Sensitivity of Antenna to Different Perturbations

Raul Monsalve

SESE, Arizona State University

August 1, 2013

Description

These slides describe two tests performed to estimate the sensitivity of the antenna.

Description of Test 1

Test 1 consists of:

1. measuring in the lab the reference distance between panels at the nylon separators (labeled *inner*) and at the edge capacitors (labeled *outer*), and also the height of the top plate at its four corners (labeled 1, 2, 3, and 4 from left to right as viewed from above, where 1 and 4 are closer to the center of the antenna).
2. then, the antenna is shaken mechanically in a random way, much more than expected during a long term observation. The distances are remeasured.
3. then, the top plate is cooled down with freeze spray, after which its height is remeasured.
4. then, the top plate is heated up with a heat gun, after which its height is remeasured.

The interpanel distances were measured with vernier calipers, and the height of the top plate with small-hole gauges and then calipers. In both cases the measurement precision was $\pm$ 1 mil.

Results of Test 1

	Panel Gap Taken in Two Locations							
Measurement	AB Inner (mils)	BC Inner (mils)	CD Inner (mils)	DA Inner (mils)	AB Outer (mils)	BC Outer (mils)	CD Outer (mils)	DA Outer (mils)
Baseline1	703	704	705	702	705	703	705	705
Baseline2	702	705	704	700	705	704	706	705
After Movement	702	706	704	700	705	704	706	705
Delta Between Average baseline and Movement	-0.5	1.5	-0.5	-1	0	0.5	0.5	0

	Top Cap Gap between the Antenna Panels and the Cap Plate at 4 Corners of the Plate			
Measurement	Corner 1 (mils)	Corner 2 (mils)	Corner 3 (mils)	Corner 3 (mils)
Baseline 1	188	198	205	257
Baseline 2	188	199	204	256
After Movement	191	203	200	255
After Cooling	189	205	203	255
After Heating	190	201	201	254
Delta Between Average baseline and Movement	3	4.5	-4.5	-1.5
Delta Between Average baseline and Cooling	1	6.5	-1.5	-1.5
Delta Between Average baseline and Heating	2	2.5	-3.5	-2.5

Figure: (1): TOP: The four panels are labeled *A*, *B*, *C*, and *D*. Two baseline measurements are taken for consistency checking. The separation after shaking changes by amounts that are mostly within the precision of the measurements. BOTTOM: The change in height of the top plate is significant after shaking. Primarily, corners 2 and 3 (farther from the center), evidence a tilt. Using this state as a reference and focusing on corners 2 and 3, they go up after cooling, an down after heating. This implies that the capacitance between top plate and panel decreases and increases, respectively. This is consistent with the results of simulations where height of the plate is varied. The changes in height of corners 1 and 4 (closer to the center of the antenna) during cooling/heating are marginal and within the measurement precision.

Description of Test 2

Test 2 consists of:

1. measuring a reference trace of the antenna reflection coefficient on the rooftop of our building. The active panels are aligned along the N-S axis, parallel to a wall $\sim$ 4 m East of the antenna.
2. The tip of the panel pointing South is pulled by $\sim$ 1 cm to the East and then released. The antenna is given $\sim$ 2 minutes to stabilize. Then the reflection coefficient is remeasured. This process is repeated 5 times.
3. Same as above but pulling the South tip to the West and releasing.

The support of the antenna panels consists of only the four square fiberglass beams. The mechanical shift of the panels due to the perturbations is the largest allowed by the antenna in this configuration, and extremely unlikely to occur during normal operation.

Results of Test 2

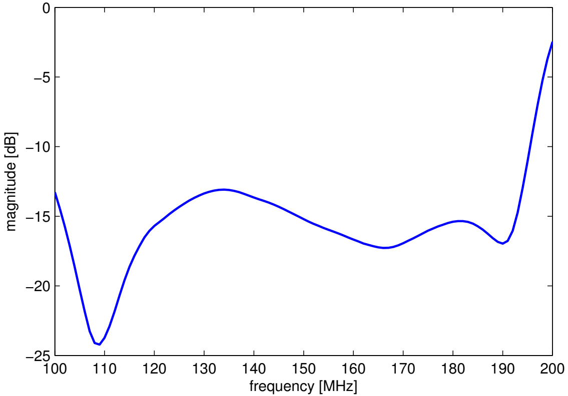

Figure: (2): Reference trace.

Results of Test 2

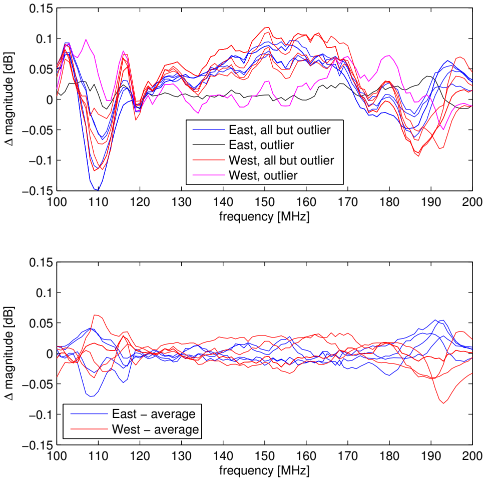

Figure: (3): TOP: 10 measurements after perturbations, relative to the reference trace. Most residuals follow a similar pattern. Two outliers (one from a perturbation to the East and one to the West) show a lower impact to the perturbations. The pattern followed by most traces suggests that the antenna could systematically reach a mechanical state different to the reference one, after perturbations of this kind. BOTTOM: Scatter of traces (except outliers) after removing the average pattern. Within 120 - 180 MHz the scatter is of order 0.05 dB. There is no systematic difference between perturbing the antenna in one direction versus the other.

Conclusion

Test 1: Shaking the antenna does not seem to affect significantly the interpanel distance. It does affect the distances between the top plate and the panels. When the top plate is cooled (heated), the height of its edge farthest from the antenna center gets increased (decreased). This is consistent with the simulated and observed antenna behavior. Most likely, this is produced by the presence of the copper rod tightly attached to the plate. For example, when the plate is heated it tries to expand horizontally, but the rod/nut combination acts as a pivot restricting its movement in a way that decreases the height of the outer edge of the plate.

Test 2: This test had the purpose of estimating the level of recovery of the antenna after a temporary horizontal perturbation to the panels. The raw scatter is of order 0.1 dB in the range of interest. However, the antenna reaches a state that is similar in most cases, with an identifiable pattern. The scatter about this pattern is about 0.05 dB. It is not clear how generalizable this result is when considering all the mechanical degrees of freedom. In any case, this was obtained for unrealistic perturbations and should be treated as an upper limit.