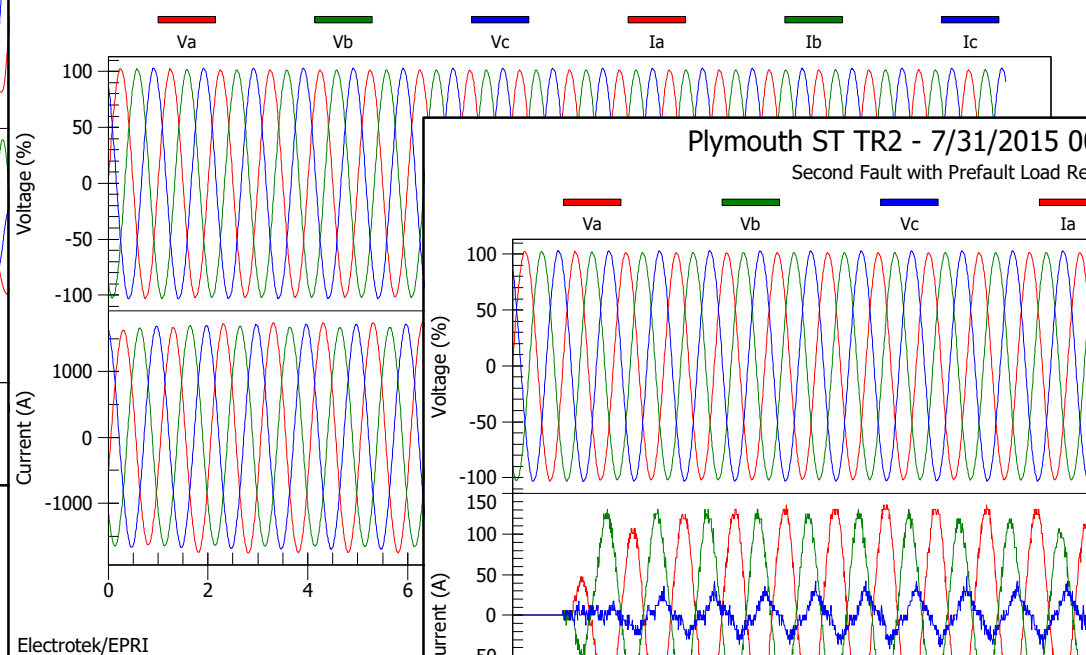
Plymouth ST TR2 - 7/30/2015 23:59:08.9440

Initial Single-Phase Fault



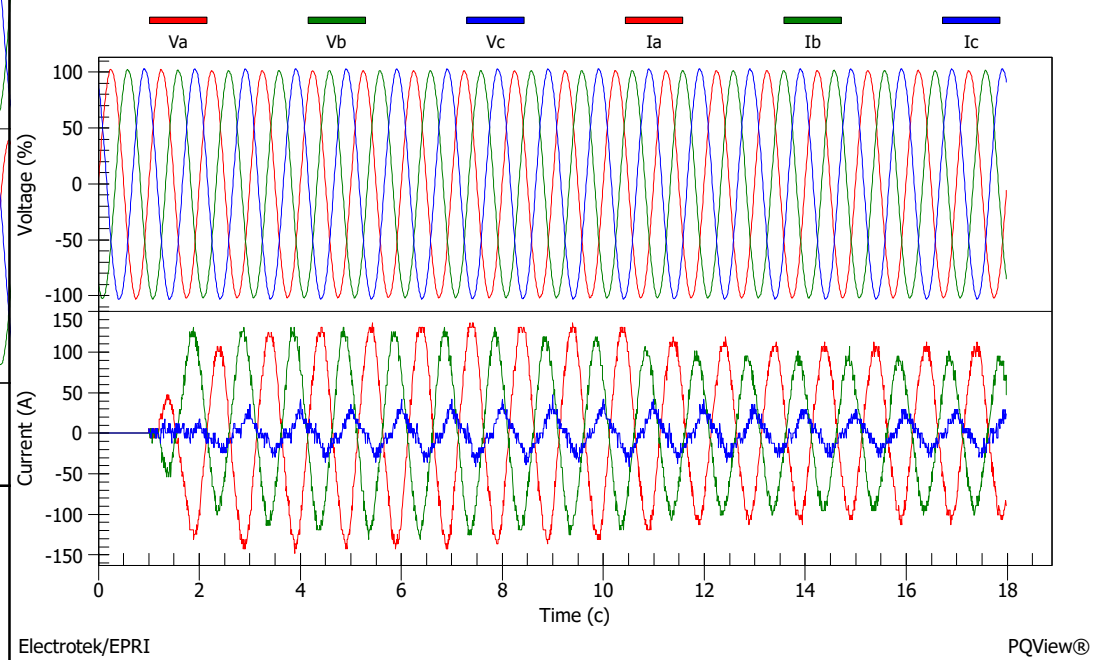
Plymouth ST TR2 - 7/31/2015 00:01:34.4680

Second Fault

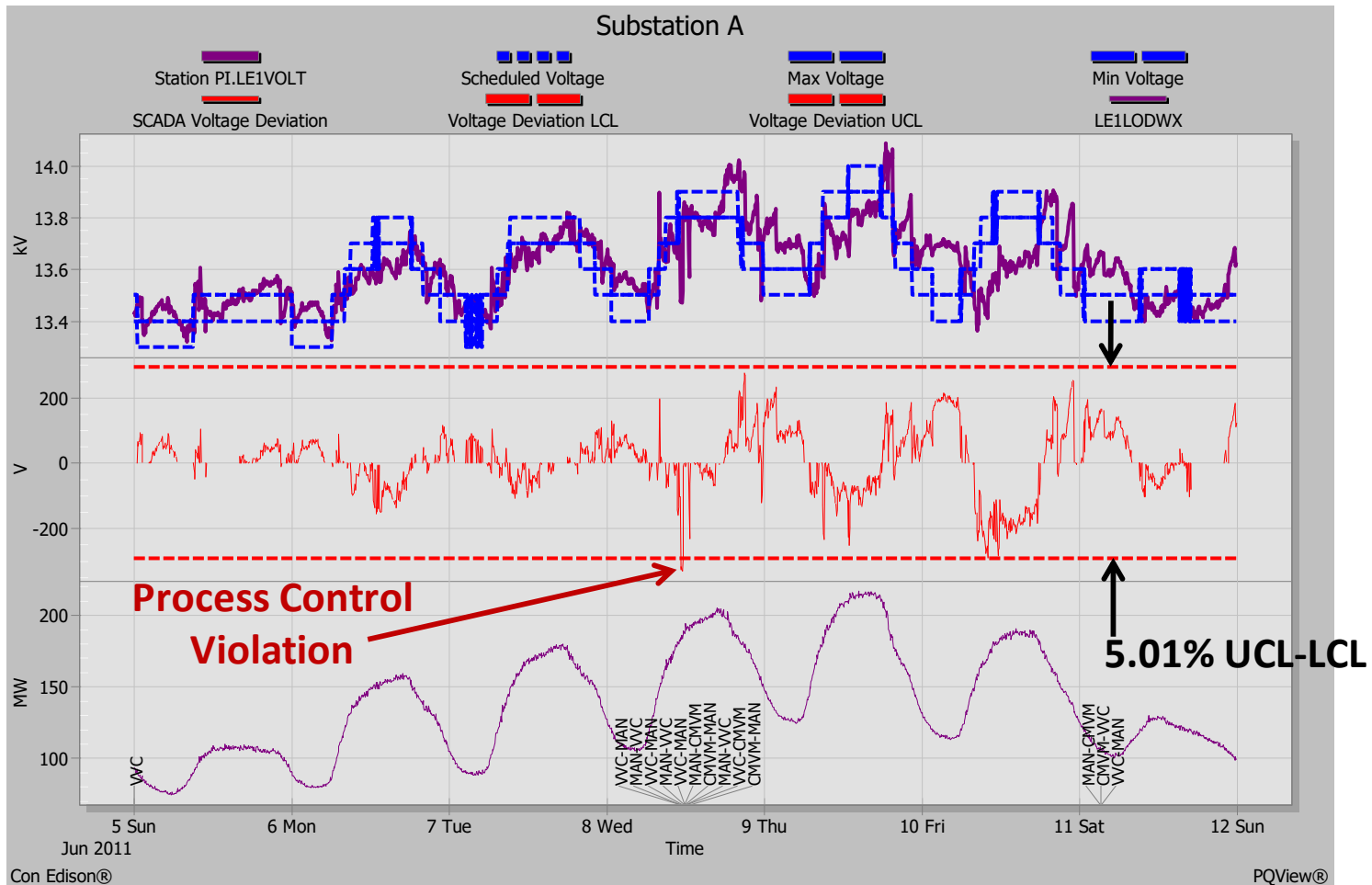


Plymouth ST TR2 - 7/31/2015 00:01:34.4680

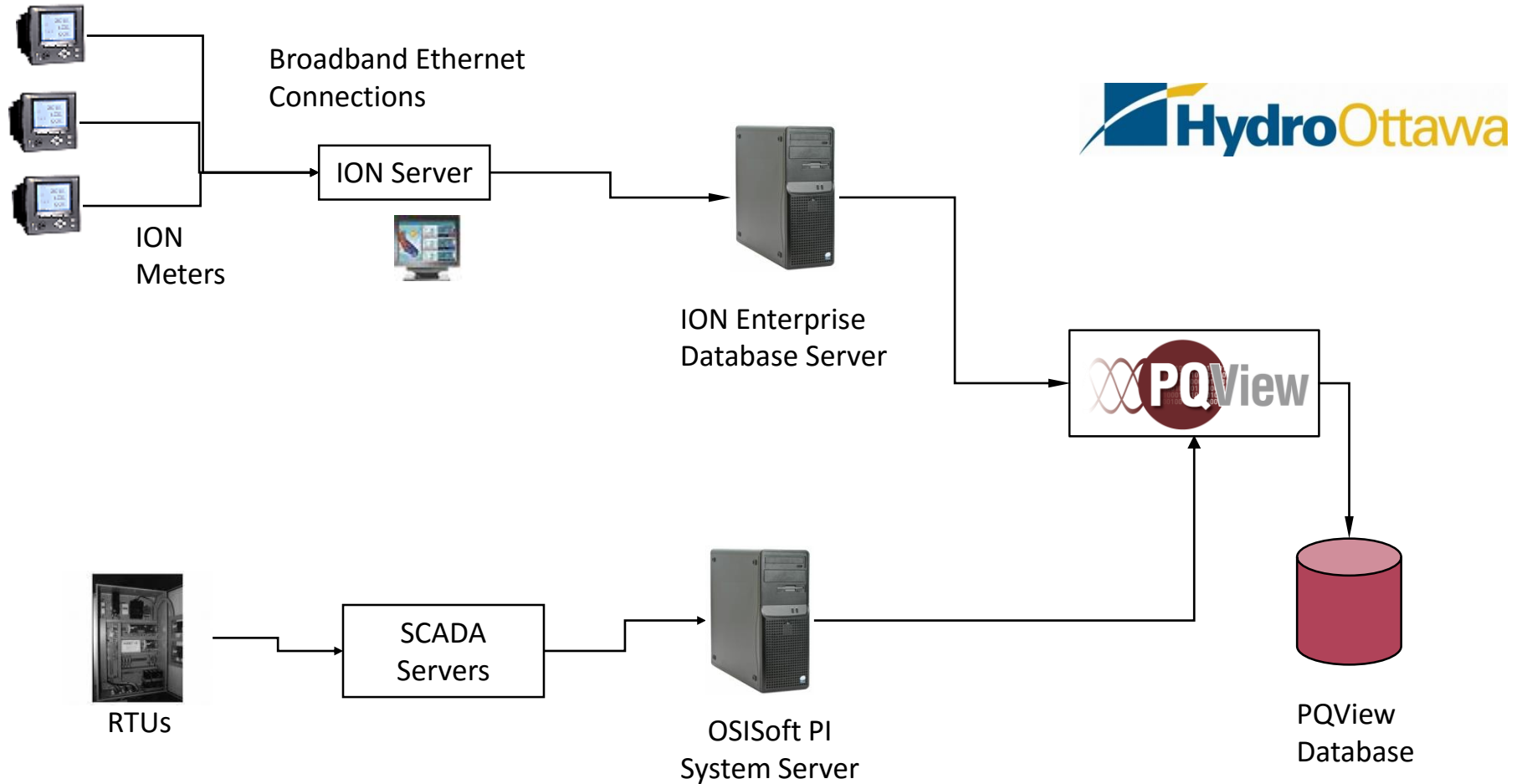
Second Fault with Prefault Load Removed



Using SCADA and Power Quality Measurements Together

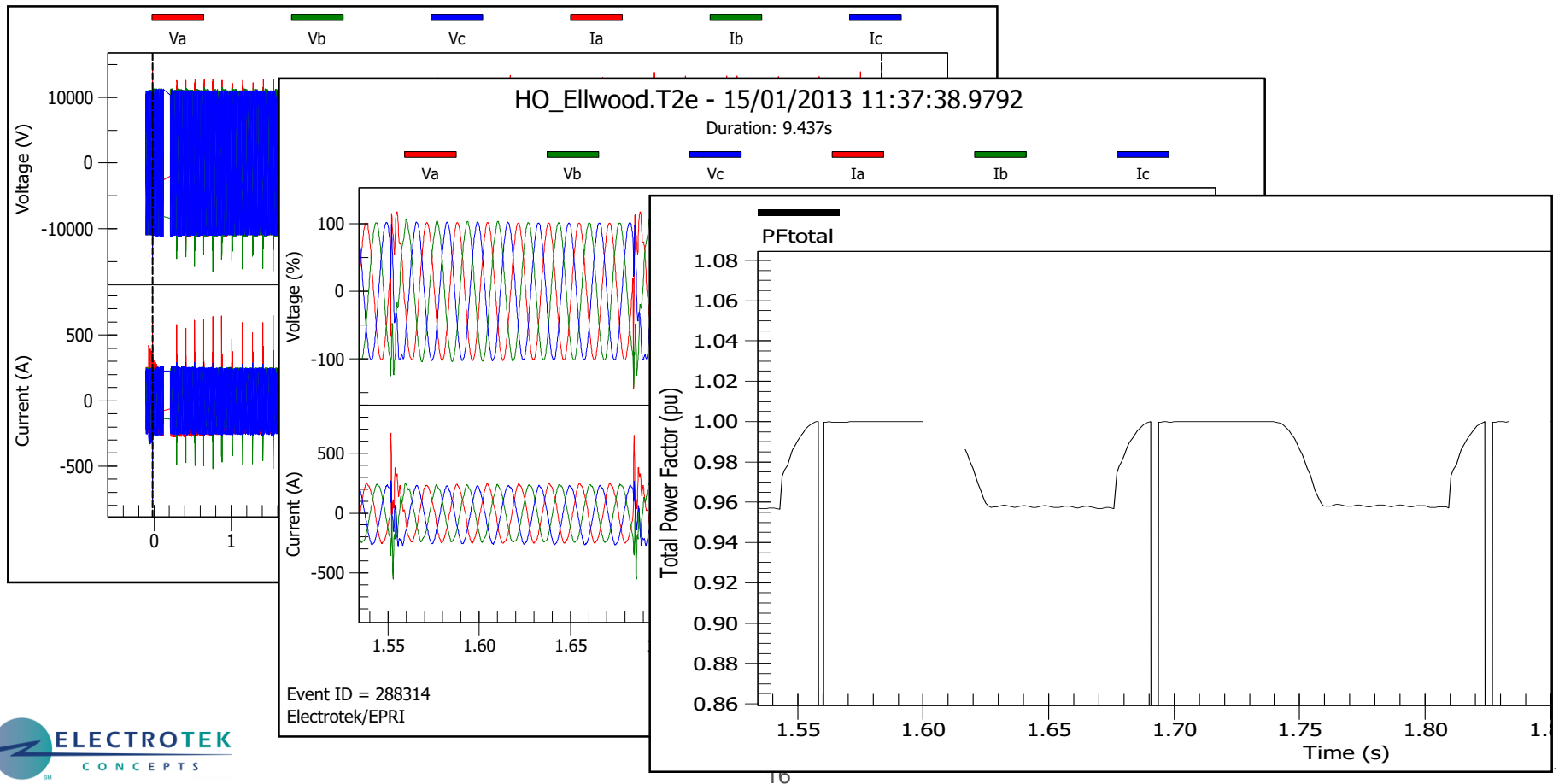


Data Integration at Hydro Ottawa



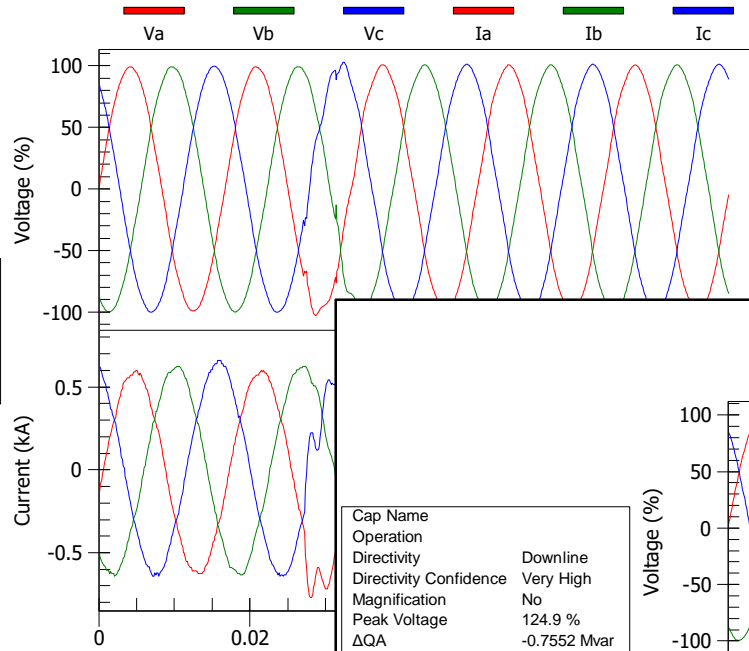
Analyzing Capacitor Performance

- Capacitor Switching anomaly when new capacitor bank was put in service Operated 70 times in 10 seconds



Automated Capacitor Analysis

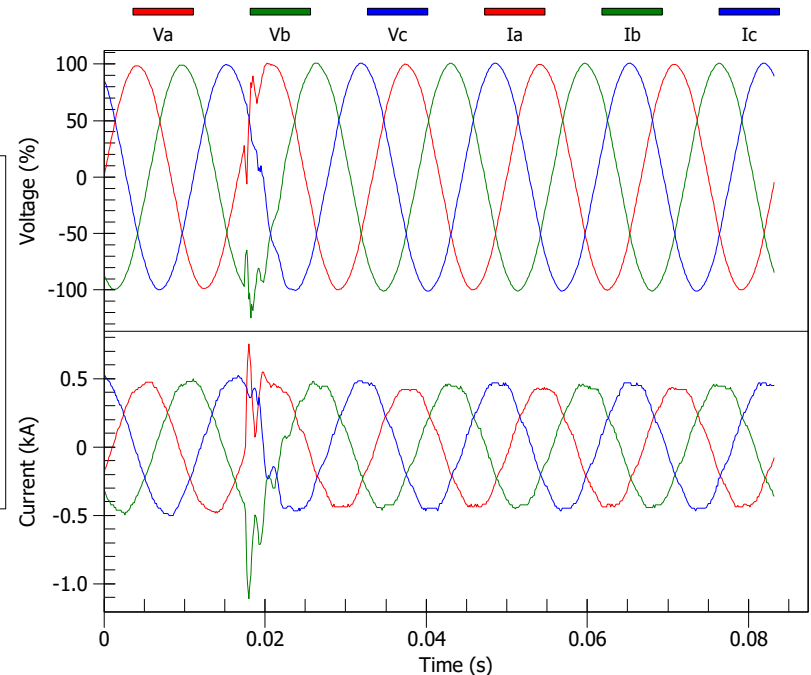
Joslyn Closing Analysis



Cap Name	CAP_1A CIS	
Operation	OUT-INSEVIC	
Channel	Time	Status
Va	0.7417 ms	Synchronous
Vb	0.5516 ms	Synchronous
Vc	0.7417 ms	Synchronous

Electrotek/EPRI

Capacitor Analysis

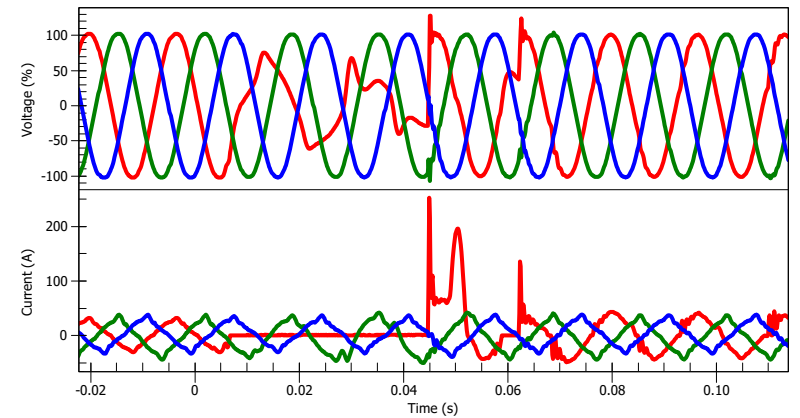
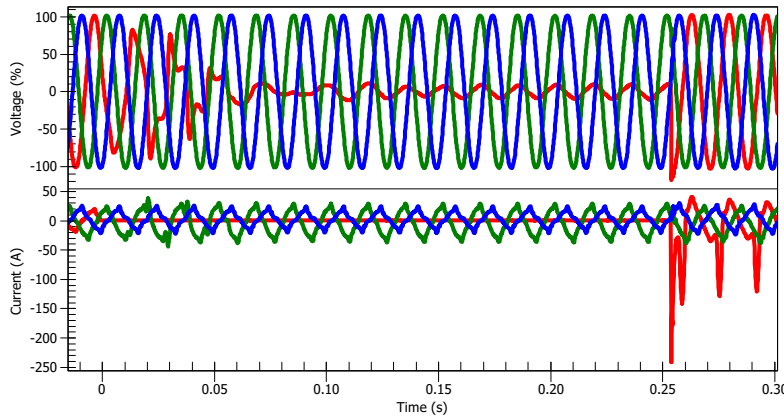
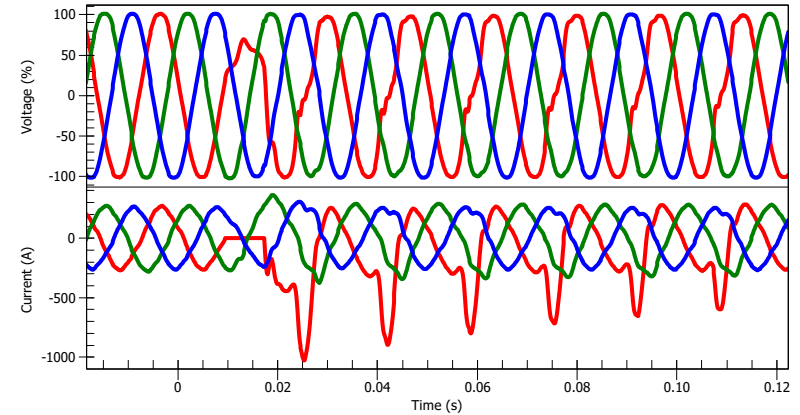
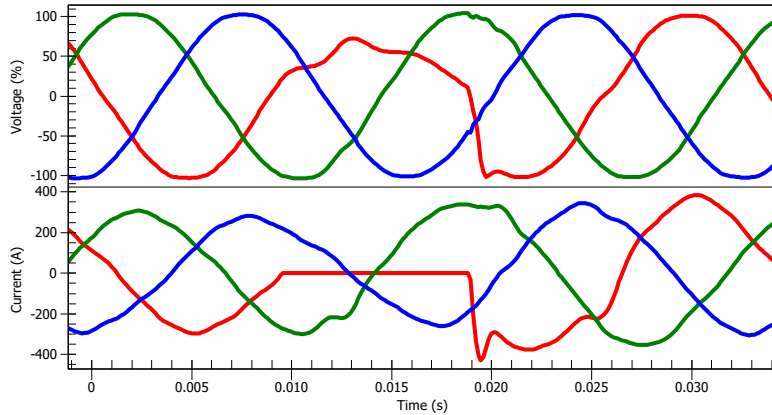


Cap Name	
Operation	
Directivity	Downline
Directivity Confidence	Very High
Magnification	No
Peak Voltage	124.9 %
ΔQA	-0.7552 Mvar
ΔQB	-0.7812 Mvar
ΔQC	-0.7689 Mvar
$\Delta QTotal$	-2.305 Mvar
ΔPFA	7.21%
ΔPFB	5.42%
ΔPFC	6.29%
$\Delta VTHDA$	0.27%
$\Delta VTHDB$	0.26%
$\Delta VTHDC$	0.30%
Resonant Frequency	565.5 Hz

Electrotek/EPRI

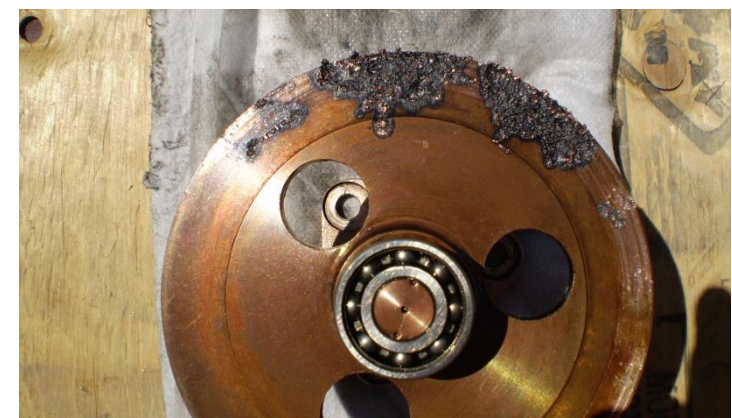
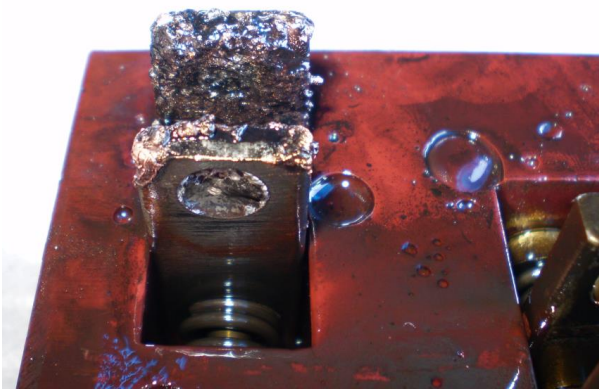
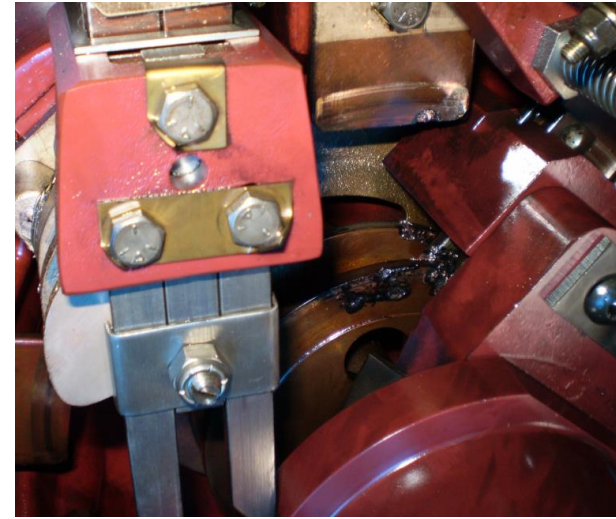
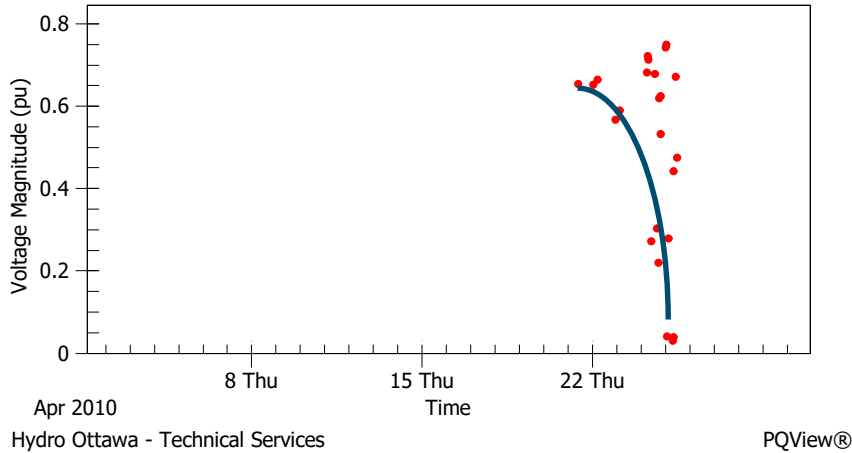
PQView®

Waveforms from Defective Tapchanger



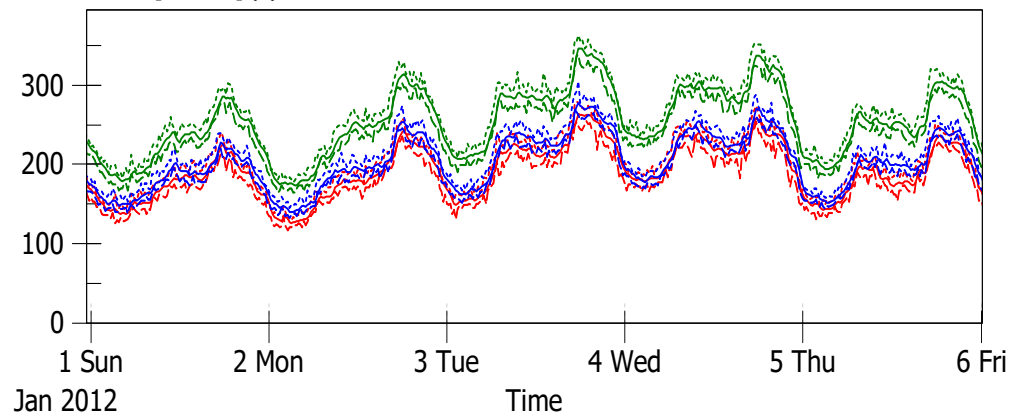
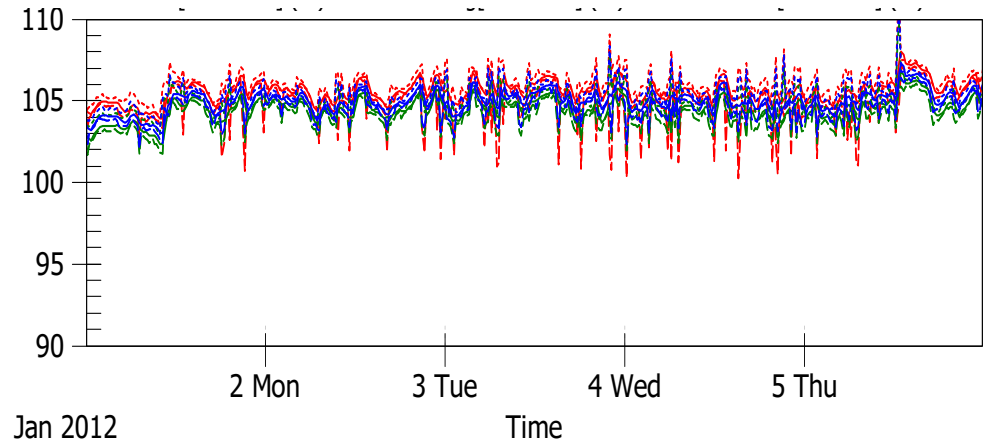
Voltage Sags and Damage from Transformer 1

RMS Variation Magnitude Time Scatter Plot
Transformer 1

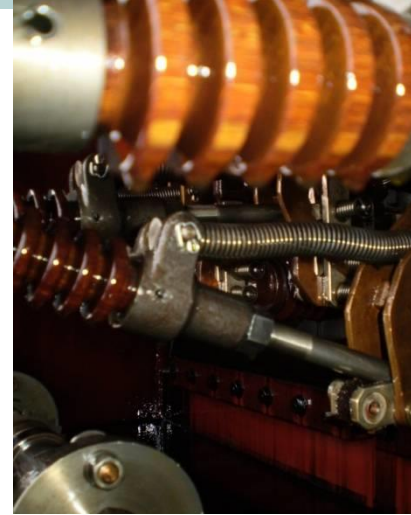
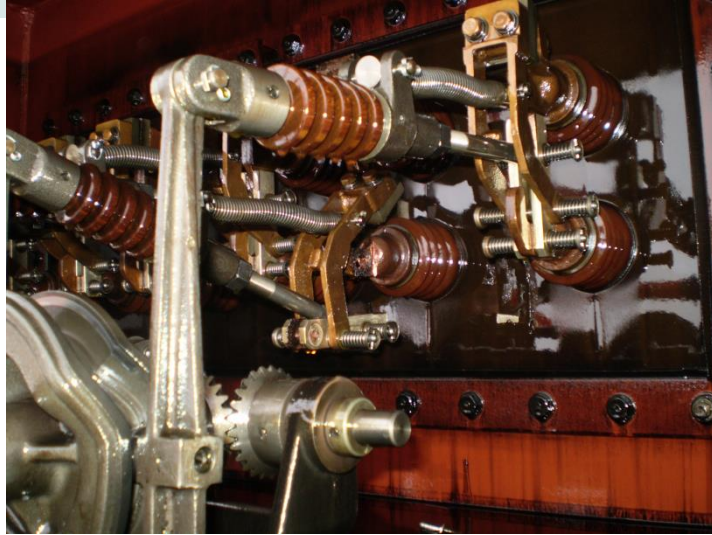


No Voltage Sags at Transformer 2

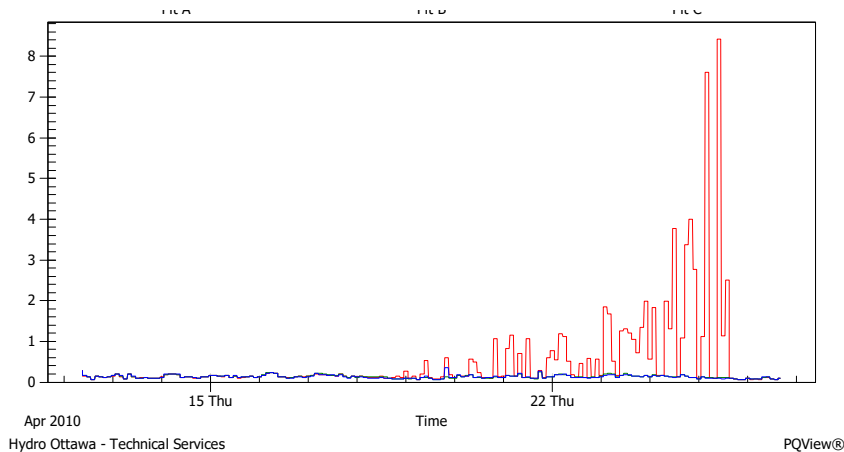
- There were no sags or transient events recorded during this period.
- Voltage Trend data showed a frequent number of minor rms voltage changes that were not associated with current inrush or faults.
- Transformer was taken out of service and inspected and damage was found.



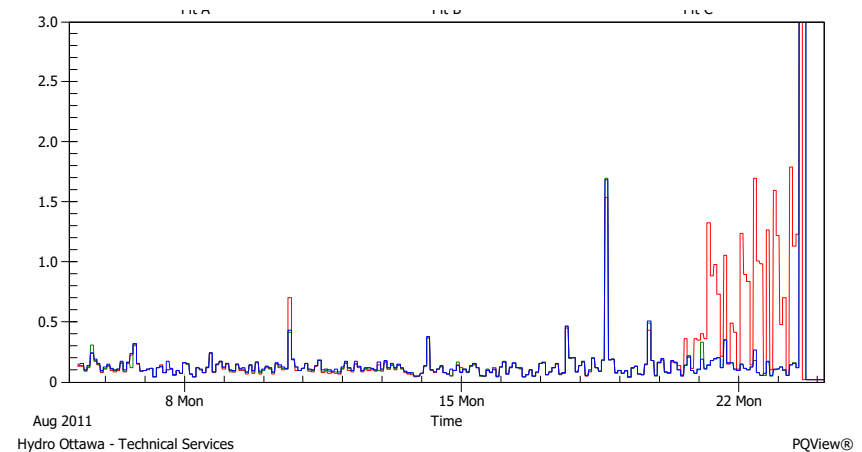
Transformer 2 Tapchanger Damage



Voltage Plt Flicker Trends at Transformer 3

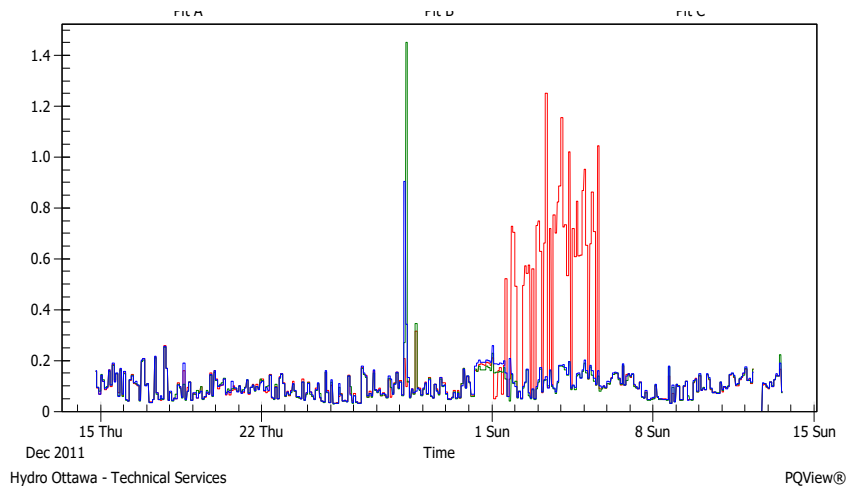


Transformer 1



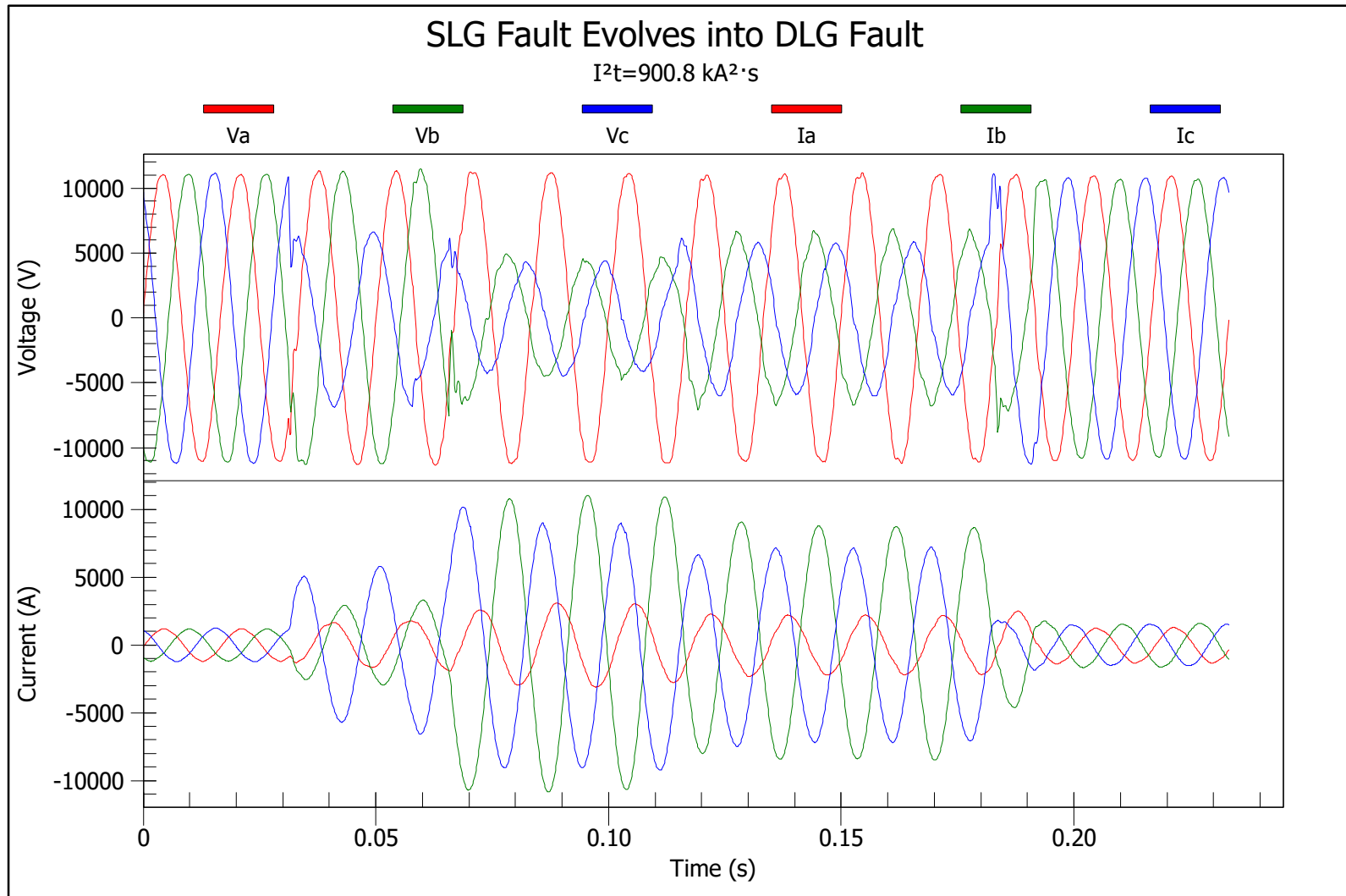
Transformer 2

Pst and Plt flicker data identified the start of the **serious** damage to the tapchanger within hours on all three transformers.



Transformer 3

Breaker Asset Management using I^2t



Future Trend: Comprehensive Power Quality Monitoring Systems

- Integrated Monitoring of Many Types of IEDs
 - IEEE 1159.3 PQDIF
 - IEEE C37.111-2013/
IEC 60255-24:2013 COMTRADE
 - IEC 61850
- Single-Event Analysis
 - IEEE 1159, IEEE 1564
- Site-Site and System Indices
 - IEEE 1564, 1453, 519
- Automated Summaries & Compliance Reporting
 - EN 50160, IEC 62749
- Fault Analysis & Fault Location
 - IEEE C37.114-2014
- Real-Time and Historical Data Analytics
 - IEEE Working Group on Power Quality Data Analytics
- Device Asset Management