EMC Considerations in the Smart Grid

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Abstract

EMC is an important factor for consideration in standards relating to the Smart Grid, including the work on IEEE P2030 . For the Smart Grid to function properly and coexist with other electrical and electronic systems, it must be designed with due consideration for electromagnetic emissions from the grid and for immunity to various electromagnetic phenomena near or from the grid. <u>EMC must be addressed</u> effectively if the Smart Grid is to achieve its potential and provide its benefits when deployed.

Haddam Neck, CT 1997
Halon gas release caused by a camera flash

Interoperability means Compatibility

- **The situation:**
  - IEEE – EMC Society believes that for the Smart Grid to achieve its potential it must be reliable, secure and fault-tolerant.
  - If the Smart Grid is less reliable, less secure or less resistant to faults than the existing grid, is it ready for deployment?
  - Electromagnetic Compatibility (EMC) is the ability of equipment to withstand its EM environment while not causing disturbances.
  - These EM disturbances from or to the power grid have caused degradation, outages, shutdowns and system failures.
  - EMC is required for grid components / controls to operate or interoperate reliably.

Southern Illinois 9/25/01
Relaying shutdown caused by a radio

Broad Categories of EMC events:

- **Common events (ESD, fast transients, powerline disturbances)**
- **RF Interference from various emitters/transmitters**
- **Coexistence of various wireless devices**
- **High-level EM disturbances**
  - Naturally-occurring lightning surges or geomagnetic storms
  - Intentional EMI (terrorist acts) or High-altitude Electromagnetic Pulse (HEMP)

Smart Grid should be immune to these events, or if that immunity fails, fault-tolerant so failures don't lead to system disruption. Signals should not interfere with others. (control of emissions)

Indian Point, New York 3/23/08
Cooling shutdown caused by a camera

Commonly occurring EMC events

- **Unintended emissions can cause harmful interference**
- **Limits on emissions are critical for interoperability**
- **Emissions limits & methods exist and should be used**
- **Immunity to EM phenomena must be demonstrated**
- **Variety of environments:**
  - Information Technology Equipment to IEC/CISPR 24
  - Substation equipment to IEC 60255-26, 61000-6-5, IEEE 1613
  - Wireless devices to various IEEE / IEC Standards
- **Inadequate immunity to interference causes failures**

Commonly occurring EMC events

- **EM phenomena that can cause upset:**
  - Electrostatic discharge (from humans or furniture)
  - Electrical Fast Transients (from switching operations)
  - Lightning strike (surge, both unipolar and oscillatory)
  - Radiated RF energy
  - Conducted RF energy
  - Power-frequency magnetic fields
  - Dips & Interruptions
- **Robustness must be demonstrated like never before**
- **Field failures indicate need for immunity test criteria**

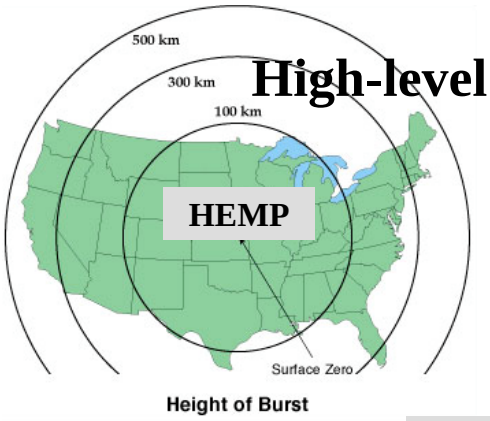
Interference from Wireless Transmitters

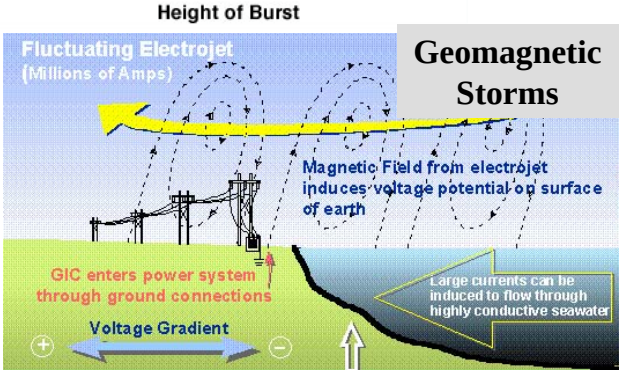
- Wireless transmitters induce RF currents
- May be fixed in frequency, power & location
- May be mobile in all three relative to the grid
- Power levels range from 5W to 1500W
- Various modulation schemes used
- Environment simulated by testing variables:
  - Frequency range
  - Power levels
  - Modulation
  - Criteria for Acceptance

Coexistence with Wireless Devices

- Co-related issue arising from use of wireless devices
- Wireless devices can cause and receive interference
- Coexistence with other devices & incumbents needed
- Interoperability won't happen unless this is addressed
- EMC planning, analysis & research prevents failures

High-level EM Disturbances





EMC Concerns

- **The EM phenomena we've discussed causes problems:**
  - Momentary, self-correcting malfunctions
  - Localized network failure
  - Large-scale interruptions
- **Naturally generated, grid-caused & man-made**
- **Unintentionally or intentionally generated interference**
- **Results are the same:**
  - Grid doesn't function as intended
  - Grid can't interoperate if it can't stay operating
- **EMC Standards need to be referenced in P2030**

Summary

- **We have modeling, simulation and testing technologies**
- **Costs increase and reliability suffers without EMC**
- **Power, IT and COM for Smart Grid is multidisciplinary**
  - Synergy of expertise must be applied
  - EMC designed in early to reduce costs, increase effectiveness
  - EMC discipline includes Dynamic & Adaptive Spectrum Mgmt.
- **IEEE – EMC Society is the leading source of expertise**
- **Design & validation testing minimize EMC problems**
- **Smart Grid devices need "hardening" to interference**
- **Please contact Andy Drozd: adrozd@androcs.com**

References

EMC Standards:

•ANSI C63.4 (Emission Measurements)
•IEEE C37.90.1 (Relay and electric power apparatus surge withstand capability)
•IEEE C37.90.2 (Relay system withstand capability to radiated EM interference from transceivers)
•IEEE C37.90.3 (ESD measurements of protective relays)
•IEEE 1613 (Requirements for Communications Networking Devices Installed in Electric Power Substations)
•IEEE 473 (EM site survey)
•IEEE 139 (In-situ measurement of Industrial, Scientific and Medical equipment)
•IEEE 1560 (RFI filter capability measurement)
•IEEE 1597.2 (EM computer modeling applications)
•IEC/CISPR 22 (ITE emissions) and CISPR 24 (ITE immunity)
•IEC 61326-x series (Electrical Equipment for Measurement, Control and Laboratory use—EMC)
•IEC 60255-25 (Relay and protection equipment measurements—EMC Emissions)
•IEC 60255-26 (Relays and protection equipment measurements—EMC Immunity)
•IEC 61000-6-5 (Immunity for power station and substation environments—EMC)
•IEC 61000-4-2 (ESD measurements)
•IEC 61000-4-3 (Radiated immunity measurements)
•IEC 61000-4-4 (Fast transient/bursts measurements)
•IEC 61000-4-5 (Surge measurements)
•IEC 61000-4-6 (Conducted immunity measurements)
•IEC 61000-4-8 (Magnetic field immunity measurements)
•IEC 61000-4-11 (Voltage dips/variation immunity measurements)
•IEC 60439-1 (Cable distribution cabinets for power distribution networks)
•IEC 60870-2-1(Telecontrol equipment power supply and EMC)

References

HEMP Standards:

- IEC 61000-1-3 (Effects of High-Altitude EMP (HEMP) on Civil Equipment and Systems-EMC)
- IEC 61000-2-9 (Description of HEMP Environment - Radiated Disturbance, Basic EMC Publication)
- IEC 61000-2-10 (Description of HEMP Environment - Conducted Disturbance – Basic EMC Publication)
- IEC 61000-2-11 (Classification of HEMP Environments - EMC)
- IEC 61000-4-25 (HEMP Immunity Test Methods for Equipment and Systems - EMC)
- IEC 61000-4-32 (HEMP Simulator Compendium - EMC)
- IEC 61000-4-35 (HPEM Simulator Compendium - EMC)
- IEC 61000-5-6 (Mitigation of External EM Influences - EMC)
- IEC 61000-5-8 (HEMP Protection Methods for the Distributed Infrastructure - EMC)
- IEC 61000-6-6 (HEMP Immunity for Indoor Equipment – EMC Generic Standards)

IEMI Standards:

- IEC 61000-1-5 (High Power Electromagnetic (HPEM) Effects on Civil Systems - EMC)
- IEC 61000-2-13 (High-Power Electromagnetic (HPEM) Environments - Radiated and Conducted EMC)
- IEC 61000-4-33 (Measurement Methods for High-Power Transient Parameters – T&M Techniques)
- IEC 61000-4-35 (HPEM Simulator Compendium - EMC)