TESLA 4000 NERC PRC-002-2 Compliance

Introduction

This document outlines how TESLA 4000 complies with recording requirements from the North American Electric Reliability Corporation (NERC) PRC-002-2 standard.

PRC-002-2 excerpts below, shown in blue italics, are copied directly from the latest NERC original standard document at the time this application note was prepared.

For this document, a TESLA 4000 with 36 analog inputs, 64 external (digital) inputs and firmware v2.0 is assumed.

Recording Requirements

Sequence of Events Recording (SER)

"*R2. Each Transmission Owner and Generator Owner shall have SER data for circuit breaker position (open/close) for each circuit breaker it owns connected directly to the BES buses identified in Requirement R1 and associated with the BES Elements at those BES buses. [Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]*"

TESLA 4000 has 64 external inputs available to be independently assigned to circuit breakers' status and configured to monitor and log their status changes (position open/close) by creating events recorded with date, time and a detailed event description.

Fault Recording (FR)

"*R3. Each Transmission Owner and Generator Owner shall have FR data to determine the following electrical quantities for each triggered FR for the BES Elements it owns connected to the BES buses identified in Requirement R1: [Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]*

3.1 Phase-to-neutral voltage for each phase of each specified BES bus.

3.2 Each phase current and the residual or neutral current for the following BES Elements: ..."

"R4. Each Transmission Owner and Generator Owner shall have FR data as specified in Requirement R3 that meets the following: [Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]

4.1 A single record or multiple records that include:

- *A pre-trigger record length of at least two cycles and a total record length of at least 30-cycles for the same trigger point, or*
- *At least two cycles of the pre-trigger data, the first three cycles of the post-trigger data, and the final cycle of the fault as seen by the fault recorder.*

4.2 A minimum recording rate of 16 samples per cycle.

4.3 Trigger settings for at least the following:

4.3.1 Neutral (residual) overcurrent.

4.3.2 Phase undervoltage or overcurrent."

TESLA 4000 is available in two models, 18 or 36 analog inputs that can be configured either as current (phase quantities) or voltage (phase-to-neutral or phase-phase quantities) inputs.

Residual or Neutral currents can be either brought to TESLA 4000 as one of the analog inputs or calculated by TESLA 4000 as a result of the phasorial summation of phase currents from phases A, B and C using a summation channel.

For each channel, a set of triggers – among them, overcurrent and undervoltage – are available and can be configured independently.

Two 'trigger modes' can be set to determine the length of the TESLA 4000 High Speed Records (PRC-002-2 "FR" records):

- For 'edge mode', 'pre-trigger time' can be set up to 8 seconds; the 'normal record length' up to 15 seconds and the record can be extended to the 'maximum record length' of up to 30 seconds upon multiple triggering.
- For 'duration mode', 'pre-trigger time' can be set up to 8 seconds and 'post-trigger time' up to 15 seconds. The 'maximum record length' can be set up to 30 seconds.

TESLA 4000's analog input channel sampling rate is user-selectable from 32 to 384 samples per cycle.

Dynamic Disturbance Recording (DDR)

"*R6. Each Transmission Owner shall have DDR data to determine the following electrical quantities for each BES Element it owns for which it received notification as identified in Requirement R5: [Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]*

6.1 One phase-to-neutral or positive sequence voltage.

6.2 The phase current for the same phase at the same voltage corresponding to the voltage in Requirement R6, Part 6.1, or the positive sequence current.

6.3 Real Power and Reactive Power flows expressed on a three-phase basis corresponding to all circuits where current measurements are required.

6.4 Frequency of any one of the voltage(s) in Requirement R6, Part 6.1."

"*R7. Each Generator Owner shall have DDR data to determine the following electrical quantities for each BES Element it owns for which it received notification as identified in Requirement R5: [Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]*

7.1 One phase-to-neutral, phase-to-phase, or positive sequence voltage at either the generator step-up transformer (GSU) high-side or low-side voltage level.

7.2 The phase current for the same phase at the same voltage corresponding to the voltage in Requirement R7, Part 7.1, phase current(s) for any phase-to-phase voltages, or positive sequence current.

7.3 Real Power and Reactive Power flows expressed on a three-phase basis corresponding to all circuits where current measurements are required.

7.4 Frequency of at least one of the voltages in Requirement R7, Part 7.1."

"*R8. Each Transmission Owner and Generator Owner responsible for DDR data for the BES Elements identified in Requirement R5 shall have continuous data recording and storage.*"

"*R9. Each Transmission Owner and Generator Owner responsible for DDR data for the BES Elements identified in Requirement R5 shall have DDR data that meet the following: [Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]*

9.1 Input sampling rate of at least 960 samples per second.

9.2 Output recording rate of electrical quantities of at least 30 times per second."

PRC-002-2 DDR continuous data recording is handled via the TESLA 4000 Continuous Disturbance Recorder (CDR) feature. The TESLA 4000 CDR has user-configurable recording rates of 6 to 60 samples per second. These CDR records are derived from analog input channels, whose minimum sampling rate is 1920 samples per second (for a 60Hz power system). CDR can be set to record data at the PRC-002-2 specified rate of 30 samples per second.

12 frequencies (derived from user-selectable reference quantities) on any of the 36 analog channels (which can be associated to either phase current or phase-to-neutral voltage quantities), can be selected to be recorded by TESLA 4000's Continuous Disturbance Recorder.

TESLA has derived channels to record calculated quantities derived from the analog inputs, e.g. sequence and three-phase power quantities.
For Continuous Disturbance Recorder files, all derived channels are calculated and shown by RecordGraph (ERL's graphical analysis software tool).

In addition to the CDR feature above, the user may enable TESLA's IEEE C37.118-2011-2014 Compliant PMU streaming capability, and record (on a third party supplied Phasor Data Concentrator) up to 36 phasors, 24 analogs, 64 digital inputs to dual PDC clients.

General Requirements

"*R10. Each Transmission Owner and Generator Owner shall time synchronize all SER and FR data for the BES buses identified in Requirement R1 and DDR data for the BES Elements identified in Requirement R5 to meet the following: [Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]*

10.1 Synchronization to Coordinated Universal Time (UTC) with or without a local time offset.
10.2 Synchronized device clock accuracy within ± 2 milliseconds of UTC. "

"R11. Each Transmission Owner and Generator Owner shall provide, upon request, all SER and FR data for the BES buses identified in Requirement R1 and DDR data for the BES Elements identified in Requirement R5 to the Responsible Entity, Regional Entity, or NERC in accordance with the following:
[Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]
11.1 Data will be retrievable for the period of 10-calendar days, inclusive of the day the data was recorded.
11.2 Data subject to Part 11.1 will be provided within 30-calendar days of a request unless an extension is granted by the requestor.
11.3 SER data will be provided in ASCII Comma Separated Value (CSV) format following Attachment 2.
11.4 FR and DDR data will be provided in electronic files that are formatted in conformance with C37.111, (IEEE Standard for Common Format for Transient Data Exchange (COMTRADE), revision C37.111-1999 or later.
11.5 Data files will be named in conformance with C37.232, IEEE Standard for Common Format for Naming Time Sequence Data Files (COMNAME), revision C37.232-2011 or later."

TESLA 4000 creates sequence of events records tagged with UTC time (with optional Local Time Offset).

TESLA 4000 synchronization clock accuracy is better than ± 2 milliseconds of UTC.

Storage capability (non-volatile memory) and retention period:

- TESLA 4000 can store up to 500 sequence of events in a circular buffer.
- TESLA 4000 can store up to 1000 records with 2 seconds (120 cycles) of length with all 36 channels sampled at 96 samples per cycle. An alarm can be set based on the percentage of memory used to store Fault Recording (FR) records.
- TESLA 4000 can continuously record at a rate of 30 samples per second and store up to 33 days of Dynamic Disturbance recording data for one monitored circuit (4 current and 3 voltage inputs) with a 4GB flash standard capacity.

Data format:

- Sequence of Events Recording (SER) can be (manually) exported in CSV format from within the TESLA Control Panel software interface.
- Fault Records (FR) can be (manually) exported to COMTRADE format, as per IEEE C37.111-1999, also using the TESLA Control Panel software interface.
- Prior to exporting continuous data recording of a DDR event to COMTRADE (i.e. a TESLA 4000 CDR record), as per IEEE C37.111-1999, the CDR record needs to be opened in RecordGraph (ERL's graphical analysis software tool), to calculate respective

derived quantities. From within RecordGraph, the CDR records can then be exported to COMTRADE.
- Data file naming meets IEEE C37.232-2011 (COMNAME), or can optionally configured to a shortened version of that naming convention.

Monitoring Capabilities

A single TESLA 4000 unit, monitoring up to 12 frequency quantities and calculating the neutral current, can monitor up to:

- 4 Circuits with a Standard Capacity flash memory, or
- 6 Circuits with Extended Capacity flash memory

See tables below for approximate storage capacities at various recording rates.

Days

Standard Storage

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
24	56	33	28	22	16	11	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

Extended Storage

Number of channels	Sample Rate (RMS records per second per channel)						
	6	10	12	15	20	30	60
36	115	69	57	46	34	23	11
24	169	101	84	67	50	33	16
18	221	133	110	88	66	44	22
12	320	192	160	128	96	64	32
9	412	247	206	164	123	82	41

Note:

In order to ensure the availability of critical data for future review/analysis, users are strongly encouraged to retrieve and store the data via the use of frequent automated polling, as is provided with our Record Base Central Station software package. Depending on the nature of the disturbance/event, and the volume of data generated by these events, the unit's data storage might be over-written, and the data lost, if not retrieved periodically.

If you need any further assistance,
please contact

ERLPhase Customer Service at **+1 204-477-0591**

Or

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