# IEEE Standard 1159

## Recommended Practice for Monitoring Electric Power Quality A Status Update

**E. R. "Randy" Collins, Jr., PhD, PE**
Chair, Working Group for Monitoring Electric Power Quality

Clemson University
Department of Electrical and Computer Engineering
201 Riggs Hall, Clemson SC 29634-0915
randy.collins@ces.clemson.edu

2008 IEEE T&D Conference, Chicago IL, April 23, 2008

## Working Group for Monitoring Electric Power Quality

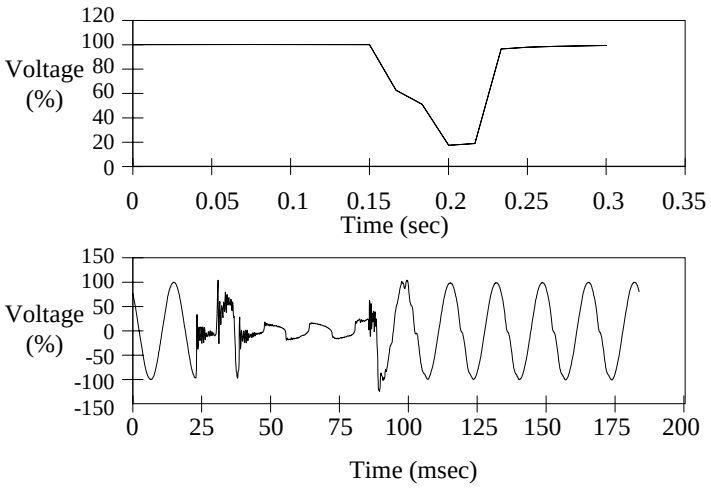
- IEEE PES
  - Transmission and Distribution Committee
    - Power Quality Subcommittee
      - Working Group for Monitoring Electric Power Quality
        - » Standard 1159
        - » Standard 1159.3
        - » Other PQ Monitoring activities
        - » Liaison with SCC-22 (Standards Coordinating Committee 22: PES and IAS)

## What Do Power Quality Monitors Do?

- PQ Monitors are widely available
- Measure voltage and currents
- Capture PQ events
  - Voltage sags (dips)
  - Voltage swells
  - Transients
  - Harmonics
  - Exceedance values
- Some mathematical analyses of waveforms
  - Power, energy, etc.

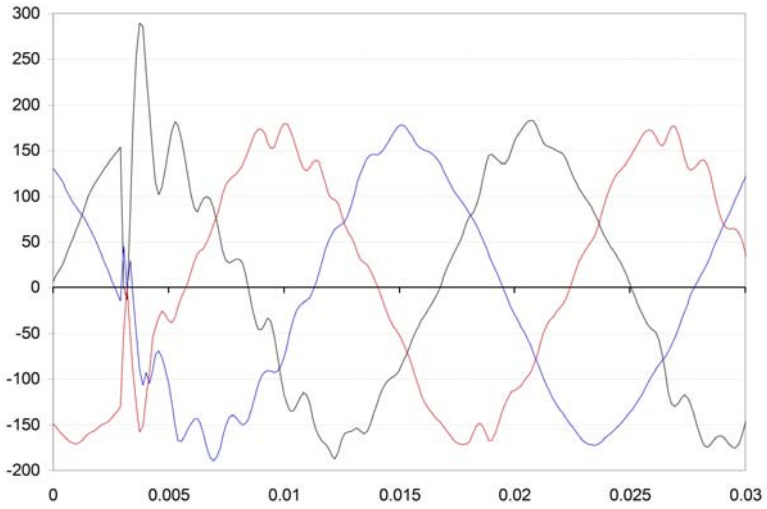
3

## Voltage Sag



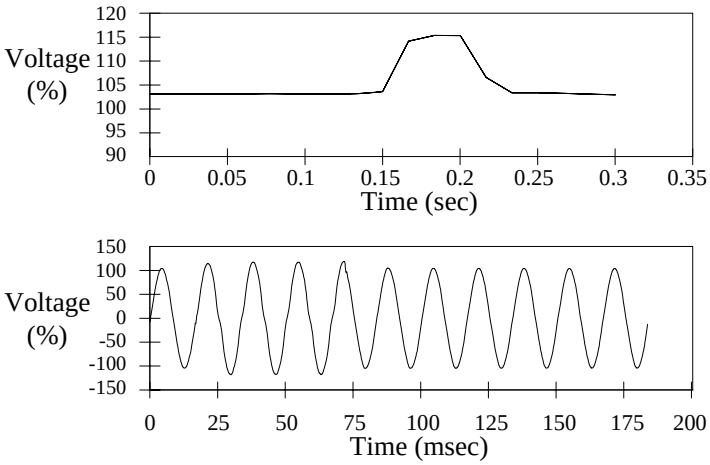

4

# Low Frequency Oscillatory Transient




5

# Voltage Swell




6

## History of IEEE Std 1159

- Working Group for Power Quality Monitoring formed in nearly 20 years ago in response to a need for standardizing burgeoning power quality monitoring manufacturing industry and the use of these monitors in the field by utilities and end-users.
  - Consistent terminology
  - Definitions
  - Applications
  - Data interpretation

7

## History cont'd

- First 1159 finalized and balloted in 1994, published in 1995.
- Activity from 1995 to 2001 focused on three activities:
  - 1159.1 Monitor qualification
  - 1159.2 Characterization of PQ events
  - 1159.3 Data interchange format (PQDIF)
- IEEE 1159 Reaffirmed in 2001
- IEEE 1159.3 Balloted and Published in 2003
- 1159.1 and 1159.2 efforts merged, attempted coordination with IEC 61000-4-30, PAR expired and efforts tabled in 2005.
- Complete revision of IEEE 1159 begun in approximately 2003 and final draft completed February 2008
  - Balloting began March 18, 2008
  - Balloting ended April 18, 2008

8

## Ballot results

- Success!
  - IEEE-Standards Association requires 75% response of balloters with 75% approval.

9

## Statistics

**RESPONSE RATE**

This ballot has met the 75% returned ballot requirement.
118 eligible people in this ballot group.

| | |
|---|---|
| 92 | affirmative votes |
| 3 | negative votes with comments |
| 0 | negative votes without comments |
| 8 | abstention votes |
| 103 | votes received = 87 % returned |
| | 7 % abstention |

**APPROVAL RATE**

The 75% affirmation requirement is being met.

| | |
|---|---|
| 92 | affirmative votes |
| 3 | negative votes with comments |
| 95 | votes = 96% affirmative |

10

## Next Steps

- Resolve the mandatory and editorial comments.
- Recirculate the ballot.
- Gain approval from IEEE REVCOM
- Publish the standard

- Projected schedule
  - Comments resolved by Summer IEEE PES meeting in Pittsburgh, July 2008.
  - Recirculate ballot in August 2008.
  - REVCOM approval and publication by end of 2008.

11

## Future IEEE PQ Monitoring Working Group Activities

- Complete IEEE 1159 revision.
- Renew the effort to create an IEEE Standard that coordinates with IEC 61000-4-30 and adds additional meaningful attributes. This will likely involve resurrecting P1159.1.
- Get involved!
  - Next meeting at the IEEE PES General Meeting, July 2008, in Pittsburgh.

- Contact Tim Unruh (Vice Chair) timu@customenergy.com or Randy Collins (Chair) to be added to email list.

12

## Scope of P1159

This recommended practice encompasses the monitoring of electrical characteristics of single-phase and polyphase ac power systems. It includes consistent descriptions of conducted electromagnetic phenomena occurring on power systems. The document presents definitions of nominal conditions and deviations from these nominal conditions that may originate within the source of supply or load equipment, or from interactions between the source and the load. Also, this document presents recommendations for measurement techniques, application techniques, and interpretation of monitoring results.

13

## Purpose

The use of equipment that causes and is susceptible to various electromagnetic phenomena has heightened the interest in power quality. An increase in operational problems has led to a variety of attempts to describe the phenomena. Because different segments of the technical community have used different terminologies to describe these electromagnetic events, this Recommended Practice will provide users with a consistent set of terms and definitions for describing these events. An understanding of how power quality events impact the power system and end-use equipment is required in order to make monitoring useful. Proper measuring techniques are required to safely obtain useful accurate data. Appropriate location of monitors, systematic studies, and interpretation of results will enhance the value of power quality monitoring. The purpose of this Recommended Practice is to assist users as well as equipment and software manufacturers and vendors by describing techniques for defining, measuring, quantifying, and interpreting electromagnetic disturbances on the power system.

14

## Clauses

- 1 and 2. Front Matter
- 3. Definitions
- 4. Power Quality Phenomena
- 5. Monitoring Objectives
- 6. Measurement Instruments
- 7. Application Techniques
- 8. Interpreting Power Quality Monitoring Results
- Annex A. Calibration and Self-Testing
- Annex B. Bibliography

15

## Clause 3. Definitions (Not defined elsewhere as used in 1159)

- 3.1) Impulsive transient:
- 3.2) Variation, RMS; also RMS variation.
- 3.3) Variation, Long Duration RMS; also long duration RMS variation
- 3.4) Variation, Short Duration RMS; also short duration RMS variation
- 3.5) Instantaneous
- 3.6) Interruption, Momentary; also momentary interruption
- 3.7) Interruption, Temporary; also temporary interruption
- 3.8) Voltage Interruption
- 3.9) Interruption, Sustained; also sustained interruption
- 3.10) Imbalance; also unbalance (voltage or current)
- 3.11) Waveform Distortion
- 3.12) Interharmonic (component)
- 3.13) Voltage Fluctuation
- 3.14) Voltage Change
- 3.15) Flicker
- 3.16) Fundamental (component)

16

## Clause 4. Phenomena

- 4.1 Introduction
- 4.2 Electromagnetic Compatibility
- 4.3 General Classification of Phenomena
- 4.4 Detailed Descriptions of Phenomena

17

## Clause 5. Monitoring Objectives

- 5.1 Introduction
- 5.2 Need for Monitoring Power Quality
- 5.3 Equipment Tolerances and Effects of Disturbances on Equipment
- 5.4 Equipment Types
- 5.5 Effect on Equipment by Phenomena Type

18

## Clause 6. Measurement Instruments

- 6.1 Introduction
- 6.2 History – Four Generations
- 6.3 Reasons to Monitor vs. Type of Monitor
- 6.4 Parameters to be measured
- 6.5 Monitoring Instruments
- 6.6 Pitfalls/Cautions
- 6.7 Safety

19

## Clause 7. Application Techniques

- 7.1 Safety
- 7.2 Monitoring Location
- 7.3 Equipment Connection
- 7.4 Measurement Thresholds

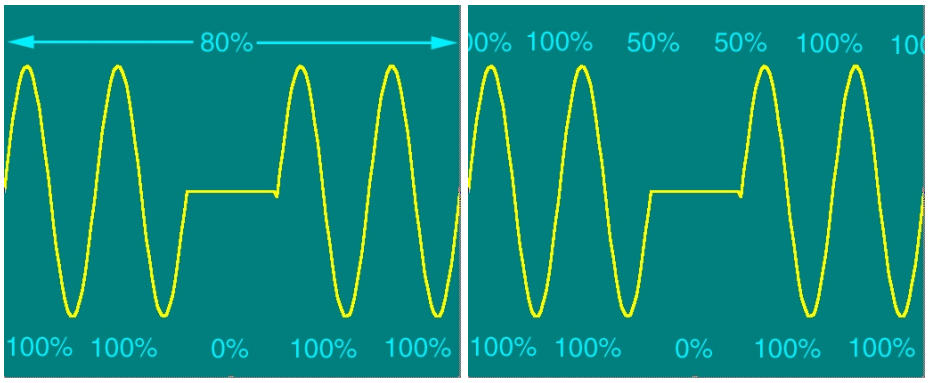
20

## Clause 8. Data Interpretation

- 8.1 Introduction
- 8.2 Interpreting Data Summaries
- 8.3 Critical Data Extraction
- 8.4 Interpreting Critical Events
- 8.5 Verifying Data Interpretation

21

## Two instruments measuring the same event: Which one is right?

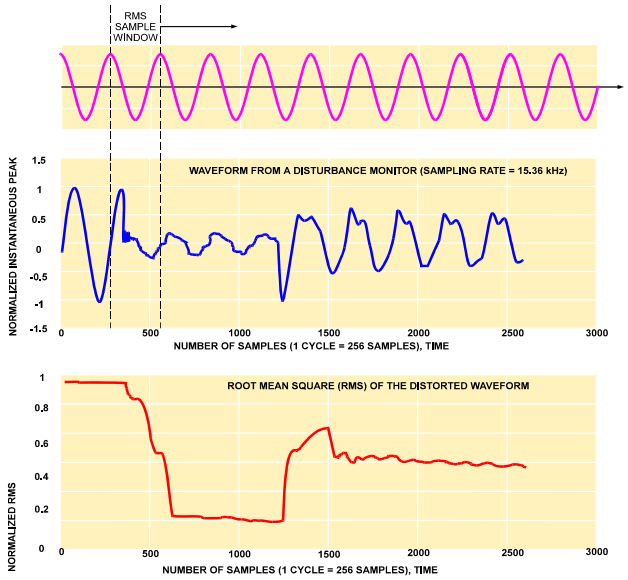



Meter A: Measures the rms value with a 5-cycle window

Meter B: Measures the rms value with a 1-cycle window

22

# How about a complex sag?




23

# IEEE 1159 only partially addresses these situations

- These waveforms have more going on than simple rms or peak values.
- The standard defines some of the waveform attributes, but does not tell you how to measure them or implement the algorithm to determine the numbers.
- Some situations do not require detailed analysis of complex waveshapes, others do.

24

## 1159 states that there are additional waveform attributes

Steady state phenomena:

- Amplitude
- Frequency
- Spectrum
- Modulation
- Source impedance
- Notch depth
- Notch area

Non-steady state phenomena:

- Rate of rise
- Amplitude
- Duration
- Spectrum
- Frequency
- Rate of occurrence
- Energy potential
- Source impedance

25

## IEC PQ Standards

- 61000-1-X - Definitions and methodology
- 61000-2-X - Environment (e.g. 61000-2-4 is compatibility levels in industrial plants)
- 61000-3-X - Limits (e.g. 61000-3-4 is limits on harmonics emissions)
- 61000-4-X - Tests and measurements (e.g. 61000-4-30 is power quality measurements)
- 61000-5-X - Installation and mitigation
- 61000-6-X - Generic immunity & emmissions standards

26

## Why coordinate?

- PQ Monitors should always give meaningful answers.
- PQ Monitors using IEEE Standard definitions should not give different results from those using IEC Standard definitions.
- Where are we now? Where are we going? Where should we be going? How will be get there?

27

## Today's Panel Session

- Clause 4 – Electromagnetic Phenomena
  - *Erich Gunther,* Enernex
- Clause 6 – Measurement Instruments
  - *Rich Bingham*, Dranetz-BMI
- Clause 7 – Application Techniques
  - Tim Unruh, Custom Energy
- Coordination with IEC and International Stds
  - *Alex McEachern,* Power Standards Lab
- Initiation of 1159.1 – Characterization and Meter Qualification
  - *Charles Perry,* EPRI
- Paper Presentation: "Monitoring Power Quality Beyond EN 50160 AND IEC 61000-4-30," Preprint Number: 08TD0747
  - *A. Broshi*, Elspec Ltd.

28