Synchrophasor Measurement Standard – IEC/IEEE 60255-118-1

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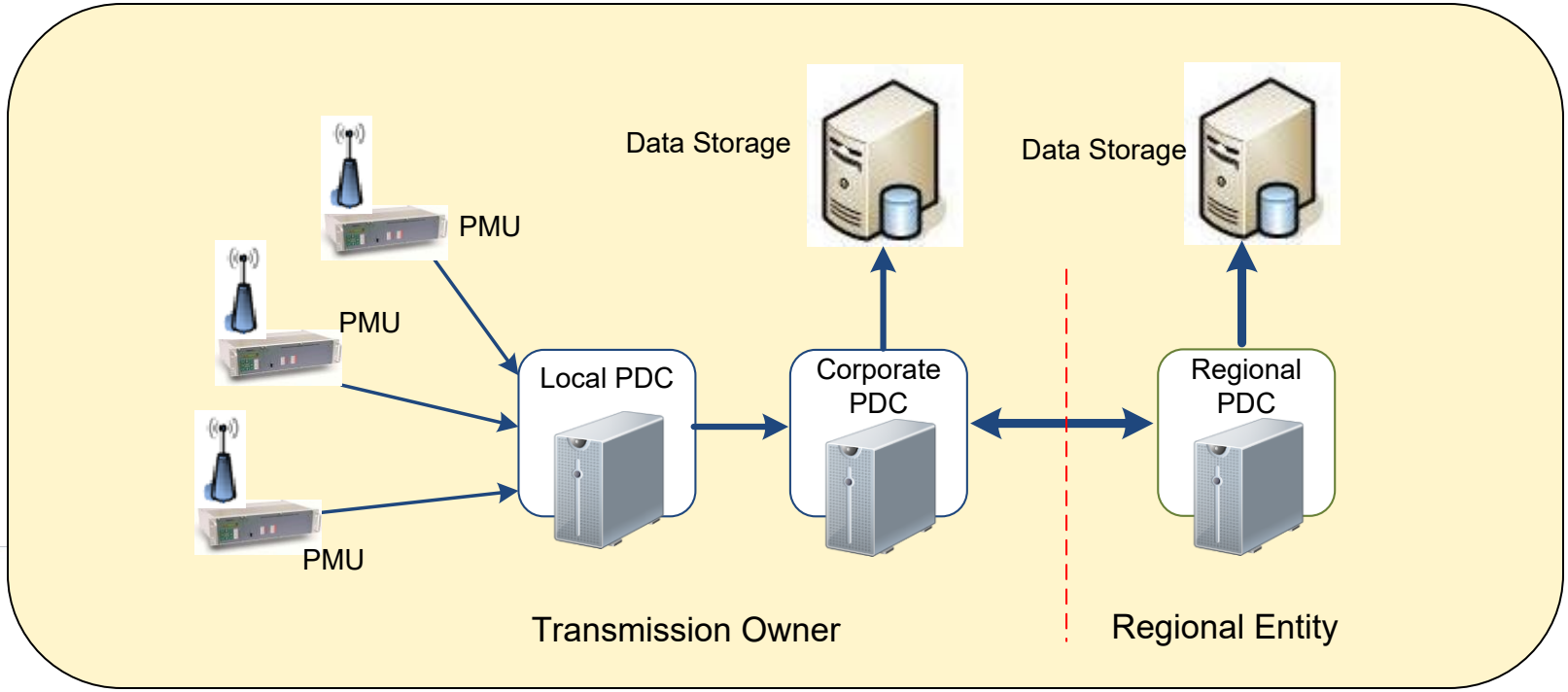
Synchrophasor Measurement System

- Measurements at substations, data sent to control center in real-time
- Data collected & aligned, sent on to applications or higher level processing; also recorded for analysis
- Continuous measurement and data processing



Synchrophasor Standard C37.118-2005

- Measurement requirements
  - Test method & error limits specified
  - Steady-state phasor only
- Data transmission formats
  - Improved status and error indications
  - Includes single or multiple PMU data
  - Adaptable for network communication
- Widely used & very few problems

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IEC/IEEE 60255-118-1 Synchrophasor Measurement

- The 2011 revision split C37.118-2005 into separate measurement and communication standards
  - Improved compatibility with IEC standards
- The Measurement standard added--
  - Definitions for the measurement that would clarify the expected result under varying conditions, particularly dynamic-state
  - Compliance tests for measurement under conditions where the parameters were changing (Dynamic-state) conditions
  - Compliance verification for Frequency which was widely used and reported inconsistently
- The other provisions were brought forward & updated

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Synchrophasor Definition Extended

- Generalized case where all parameters change:
  - Amplitude = $X_m(t)$
  - Phase argument = $\theta(t)$
  - Additive signals = D(t)
- The signal is defined: $x(t) = X_m(t) \cos[\theta(t)] + D(t)$
- To simplify notation, all deviation from the nominal power system frequency were combined in one function, $\varphi(t)$: $\theta(t) = 2\pi f_0 t + \varphi(t)$
- The phasor value is: $\boldsymbol{X}(t) = (X_m(t)/\sqrt{2})e^{j(\varphi(t))}$

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Further Definitions

- For the signal: $x(t) = X_m(t) \cos[\theta(t)]$
- Frequency: $f(t) = 1/(2\pi)\, d\theta(t)/dt$
- ROCOF: $ROCOF(t) = df(t)/dt$
- Same definitions at C37.118 series
- All measurements are estimated for the time of measurement (timetag)
- Frequency & ROCOF are defined as instantaneous values but could be smoothed over a window.

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Extended Definition example

- For application of the definitions, specific formulas are substituted for the generalized parameters $X_m()$, *φ(), and f().*
- In the case of phase and amplitude oscillation we have:
  - $X_m(t) = X_m [1+k_x \cos(2\pi f_m t)]$
  - $\varphi(t) = k_a \cos(2\pi f_m t)$
  - $D(t) = 0$ (assume no interference for this test)
  - X_m , k_x , and k_a are constants, f_m is the modulation frequency
- The signal is then:

$$x(t) = X_m [1+k_x \cos(2\pi f_m t)] \cos[2\pi f_0 t + k_a \cos(2\pi f_m t)]$$

- The phasor is:

$$\boldsymbol{X}(t) = (X_m/\sqrt{2}) [1+k_x \cos(2\pi f_m t)] e^{j(ka \cos(2\pi fm t))}$$

- Frequency is: $f(t) = f_0 - k_a f_m \sin(2\pi f_m t)$

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Key points

- The synchrophasor standard defines a model for the measurement as it relates to the power system.
- It extends the original concept beyond steady-state for addition of measurement requirements under dynamic operating conditions.
- The model is fully compatible with all existing development under previous standards.
- The model provides an easy way to setup tests and evaluate PMU measurement results
- The standard does not prescribe specific algorithms to estimate values, but relies on tests under specific conditions to assure the measurements meet minimum requirements
- The standard with dynamic definitions has been in service 15 years without significant concerns expressed by manufacturers or users

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That's the introduction!

- QUESTIONS?

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