

Capturing Generator Rotor Angle and Field Quantities – SDG&E Experience and Approach to Using Nontraditional Generator Measurements

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Serving the San Diego Area

SDG&E

- Sub
- Reg
- Saf
- 3.4
- 1
- 8
- 4,10
- San
- (25 cities)



Counties

SDG&E System Overview

- 1,8
- an
- Tw
- na
- 8,1
- 6,2
- 4,3



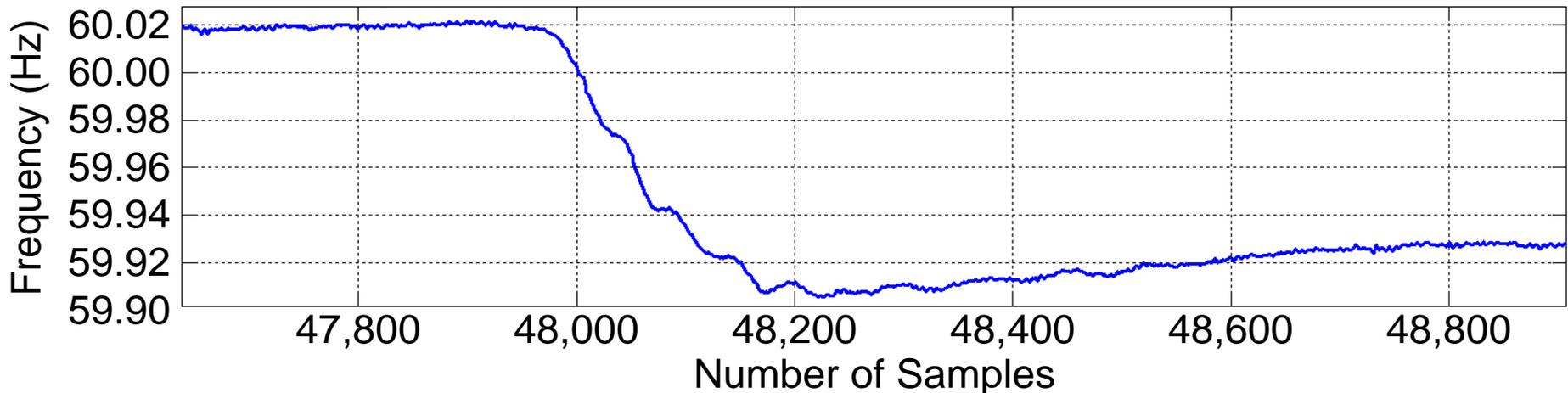
s
lines

Initiating Project and Establishing Goals

- Acquiring field quantities for generator model validation
- Analyzing interaction of mechanical and electrical quantities
- Verification of generator parameters per NERC MOD-025 thru MOD-027 requirements
- Continuous condition assessment
- Developing real-time condition assessments based on physical parameters

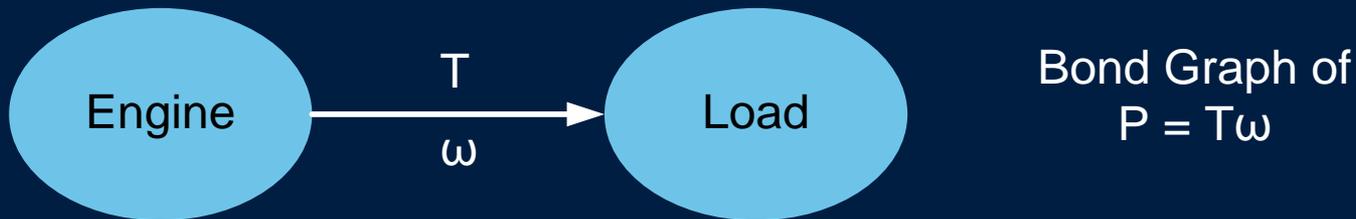
Motivation

- Power system stability studies primarily deal with transients in (power) angle, voltage, and frequency
- Typical transient effects in ac frequency are due to power loss

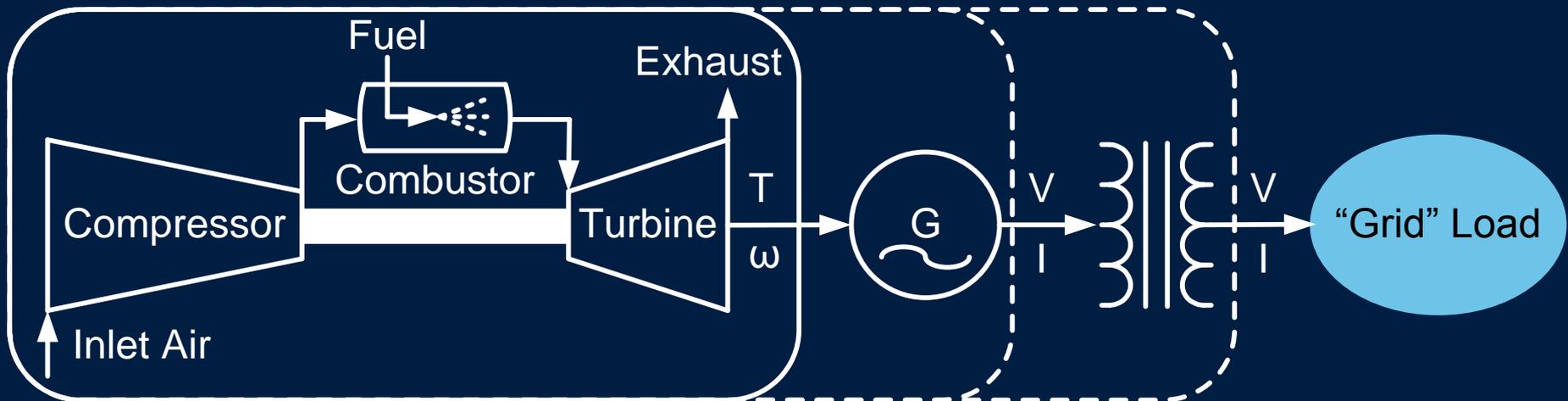


Motivation

Transient effects are due to dynamic coupling and interaction dynamics between generation and load

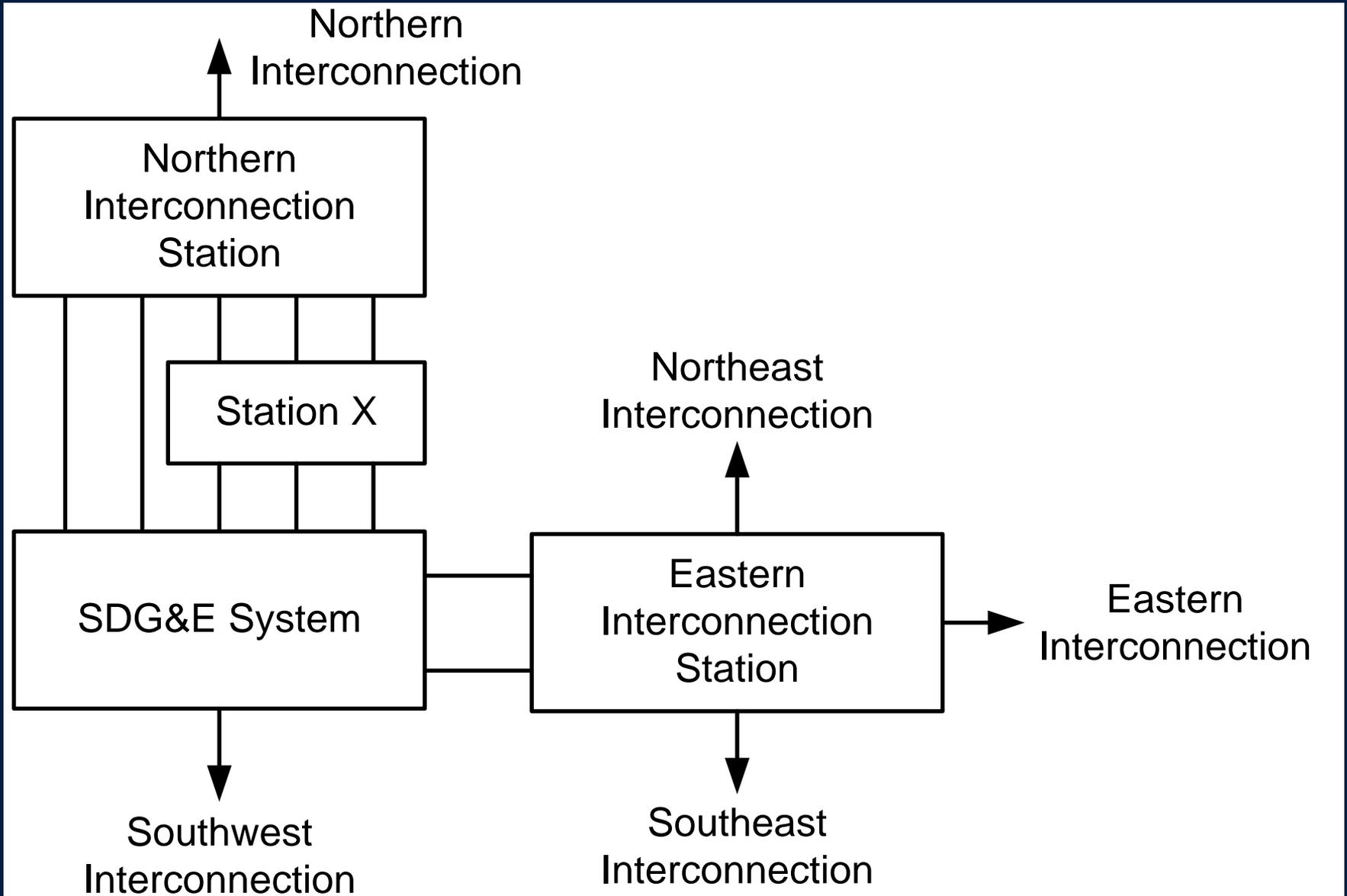


For grid-tied turbine / generator interaction



We can assume interaction is "one way from grid"

Major Interconnections



Selecting the Site

Combined Cycle Plant



2 Gas Turbine Generators
1 Steam Turbine Generator

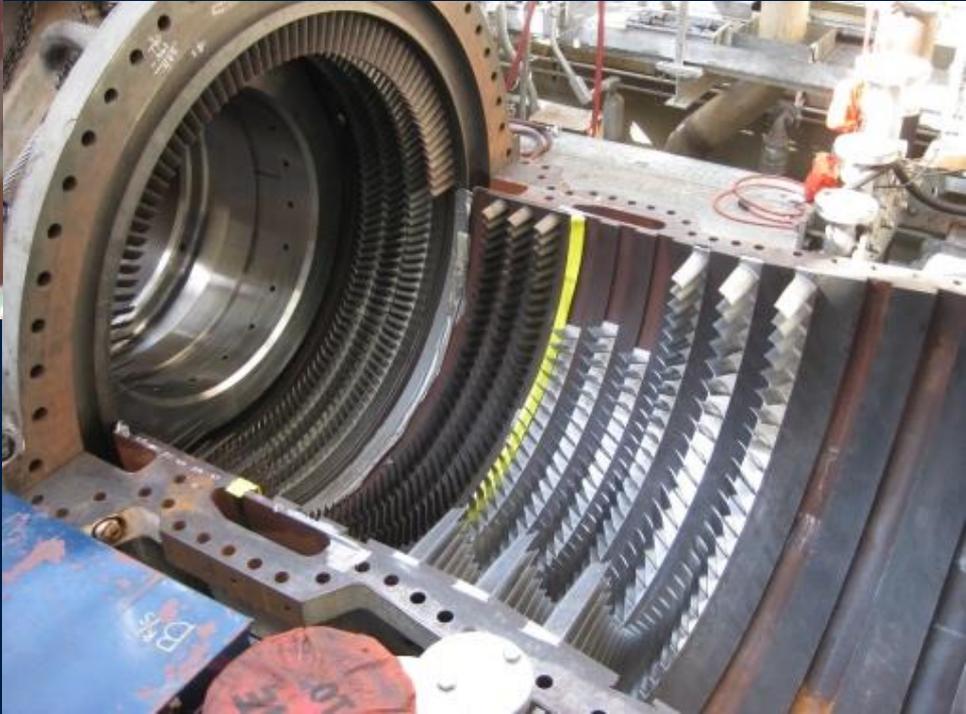
Map data ©2015 Google

Taking Advantage of Opportunities

February 2014 Plant Shutdown

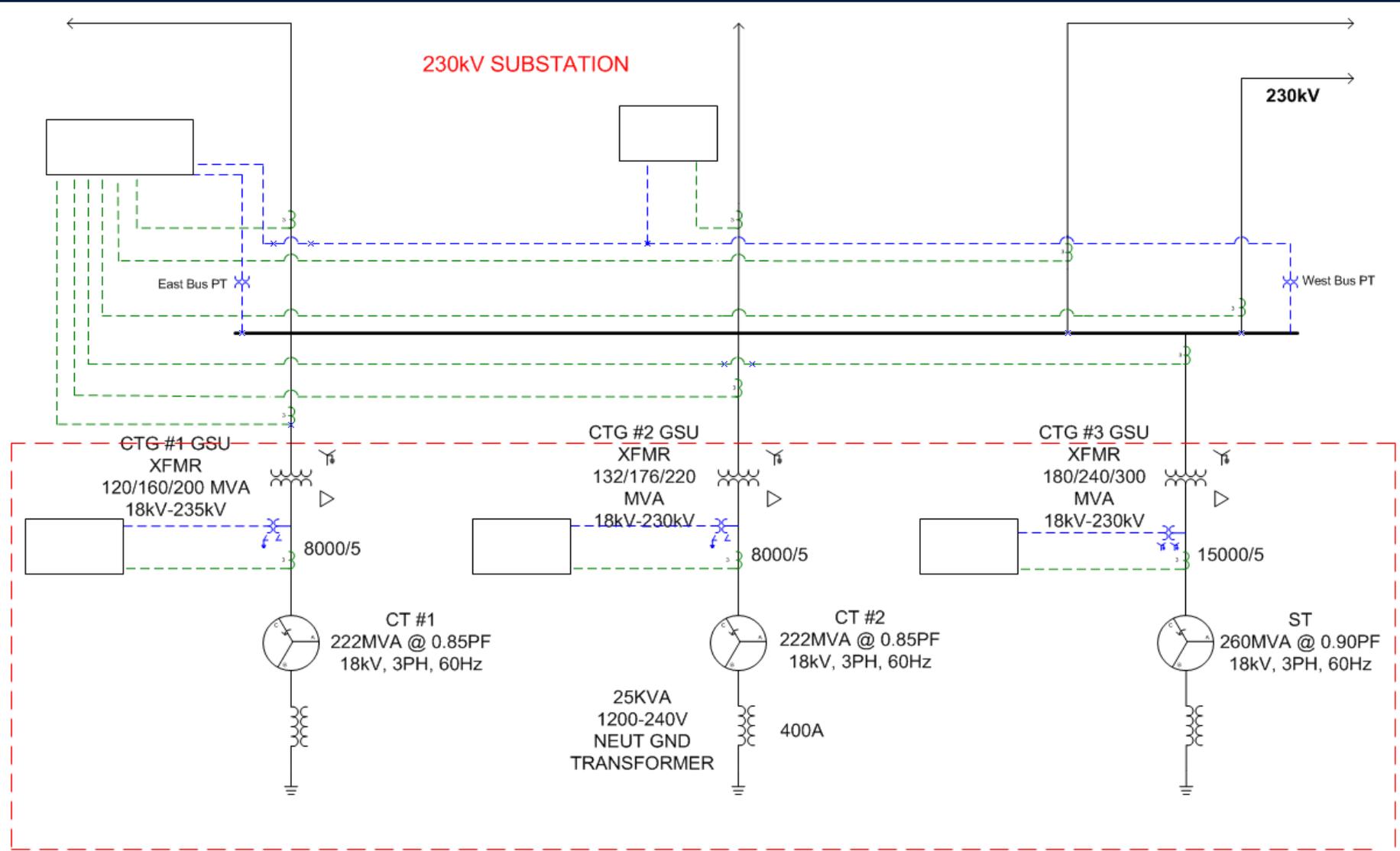


40,000-Hour
Maintenance



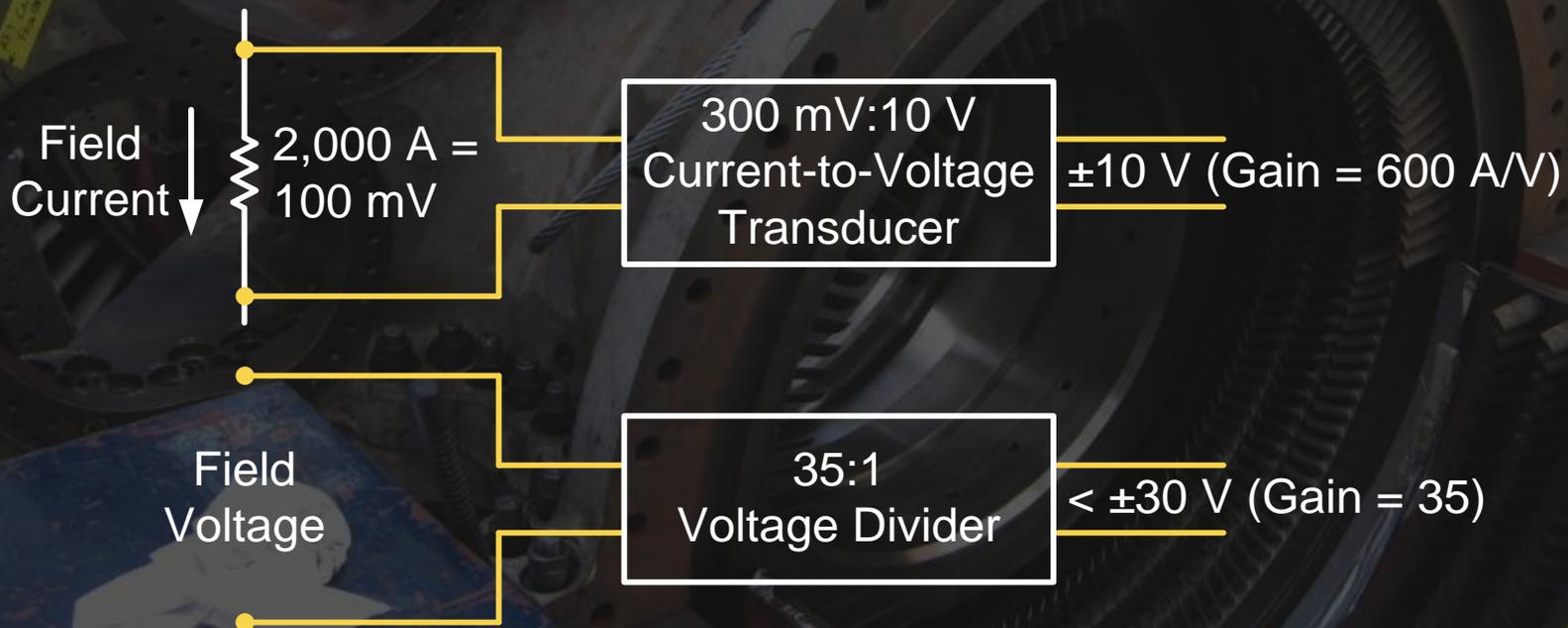
Complete Overhaul
of All Machines

One Line

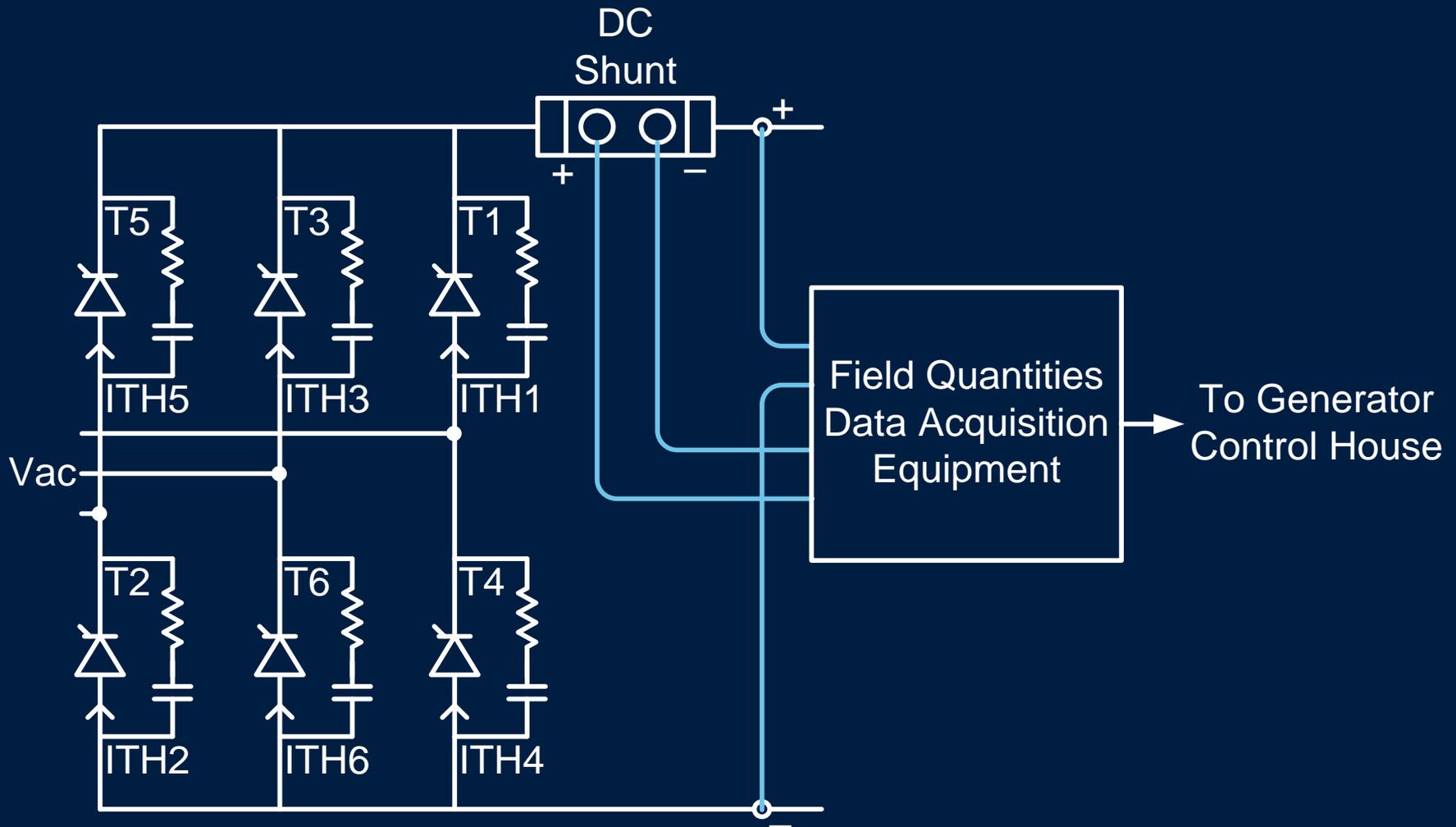


Instrumenting Machines to Capture New Data

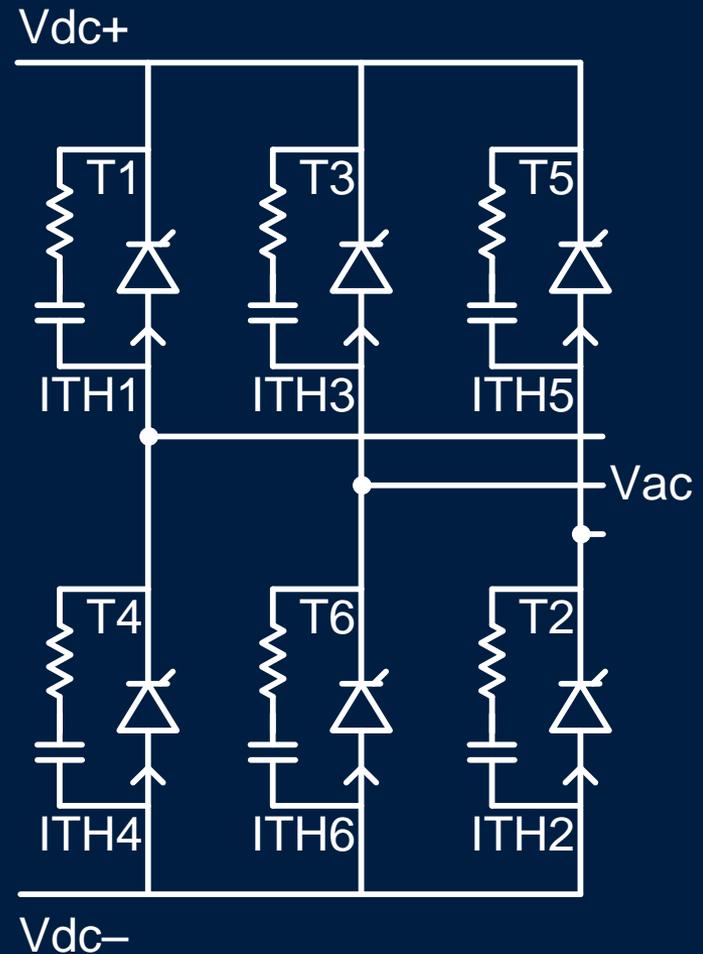
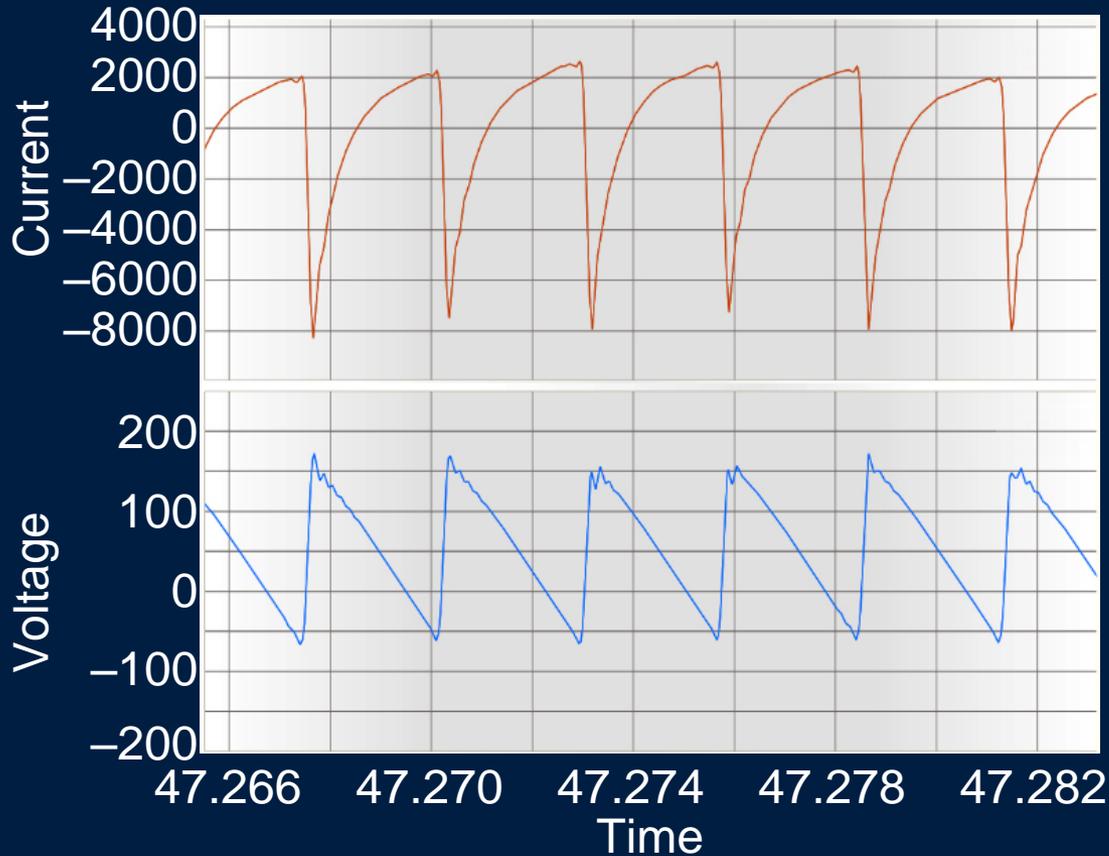
- Generator rotor angle
- Field voltage
- Field current



How Do We Capture Field Quantities?



Creating the Rotating Magnetic Field



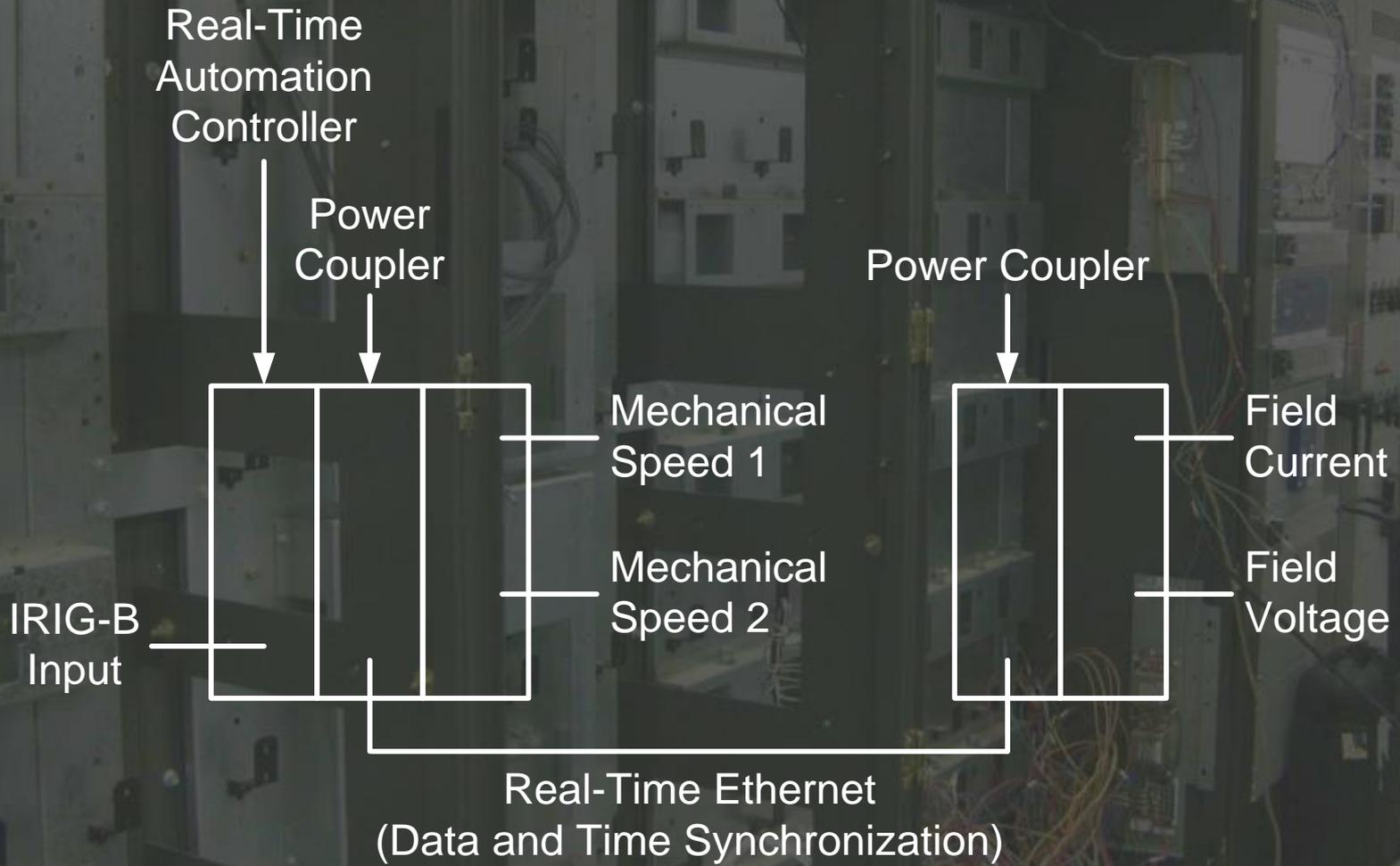
Instrumenting the Field Quantities



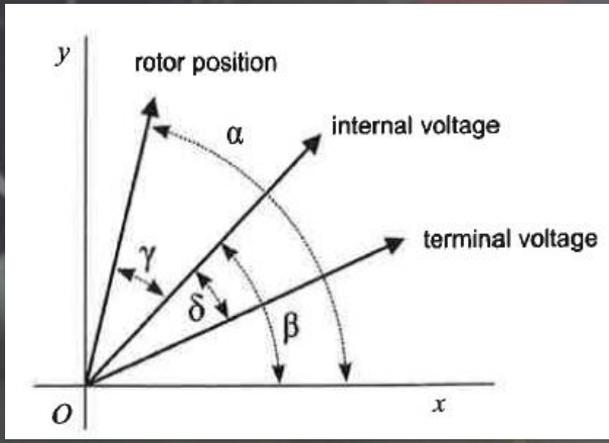
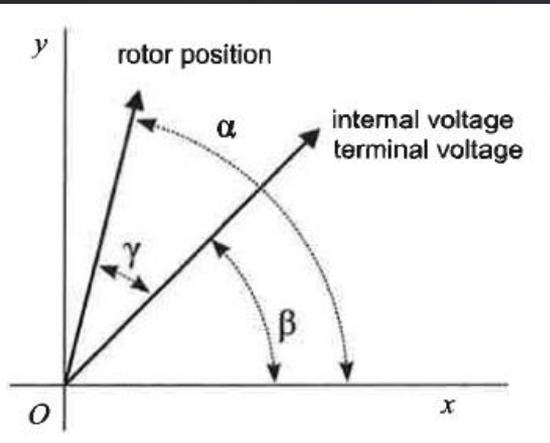
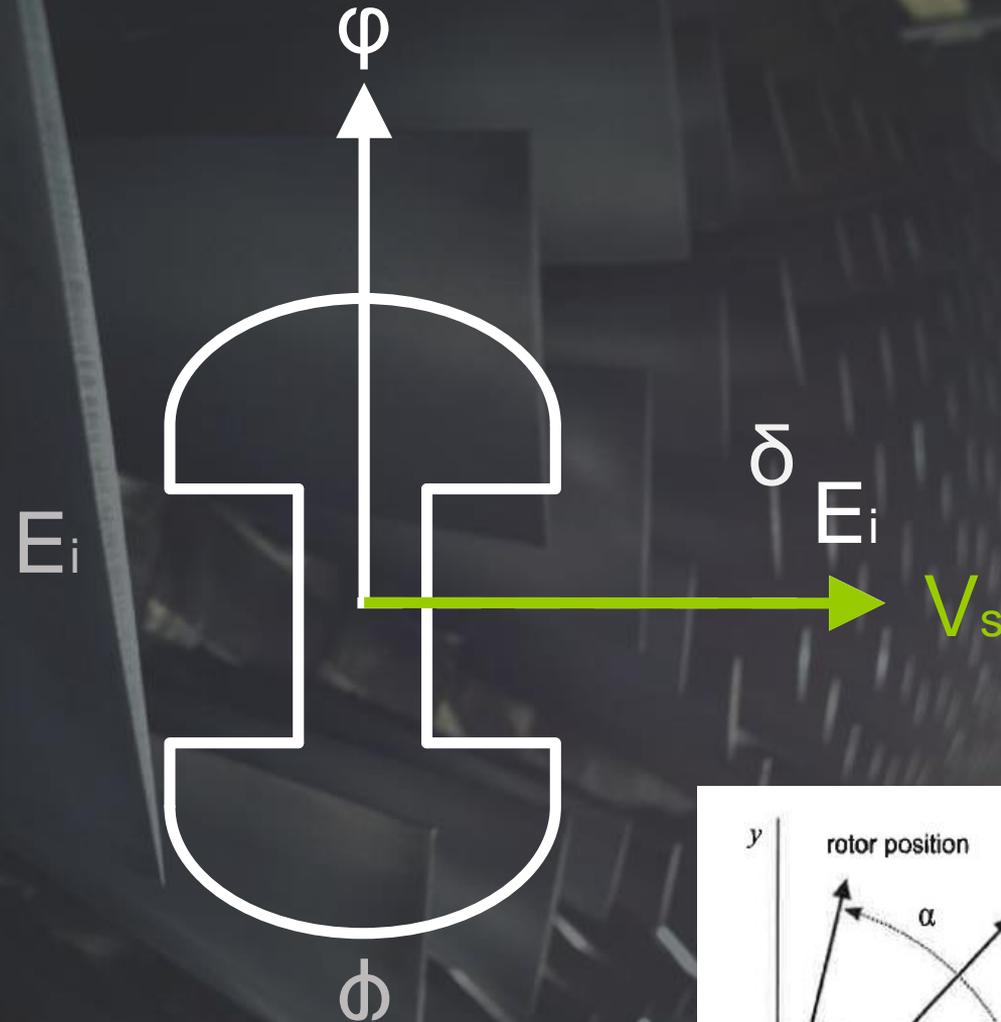
DC Bus



Architecting a Solution

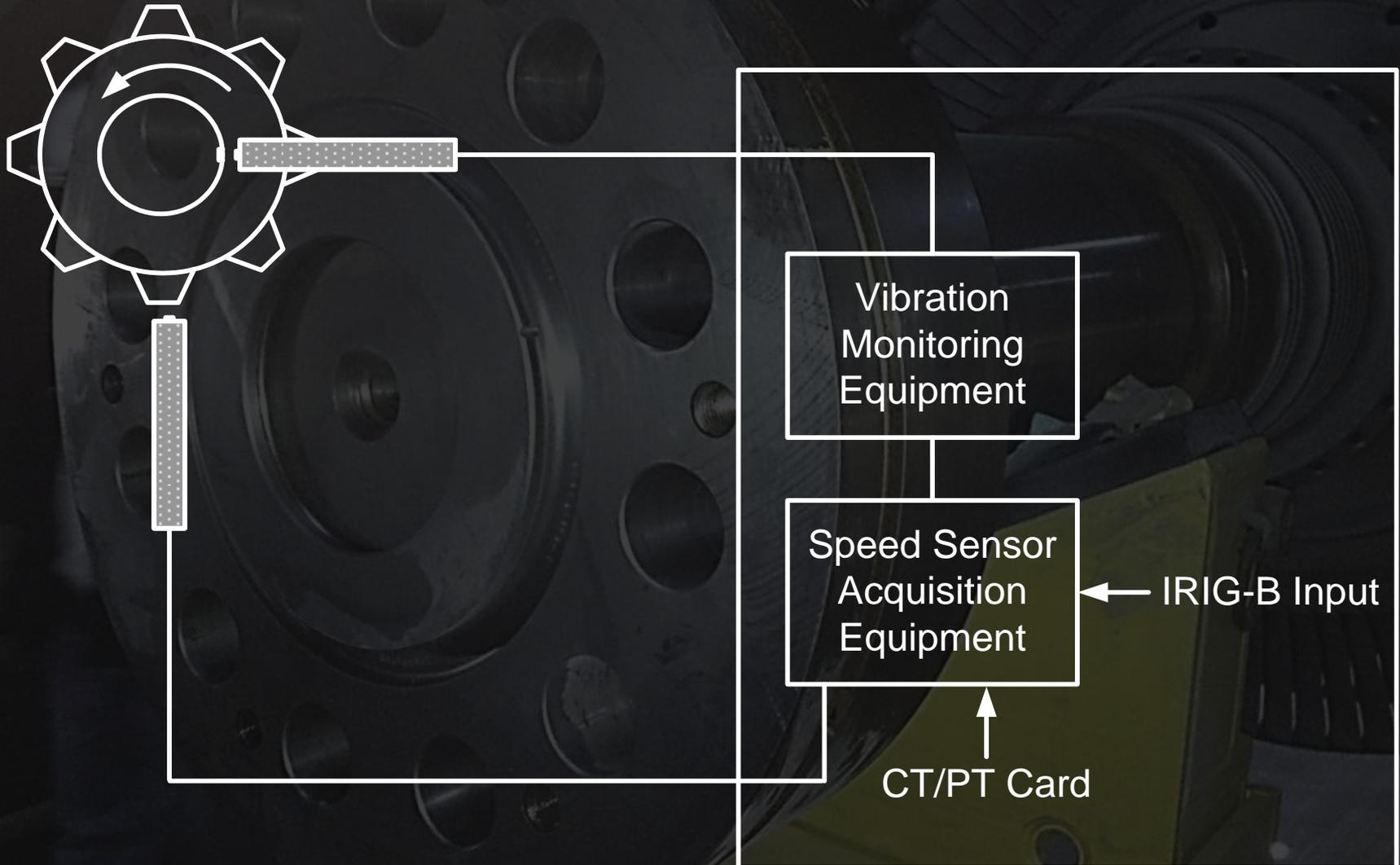


Angle of Rotor Relative to What?

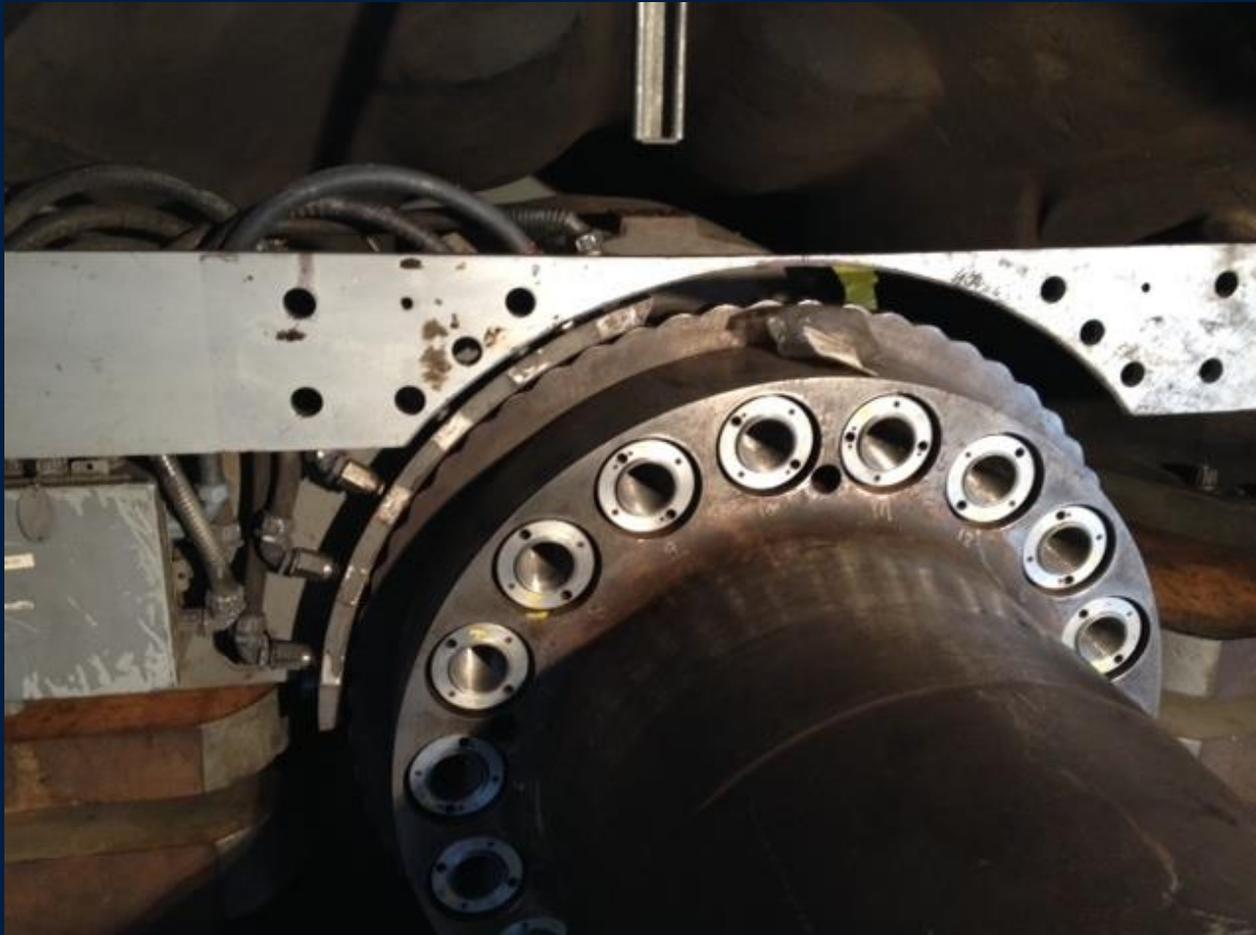


Instrumenting for Mechanical Signals

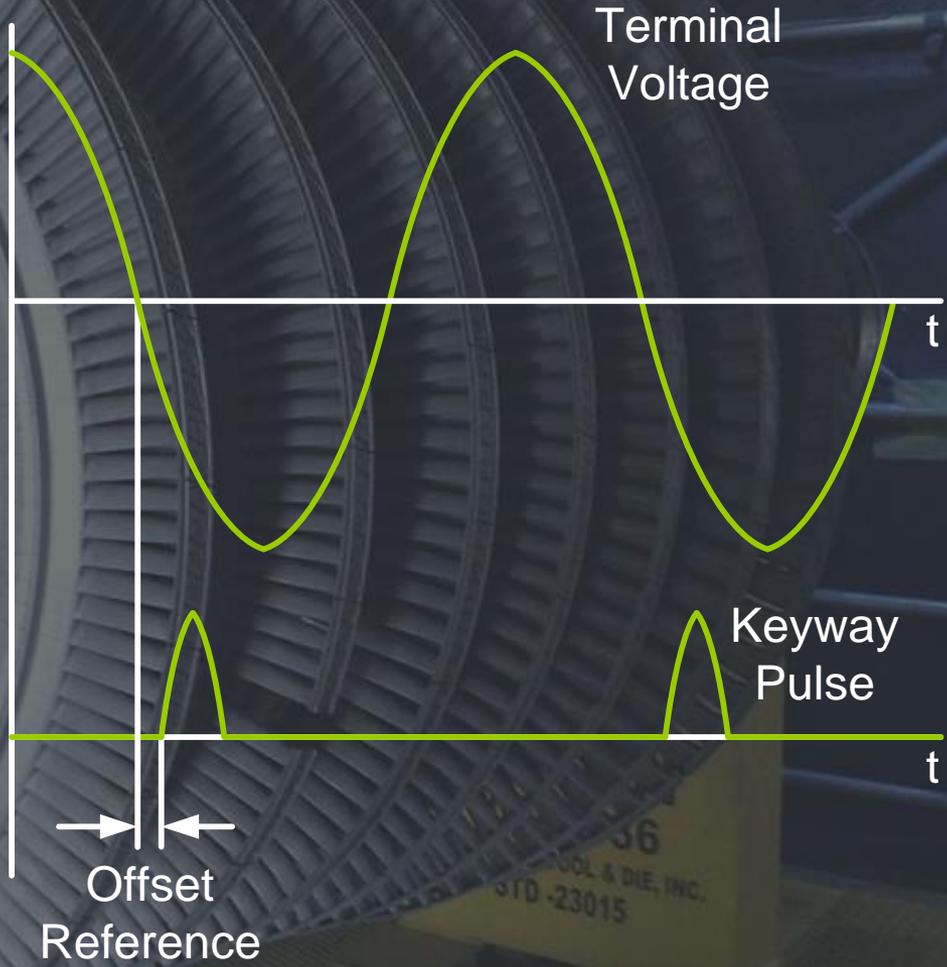
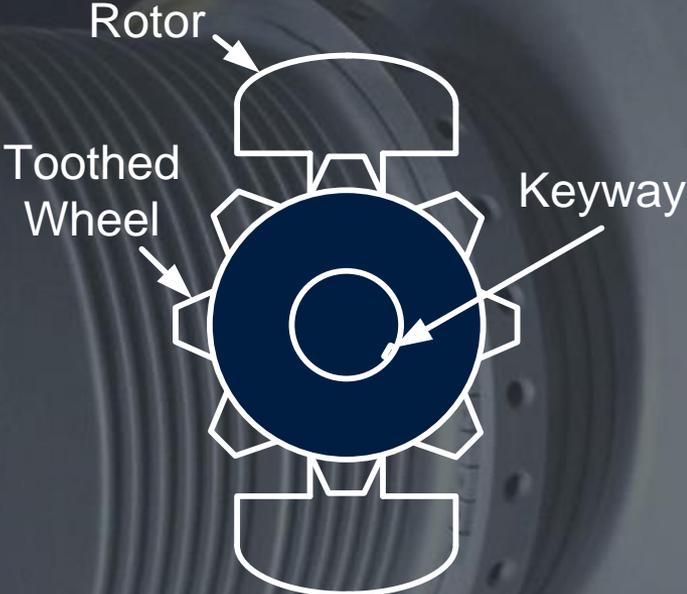
Rotor Speed and Angle



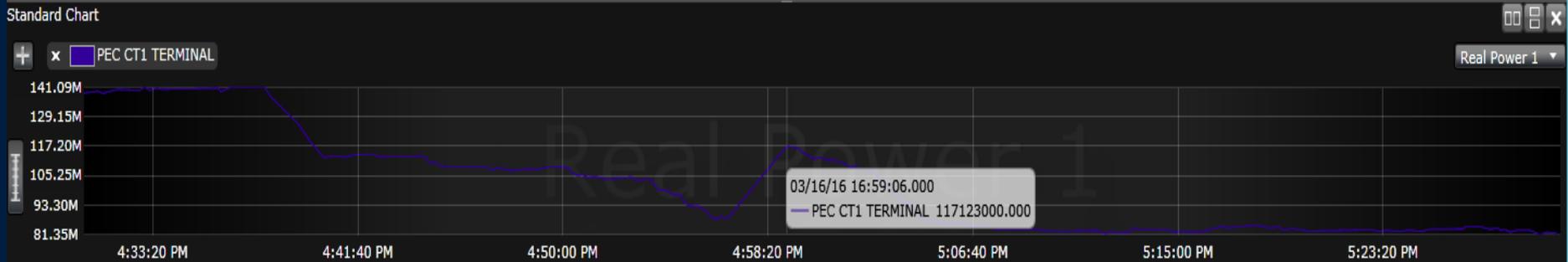
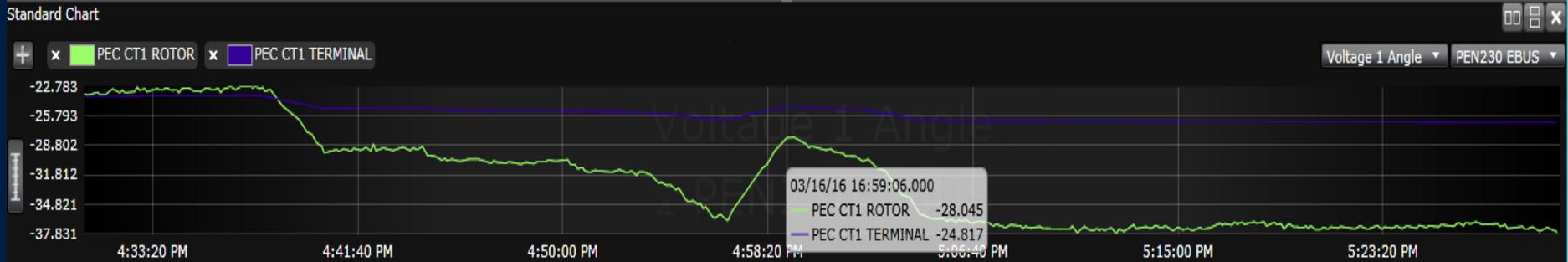
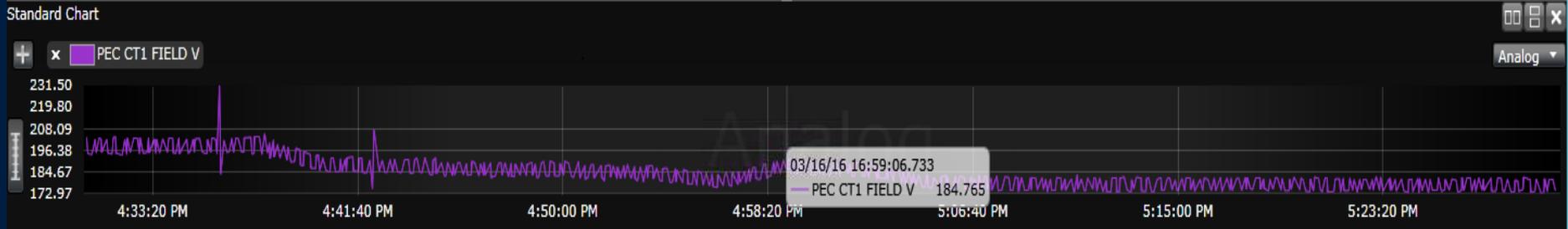
Exactly What Are We Instrumenting?



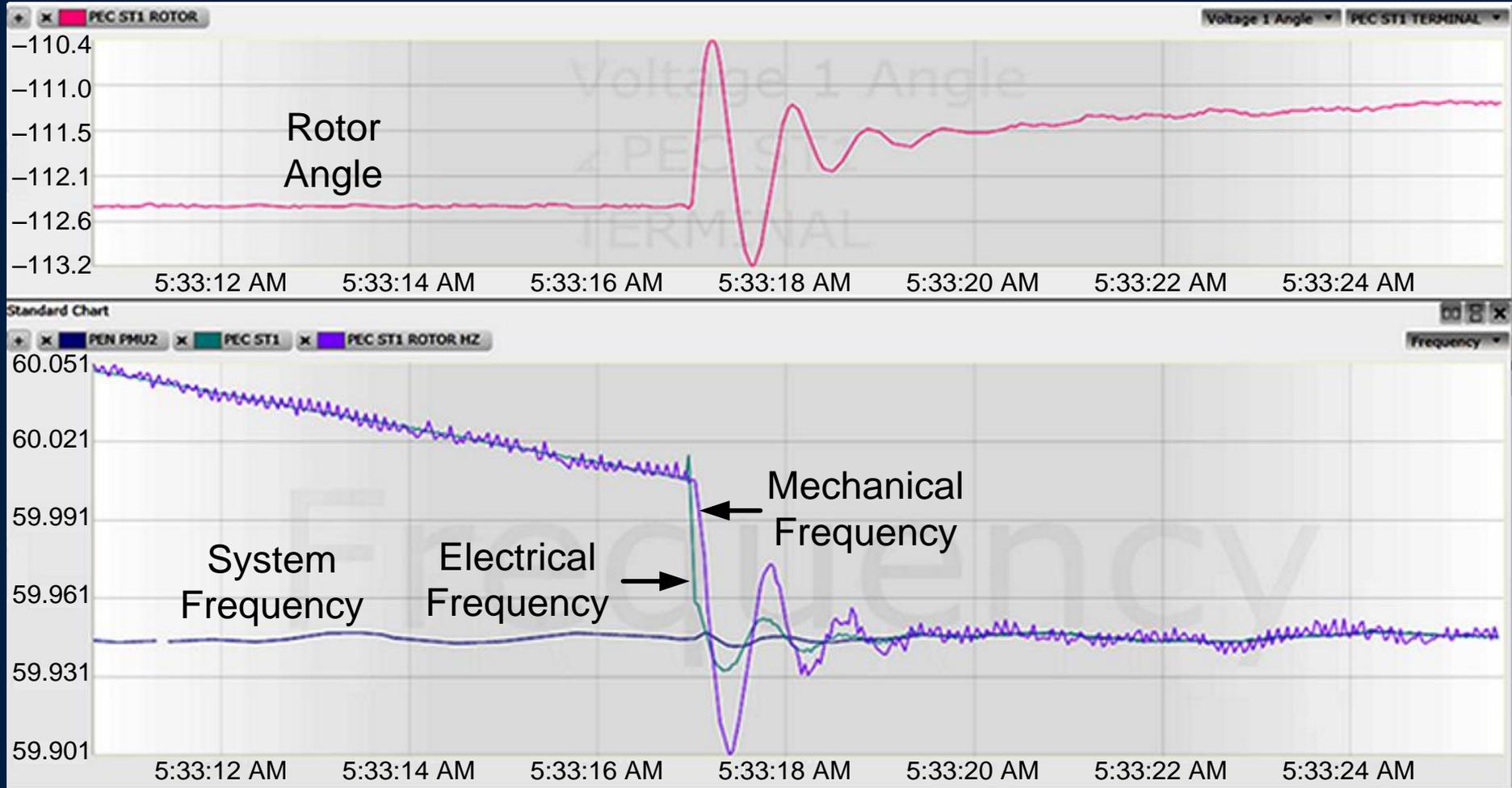
Combining Electrical and Mechanical Data



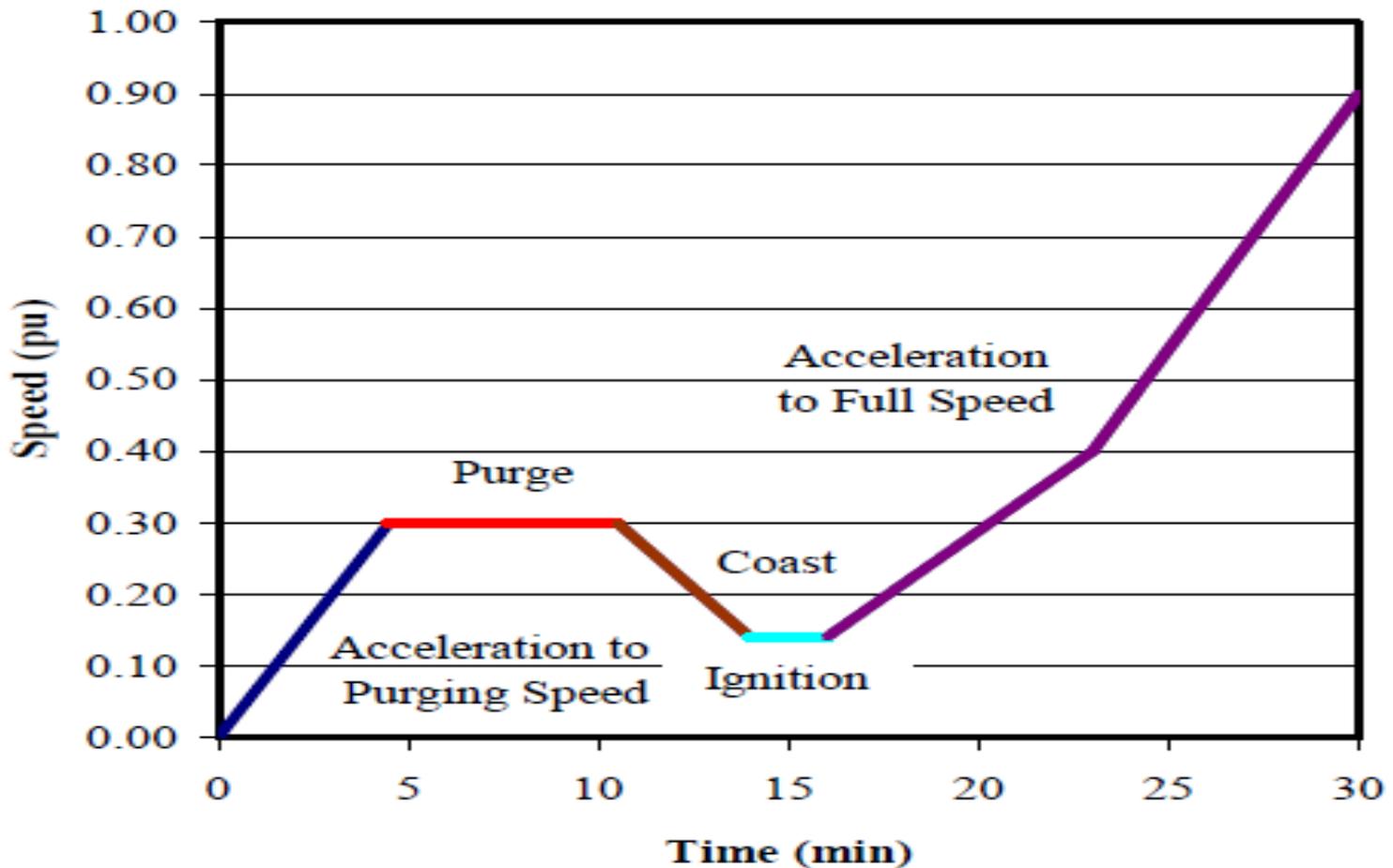
PMU Data



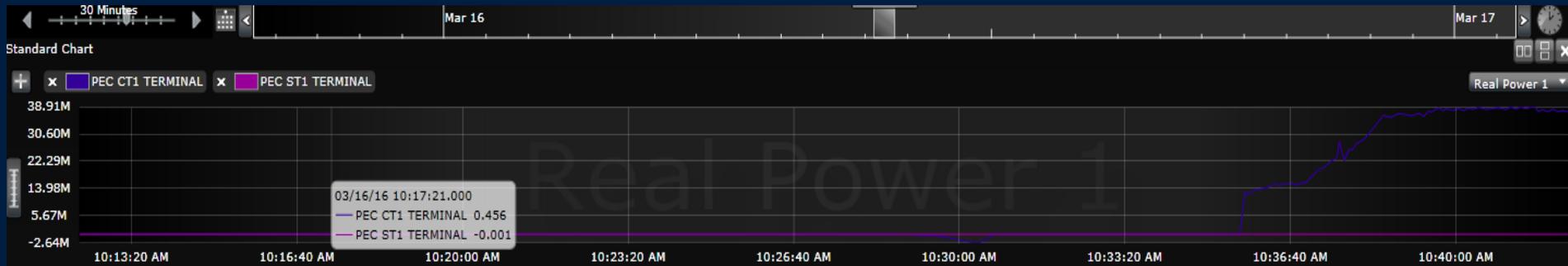
Watching 20 Tons of Metal Get Tossed Around – A Synchronization Story



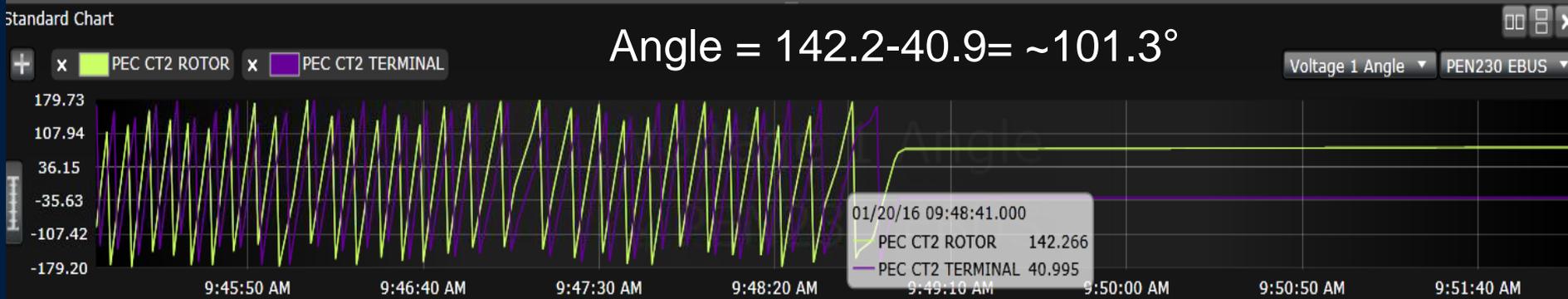
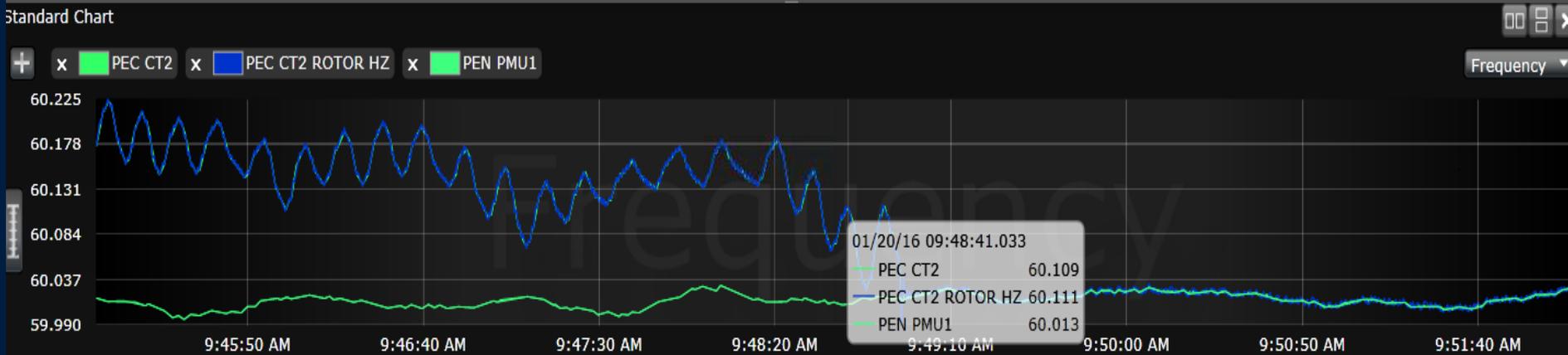
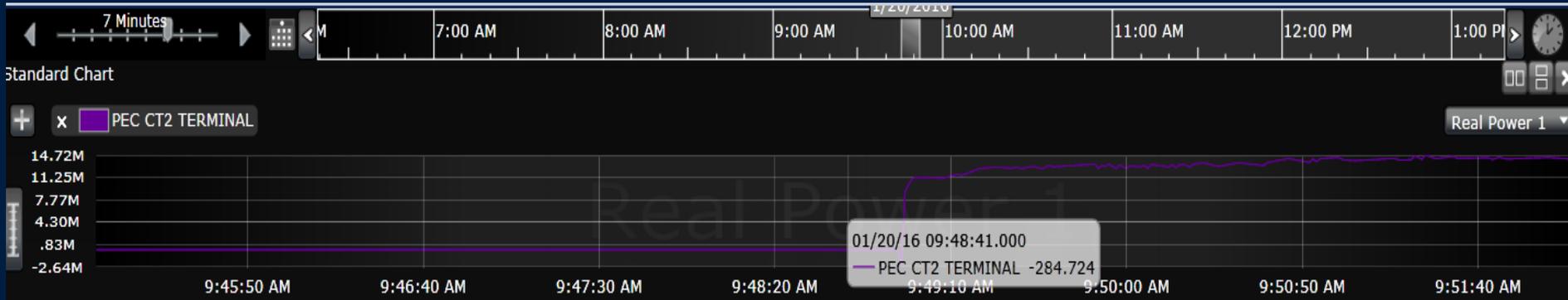
Standard Start Load-Commutated Inverter



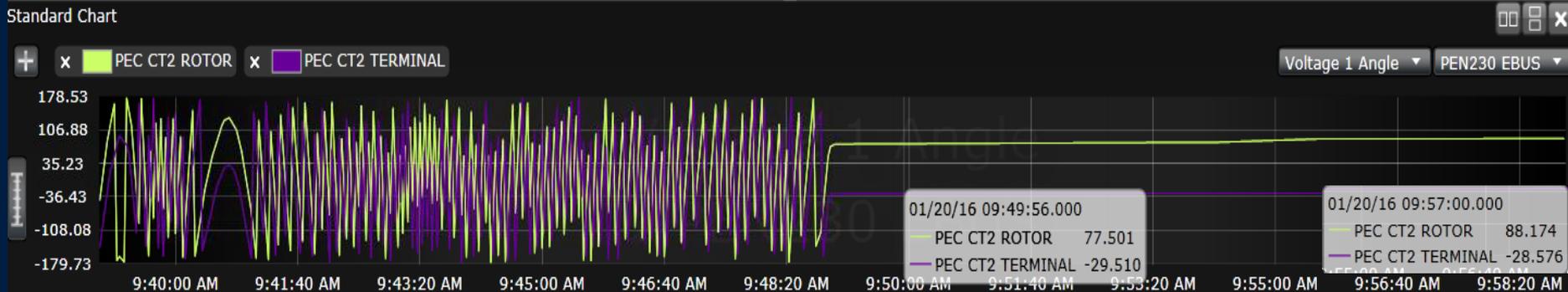
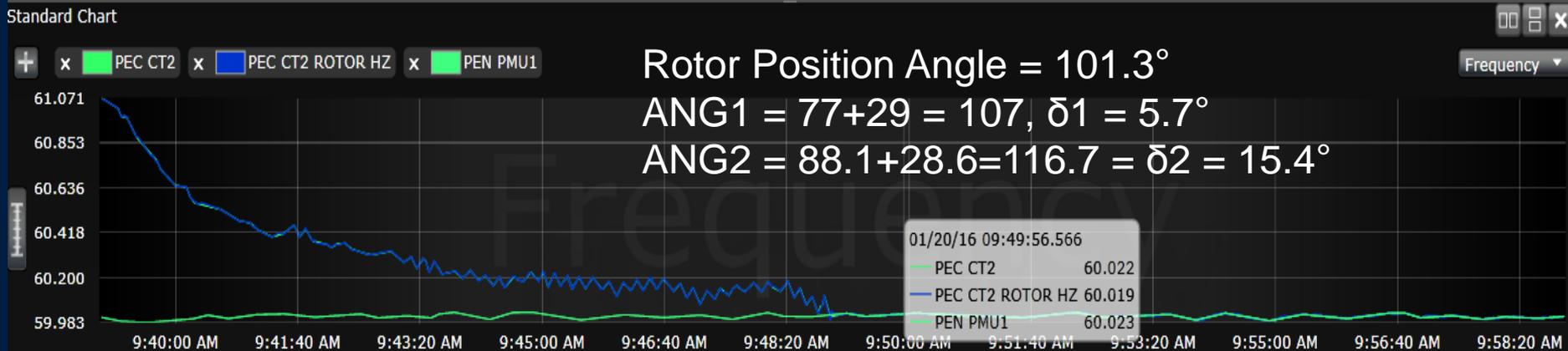
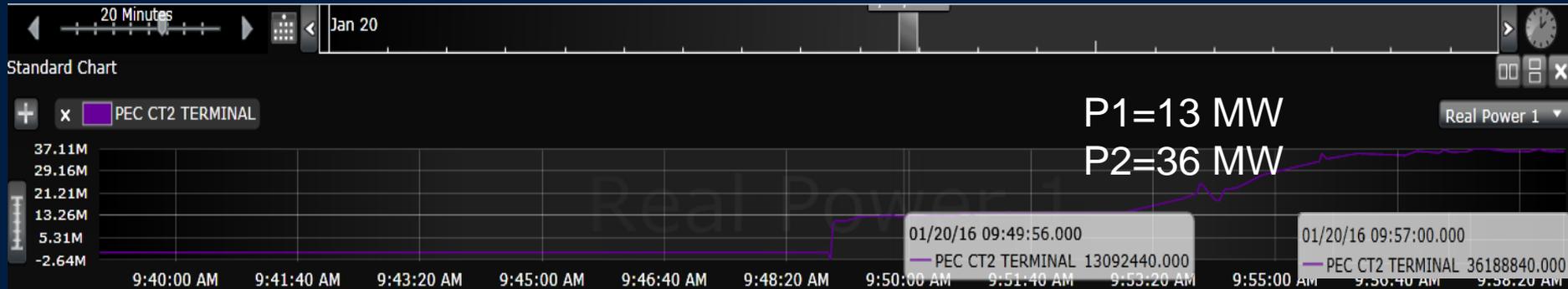
Starting a Machine With a Load-Commutated Inverter



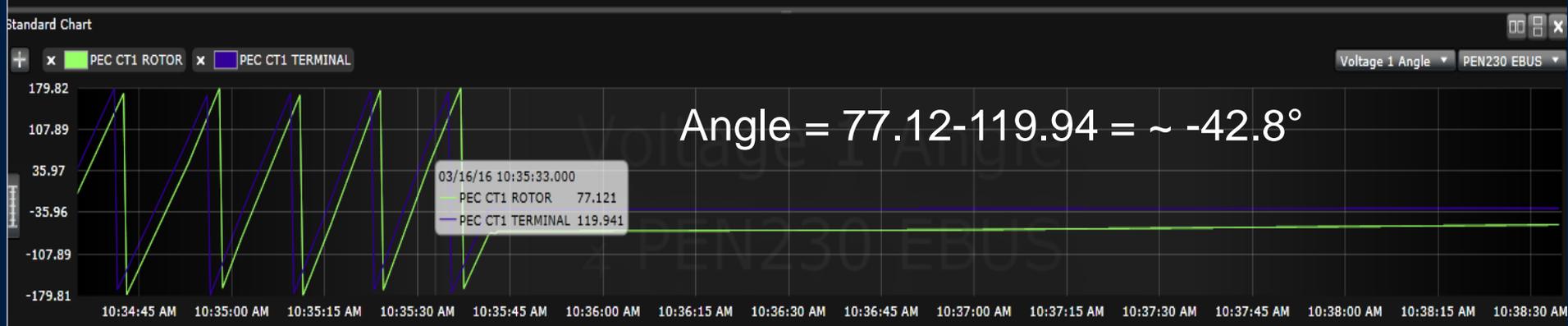
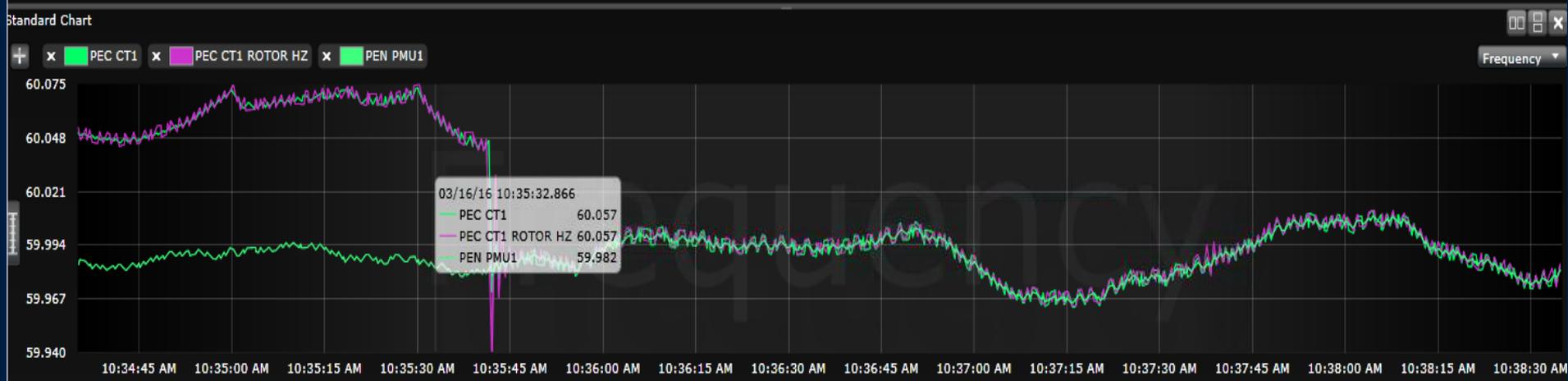
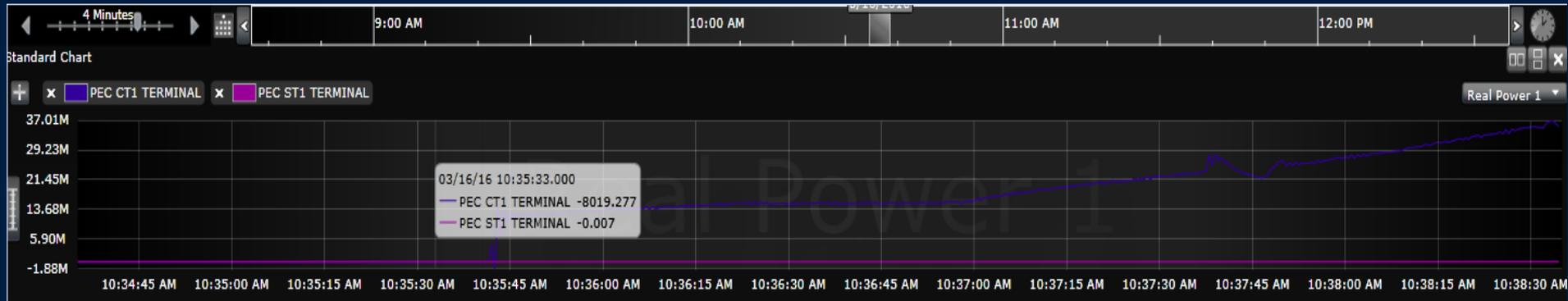
CT2 Startup



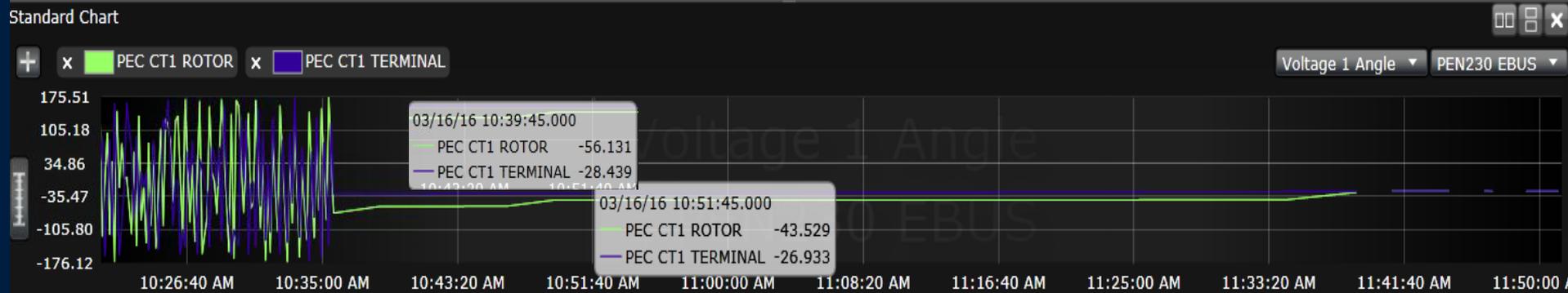
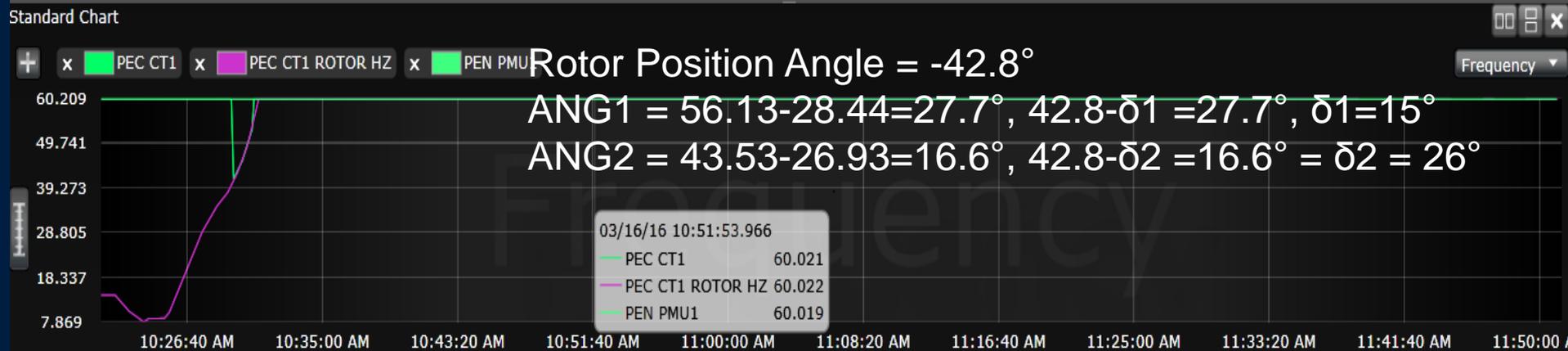
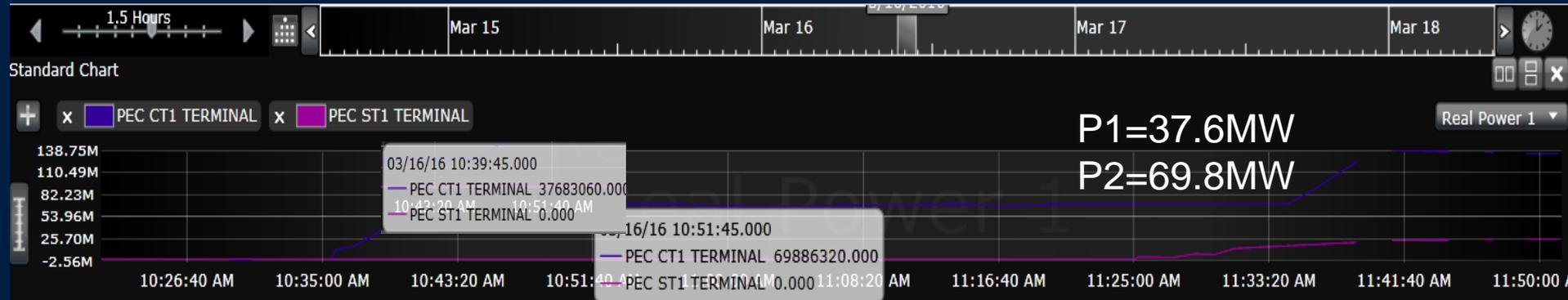
CT2 Loading



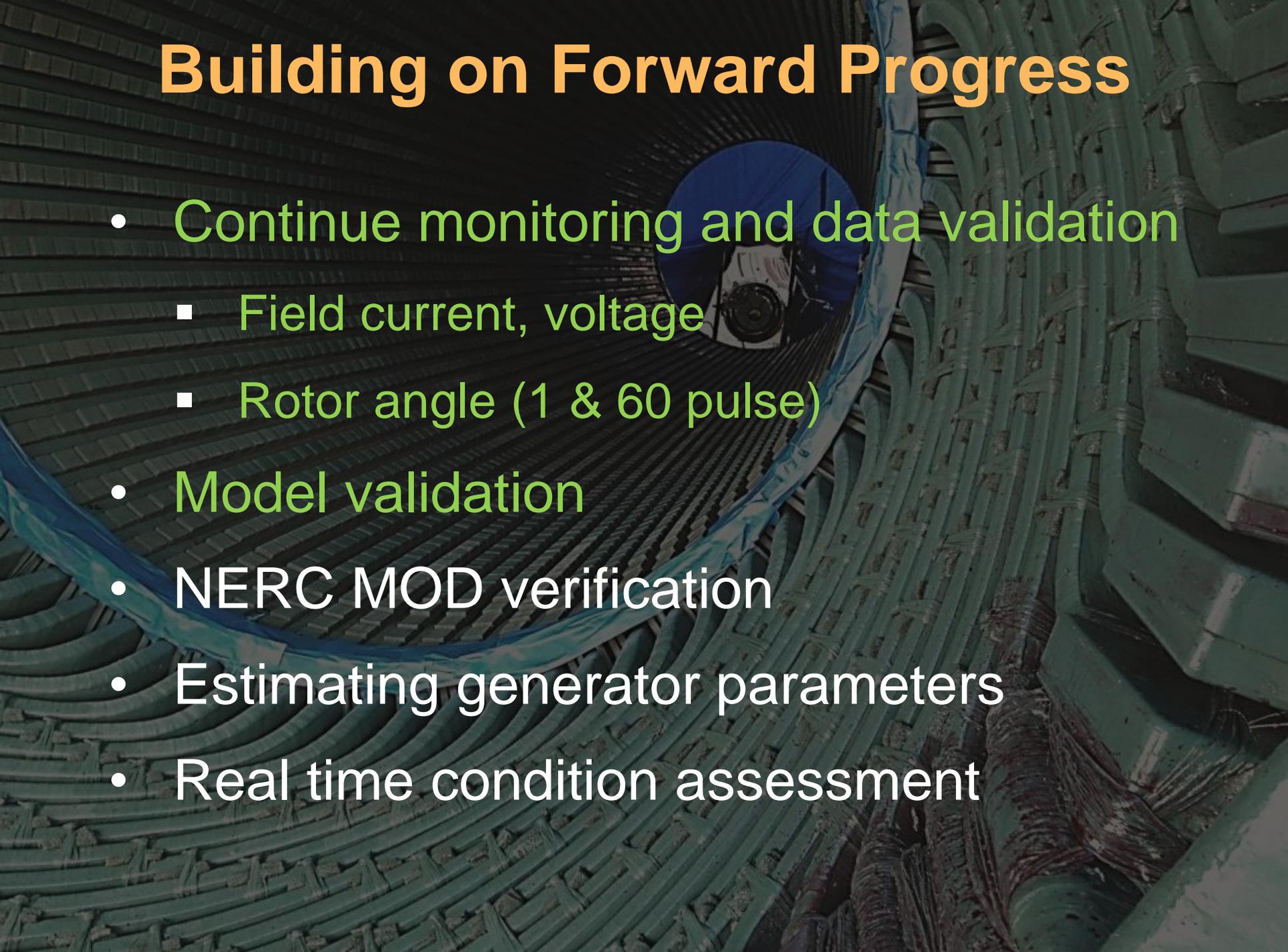
CT1 Startup



CT1 Loading



Building on Forward Progress



- Continue monitoring and data validation
 - Field current, voltage
 - Rotor angle (1 & 60 pulse)
- Model validation
- NERC MOD verification
- Estimating generator parameters
- Real time condition assessment

Questions?