VLBA Antenna Memo #43

Lightning Protection at VLBA Pie Town

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Introduction

This report describes the current LPS (Lightning Protection System) at VLBAPT and recommends corrective action. Lightning has caused damage at Pie Town repeatedly since the facility was built. Various improvements have been made to the facility LPS over the years, some of the improvements at the advice of Dr. Charles Moore, a NM Tech Professor Emeritus and recognized lightning researcher. This report is written in response to a lightning-induced failure in July 2002 and to Charlie's advice to keep making improvements whenever such failures occur.

The Most Recent Failure

The VME-based station computer failed after a lightning storm around July 21. One and one-half days of observing time were lost while various boards in the computer were replaced. The computer is in room 103 of the station building. The only other reported failure from that incident was a switch on the helium compressor; that failure is considered coincidental and not necessarily the result of lightning damage. There was not apparent burning; just failed digital circuits in the VME computer.

Description of existing LPS

1. The main transformer has arc-over type lightning arrestors on the primary bushings. All grounds in the transformer cabinet are bonded to each other. Two 208/120 3 phase secondary cables lead through separate conduits to MDP (Main Distribution Panel) in the Station Building. One of the cables includes a ground wire which is connected to ground at the transformer cabinet.

2. Architectural drawing F51031E001 shows ground rods and a counterpoise for the antenna. The grounding rods are not visible but there are ground cables leading to where they should be and the connections which are visible appear solid. Radials for the rods are not shown on the drawing. A lightning rod is located at the apex and a combination of down conductors and steel structure connect the rod to ground.

A ground bus at the base of the pintle bearing housing connects to the:

a) counterpoise in the foundation concrete,
b) structural steel on the fixed side of the pintle bearing,
c) structural steel on the rotating side of the pintle bearing via the wrap up,
d) electrical box in the base,
e) steel structure at the top of the bearing housing via the wrapup (two cables, 1 ~250 MCM, and 1 ~1/0).

A copper ground bus added to the cable way in the pedestal room is grounded to structural steel. Equipment in the pedestal room is grounded to the bus.

Surgeonics Limited Trans-lock Model 704-3 Surge Suppressors protect AC power in the pedestal room. The suppressors are labelled "suppression to 325/575 V peak" and the address of the maker is shown as 50 Pine Street, Hudsoan Falls, NY 12839. A 5 KVA UPS provides power to the electronic equipment in the pedestal and vertex rooms.

3. A single lightning rod is located on the station building which is connected to a ground rod. Neither are shown on the drawings nor is there evidence of radials on the ground rod.

Translock surge suppressors are mounted on the MDP. A 10 KVA UPS provides power to electronic equipment and PCs in the Control Building and to the weather station (outside).

Cables to the antenna terminate in an aluminum box under the floor in room 104. The flooring has been cut away so that the box rests on the metal screen that surrounds room 104. The box is bonded to the building ground, floor stanchions, other connector panels, and equipment via various ground cables.

Polyphasor transient suppressors protect the IF (RF) lines while silicon avalanche diodes protect some of the digital signal lines. Digital lines include the MCB, RS232, and status lines to the Utility Module.

4. The copper phone lines from WNM terminate on a punch block in room 101 of the Control Building. Button-type suppressors, thought to be gas tubes, protect each line. There is no apparent connection of the suppressors to ground; if that is the case, the suppressors perform no function. The fiber optic cable terminates in the same box. The armor on the cable is connected to building ground via a ground braid.

Some of the phone lines (thought to lead to the antenna) are re-terminated in room 103 with more suppressors. In this case, the suppressors are connected to "green wire" ground via a short #12 wire.

5. The external GPS experiment connects to equipment in the building through a metal bulkhead nicknamed a "dollar." The dollar is bonded to the architectural screen. The Web cam camera and the UNAVCO "Turbo rogue" also connect through the building wall, but in these cases, there are no bulkheads, no connection to ground, and no transient protection. Neither are the penetrating holes adequately sealed against the weather.

Corrective Action

The VME failure was probably caused by impedance in the ground plane causing potential differences to develop. Much of the corrective action recommended is aimed at reducing the impedance of the ground system.

Immediate corrective action was to connect the cable bulkhead panel under the floor in room 104 to ground, and to tighten a loose ground on the VME computer rack connector bulkhead box. Here are recommendations for others:

1. Find all ground rods and add 6' radials as was done at the VLA Control Building a few years ago. Doing so helps dissipate the currents introduced by a direct lightning hit by lowering the impedance of the grounding system.

2. Round the tip of all lightning rods to include the one on the antenna. Doing so greatly improves the likelihood of lightning hitting the rod instead of the structure, according to published literature. If lightning hits the rod instead of the structure, the lightning current is more likely to be dissipated in a controlled manner.

3. Install a lightning rod at the other end of the the Control Building and connect the two together with a conductive cable along the roof line. Bond the panels of the metal roof electrically and to the lightning rod system. A separate down conductor and ground rod must be installed for the new lightning rod. Any metal objects on the roof must be bonded to roof ground.

4. Find and put into place a test procedure for the Trans-lock suppressors. If none can be found, then these units should be replaced with equipment that can be tested and its operation verified.

5. Bond the VME computer rack to a conductive part of the floor or to the building ground cabling under the floor. All other equipment not already connected should be similarly bonded to ground. The connection should be made with 1" or larger flat copper braid fastened at both ends with a flat washer to a clean, paint-free surface to achieve maximum conductivity. All braid connections should be as short as possible.

6. Cable ground shields must be bonded to ground at both ends. Where one end of a shield is lifted to prevent a ground loop, replace the cable with one having a double shield and terminate both ends of the outer shield.

Add transient protection, where missing, to all signal lines between antenna and control building. Protection should be at both ends. The ground on all suppressors should connect to building ground with copper braid as described earlier.

Note that the antenna is more likely to be struck by lightning than the Control Building, so that cabling between the two structures must receive careful grounding attention.

7. Connect phone line surge suppressors to ground with copper braid as described earlier. The #12 ground wire to "green wire" ground should be replaced with copper braid.

8. Install a grounded bulkhead and suppression for the Web Cam and Turbo rogue equipment. Establish procedures which prohibit any penetration of the building without drawings that show the installation is planned to comply with the LPS and provides for sealing the holes against the weather. Any building penetrations must be approved by the Field Group Supervisor.

9. Establish a PM procedure which calls for checking the LPS, preferrably in May before the onset of the lightning storm season. The PM will include checking the tightness of all ground connections and checking transient protectors.

10. Update F51031E001 and other drawings to show the current LPS. Locate and review any reports on Charlie Moore's visits to the site. Provide a monthly report on progress in improving the LPS with a target of completing the update by June 2003.

11. Establish LPS requirements for other VLBA sites, as appropriate, and schedule corrective action.

References:

1. VLA Electronics Memo No. 243, "Lightning Protection, VLA Control Building," by B. Broilo and C. Janes, July 18, 2002.