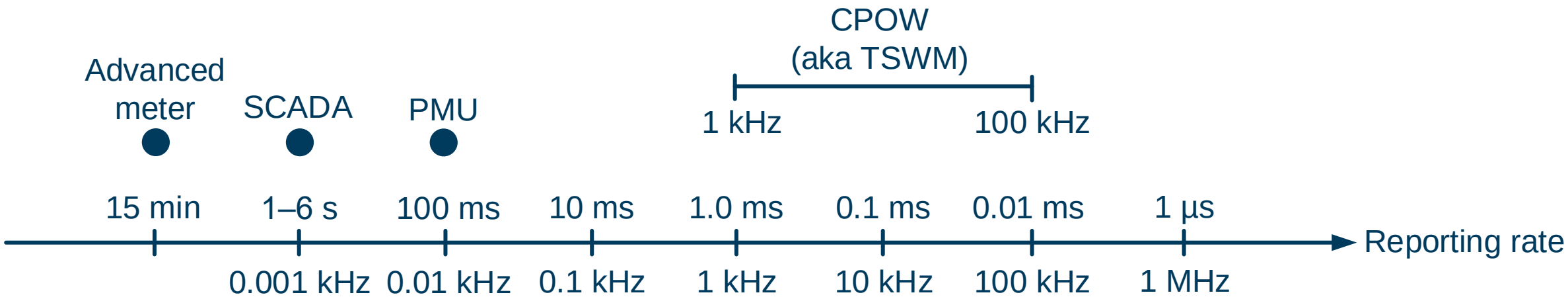
Case Study of Building Loads Using Continuous Time-Synchronized Waveform Measurements

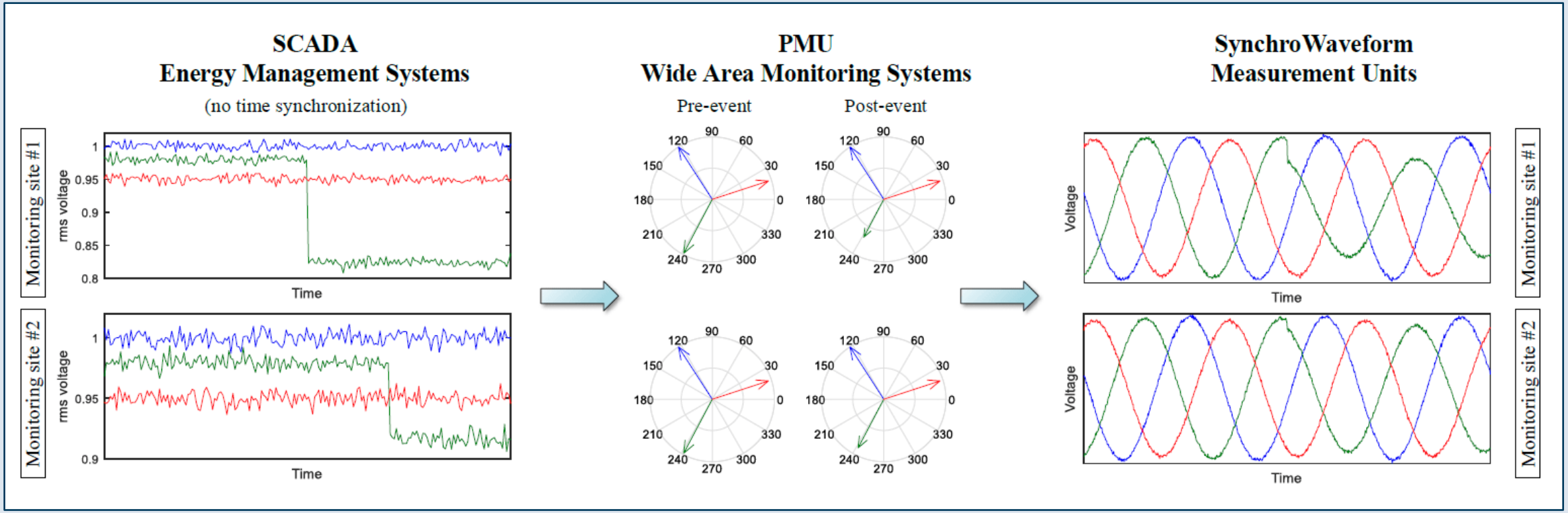
Jared Bestebreur, Product Line Manager

Continuous oscillography reporting rate



Source: NASPI-2020-TR-004

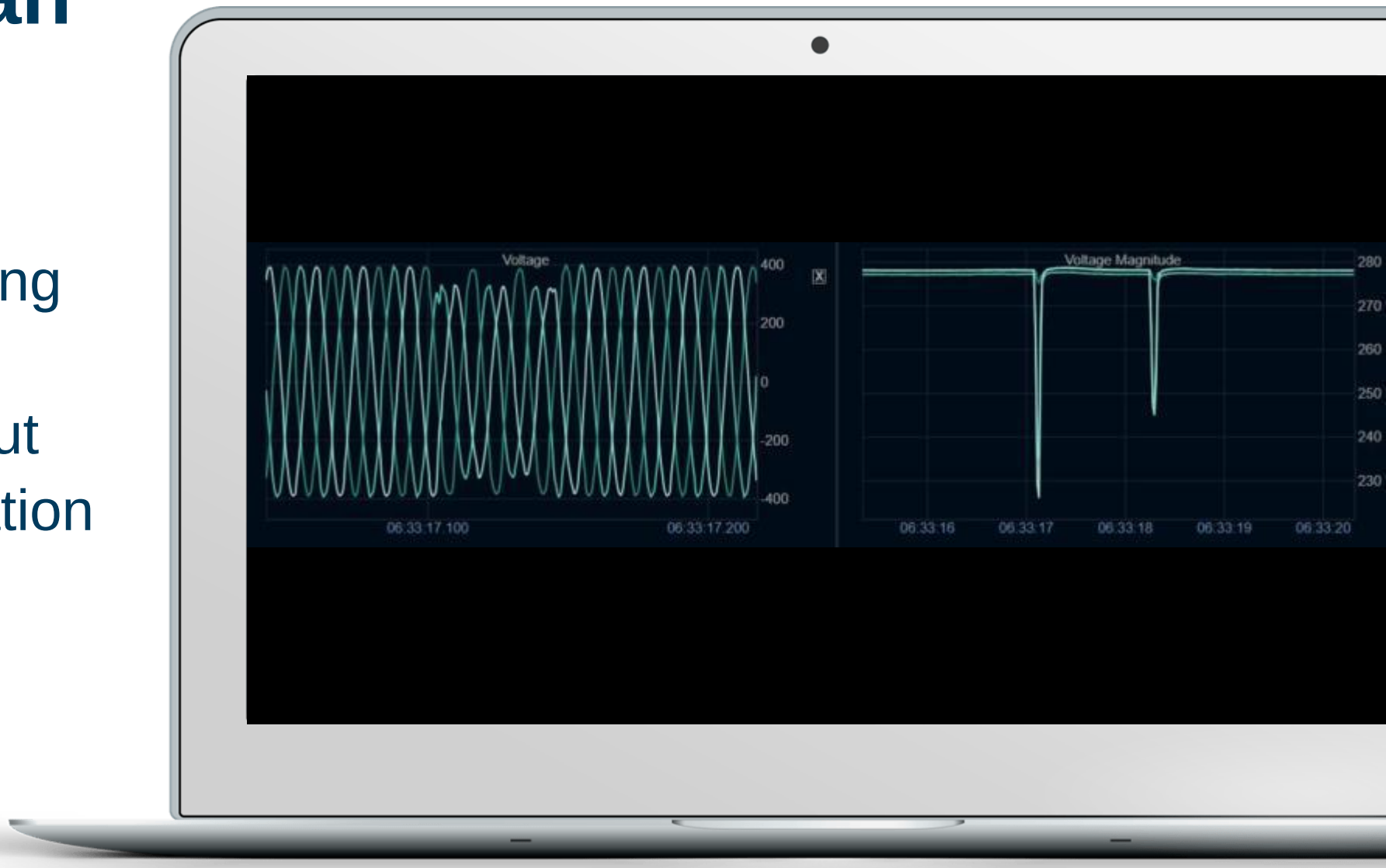
Faster sampling uncovers more disturbances



Source: A. F. Bastos, S. Santoso, W. Freitas, and W. Xu, "SynchroWaveform Measurement Units and Applications," *2019 IEEE Power & Energy Society General Meeting*, Atlanta, GA, 2019, pp. 1–5.

Never miss an event again

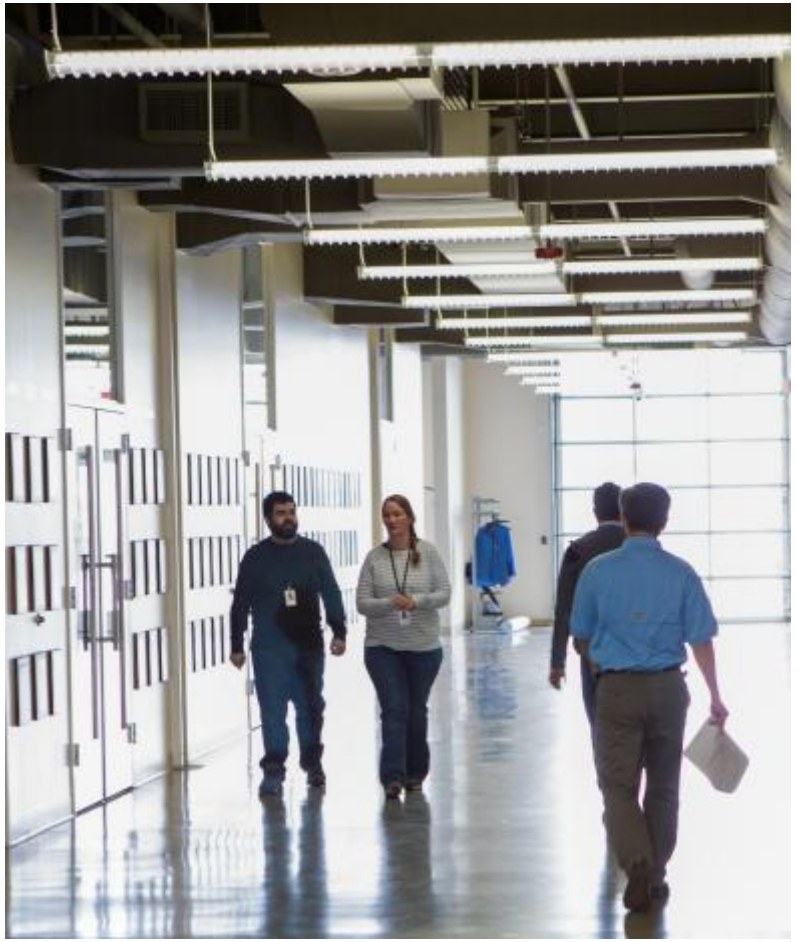
Continuous recording captures all disturbances without detection configuration



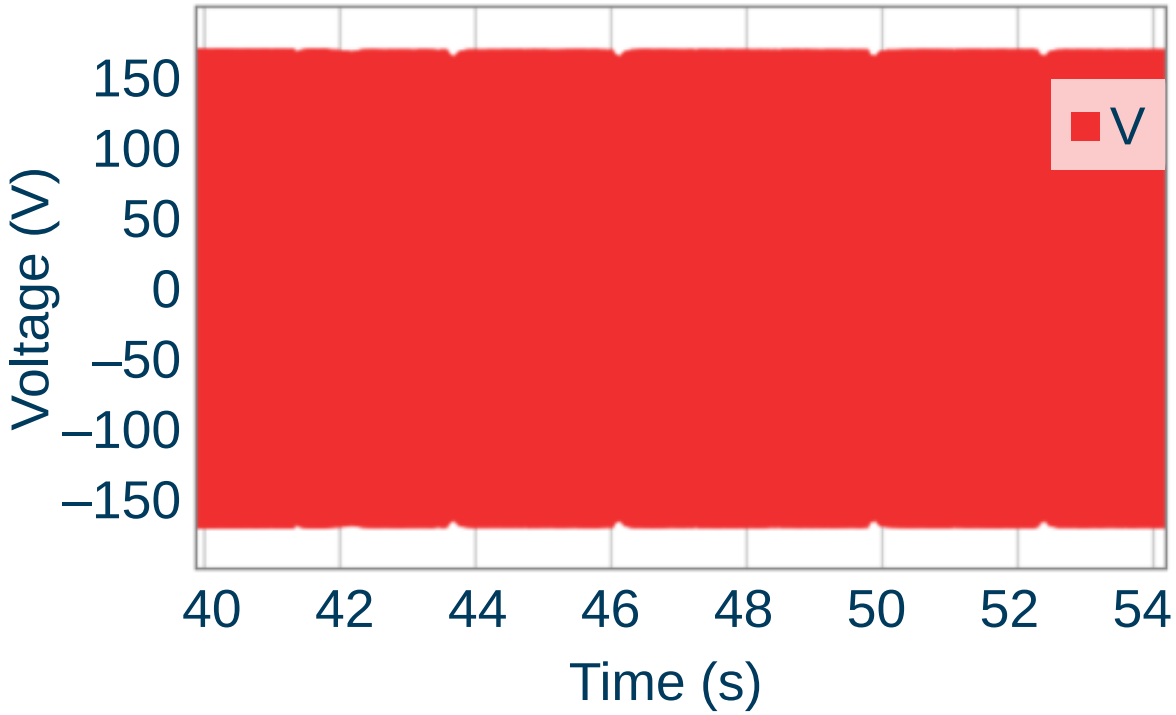
Continuous sampled oscillography

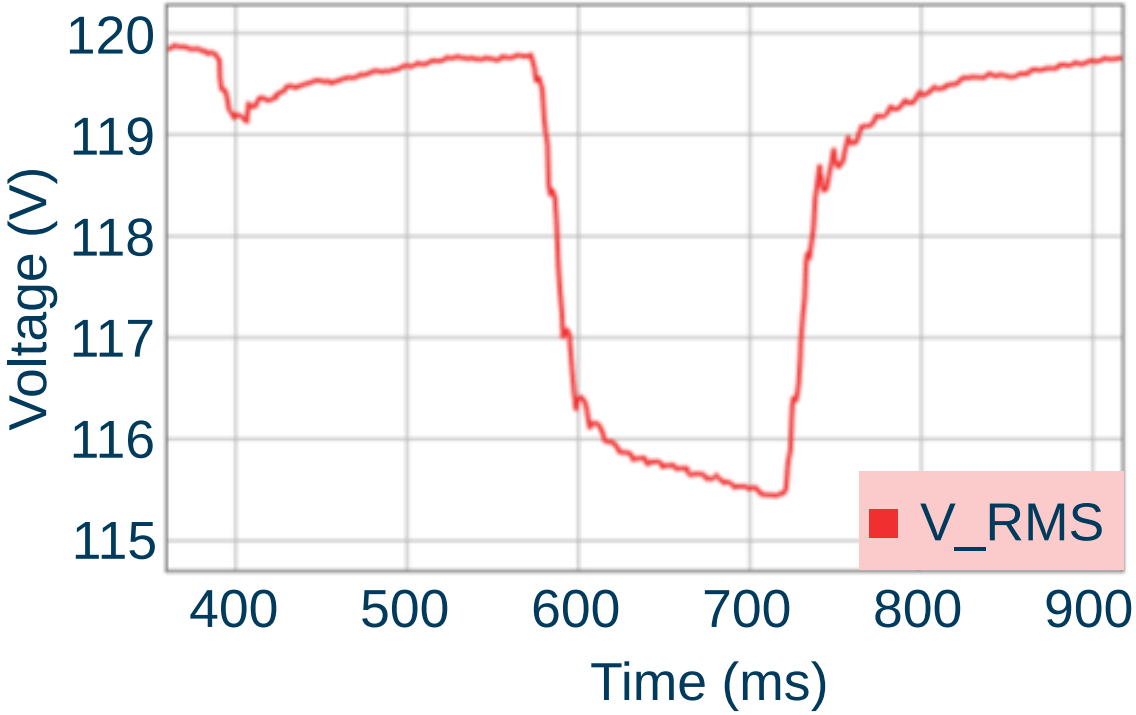
- Conversion of an analog signal to a series of discrete time-stamped values
- Fixed time interval (T_S) between samples
- Instantaneous time-domain sampled voltage and current measurements
- Granulated and legitimate fundamental data of the power system

1.5 MVA 480 V office building electric service



Lights flicker due to rapid voltage changes

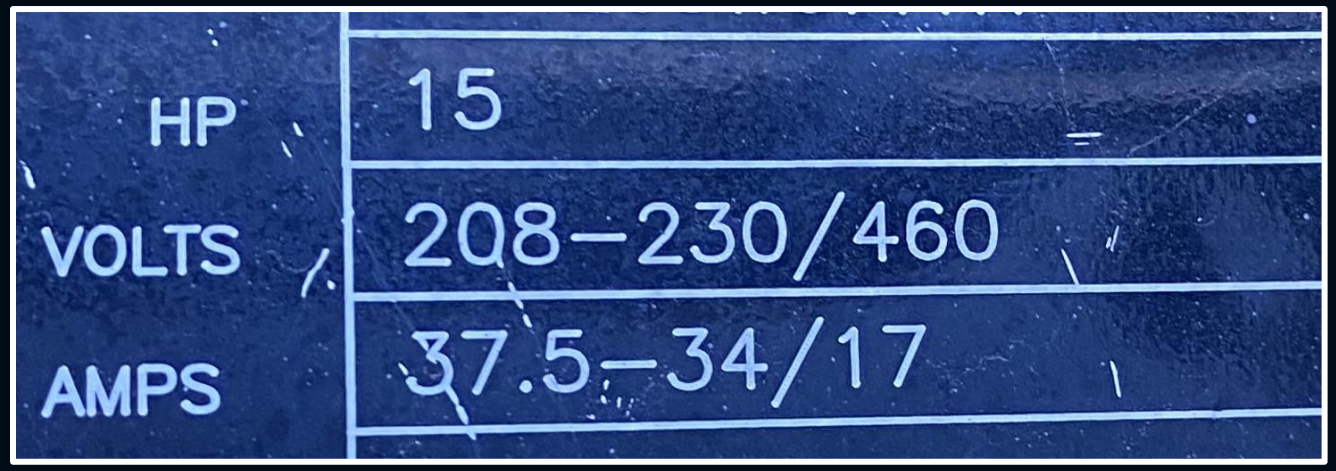




Thermal chambers constantly changing load

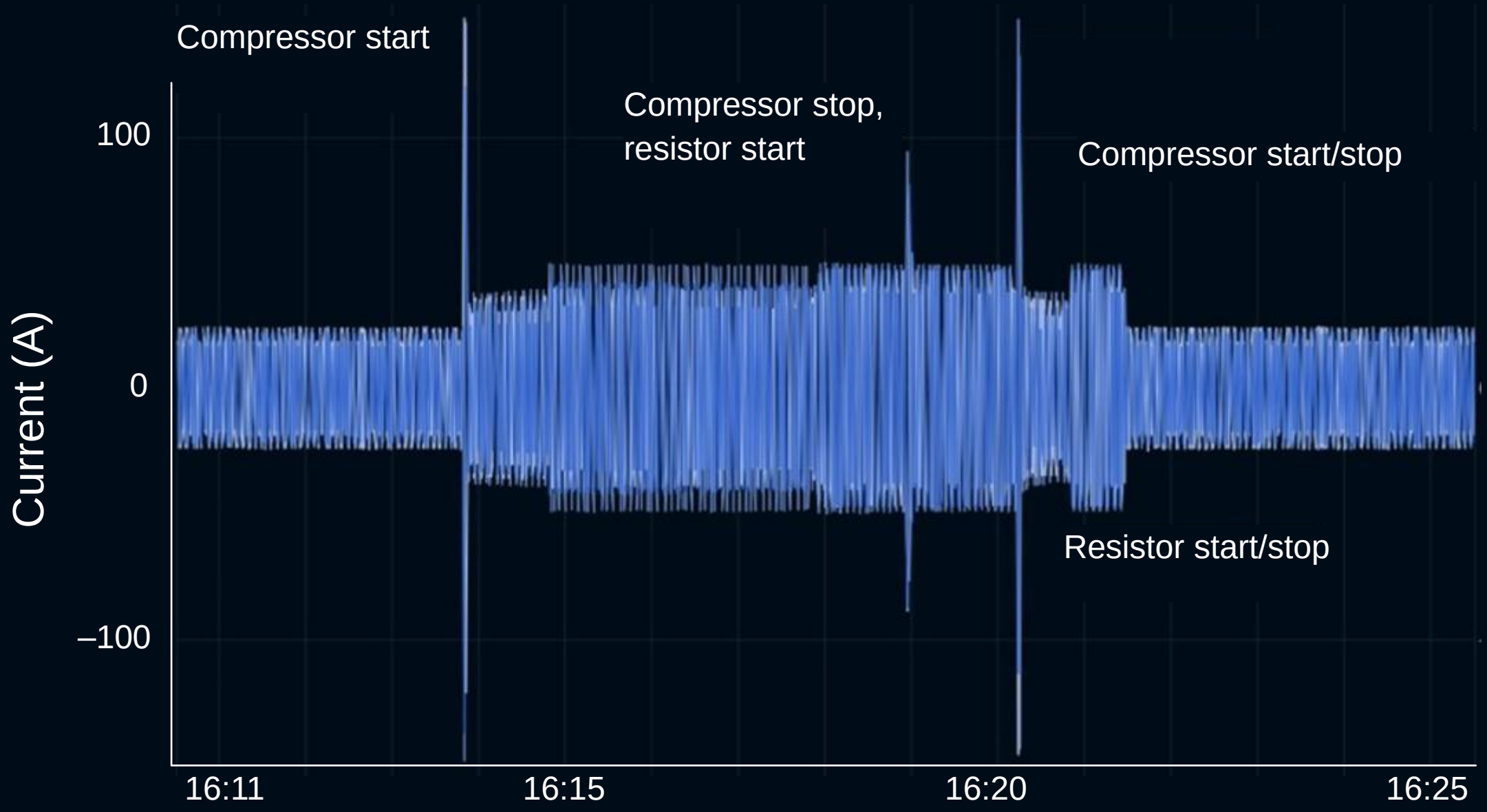
Just a few cyclical loads can add up

VOLTAGE	208-3-60
LARGEST MOTOR	2HP 13AMPS
OTHER LOADS	5.2AMPS
MAX HEATER LOAD	3.5KW 16.8AMPS
FULL LOAD AMPS	35AMPS
MINIMUM SERVICE	40AMPS

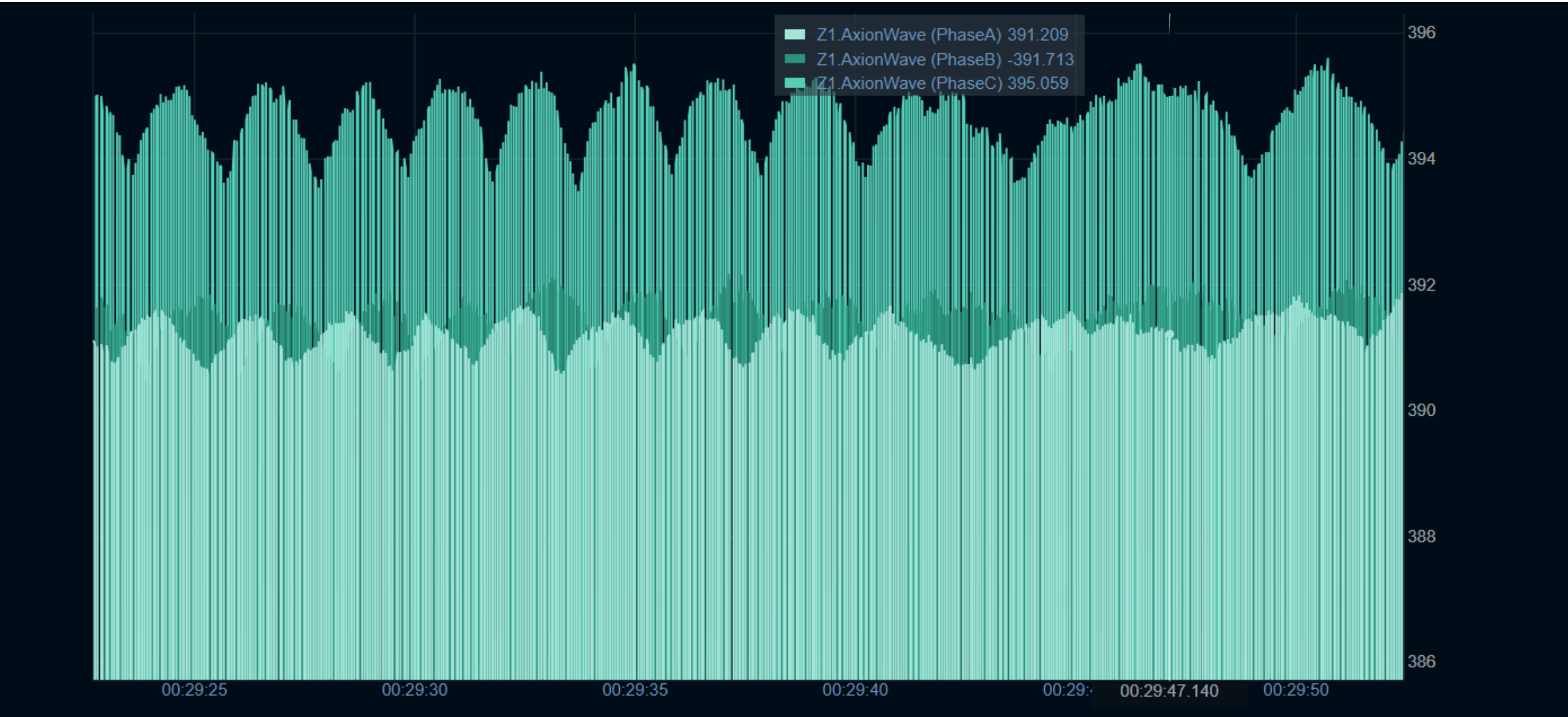


HP	15
VOLTS	208–230/460
AMPS	37.5–34/17

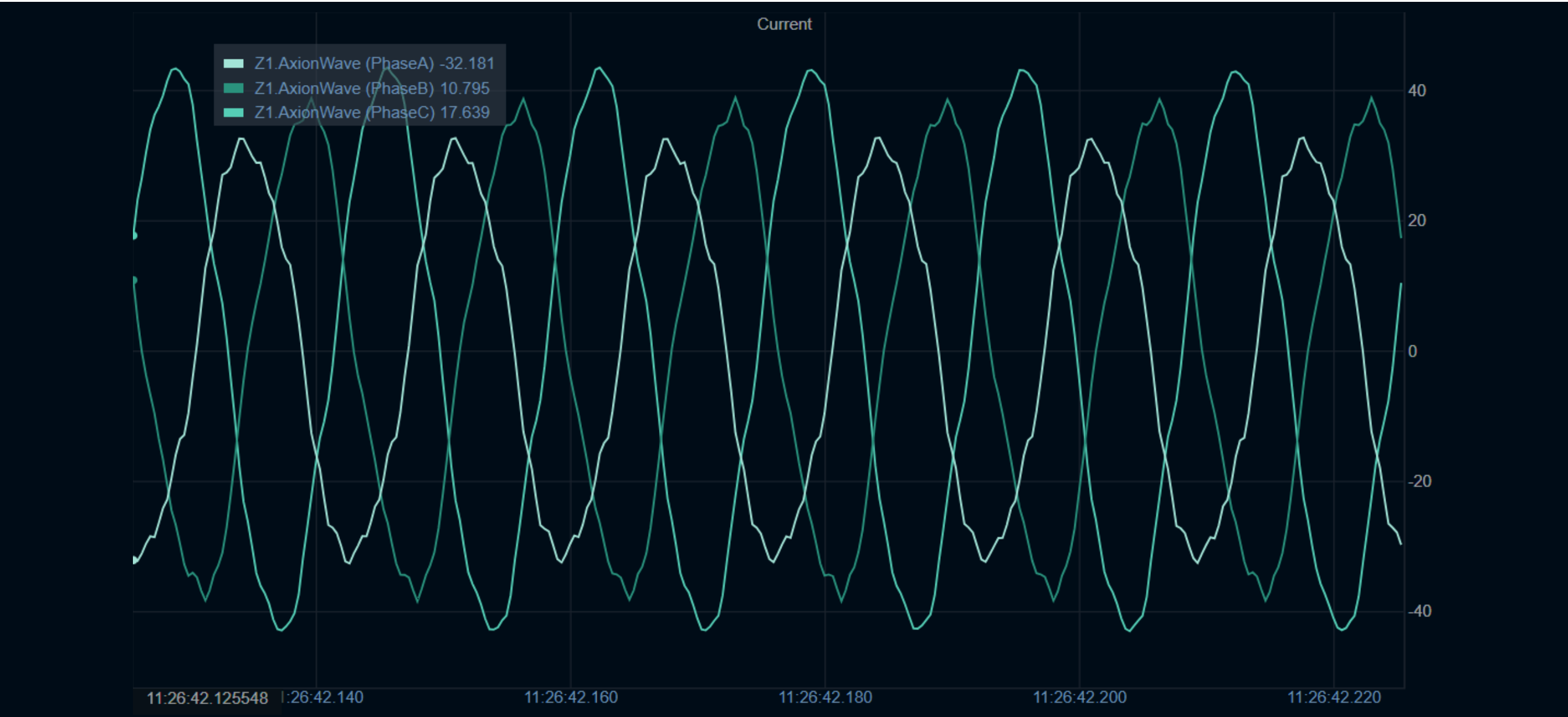
60 kW “instantaneous” power change


Compressor start
Compressor stop,
resistor start
Compressor start/stop
Resistor start/stop
100
0
–100
Current (A)
16:11
16:15
16:20
16:25

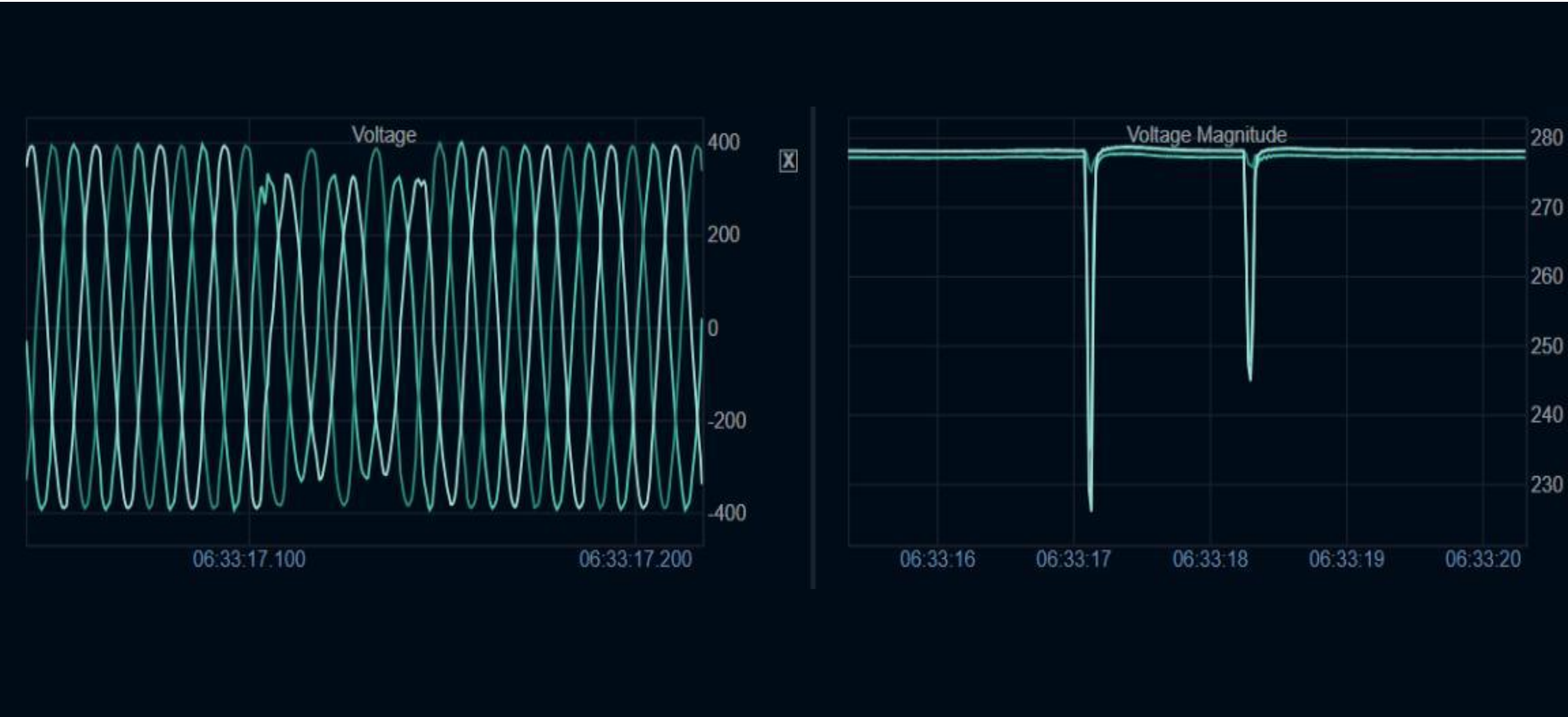
Varying loads cause voltage ripple



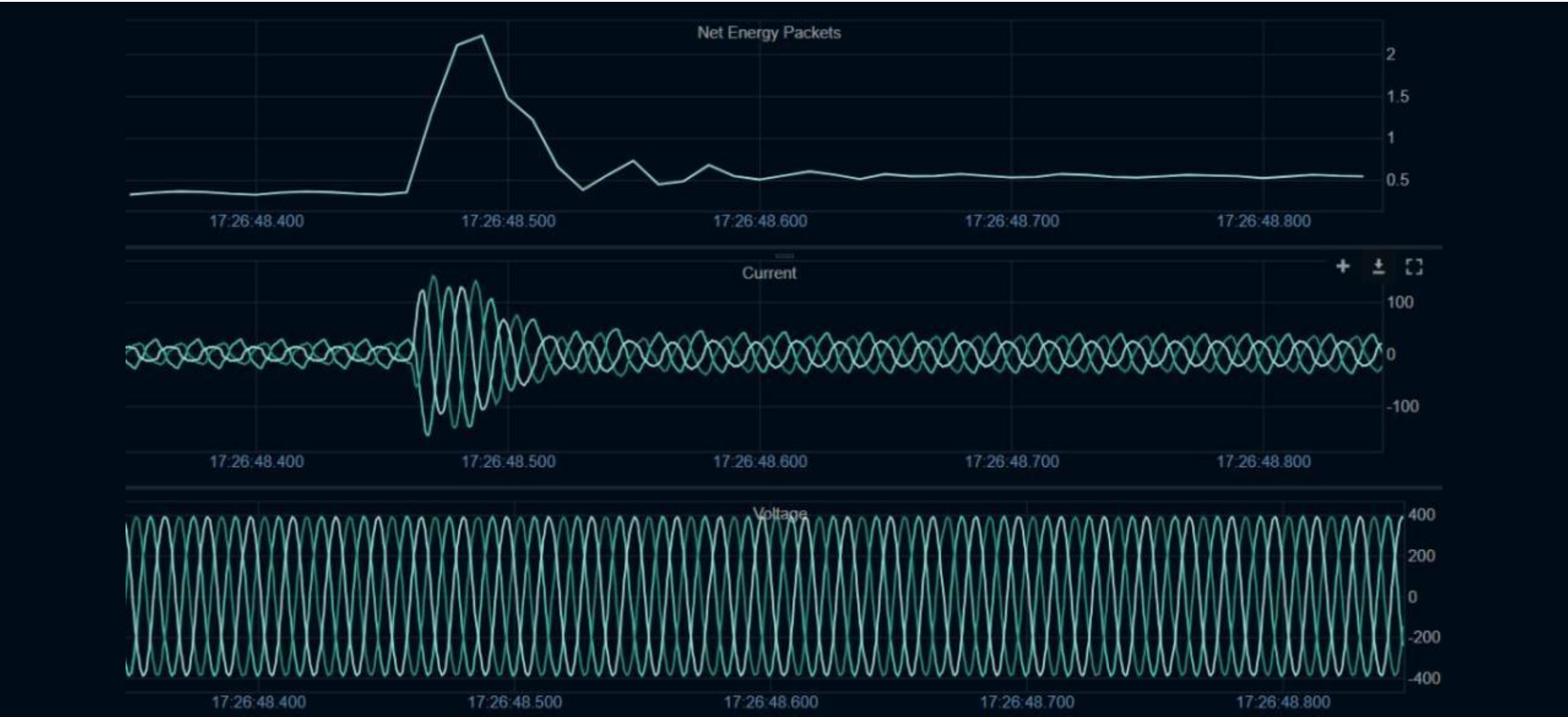
Unbalance clearly seen in current waveform



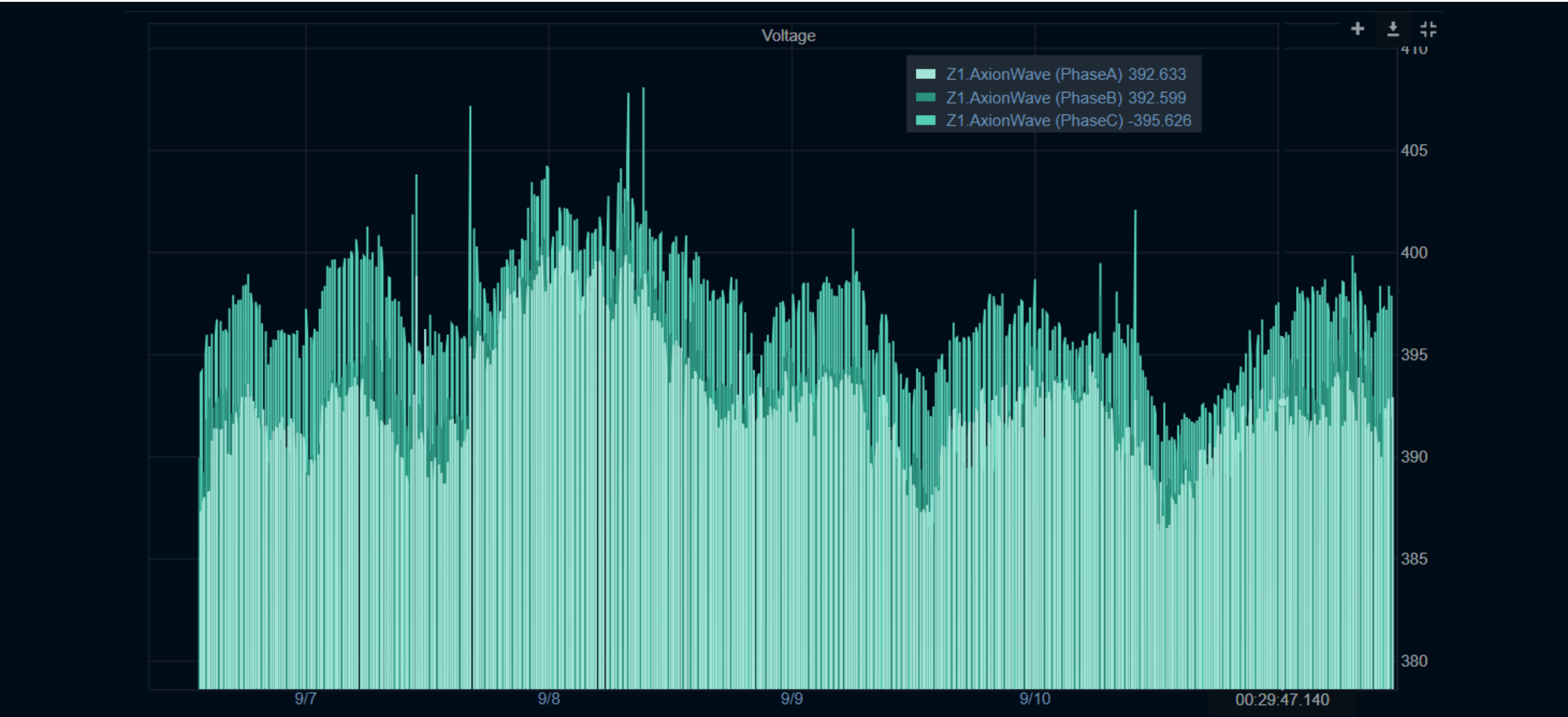
View voltage sags as waveforms and RMS



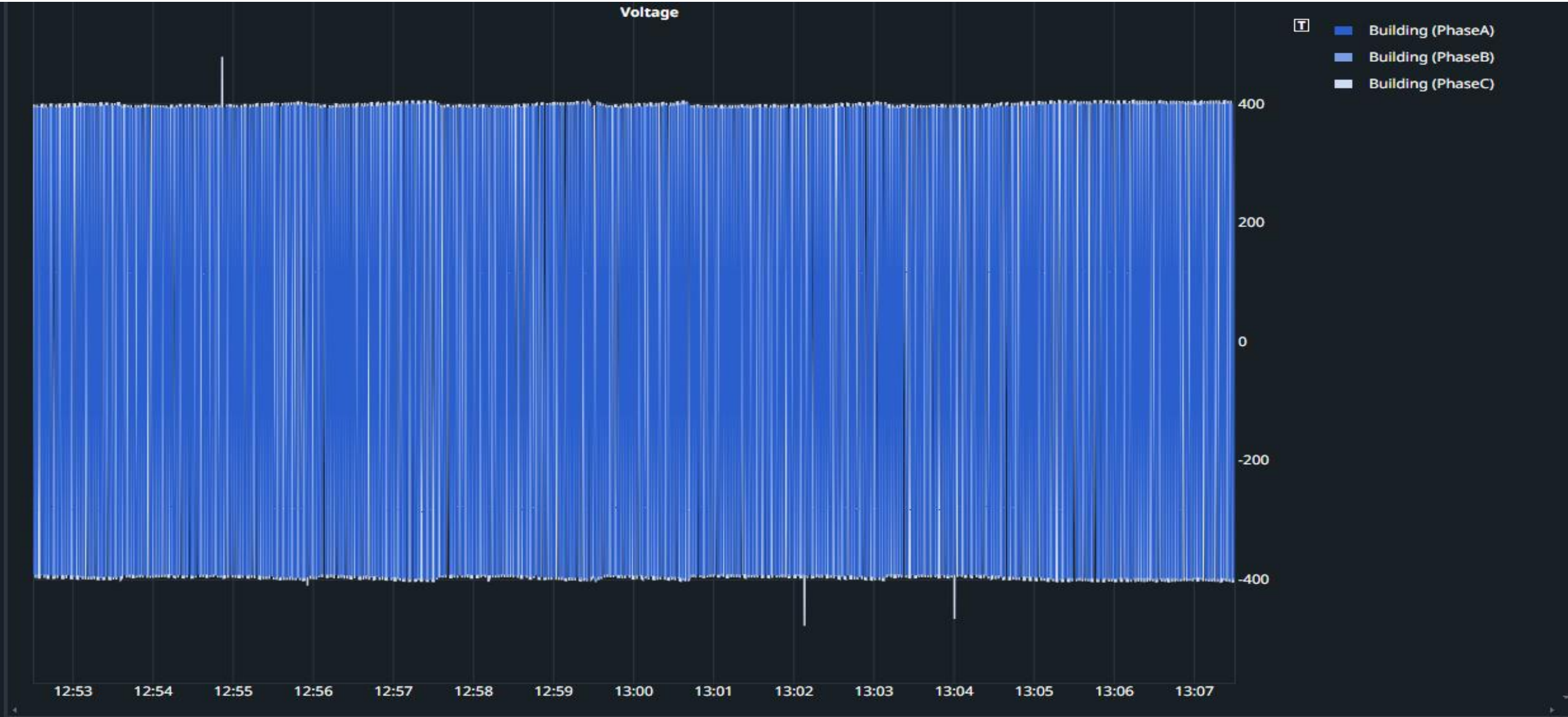
Motor starts



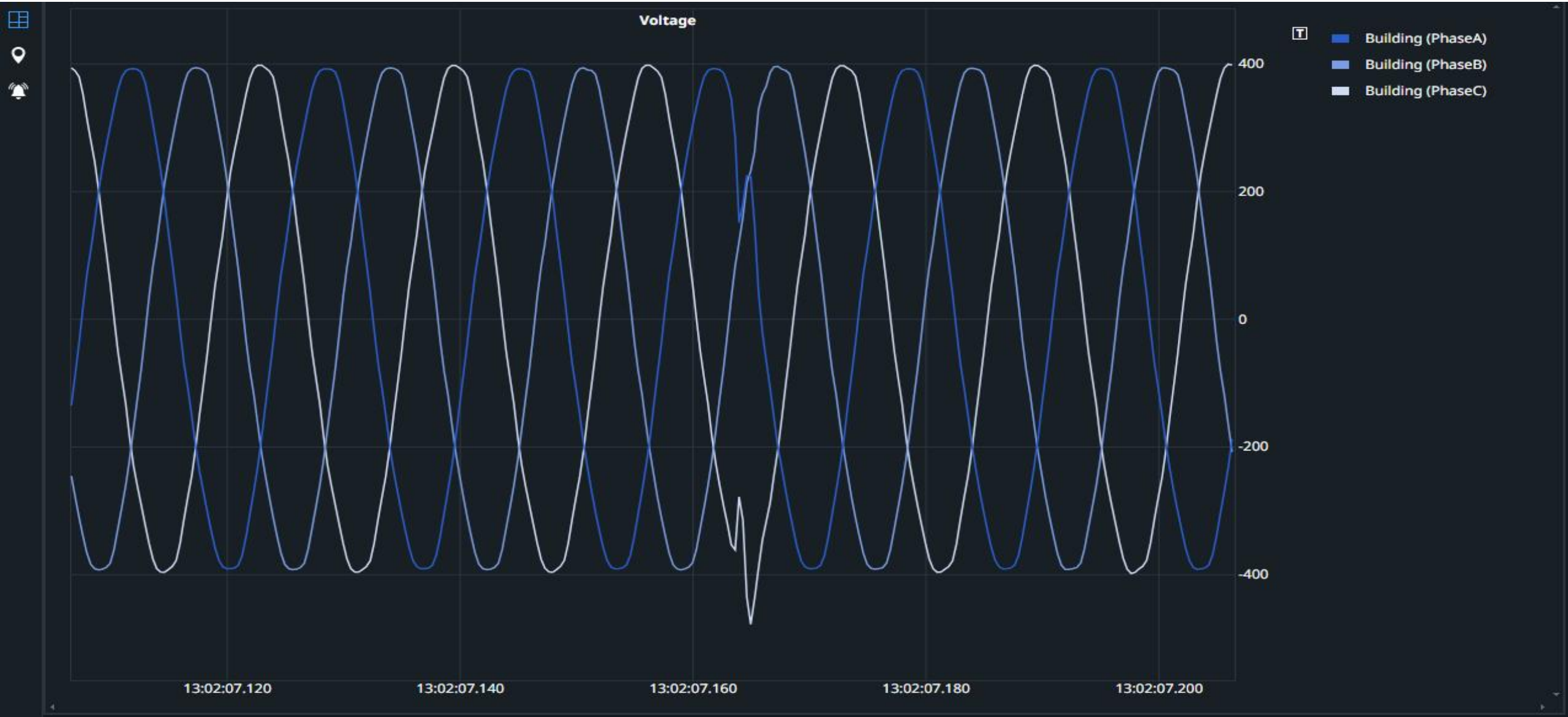
Small unexpected voltage spikes



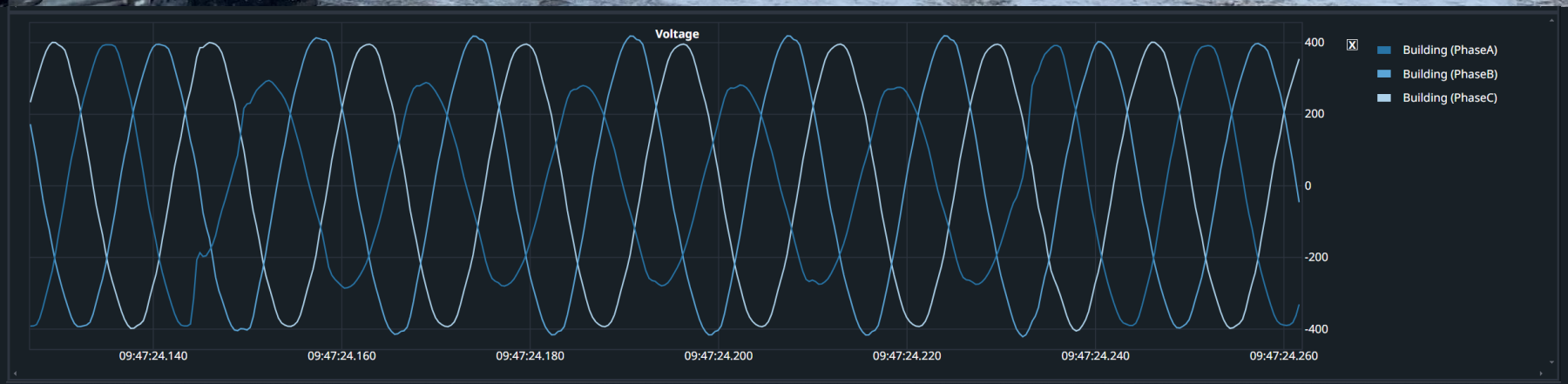
Significant voltage transients



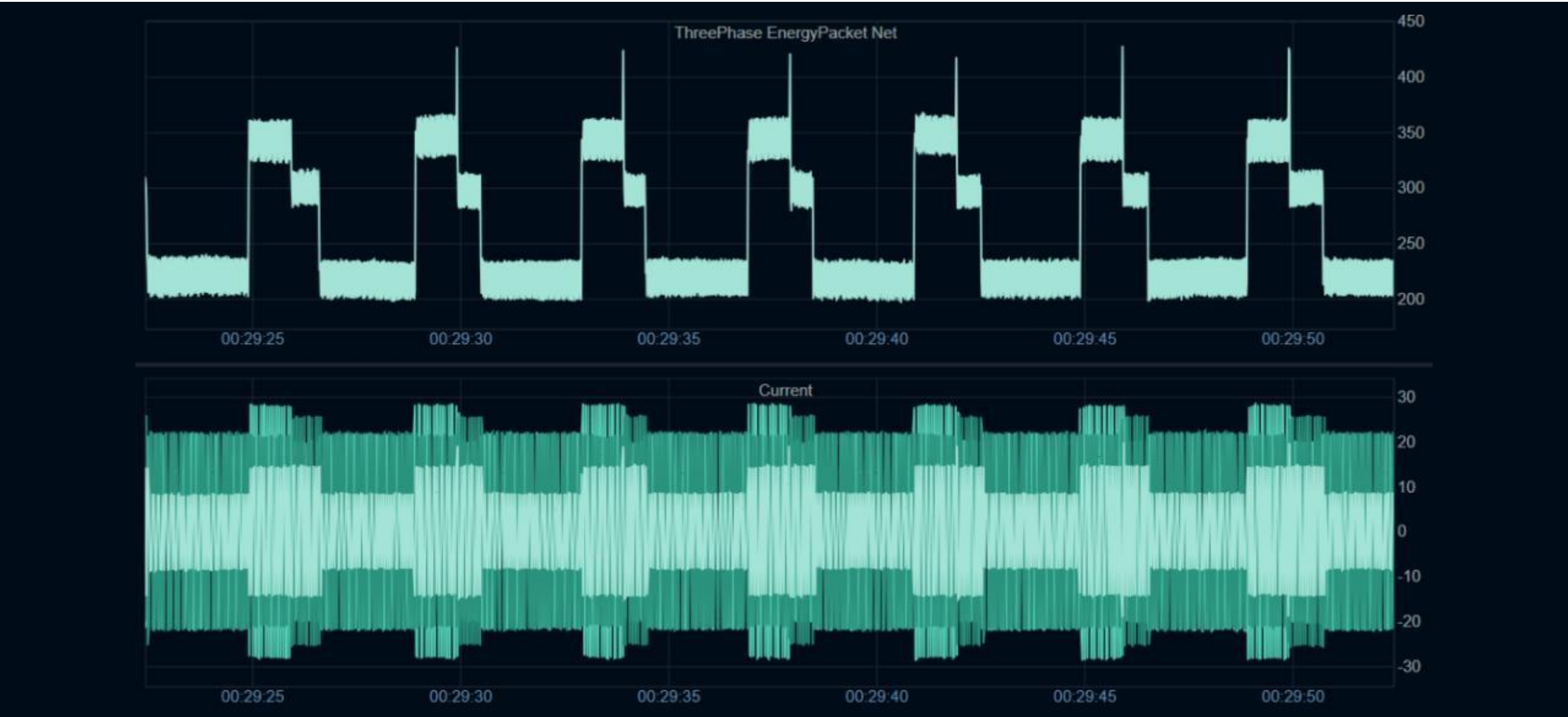
Transients measured at 120% of nominal



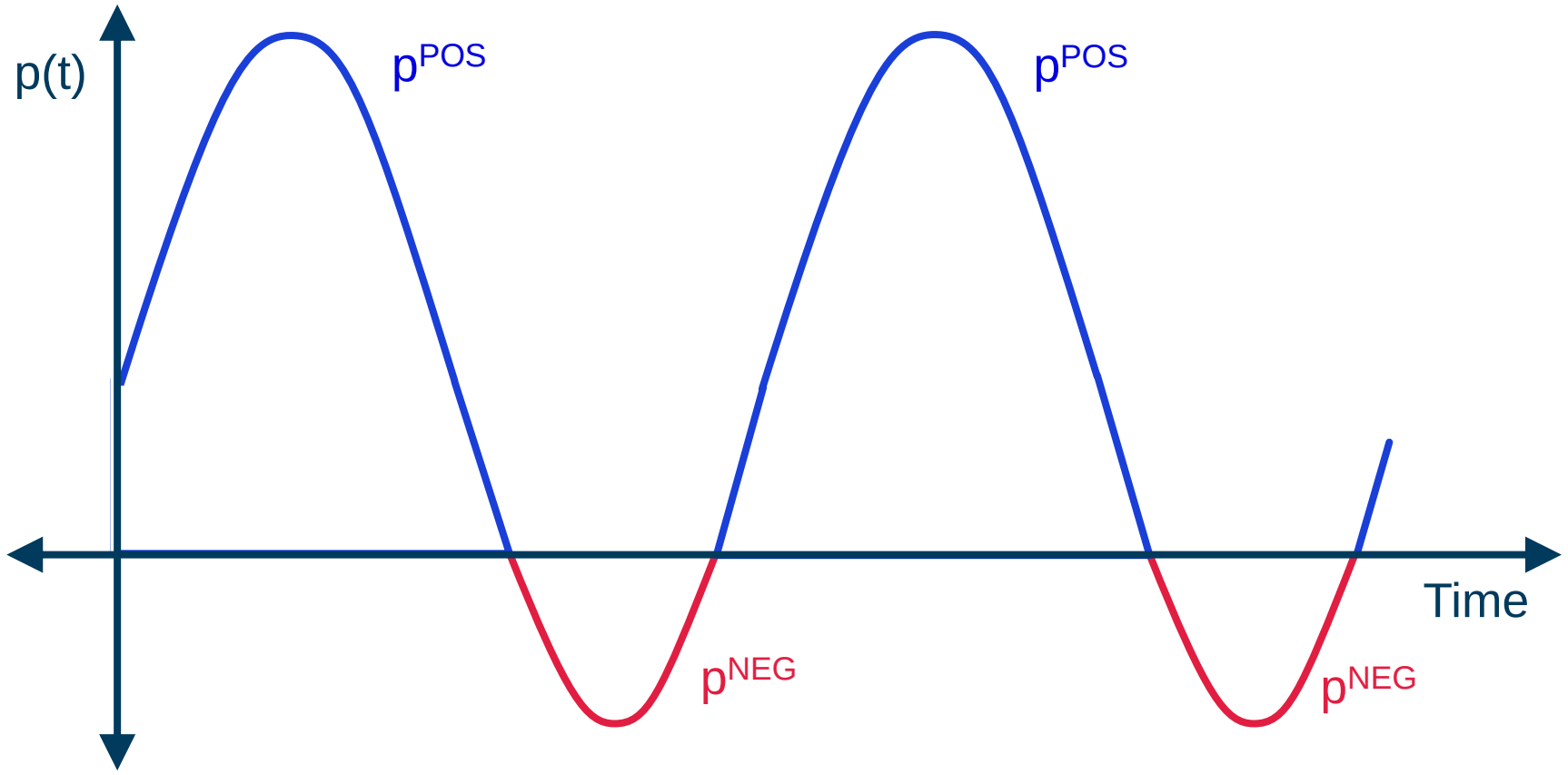
Line-to-car sag captured on adjacent feeder



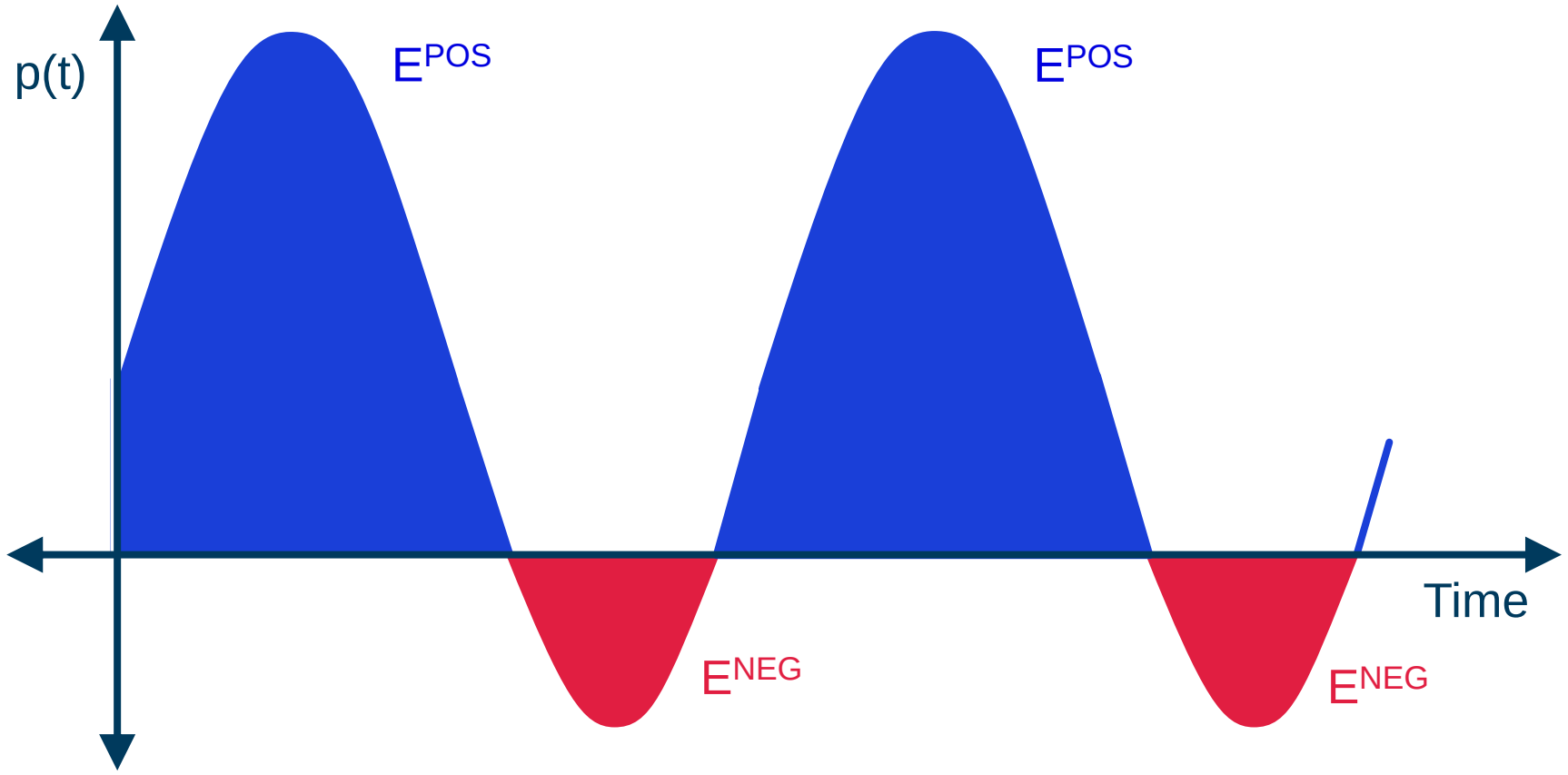
Energy packets simplify cyclical load detection



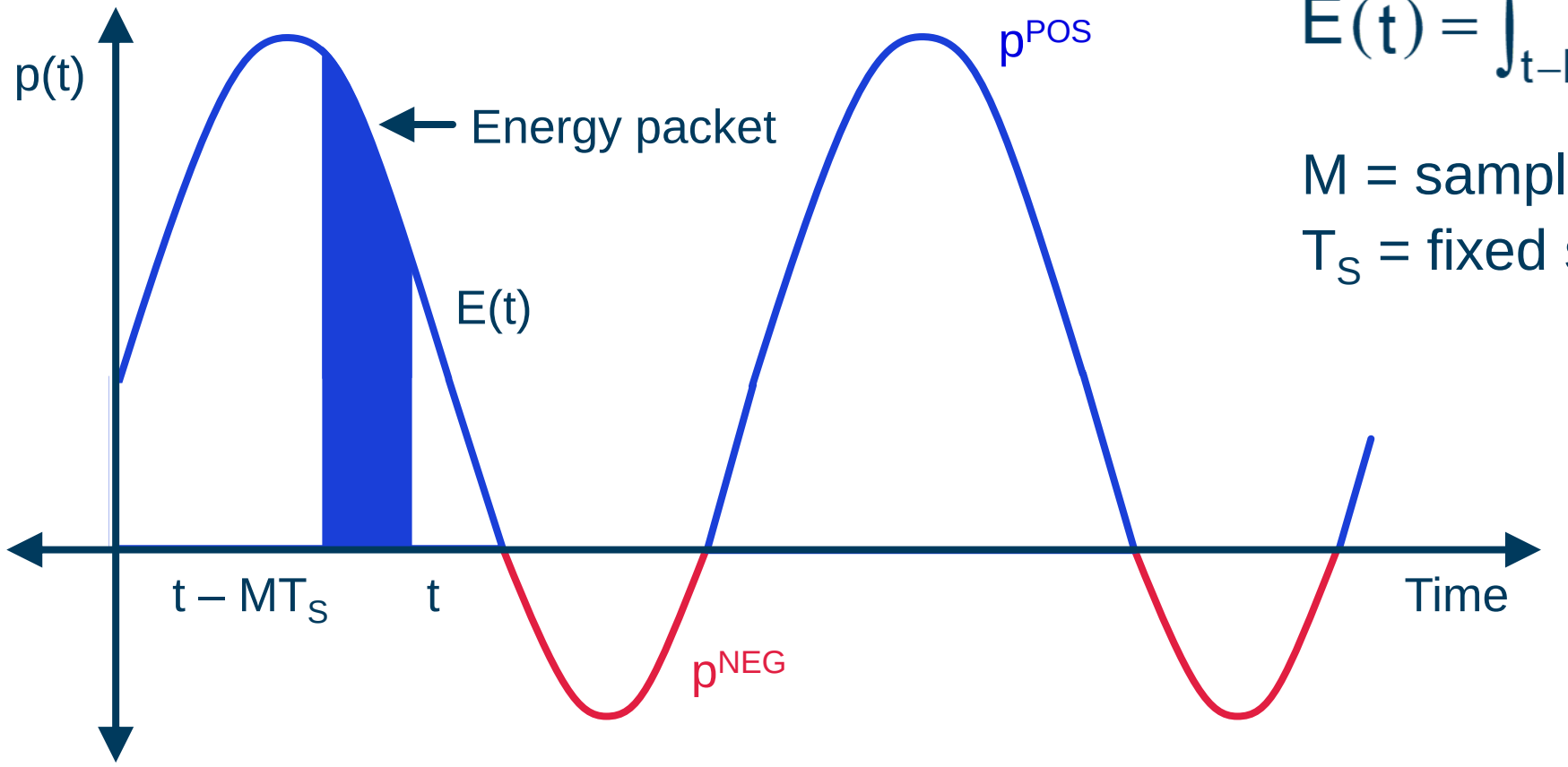
Decompose power into p^{POS} and p^{NEG} pulses



Energy is simply the integral of power



Energy packet theory – report energy in discrete time intervals

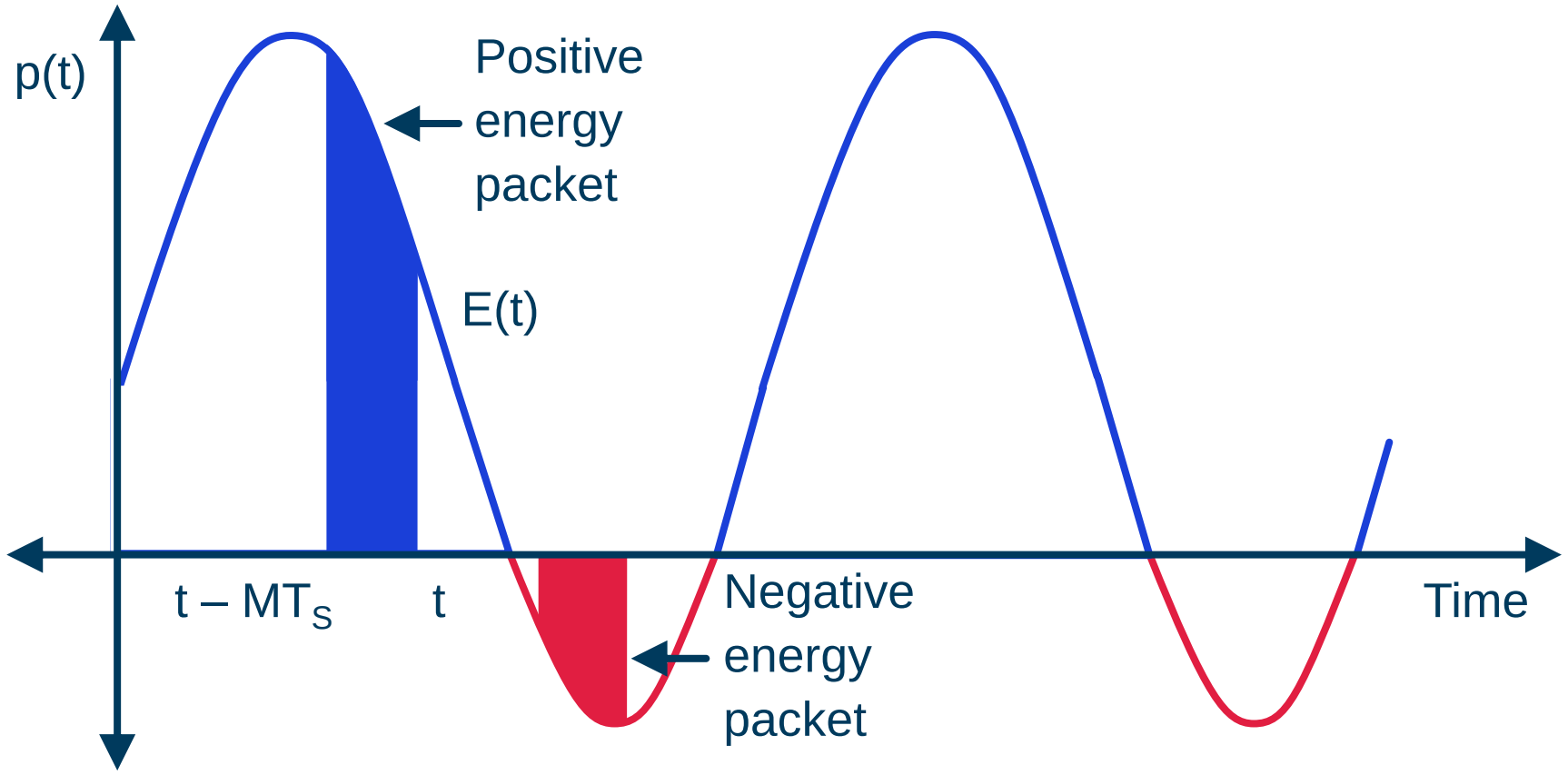


$$E(t) = \int_{t-MT_S}^{t} v(\sigma)\, i(\sigma)\, d\sigma$$

M = samples in interval

T_S = fixed sample rate

We now see bidirectional energy transfer in any time period



Thank you

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