

Advancing Power Quality Awareness with High-Resolution Continuous Waveform Recording

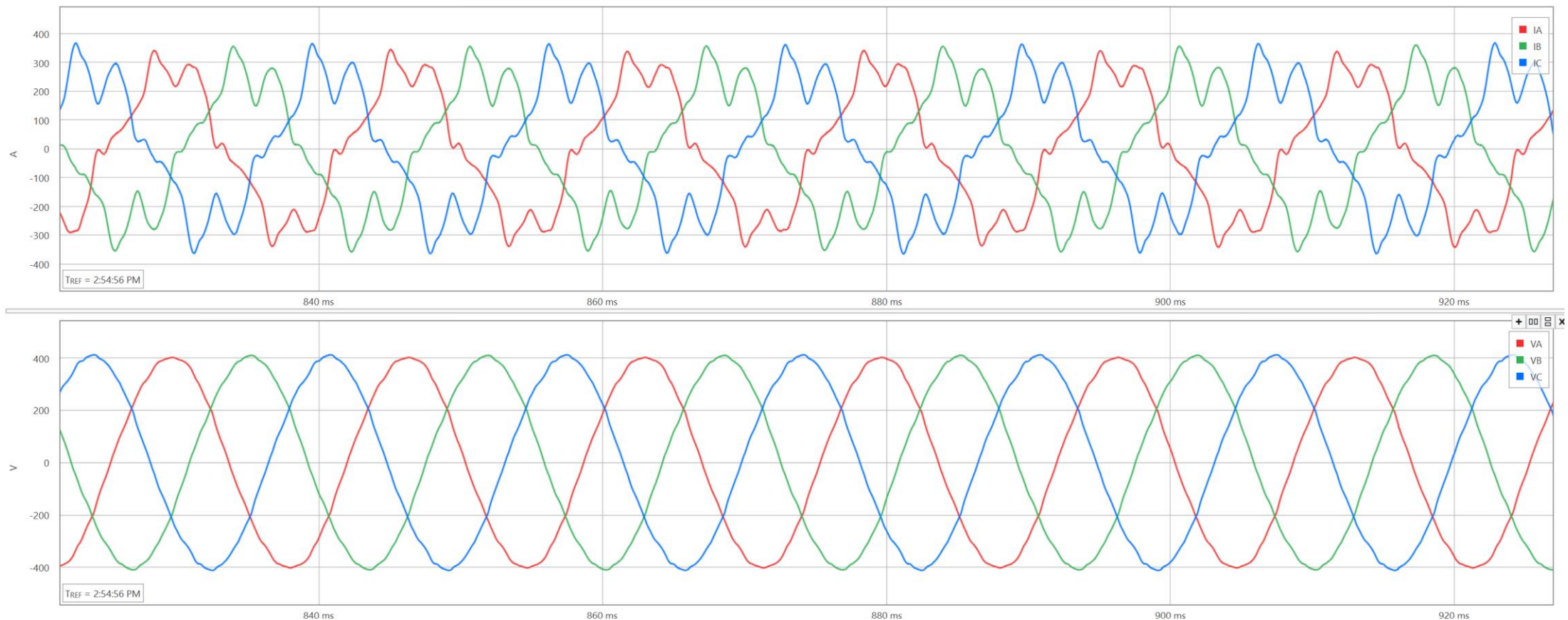


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Spring 2025 NASPI

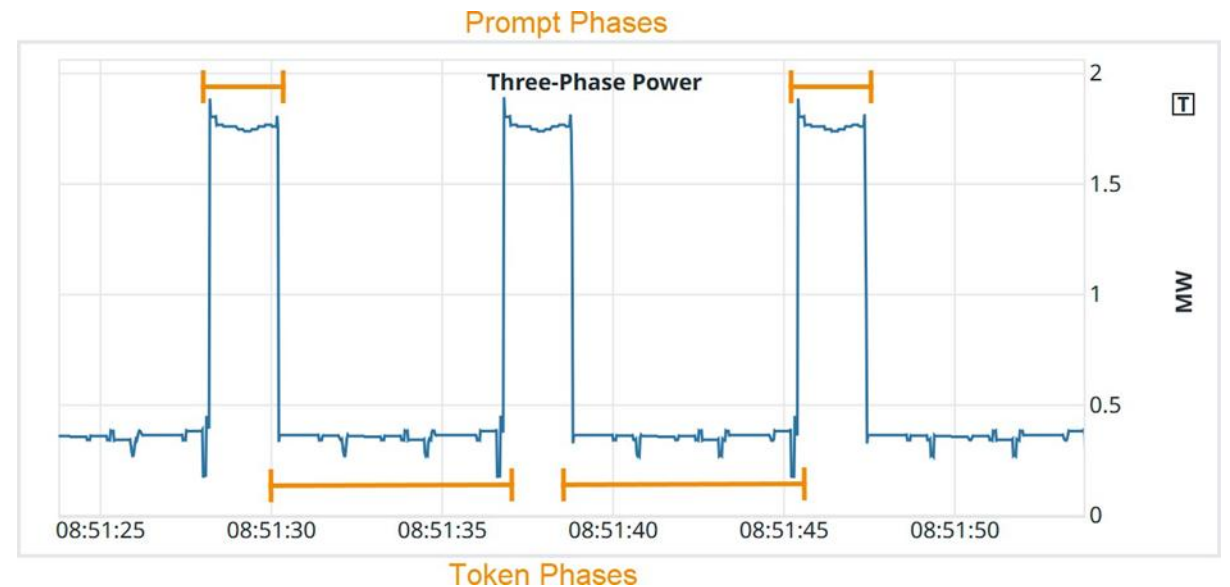
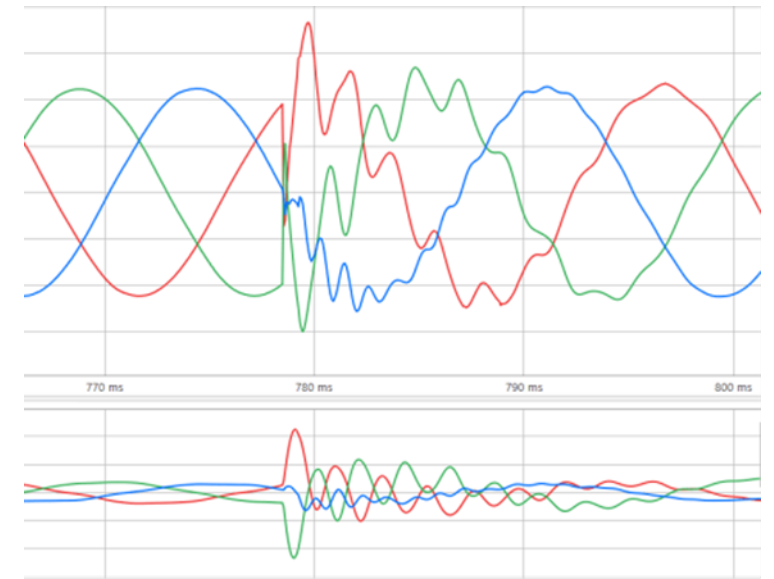
Power Quality

The consistency, reliability, and stability of the power system ensures proper function and longevity of electrical equipment.



New Era of Loads

- AI Training Algorithms
- Arc Furnaces
- EV Charging
- Crypto-currency Mining



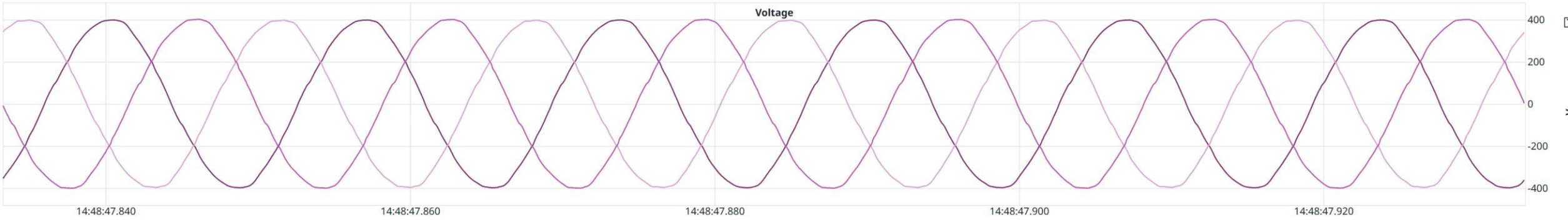
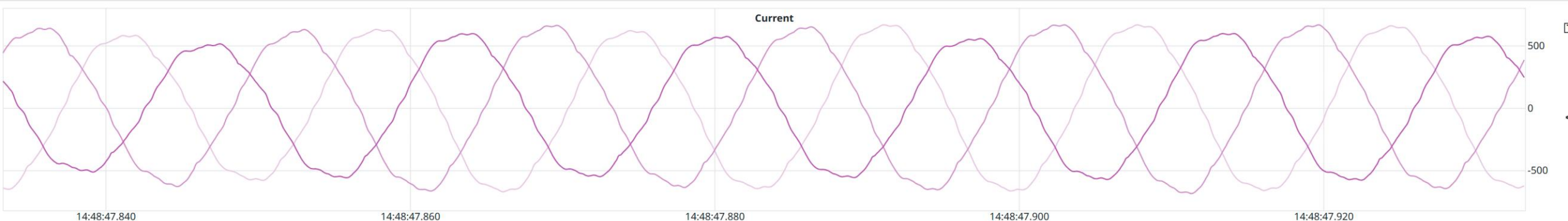
Complex Power Quality Concerns

- Visualizing Long Duration Faults
- Identifying Sub-Cycle Transients
- Detecting Oscillations
- Tracking Rapid Power Fluctuations

Continuous Waveform Streaming

- Conversion of an analog signal to a series of discrete time-stamped values
- Fixed time interval (T_s) between samples
- Instantaneous time-domain sampled voltage and current measurements

Continuous Waveform Data



Wave Data to Meter Values

**Continuous
Waveform
Stream**



Calculations and Algorithms

RMS Voltage, Current & Power

Fundamental Voltage, Current & Power

Frequency

Power Factor

Harmonics and THD

Synchrophasors

Sequence Components

Flicker

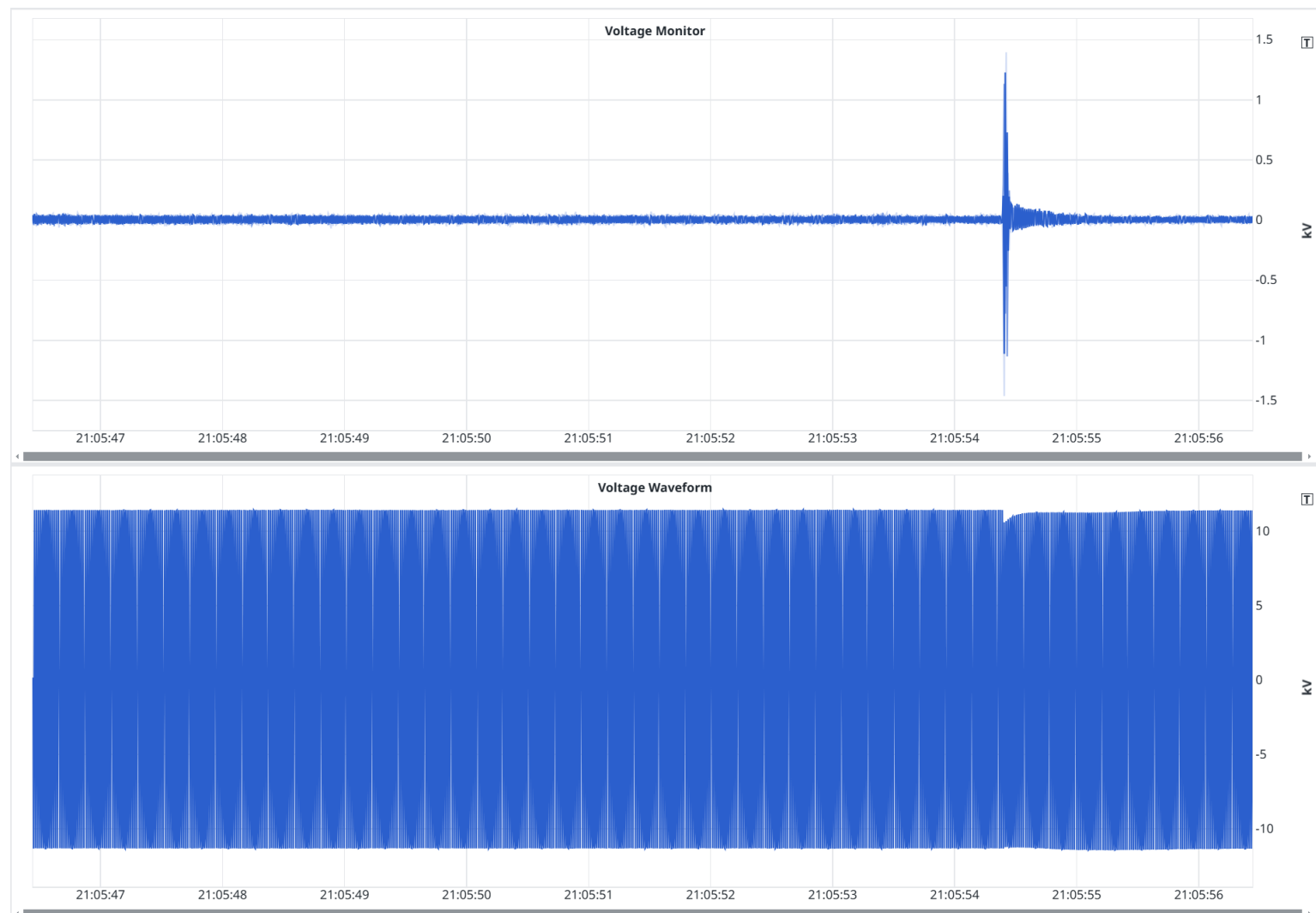
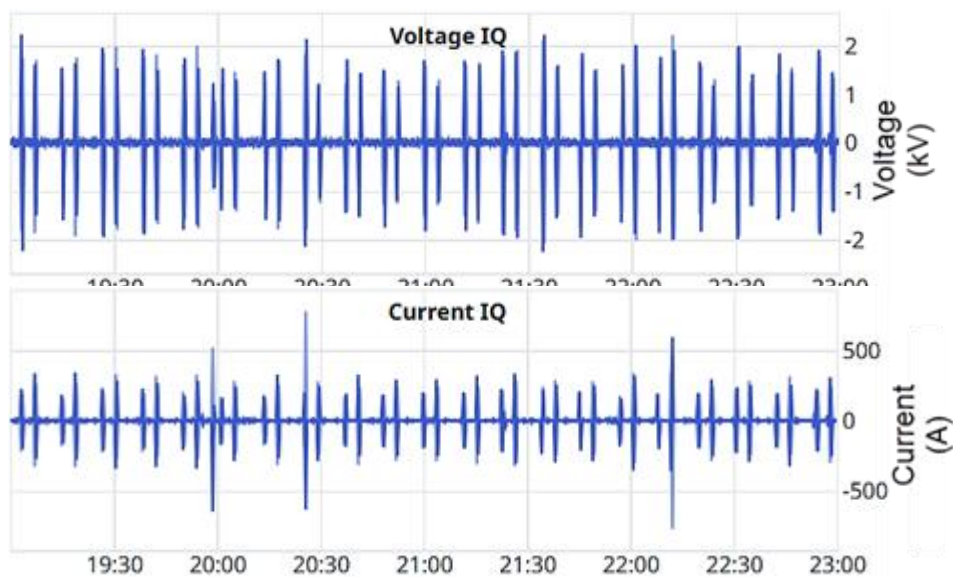


**Analysis and
Visualization**

Incremental Quantities

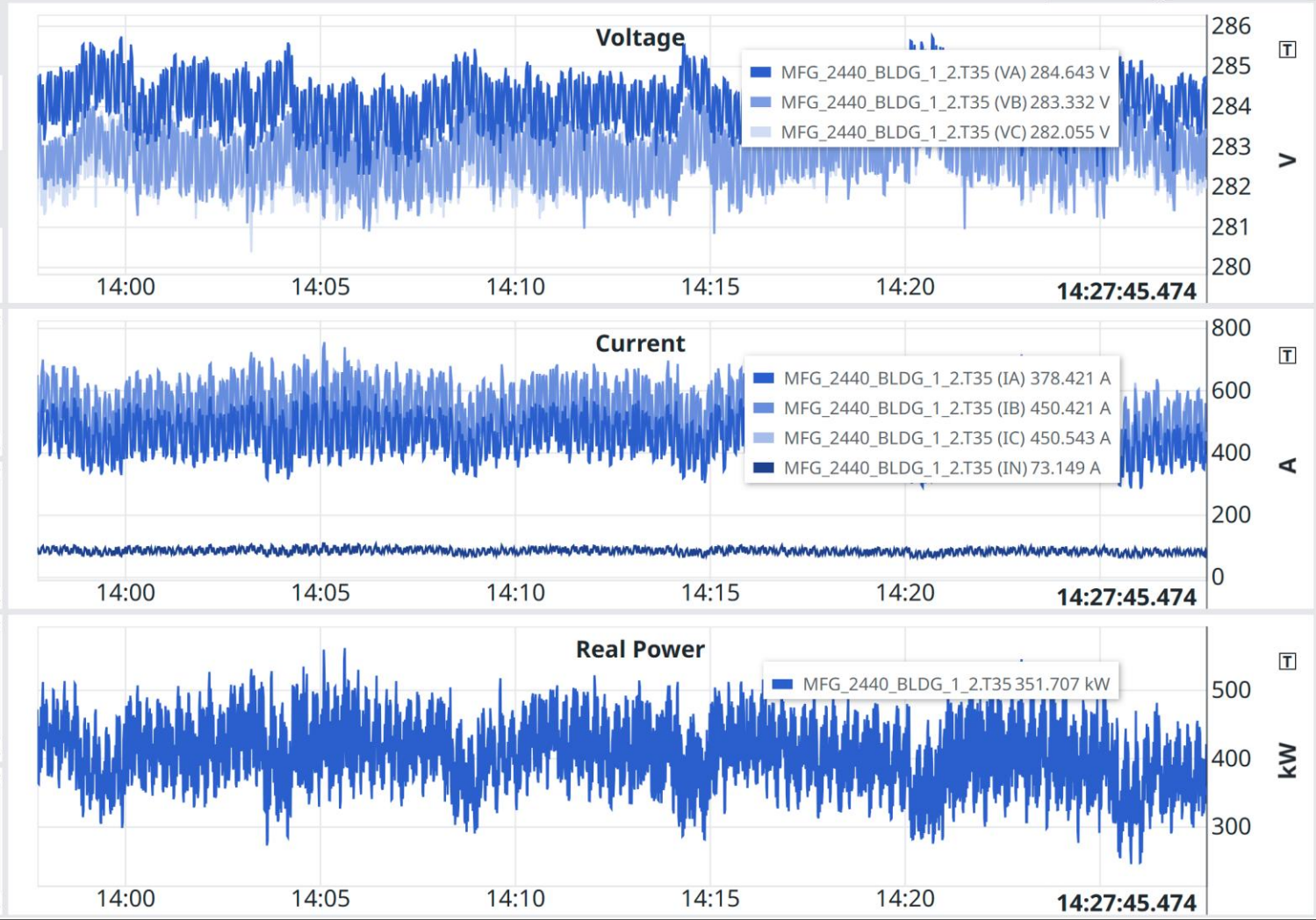
Easily identify disturbances

$$IQx[k] = x[k] - x[k - 240]$$



Meter Data

Measurement Points ▾	VA RMS	VB RMS	VC RMS	Freq
MFG_2440_BLDG...	284.327 V	282.684 V	282.837 V	59.985
Measurement Points ▾	IA RMS	IB RMS	IC RMS	IN RMS
MFG_2440_BLDG...	413.918 A	495.764 A	465.381 A	79.223 A
Measurement Points ▾	S3	SA	SB	SC
MFG_2440_BLDG...	389.460 kVA	117.688 kVA	140.145 kVA	131.627 kVA
Measurement Points ▾	P3	PA	PB	PC
MFG_2440_BLDG...	364.913 kW	111.805 kW	130.021 kW	123.087 kW
Measurement Points ▾	Q3	QA	QB	QC
MFG_2440_BLDG...	136.081 kVar	36.744 kVar	52.299 kVar	46.643 kVar
Measurement Points ▾	VA 1CYC THD	VB 1CYC THD	VC 1CYC THD	
MFG_2440_BLDG...	1.959 %	2.191 %	2.016 %	



Synchrophasors

ThreePhase Power Real

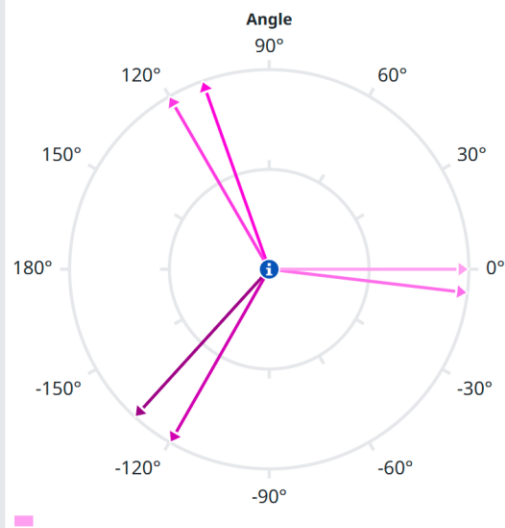
MFG_2440_BLDG_1_2.T35

370.142 kW

Frequency

MFG_2440_BLDG_1_2.T35

59.999 Hz



Voltage Magnitude

T

Voltage Magnitude

MFG_2440_BLDG_1_2.T35 (PhaseA)

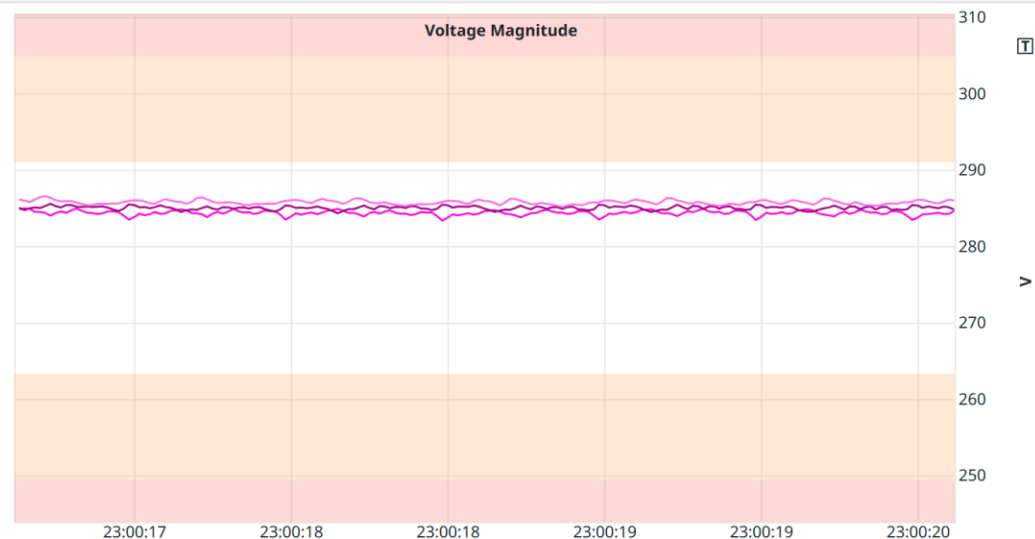
285.964 V

MFG_2440_BLDG_1_2.T35 (PhaseC)

284.609 V

MFG_2440_BLDG_1_2.T35 (PhaseB)

284.765 V



Current Magnitude

F

Current Magnitude

MFG_2440_BLDG_1_2.T35 (PhaseA)

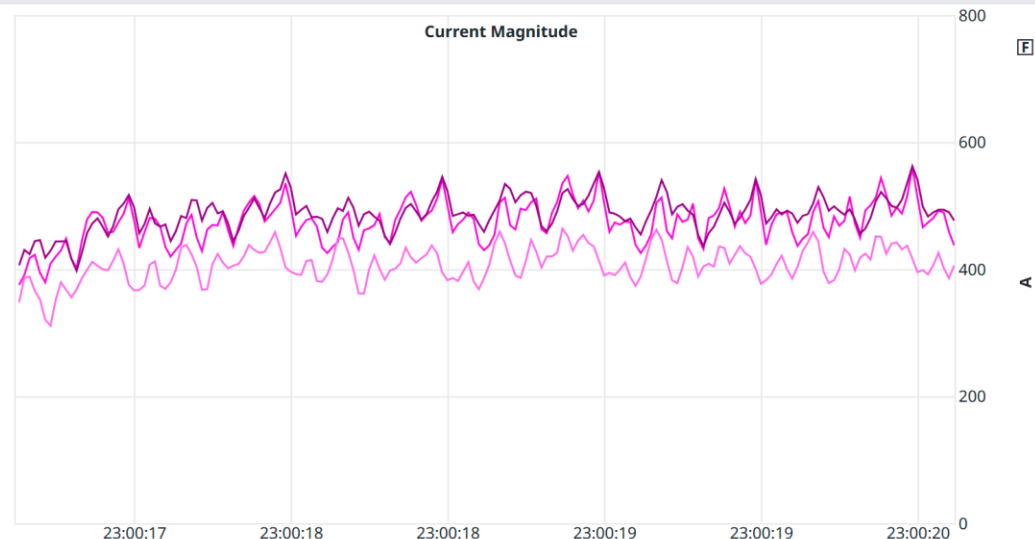
405.720 A

MFG_2440_BLDG_1_2.T35 (PhaseB)

476.691 A

MFG_2440_BLDG_1_2.T35 (PhaseC)

437.615 A



Load Profile Trending

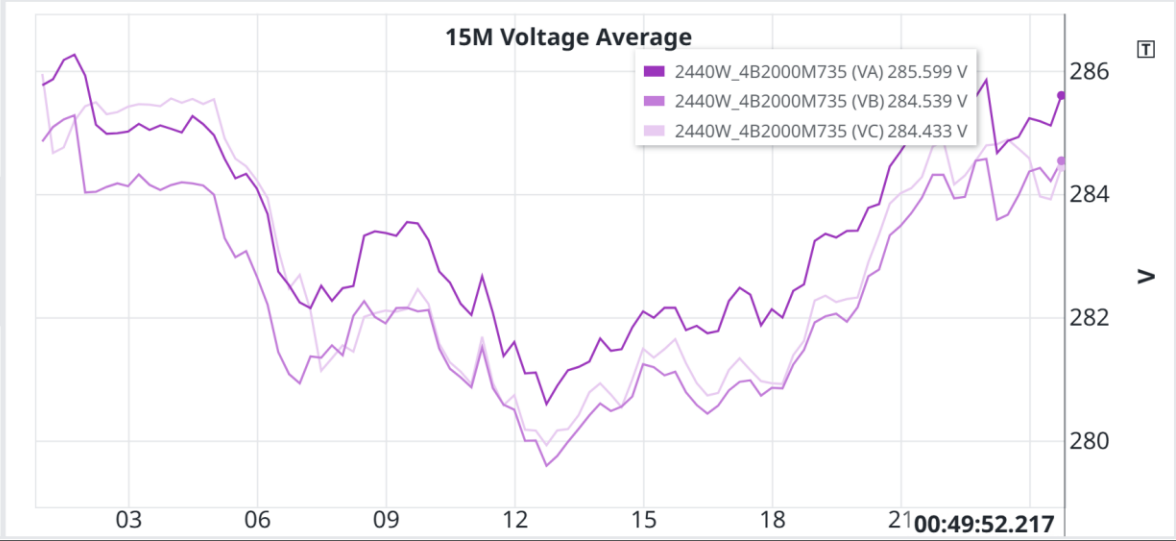
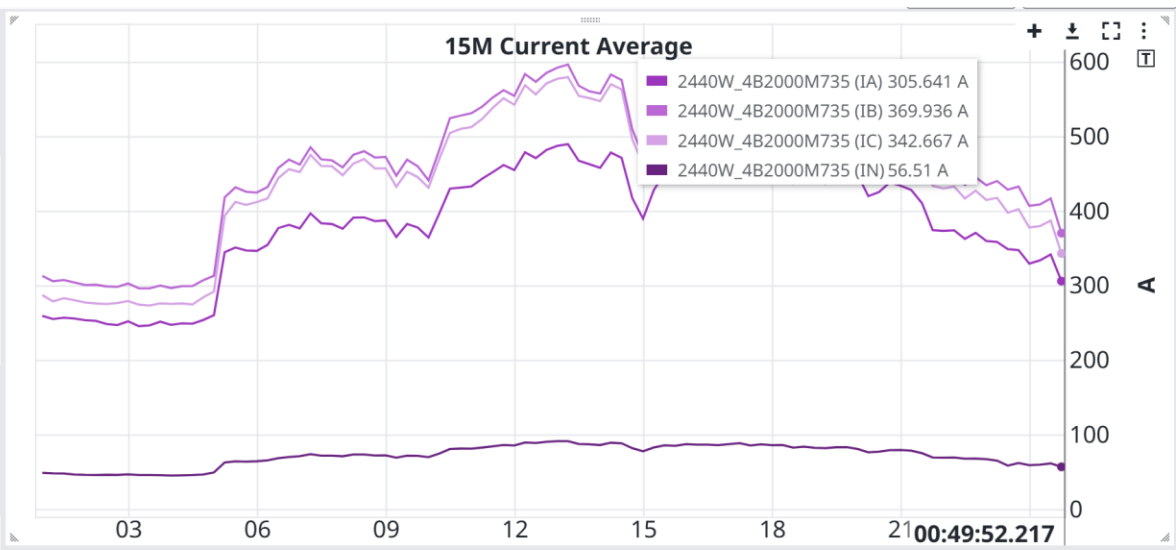
- Data Compression: End-of-Interval
- Identifying Metrics: Max, Min, Average.
- Simple calculations: Sum, RMS, Change-Over-Interval

Load Profile Data

Measurement Points	LDP IA	LDP IB	LDP IC	LDP IN	LDP VA	LDP VB	LDP VC
	RMS	RMS	RMS	RMS	RMS	RMS	RMS
	MAX	MAX	MAX	MAX	MAX	MAX	MAX
	900	900	900	900	900	900	MAX 900
2440W_4B2000M...	453.220 A	557.480 A	539.776 A	77.680 A	287.247 V	285.978 V	285.650 V

Measurement Points	LDP IA	LDP IB	LDP IC	LDP IN	LDP VA	LDP VB	LDP VC
	RMS	RMS	RMS	RMS	RMS	RMS	RMS
	MIN	MIN	MIN	MIN	MIN	MIN	MIN
	900	900	900	900	900	900	MIN 900
2440W_4B2000M...	180.235 A	220.236 A	198.831 A	40.479 A	283.202 V	281.985 V	282.043 V

Measurement Points	LDP IA	LDP IB	LDP IC	LDP IN	LDP VA	LDP VB	LDP VC
	RMS	RMS	RMS	RMS	RMS	RMS	RMS
	AVG	AVG	AVG	AVG	AVG	AVG	AVG
	900	900	900	900	900	900	AVG 900
2440W_4B2000M...	305.641 A	369.936 A	342.667 A	56.510 A	285.599 V	284.539 V	284.433 V



Data Management

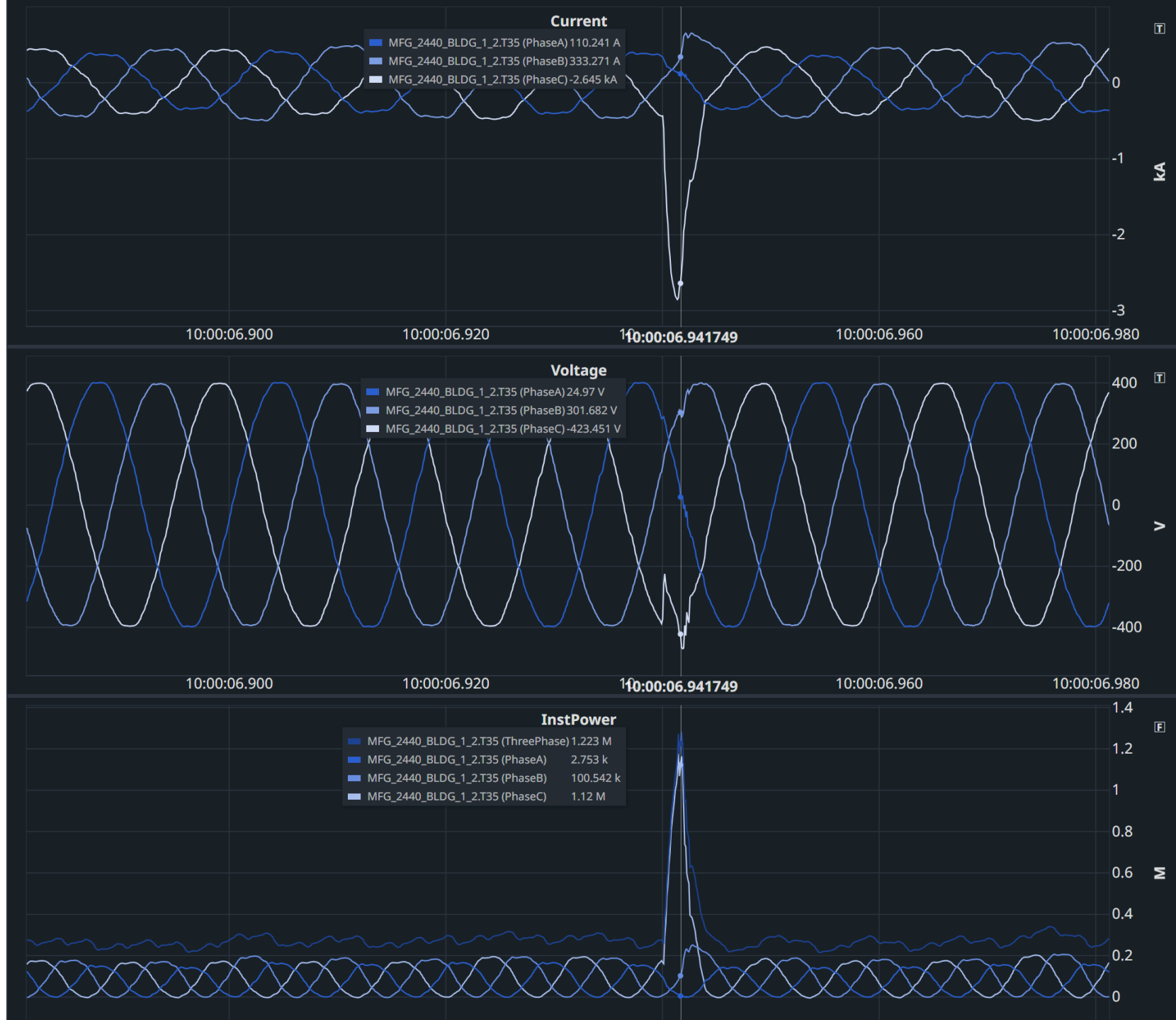
- 14.4 ksps wave form data: 5GB per day per phase
- $\frac{1}{2}$ cycle virtual meter data: <100MB per day per analog
- Synchrophasors: < 50 MB per day per phasor
- 15M average LDP data = <5 KB per day per channel

277/480 V Industrial Manufacturing Plant



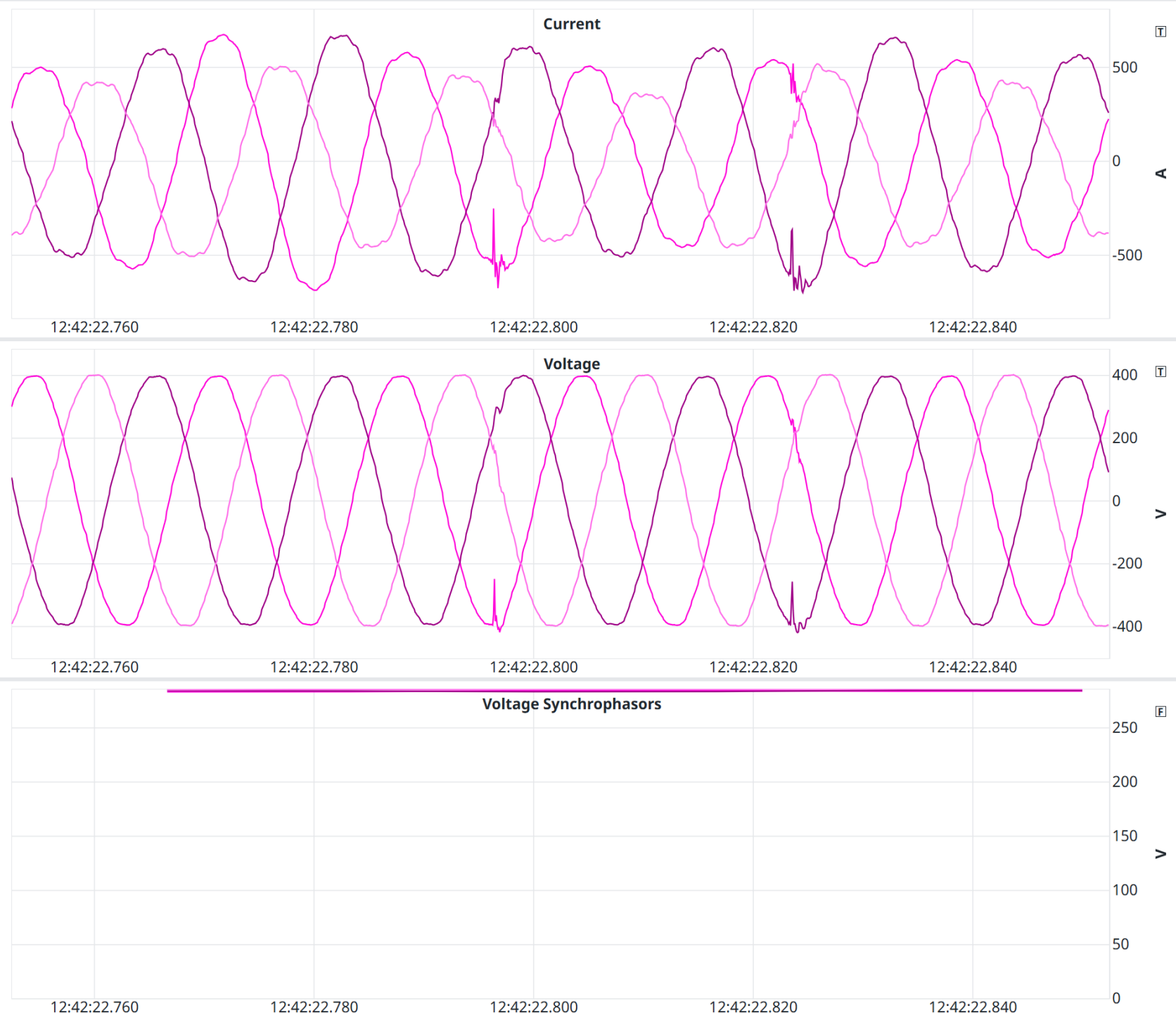
Captured Sub-Cycle Transient

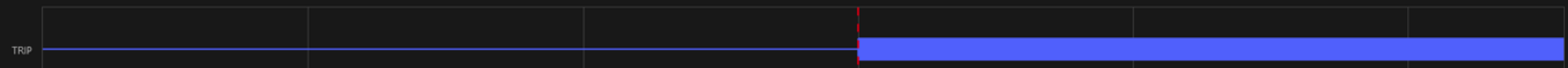
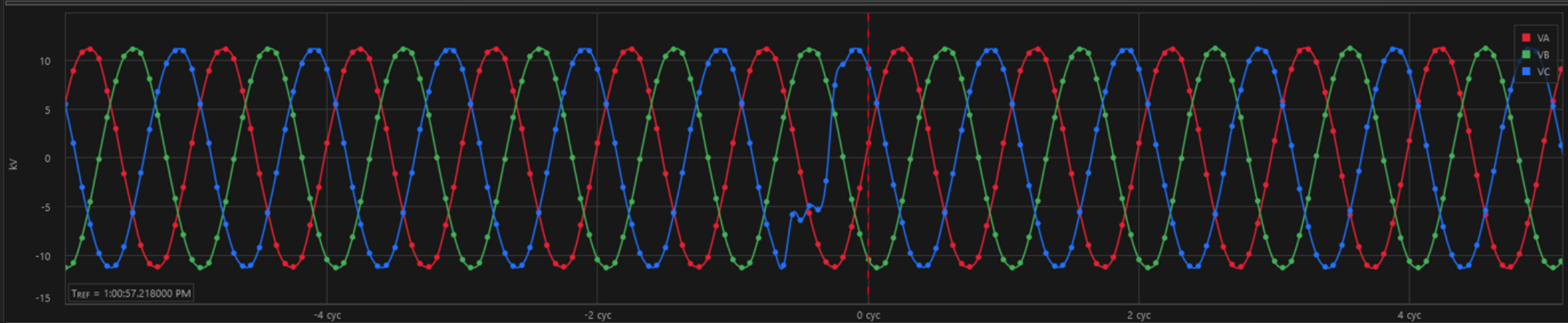
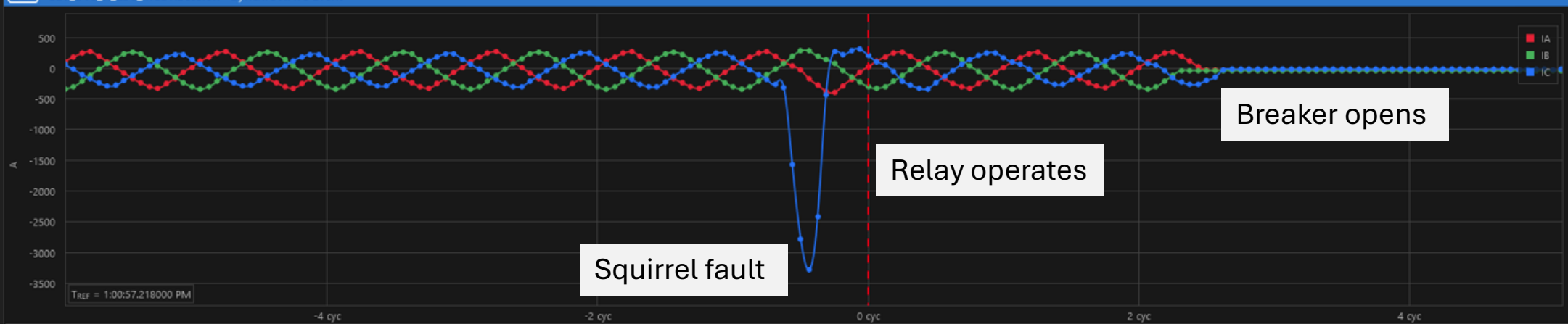
Instantaneous Fault
Current in excess of
2.8 kA



More Sub-Cycle Transients

Identifying Arcing Faults





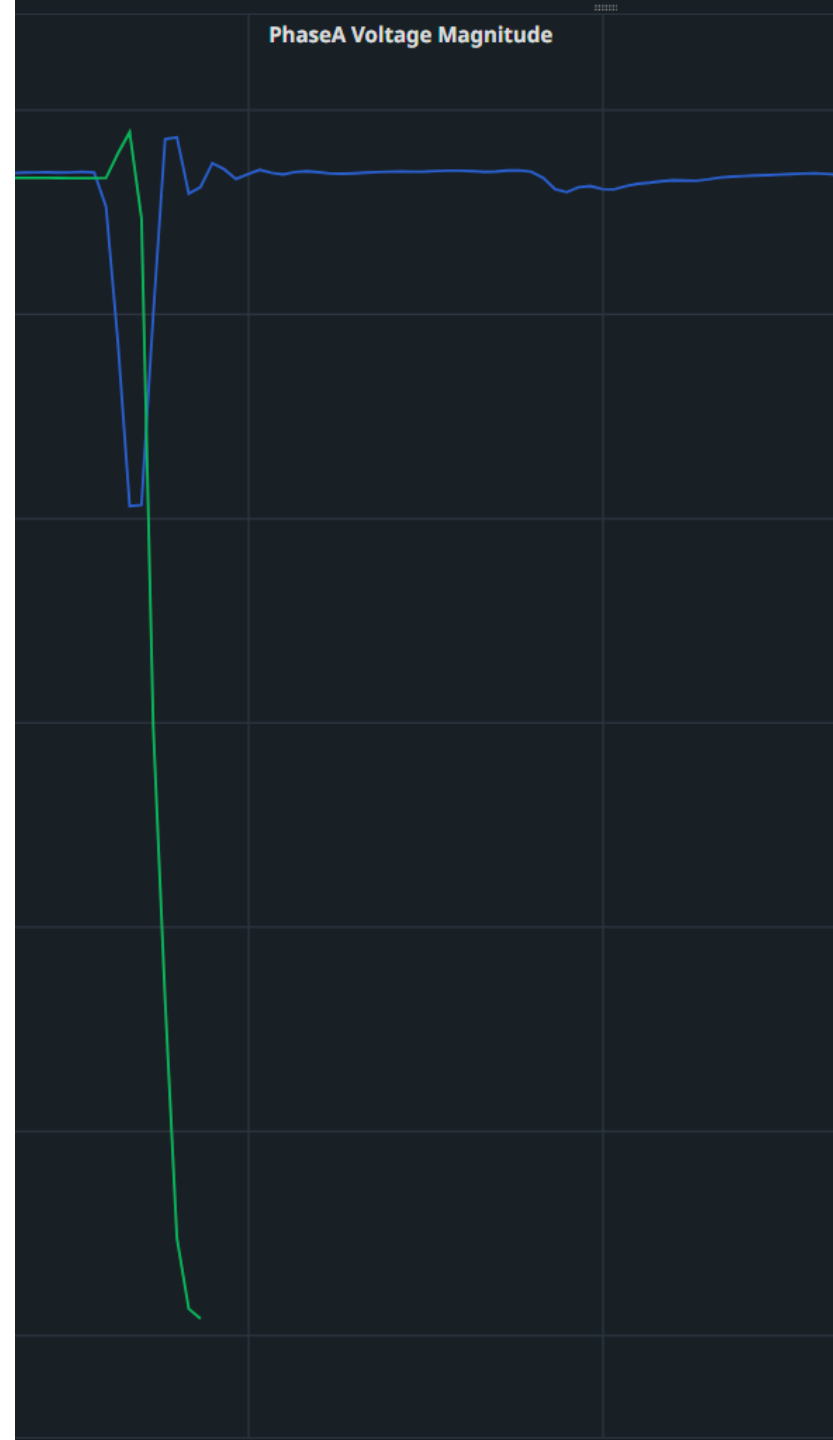
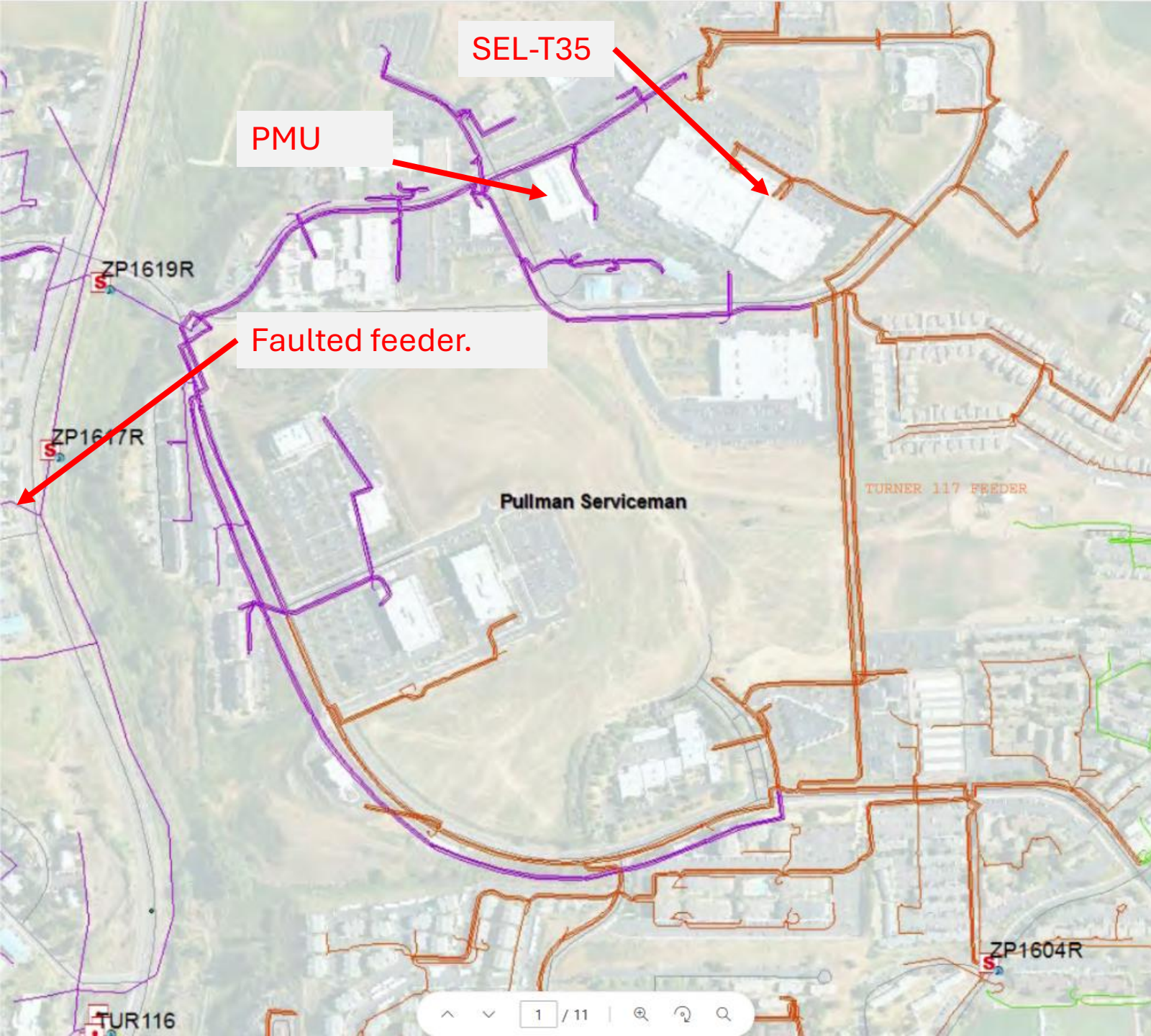
50G1

S2A

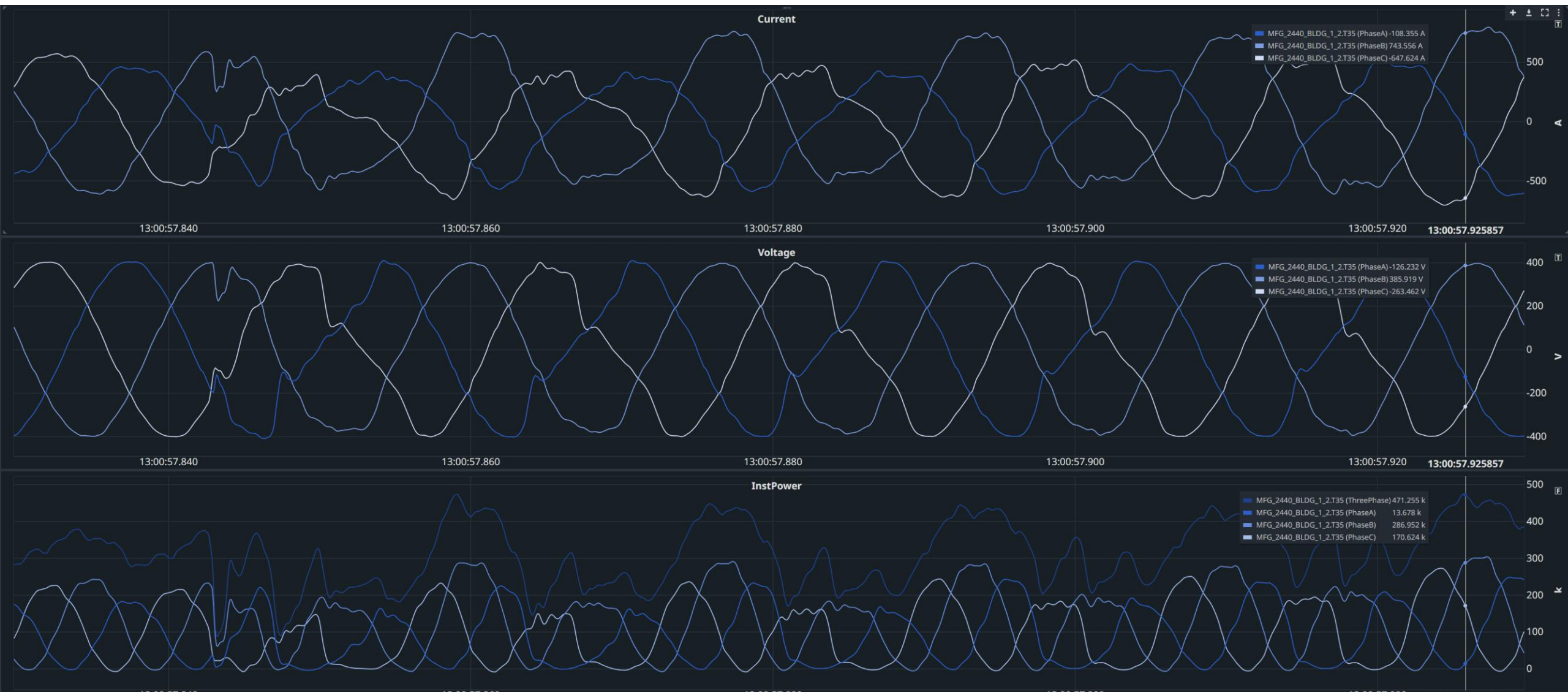
SH0

LT6

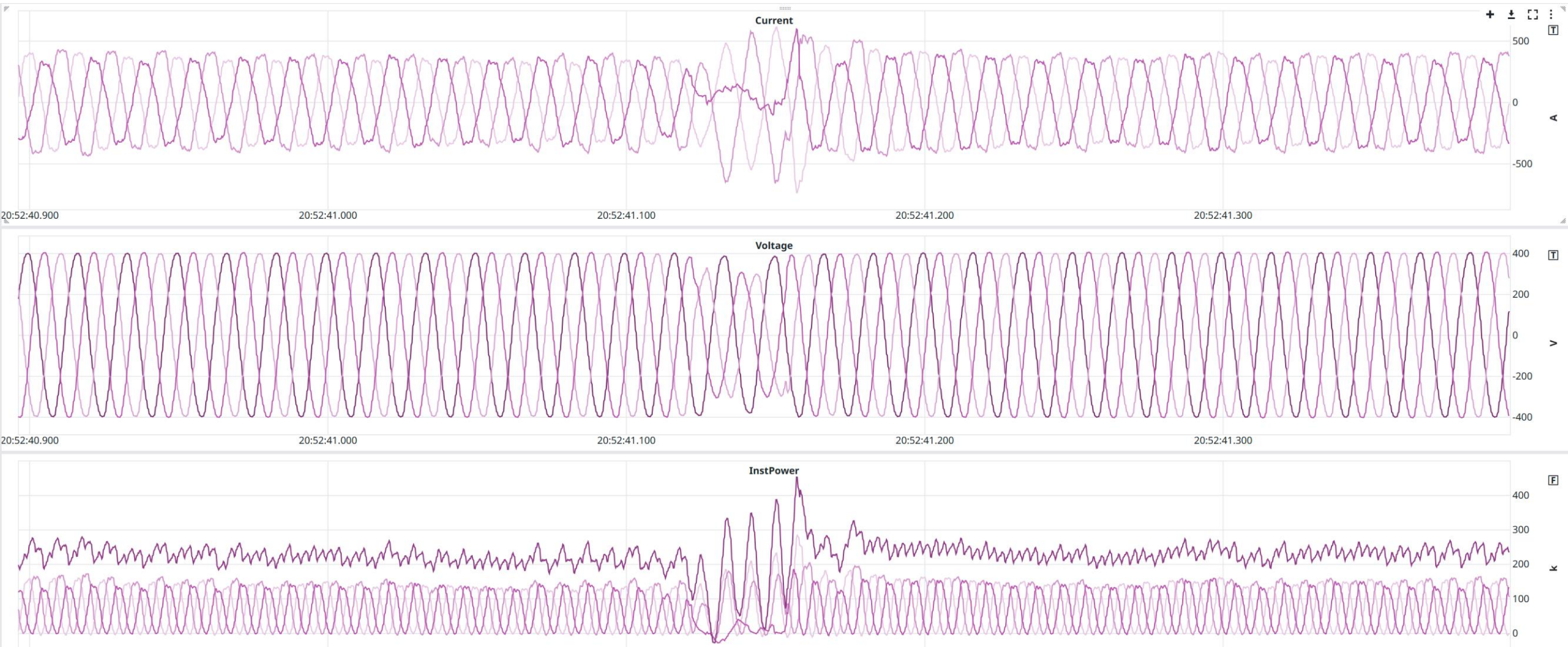
SEL-351S relay in substation captures squirrel-induced fault and breaker operation

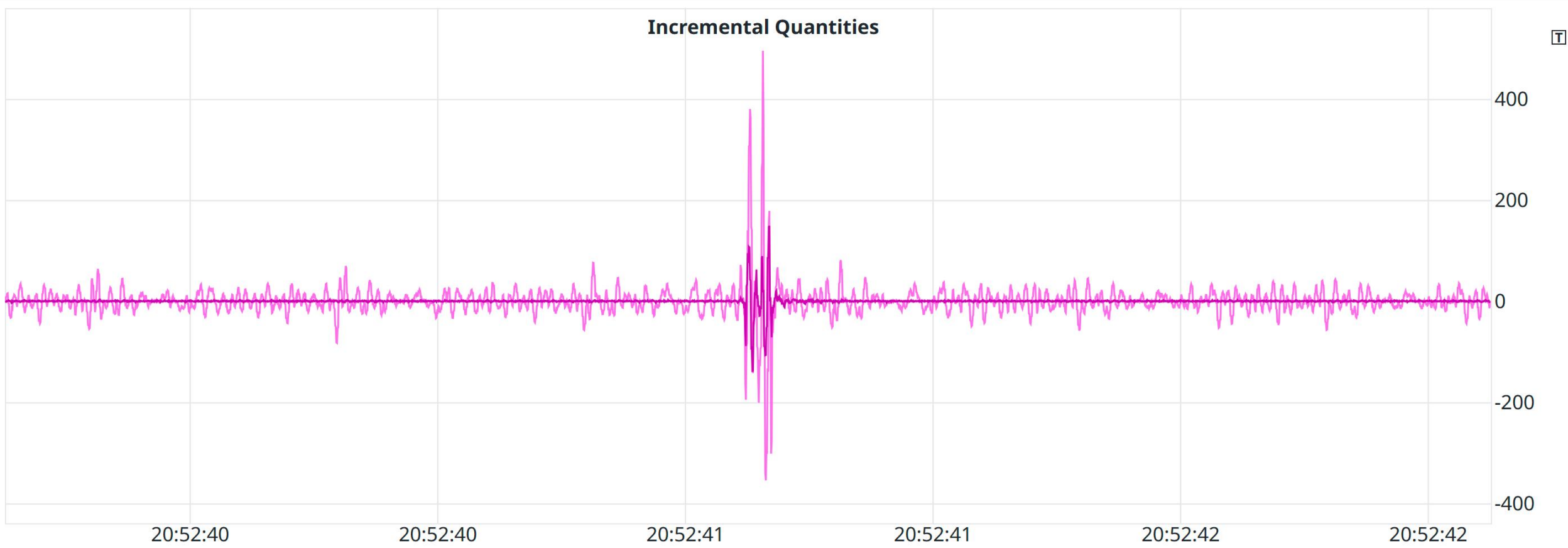
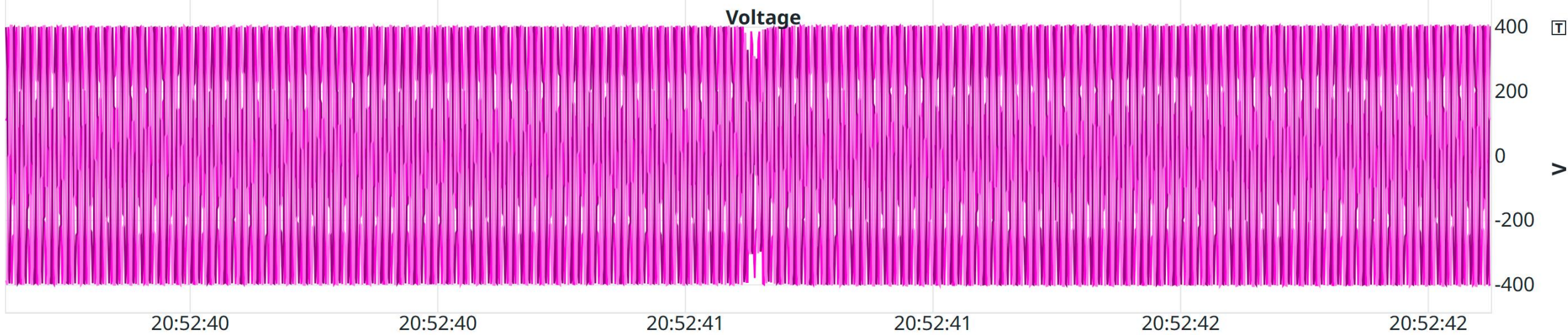


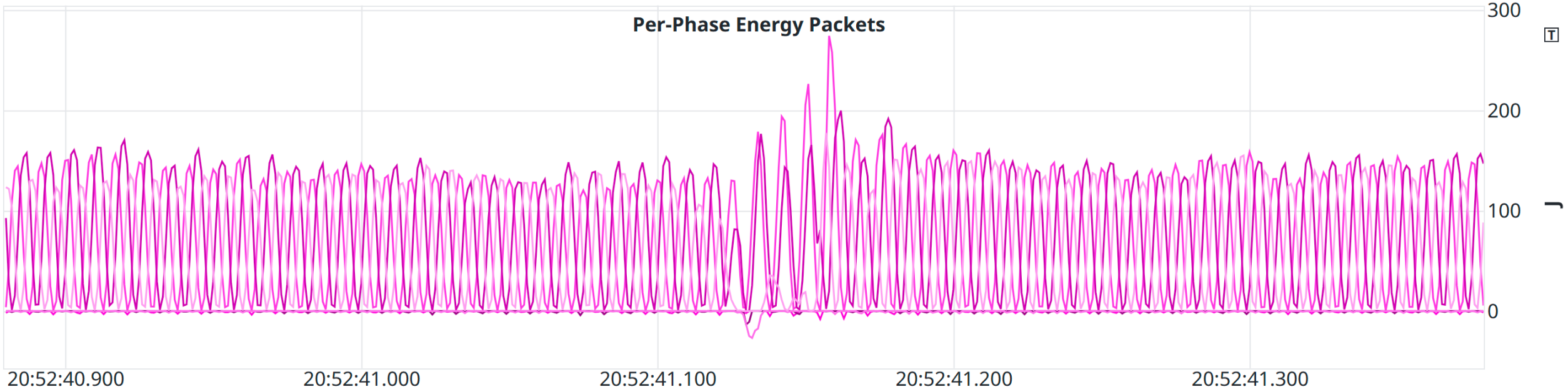
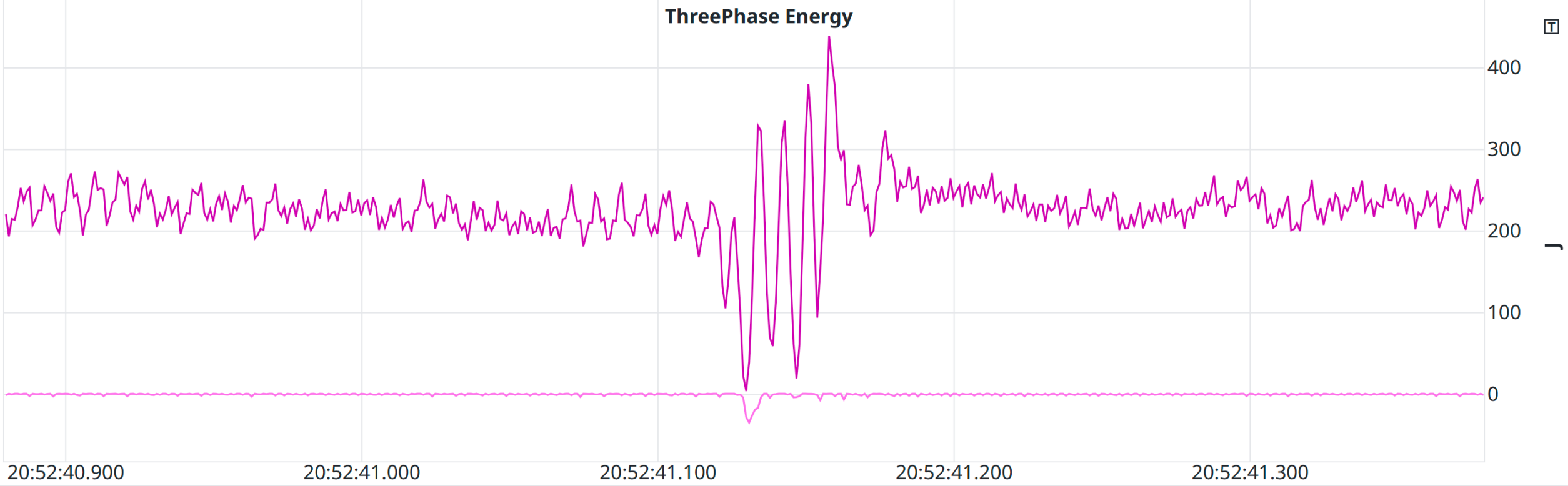
Sympathetic Response



Breaking Down Events in Real Time







Measurement Points ▼	VA RMS	VB RMS	VC RMS	Freq
MFG_2440_BLDG...	211.646 V	204.411 V	276.626 V	59.998

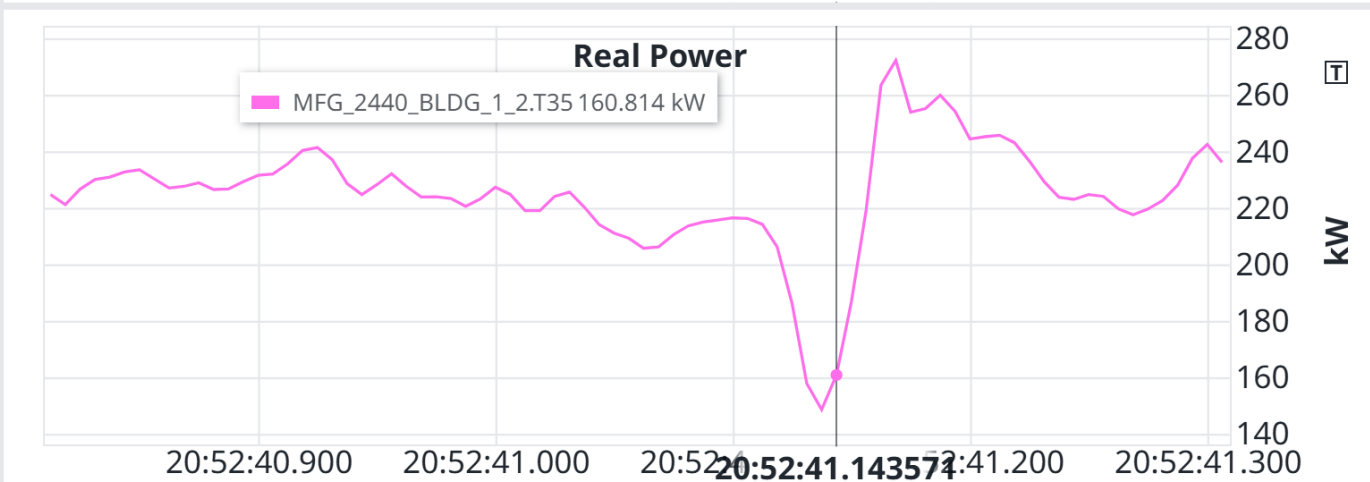
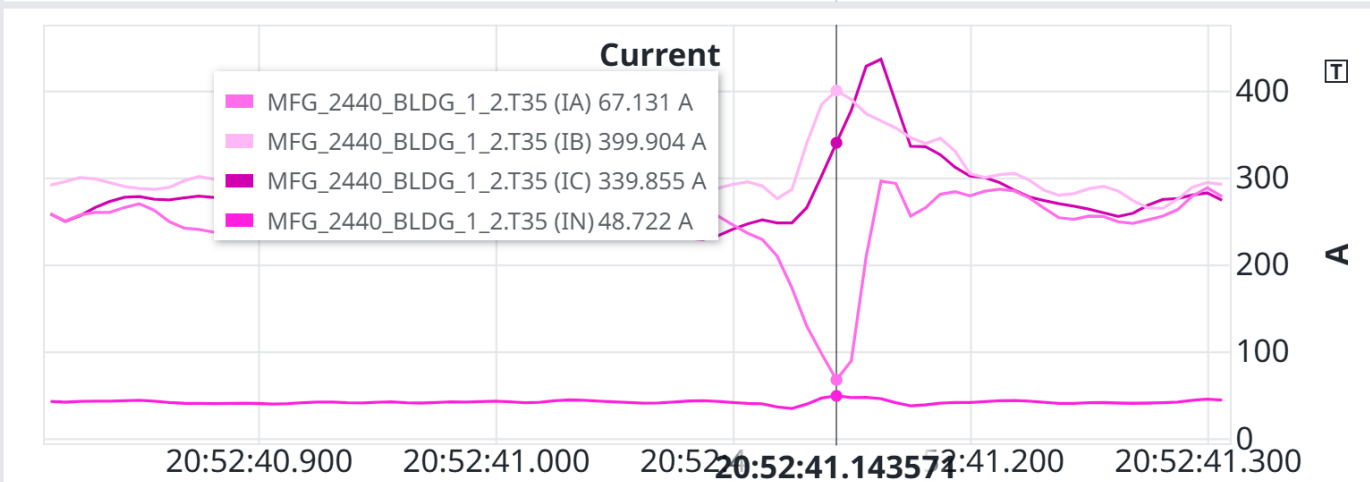
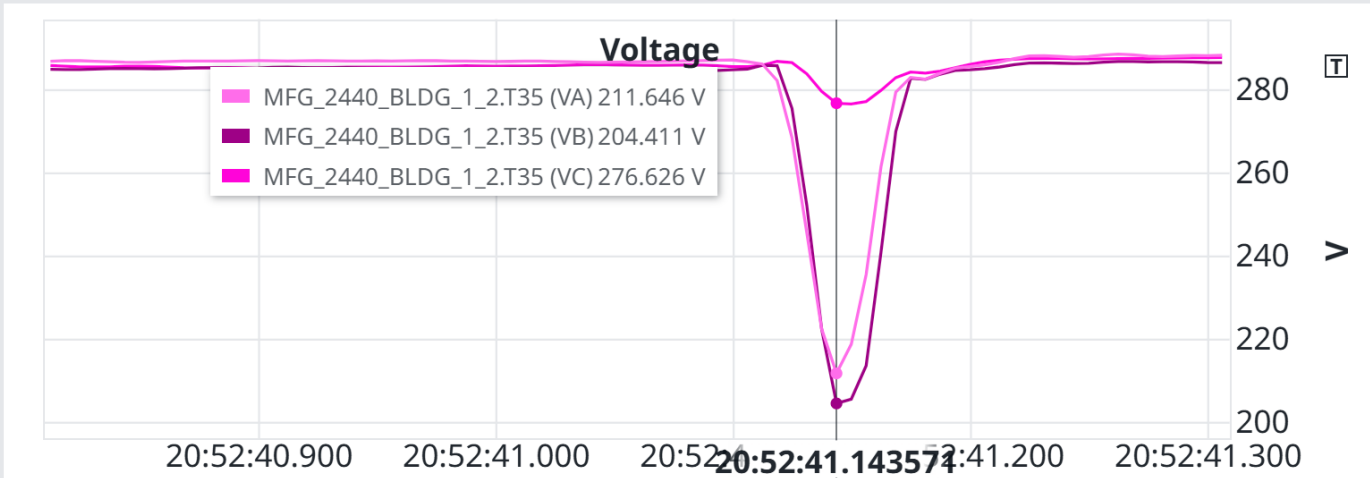
Measurement Points ▼	IA RMS	IB RMS	IC RMS	IN RMS
MFG_2440_BLDG...	67.131 A	399.904 A	339.855 A	48.721 A

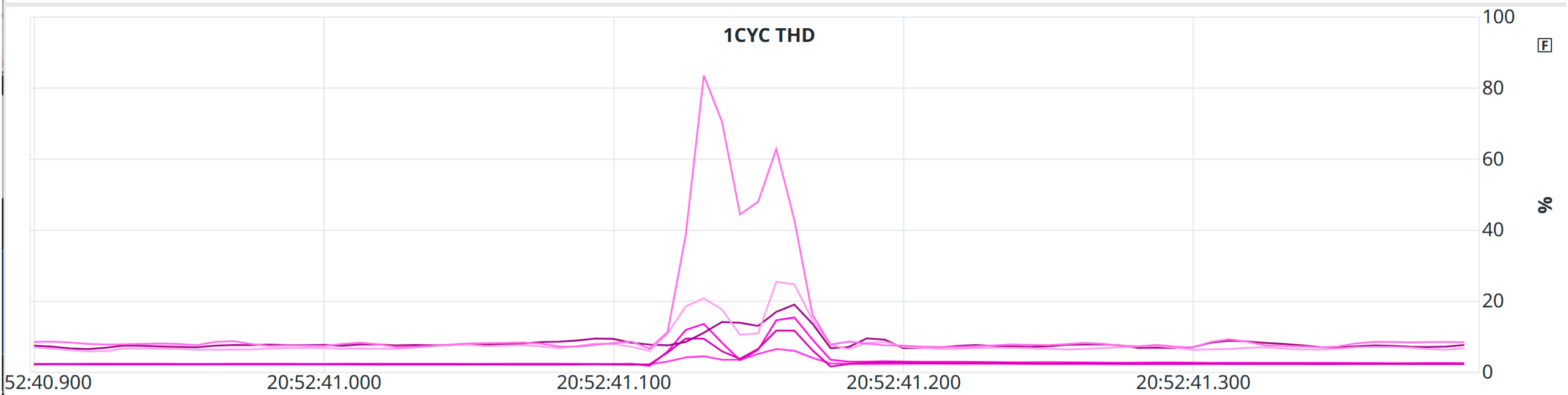
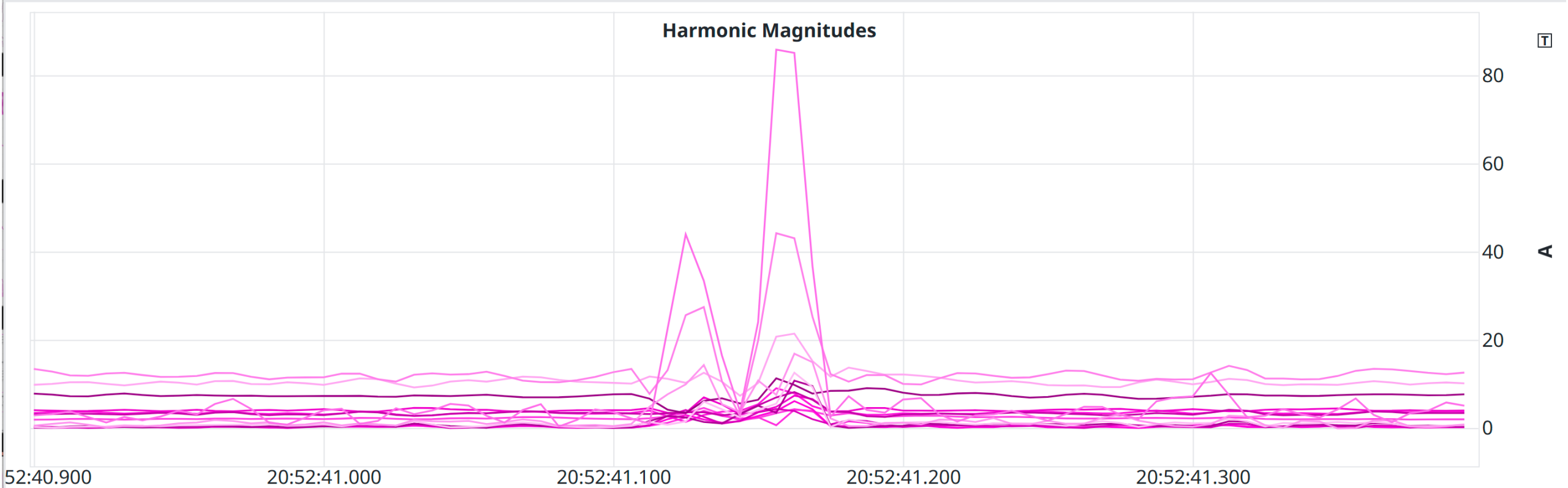
Measurement Points ▼	S3	SA	SB	SC
MFG_2440_BLDG...	189.730 kVA	13.667 kVA	82.015 kVA	94.047 kVA

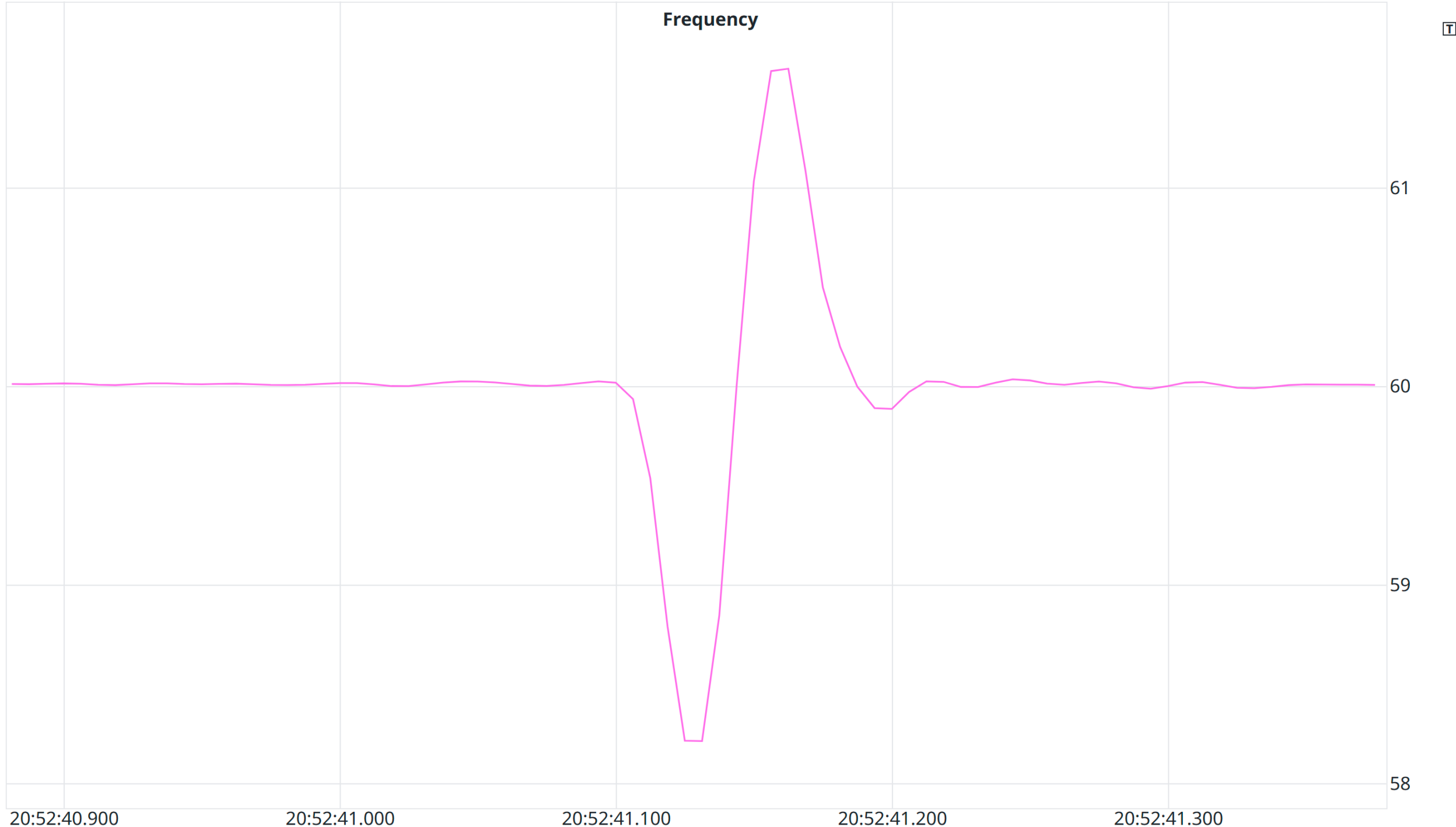
Measurement Points ▼	P3	PA	PB	PC
MFG_2440_BLDG...	160.814 kW	3.137 kW	69.401 kW	88.277 kW

Measurement Points ▼	Q3	QA	QB	QC
MFG_2440_BLDG...	-122.210 kVar	-19.429 kVar	-43.210 kVar	32.395 kVar

Measurement Points ▼	VA 1CYC THD	VB 1CYC THD	VC 1CYC THD
MFG_2440_BLDG...	3.639 %	3.272 %	3.385 %







Thank you

