Grounding and Bonding in Communications Systems

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This talk concentrates on:

Interconnection of equipment and connection to earth
April 15 is coming

• The only difference between a tax man and a taxidermist is that the taxidermist leaves the skin.

-- Mark Twain
Grounding and Bonding

Grounding and bonding are fundamental components of power quality and reliability, and should be robust before you do anything else.
Grounding

Grounding is the intentional connection of the electrical system to the “earth” or a body that serves in place of the earth.
Bonding

Bonding is the intentional interconnection of normally non-current-carrying parts of electrical equipment to prevent shock and voltage differences in the event of a fault.

The terms “grounding” and “bonding” are sometimes used incorrectly and often interchanged.
Orange County, FL 9-1-1 system

Retrofit of existing sites
Orange County, FL 9-1-1

11 transmitter sites
Orange County, FL 9-1-1

Headquarters
Apopka, FL

- Source: Power & System Innovations, Inc., Orlando
Orange County 9-1-1 - Apopka

280 foot tower
3 sets of 5 guys
Orange County 9-1-1 - Apopka

$100 K/yr. damage at Apopka alone
Orange County 9-1-1 System

$1-2 million equipment losses system-wide /year
Step 1

Staff was not expert in power quality, called in knowledgeable professional
3 Independent grounds

un-maintained

guys

60 Ω

tower

cox

firewall

threaded rod

elec svc gnd
No connection
Refitted site

Everything bonded together
Throughout The System

Ungrounded equipment cabinets
Facility ground at Apopka

Main electrode was all-thread rod
Old Apopka ground rod

Measured 550 ohms
Apopka Tower Grounding

Retrofits:
Deep (60 ft) electrode supplements tower
Proper coax shield grounds:
New bus on tower

For coax grounds then 4/0 to electrode
Coax Shields

Coax shield bonded to bus, to electrode system
Outside Firewall

Only ONE Cu strip connected to electrode
Outside Firewall

Strip bonded together and to ring with 4/0
At all Equipment Cabinets

Bond equipment properly
Separate Bonding

All equipment bonds brought to buses
Buses tied to halo rings
Reedy Creek

Remote repeater near Disney World
Reedy Creek

More real estate to work with
Reedy Creek Layout

double rings plus deep electrodes
Deep ground rods

Each rod was driven deep enough to achieve < 5 ohms independently.
Note wide turns

Lightning doesn’t like right angles
Equipment incorrectly bonded

Replacing connections like this
Equipment connections

Note lock washer, double nuts
SPD’s (TVSS)

SPD’s on main service entrance
Experience

• Thousands of events recorded
• One strike witnessed

• NO Downtime! No equipment damage.
Major lessons from OC 9-1-1

3 different contractors
- electrical
- radio room
- tower

No one party had
- responsibility
Major lessons from OC 911

Low bid
No maintenance
Minimal design
Power Quality is Cost-effective

OC 911:
<$100,000 cured $1 million damages

6-mos. to 1 year paybacks common
Case Study: Winter Park, FL Comm. Ctr.

- 4/0 AWG ring ground completely surrounds building

Source: Power & System Innovations, Inc.
Tower alongside building

- Tower now has four 50 ft. vertical electrodes in
- X-pattern, connected to ring ground
Was Ufer ground even connected?

- Original phone #2 AWG
tower Ufer grounding
Cellular side of site

- Original coax ground on
- Horizontal run
- #2 Cu. conductor
Coax bonding

- Coax braid has 29X
- Lightning cable clamped,
- re-wrapped

- Note location on vertical run
Straight vertical runs

- 29X lightning cable then
- connects to 4/0 vertical
- to 5- 50 ft. electrodes
- under tower
Outside firewall

- Outside copper firewall
- 4/0 vertical to
- ring ground
Inside firewall

- Inside copper firewall
- 4/0 connects to “halo” and grounding electrode system

- Note large radii
Rack bonding

- Every steel joint jumpered with #2 copper
Busbars for connections

- Every joint, tray and cabinet bonded and jumped with #2 to plate, then 4/0 connects to “halo”
SPD at electric service

- TVSS at the service and all branch panels
- All cabinets bonded with copper jumpers then to ring ground with 4/0 copper
Everything bonded

- Even the downspout is bonded to the ring ground
Resultant layout

- 4/0 ring
- 20 ft rod every 20 ft.
- 5- 50 rods under tower
Sumter County, FL 9-1-1

2004 lightning strike took out entire facility
Tower had separate grounding

121 foot tower erected in 2007
Separate ground independent from building
230 Ohms to ground

Building had single galvanized rod
Independent grounds

2 emergency generators each had independent ground
Hose clamp connection
Steel was not grounded

2 transformers were grounded to building steel, but steel was not bonded to ground electrode
Sumter County 911
Sumter County 911

Complete renovation of bonding and grounding
- Removed daisy-chained grounds
- Ground system supplemented and tied together
- Building steel bonded to electrode

No outages since retrofit
KKIT - FM

Angel Fire, NM
Actual tower grounding

Proper connection methods?
Actual connection to ground rod

Proper connection methods?
Actual water pipe bonding

Corrosion and connection errors.
Think of “current divider”

Energy

High R

Low R
KPTH - KMEG

1988 ft. tower
Near S. Sioux City, NE
Ufer ground after lightning
At tower base

2- 8 ft. ground rods
190 Ω
Ice bridge

#2 AWG connected to same rods
Guy wires

Note double U-bolts
Connectors not listed
90° angles
Vibration
Guy grounding

Note right angles
Guy grounding

New “listed” tin-plated silicon-bronze connectors
Parallel to guy wires
Guy grounding

3-80 ft. deep SS rods
250 kcmil to ring
Ice bridge

Note rust
Strap has lower impedance
Result

NOTES:
1. GROUND RODS DRIVEN TO REJECTION
2. NOT TO SCALE
3. ELEVATION OF GUY ANCHORS VARIES
One ground system

Network of air terminals

Layout per Code NFPA-780

Copper Down Conductors

Ring Ground

Telecom

Panelboard

TVSS
Recommended Practice

Correct corrosion issues
Recommended Practice

*Use bolt-in CB’s, not snap-in*
Inadequate Tower Grounding

Is Ufer EGC actually bonded to rebar?
Ground wire outside conduit

Proper wiring methods?
Separate Neutral and Ground

Improper N-G bonds
Are connections proper?

Look for paint or other insulation
After commissioning

Check resistance to earth annually

Under 5 ohms is desirable
Do not “daisy-chain” equipment

“Radial” bonding to a ground bus avoids ground loops
Interior Grounding

There should be ONE central point connecting the neutral to the ONE exterior grounding electrode system.
Earth is not a current path

No separate grounds – one grounding system
Examples of “clean” grounds

Be wary of the term
“clean ground”
Resultant layout

- 4/0 ring
- 20 ft. rod
  every 20 ft.
- 5-50 rods under tower
Desired grounding

**Figure 6-1** Typical Type B External Grounding Electrode System
All equipment needs SPD’s at service, at panelboards
leads as short as possible
Takeaways

1. Exceed the Code, but don’t violate the Code! (Code minimum is one step above “illegal”)

2. You don’t get what you expect, you only get what you inspect.

3. Have a written plan and procedures. Insist contractors follow it.

3. Get the grounding and bonding right before anything else. Most lightning and transient problems can be cured at minimal cost.
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