

VLA Electronics Memo #245

Antenna 16 Failure and Repair Report

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On Friday, March 30 2007, at approximately 20:35 MT a failure with Antenna 16 was detected by VLA operator (Matt). The problem was a catastrophic failure of the limit tree assembly resulting in the antenna driving ~520 degrees past the maximum recommended Azimuth CW travel. The antenna stopped because of multiple failures in several cables routed up the maypole cable wrap: cable failures resulted in the following maintenance report (C120127) filed by the VLA operator.

Maintenance Form (verbatim):

First indication of problem is WYEMON displaying local e-stop, and alerts for +28V Fault, Phase Loss, NCP Fault, Fire failure, ie. everything except ACU alert. EVLA software shows 16 in computer control at 79.xx deg EL, but ACU, FRM and other screens display red box (loss of communication) and no values (not even zeroes) nor yellow indicators of faults. EVLA commands have no effect. Unable to stow antenna but it is almost vertical and wind (~5mph) & sky are very calm. Occurred not long after a soft reboot of Boss & Monty when Boss failed. No other antenna had a problem and 16 was working fine prior to the MODCOMP failure (C120126). Got a Correlator UPS alarm later while talking with Jaime but did not reoccur. Attempted to reach Jim Jackson, then talked to Jaime Montero who felt it sounded like a servo issue. Attempted to call Tom F, Ken L & Dennis M; was able to reach Doug Whiton but he was unable to come out - he will call back in the morning and felt it was safe to leave antenna in this state until then. Follow up - Tom Frost came out at app. 8:30am. The antenna had driven itself past the azimuth software and mechanical limits, causing the breakage of power and fiber cables, which in turn tripped the fire alarm, and shutting off the power to the antenna. Antenna at 85 had auto-stowed . D.M.

Damage:

Damage to the antenna cable wrap. Damaged cables include: 1) W-101, the 15pr FRM data cable to apex, 2) W-104, the 15pr FRM data cable to apex, 3) W-45, the 3pr E-STOP cable, 4) W-301, the 13pr communication data cable, and 5), W-40, the AZ encoder data cable. The Vertex power cable that was broken and the two DC power cables had some minor insulation damage, Figure 1. More damaged cables may be found as the repair process continues. Four carabineers that connect the cable support chains to the guide rings were broken, Figure 2. Fortunately, there was no damage to the fiber wrap, Figure 3. This is only because the motion was CW, which fed the fiber into the tray, albeit, to excess. The fiber did loop back onto itself, but the integrity of the fiber was not compromised.



Figure 1. Maypole Cable Damage



Figure 2. Carabineer Damage



Figure 3. Fiber Cable Wrap

Antenna Motion

The archive data shows that the antenna failed before 7:57 pm MT. At 7:57 pm MT, the antenna rolled the encoder bits over and expected to see the MSB set. The data indicate that the lead/lag switch did not trip. When the bits rolled over to zero, the ACU thought it was at zero and sent the antenna running CW to get back to where it was supposed to be. The antenna ran at full slew for about 850 degrees before the cables failed. The Figure 4 show the azimuth data of antenna 16 compared to antenna 14.

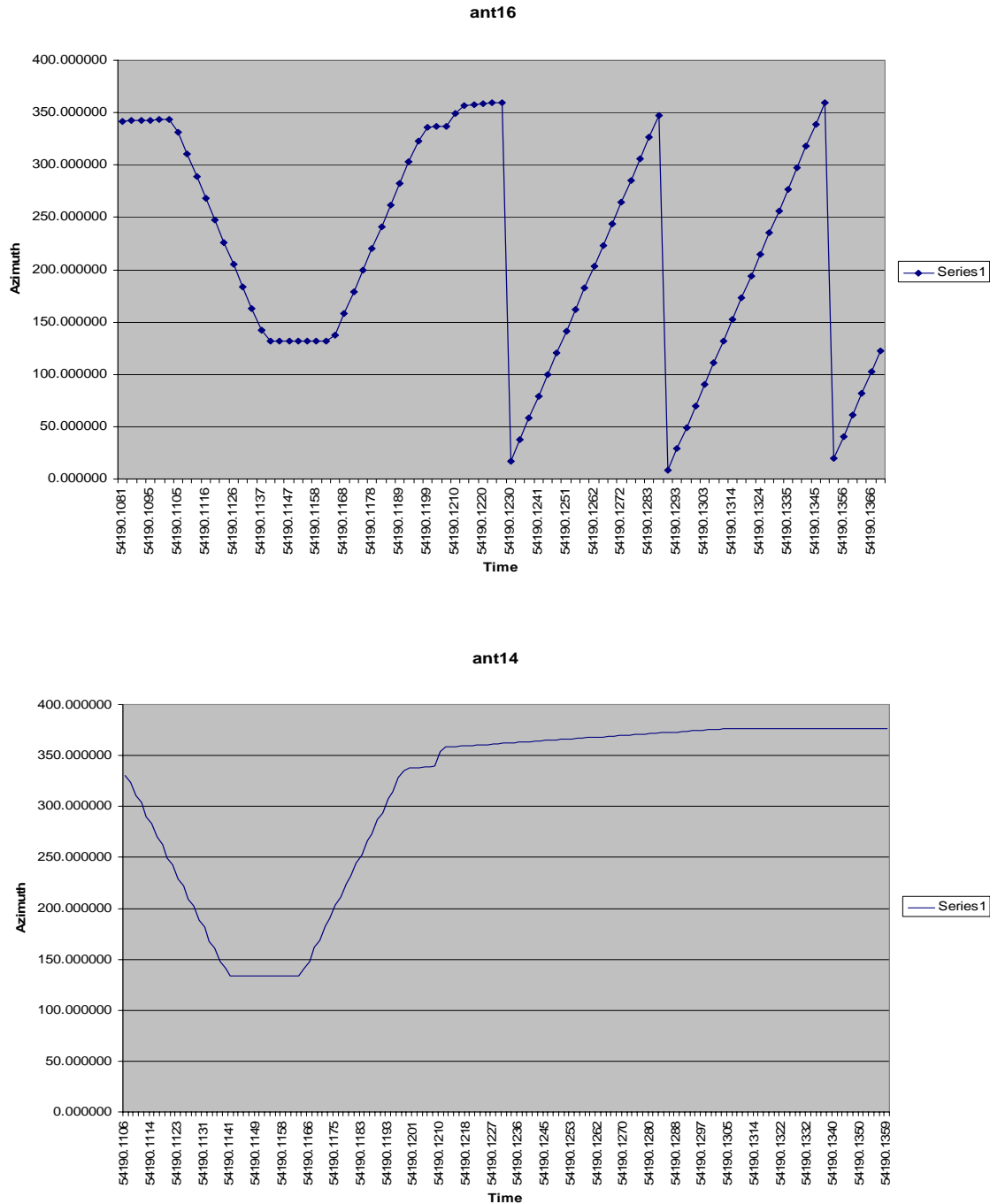


Figure 4. Antenna 16 and 14 Movement

Cause of Failure:

Initially it was thought that a power glitch or the reboot of the MODCOMP had played a role in the failure by causing a default ACU command to zero position. Analysis of the archive data clearly shows that the antenna just got lost and was trying to find the commanded position. This led to an evaluation of the limit tree. The limit tree was found inoperative and had failed near the lower limit of travel, Figure 5.

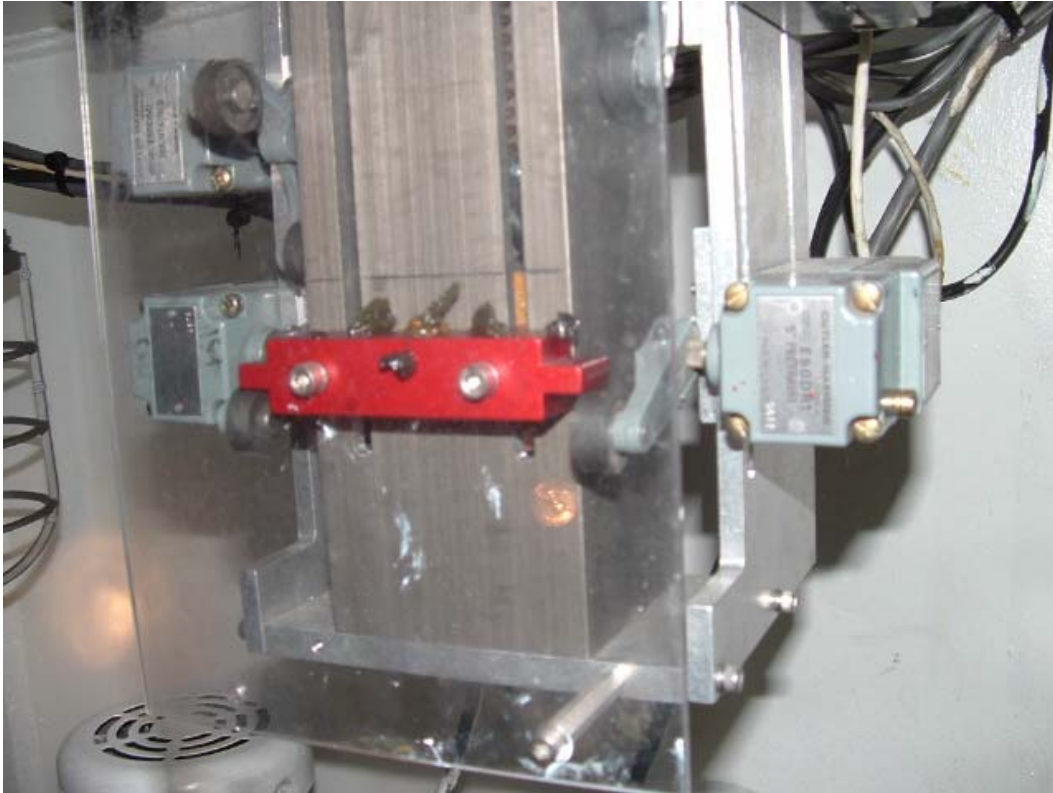


Figure 5. Failed Limit Tree Position

The limit tree internal assembly has two ball nuts that roll on a worm gear and guide an aluminum block that trips the lead/lag and limit switches. Each ball nut normally has several (~20 to 30) balls within the raceway. The ball nuts have an external tube that recirculates the ball-bearings onto and off of the worm gear, Figure 6. The tube has fingers that help guide the balls. This limit tree failure was a result of the roller balls being missing from the ball nuts. At some point in the past, the limit tree was assembled or reassembled without the roller balls. This left only the tube guide fingers to make contact with the worm gear. Overtime, the fingers were completely worn away, and the block began slipping on the worm gear.



Figure 6. Internal Limit Tree Assemblies

Action Items:

Damage to the antenna was limited to the cable wrap and the limit tree. The four carabineers that connect the cable support chains to the guide rings will be replaced. The W-101, W-104, W-45, W-301, and W-40 Cables will be replaced. The Vertex power cable will be spliced. The two DC power cables which had minor insulation damage will be taped. The limit tree will be replaced with the spare. A thorough inspection of the other 27 limit trees will be made in the near future.

During the repair process, the cable trays in the pedestal room will be replaced. These trays were scheduled to be replaced during the next EVLA retrofit. Replacing the cable trays will allow a thorough inspect all cables. Fortunately, there was no damage to the fiber wrap.