Improve system operations with continuous recording

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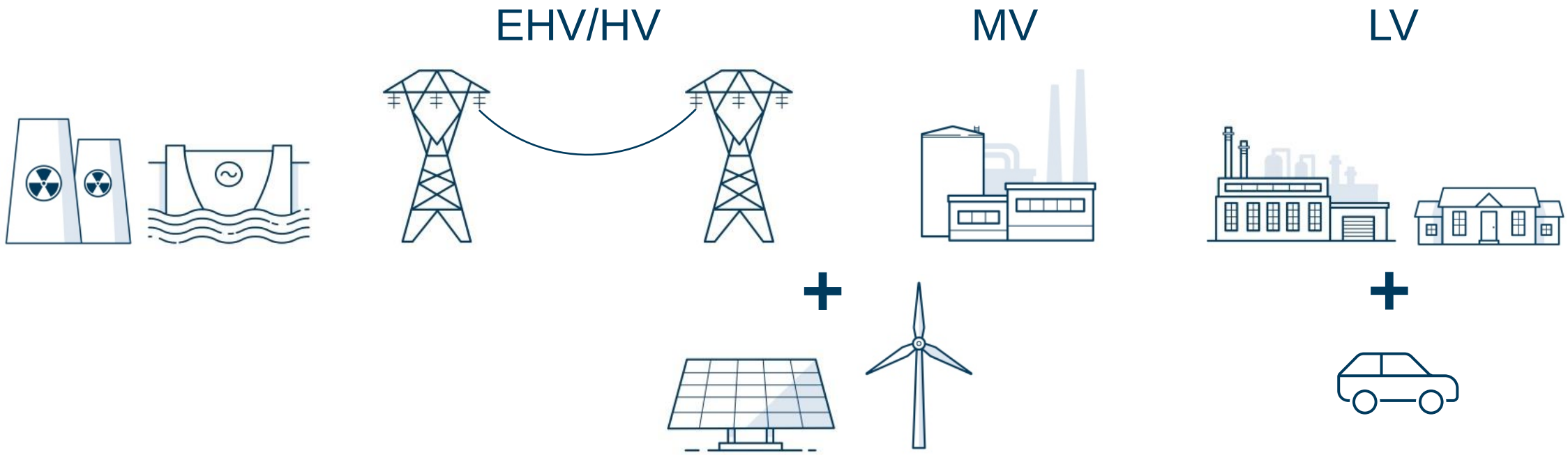
Today’s systems are nonsinusoidal

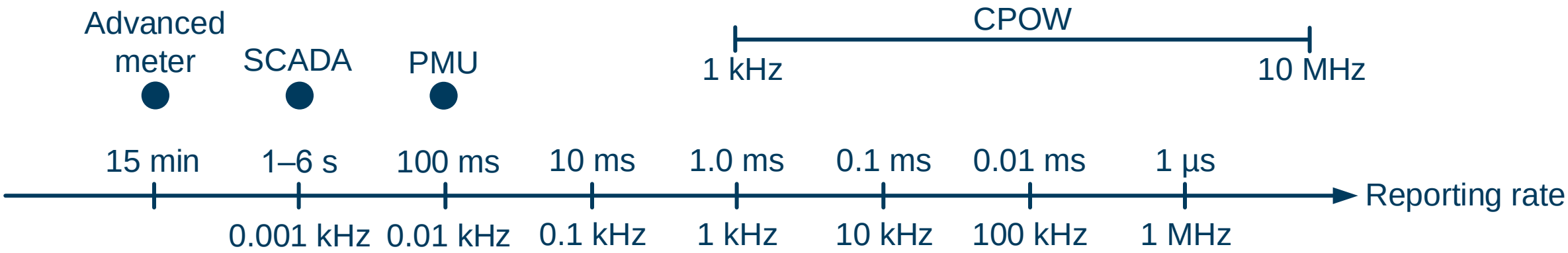
Nonsinusoidal waveform is deviation from sinusoidal waveform



Never miss an event

CONTINUOUS SYNCHRONIZED WAVEFORM RECORDING

- Waveform measurement unit (WMU)
- WMUs with 1 µs resolution waveform sampled data

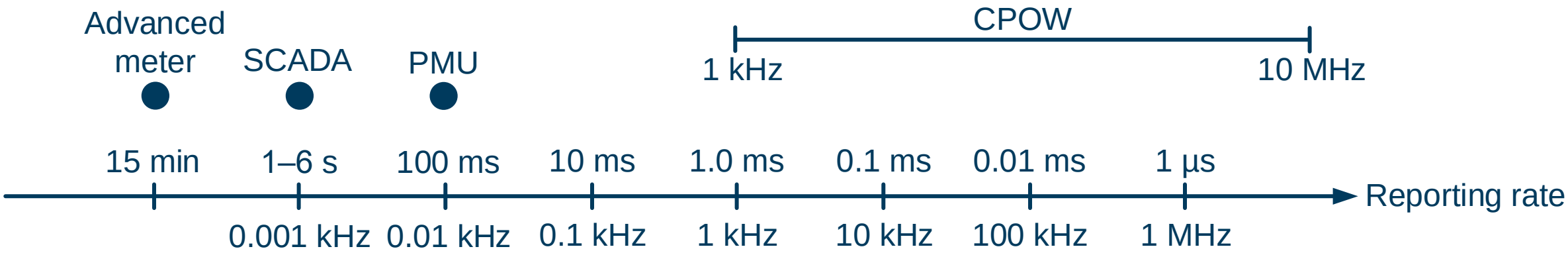


Source: NASPI-2020-TR-004

Never miss an event

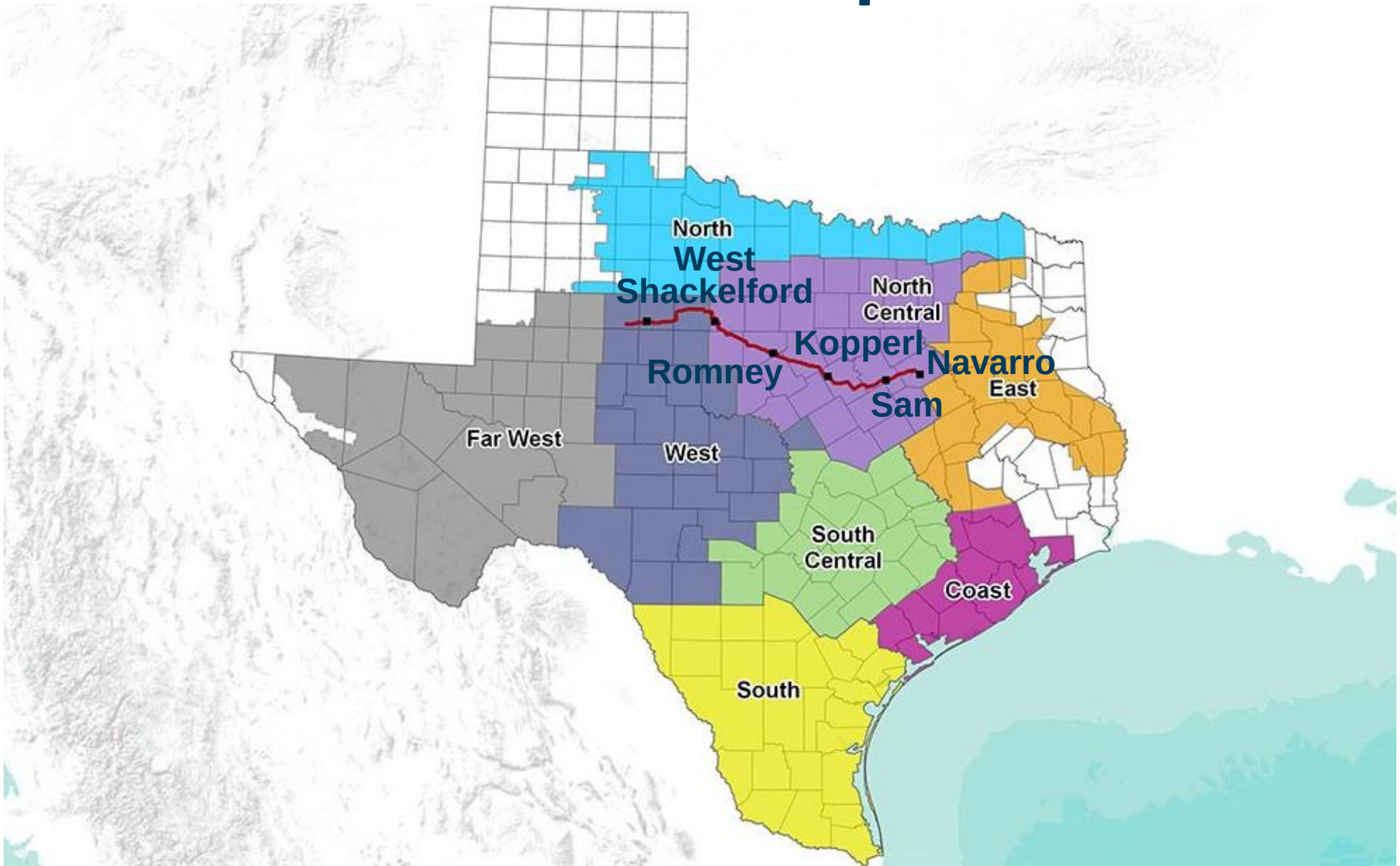
CONTINUOUS SYNCHRONIZED WAVEFORM RECORDING

- High availability, streamed from WMUs
- UTC precise time-stamped time source, < 100 ns



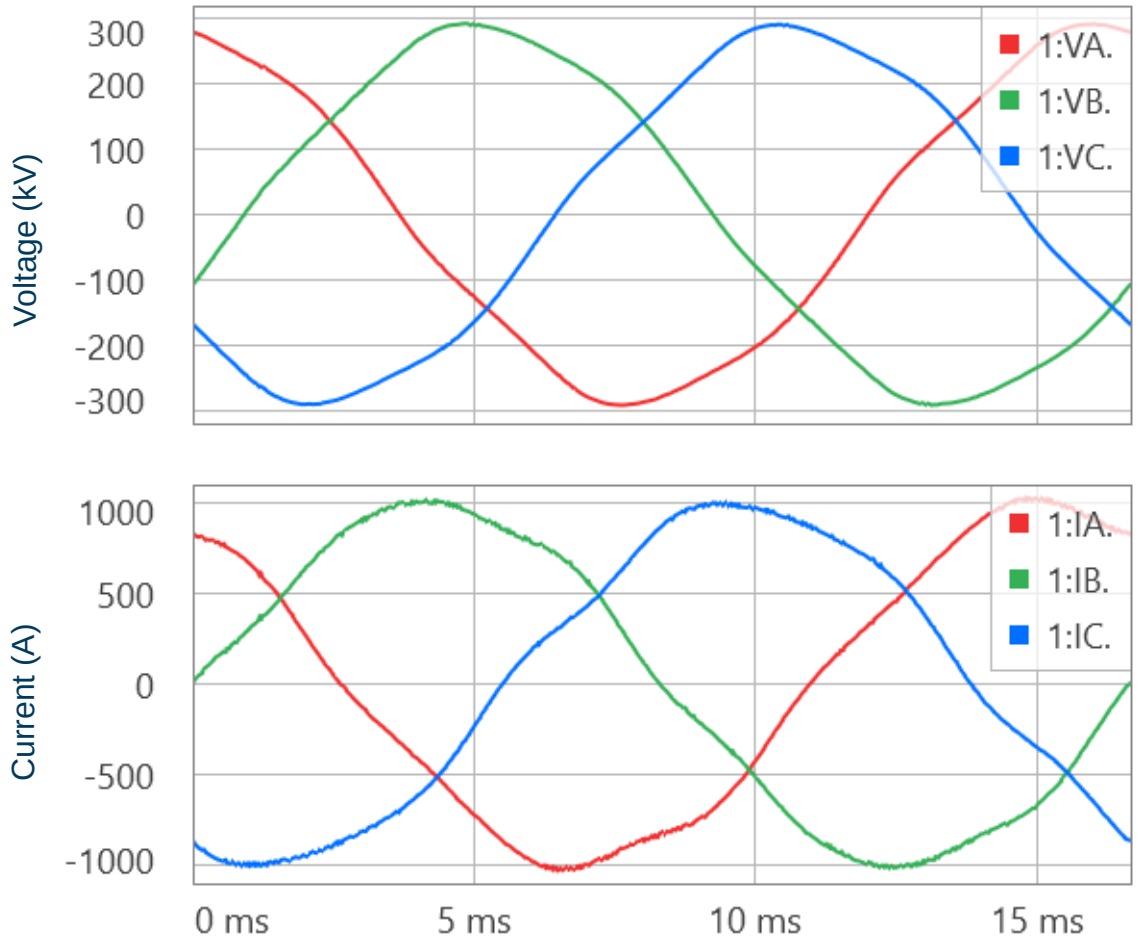
Source: NASPI-2020-TR-004

Nonsinusoidal 345 kV compensated lines

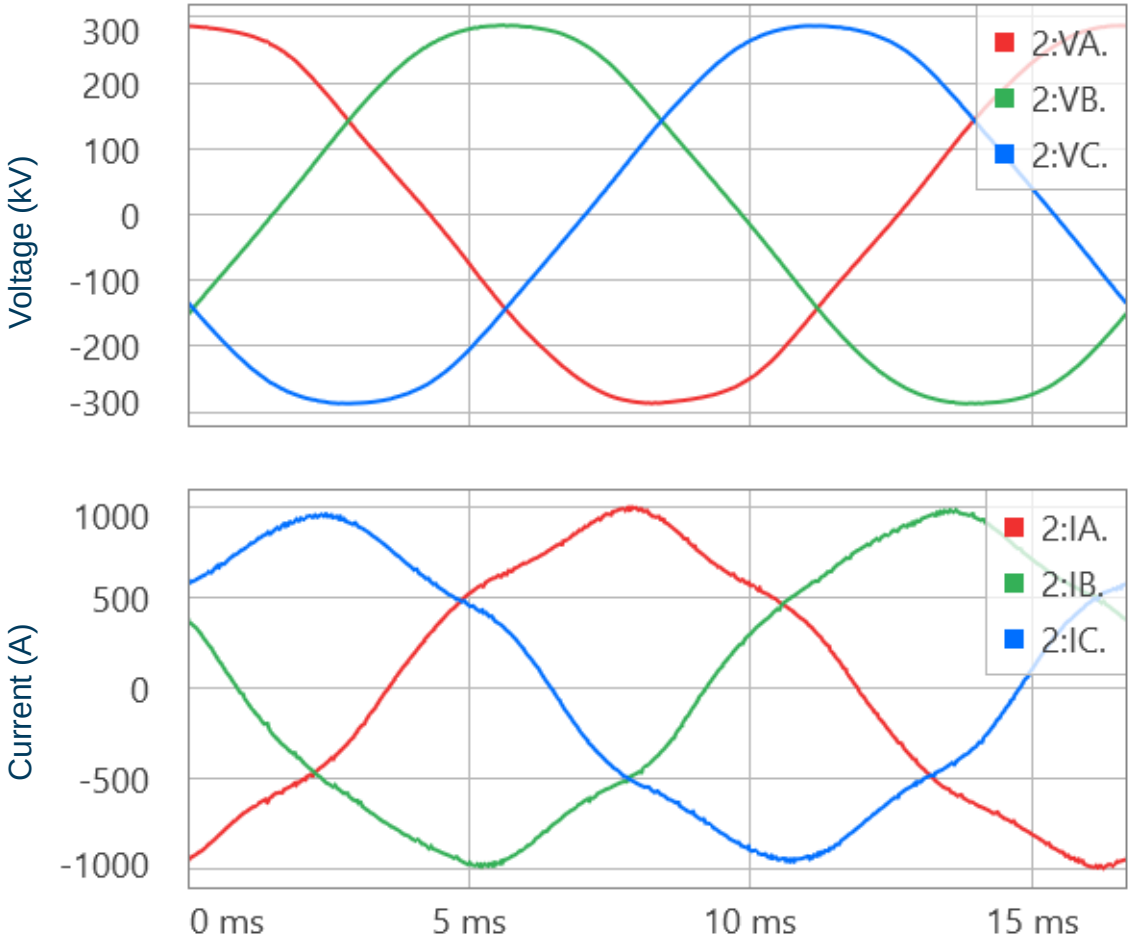


Even continuous steady state is useful

WEST SHACKELFORD

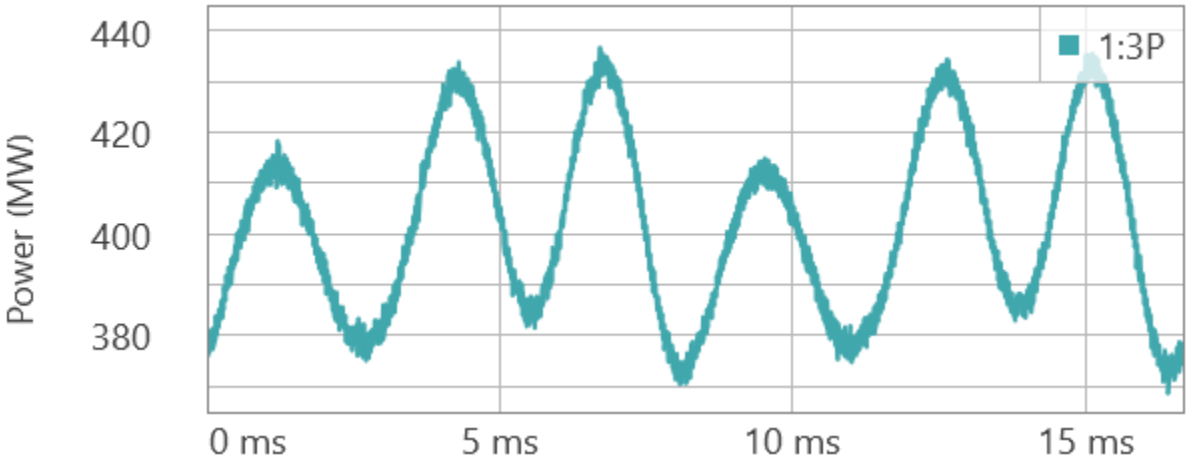


NAVARRO

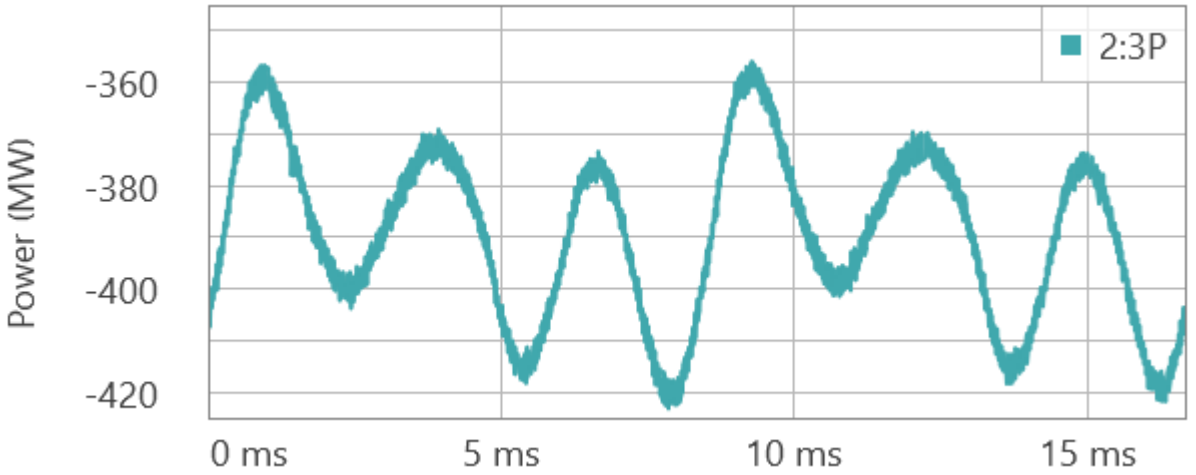


Current unbalance and harmonic content causes power to ripple

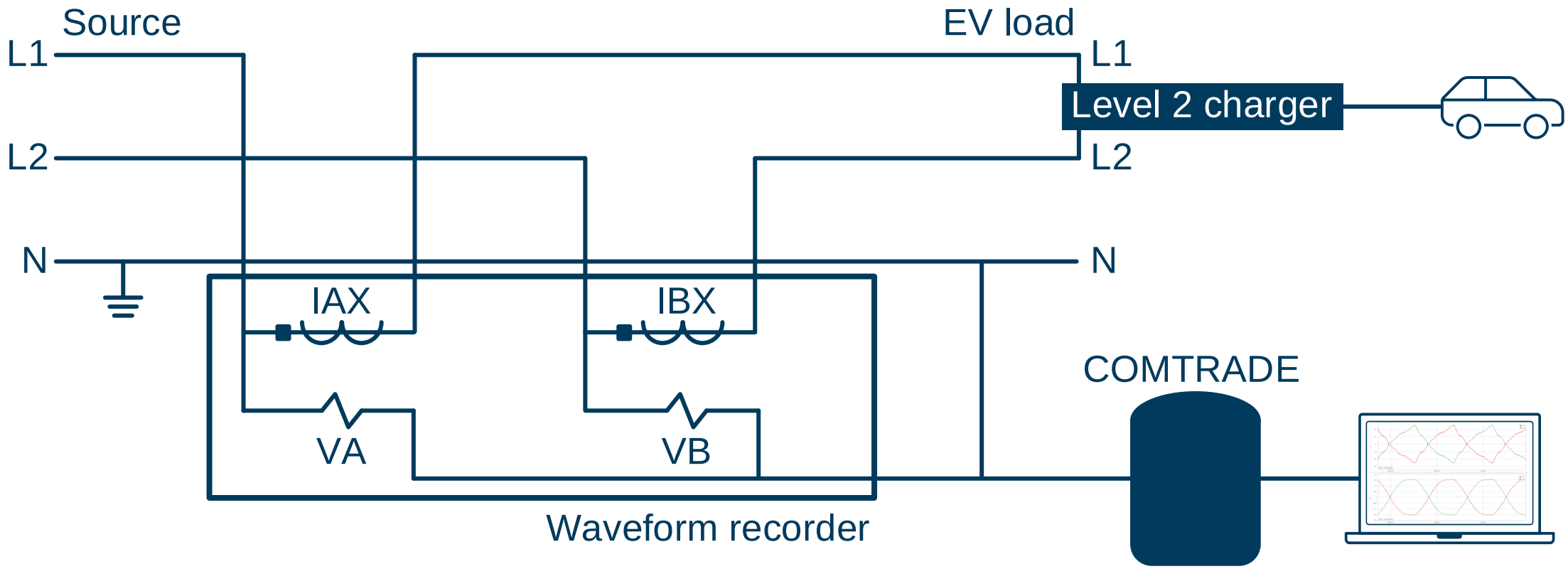
WEST SHACKELFORD



NAVARRO



EV charging creates waveform distortion, notching, and ripple



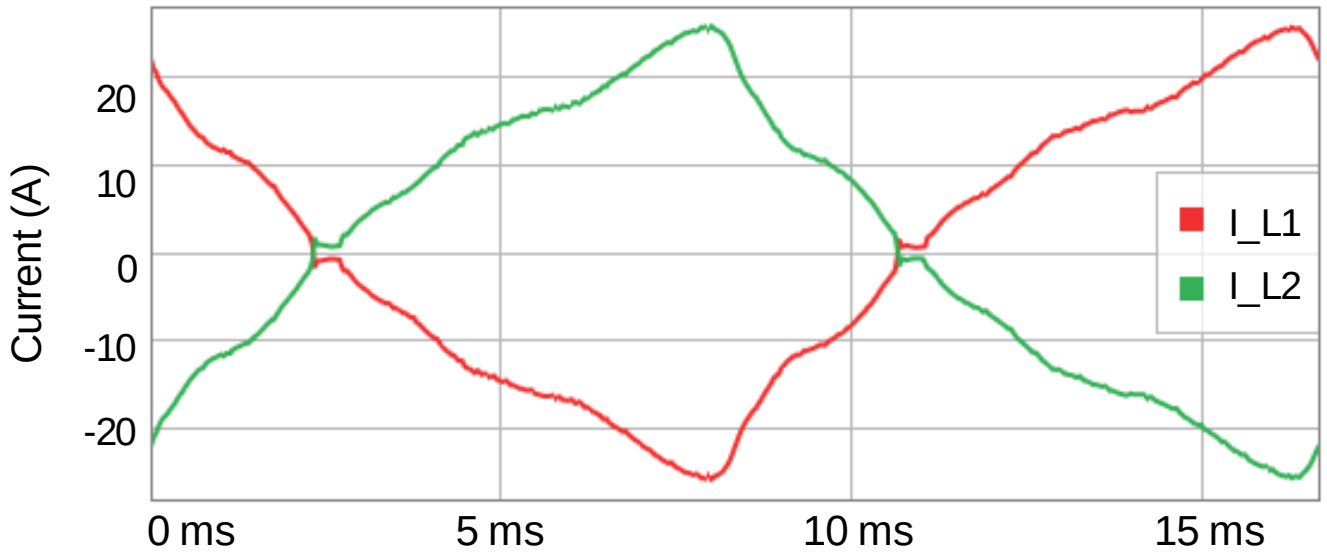
$$p[k] = v_1[k] \cdot i_1[k] + v_2[k] \cdot i_2[k]$$

EV charging waveform recording

- EV
- Level 2 charger
- 240 V source
- Waveform recorder

Are distribution transformers rated for current waveform distortion from multiple EVs?

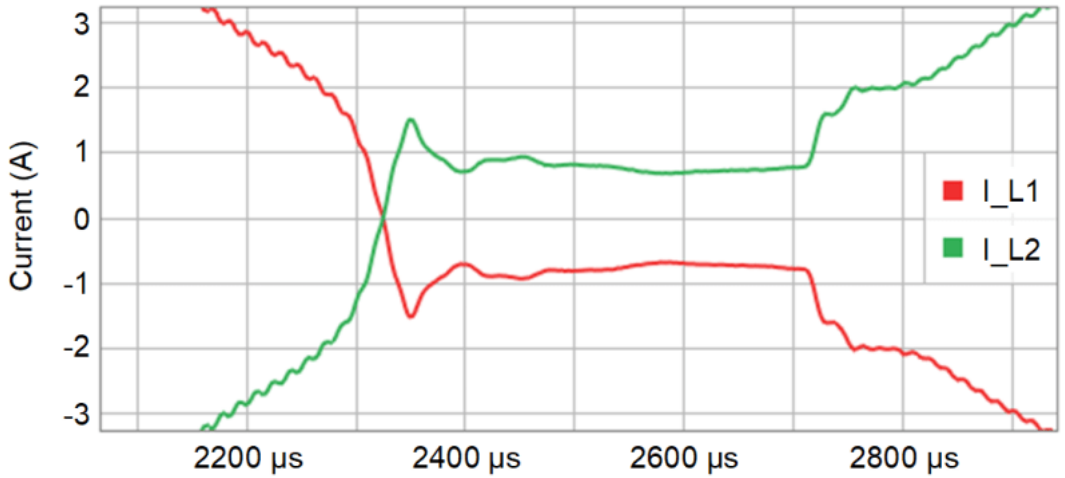
- Triangular waveshape
- Notching at zero crossing
- High-frequency ripple
- Increased I^2R losses



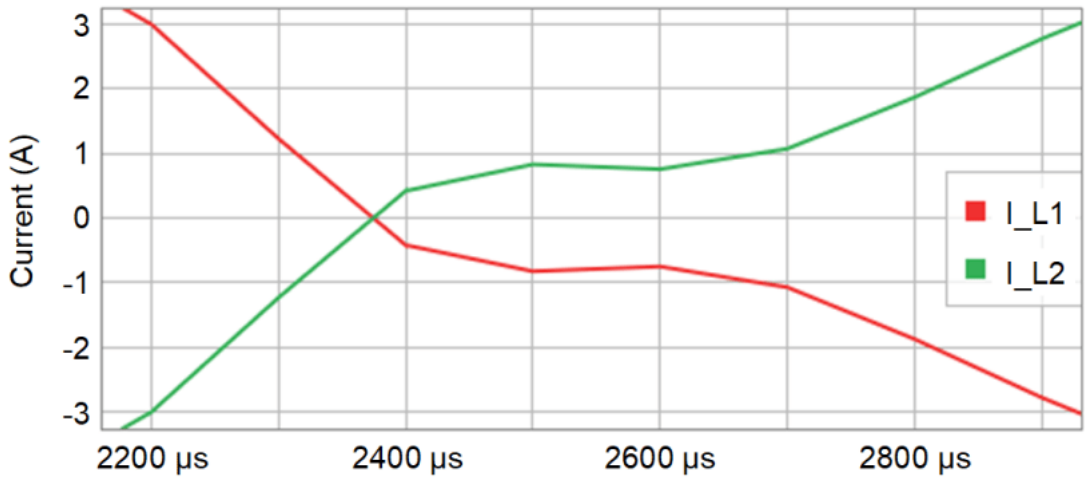
Current distortion at zero crossing captured by 1 Msps sampling

- ~1 A plateau occurs at zero crossing
- Switching between two polarized transistors is likely cause
- 10 ksps undersampled the distortion

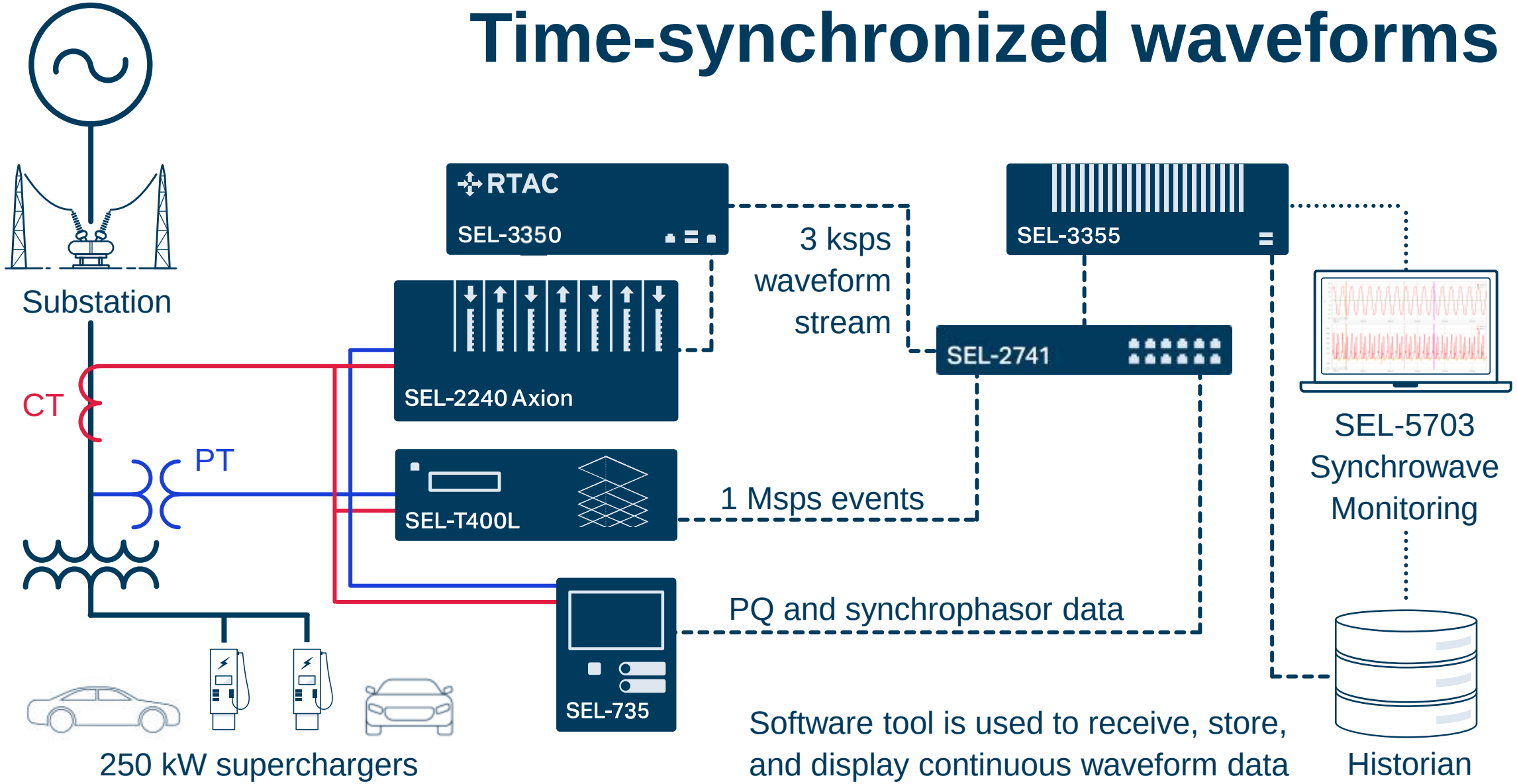
1 Msps



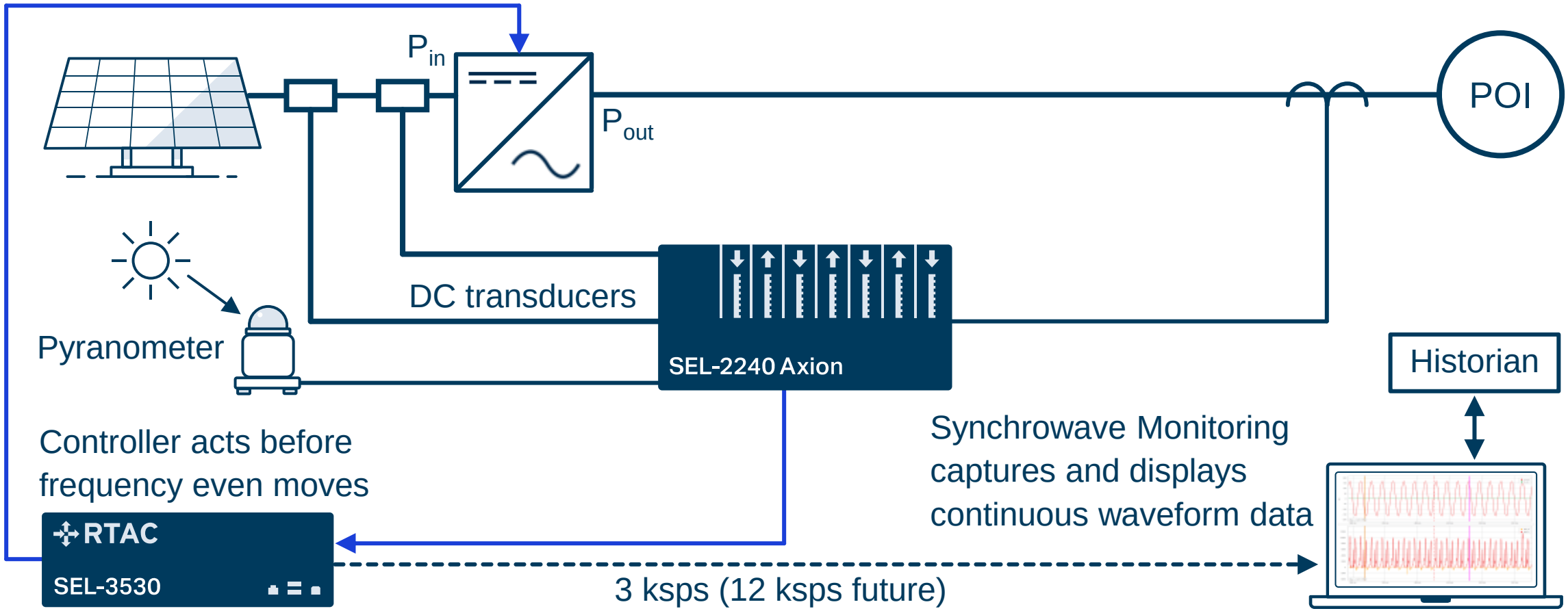
10 ksps



Time-synchronized waveforms



Millisecond streaming can improve inverter response times



Next steps

- Adapt to evolving power system of today
- Apply improved tools
- Perform field trials to validate laboratory results
- Utilize synchronized waveform measurements from WMUs
- Collect higher sample rate data to provide more insight

Thank you

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