Frequency Dependence of ATA Antenna Effective Area and Beamwidth with Focus Set for 6GHz

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1 Effect of Axial Focus Error, Δx

The phase center of the feed operating at wavelength λ is at x = 1.4λ, where x is the distance along the feed axis from the feed vanishing point. For operation at a particular wavelength, the corresponding position x should be at the focal point of the optical system. For that choice of x, operation at any other wavelength with its different phase center will experience a quadratic phase error with peak value Φ_m at the edge of the exit window 6m diameter aperture given by

$$\Phi_m = \frac{2\pi}{\lambda}\frac{2\Delta x}{1+(4F)^2} \tag{1}$$

where Δx is the difference between where the antenna is focused and x(λ) referred to the focus position for 6 GHz, and F is the beam focal ratio, .65 for the ATA. If the antenna were radiating, the electric field at an angle θ from the optical axis would be proportional to

$$\psi(\theta) \propto \int_0^3 e^{i\Phi_m(r/3)^2}[.210 + .786(1-(r/3)^2)^{1.9}]J_0[\frac{2\pi}{\lambda}rSin(\theta)]rdr, \tag{2}$$

where the term in the square braces is the aperture electric field produced by the feed and J_0 is the Bessel function. The effective antenna collecting area is proportional to the square of the above integral for $\theta = 0$. It also depends on feed losses, aperture illumination, spillover and surface roughness. The measured surface roughness is 0.7mm RMS, and the fractional aperture efficiency, E, including the above effects but without any focus error, is given in column 5 of the table below. The aperture efficiency exceeds 0.5 at all frequencies. The efficiency, including focus error, E(of), is in column 6. Column 7 shows the 3db beam size with no focus error. It is given by 3.495(λ((cm)/30) degrees. Column 8 shows the beam size including focus error.

Freq(GHz)	x(cm)	$\|\Delta x\|_6$	Φ_m	E	E(of)	FWHM	FWHM(of)
0.5	86.4	79.2	2.14	.584	.415	6.99^o	7.99^o
1.0	43.2	36.0	1.95	.589	.444	3.50^o	3.69^o
1.5	28.8	21.6	1.75	.589	.470	2.33^o	2.43^o
2.0	21.6	14.4	1.55	.587	.491	1.75^o	1.80^o
4.0	10.8	3.6	.78	.574	.549	$.87^o$	$.88^o$
6.0	7.2	0.0	0.0	.559	.559	$.58^o$	$.58^o$
8.0	5.4	1.8	.78	.543	.519	$26.2'$	$26.3'$
10.0	4.3	2.9	1.56	.526	.440	$20.9'$	$21.6'$
11.5	3.7	3.5	2.15	.512	.364	$18.2'$	$19.4'$

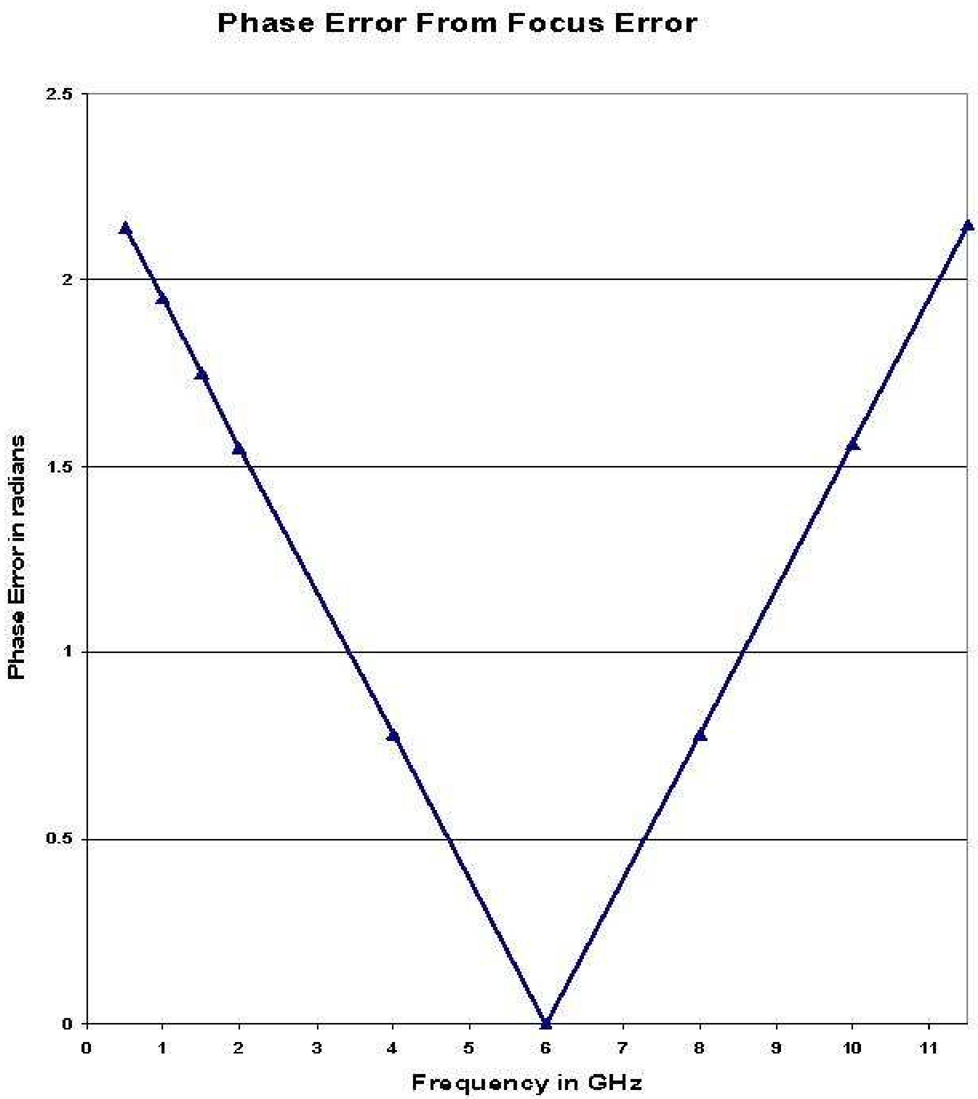

Figure 1: The edge quadratic phase error as a function of frequency for focus set at 6 GHz

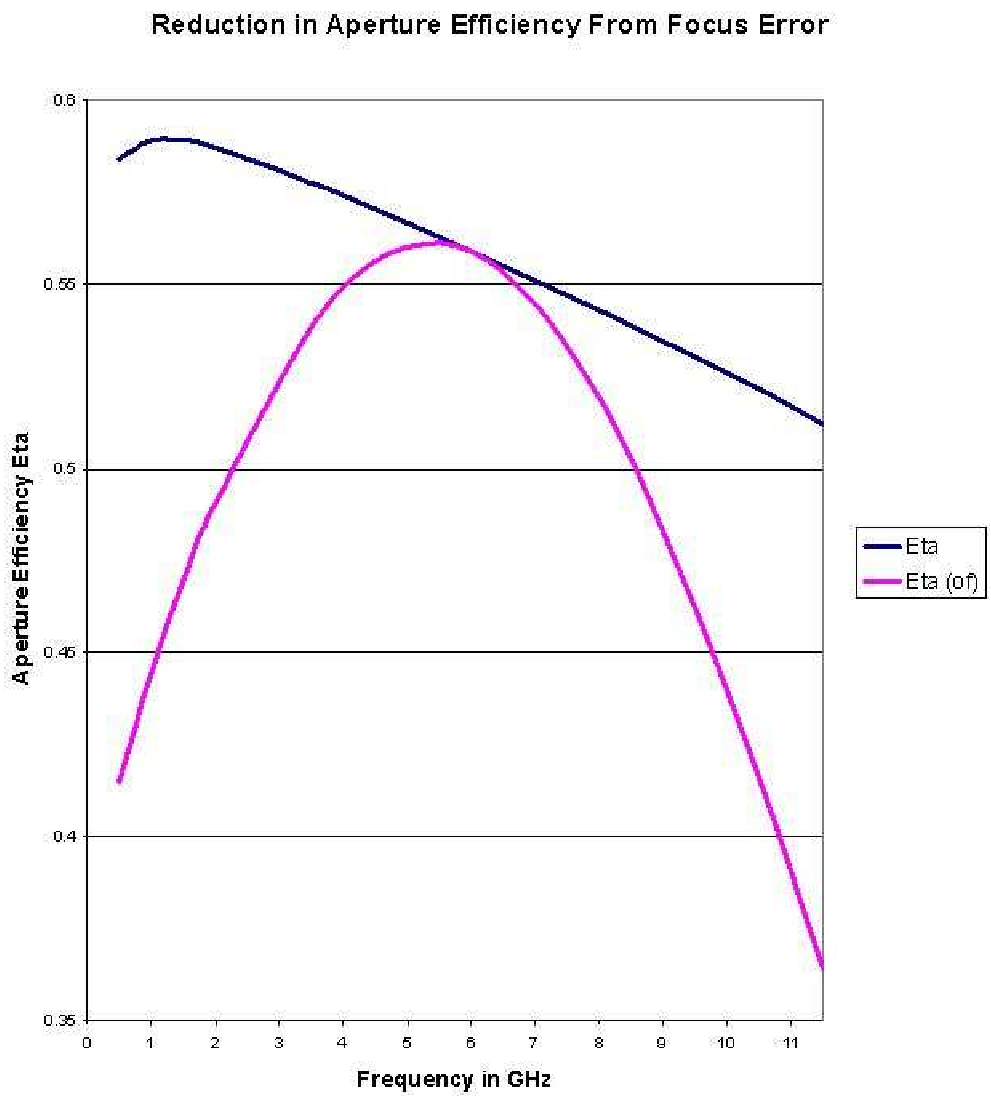

Figure 2: Beam efficiency as a function of frequency for focus set at 6 GHz

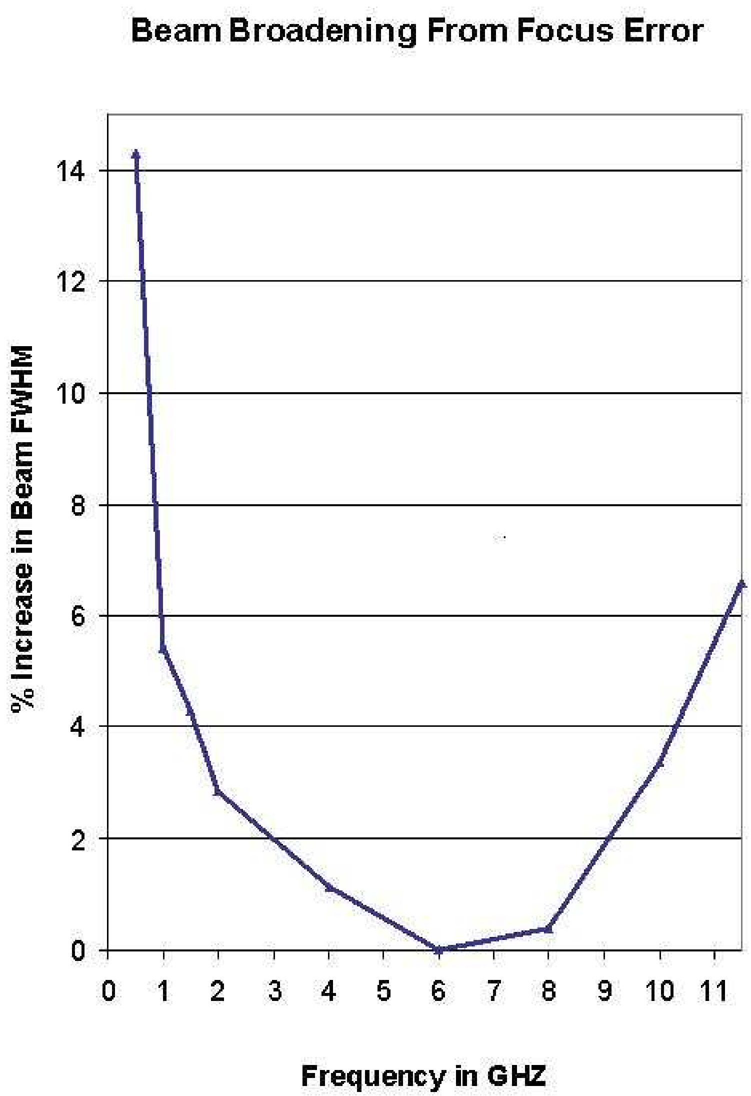

Figure 3: Beam broadening as a function of frequency for focus set at 6 GHz

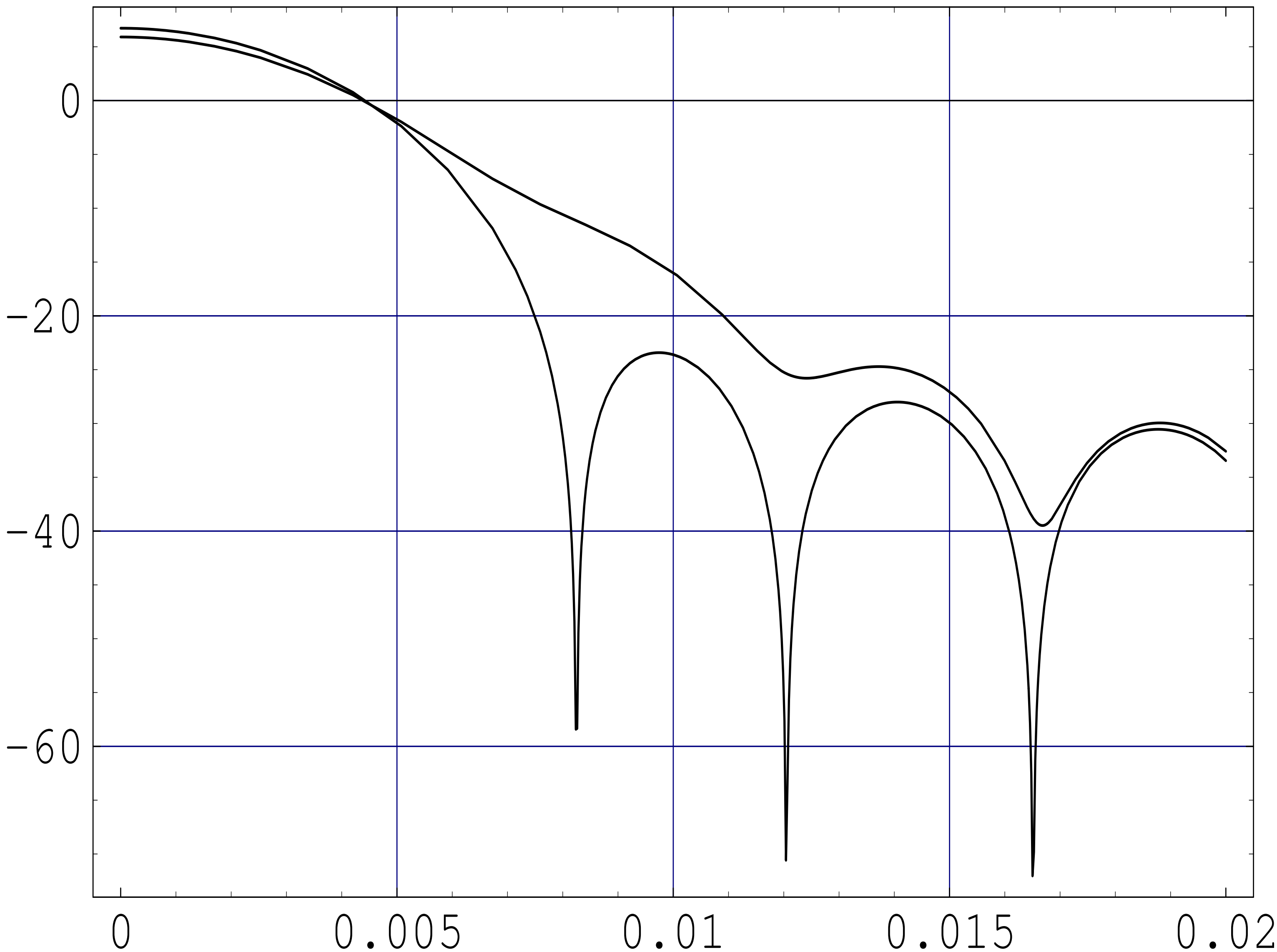

Figure 4: The pattern with sharp nulls is for the telescope focused at 10 GHz. The other pattern is also for 10 GHz but with the telescope focused at 6 GHz. The abscissa is angle in radians. The ordinate is in DB.