VLA Electronics Memo No. 243

Lightning Protection, VLA Control Building

Bob Broilo and Clint Janes

July 18, 2002

Introduction

Lightning can and has caused extensive damage to electronic equipment in the VLA CB (Control Building.) This document describes the LPS (Lightning Protection System) at the CB and action required to maintain its integrity.

Description

An aerial cable over the top of the building connects to lightning rods, ground cable along the parapets, and down conductors on major corners of the building. Down conductors connect to 8' ground rods and radials in an attempt to provide an alternate path for direct lightning strikes. Bonding all the ground conductors reduces potential gradients across the building.

All conductive cables leading into the building have ground shields bonded to building ground at the building entrance. In addition, many signal conductors are protected by gas tube suppressors at or near the building entrance.

Implementation

Installers and maintenance personnel are required to bond cable shields and armor to building ground on new and repaired conductors that lead into the building. The bonding shall be performed to provide a conductive, gas tight connection.

In addition, each conductive signal wire for new installations leading into the building must be connected to a gas tube suppressor at or near the building entrance. The ground side of the gas tube must be bonded to building ground through a ground braid of at least 1" in lateral dimension that is as short as possible. Connections must be soldered or connected with a gas-tight connection such as a punch block, solder, or cad-weld. The gas tubes shall have a firing threshold of 90 v. A small resistance of ~10 ohms and or inductor of ~10 microhenries should be installed in series with the signal lines before the suppressor for current limiting.

All conductive conduits, plumbing, or other piping must be bonded to building ground at the building entrance. Existing installations, such as the wyecom and wyemon, will not be required to have the gas tube protection on the signal conductors. The bond to ground on the cable ground shield should be sufficient to protect adjacent equipment from damage, and the wyemon and wyecom equipment has proven sufficiently robust not to require additional protection.

It is recommended that additional transient protection, such as a silicon avalanche diode (General Semiconductor Transzorb), be installed on each metallic signal conductor at the circuit board.

The diode is connected between signal and ground. Its conducting threshold is to be selected based on the susceptibility of the circuit it is protecting. Doing so will suppress smaller transients that are insufficient to jump through cable insulation but can be large enough to overcome circuit susceptibilities. Tranzorbs can be important for the application, but are not necessary to protect adjacent equipment.

The AC power system shall be protected following commonly accepted practice.

Verification

A representative of the ES Division will periodically inspect the LPS for compliance, perform any needed maintenance, and report installations that violate the LPS requirements. The inspection will be conducted annually before the onset of the lightning season which begins typically around 1 July. The ES Division will establish a procedure, checklist, and log for the inspections.

References:

1. "Site LPS Modifications" by Guy Stanzione, October 16, 1997.

2. "Implementation Meeting #2" by William Brundage and Richard Perley, February 2, 1989.

3. "Implementation Meeting #2, VLA Lightning Protection" by William Brundage and Richard Perley, January 26, 1989.

4. "Assessment and recommendations concerning VLA site lightning/grounding protection" by Rick Perley and Ken Bartos, August 12, 1988.

Subject: Site LPS Modifications
Date: Thu, 16 Oct 1997 13:42:20 -0600
From: Guy Stanzione <gstanzio@nrao.edu>
To: lserna@nrao.edu, bbroilo@nrao.edu, lserna@nrao.edu
CC: cjanes@nrao.edu

Here's a condensed listing of items that need to be addressed; from Bill Brundage and Clint Janes recommendations.
This could grow or shrink??

We should meet sometime this month, for a preliminary review.
Thanks,
Guy

1. At the CB we have a canopy installed as a result of recommendations by Charley Moore and Bill Rison of Tech. Here are followup notes:
a) Rison says he can reconstruct report from his notes.
b) At least part of the masts for the canopy should be dielectric according to Rison; we should verify the design complies with the recommendations.
c) The downconductors should be connected to radials or perhaps even a mesh in addition to a ground rod according to Rison. The important point is surface area, not rod-to-ground resistance. 25884
d) Both Moore and Rison state lightning rods should be rounded, not pointed, for best results. 25885 cale - ~~USA~~ RFI
e) The lightning ground and the building ground should be connected according to Rison, the IEEE Emerald Book, IEC 1024-1, FAA-STD-109b, MIL-HDBK-419A, NEC-70-1966, and NFPA-780. 25886
f) We need maintenance procedures that require an annual inspection of the CB LPS.
g) Does CB have counterpoise?
h) Is the existing ground system on the top of the bldg. Functional? 25887
2. Items 1.c. - 1.f. should be implemented on all site buildings. Gnd Loops

? 3. a) Any copper lines eminating from the CB, and other buildings for that matter, must be protected at both ends.
? b) Ground leads to protective equipment must be very short for low inductance and connected to earth ground, such as 8' ground rod, radials and/or mesh counterpoise, water pipe, or heavy ground braid and bus bars leading to building ground in the case of equipment racks. A small resistance ~10 ohms and/or inductor of ~10 uH should be installed in series with the signal lines before the diode for current limiting.
? c) Where the signal lines are in metal conduit, the conduit should be bonded to the building ground. d) This action must be taken for all signal, telephone, fire alarm, antenna leads leaving the building.
e) In addition, we must have a documented maintenance procedure to make sure that all this protection is checked periodically, say, annually;
f) and policies that require that new wiring be protected.
g) There may be plumbing between the chiller tower and the CB that needs bonding as well as signal lines that need protection

4. a) Are we using UPSs for lightning protection?
b) If so, are they equipped to do this?
c) If not, should we add surge protection to the input and output of the UPSs and again at the load where the load is removed from the UPS by many feet, say, over 20'?

5. a) Metal-roofed buildings do not need lightning rods, but the roof MUST be grounded by down conductors and radials. 25888
b) We need to check the VSQ and metal buildings to make sure they are

~~[illegible] rods on~~

adequately grounded for lightning.
c) How about the gazebos for visitors, are they adequately protected? Add Inventory?
d) Need to verify that Tech Services bldgs have counterpoises? 25890

6. Personnel safety:
a) Do we have an adequate procedure in the Safety Manual? For example, we should have no crane operations when lightning present, even in the AAB. Also, cranes left outside must be lowered or retracted during storms or grounded so that flashovers to adjacent structures.
b) Do we need signs warning the public of lightning danger (Rich Kithill of the National Lightning Safety Institute (NLSI) says we do)?
c) Should we send our safety/facility people to an NLSI workshop?
d) Do we need lightning detection to provide early warning to visitors and employees of an approaching storm and dangerous electrical fields (NLSI says we should)?
e) Do we need a documented safety orientation for our official site visitors (observers)?

7. Surge protection devices, i.e., plug strips, should be UL1449.
a) Plug strips should be used at sensitive locations like PCs and workstations. Protected plugstrips are an important part of the LPS, but many labels are non-effective.

8. Though the zinc ribbon installed along the waveguide as a passive cathodic protection system was rendered unnecessary for corrosion protection by the impressed current system, it did serve as a lightning protection system.
a) However, we should determine if the ribbon should be replaced with a copper wire for security against lightning-induced currents in the waveguide which could cause heat damage, ref MIL-A-9094D (ASG) and Bechtol Job No. 10709.

9. The LPS at VLBA sites was improved (Serna, 1989, Brundage, 1990, and others).
a) Those improvements should be adapted and installed at the VLA; e.g., surge protection devices should be installed at VLA antennas for AC power.
b) Wyecom wiring should be protected per para 3 above.
c) Antenna grounds should include radials and/or mesh.
d) As well, recent lightning damage at VLBA LA and perhaps other VLBA sites indicates the need to improve the LPS at certain VLBA sites.

To

DRAFT 8/12

From: Rick Perley, VLA; Ken Bartos, JPL

Subject: Assessment and recommendations concerning VLA site lightning/grounding protection

Review team: Charlie Moore, Langmuir Lab for Atmospheric Research

Dr. Bill Rison, Langmuir Lab for Atmospheric Research

Jim Stahmann, KSC Lightning Safety Committee

Rick Perley, Deputy Site Director, VLA

Ken Bartos, JPL

The review team met at the VLA site on 9 August 1988 to assess the adequacy of the lightning protection at the VLA. A site survey was conducted, lightning protection principles were discussed with VLA engineering staff, and recommendations were made to increase the level of protection.

FINDINGS

The VLA has lightning protection on all the buildings, either with air terminals on the roofs or by grounding metal buildings. Some line surge suppressors and lightning arrestors are installed. The team observed that over the years the protection has been violated by placing communication devices and their support structures outside (above) the protective envelope afforded by the lightning protection devices. Some line suppressors were found to be ineffective since the suppressors were not grounded per design.

The shielded computer and control rooms inside the Control Building are indeed providing protection. Signal cables enter the shielded rooms via suppression bulkheads. The power and telephone cables entering the shielded rooms need to be inspected in detail to validate suppressors exist.

The satellite communication installation is not adequately protected. The overhead power and control cables are exposed and not protected. The control cable entering the satellite transmitter hut in shielded but the shield is not grounded. The control wires themselves do not have line suppressors.

Interconnection of the on-site power generator control ground and the power neutral at multiple locations could lead to differential ground potentials during a lightning stroke.

PRINCIPLES THAT APPLY

The principles that assure lightning protection are few and simple, but they must be applied without exception. A listing is attached of several codes and papers that provide detail guidance to the implementor.

DRAFT 2/12

1. Provide an envelope of protection well above the tallest part of the structure by installing lightning arrestors and proper grounding.

2. Control every cable penetration of the envelope with filtration and suppression.

RECOMMENDATIONS

1. Install an additional lightning air terminal system above the Control Building. The team should review and approve the detail design.

2. Install line suppressors and/or filters on all power, control and data lines as they enter the building. Special consideration should be given to the cables entering from the roof.

3. Check the integrity of the telephone company suppressors.

4. Install an additional lightning air terminal system above the cables that service the satellite communication facility. The team should review and approve the detail design.

5. Install a lightning air terminal system above the satellite communication antenna behind the RF pattern. The team should review and approve the detail design.

6. Install line suppressors and/or filters on all power, control and data lines as they enter the satellite communication transmitter hut.

7. Conduct a detail engineering analysis of the site power neutral and site power distribution equipment grounding. The analysis should be the subject of a separate review by the team.

8. Disconnect the inter-building cables when the SLOB is mothballed.

9. Consider installing a cloud charge sensor to indicate to JPL operations the onset of atmospheric conditions with high potential for lightning occurring at the VLA site.

REFERENCES

a. Uman, Martin, "Lightning",

b. Uman, Martin, "Understanding Lightning"

c. NFPA 78, 1987 Edition, "Lightning Protection Code"

d. Kennedy Space Center Design Standard for Lighting Protection for Facilities, KSC-STD-E-0013 Rev B (Jim is sending copy)

e. Kennedy Space Center Design Standard for Grounding and Bonding, KSC-STD-E-0012 Rev A (Jim is sending copy)

f. Moore, Charlie, "his paper" ← Bartos needs copy

g. Stahmann, J.R., "Inside the cone of Protection"

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FOR REVIEW + COMMENT:
R. PERLEY
W. DELGIUDICE
C. MOORE

January 26, 1989

DRAFT

Donald W. Brown
MS 303-403
JPL/CalTech
4800 Oak Grove Drive
Pasadena, CA 91109

SUBJECT: Implementation Meeting #2, VLA Lightning Protection

Dear Don:

R. Perley, W. Brundage, W. delGuidice, and G. Stanzione of VLA and C. Moore and W. Risson of NMIT Langmuir Lab met January 24, 1989, to review in detail the implementation plans for VLA lightning protection. We reviewed the three areas of VLA responsibility:

1. Protection over the control building.
2. Protection on all cables entering the control building.
3. Power distribution grounds.

Area 1: Protection Over the Control Building

We reviewed the detailed drawings for the overhead ground wire (OHGW) air terminal. The significant points are:

a. For protection from ultraviolet deterioration, we will paint the fiberglass insulators.

b. We will terminate the downwire near the control building power transformer in several radial current dispersing conductors which terminate in ground rods distant (greater than 10 feet) from the building and buried cables. The conductors may be on or just below the ground surface.

c. The only connection between the present lightning air terminal system and the new OHGW system will be at or below ground level.

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UNDER CONTRACT WITH THE NATIONAL SCIENCE FOUNDATION

d. We will remove the present air terminals (rods) after the OHGW system is in place.

e. We will disconnect the present roof lightning wires from all objects on the building roof.

f. The measured ground rod to ground resistance will be less than 10 ohms. Charlie Holmes of Socorro could be a consultant on measurement techniques.

Area 2: Protection on all Cables Entering the Control Building

a. Surge protection and optical isolation on cables to Tech-services and Cafeteria buildings will be investigated and added where needed.

b. Surge protection on telephone lines will be investigated and repaired/added where needed.

c. After the CODEX is moved from the SLOB to the Control Building, the only remaining cable will carry the fire alarm circuits. Surge protection will be added.

d. Roof mounted antennas and coax will be located well below the OHGW, so no additional protection will be added.

Area 3: Power Distribution Ground

a. VLA power distribution is buried below ground and grounding conforms to the National Electrical Code. Therefore no changes will be made.

b. The steel generator building is an effective Faraday shield as it is adequately grounded to a buried counterpoise.

c. We will add surge protectors to all generator control wiring.

entering the building. We will determine the protector requirements in consultation with J. Dorman when we complete the generator electrical drawings next week.

d. To minimize voltage transients between the generator control ground and the switch gear ground, we will not remove the ground strap between the primary and secondary grounds of the generator transformer.

Implementation Schedule

Jan 23 - Jan 31	Order materials and tools for OHGW.
Feb 01 - Mar 31	Install OHGW system.
Mar 01 - Mar 31	Test ground resistances.
Jan 30 - Feb 15	Investigate and plan surge protection for fire alarm, comm, telephone, and generator control cables.
Feb 15 - Feb 20	Order all surge protectors.
Mar 01 - Mar 31	Install all surge protectors.

Sincerely yours,

William Brundage
VLA-Voyager Implementation Manager

Richard Perley
Deputy Director, NM Operations

WB:RP/el

cc: M. Goss
W. delGuidice
G. Stanzione
J. Campbell
G. Hunt
C. Moore (NMIT)
W. Risson (NMIT)

NATIONAL RADIO ASTRONOMY OBSERVATORY

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February 2, 1989

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MS 303-403
JPL/CalTech
4800 Oak Grove Drive
Pasadena, CA 91109

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f. We will disconnect the present roof lightning wires from all objects on the building roof.

Area 2: Protection on all Cables Entering the Control Building

a. Surge protection and possibly optical isolation on cables to Tech-services and Cafeteria buildings will be investigated and added where needed.

b. Surge protection on telephone lines will be investigated and repaired/added where needed.

c. After the CODEX is moved from the SLOB to the Control Building, the only remaining cable will carry the fire alarm circuits. Surge protection will be added.

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