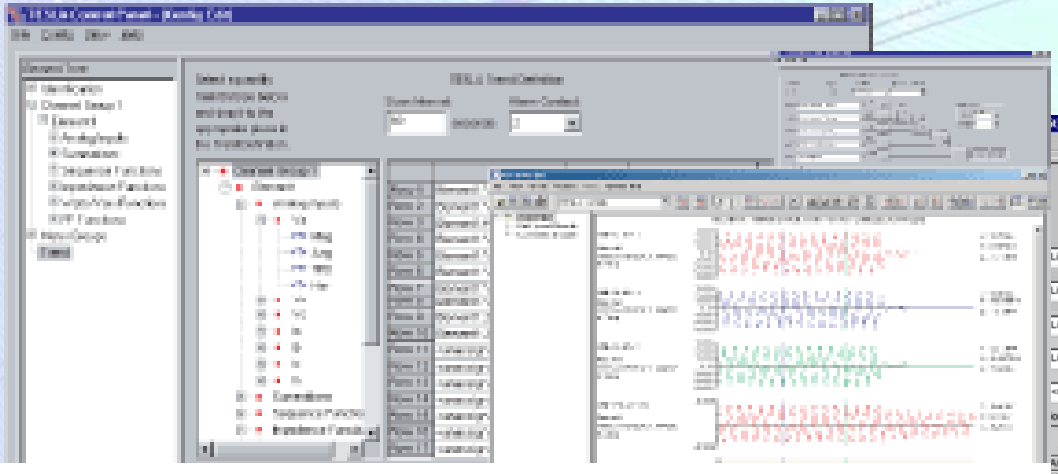
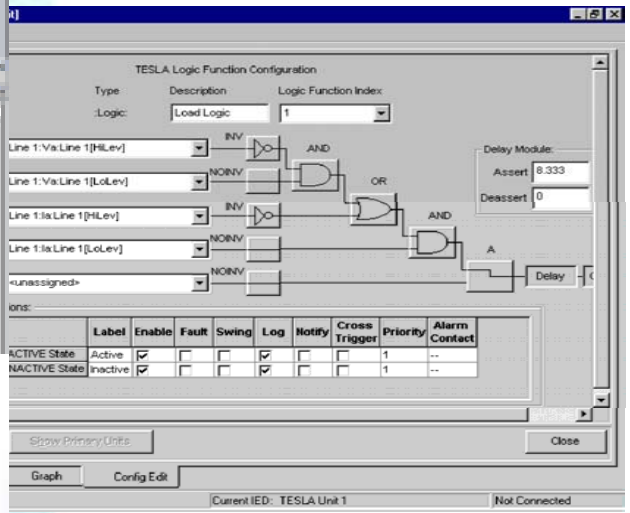
TESLA Recorder PMU Capabilities





Krish Narendra

GM- Technology & Quality

ERLPhase Power Technologies Ltd

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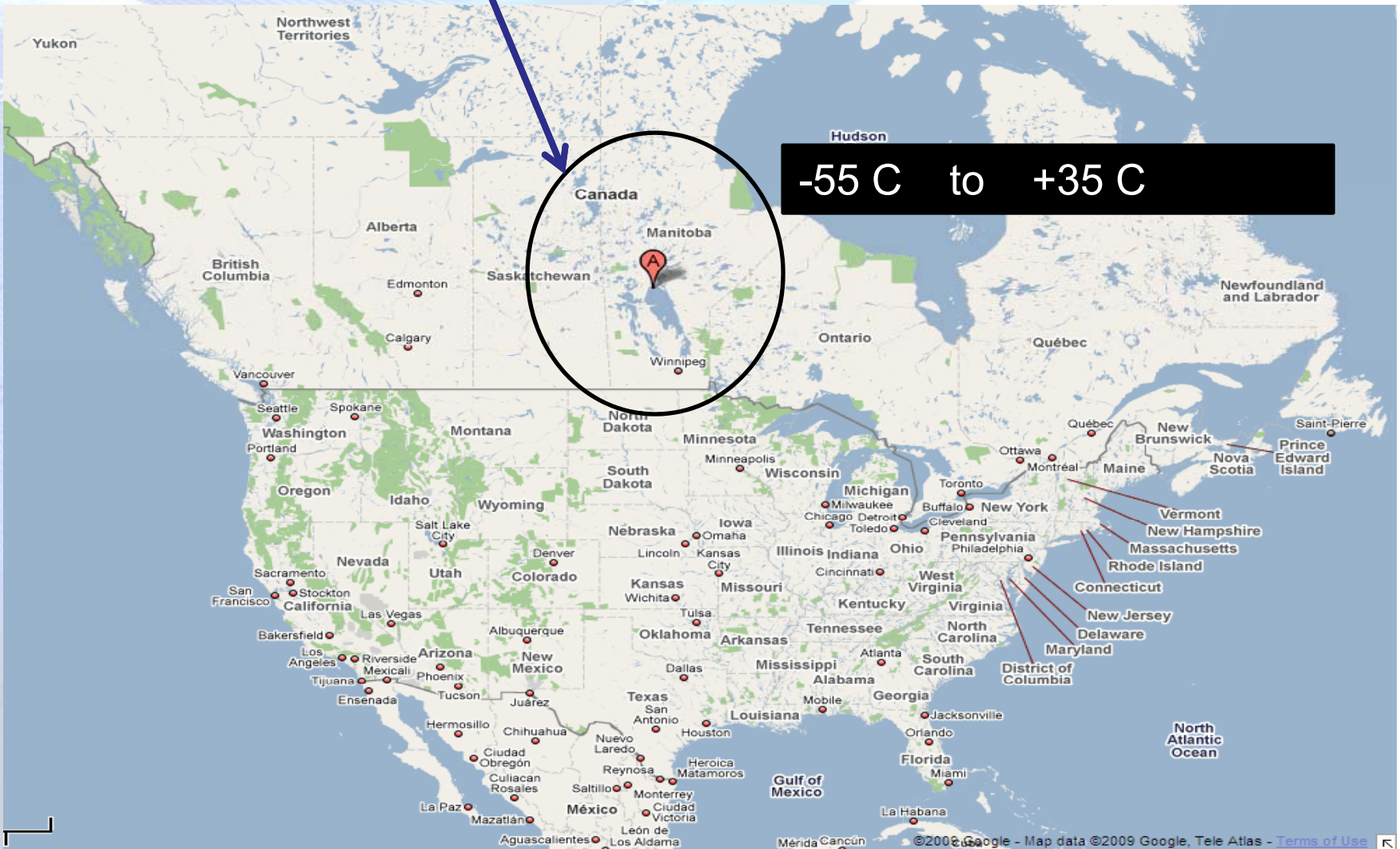
- TESLA 4000 PMU & IEC 61850
- Conclusions

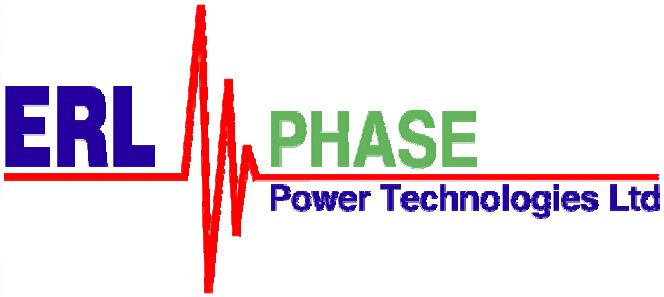
About ERLPhase

Charles Legeyt Fortescue

- Inventor of SYMMETRICAL COMPONENTS



About ERLPhase



- ERLPhase was formed in 2007 as the next generation of APT Power Technologies and the Relay and Recorder division of NxtPhase T&D Corp.

- ERLPhase is formed as a division of Easun Reyrolle Ltd., a growing international company.

ERLPhase
Relays & Recorders

Protection Relays

L-PRO 2100 / 4000
(line relay)

T-PRO 8700 / 4000
(transformer relay)

B-PRO 8700 / 4000
(bus relay)

F-PRO 5100 / 3000
(feeder relay)

RecordBase
(central station)

Disturbance Recorders

TESLA 3000 / 4000 Recorders

ALL 4000 Series Products and F-PRO 3000 Support IEC 61850 communication protocol

TESLA LITE
New!

TESLA Power System Recorder

TESLA 3000 Power System Recorder

DFR	DSR	SER	PQR	LTR	CDR	PMU
Digital Fault Recorder	Digital Swing Recorder	Sequence of Event Recorder	Power Quality Recorder	Trend Recorder	Continuous Disturbance Recorder	Synchrophasors
0 - 30 sec	1 - 30 min			1 - 90 day	4-140 day	Real Time

TESLA Overview

The TESLA is a complete, state of the art, user friendly multi timeframe dynamic power system recorder with advanced PMU and Continuous Disturbance Recording capabilities

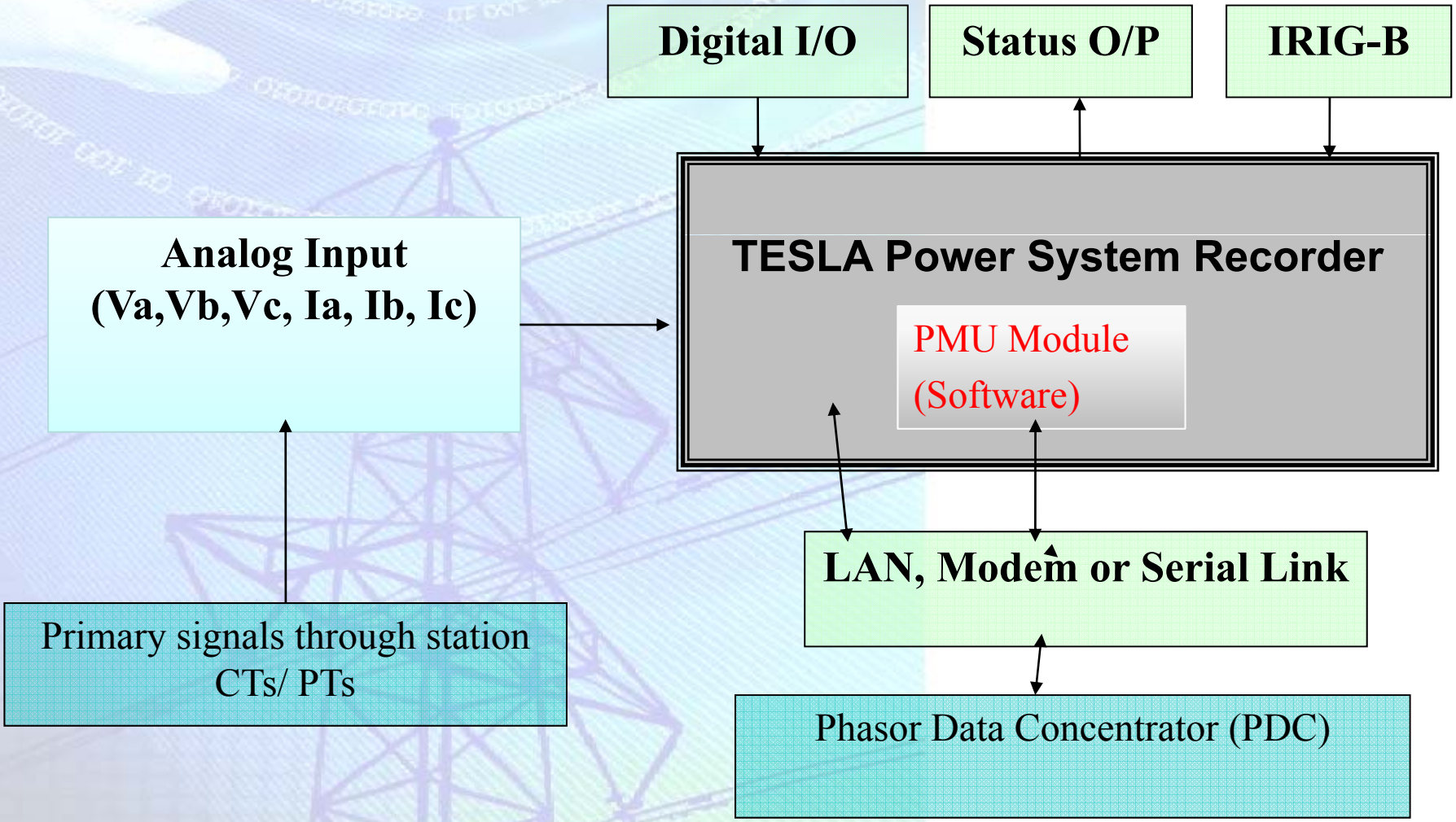
- 36A (64 DI) and 18A (32 DI)Channels; cooperative mode: 144A (256 DI)
- Sampling: 32, 64, 96, 128, 256 & 384 samples/cycle
- NERC Compliant Continuous Disturbance Recording Capabilities
- Multiple Time-Frame Recording Device
  - Transient (Fault) Recording
  - Extended Disturbance (Swing) Recorder
  - Event Logger (SOE)
  - Long term Trend Recorder
  - Continuous Disturbance Recording (FIFO)
- PMU – Phasor Measurement Unit (IEEE C37.118)
- Fault Location (10 devices)

TESLA Overview

OVER 120 CALCULATED CHANNELS PER RECORDER:

- Summation: (30 channels) High & Low Magnitude; + & - ROC triggers
- Sequence: (12 channels) +, -, 0 sequence triggers
- Watts/Vars: (18 channels) high & low magnitude; + & - ROC triggers
- Impedance: (18 channels) ROC within defined impedance circle around origin
- Logic: (30 channels) AND, OR, etc triggers on transition to ON or OFF state
- Power Factor: (18 channels) separate triggers for lagging (inductive) and leading (capacitive)
- Fault Locator: (10 channels) creates event message
- Frequency: (2 channels) High & Low Magnitude; + & - ROC triggers

TESLA Recorder
PMU (IEEE C37.118) Capabilities



TESLA PMU Module

- Complies with IEEE C37.118
- Field upgradeable
- Exists simultaneously with the other recording features
- Superior communication capabilities
- Wide range frequency response
- Easy to configure and use
- Excellent time synchronization accuracy (+/- 1.5 uS)

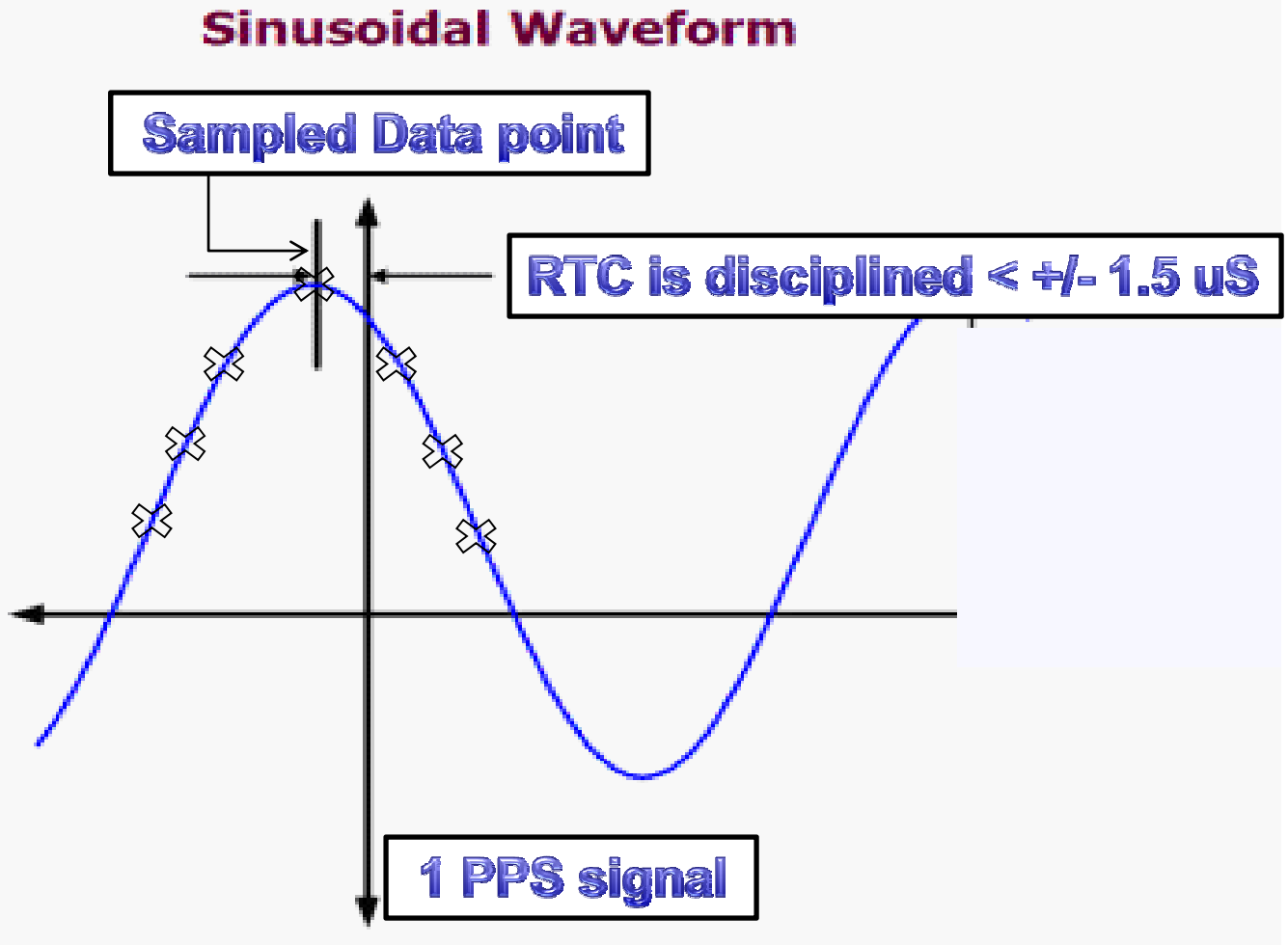
TESLA PMU Capabilities

- **All Triggers are based on PMU measurements**
  - Voltage and Current Phasor Trigger
  - Sequence Components Trigger
  - Summation Trigger
  - Impedance Trigger

  (Triggers: high, low, positive, negative, rate of change etc.,.)

TESLA PMU Capabilities…

- Synchronized sampling with IRIG signal (1 PPS)



TESLA PMU Capabilities…

- **PMU Recording in Swing Domain (1 - 30 minutes)**
  - PMU Magnitude and Phase angle recording available based on different trigger event
  - Frequency channels are also available

TESLA PMU Capabilities…

- **Trend PMU Data over 90 days**
  (10 – 3600 sec interval)
  - PMU Phase Angle Trending over 90 days
  - PMU Phasor Magnitude Trending over 90 days
  - Frequency channels trending

TESLA PMU Capabilities…

- **Continuous Storage of PMU data from 10 – 60 Frames / sec on a 4GB on board flash disc (mini PDC)**
  - Voltage and Current Phasors can be stored as per NERC's requirement ranging from 3 – 140 days on the local storage memory
  - Recording can be made based using continuous data

TESLA PMU Capabilities…

NERC CDR Compliance:

Number of channels *	Sample rate (RMS records per second per channel)						
	6	10	12	15	20	30	60
36	38	22	19	15	11	7	3.8
24	56	33	28	22	16	11	5.5
18	73	44	36	29	22	14	7
12	106	63	53	42	31	21	10
9	136	81	68	54	40	27	13

No. of days the continuous data can be stored on the TESLA 3000 DFR

Sample rate – RMS records per second per channel

6 records per sample is the requirement from NERC and TESLA 3000 DFR can store depending on the number of channels up to 136 days of data

TESLA PMU Capabilities…

Installation Benefits:

- Best retrofit recorder solution to the industry
  - Can use existing wiring (split core CTs)
  - Smallest footprint among recorders allows easy retrofit and installation
- Remote input modules up to 1200 meters (4000 feet) away save on costly CT and PT wiring runs
- Flexible Installation : Centralized, distributed, or hybrid installation
  - PMU and CDR recording capability are field upgradable on existing TESLA 3000 installations

Utilities can save nearly $250k in installation cost for synchrophasor applications

TESLA PMU Capabilities…

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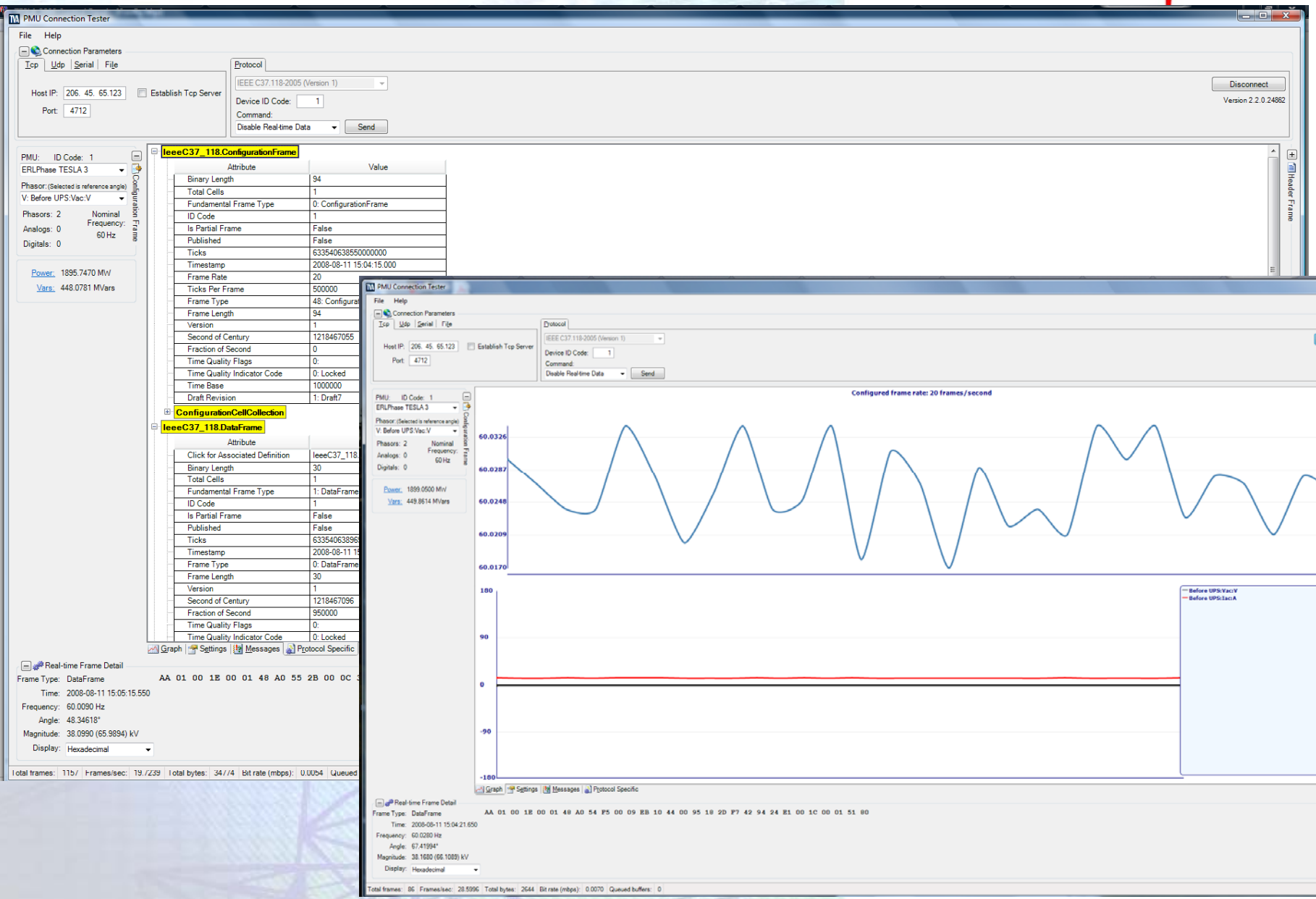
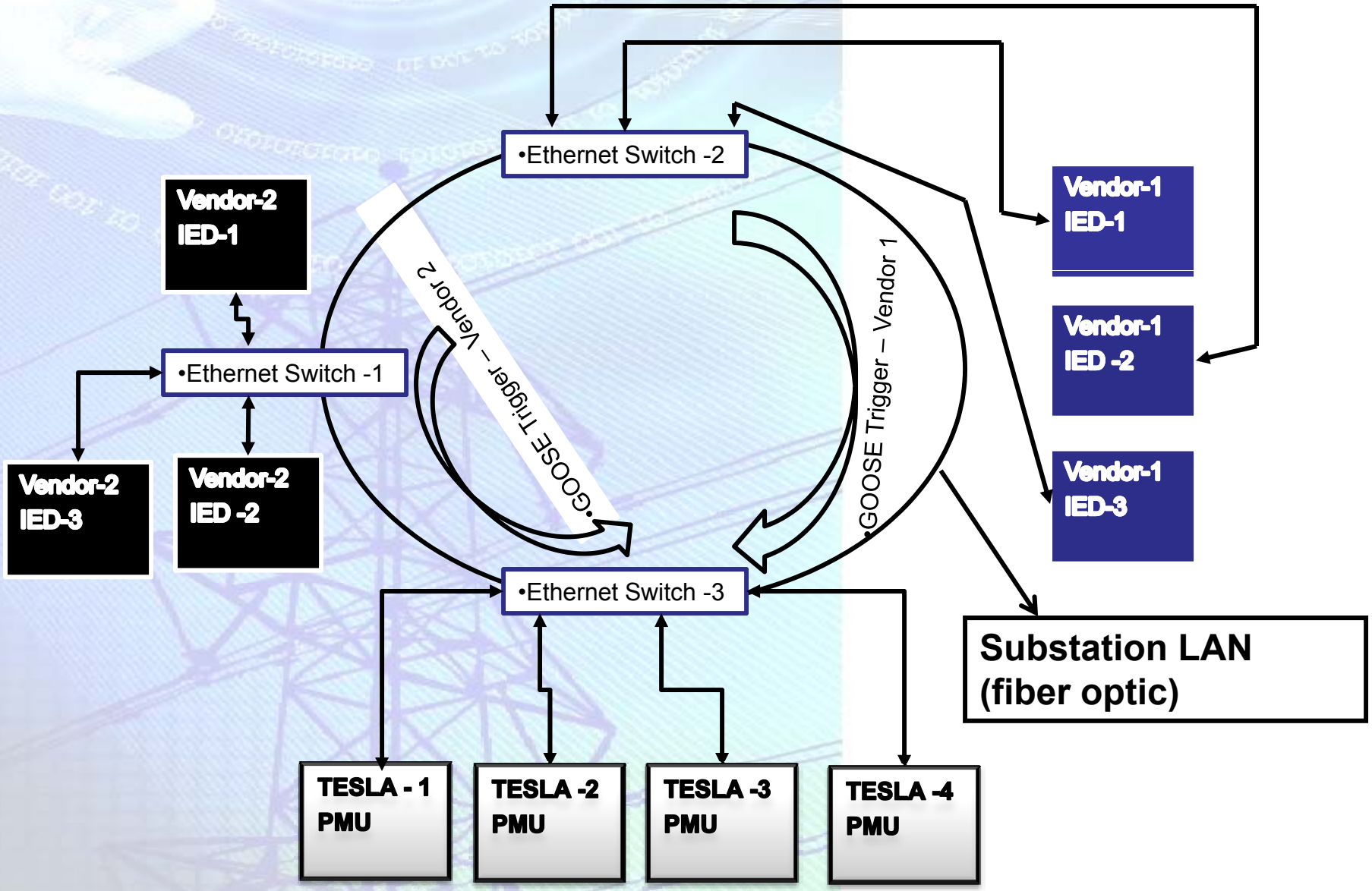


TESLA 4000 PMU & IEC 61850



TESLA 4000 PMU Cross Triggering

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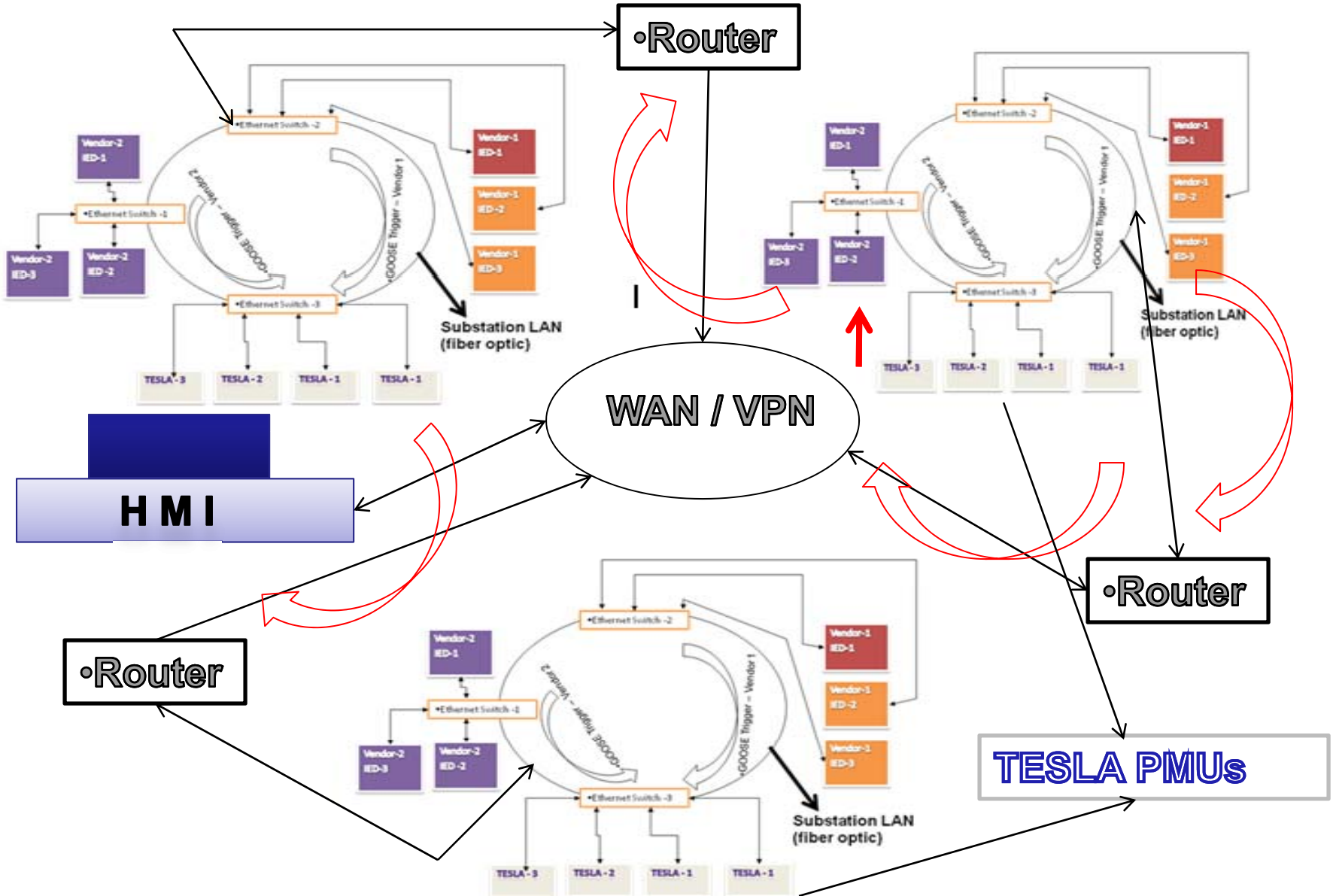

Conclusions:

- TESLA PMUs are field upgradable through firmware update, easy to install, and cost effective
- Provides built in redundancy to PMU Phasor Data, and supports event based recording capabilities at 60Hz sample rate
- Still need to establish interoperability for wide area monitoring and control
- IEC 61850 and PMU standards are implemented in small scale (especially in North America) and hence the limitations are not fully understood
- Number of challenges for both vendors and utilities ahead to adopt to the rapid changing standards and regulations.

QUESTIONS ??