

IEEE 1159

Chapter 4 - Phenomena

Presented at the:
IEEE 2008 T&D Show
Chicago, IL
April 23, 2008

Presented by:
Erich W. Gunther
EnerNex Corporation
(865) 691-5540 ext. 114
<http://www.enernex.com>
erich@enernex.com

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Table 4-2: Power Quality Phenomena Categories

This chapter amplifies the definitions of Clause 3 and the Glossary in Annex B by providing technical descriptions and examples of the principal electromagnetic phenomena causing power quality problems

1. Transients
2. Short Duration RMS Variations
3. Long Duration RMS Variations
4. Unbalance
5. Waveform Distortion
6. Voltage Fluctuations
7. Power Frequency Variations

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Attributes

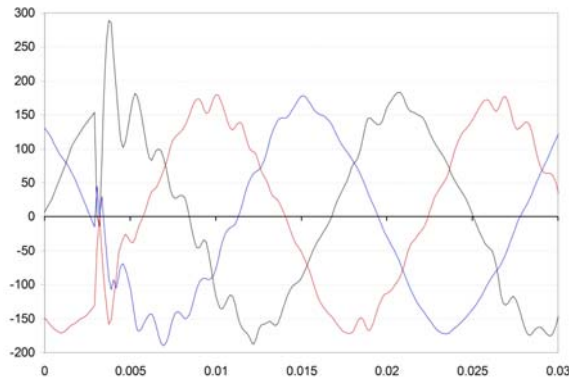
- | | |
|---|---|
| <ul style="list-style-type: none"> ■ Steady State Attributes <ul style="list-style-type: none"> ➤ Amplitude ➤ Frequency ➤ Spectrum ➤ Modulation ➤ Source impedance ➤ Notch depth ➤ Notch area | <ul style="list-style-type: none"> ■ Event Attributes <ul style="list-style-type: none"> ➤ Rate of rise ➤ Amplitude ➤ Duration ➤ Spectrum ➤ Frequency ➤ Rate of occurrence ➤ Energy potential ➤ Source impedance |
|---|---|

The categories of Table 4-2, when used with the attributes mentioned above, provide a means to clearly describe an electromagnetic disturbance.

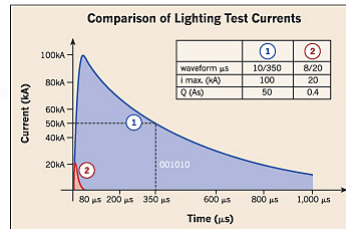
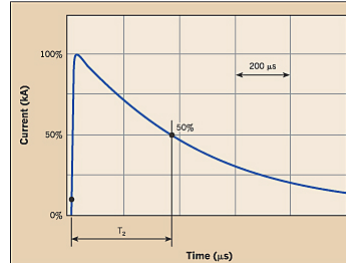
PQ Categories - Transients

Categories	Typical Spectral Content	Typical Duration	Typical Voltage Magnitude
1.0 Transients			
1.1 Impulsive			
1.1.1 Nanosecond	5 ns rise	< 50 ns	
1.1.2 Microsecond	1 μs rise	50 ns -1 ms	
1.1.3 Millisecond	0.1 ms rise	> 1 ms	
1.2 Oscillatory			
1.2.1 Low Frequency	< 5 kHz	.3 - 50 ms	0 - 4 pu ³
1.2.2 Medium Frequency	5 - 500 kHz	20 μs	0 - 8 pu
1.2.3 High Frequency	0.5 - 5 MHz	5 μs	0 - 4 pu

Transients – Impulsive and Oscillatory



Oscillatory Transient – Capacitor Switching



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RMS Variations

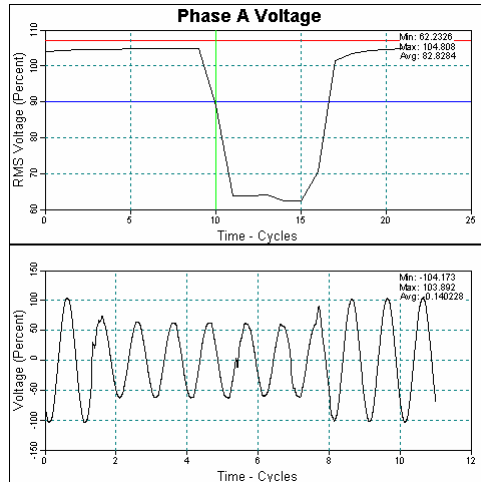
Categories	Typical Spectral Content	Typical Duration	Typical Voltage Magnitude
2.0 Short Duration RMS Variations			
2.1 Instantaneous			
2.1.1 Sag		0.5 - 30 cycles	0.1 - 0.9 pu
2.1.2 Swell		0.5 - 30 cycles	1.1 - 1.8 pu
2.2 Momentary			
2.2.1 Interruption		0.5 cycles - 3 s	< 0.1 pu
2.2.2 Sag		30 cycles - 3 s	0.1 - 0.9 pu
2.2.3 Swell		30 cycles - 3 s	1.1 - 1.4 pu
2.3 Temporary			
2.3.1 Interruption		3 s - 1 min	< 0.1 pu
2.3.2 Sag		3 s - 1 min	0.1 - 0.9 pu
2.3.3 Swell		3 s - 1 min	1.1 - 1.2 pu
3.0 Long Duration RMS Variations			
3.1 Interruption, Sustained		> 1 minute	0.0 pu
3.2 Undervoltages		> 1 minute	0.8 - 0.9 pu
3.3 Overvoltages		> 1 minute	1.1 - 1.2 pu
3.4 Current Overload		> 1 minute	

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Instantaneous

Minimum Voltage: 62%
Duration: 7 cycles

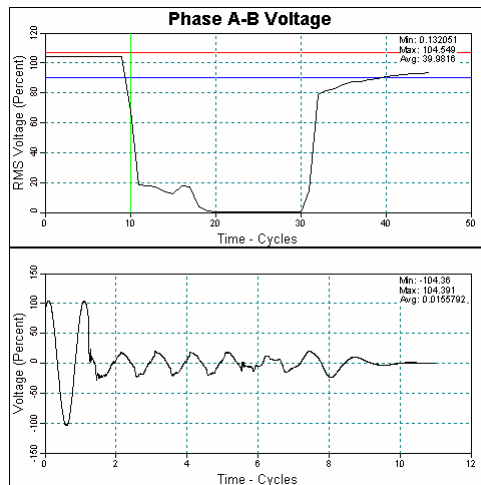


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Momentary

Minimum Voltage: 0%
Duration: 30 cycles

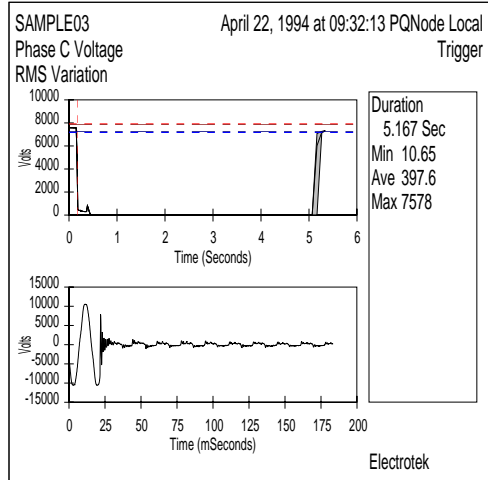


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Temporary

Minimum Voltage: 0%
Duration: 5.167 sec

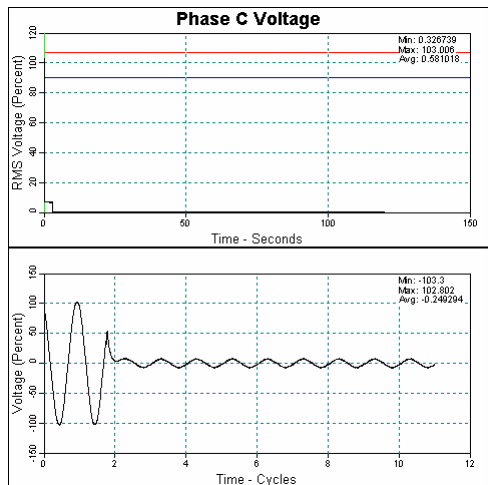


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Long Duration

Minimum Voltage: 0%
Duration: 1m 57s

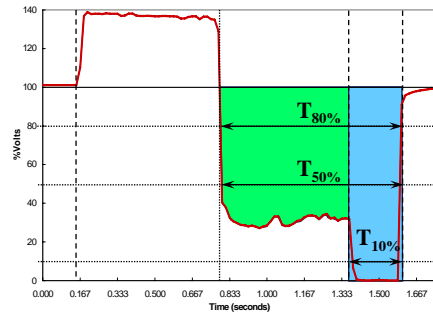


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Characterization of RMS Variations

- **Magnitude:**
 - Rises and drops assessed separately
 - Maximum deviation among 3 phases
- **Duration:**
 - Time span below threshold voltage level
- **Volt × Seconds Lost**
 - Product of magnitude and duration



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Steady State Phenomena

Categories	Typical Spectral Content	Typical Duration	Typical Voltage Magnitude
4.0 Unbalance			
4.1 Voltage		steady state	0.5 - 2%
4.2 Current		steady state	1.0 - 30%
5.0 Waveform Distortion			
5.1 DC Offset		steady state	0 - 0.1%
5.2 Harmonics	0 - 9 kHz	steady state	0 - 20%
5.3 Inter-harmonics	0 - 9 kHz	steady state	0 - 2%
5.4 Notching		steady state	
5.5 Noise	broad-band	steady state	0 - 1%
6.0 Voltage Fluctuations	< 25 Hz	intermittent	0.1 - 7% 0.2 - 2 P _{st} ²
7.0 Power Frequency Variations		< 10 s	+/- 0.10 Hz

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Unbalance, Waveform Distortion

$$V_{AB} = V_{AN} - V_{BN} = 275\angle 0^\circ - 295\angle -115^\circ = 476.7\angle 34.1^\circ$$

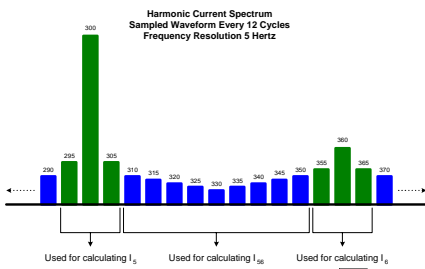
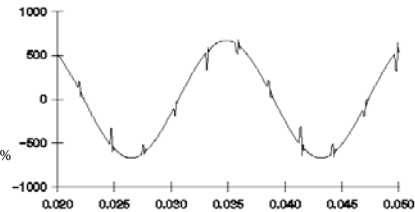
$$V_{BC} = V_{BN} - V_{CN} = 295\angle -115^\circ - 270\angle 122^\circ = 496.7\angle -87.9^\circ$$

$$V_{CA} = V_{CN} - V_{AN} = 270\angle 122^\circ - 275\angle 0^\circ = 476.7\angle 151.3^\circ$$

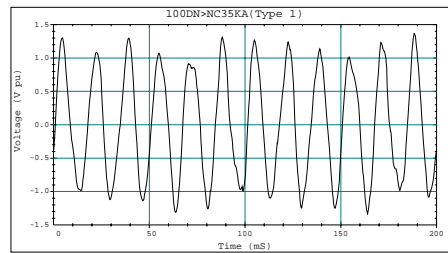
$$V^+ = \frac{1}{3}(V_{AN} + V_{BN} \cdot 1\angle 120^\circ + V_{CN} \cdot 1\angle -120^\circ) = 279.8\angle 2.4^\circ$$

$$V^- = \frac{1}{3}(V_{AN} + V_{BN} \cdot 1\angle -120^\circ + V_{CN} \cdot 1\angle 120^\circ) = 7.07\angle 171.2^\circ$$

$$\% \text{ Unbalance} = \frac{7.07}{279.8} \times 100\% = 2.5\% \quad \% \text{ Unbalance} = \frac{496.7 - 483.4}{483.4} \times 100\% = 2.8\%$$



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Questions?

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