

Problem Statement

The existing NERC Glossary of Terms definition for a Special Protection System (SPS or, as used in the Western Interconnection, a Remedial Action Scheme or RAS) lacks clarity and specificity necessary for consistent identification and classification of protection schemes as SPS or RAS across the eight NERC Regions, leading to inconsistent application of the related NERC Reliability Standards.

Background

NERC Definitions

The existing NERC *Glossary of Terms* defines an SPS and RAS as:

Special Protection System (Remedial Action Scheme)

An automatic protection system designed to detect abnormal or predetermined system conditions, and take corrective actions other than and/or in addition to the isolation of faulted components to maintain system reliability. Such action may include changes in demand, generation (MW and Mvar), or system configuration to maintain system stability, acceptable voltage, or power flows. An SPS does not include (a) underfrequency or undervoltage load shedding or (b) fault conditions that must be isolated or (c) out-of-step relaying (not designed as an integral part of an SPS). Also called Remedial Action Scheme.

In this document, use of the term SPS in general discussions and proposals for future definitions and standards apply to both SPS and RAS. Specific references to existing practices within Regions use the term SPS or RAS as appropriate for that Region.

The NERC *Glossary of Terms* defines a Protection System as:

Protection System

- Protective relays which respond to electrical quantities,
- Communications systems necessary for correct operation of protective functions
- Voltage and current sensing devices providing inputs to protective relays,
- Station dc supply associated with protective functions (including batteries, battery chargers, and non-battery-based dc supply), and
- Control circuitry associated with protective functions through the trip coil(s) of the circuit breakers or other interrupting devices.

Inclusion of the words “protection system” in the term Special Protection System has raised questions whether this is an intentional reference such that SPS are a subset of Protection Systems. Use of protection system (lower case) within the SPS definition identifies that SPS are not Protection Systems. While SPS may include the same types of components as Protection Systems, SPS are not limited to detecting faults or abnormal conditions and tripping affected equipment. SPS may, for example, effect a change to the operating state of power system elements to preserve system stability or to avoid unacceptable voltages or overloads in response to system events. There are many reasons for implementing an SPS; for example, an SPS can be implemented to ensure compliance with the TPL Reliability Standards, to mitigate temporary operating conditions or abnormal configurations (e.g., during construction or maintenance activities), or in instances where system operators would not be able to respond quickly enough to avoid adverse system conditions.

A second area in which the existing SPS definition lacks clarity is the actions that are characteristics of SPS. The actions listed in the definition are broad and may unintentionally include equipment whose purpose is not

expressly related to preserving system reliability in response to an event. Inclusion of any system taking “corrective action other than ... isolation of faulted components to maintain system reliability” could be deemed to include equipment such as voltage regulators and switching controls for shunt reactive devices. This inclusion would then make these elements subject to single component failure considerations (sometimes referred to as redundancy considerations), coordination, reporting, and maintenance and testing requirements that may be required in the NERC Reliability Standards related to SPS.

This report proposes a revised definition of SPS to address these issues. Development of the proposed definition considered other definitions, common applications, and existing practices regarding classification of SPS.

Chapter 1 – SPS Definition

Considerations for a Revised Definition

Common Application of SPS in Industry

Most SPS are used to address a range of system issues including stability, voltage, and loading concerns. Less common applications include arresting sub-synchronous resonance and suppressing torsional oscillations. Actions taken by SPS may include (but are not limited to): system reconfiguration, generation rejection or runback, load rejection or shedding, reactive power or braking resistor insertion, and runback or fast ramping of HVdc.

SPS are often deployed because the operational solutions they facilitate are substantially quicker and less expensive to implement than construction of transmission infrastructure. Permanent SPS have been implemented in some cases where the cost associated with system expansion is prohibitive, construction is not possible due to physical constraints, or obtaining permits is not feasible. In other cases temporary SPS have been implemented to maintain system reliability until transmission infrastructure is constructed; or when a reliability risk is temporary (e.g., during equipment outages) and the expense associated with permanent transmission upgrades is not justified.

The deployment of SPS adds complexity to power system operation and planning:

“Although SPS deployment usually represents a less costly alternative than building new infrastructure, it carries with it unique operational elements among which are: (1) risks of failure on demand and of inadvertent activation; (2) risk of interacting with other SPS in unintended ways; (3) increased management, maintenance, coordination requirements, and analysis complexity.”¹

Classification of SPS Types

Three regions classify SPS according to various criteria, including the type of event the SPS is designed to address as well as the ability of the SPS to impact on a local versus wide-area reliability. Also in this context, what constitutes local versus wide-area varies among Regions and is not based on the NERC glossary term Wide Area, which is specific to calculation of Interconnection Reliability Operating Limits (IROL).²

SPS classification differentiates the reliability risk associated with SPS and provides a means to establish more or less stringent requirements consistent with the reliability risk. For example, it may be appropriate to establish less stringent requirements pertaining to monitoring or single component failure of SPS that present a lower reliability risk. A recommendation for classification of SPS is included with the proposed definition and subsequent discussion of standard requirements includes recommendations where different requirements based on classification are deemed appropriate.

¹ McCalley, et al, “System Protection Schemes: Limitations, Risks, and Management”, PSERC Publication 10-19, Dec 2010.

² The NERC Glossary defines Wide Area as “The entire Reliability Coordinator Area as well as the critical flow and status information from adjacent Reliability Coordinator Areas as determined by detailed system studies to allow the calculation of Interconnected Reliability Operating Limits.”

Common Exclusions from the SPS Definition in Industry

Exclusions provide a means to assure that specific protection or control systems are not unintentionally included as SPS. The NERC glossary definition of SPS states that “An SPS does not include (a) underfrequency or undervoltage load shedding or (b) fault conditions that must be isolated or (c) out-of-step relaying (not designed as an integral part of an SPS).”

Even with the exclusions in the NERC definition, other commonly applied protection and control systems meet the general language in the SPS definition. Considerable effort has been expended by industry discussing what systems are SPS. NPCC and SERC have documented examples of exclusions to the SPS definition in their regional guidelines. NPCC explicitly excludes “Automatic underfrequency load shedding; Automatic undervoltage load shedding and manual or automatic locally controlled shunt devices.”³ SERC’s SPS guideline calls out specific exclusions as follows:

- a. UFLS and/or UVLS,
- b. Fault conditions that must be isolated including bus breakup / backup / breaker failure protection,
- c. Relays that protect for specific equipment damage (such as overload, overcurrent, hotspot, reclose blocking, etc.),
- d. Out of step relaying,
- e. Capacitor bank / reactor controls,
- f. Load Tap Changer (LTC) controls,
- g. Automated actions that could be performed by an operator in a reasonable amount of time, including alternate source schemes, and
- h. Scheme that trips generation to prevent islanding

A recommended list of protection and control systems that should be excluded from classification as SPS is included with the proposed definition.

Exclusion for Operator Aides

SAMS and SPCS considered a number of factors in discussing this subject including:

- 1) whether the actions are required to be completed with such urgency that it would be difficult for an operator to react and execute in the necessary time, and
- 2) whether the required actions are of such complexity or across such a large area that it would be difficult for an operator to perform the actions in the necessary time.

It is difficult to address these questions with concise and measurable terms, making it difficult to explicitly exclude them in the definition without introducing ambiguous terms counter to the objective of providing needed clarity in the SPS definition. Whether its existence is based upon convenience or not, any automated system with the potential to impact bulk power system reliability should be defined and expressed to the appropriate authority (e.g., Planning Coordinator, Reliability Coordinator) for the purposes of system modeling and coordination studies, to ensure that these systems are properly coordinated with other protection and control systems, and to ensure that inadvertent operations do not result in adverse system impacts.

On these bases, SAMS and SPCS decided not to provide an exclusion for schemes based on a general criterion as to whether the scheme automates actions that an operator could perform in a reasonable amount of time or schemes installed for operator convenience. However, SAMS and SPCS do recommend exclusions for specific applications that meet these criteria such as automatic sequences that are initiated manually by an operator. Furthermore, any

³ NPCC *Glossary of Terms Used by Directories*

scheme that is not installed “to meet system performance requirements identified in the NERC Reliability Standards, or to limit the impact of two or more elements removed, an extreme event, or Cascading” would be excluded by definition, regardless of whether it is installed to assist an operator.

Voltage Threshold

All elements, at any voltage level, of an SPS intended to remediate performance issues on the bulk electric system (BES), or of an SPS that acts upon BES elements, should be subject to the NERC requirements.

Proposed Definition

The proposed definition clarifies the areas that have been interpreted differently between individual entities and within Regions, in some cases leading to differing regional definitions of SPS. The proposed definition provides a framework for differentiating among SPS with differing levels of reliability risk and will support the drafting of new or revised SPS standards.

Special Protection System (SPS)

A scheme designed to detect predetermined system conditions and automatically take corrective actions, other than the isolation of faulted elements, to meet system performance requirements identified in the NERC Reliability Standards, or to limit the impact of: two or more elements removed, an extreme event, or Cascading.

Subject to the exclusions below, such schemes are designed to maintain system stability, acceptable system voltages, acceptable power flows, or to address other reliability concerns. They may execute actions that include but are not limited to: changes in MW and Mvar output, tripping of generators and other sources, load curtailment or tripping, or system reconfiguration.

The following schemes do not constitute an SPS in and of themselves:

- a) Underfrequency or undervoltage load shedding
- b) Locally sensing devices applied on an element to protect it against equipment damage for non-fault conditions by tripping or modifying the operation of that element, such as, but not limited to, generator loss-of-field or transformer top-oil temperature
- c) Autoreclosing schemes
- d) Locally sensed and locally operated series and shunt reactive devices, FACTS devices, phase-shifting transformers, variable frequency transformers, generation excitation systems, and tap-changing transformers
- e) Schemes that prevent high line voltage by automatically switching the affected line
- f) Schemes that automatically de-energize a line for non-fault operation when one end of the line is open
- g) Out-of-step relaying
- h) Schemes that provide anti-islanding protection (e.g., protect load from effects of being isolated with generation that may not be capable of maintaining acceptable frequency and voltage)
- i) Protection schemes that operate local breakers other than those on the faulted circuit to facilitate fault clearing, such as, but not limited to, opening a circuit breaker to remove infeed so protection at a remote terminal can detect a fault or to reduce fault duty
- j) Automatic sequences that proceed when manually initiated solely by an operator
- k) Sub-synchronous resonance (SSR) protection schemes

- l) Modulation of HVdc or SVC via supplementary controls such as angle damping or frequency damping applied to damp local or inter-area oscillations
- m) A Protection System that includes multiple elements within its zone of protection, or that isolates more than the faulted element because an interrupting device is not provided between the faulted element and one or more other elements

SPS are categorized into four distinct types. These types may be subject to different requirements within the NERC Reliability Standards.

- Type PS (planning-significant): A scheme designed to meet system performance requirements identified in the NERC Reliability Standards, where failure or inadvertent operation of the scheme can have a significant impact on the BES.
- Type PL (planning-limited): A scheme designed to meet system performance requirements identified in the NERC Reliability Standards, where failure or inadvertent operation of the scheme can have only a limited impact on the BES.
- Type ES (extreme-significant): A scheme designed to limit the impact of two or more elements removed, an extreme event, or Cascading, where failure or inadvertent operation of the scheme can have a significant impact on the BES.
- Type EL (extreme-limited): A scheme designed to limit the impact of two or more elements removed, an extreme event, or Cascading, where failure or inadvertent operation of the scheme can have only a limited impact on the BES.

An SPS is classified as having a significant impact on the BES if failure or inadvertent operation of the scheme results in any of the following:

- Non-Consequential Load Loss \geq 300 MW
- Aggregate resource loss (tripping or runback of generation or HVdc) $>$ the largest Real Power resource within the interconnection⁴
- Loss of synchronism between two or more portions of the system each including more than one generating plant
- Negatively damped oscillations

If none of these criteria are met, the SPS is classified as having a limited impact on the BES.

Definition of Significant and Limited Impact

The parameters used to define the bright line between “significant” and “limited” impacts are proposed to consider only the electrical scale of the event. Defining the bright line in this way eliminates the difficulty in distinguishing the geographic impact of an SPS as either “wide” or “local.”

NERC Standard EOP-004-1, DOE Form OE-417 Electric Emergency Incident and Disturbance Report, establishes the criteria by which an event is categorized as a Disturbance and requires a disturbance report. In terms of SPS, the proposed criteria for significant impact mirrors EOP-004-1 by including a non-consequential load loss value of 300 MW.

NERC Reliability Standards require consideration of loss of any generating unit; therefore, generating unit loss would not impact reliability of the bulk power system unless the combined capacity loss exceeds the largest unit within the

⁴ I.e., Eastern, Western, ERCOT, or Quebec Interconnection.

interconnection. The generation loss level was selected as a loss greater than the largest unit within an interconnection on this basis.

Tripping multiple generating units exceeding the capacity of the largest unit within an interconnection, system separation (loss of synchronism) that results in isolation of a portion of an interconnection, or system oscillations that increase in magnitude (negatively-damped) are indicators of adverse impact to the reliability of an interconnection. These criteria identify system performance indicative of the potential for instability, uncontrolled separation, or cascading outages, without requiring detailed analyses to confirm the extent to which instability, uncontrolled separation, or cascading outages may occur. These indicators, combined with the loss of load criterion, are proposed to identify the potential reliability risk associated with failure of a SPS. Subsequent sections of this report recommend requirements for assessment and design of SPS based on whether the potential reliability risk associated with the SPS are significant versus limited impacts.

The proposed thresholds differentiate between significant and limited impact. While it should be clear there is no upper threshold on what constitutes a significant impact, there also is no lower threshold proposed as to what constitutes limited impact. Whether a scheme is an SPS is determined by the definition; significant and limited impact are used only to classify SPS. For example, if a scheme is installed to meet system performance requirements identified in the NERC Reliability Standards then it is an SPS regardless of its potential impact. A failure of the SPS would result in a violation of a NERC Reliability Standard. Thus, excluding a scheme with impact below a certain threshold would undermine the reliability objective of the standard requirement the scheme is installed to address.