Effective Utilization of PMU data for Triggers and Continuous Recording and communication experiences using Digital Fault Recorder

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Outline

• ERLPhase – History, Products, New Generation Devices

• TESLA Power System Recorder with Phasor Measurement Unit (PMU)

• Advanced PMU Functionalities

• Continuous PMU data Recording

• Communication Redundancy and PMU Recording using IEC 61850

• MB Hydro PMU Communication experiences and Tests

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

ERLPhase is a subsidiary of Easun Reyrolle Ltd of India, an expanding international company. A major in the field of power management, encompassing protection, control, automation, metering and switchgear.
ERLPhase - History

• R&D, engineering, production and customer support base in Winnipeg, Canada.

• Center of Excellence for the transmission level grade relay and recorder products.

• Direct sales responsibility into the America’s plus support the international marketing group for rest of the world.

• Application engineers and sales managers throughout USA, Canada and Latin America.
ERLPhase – Products

Products
Our relay & recorder line provides smart, easy-to-use protection & monitoring of electrical power systems.

Recorders
TESLA Multi-timeframe Disturbance Fault Recorders
- TESLA 4000
- TESLA 3000
- TESLA LITE

Relays
- Bus Protection
  - B-PRO 4000
  - B-PRO 8700
- Line Protection
  - L-PRO 4000
  - L-PRO 2100
- Transformer Protection
  - T-PRO 4000
  - T-PRO 8700
- Distribution Protection & Management
  - F-PRO 5100

OTHER PRODUCTS
- TESLA 4000
- TESLA 3000
- TESLA LITE
- RecordBase Central Station
- PMU+CDR Modules
- L-PRO 4000 Relay
- L-PRO 2100 Relay
- B-PRO 4000 Relay
- B-PRO 8700 Relay
- T-PRO 4000 Relay
- T-PRO 8700 Relay
- F-PRO 5100 Relay

DOCUMENTS
- Data Sheets
- Brochures
- Manuals
- Certifications
- Ordering Templates
TESLA Power System Recorder with PMU

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

10 Year Warranty
ADVANCED DFR PMU FUNCTIONALITIES

- Synchronized sampling with IRIG signal (1 PPS)
  - One sample insured to be within 0.75µs of UTC pulse

Benefits:

- Improved fault location due to synchronized sampled phasor from both ends.
- Line current differential protection validation
ADVANCED PMU FUNCTIONALITIES…

• PMU Recording based on system events
  – Triggered PMU magnitude and angle record
  – Used for slow time-varying events
  – Record at 1 sample/cycle
  – 10 second to 15 minute record with automatic extension
  – Extend up to 30 minutes under multiple trigger conditions

Benefits:
• Very valuable because PMU data record is triggered by and associated with an event, and all related data is recorded
• Recorded data is identical to streamed data, so the DSR effectively acts as a local PMU recorder – first level of redundancy
• Long Term Trending PMU Data
  – Long term PMU magnitude, angle, and frequency record
  – User can define up to 60 trends
  – Record at defined sample rate – 10 to 3600 seconds
  – Maintain log for 90 days
  – Configure to overwrite or stop when full
  – Configure trend-full output contact

Benefits:
• Capture long term variances
• Long term trending PMU data effectively acts as a local PMU recorder – second level of redundancy
Continuous PMU data Recording

- Record up to 36 phasors from 6 to 60 Hz
- Records stored locally (onboard) on 4G flash memory
- Exceeds NERC CDR standards (PRC-002-1)
  - Record anywhere from 3 to 140 days, depending upon config
- Automatic data overwrite
- User selectable range of data can be retrieved

Benefits:

- Effectively acts as a local PDC – third level of redundancy
- Provides for delayed recovery of post-event data
Continuous PMU data Recording…

- CDR – Continuous PMU Recording
- NERC Requirements (6Hz and 9 channels)

<table>
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<th>Number of channels *</th>
<th>Sample rate (RMS records per second per channel)</th>
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<td>106</td>
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<td>9</td>
<td>136</td>
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</table>

Number of days the continuous data can be stored on DFR

With 9 channels configured with a sample rate of 6 records/second/channel the DFR can store up to 136 days of data.
Communication Redundancy...

- Dual Fibre Optic Ethernet Ports (4000 SERIES)
  - The DFR is designed to have 2 independent physical MAC addresses.
  - PMU data can be streamed simultaneously over two Ethernets to two independent PDCs

Benefits:
- Provides communication redundancy in the event of communication failure – reduction in capital cost on the redundant PMU
TESLA PMU data flow

Synchronozed Phasor Calculations used – PMU data

DFR
Digital Fault Recorder
0 - 30 sec

DSR
Digital Swing Recorder
1 - 30 min

SER
Sequence of Event Recorder

PQR
Power Quality Recorder
1 - 90 day

LTR
Trend Recorder
4 - 140 day

CDR
Continuous Disturbance Recorder
PMU Recording using IEC 61850 GOOSE

Substation LAN - Station Bus

Substation LAN (fiber optic)

GOOSE Trigger Vendor 2

GOOSE Trigger Vendor 1

Switch 1

Switch 2

Switch 3

L-PRO IED-1

T-PRO IED-2

B-PRO IED-3

Vendor-1 IED-1

Vendor-1 IED-2

Vendor-1 IED-3

TESLA-1 PMU + DFR

TESLA-2 PMU + DFR

TESLA-3 PMU + DFR

TESLA-4 PMU + DFR
PMU Recording using IEC 61850 GOOSE....

System WAN

- Load Shedding
- Capacitor bank switching
- Distance Relay Operation validation
- Voltage profile during swing conditions

IEC 61850 - 90-1 Communication between substations
PMU Communication Traffic in a Utility Environment

3750 Switch-FastEthernet1/0/7 - Phasor Measurement Unit
Total Bytes Transferred Every 5 Minutes

3750 Switch-GigabitEthernet1/0/2 - Gig
Total Bytes Transferred Every 5 Minutes

PMU Unit Installed May 25 07

Spikes due to a query for data from TFR not from PMU traffic

Normal PMU traffic three orders of magnitude less than regular traffic over the LH to Portage South or to Taylor (normally in order of 64 bytes not Mbytes)
Test Cases
Test cases...
Conclusions

• The DFR’s advanced PMU recording based on triggers helps correlating the data with system events
• The DFR stores Continuous Recording of PMU data using 4GB on-board flash memory and hence provides data redundancy in the event of communication failure with PDC
• Communication bandwidth increase requirement has not increased with PMU traffic at this specific location
• Careful planning is needed for lower bandwidth media depending on the applications.
• Steady-state PMU TVE can be verified on the bench prior to installation and includes error due to time synchronization implicitly in the angle error.
Questions?

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