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# Compliance Solutions

for NERC protection and control standards

## NERC PRC-027-1 – Coordination of Protection Systems for Performance During Faults

### At a glance

The North American Electric Reliability Corporation (NERC) Reliability Standards program ensures that the North American Bulk Electrical System (BES) is operated in a reliable and safe manner by developing timely, effective and enforceable standards. The Protection and Control (PRC) standards are an important component of these standards. They apply to protection systems and provide compliance requirements that protection systems have to adhere to, so that BES reliability is maintained at all times.

NERC Reliability Standard PRC-027-1 was approved by the Federal Energy Regulatory Commission (FERC) on June 7, 2018 and will be effective

(enforceable) on October 1, 2020. It requires transmission owners, generator owners that interconnect to the BES, and certain distribution providers to *“maintain the coordination of Protection Systems installed for the purpose of detecting faults on BES elements and isolating those faulted elements, such that the Protection Systems operate in the intended sequence during faults.”*

### Requirements and measures

There are three requirements outlined in this standard.

- **Requirement R1:** Establish a process for developing new and revised protection system settings such that the protection systems operate in the intended sequence during faults.

This entails a review and update of the short-circuit and protection model for the BES Elements under study, development of a standardized protection philosophy and settings, and a plan for maintaining both the short-circuit and protection models over time.

- **Requirement R2:** For the impacted protection system
  - a) Perform a protection coordination study in a time interval not to exceed six years (or)
  - b) Compare present fault current values to an established baseline and perform a protection system coordination study when the comparison identifies a deviation of 15%, all within a six-year period (or)
  - c) Utilize a combination of Options a) and b) to show compliance
- **Requirement R3:** calls for each transmission owner, generator owner and distribution provider to utilize its process established in R1 to develop new and revised Protection System settings for BES Elements.

### Our solution

Siemens offers two independent solution paths for performing comprehensive protection performance assessments. For PSS®SINCAL users, the fully integrated SIGUARD®PSA tool is a proven method used by protection engineers to evaluate protection behavior. For PSS®CAPE users, the built-in wide-area sensitivity and wide-area coordination macros, and the associated reporting and visualization tools, available in the program for more than 10 years, constitute a well-proven method for detailed protection security assessments.

Either solution enables protection engineers to automatically simulate, assess and improve the selectivity, sensitivity and speed of the protection system for various network and operation conditions.

Both PSS®CAPE and SIGUARD®PSA (in PSS®SINCAL) support the complete workflow required for PRC-027-1 – data collection, network and protection modeling, protection simulation and assessment, followed by protection system improvements. The underlying state of the art protection security assessment method has been successfully deployed for large-scale system reviews in transmission and distribution systems worldwide. The typical protection evaluation process is shown in Figure 1:

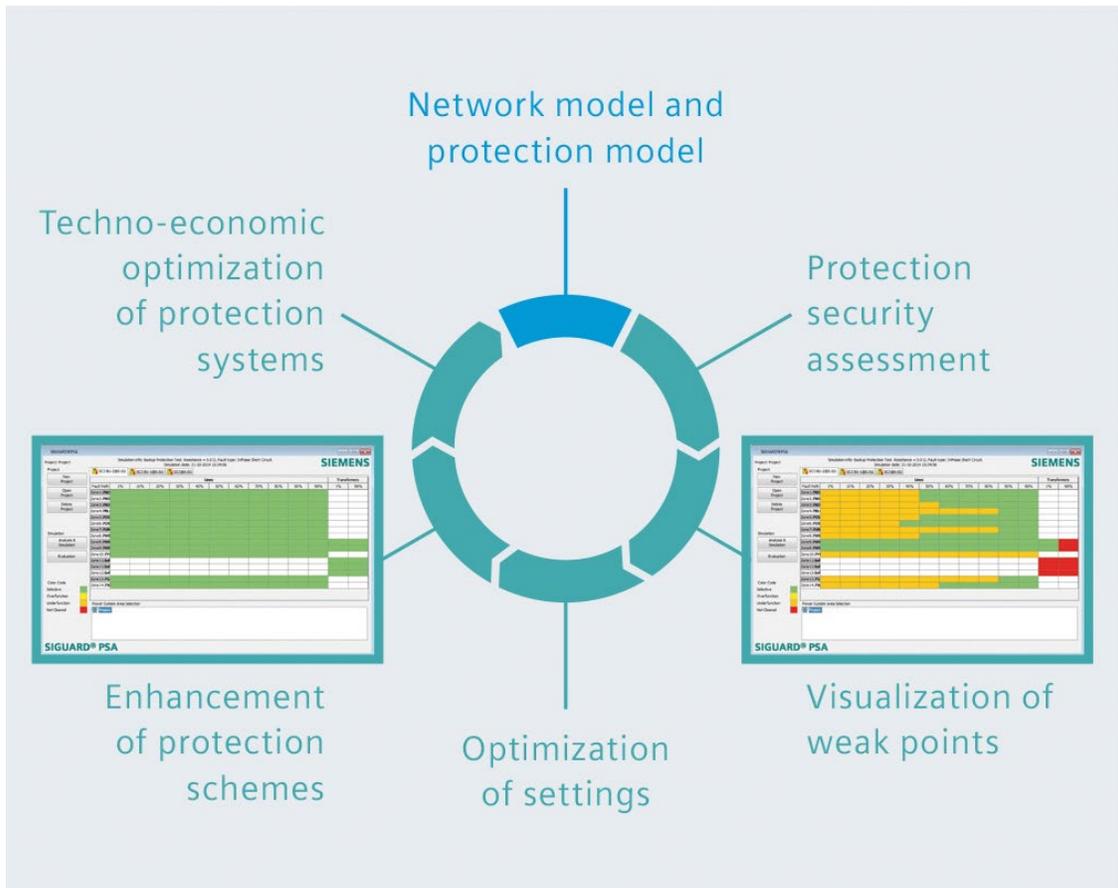


Figure 1: Continuous system-wide assessment of protection system performance

## Solution to support NERC PRC-027-1 compliance

Here is how PSS®CAPE and SIGUARD®PSA facilitate compliance with PRC-027-1:

### 1) Requirement R1

- Electronically available short-circuit model data and protection data can be directly imported into PSS®CAPE or SIGUARD®PSA. Alternatively, there are easy-to-fill data collection spreadsheets that can be used for this purpose.
- Both programs are equipped with multi-level data plausibility checking tools to eliminate gross data errors. This ensures high quality network and protection data, which in turn provides confidence in the results of the simulations.

The models of the protective devices used in the software are based on the operating equations and logic used in the actual devices, to the extent that such information can be obtained from publicly available manuals and data.

### 2) Requirement R2

- PSS®CAPE and PSS®SINCAL are full-featured short-circuit programs capable of performing fault studies on a system-wide basis.
- PSS®CAPE provides built-in tools to store the results of a fault study in its database. This allows fault currents to be tracked over time, so that protection coordination checks can be triggered at the appropriate time.
- PSS®CAPE and SIGUARD®PSA can perform automated fault clearing studies on a system-wide basis. The user can specify various fault locations, fault types, primary equipment outages, protection outages and other scenarios to challenge the protection system reliability.

The results of the simulation are summarized and visualized using color-coded tables, charts and other aids (Figure 2). Simulation results are presented in layers – from a high-level executive summary down to detailed element-level analysis. All currents, voltages, and impedances measured by protection devices are reported for explanation of the protection system behavior. This allows the protection engineer to quickly isolate the protection issue and work on a mitigating action.

Main		Element Level Results		Contingency Based Results					
Elements exhibiting CTI violations or miscoordinations				Substation: COMMERCE					
Element: 95 IOC ****				LZOP: Center 115 Line					
Color of cell indicates the type of element misbehavior. Data shown: CTI Violation: Fault Number, Event Number and Available CTI. Miscoordination: Fault Number, Event Number and Time of Event.									
Failed Line	System Condition / Outage	Fault Type	ClsIn	10%	15%	50%	85%	90%	RemCIsIn
177 CENTER 230 to 183 W...	Primary System Normal/Pilot Out	SINGLE_LINE_G...	1, 2, 4, 50	N/A	2, 2, 4, 50	OK	OK	N/A	OK
177 CENTER 230 to 183 W...	Line : 177 (CENTER 230)-154 (GANSVLE2C23...	SINGLE_LINE_G...	21, 2, 4...	N/A	22, 2, 4...	OK	24, 2, 3...	N/A	OK
177 CENTER 230 to 183 W...	Line : 177 (CENTER 230)-175 (BIO 230)-1( J/PI...	SINGLE_LINE_G...	31, 2, 4...	N/A	32, 2, 4...	OK	OK	N/A	OK
177 CENTER 230 to 183 W...	XFMR : (WINDER) 183-1316-1 ( Bank C)/Pilot ...	SINGLE_LINE_G...	41, 2, 4...	N/A	OK	OK	OK	N/A	OK
177 CENTER 230 to 183 W...	Line : 183 (WINDER 230)-105 (LAWRVILLE23...	SINGLE_LINE_G...	51, 2, 4...	N/A	OK	OK	OK	N/A	OK
177 CENTER 230 to 183 W...	Line : 183 (WINDER 230)-141 (CONYERS 230)...	SINGLE_LINE_G...	61, 2, 4...	N/A	OK	OK	OK	N/A	OK
Substation: PAV B620_3034									
LZOP: AGC B624_3301_Cir_1_230 kV									
Failed Line	System Condition / Outage	Fault Type	ClsIn	10%	15%	50%	85%	90%	RCIsIn
28181 155E-230 to 3211 NNC B639 on "	Primary System Normal/Pilot Out	SINGLE_LINE_GROUND	OK	OK	OK	OK	313; 1; 11.60	314; 1; 10.30	315; 1; 7.90
28181 155E-230 to 3211 NNC B639 on "	XFMR : 28181-24181-1 (INTER_3 XFMR_991)	SINGLE_LINE_GROUND	323; 1; 5.70	324; 3; 38.50	OK	OK	327; 1; 13.70	328; 1; 11.90	329; 1; 8.80
28181 155E-230 to 3211 NNC B639 on "	XFMR : 28181-24181-2 (INTER_4 XFMR_992)	SINGLE_LINE_GROUND	337; 1; 5.80	338; 3; 38.50	OK	OK	341; 1; 13.70	342; 1; 11.90	343; 1; 8.80
28181 155E-230 to 3211 NNC B639 on "	Line : 28181-28371-1(-)	SINGLE_LINE_GROUND	OK	OK	OK	OK	355; 1; 11.80	356; 1; 10.50	357; 1; 8.10
28181 155E-230 to 3211 NNC B639 on "	Line : 28181-28371-2(-)	SINGLE_LINE_GROUND	OK	OK	OK	OK	369; 1; 11.80	370; 1; 10.50	371; 1; 8.10
28181 155E-230 to 3211 NNC B639 on "	Line : 28181-29182-2(-)	SINGLE_LINE_GROUND	OK	OK	OK	OK	383; 1; 11.60	384; 1; 10.30	385; 1; 7.80
28181 155E-230 to 3211 NNC B639 on "	XFMR : 3211-3581-1 (T648 XFMR_403)	SINGLE_LINE_GROUND	393; 2; 13.10	394; 2; 8.50	395; 2; 6.20	OK	397; 1; 9.70	398; 1; 8.80	399; 1; 6.90
28181 155E-230 to 3211 NNC B639 on "	XFMR : 3211-3582-1 (T649 XFMR_404)	SINGLE_LINE_GROUND	407; 2; 13.10	408; 2; 8.50	409; 2; 6.20	OK	411; 1; 9.70	412; 1; 8.80	413; 1; 6.90
28181 155E-230 to 3301 AGC B624 on "	Primary System Normal/Pilot Out	SINGLE_LINE_GROUND	OK	OK	OK	OK	439; 1; 5.90	440; 1; 4.60	441; 3; 6.70
28181 155E-230 to 3301 AGC B624 on "	XFMR : 28181-24181-1 (INTER_3 XFMR_991)	SINGLE_LINE_GROUND	449; 1; 5.40	450; 3; 10.60	451; 3; 14.20	OK	453; 1; 6.30	454; 1; 4.90	455; 3; 6.70
28181 155E-230 to 3301 AGC B624 on "	XFMR : 28181-24181-2 (INTER_4 XFMR_992)	SINGLE_LINE_GROUND	463; 1; 5.50	464; 3; 10.60	465; 3; 14.20	OK	467; 1; 6.30	468; 1; 4.90	469; 3; 6.70
28181 155E-230 to 3301 AGC B624 on "	Line : 28181-28371-1(-)	SINGLE_LINE_GROUND	OK	OK	OK	OK	481; 1; 6.00	482; 1; 4.70	483; 3; 6.70
28181 155E-230 to 3301 AGC B624 on "	Line : 28181-28371-2(-)	SINGLE_LINE_GROUND	OK	OK	OK	OK	495; 1; 6.00	496; 1; 4.70	497; 3; 6.70
28181 155E-230 to 3301 AGC B624 on "	Line : 28181-29181-1(-)	SINGLE_LINE_GROUND	OK	OK	OK	OK	509; 1; 6.00	510; 1; 4.70	511; 3; 6.70
28181 155E-230 to 3301 AGC B624 on "	Line : 3301-3155-1(-)	SINGLE_LINE_GROUND	OK	OK	OK	OK	537; 1; 5.80	538; 1; 4.60	539; 3; 6.70
28181 155E-230 to 3301 AGC B624 on "	Line : 3301-3155-2(-)	SINGLE_LINE_GROUND	OK	OK	OK	OK	551; 1; 5.80	552; 1; 4.60	553; 3; 6.70
28181 155E-230 to 3301 AGC B624 on "	Line : 3301-3355-1(-)	SINGLE_LINE_GROUND	OK	OK	OK	OK	565; 1; 5.90	566; 1; 4.60	567; 3; 6.70
28181 155E-230 to 3301 AGC B624 on "	Line : 3301-3355-2(-)	SINGLE_LINE_GROUND	OK	OK	OK	OK	579; 1; 5.90	580; 1; 4.60	581; 3; 6.70
28181 155E-230 to 3301 AGC B624 on "	Line : 3301-3592-1(-)	SINGLE_LINE_GROUND	OK	OK	OK	OK	592; 1; 14.90	593; 1; 5.50	594; 1; 4.30
28181 155E-230 to 3301 AGC B624 on "	Line : 3301-4411-1(-)	SINGLE_LINE_GROUND	OK	OK	OK	OK	607; 1; 5.80	608; 1; 4.60	609; 3; 6.70
28181 155E-230 to 28371 NEJA-230 on "	XFMR : 28181-24181-1 (INTER_3 XFMR_991)	SINGLE_LINE_GROUND	631; 1; 5.40	632; 1; 12.10	OK	OK	OK	OK	OK
28181 155E-230 to 28371 NEJA-230 on "	XFMR : 28181-24181-2 (INTER_4 XFMR_992)	SINGLE_LINE_GROUND	645; 1; 5.50	646; 1; 12.20	OK	OK	OK	OK	OK
28181 155E-230 to 28371 NEJA-230 on "	XFMR : 28181-24181-1 (INTER_3 XFMR_991)	SINGLE_LINE_GROUND	785; 1; 5.40	786; 1; 12.10	OK	OK	OK	OK	OK
28181 155E-230 to 28371 NEJA-230 on "	XFMR : 28181-24181-2 (INTER_4 XFMR_992)	SINGLE_LINE_GROUND	799; 1; 5.50	800; 1; 12.20	OK	OK	OK	OK	OK

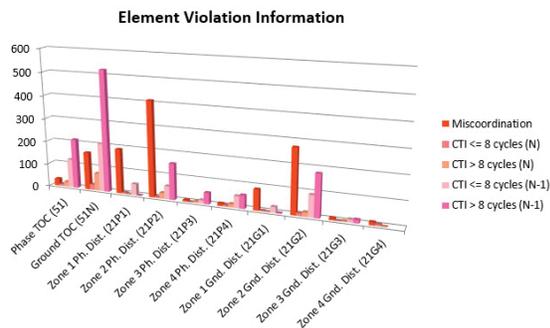
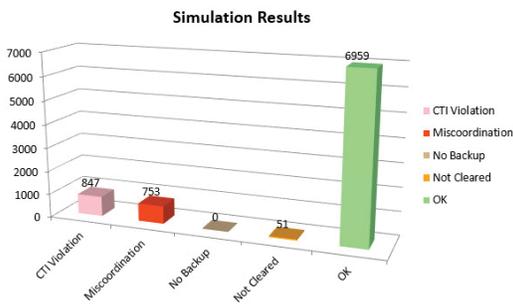


Figure 2: Visualization of the results of a protection security study

### 3) Requirement R3

- PSS®CAPE and SIGUARD®PSA can automatically improve, or correct problematic protection settings based on pre-defined rules. The protection settings can also be optimized in the entire system. This process is followed by a repeat protection security assessment (process in Requirement R2) to ensure that no new coordination problems are detected.
- When selective protection coordination cannot be achieved with improved settings, PSS®CAPE and SIGUARD®PSA can clearly indicate that an adjustment of the protection scheme is necessary. A potential solution might be the addition of high-speed schemes such as line differential or impedance-based permissive or blocking schemes.

In summary, PSS®CAPE and SIGUARD®PSA facilitate automated protection coordination studies, relieve the protection engineer from the tedium of clicking buttons, and focus their attention on the resolution of the problems found.

North American transmission owners, generator owners and distribution providers seeking a timely, cost-effective and proven solution can leverage Siemens Power Technologies International's (Siemens PTI's) vast industry expertise to comply with the PRC-027-1 reliability standard. Using PSS®CAPE or SIGUARD®PSA, we can design a customized solution that fits individual needs. Please see Figure 3.

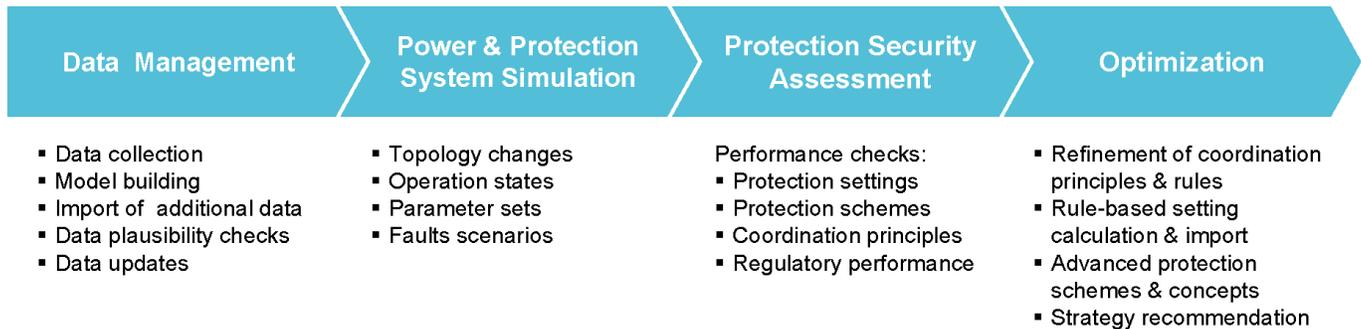


Figure 3: Flexible solution options to support NERC PRC-027-1 compliance

#### How to get started

For more information, contact Siemens PTI consulting sales at +1-518-395-5000 or send an email to: [pti-consulting.ptd@siemens.com](mailto:pti-consulting.ptd@siemens.com)

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