

# TESLA 4000 DFR/DDR Compliance

## with NERC PRC-002-RFC-01

This document describes the compliance of TESLA 4000 DFR/DDR recording/monitoring device with the NERC-RFC PRC-002-RFC-01 standard. Compliance to requirements is explained in reference to the standard.

### Introduction

The TESLA DFR is a multi-timeframe recording system used to monitor electrical power systems at various voltage levels, including 600V to 69kV (Generation and Distribution), 110kV, 130kV, 200kV, 500kV (Transmission). It can record up to 36 analog channels and 64 digital (status) channels, and can store up to 1000 recordings. Up to 4 recorders can be operated as a co-operative group to achieve greater numbers of channels. The TESLA can record data simultaneously in 3 time domains: high speed transient fault (up to 384 samples/ cycle), low speed dynamic swing (up to 30 minutes), and continuous trend (10 second to 1 hour intervals). A wide variety of triggers are available to initiate recording. The recording system consists of a recorder, analog input isolation modules and TESLA Control Panel Windows user interface software. There are various analog input isolation modules available to interface to signal sources. Modules are available to connect to standard signals found in a typical electric power substation including secondary ac voltage and current and low level dc voltage and current signals.

These modules can generally be installed up to 4000 ft from the recorder unit, allowing them to be located near the source of the signals being monitored. The TESLA Control Panel Windows user interface software provides tools to configure the recorder, trigger, retrieve and manage records and display real time measured values. TESLA Control Panel also includes RecordGraph, an intuitive graphical record display and analysis software tool. An optional central station program (called RecordBase) is available to automatically collect and store records from multiple recorders. RecordBase provides fast network-based access to collected records through distributed RecordBase View desktop clients.

Phasor Measurement Unit (PMU) functionality is a standard software product feature in the TESLA 4000. The PMU functionality complies with IEEE C37.118 – 2005 [1]. Up to 36 user selectable phasors (as individual phase quantities or three-phase positive, negative or zero sequence phasors or summated phasors) can be transmitted at rates up to 60 frames each second. The TESLA 4000 additionally streams up to 12 analog quantities of Watts, VARS, and VA and 64 digital (status) quantities. The PMU functionality is designed to work simultaneously with the existing DFR features such as triggering, recording and trending. This means one can connect to the TESLA 4000 to view metering, modify configuration settings and transfer records while the unit is simultaneously streaming PMU data over the same Ethernet port.

The TESLA 4000 comes with two Ethernet ports (copper or optical as required) with independent MAC addresses. Hence if desired, one Ethernet port can be used exclusively to stream PMU data to an external PDC, while the other independent MAC address Ethernet port can be used for all other DFR functions within a secure LAN.

## Comparison of TESLA DFR Requirements as per PRC-002-RFC-01

Continuous Recording Capability (CDR) is an additional feature, which is implemented in TESLA DFR as per NERC's standard PRC-002-01, PRC- 018. The comparison of implementation as per PRC-002-RFC-01 is as follows:

### Section R1.2:

**SOE recording equipment shall be capable of determining and recording the time that an input is received to within  $\frac{1}{4}$  of an electrical cycle (or less) of input change of state.**

*TESLA DFR exceeds R1.2 since it can determine and record time of inputs within 2ms (for 60 Hz system), and 2.5ms (for 50Hz system) of input change of state.*

### Section R1.3:

**SOE recording equipment shall have time stamp capability to record seconds to at least three decimal places (i.e. ss.000).**

*TESLA DFR exceeds R1.3 since it can time stamp recorded data with 6 decimal places.*

### Section R2.2:

**R2.2.1 The three phase to neutral voltages on**

**R2.2.1.1 the monitored line or "outer" buses for breaker-and a-half bus arrangements, or**

**R2.2.1.2 the monitored line for ring bus arrangement, or**

**R2.2.1.3 the monitored bus for other bus arrangements**

**R2.2.2 The three phase currents and the residual or neutral currents of each monitored line and transformer.**

**R2.2.3 Polarizing currents, if used**

**R2.2.4 Frequency**

**R2.2.5 Megawatts and megavars**

*TESLA DFR measures all the phase voltages (A,B,C) and Currents (A,B,C and N if desired), and using these quantities, user can configure all the above channels such as neutral voltage, neutral currents, MW, MVAR, summation (ring bus application), polarizing current etc. More than 200 derived or calculated channels can be configured for analysis and triggering.*

### Section R2.3:

**R2.3.1 Fault recording equipment shall record at least two-cycles of pretrigger data.**

*TESLA DFR exceeds this requirement and user can configure pre trigger from 1 to 60 cycles.*

**R2.3.2 Fault recording equipment shall record any one of the following:**

- A post trigger record length of at least 50 cycles, or
- The first three cycles of an event and the final cycle of an event, using either a single continuous record or multiple triggered records

*TESLA DFR exceeds this requirement and the user can have up to 900 cycles of post fault recording and the recording can be extended to cover all the triggers up to 1800 cycles.*

**R2.3.3 Fault recording equipment shall have a minimum recording rate of 16 samples per cycle.**

*TESLA DFR exceeds this requirement and the user can configure different sample rates such as 32, 64, 96, 128, 256, and 384 samples per cycle.*

**R2.3.4 Fault recording equipment triggering parameters shall include one or more of following:**

- **negative sequence voltage**
- **negative sequence current**
- **zero sequence current (tertiary or residual)**
- **under voltage**
- **over voltage**
- **over current**

**and also one or more of the following:**

- **DC trip buses**
- **circuit breaker contact opening**
- **protective relay operation**

*TESLA DFR exceeds this requirement and the user can set the trigger for more than 200 different derived channels including the above stated once as per the standard.*

### **Section R3.3:**

**R3.3.1 Bus Voltage (at least one per voltage level of 200 kV or above at each DDR location)**

**R3.3.2 Frequency (at least one per DDR location)**

**R3.3.3 Line Current**

**R3.3.4 MW and MVAR flows expressed on a three-phase basis (per each monitored line or transformer)**

*TESLA DFR exceeds the above requirements.*

### **Section R3.4:**

**R3.4.1 Any new DDRs shall have the capability of continuous recording.**

*TESLA DFR meets the above requirement.*

**R3.4.2 Existing DDRs which do not have continuous recording capability shall be triggered according to the following:**

**R3.4.2.1 DDRs shall be capable of rate-of-change of frequency and rate-of-change of voltage triggers.**

**R3.4.2.2 Oscillation triggers, if available, shall be set to trigger for low frequency oscillations in 0.1 to 4.0 Hz range.**

**R3.4.2.3 DDRs shall be capable of recording minimum record lengths of not less than three minutes.**

*TESLA DFR meets the above requirement simultaneously with R3.4.1.*

**R3.4.3 Sample data at a rate of at least 960 samples per second and shall record the RMS value of electrical quantities at a rate of at least 6 records per second.**

*TESLA DFR exceeds the above requirement. See table for number of channels and the retention days (i.e. number of days the data can be stored on the TESLA DFR flash disk memory).*

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 4000 DFR

Sample rate – RMS records per second per channel

6 records per sample is the requirement form NERC and TESLA 4000 DFR can store depending on the number of channels up to 136 days of data