Continuous Recording of Synchro-waveforms in Distribution Systems: Field Experiments and Data Analysis

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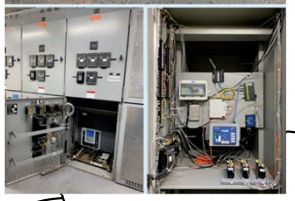
Experiments Setup:

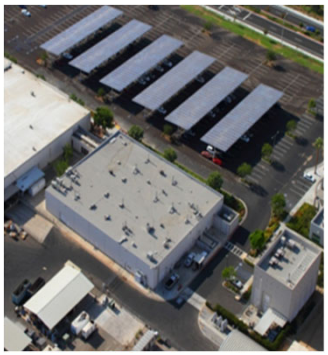
12.47 kV
Event-Triggered WMU



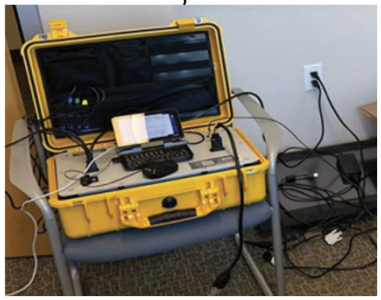
12.47 kV/69 kV/12.47 kV/480 V

Three Phase (480 V)

(Continuous WMU)



480 V



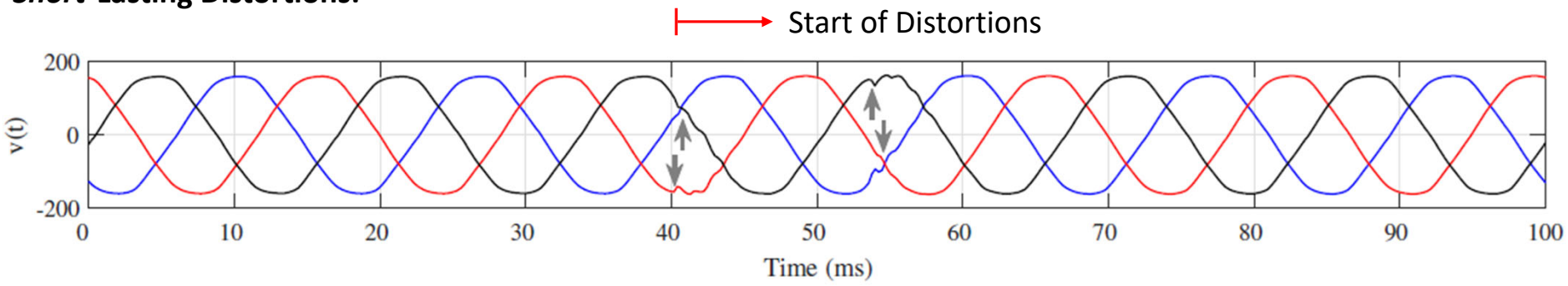
GPS Time-Synchronization

Single Phase (120 V)

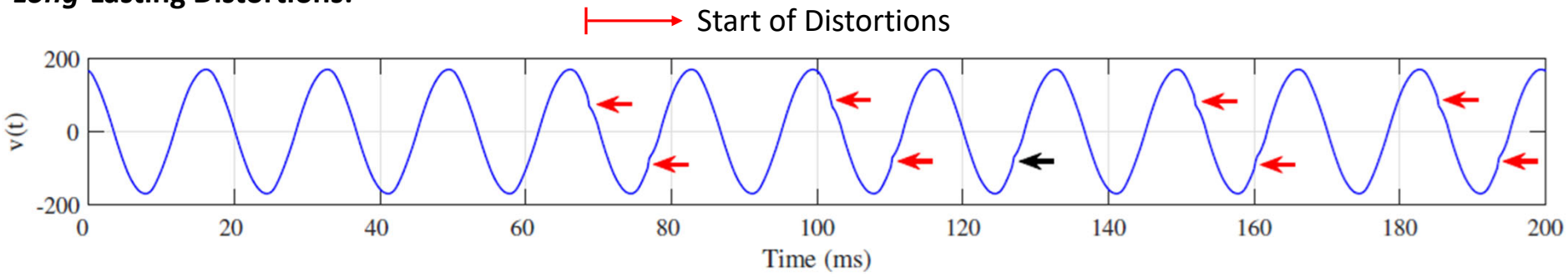
(Continuous WMU)

Continuous Waveform Measurements:

***Short*-Lasting Distortions:**

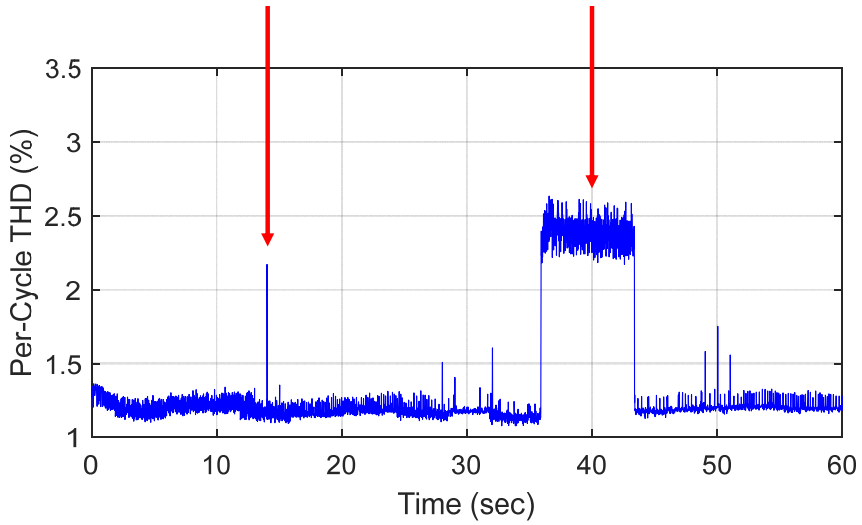


***Long*-Lasting Distortions:**

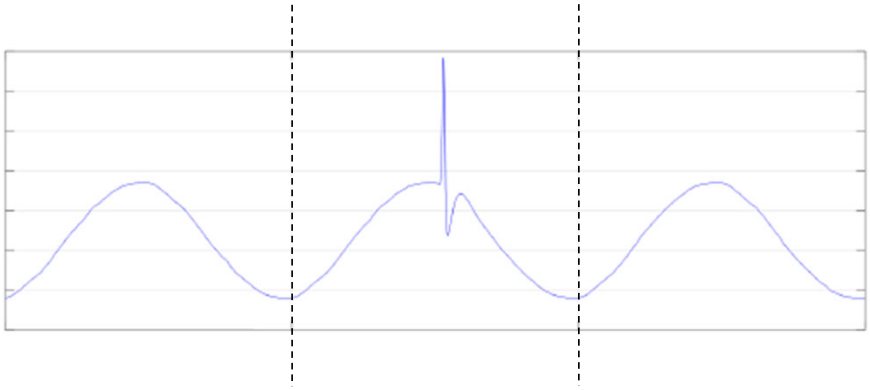


Per-Cycle THD in Continuous Waveforms:

Short-Lasing Event *Long*-Lasing Event



$$\mathrm{THD} = \sqrt{(V_{\mathrm{rms}}/V_1)^2 - 1}\,.$$



One Cycle

$V_{\mathrm{rms}}\,, V_1$

Note: May depend on definition of cycle (Cycle starts from which zero-crossing).

Event Detection in Continuous Waveforms:

$$\Delta\text{THD} = |\text{THD}^2_{\text{present}} - \text{THD}^2_{\text{prior}}| \geq \alpha$$

$$v_k(t) = v_{k-1}(t) + \Delta v_k(t),$$

Present Cycle

Prior Cycle (Baseline)

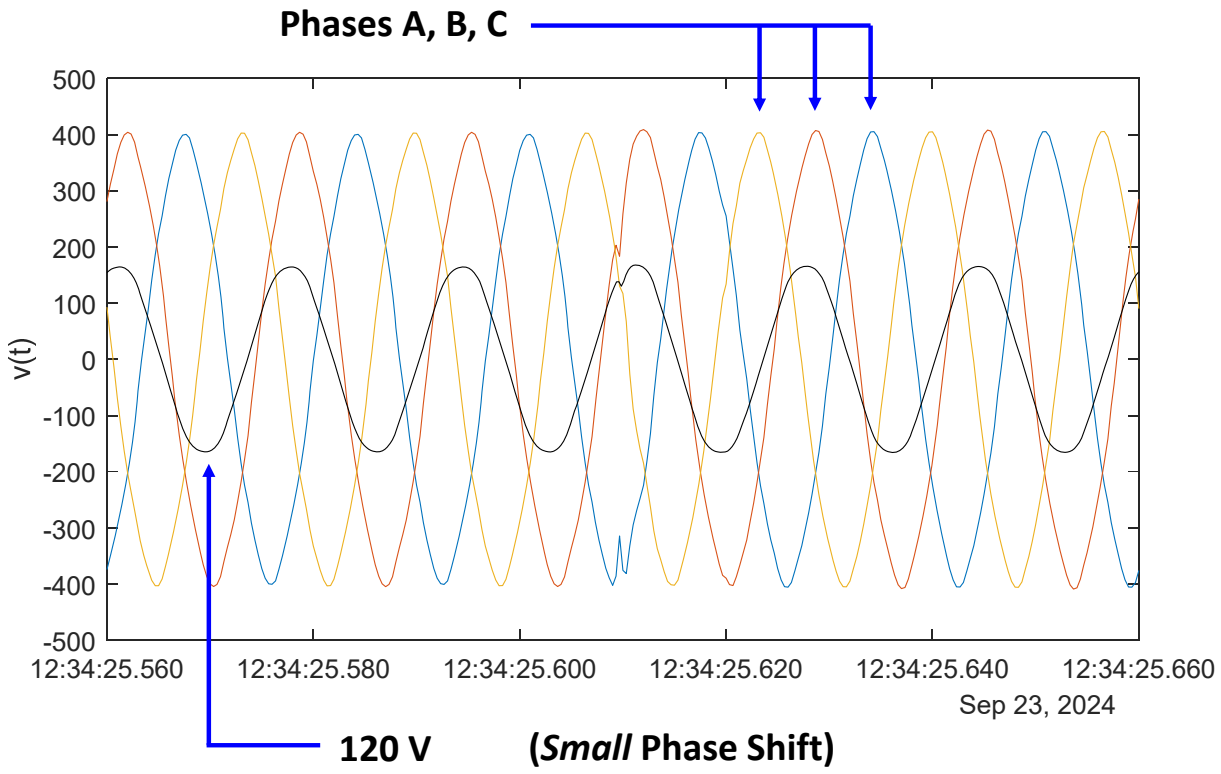
Event

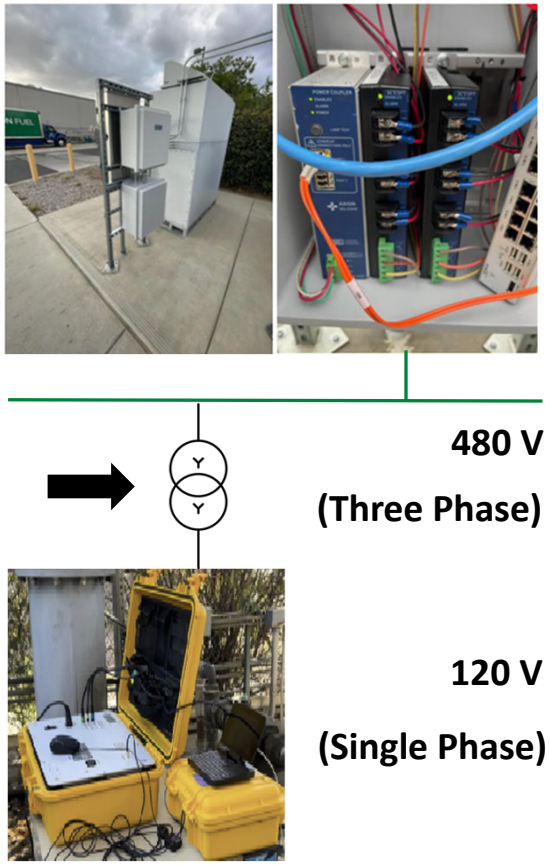
Differential Waveform

Theorem: We can approximate Δ THD as follows:

$$\Delta\text{THD} \approx \frac{\text{RMS}^2\{\Delta v_k(t)\}}{\text{Fundamental}^2\{v_k(t)\}}$$

Waveforms at Different Voltage Levels:





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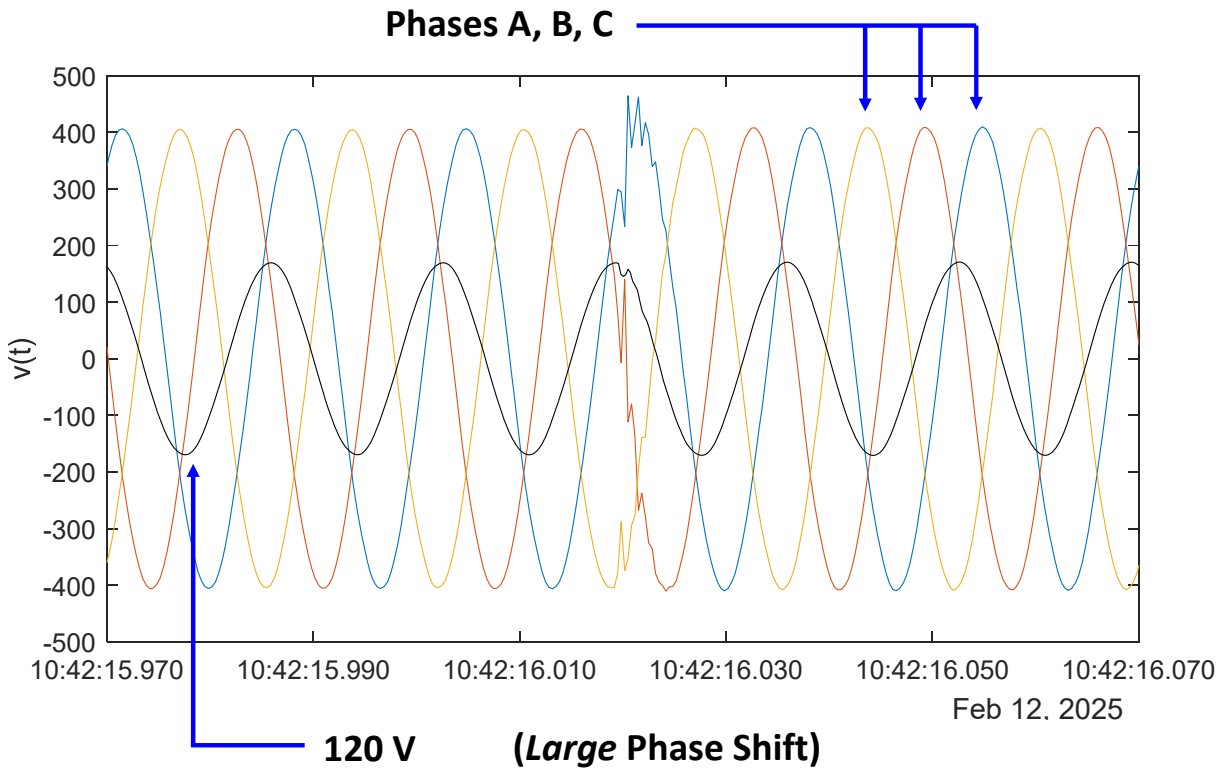
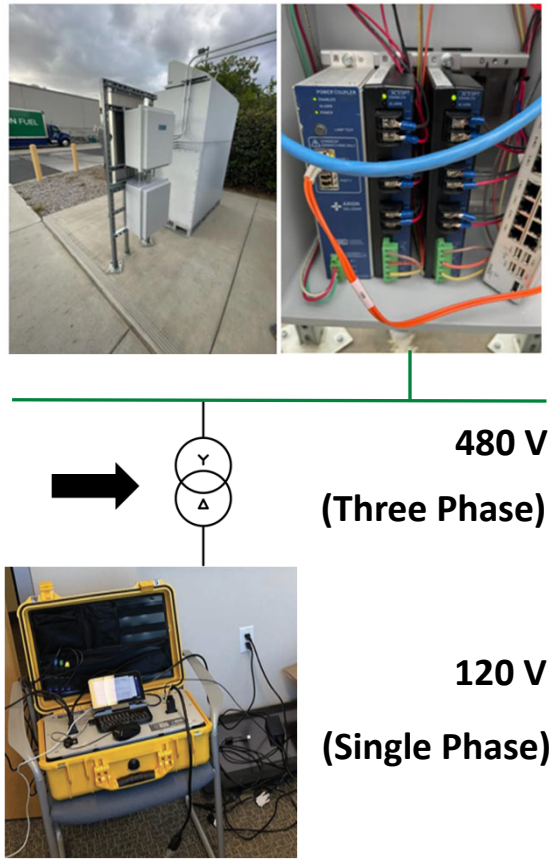
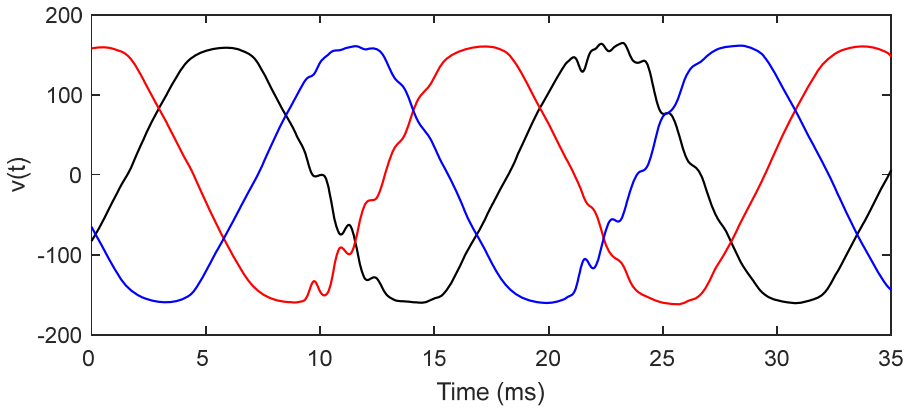




Three Single-Phase Synchro-Waveforms:

Three ***Separate*** Power Outlets / Devices:

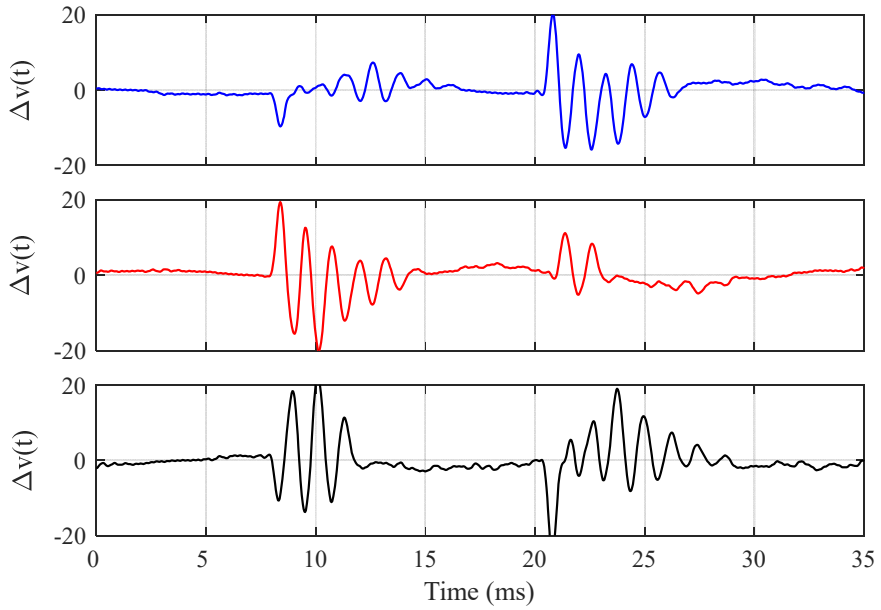


Phase A: 120 V

Phase B: 120 V

Phase C: 120 V

Differential Waveforms:



Frequencies on *all* Phases: 842 Hz

Additional Details:

Narges Ehsani, Fatemeh Ahmadi-Gorjayi, Zong-Jhen Ye, Alex McEachern, and Hamed Mohsenian-Rad, "Event Detection and Characterization in Continuous Recording of Synchro-waveforms: Field Experiments and Data Analytics," accepted for publication in the *IEEE Transactions on Industrial Informatics*, July 2025.

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