

Energy 2002 – Palm Springs, June 2, 2002



The Impact of Power Quality in the Telecommunications Industry

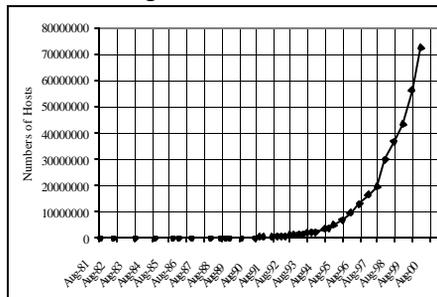
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Characteristics of the Telecommunications Industry



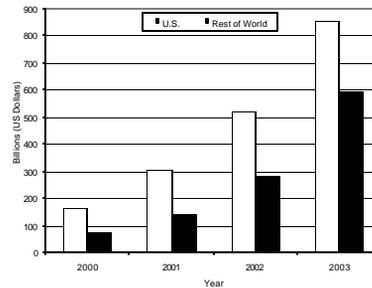
- Tremendous growth



Growth of Internet Hosts

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Characteristics of the Telecommunications Industry



Growth of eCommerce in the United States

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Characteristics of the Telecommunications Industry

- Recent downturn merely an adjustment
 - Market was inflated
 - Infrastructure left in place
- Resurgence a certainty
- Extent of automation with sensitive, high frequency equipment
 - Electrical loads primarily non-linear
 - Improvements indicated by higher speeds and frequencies, lower voltages

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Characteristics of the Telecommunications Industry

YEAR	PROCESSOR	SPEED (MHZ)	V _{cc} (V)	I _{cc} (A)
1979	8086	5 TO 8	5.0	<< 1
1985	Intel386	16 to 20	5.0	<1
1989	Intel486	25 to 100	3.3/5.0	1
1993	Pentium	60 to 66	5.0	3
1994	Pentium	90 to 233	2.8/3.3	5
1995	Pentium Pro	150 to 200	3.1/3.3	15
1997	Pentium II	233 to 300	2.8	14

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Characteristics of the Telecommunications Industry

- Need for reliability
 - Expense of processes controlled
 - Criticality of data

Level of Reliability	99.9%	99.99%	99.999%	99.9999%	99.99999%
Number of Nines (9's)	3	4	5	6	7
Duration of Equipment Downtime	8.8 hours	53 minutes	5.2 minutes	31.5 seconds	3.2 seconds

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Power Quality Issues of Unique Importance

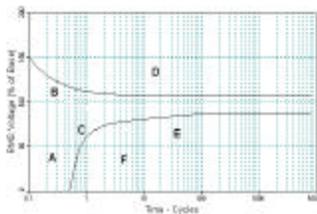
- Voltage sags
- Harmonics
- High frequency grounding



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Power Quality Issues of Unique Importance

- Voltage sags
 - Reduction in voltage from the nominal
 - Very short duration
 - Can result in equipment misoperation



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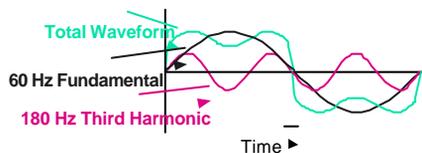
Power Quality Issues of Unique Importance

- Problem greater with increased use of sensitive equipment
 - Losses not uncommon at only 10%-15% voltage sag, for tenths of a second
 - Proportional to value-added product
- Causes: line faults, fog, brush fires
- Solutions straightforward, though
 - Isolation transformers
 - Uninterruptible Power Supplies (UPSs)

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Power Quality Issues of Unique Importance

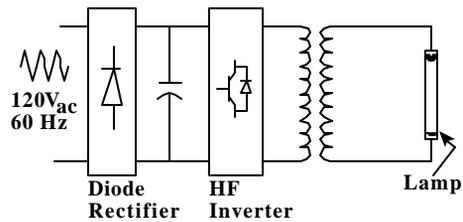
- Harmonics
 - Multiples of 60 Hz
 - Total Harmonic Distortion (THD) the sum of all harmonics



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Power Quality Issues of Unique Importance

- Most common cause is converter-based equipment



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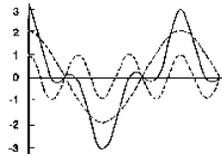
Power Quality Issues of Unique Importance

- Other Causes of harmonics
 - Saturated transformers
 - Arcing equipment (welders, blast furnaces, etc.)
 - Electrical generators

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Power Quality Issues of Unique Importance

- Effects of Harmonics
 - Overheated neutrals in 3-phase, 4-wire systems
 - Overheated transformers due to circulating currents
 - Telephone Interference Factor (TIF)
 - Communications timing



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Power Quality Issues of Unique Importance

- Mitigation of Harmonics Effects
 - Filters
 - Passive
 - Active
 - Zig-zag transformers
 - K-Factor Transformers
 - Purchase equipment low in harmonics

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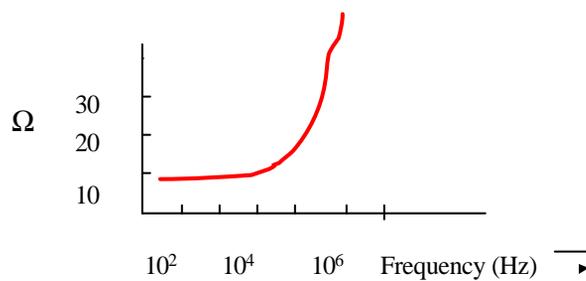
Power Quality Issues of Unique Importance

- High frequency operations and grounding
 - Traditional purposes of grounding
 - Safety
 - Operations (noise control)
 - Grounding systems designed for 60 Hz
 - Current generations of equipment designed for MHz, GHz and up
 - Grounding systems essentially ineffective

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Power Quality Issues of Unique Importance

- The effect of high frequency operations



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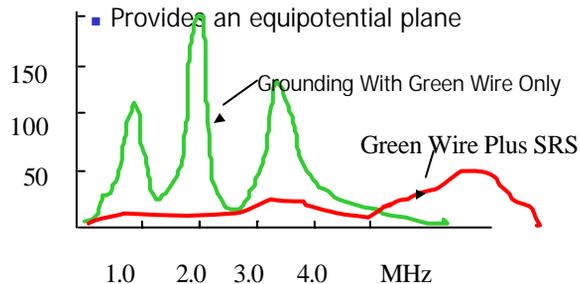
Power Quality Issues of Unique Importance

- The solution: a **Signal Reference Structure**
"A system of conducting paths that reduce noise-induced voltage levels that minimize improper operation. Common configurations include grids and planes." (*Emerald Book, IEEE Std 1100-1999*)
 - Provide equipotential plane at many frequencies
 - Allows connections to ground of varying lengths

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Power Quality Issues of Unique Importance

- Benefits of an SRS
 - Effective from DC to MHz
 - Provides an equipotential plane



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Where to From Here?

- Can continue with traditional (60-Hz) approach
 - Failed operations
 - Damaged equipment
- Recommended approach
 - Recognize the significance of high frequency operations
 - Train in-house personnel
 - Use outside expertise selectively