IEEE P1564 Voltage Sag Indices Task Force Meeting

Orlando, Florida, United States
January 8, 2007

Chair
Dan Sabin
d.sabin@ieee.org

IEEE P1564 Task Force Meeting
Agenda

- PAR Status
- Draft Status
- Review Document

IEEE P1564 PAR
Status

- The IEEE P1564 PAR was initially approved on January 30, 2000. It expired and was administratively withdrawn on January 30, 2006.
- New PAR resubmitted to IEEE New Standards Committee (NesCom) in January 2007.
  - Next NesCom processing cycle begins 29-Jan-2007
  - Next NesCom conference call will be held on 20-Feb-2007
  - Next NesCom meeting will be held 21-Mar-2007 in Piscataway

IEEE PAR P1564
Title

- Old Title
  - *IEEE Recommended Practice for the Establishment of Voltage Sag Indices*
- New Title
  - *IEEE Guide for Voltage Sag Indices*

IEEE PAR P1564
Scope

- Old Scope
  - This recommended practice identifies useful voltage sag indices for customers, vendors and the electric utilities. The document will identify the method of calculating such indices. The indices are intended to be applied to distribution substations, circuits and defined regions
- New Scope
  - This guide identifies appropriate voltage sag indices and characteristics as well as the methods for calculating them. Methods are provided for quantifying the severity of individual events (single-event characteristics), for quantifying the performance at a specific location (single-site indices), and for quantifying the performance of the whole system (system indices). Multiple methods are presented for each. The methods are appropriate for use in transmission, distribution, and utilization electric power systems.

IEEE PAR P1564
Purpose

- Old Purpose
  - Sag indices are needed to indicate the different performance levels experienced at the transmission, subtransmission, substation and distribution circuit levels. In addition, the characteristic exposure that a typical distribution system encounter needs to be quantified in order to guide manufacturers in the appropriate design of ride-through alternatives for user load equipment. The proposed standard should help utilities and manufactures to compute the advantages/disadvantages of various connections to the electrical system. Sag indices will be determined using the work of IEEE 1250-1995, Std 1159-1995, Std 1346-1998, Chapter 9 of IEEE Std 493, and recent surveys of power quality users and utility systems
- New Purpose
  - This document identifies and defines different characteristics and indices. It does not recommend the use of a specific set of indices, but instead recommends the method for calculating specific indices when such an index is used. The large variation in customers sensitive to voltage sags and power providers supplying them makes it impossible to prescribe a specific set of indices. Instead this document aims at assisting in the choice of index and ensuring reproducibility of the results after a certain index has been chosen. The user of this document may decide to calculate the value for just one index or for a number of different indices, depending on the application.

IEEE PAR P1564
Need

- Numerous papers and reports refer to voltage sags indices, but there is no IEEE definition of them. This guide will present IEEE's first definitions for voltage sag indices to make it easier for comparisons of monitoring campaigns.
- Similar methods for system performance, but concerning interruptions, are defined in IEEE Std. 1366. It is however important to realize that IEEE Std. 1366 considers events in the transmission and/or distribution system, whereas this document considers impact of events in any part of the power grid to electric power consumers.

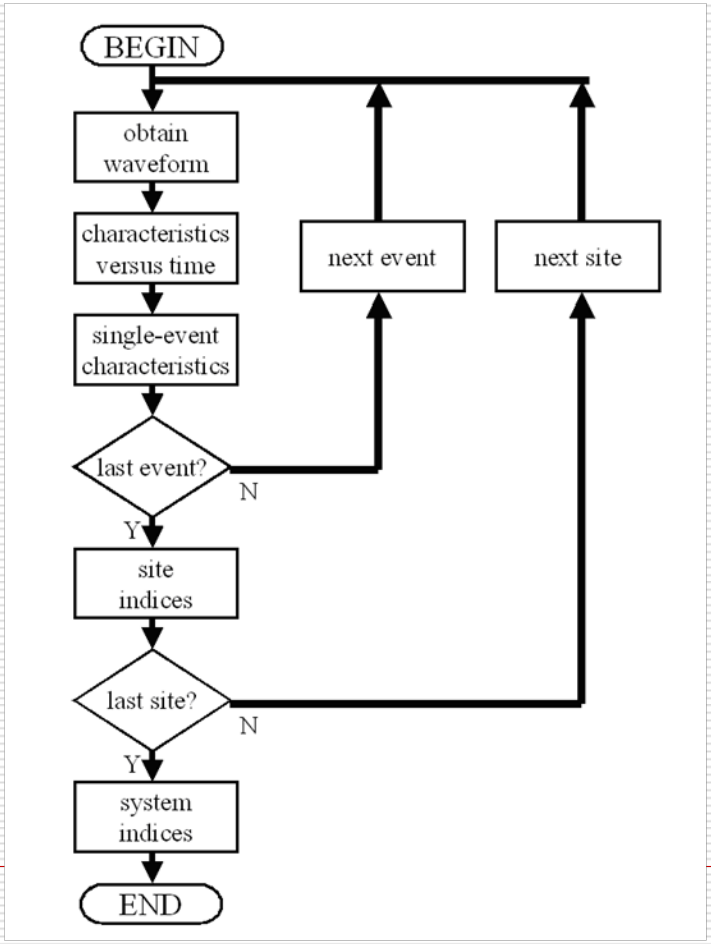
IEEE PAR P1564
Stakeholders

- The stakeholders for this project include power producers (electrical utilities), power consumers, university researchers, and electric power consultants.

IEEE P1564 Draft Review

- Provides definitions useful for assessing counts, rates, and severity of voltage sags, voltage swells, and interruptions
- Current draft provide coordination with a number of existing and draft standards
  - IEC 61000-2-8
    - Voltage dips and short interruptions on public supply systems with statistical measurement results
  - IEC 61000-4-11
    - Voltage dips, short interruptions and voltage variations immunity tests
  - IEC 61000-4-30
    - Testing and measurement techniques – Power quality measurement methods
  - IEEE Std. 1159-2001
    - IEEE Recommended Practice for Monitoring Electric Power Quality
  - IEEE Std 1366-2003
    - IEEE Guide for Electric Power Distribution Reliability Indices

IEEE P1564 Draft Review
Basic Procedure



IEEE P1564 Draft Review
Single Event Characteristics

- Magnitude-Duration
  - Retained Voltage
    - smallest one-cycle rms voltage (from series of rms values recomputed every half-cycle)
  - Duration
    - Time difference between beginning and end of voltage sag
- Mirrors definitions in IEC 61000-4-30 and IEC 61000-2-8

IEEE P1564 Draft Review
Drawing on IEC 61000-2-8

- Threshold Recommendations
  - Sag Start Time: 90% of reference voltage
  - Interruption Start Time: 10% of reference voltage
  - Sag End Time: 91% of reference voltage

IEEE P1564 Draft Review
More Single Event Characteristics

- Voltage Sag Energy
  - duration of an interruption leading to the same loss of energy for an impedance load as the voltage sag

$$E_{VS} = \left[1 - \left(\frac{V}{V_{nom}}\right)^2\right] \times T$$

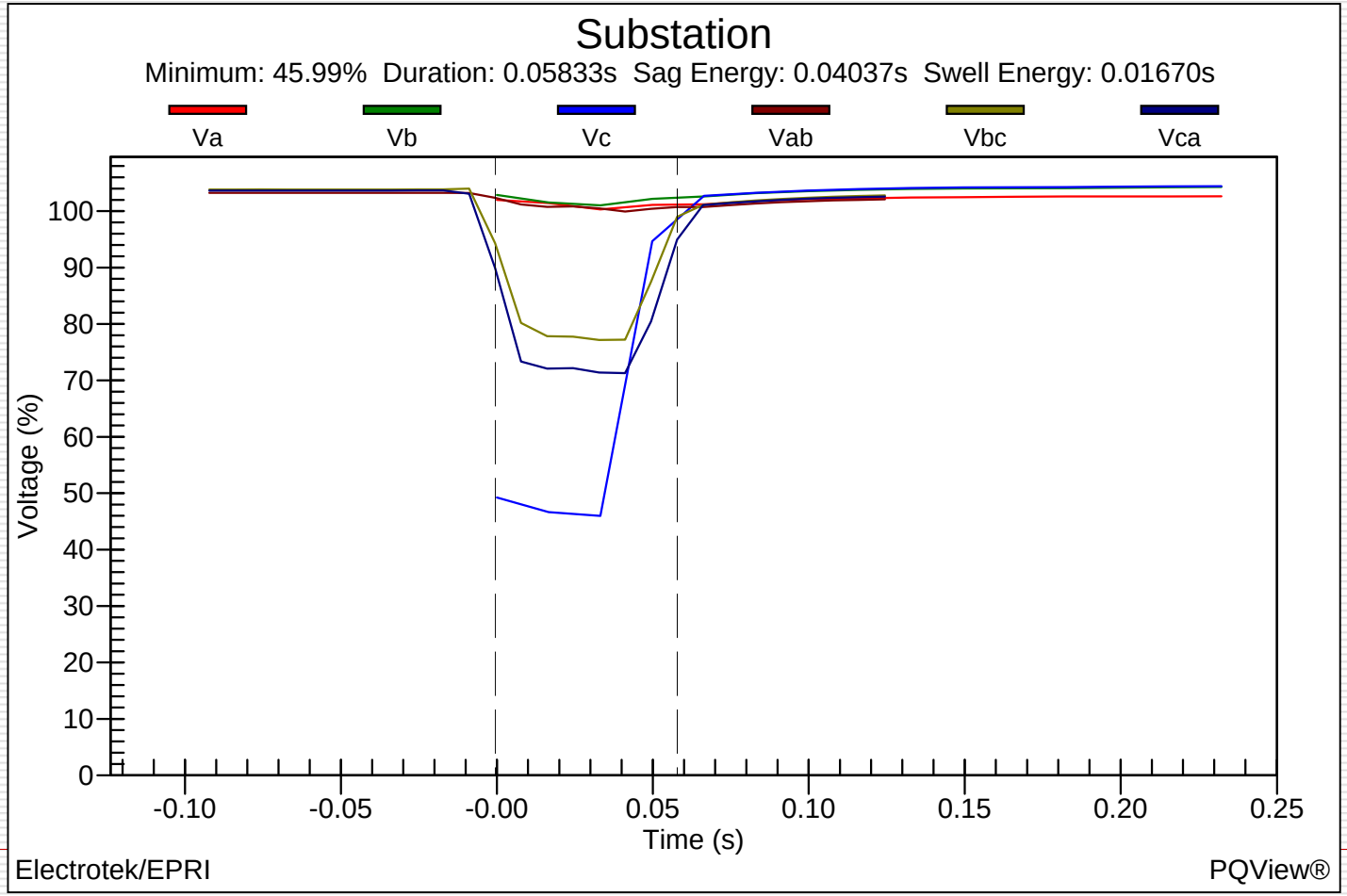
- Voltage Swell Energy

$$E_{VS} = \left[\left(\frac{V}{V_{nom}}\right)^2 - 1\right] \times T$$

- Voltage Sag Severity
  - Compares voltage sag magnitude with sensitivity curve such as the SEMI curve or lower ITIC curve

$$S_e = \frac{1 - V}{1 - V_{curve}(d)}$$

Example Calculation of Retained Voltage, Duration, Sag Energy, and Swell Energy



IEEE P1564: Draft Review
How to deal with three-phase measurements?

- Most Common Method: Lowest Line-Neutral or Line-Line RMS Voltage based on meter connection
  - V_A, V_B, or V_C
  - V_{AB}, V_{BC}, or V_{CA}
- P1564 Proposed Alternative: Characteristic Voltage
  - Lowest magnitude of the rms voltages computed from six phases V_A, V_B, V_C, V_{AB}, V_{BC}, and V_{CA}
  - Voltages are first “reduced” by subtracting zero-sequence voltage
    - $V_0 = (V_A + V_B + V_C)/3$

IEEE P1564 Draft Review
Site Indices for SARFI

- *SARFI*: System Average RMS Variation Frequency Index
  - SARFI-X
    - SARFI-90: Count or rate of voltage sags and interruptions with retained voltage below 90% of voltage reference
    - SARFI-80: Count or rate of voltage sags and interruptions with retained voltage below 80% of voltage reference
    - SARFI-110: Count or rate of voltage swells with retained voltage above 110% of voltage reference
  - SARFI-Curve
    - SARFI-ITIC: : Count or rate of voltage sags and interruptions with retained voltage and duration below the lower portion of the ITI (CBEMA) Curve
    - SARFI-SEMI: : Count or rate of voltage sags and interruptions with retained voltage and duration below the lower portion of the SEMI F47 Curve
- Temporal aggregation recommended to account multiple recordings due to reclosing
- Event rate requires determination of monitor availability

IEEE P1564 Draft Review
Site Indices for Magnitude-Duration

- Voltage Sag Tables
  - Count of rate of retained voltage and duration of voltage sags in to tables
    - UNIPEDE, IEC 61000-4-11, IEC 61000-2-8
- Temporal aggregation recommended
- Event rate requires determination of monitor availability

	<0.1 s	0.1-0.25 s	0.25-0.5 s	0.5-1 s	1-3 s	3-20 s	20-60 s	1-5 min
80-90%								
70-80%								
60-70%								
50-60%								
40-50%								
30-40%								
20-30%								
10-20%								
<=10%								

IEEE P1564 Draft Review

South African Voltage Sag Table

- NRS-048-2 Sag Reporting Method

retained voltage	Duration t		
	20 ≤ t < 150 (ms)	150 ≤ t < 600 (ms)	0.6 ≤ t < 3 (s)
90> U ≥ 85	Y		
85> U ≥ 80			
80> U ≥ 70			Z1
70> U ≥ 60	X1	S	
60> U ≥ 40	X2		
40> U ≥ 0	T		Z2

IEEE P1564 Draft Review
Site Indices for Sag Energy

- The sag energy method of characterization uses three site indices
  - number of events per site
  - “total lost energy” per site (Sag Energy Index, or SEI)
  - “average lost energy” per event (Average Sag Energy Index, or ASEI)

IEEE P1564 Draft Review
Site Indices for Voltage Sag Severity

- Total Voltage-Sag Severity $S_{SITE} = \sum_{i=1}^{N} S_{e-i}$
- Average Voltage-Sag Severity $S_{average} = \frac{S_{SITE}}{N}$
- Count of Voltage Sags for the Site N

IEEE P1564 Draft Review
System Indices

- "System" definition is scalable
  - Could be a collection of customers, feeders, substations, networks, etc.
- System indices are a statistic of a given voltage sag site index from multiple sites
  - Average
  - Percentile
    - CP50: median or 50th percentile
    - CP95: 95th percentile
    - CP99: 99th percentile
  - Weighted Average
    - Number of customers
    - Statistical sampling weight

IEEE P1564 Draft Review
IEEE P1159.1 and P1159.2

- Relevant sections of the inactive P1159.1 and P1159.3 documents need to be incorporated

P1564 Schedule

- New PAR needs to be approved.
  - Duration: several months
- Existing document needs to be reformatted to current IEEE template.
  - A volunteer?
  - Duration: six weeks?
- Technical editing needs to be done.
  - Duration: six to eight weeks?
- Ballot pool
  - Duration: one to two months