Voltage Security

1 Descriptions of Function

Based on the work done by Dick Schulz at AEP and the paper by Nuqui, Phadke, Schulz, and Bhatt entitled: Fast On-Line Voltage Security Monitoring Using Synchronized Phasor Measurements and Decision Trees. IEEE 2001.

1.1 Function Name

Voltage Security

1.2 Function ID

IECSA identification number of the function

T-4.1,T-4.18,T-5,T-6.10

1.3 Brief Description

The Voltage Security function is designed to detect severe low voltage conditions based on phasor measurements of Power and Voltage and upon detection, initiate corrective action such as load shed.

1.4 Narrative

It has been shown through simulation that for certain credible contingencies on a power system, there can occur unacceptable consequences that are characterized by severe low voltages, excessively high power and MVar flows, and likely split-up of a utility's interconnections. System studies have shown that a combined measurement of phasor measurements (only angle needed) and power flow can be used to provide a robust (both dependable and secure) indication of proximity of power system collapse. To be included in a typical measurement set are EHV and HV system voltages and generator MVar production. Classification type Decision Trees models are utilized to predict voltage security status. Results of the Decision Tree are executed through control actions on loads and generators throughout the system.

A stressed power system is characterized by widening angular separation of bus voltage angles as it moves towards voltage insecurity. Decision Trees exploit the complex non-linear relationship between voltage security status and generator Vars/angular difference in term of hierarchical rules extracted from a large number of off-line load-flow simulations.

1.5 Actor (Stakeholder) Roles

Describe all the people (their job), systems, databases, organizations, and devices involved in or affected by the Function (e.g. operators, system administrators, technicians, end users, service personnel, executives, SCADA system, real-time database, RTO, RTU, IED, power system). Typically, these actors are logically grouped by organization or functional boundaries or just for collaboration purpose of this use case. We need to identify these groupings and their relevant roles and understand the constituency. The same actor could play different roles in different Functions, but only one role in one Function. If the same actor (e.g. the same person) does play multiple roles in one Function, list these different actor-roles as separate rows.

Grouping (Community)		***Group Description***
Voltage Security		
Actor Name	***Actor Type (person, device, system etc.)***	***Actor Description***
PhasorMeasurementUnit	Device	Source of Phasor measurements of voltage and power
PhasorDataConcentrator	Device	Collection and synchronization of phasor measurements from multiple sites
Decision System	Device	Analyzes the captured data and proposes resultant control solutions. Control options can be displayed on an operator console.
ControlSystem	Device / Operator	Implements the resultant control decision either automatically or manually
GenerationCapacityDatabase	System	Available generation capability throughout the system
CustomerLoad	System	Available sheddable load throughout the system

Replicate this table for each logic group.

1.6 Information exchanged

Describe any information exchanged in this template

Information Object Name	*Information Object Description*
Phasor Measurement	PMU captured phasor measurement of voltage and power
System state parameter measurement	System state parameters used for power flow analysis
Control decision	The resultant control decision made after analyzing the phasor and power flow, such as load shedding or generation change

1.7 Activities/Services

Describe or list the activities and services involved in this Function (in the context of this Function). An activity or service can be provided by a computer system, a set of applications, or manual procedures. These activities/services should be described at an appropriate level, with the understanding that sub-activities and services should be described if they are important for operational issues, automation needs, and implementation reasons. Other sub-activities/services could be left for later analysis.

Activity/Service Name	*Activities/Services Provided*
GetPhasorData	The process of subscribing to data from any number of Phasor Measurement Units
CheckData	The process of verifying that there are no errors in the received data packet
TriggerCapture	The process of triggering a data capture and storage of a block of data based on either a local or remote trigger criteria
ValidateControl	The process of guaranteeing that a control is legitimate
ValidateData	The process of verifying that the data came from a known source

1.8 Contracts/Regulations

Identify any overall (human-initiated) contracts, regulations, policies, financial considerations, engineering constraints, pollution constraints, and other environmental quality issues that affect the design and requirements of the Function.

Contract/Regulation	*Impact of Contract/Regulation on Function*
Sheddable Load Contracts	Defines which customer load can be shed and in what order
Quality Power Contracts	Requires a "high quality" of power to specified customers

Policy	*From Actor*	*May*	*Shall Not*	*Shall*	*Description (verb)*	*To Actor*

Constraint	*Type*	*Description*	*Applies to*

2 Step by Step Analysis of Function

{Primarily equivalent to RM-ODP Computational View and Information View, with Engineering View as part of Assumptions}

2.1 Steps to implement function

Name of this sequence.

2.1.1 Preconditions and Assumptions

Describe conditions that must exist prior to the initiation of the Function, such as prior state of the actors and activities

Identify any assumptions, such as what systems already exist, what contractual relations exist, and what configurations of systems are probably in place

Identify any initial states of information exchanged in the steps in the next section. For example, if a purchase order is exchanged in an activity, its precondition to the activity might be 'filled in but unapproved'.

Actor/System/Information/Contract	*Preconditions or Assumptions*

2.1.2 Steps – Normal Sequence

Describe the normal sequence of events, focusing on steps that identify new types of information or new information exchanges or new interface issues to address. Should the sequence require detailed steps that are also used by other functions, consider creating a new "sub" function, then referring to that "subroutine" in this function. Remember that the focus should be less on the algorithms of the applications and more on the interactions and information flows between "entities", e.g. people, systems, applications, data bases, etc. There should be a direct link between the narrative and these steps.

The numbering of the sequence steps conveys the order and concurrency and iteration of the steps occur. Using a Dewey Decimal scheme, each level of nested procedure call is separated by a dot '.'. Within a level, the sequence number comprises an optional letter and an integer number. The letter specifies a concurrent sequence within the next higher level; all letter sequences are concurrent with other letter sequences. The number specifies the sequencing of messages in a given letter sequence. The absence of a letter is treated as a default 'main sequence' in parallel with the lettered sequences.

Sequence 1:

```
1.1 - Do step 1
1.2A.1 - In parallel to activity 2 B do step 1
1.2A.2 - In parallel to activity 2 B do step 2
1.2B.1 - In parallel to activity 2 A do step 1
1.2B.2 - In parallel to activity 2 A do step 2
1.3 - Do step 3
1.3.1 - nested step 3.1
1.3.2 - nested step 3.2
```

Sequence 2:

```
2.1 - Do step 1
2.2 – Do step 2
```

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
#	*Triggering event? Identify the name of the event.*[1]	*What other actors are primarily responsible for the Process/Activity? Actors are defined in section0.*	*Label that would appear in a process diagram. Use action verbs when naming activity.*	*Describe the actions that take place in active and present tense. The step should be a descriptive noun/verb phrase that portrays an outline summary of the step. "If …Then…Else" scenarios can be captured as multiple Actions or as separate steps.*	*What other actors are primarily responsible for Producing the information? Actors are defined in section0.*	*What other actors are primarily responsible for Receiving the information? Actors are defined in section0.* *(Note – May leave blank if same as Primary Actor)*	*Name of the information object. Information objects are defined in section 1.6*	*Elaborate architectural issues using attached spreadsheet. Use this column to elaborate details that aren't captured in the spreadsheet.*	*Reference the applicable IECSA Environment containing this data exchange. Only one environment per step.*
1	$\Delta\theta$ > s.p. ΔP > s.p. ΔVar > s.p.			The PHASORMEASUREMENTUNIT shall continuously send data to the Decisioner. On detection of a trigger event, the PHASORMEASUREMENTUNIT may and the decisioner should log the stream of phasors being delivered	PHASORMEASUREMENTUNIT	Decisioner	Phasor data	Need to be able to synchronize received data	Lower Security DAC
2	Voltage Security Compromised			The decisioner shall issue controls to the controllable devices – either on/off or linear control	Decisioner	Field controllable devices	Controls		Lower Security DAC

[1] Note – A triggering event is not necessary if the completion of the prior step – leads to the transition of the following step.

2.1.3 Steps – Alternative / Exception Sequences

Describe any alternative or exception sequences that may be required that deviate from the normal course of activities. Note instructions are found in previous table.

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments

2.1.4 Post-conditions and Significant Results

Describe conditions that must exist at the conclusion of the Function. Identify significant items similar to that in the preconditions section.

Describe any significant results from the Function

Actor/Activity	***Post-conditions Description and Results***

2.2 Architectural Issues in Interactions

Elaborate on all architectural issues in each of the steps outlined in each of the sequences above. Reference the Step by number.

Microsoft Excel
Worksheet

2.3 Diagram

For clarification, draw (by hand, by Power Point, by UML diagram) the interactions, identifying the Steps where possible.

3 Auxiliary Issues

3.1 References and contacts

Documents and individuals or organizations used as background to the function described; other functions referenced by this function, or acting as "sub" functions; or other documentation that clarifies the requirements or activities described. All prior work (intellectual property of the company or individual) or proprietary (non-publicly available) work must be so noted.

ID	Title or contact	Reference or contact information
[1]		
[2]		

3.2 Action Item List

As the function is developed, identify issues that still need clarification, resolution, or other notice taken of them. This can act as an Action Item list.

ID	Description	Status
[1]		
[2]		

3.3 Revision History

For reference and tracking purposes, indicate who worked on describing this function, and what aspect they undertook.

No	Date	Author	Description
v00			
rev01	1/12/04	Ellen Liu	New Format

This page intentionally left blank.