

Fifty Years in Power Quality

By Robert Moore

**A retrospective from
1960 through 2012**

Introduction



- The following slides are a glimpse of some of the trends and events that I noted and experienced over the last fifty-plus years

Topics of Discussion

- The Decade from 1960 to 1970
- The Decade from 1970 to 1980
- The Decade from 1980 to 1990
- The Decade from 1990 to 2000
- The Last Ten Years
- The Future



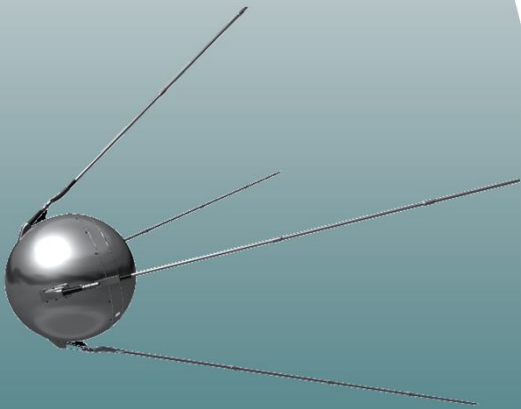
The Decade from 1960 to 1970

- High-end electronics dominated by Military Industry Complex during the Cold War.
- Started career as an engineer in the “Shake and Bake” division of Bendix Corporation.
- Power quality emerged as an issue for military & large commercial systems - not a problem for most industrial & other consumers. Loads are motors or incandescent lamps.



The Space Race Boosts Technology

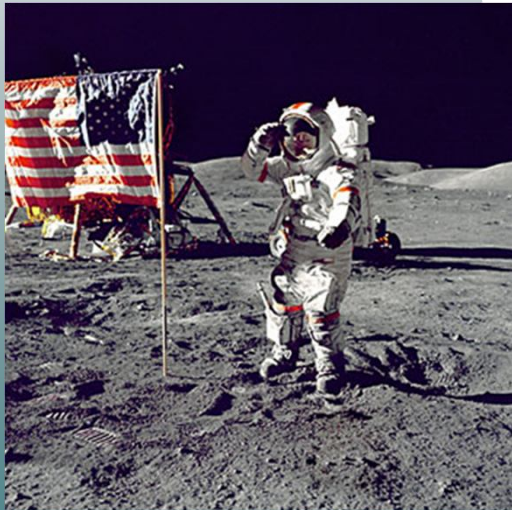
- Russia launches Sputnik
- America launches Telstar
- Russia launches dog
- America launches monkey
- Russia launches man
- America launches man
- The race to the Moon is on
- Power Quality becomes an issue as the world watches space launches



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My First Power Quality Problem

- Landing on the Moon
- No Digital Readouts
- Vertical Scale Indicator
- 50 foot Analog Display



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The Decade from 1970 to 1980

- IBM dominates the computer industry
- Specially designed, protected, secure computer rooms with 415Hz power
- The Mini-Computer emerges onto factory floor & office environments
- 50/60 Hz Power Quality problems arise
- Dranetz introduces power monitors
- Text-type readouts on early power quality monitors



Not a Power Quality Problem

- Mc Donald's
Highway Patrol found guilty
- Fish Factory
Fly's found guilty



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The Decade from 1980 to 1990



- Semiconductor & Signal Processing Technology lead to development of wave-shape capture analyzer from BMI
- PC's & Electronics proliferate
- Greater awareness of disturbances -VCR clock!
- Utilities forced to respond to complaints and PUC pressure, set up departments
- EPRI starts Power Quality initiatives to study and quantify issues, educate utilities & users

Non-Linear Loads Proliferate.

- **The Switching Power Supply**

The Good = Lighter, Cooler, Less expensive

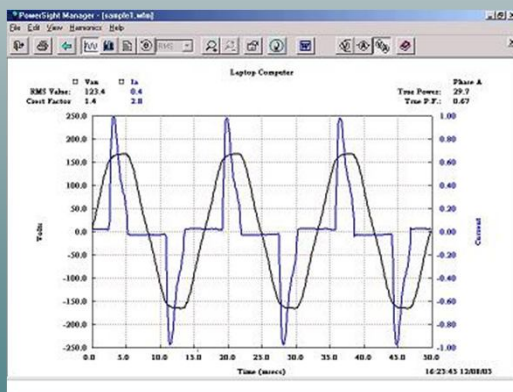
The Bad = Transient-sensitive, Harmonics

- **Harmonic Issues Emerge**

Neutral conductors catch fire

Transformers overheat

Utilities become concerned



The Decade from 1990 to 2000

- The PC overwhelms the mini-computer
- DEC, Prime, Data General go out of business
- The issues of Power Quality are strongly addressed by Utilities
- PC technology (CPU's / DSP / storage) is harnessed to measure energy + power quality
- RPM introduces first “Full Disclosure Monitor”
- Personal computer software becomes essential tool for analysis



The New Millennium 2000 on

- Deregulation emerges, utilities are broken up
- Generation, Transmission, & Distribution
- California Power Crisis - Enron
- PG&E files for bankruptcy
- Responsibility for power quality shared between industry and utilities
- Permanently installed monitors become inexpensive to permit 24 x 7 monitoring



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Hand-held, tablet, black-box choices



The Future

- Failures happen! Forensic Analysis still essential
- Trouble-shooting tools becoming less-expensive, safer, more powerful, better h/w and s/w
- Predictive Analysis will play greater role due to wide deployment of low-cost permanent monitoring
- Analysis software evolves:
 - Pattern recognition & artificial intelligence
- As “Smart-er Grid” becomes more automated the cycle of: “data - information - knowledge – action” is the key to reliability



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When My Reach Exceeded My Grasp

Z Meters

- Using two monitors to determine the impedance of electrical conductors
- Failed since the technique required highly accurate current measurement $< .1\%$ and $1/_{10}$ degree for X
- Best that could be done with existing current probes is 1% and 3 degrees

