11-9.1 Reflector Feed Spiral Mode Effect

The mode 1 spiral (flat or conical) response has a single phase cycle as φ varies cancelled when we project the circular polarization response on it after multiplying by the complex conjugant of the CP unit vector. The response has constant phase. However, when we consider using higher order spiral mode feeds, the polarization phase does not cancel the feed antenna phase and these higher order mode feeds produce a pattern null for the reflector. A mode 2 spiral response produces a single phase cycle in the phase response and, in general, a mode *N* spiral pattern produces an *N – 1* cycle phase response for the feed. This feed produces a difference pattern.

We can find the average higher order response by considering a circularly symmetric pattern as a pattern model of either the flat- or conical-spiral with a phase cycle in φ. We modify [Eq. (4-81)] for higher mode phase responses in terms of the *U* space variable of the Taylor distribution for a phase cycle *n* to obtain the pattern response.

$$f(U) = 2\pi a \int_0^1 E(r) J_n(\pi U)\, r\,dr \text{ where } \pi U = ka\sin\theta$$

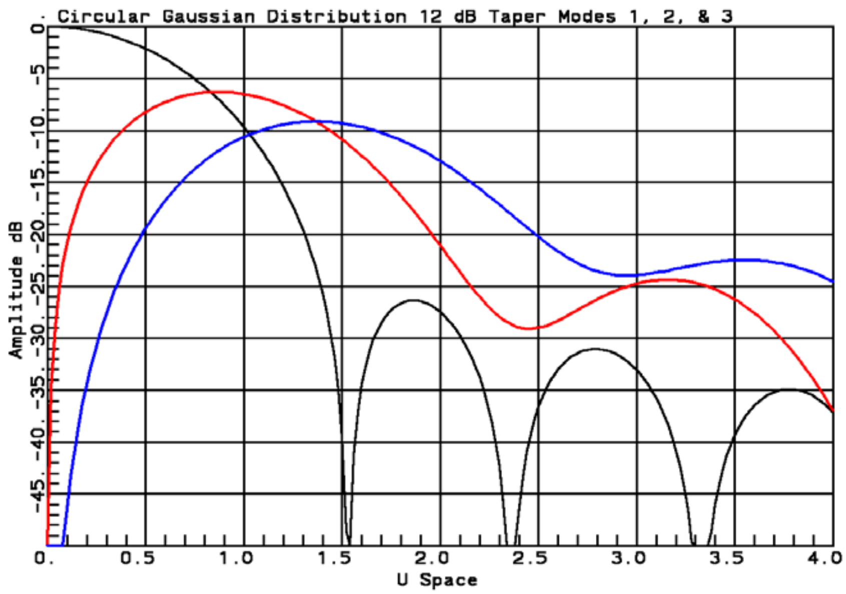

Figure 11-12a Circular aperture U-space response for spiral mode 1 (black), mode 2 (red), mode 3 (blue) for 12 dB edge taper circular Gaussian distribution similar to a parabolic reflector aperture

Figure 11-12a illustrates that the beam shifts further off boresight and has lower gain for increasing spiral modes. For the case solved in Figure 11-12a the mode 2 pattern drops 6.32 dB while mode 3 gain loss is 9.17 dB. The losses for uniform distribution are 5.87 dB for mode 2 and 8.34 dB for mode 3. This shows that splitting the beam into a butterfly pattern reduces gain by about 6 dB for mode 2 and 9 dB for mode 3 but the particular aperture distribution determines the exact value.

Example: Compute beam direction and beamwidth of 100λ diameter reflector using parameters from Figure 11-12a. $U_{3\text{ dB Mode }1} = 0.5868 = 2a/\lambda \sin\theta_{BW}$ Beamwidth = $2\sin^{-1}(.5868/100) \approx 360(.005868)/\pi = 0.67°$

Mode 2

$U_{\text{peak Mode }2} = 0.875 = 2a/\lambda \sin\theta_{peak}$ $\theta_{peak} = \sin^{-1}(0.875/100) \approx 180(0.00875)/\pi = 0.50°$

$U_{3\text{ dB Mode }2} = 0.437 = 2a/\lambda \sin\theta_{3\text{-}dB}$ $\theta_{3\text{-}dB} = \sin^{-1}(0.437/100) \approx 180(0.00437)/\pi = 0.246°$

$U_{3\text{ dB Mode }2} = 1.382 = 2a/\lambda \sin\theta_{3\text{-}dB}$ $\theta_{3\text{-}dB} = \sin^{-1}(1.382/100) \approx 180(0.01382)/\pi = 0.792°$ Beamwidth = 0.54°

Mode 3

$U_{\text{peak Mode }3} = 1.37 = 2a/\lambda \sin\theta_{peak}$ $\theta_{peak} = \sin^{-1}(1.37/100) \approx 180(0.0137)/\pi = 0.78°$

$U_{3\text{ dB Mode }3} = 0.858 = 2a/\lambda \sin\theta_{3\text{-}dB}$ $\theta_{3\text{-}dB} = \sin^{-1}(0.858/100) \approx 180(0.00858)/\pi = 0.492°$

$U_{3\text{ dB Mode }3} = 1.929 = 2a/\lambda \sin\theta_{3\text{-}dB}$ $\theta_{3\text{-}dB} = \sin^{-1}(1.929/100) \approx 180(0.01929)/\pi = 1.105°$ Beamwidth = 0.614°

If the reflector diameter was 20λ, we would multiply the results above by 5 to obtain approximate values. For example, the beam direction for mode 2 would be 2.5°.