

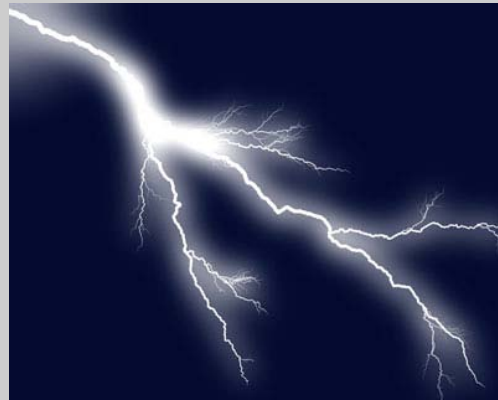
# Designing for the substation environment – A review of IEEE 1613

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i – PCGRID Workshop - 2013

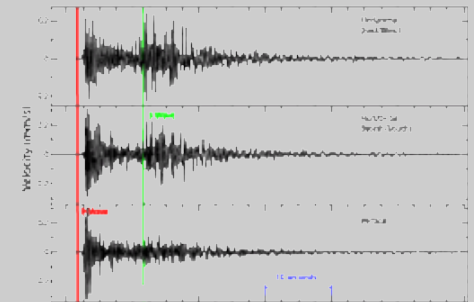
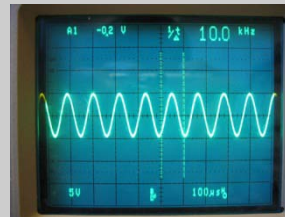
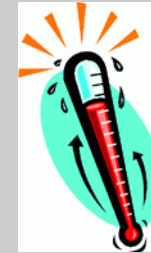
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# Why does substation equipment need hardening?



# Aspects of substation hardening

- Physical Environment
  - Temperature and humidity
  - Shock and vibration
  - Seismic
- Station Systems
  - Power quality
- Electrical Environment
  - Conducted withstand
  - Electrostatic discharge (ESD)
  - Radiated withstand (RFI)



# Major Standards Bodies

- North America

- UL
- CSA
- FCC
- IEEE



- Europe & Rest of World

- International Electro-technical Commission (IEC)
- European Union (CE) (Legal requirements for all)



# Major Standards Bodies

- North America
  - UL (Safety, Voluntary)
  - CSA (Safety, Voluntary)
  - FCC (Mainly emissions, EHV substations exempt\*)
  - IEEE (All encompassing)
  
- Europe & Rest of World
  - International Electro-technical Commission (IEC)
  - European Union (CE) (Legal requirements for all)

\*47 CFR part 15.103 Exempted Devices (para. b)

A digital device used exclusively as an electronic control or power system utilized by a public utility or in an industrial plant. The term public utility includes equipment only to the extent that it is in a dedicated building or large room owned or leased by the utility and does not extend to equipment installed in a subscriber's facility.

# How the IEC standards world works

## How to bake bread????

Standard 07055 – How to bake white bread

Standard 1 – How to measure anything

Standard 2 – How to mix anything

Standard 3 – how to bake anything

Standard 4 – How to use an oven



Standard 07055 (**product standard**) says what ingredients and how much but refers to standard 1 (**generic standard**) on how to measure. It tells you to mix the ingredients but refers to standard 2 on how to mix, and so on.

**Drawback – you will starve unless you have all the standards.**

# How the IEEE standards world works

## How to bake bread????

Standard 07055 – How to bake white bread

Standard 07056 – How to bake rye bread

Standard 07057 – How to bake wheat bread

Standard 07058 – How to bake pumpernickel bread



Each standard tells you everything you need to know to bake a specific type of bread and 90% of it is repeated in all the successive standards.

Drawback – If you buy a new oven, all standards have to be revised.





# CE Standards

- CE (or EU) standards define the minimum requirements for placing products on the market in EU countries.
- 61000-x-y series covers many of the required areas for substation operation.
  - EMI withstand and emissions
  - Power quality
  - Surge / Fast transient withstand
- Product standards call out levels and acceptance criteria
- Levels are typically well below the requirements for substation use
- CE is a legal requirement





# IEC Standards

- IEC standards are used worldwide to define requirements for substation operation.
- Cover the same areas as CE.
- Use many of the same generic IEC standards.
- Calling out the right top level (product) standards essential to ensuring proper levels and acceptance criteria.

**IEC 60255** series is the product standard for “**Protective Relaying Equipment**”

**IEC 61850-3** is the product standard for “**Communication Networks and systems in substations**”

# IEEE Substation Standards

- Created specifically by the IEEE/PES/PSRC & PSCC for substation environments based on field history and tests.
- C37.90.x series is for protective relays
  - C37.90 – Service conditions (physical, electrical)
  - C37.90.1 – SWC withstand (Oscillatory, Fast transient)
  - C37.90.2 – RFI withstand
  - C37.90.3 – ESD withstand
- C37.90 calls out specific acceptance criteria that do not apply to communications equipment.
- IEEE 1613 was developed specifically for non-protective relaying (communications & networking) equipment in substations.



# IEEE 1613 History

2003 – IEEE 1613 was published to assist new vendors enter the substation market well prepared and provide existing vendors with standardized tests

2006 – IEEE 1613 Corrigendum 1 edited 1 sentence

2008 – IEEE 1613a Amendment 1 added derating for altitude

2009 – IEEE 1613 revised to add communications profiles

2011 – IEEE 1613a Amendment 1 clarified DC control input isolation requirements

2012-2013 – Creation of 1613.1 underway

- Revise RFI requirements
- Add conducted and magnetic field tests
- Conform to IEEE guidelines



# IEEE 1613 Contents

- **Service conditions**
  - Temperature & Humidity
- **Electrical Ratings**
  - DC power & Control input ranges
  - Allowable AC in DC voltages
- **Dielectric Tests**
  - Power Frequency
  - Impulse
- **SWC Tests**
  - Oscillatory
  - Fast Transient
- **RFI Susceptibility Tests**
  - 80 MHz – 1 GHz @ 35 V/M
- **ESD Withstand Tests**
  - 8 / 15 KV Contact / Air discharge
- **Vibration & Shock Tests**
  - 1G vibration & free fall

# IEEE 1613 Shortcomings

- RFI Withstand test
  - Test is non-standard
  - Frequency band only up to 1 GHz
  - Hand held radios can exceed standard levels
- Vibration
  - Not definitive
  - No clear shock test
  - No seismic tests

# 1613 / C37.90.2 RFI issues (1)

## Lab Test issues

Labs are set up for popular standards (Mainly IEC and GR 1089)

Standard	Max level	Keying test	Modulation	Spot Frequency test	Frequency Range
IEEE C37.90.2 (1613)	20 V/M	Yes	AM 80%	Yes (5)	80 MHz – 1 GHz
IEC 61000-4-3	10 V/M	No	AM 80%	No	80-1000 MHz 1.4 - 6 GHz
Bellcore GR 1089 (issue 4)	8.5 V/M	No	AM 80% Pulse > 1GHz	Yes (18)	10 KHz – 10 GHz

# 1613 / C37.90.2 RFI issues (2)

## 3G & 4G Cell phones

Modern phones use frequencies above the maximum frequencies required by IEEE (1 GHz)

Smart phones transmit autonomously (when in a technician's pocket) so normal practices do not prevent exposure.

Carrier	System	Frequency Range
Verizon	EVDO (3G)	800, 1900 MHz
Verizon	LTE (4G)	750 MHz
AT&T	GSM (3G)	850, 1900 MHz
AT&T	GSM (4G)	750 MHz
Sprint	EVDO (3G)	1900, 2100 MHz
Sprint	WiMax (4G)	2500 MHz
All	Bluetooth	2400 MHz

# 1613 / C37.90.2 RFI issues (3)

## Handheld radio fields

A recent test of a popular hand held 3 watt 800 MHz radio showed levels far in excess of IEEE and IEC standards.

Power	Distance	Predicted by C37.90.2	Predicted by lab measurements	Theoretical maximum
5W	15 cm	35 V/M	40-90 V/M	104 V/M
5W	22 cm	20 V/M	20-40 V/M	71 V/M
3W	25 cm	17 V/M	20-45 V/M	48 V/M
3W	50 cm	8.5 V/M	12-21 V/M	21 V/M

Theoretical maximum  $\approx 7 \cdot ((TX \text{ power})^{-2})/d$   
- for a dipole antenna



# 1613 Shock / Vibration issues

**IEEE 1613 vibration and shock requirements are not as comprehensive as IEC.**

Test Type	IEC Series	IEEE 1613
Vibration Response (operating)	(10-150 Hz, 0.5G) 60255-21-1 (2-500Hz, 2G) 61850-3	(1-150 Hz, 3G)
Vibration Endurance (non-operating)	(10-150 Hz, 1G) 60255-21-1	No requirement
Shock Response (operating)	(11 ms, 5G) 60255-21-2	No requirement
Shock Endurance (non-operating)	(11 ms, 15G) 60255-21-2	Drop test
Bump (non-operating)	(16 ms, 10G) 60255-21-2	No requirement
Seismic (operating)	(2-35 Hz, 1G) 60255-21-3	No requirement

# IEEE 1613.1 Planned Improvements

Currently being revised by PSRC (expected completion in about 12 months)

- Scope broadened to include additional locations (smart meters & distributed automation)
- Adds requirements for RF devices and broadband Power Line Carrier
- Adds 5 IEC immunity tests with no IEEE equivalents
- RF withstand range extended to 6 GHz
- Removes EFT transverse test

# Conclusions

- CE compliance legally required for products destined for EU.
- IEC standards universally accepted outside US.
- North American users require C37.90 standards for protective relaying equipment.
- IEEE 1613 can be used for most other equipment and provides pretty good coverage.
  - RFI testing range is not adequate and needs additional testing
  - Vibration & shock specifications not adequate
  - No seismic requirements
  - The next revision of 1613 will be exhaustive!!!

# Questions?



# Thank You

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