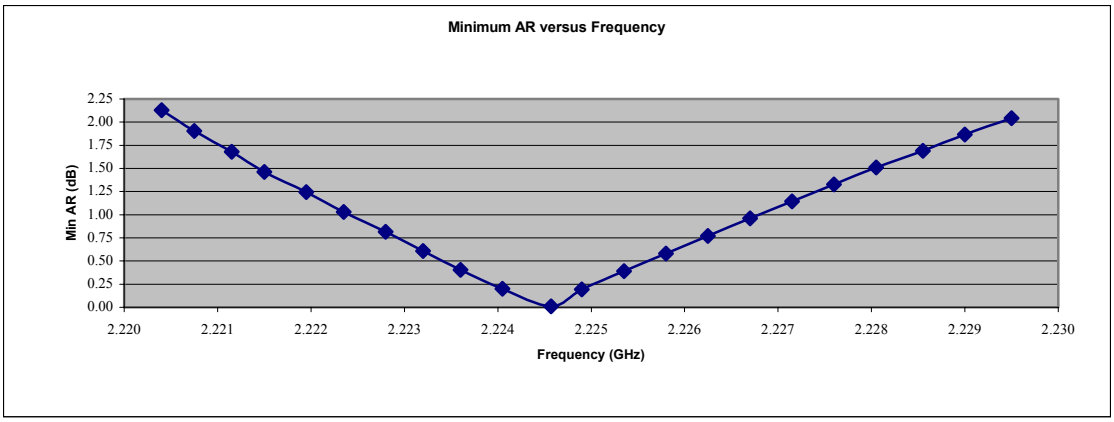
4.6 Design of Truncated Corner Telemetry Element - Cylindrical Surface

In this section, circularly polarized truncated corner telemetry elements for 6, 8, and 14-inch diameter cylinders are designed. The designs are accomplished by running Clementine simulations until the desired radiation characteristics are obtained.

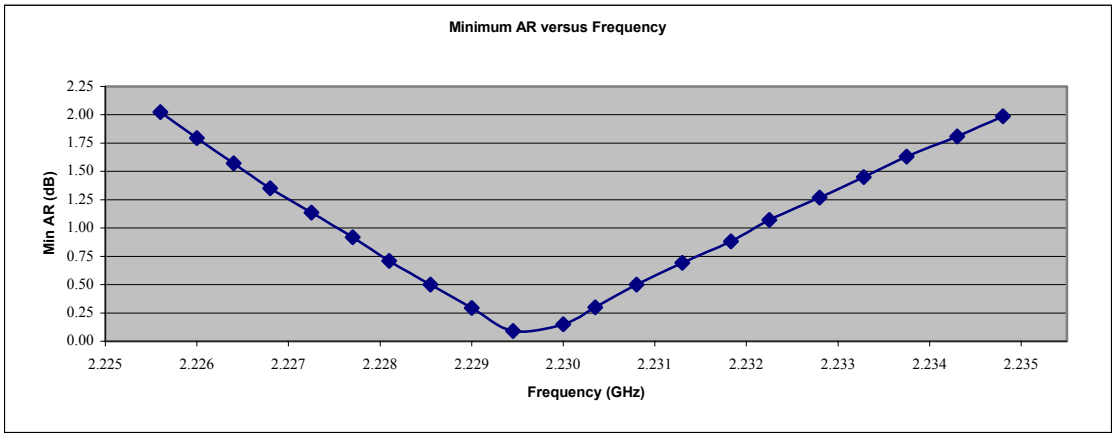
4.6.1 Effects of Varying Truncated Corner Patch Dimensions

The axial ratio of the truncated corner patch is tuned by adjusting the side lengths of the truncated corner perturbation segment. In order to observe the effect changing these lengths has on the patch's axial ratio, several patches were simulated using Clementine. Figure 4.20 shows how the minimum axial ratio changes as the sides of the triangular segment are varied equally, while the patch's length and width are kept constant. These plots are not the axial ratio of one patch but the minimum axial ratio of several patches; each point represents a patch with different truncated corner segment sizes. As seen in the figure, by adjusting the length of the corner patch only slightly, the minimum axial ratio can significantly change.

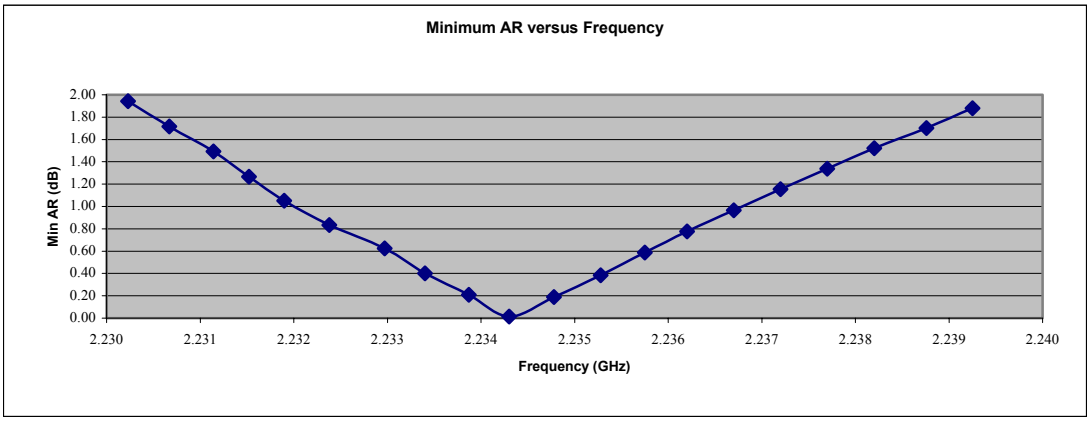
Once the minimum axial ratio is determined, then the patch can be tuned until the minimum axial ratio is located at the operating frequency. The frequency tuning is accomplished by changing the patch's length and width equally, while keeping the truncated corner area constant. Figure 4.21 shows the effects varying both patch dimensions equally has on the minimum axial ratio. What is not shown is the value of the minimum axial ratio. As in the case of the nearly square elements, the minimum axial ratio remains essentially constant as the patch length and width are modified equally.



a. patch on 14-inch diameter cylinder.

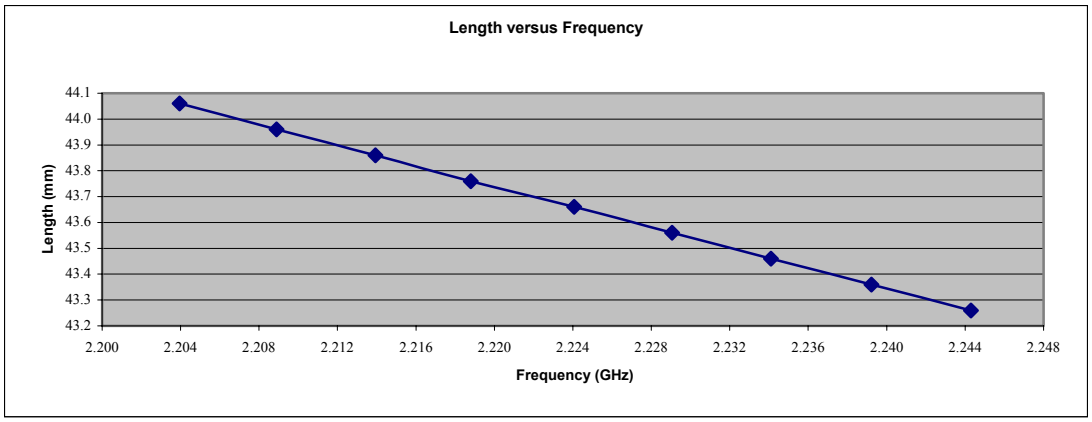


b. patch on 8-inch diameter cylinder.

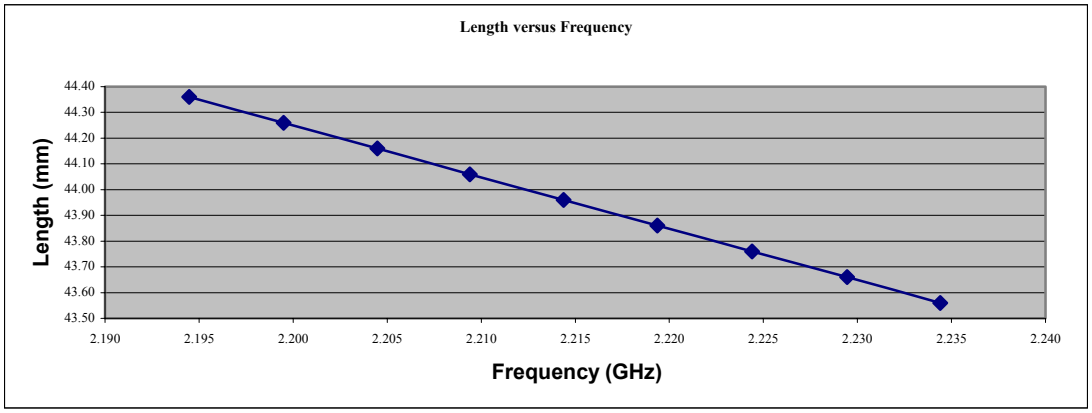


c. patch on 6-inch diameter cylinder.

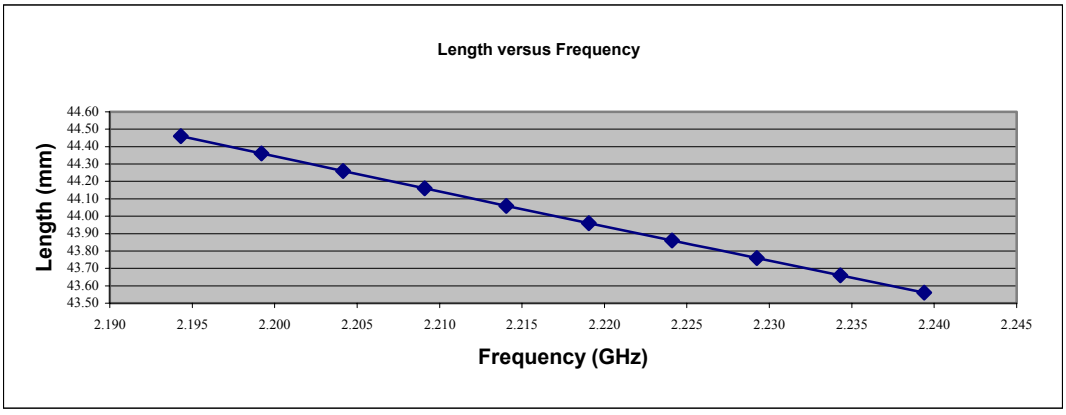
Figure 4.20. Minimum AR versus frequency for the truncated corner patch as the triangular segment length of the patch is varied in 0.05 mm steps while the length and width of the patch are held constant.



a. patch on 14-inch diameter cylinder.



b. patch on 8-inch diameter cylinder.



c. patch on 6-inch diameter cylinder.

Figure 4.21. Length versus frequency for the truncated corner patch as its length and width are reduced in 0.1 mm steps. Note that axial ratio remains nearly constant at ≈ 0.0 dB.

The results of figures 4.20 and 4.21 are summarized in tables 4.14 and 4.15. When a truncated corner patch is fabricated and tested, it will have to be tuned for both axial ratio and center frequency. The data in these tables provide valuable information because they specify how the length must be modified to tune both the axial ratio and the center frequency.

Table 4.14. Axial ratio tuning information for truncated corner telemetry patch. 'Left' and 'Right' refer to the end points in figure 4.20.

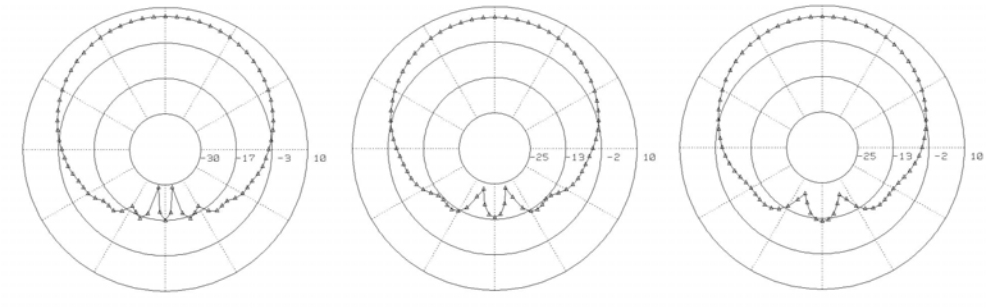
AR versus Frequency								Rate of Change	
	Left AR		Middle AR		Right AR			AR Factor	
Diameter	AR	Frequency	AR	Frequency	AR	Frequency		Left of Minimum AR	Right of Minimum AR
(inches)	(dB)	(GHz)	(dB)	(GHz)	(dB)	(GHz)		(mm/dB)	(mm/dB)
14	2.128	2.21990	0.010	2.22407	2.041	2.22900		-0.23607	0.27080
8	2.020	2.22560	0.020	2.22960	1.990	2.23480		-0.22843	0.28351
6	1.940	2.23020	0.020	2.23430	1.880	2.23930		-0.23438	0.26882

Table 4.15. Frequency tuning information for truncated corner telemetry patch. 'Left' and 'Right' refer to end points in figure 4.21.

AR versus Frequency						Rate of Change
	Left Data Point		Right Data Point			Frequency Factor
Diameter	Length	Frequency	Length	Frequency		
(inches)	(mm)	(GHz)	(mm)	(GHz)		(mm/MHz)
14	44.06	2.20395	43.26	2.24430		-0.01983
8	44.36	2.19448	43.56	2.23440		-0.02004
6	44.46	2.1943	43.56	2.23940		-0.01996

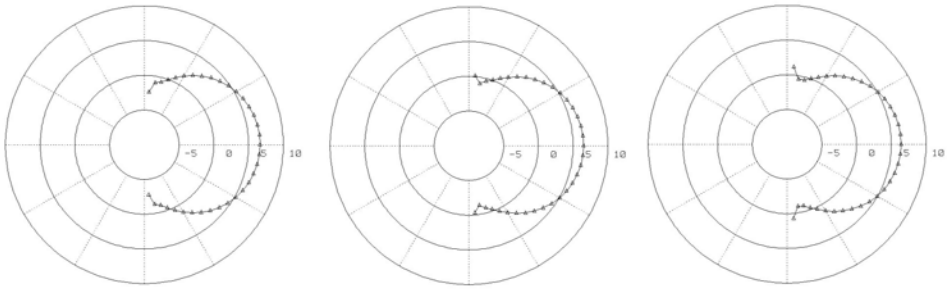
4.6.2 Performance of Truncated Corner Telemetry Patch

Truncated corner telemetry patches were tuned (axial ratio of 0 dB at 2.2155 GHz) for 6, 8, and 14-inch diameter cylinders using Clementine. The dimensions of the antennas are shown in table 4.16. The performance of these patches is shown in figures 4.22 – 4.27 and tabulated in table 4.17. The patches were matched to a 50 ohm microstrip feed using L-section matching networks.



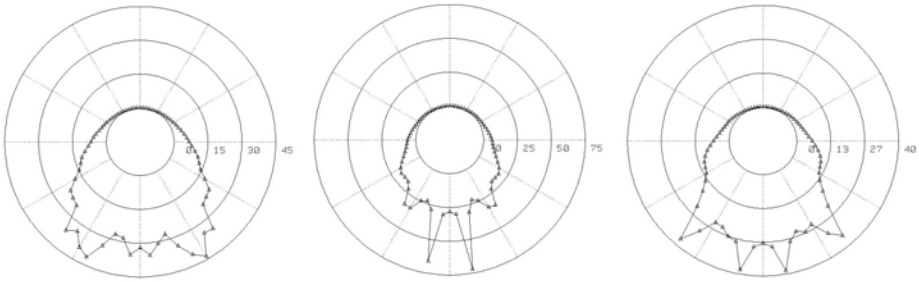
a. 14-inch diameter **b.** 8-inch diameter **c.** 6-inch diameter

Figure 4.22. Gain for truncated telemetry element in the azimuth plane.



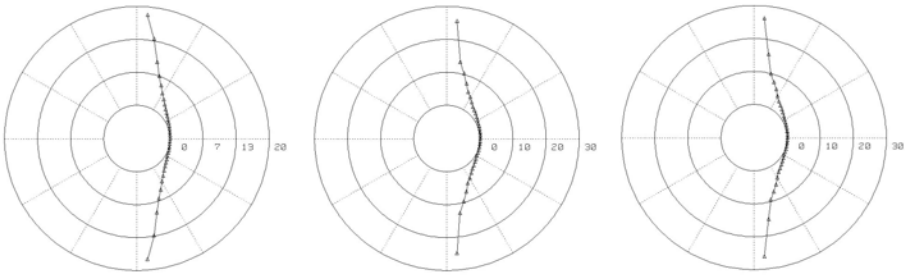
a. 14-inch diameter **b.** 8-inch diameter **c.** 6-inch diameter

Figure 4.23. Gain for truncated telemetry element in the elevation plane.



a. 14-inch diameter **b.** 8-inch diameter **c.** 6-inch diameter

Figure 4.24. Axial ratio for truncated telemetry element in the azimuth plane.



a. 14-inch diameter **b.** 8-inch diameter **c.** 6-inch diameter

Figure 4.25. Axial ratio for truncated telemetry element in the elevation plane.

Table 4.16. Telemetry truncated corner patch dimensions.

Diameter (in)	6	8	14
Frequency (GHz)	2.2155	2.2155	2.2155
Height (mm)	1.524	1.524	1.524
Permittivity	2.33	2.33	2.33
Loss Tangent	0.001	0.001	0.001
Length (mm)	44.03	43.94	43.83
c (mm)	3.945	3.93	3.966
Zin (Ohms)	125.6 - j 16.2	134.3 - j 5.66	141.8 + j 10.7

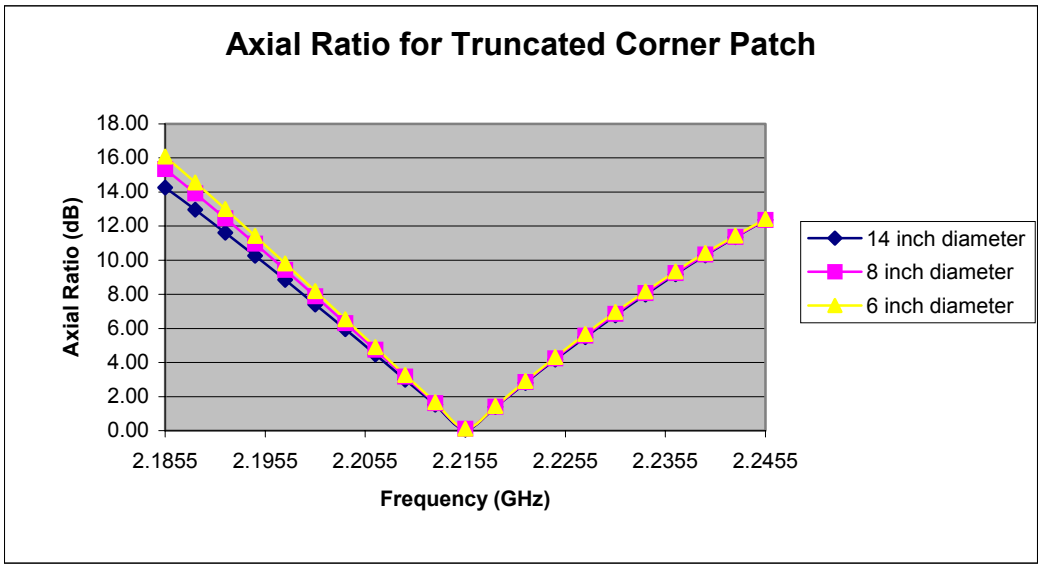


Figure 4.26. Truncated telemetry patch axial ratio versus frequency.

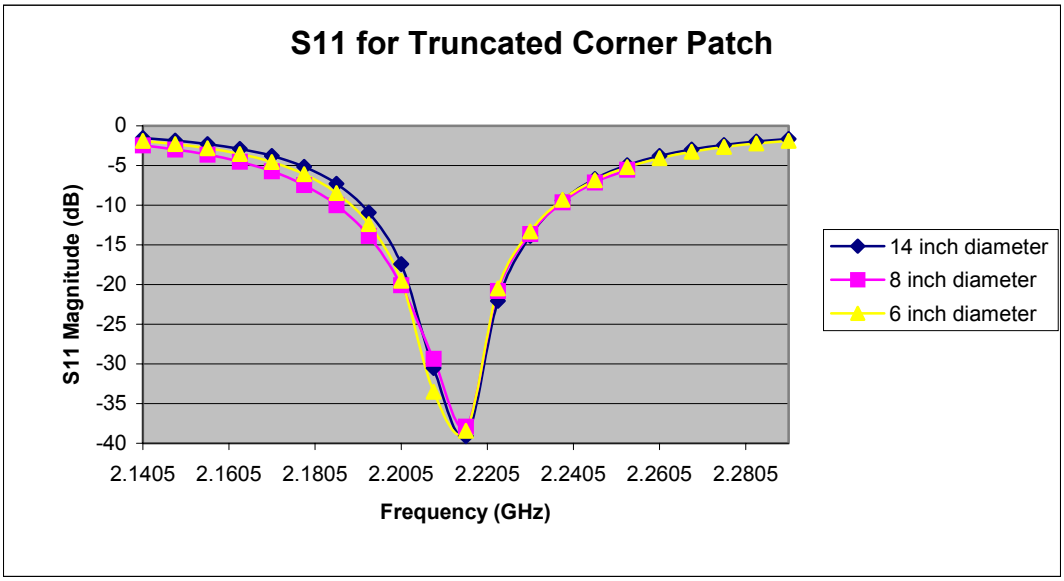


Figure 4.27. S_{11} versus frequency for truncated telemetry patch

Table 4.17. Telemetry truncated corner patch performance data.

Diameter	Azimuth Plane		Elevation Plane		Broadside		
	3 dB Beamwidth	6 dB AR Beamwidth	3 dB Beamwidth	6 dB AR Beamwidth	Gain	Impedance Bandwidth	6 dB AR Bandwidth
(inches)	(degrees)	(degrees)	(degrees)	(degrees)	(dB)	(MHz)	(MHz)
14	95	180	90	140	6.7	104	25.2
8	90	185	90	140	6.5	125	24.3
6	90	180	90	135	6.4	119	23.7

4.6.3 Comparison of Nearly Square and Truncated Corner Telemetry Elements

The performance of the nearly square element discussed in section 4.5 and the truncated corner element discussed in this section are essentially the same; however, the patches have different antenna lengths, perturbation sizes, and input impedances. The length of the truncated corner patch is approximately 0.8 mm longer than the nearly square patch. The truncated corner has less input reactance than the nearly square patch, which implies it will be easier to tune with an L-section matching network. The truncated corner also has a much larger perturbation dimension, which implies it will provide more control in the fabrication of the antenna and tuning its axial ratio performance. Therefore, while the performances of the antennas are the same, the truncated corner patch appears to be the more practical of the two antennas to design and fabricate.