3.12.1 Axisymmetric Element Pattern Array Gain

Figures 3-22 and 3-23 give the array gain for elements in the array with equal *E*- and *H*-plane beamwidths. The Phi integral in equation 3-29 can be evaluated as the Bessel function J_0.

$$\frac{R_{12}(x)}{R_{11}} = \frac{\text{element directivity}}{2}\int_0^{\pi} E_e^2(\theta)(J_0\left(\frac{2\pi x}{\lambda}\sin\theta\right)+1)\sin\theta d\theta - 1$$

Figures 3-22 and 3-23 use the pattern approximation $E(\theta)=\cos^N(\theta/2)$ and the equation above reduces to

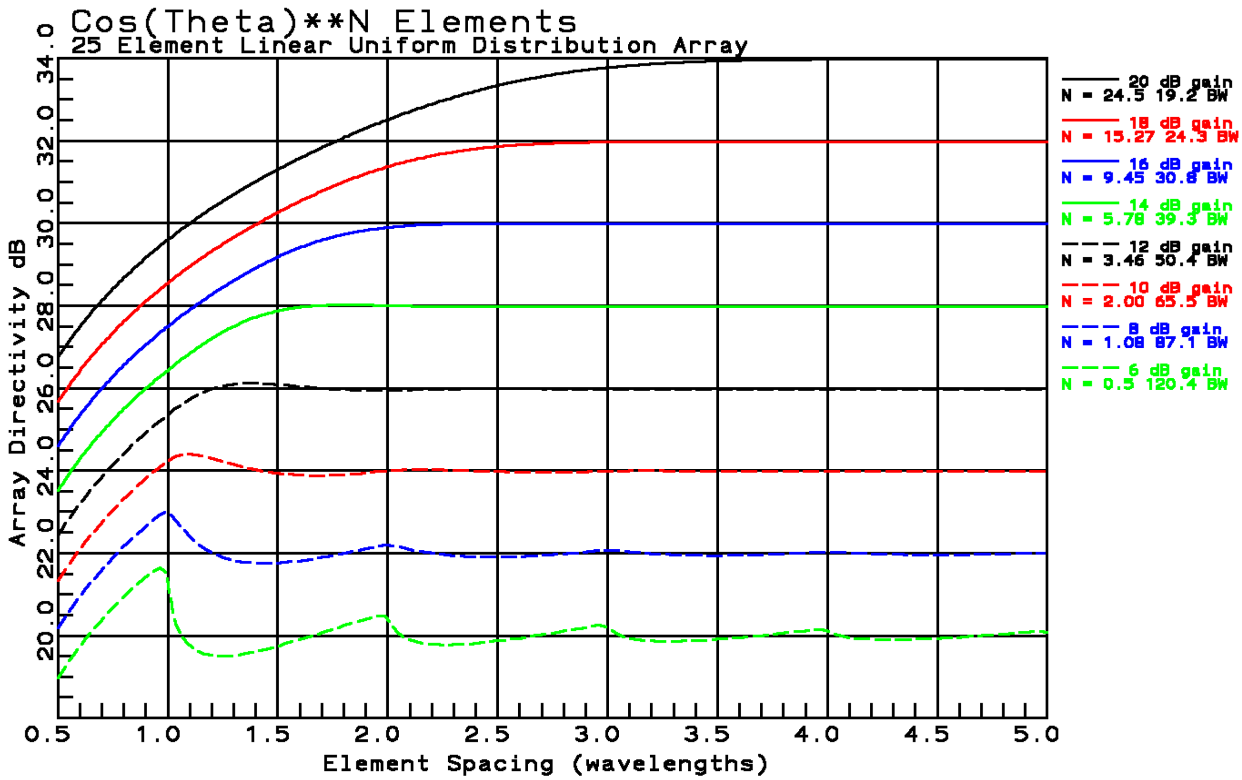
$$\frac{R_{12}(x)}{R_{11}} = \frac{N+1}{2}\int_0^{\pi} \cos^{2N}(\theta/2)(J_0\left(\frac{2\pi x}{\lambda}\sin\theta\right)+1)\sin\theta d\theta - 1$$

This pattern approximation has a finite value beyond 90° which does not match well for an array on a ground plane. The approximation $E(\theta)=\cos^N(\theta) \quad \theta \le \pi$ is a better element pattern approximation for an array located on a ground plane. The equation for normalized mutual resistance becomes

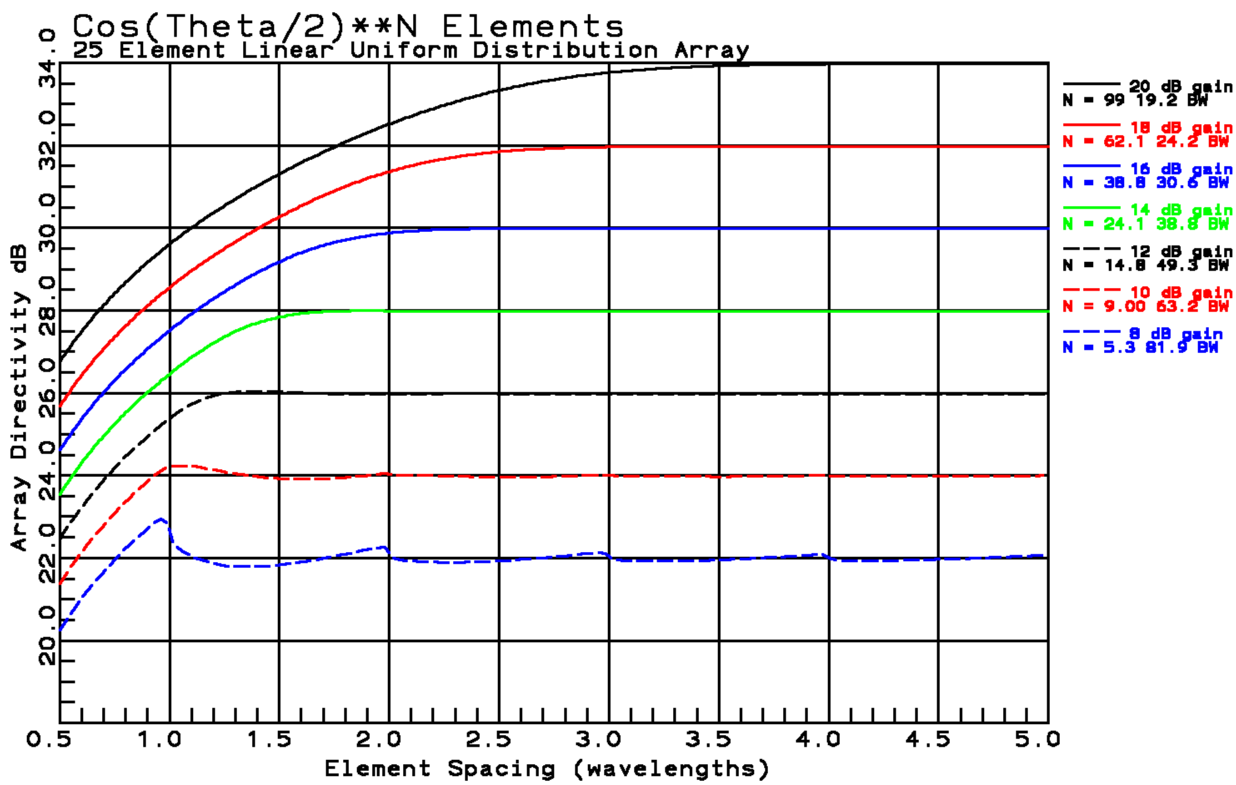
$$\frac{R_{12}(x)}{R_{11}} = (2N+1)\int_0^{\pi/2} \cos^{2N}(\theta)(J_0\left(\frac{2\pi x}{\lambda}\sin\theta\right)+1)\sin\theta d\theta - 1$$

A table of normalized mutual resistance versus spacing is generated for a given array element gain (or beamwidth) using the integral expressions given above. Because J_0 cycles through many zeros as spacing increases, it is necessary to sample enough points in the integral to meet the Nyquist criterion for the lowest order integral of a Romberg integral sequence of trapezoidal rule samplings before interpolating spacing to zero for the final integral evaluation.

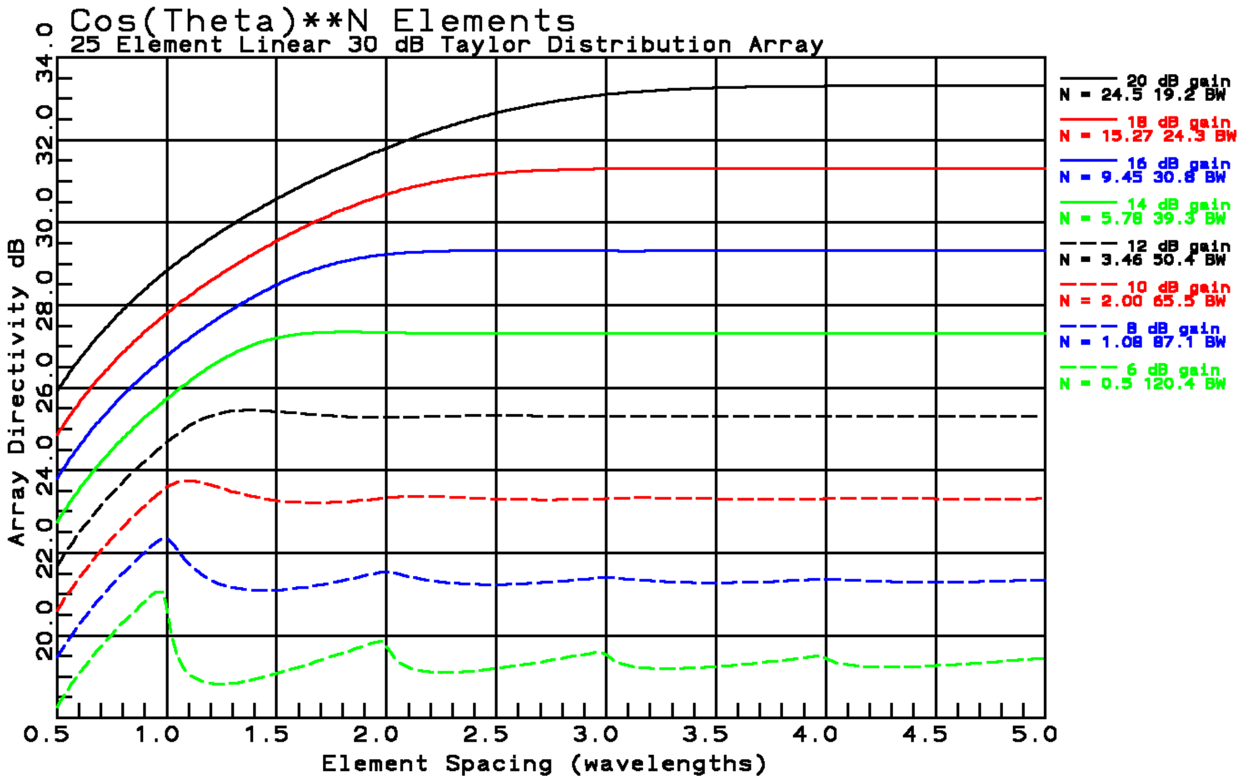
The plots below illustrate that array gain is the product of the number of elements times element gain when the elements are widely spaced and mutual coupling is low. As the elements become closely spaced array gain is determined by the array area because the effective areas of high gain array elements overlap and share their areas. Summing mutual resistance from each element in the array to every other element gives the effective radiation resistance of that element.



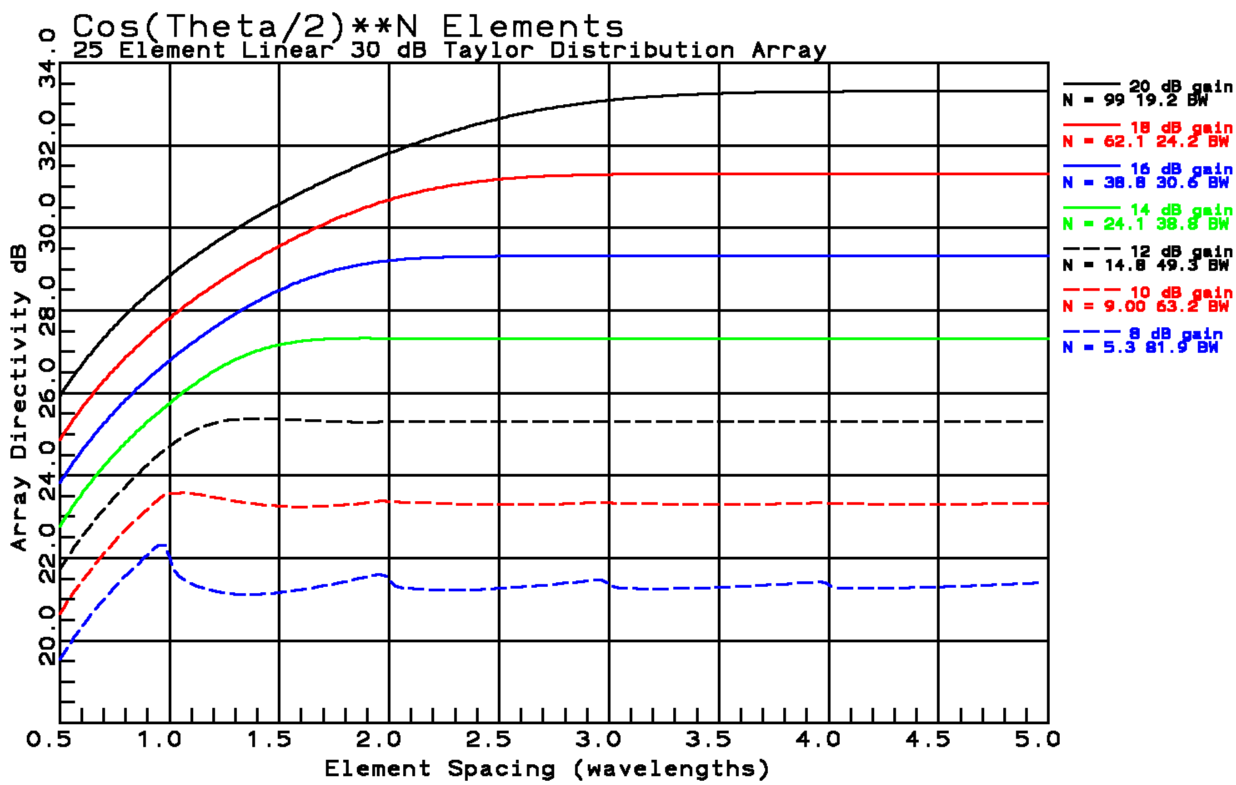
25 element linear array with uniform distribution



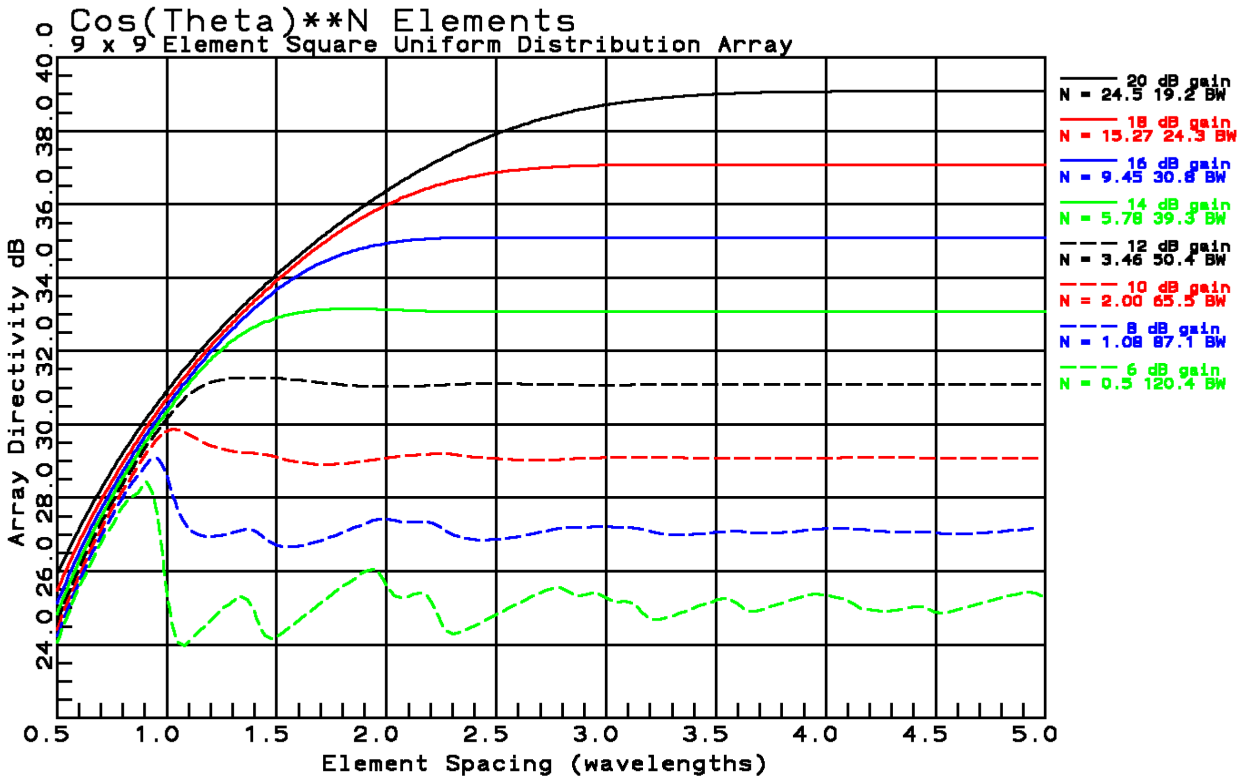
25 element linear array with uniform distribution



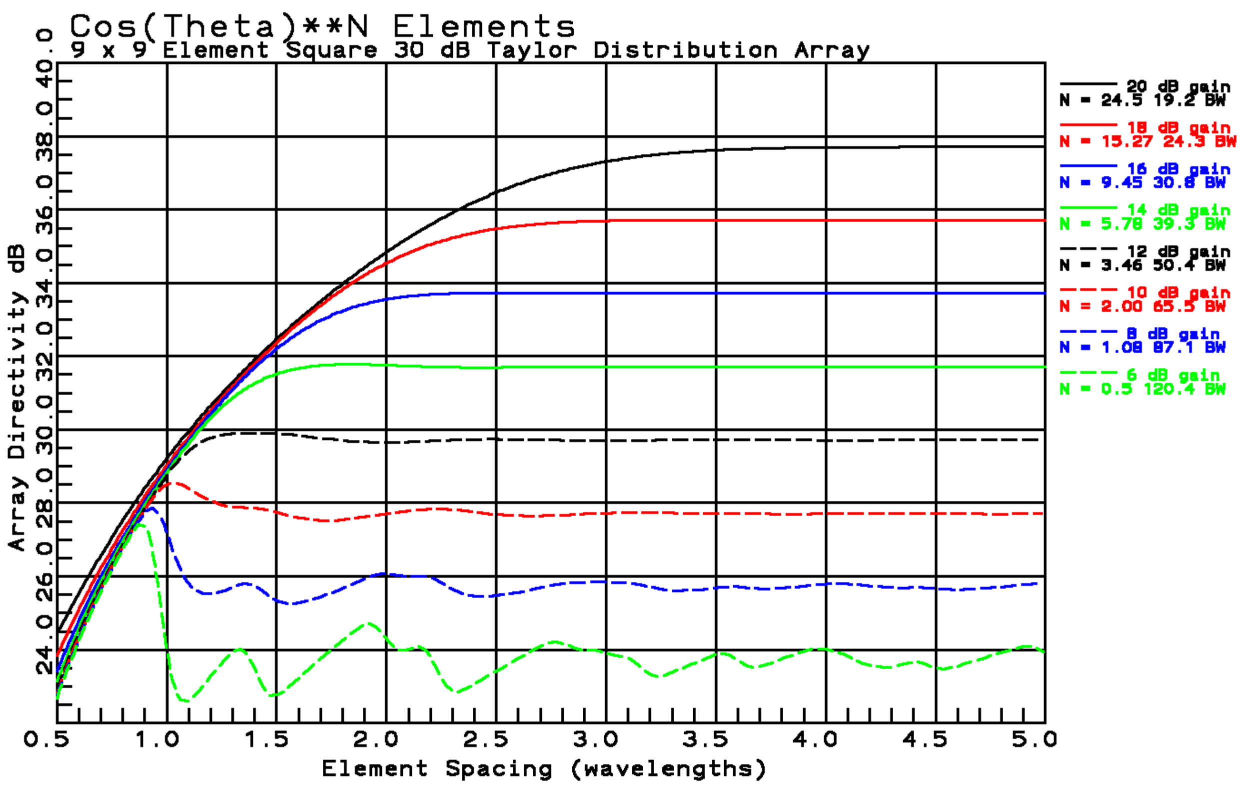
25 Element Linear Array with 30 dB Linear Taylor Distribution



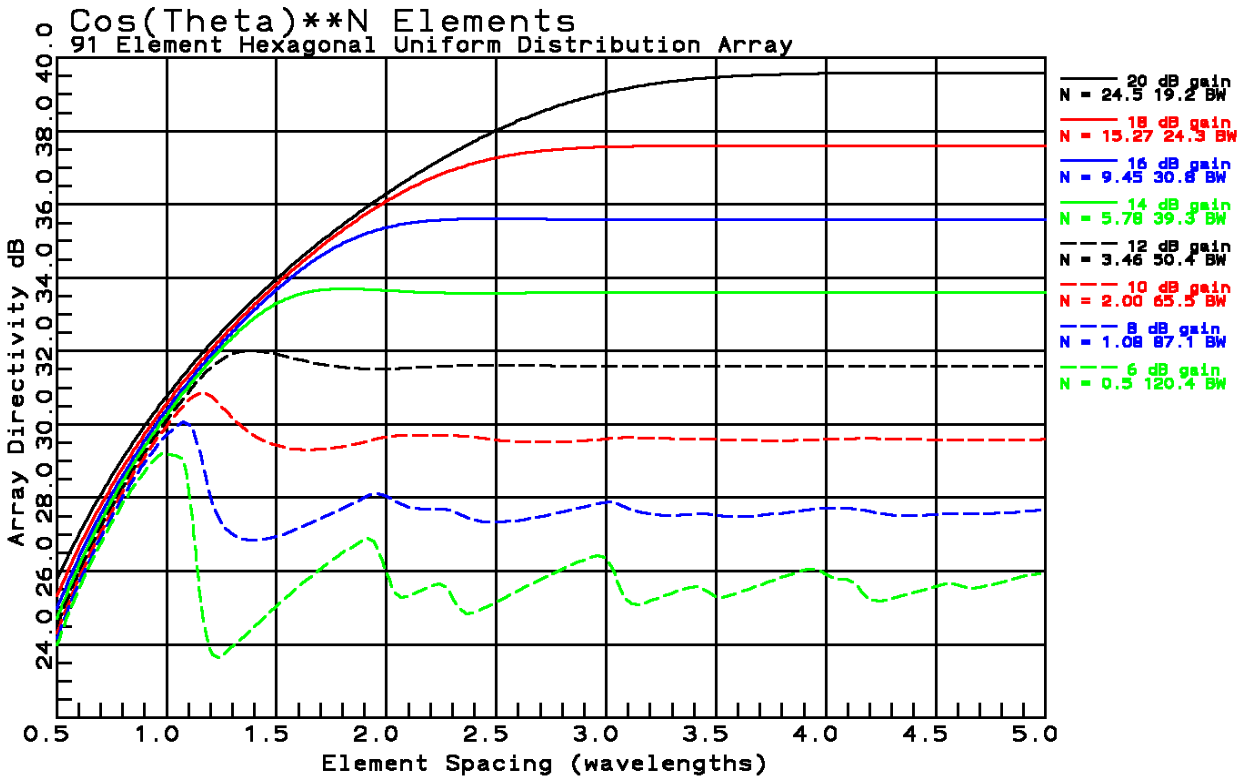
25 Element Linear Array with 30 dB Linear Taylor Distribution



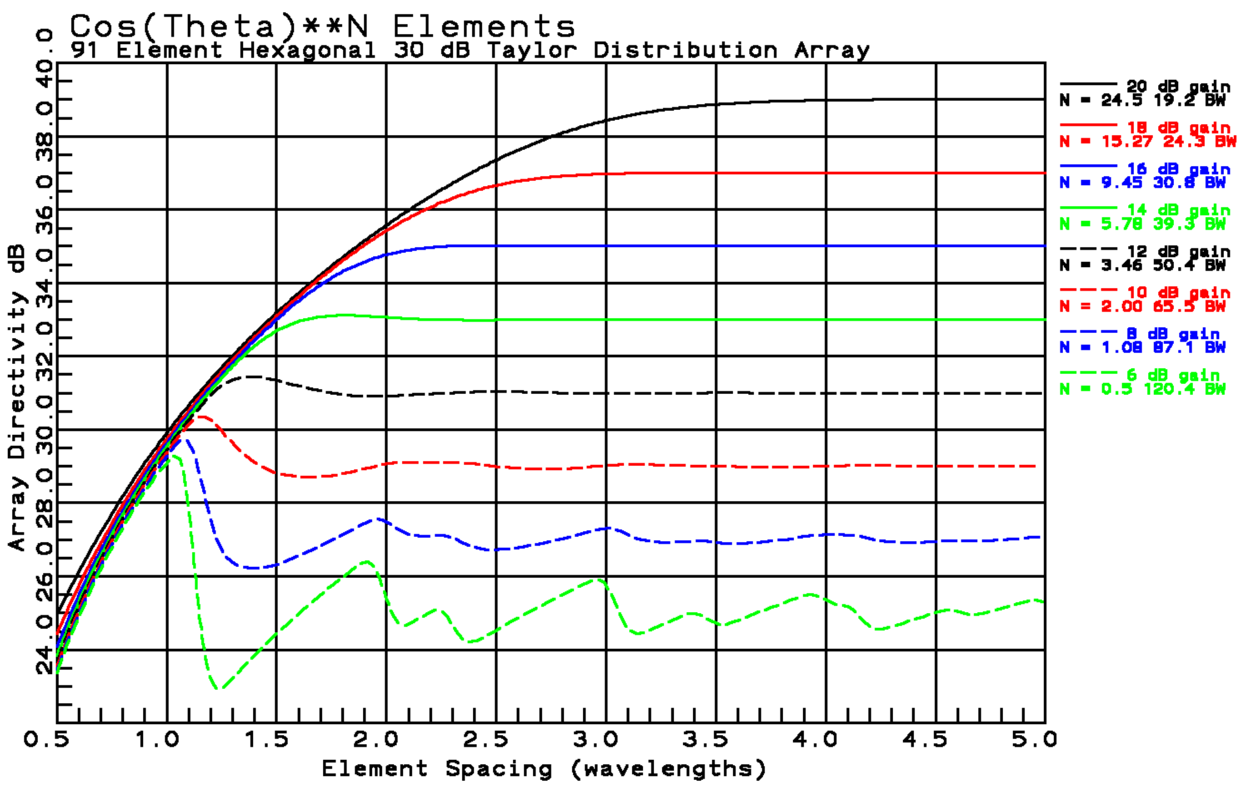
81 Element Square Array with Uniform Distribution



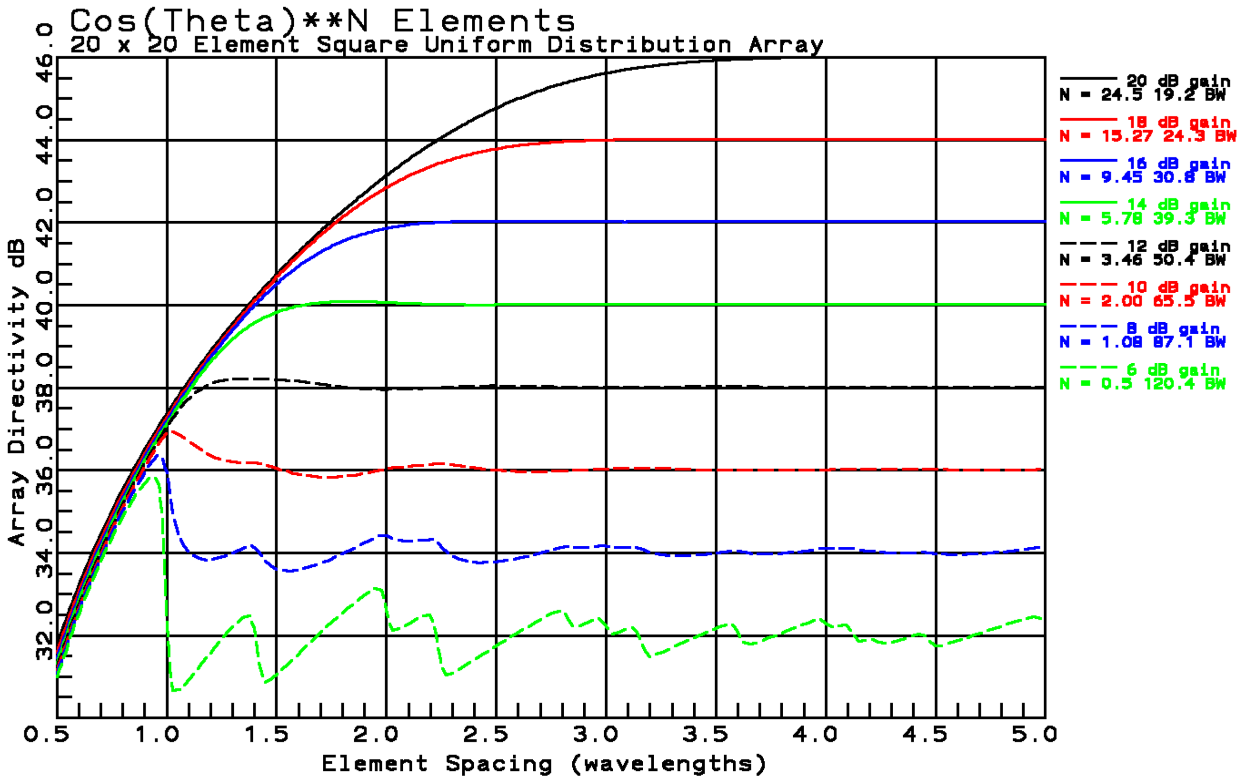
81 Element Square Array with 30 dB dual Linear Taylor Distribution



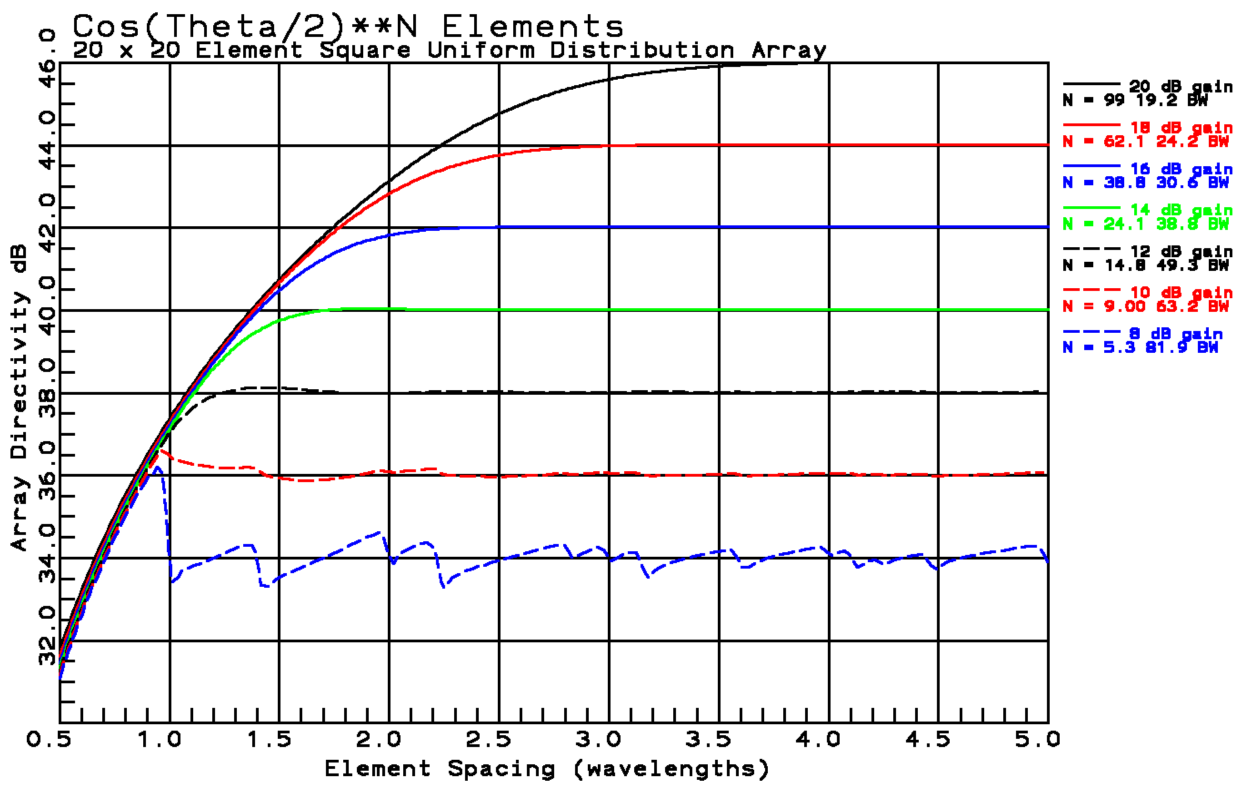
91 Element Hexagonal Array with Uniform Distribution



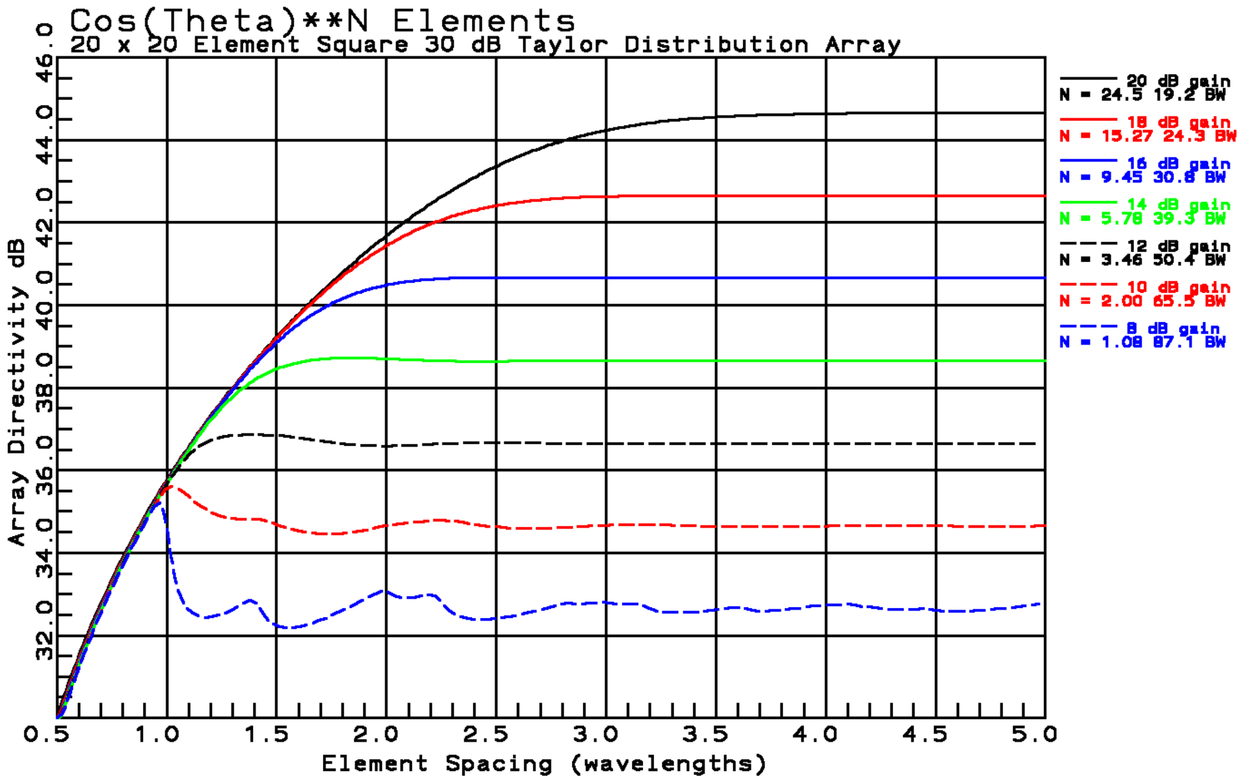
91 Element Hexagonal Array with 30 dB Circular Taylor Distribution



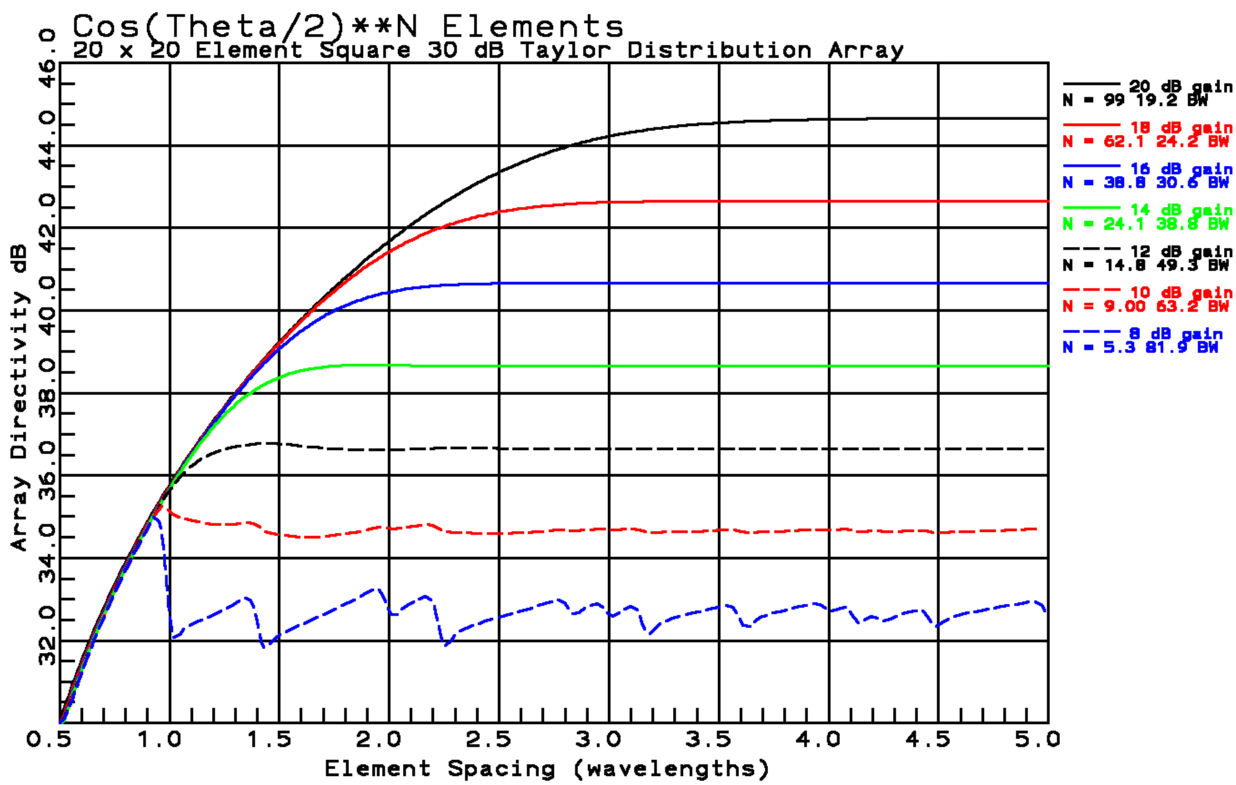
400 Element Square Array with Uniform Distribution



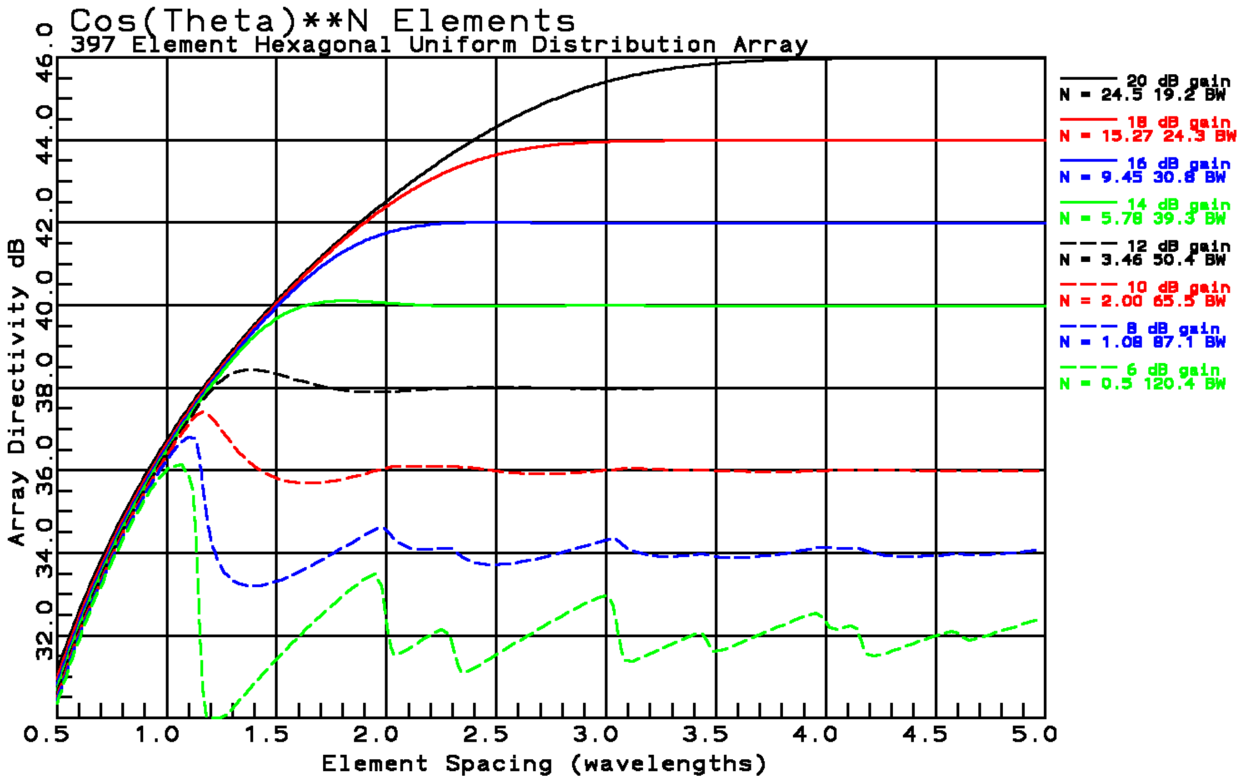
400 Element Square Array with Uniform Distribution



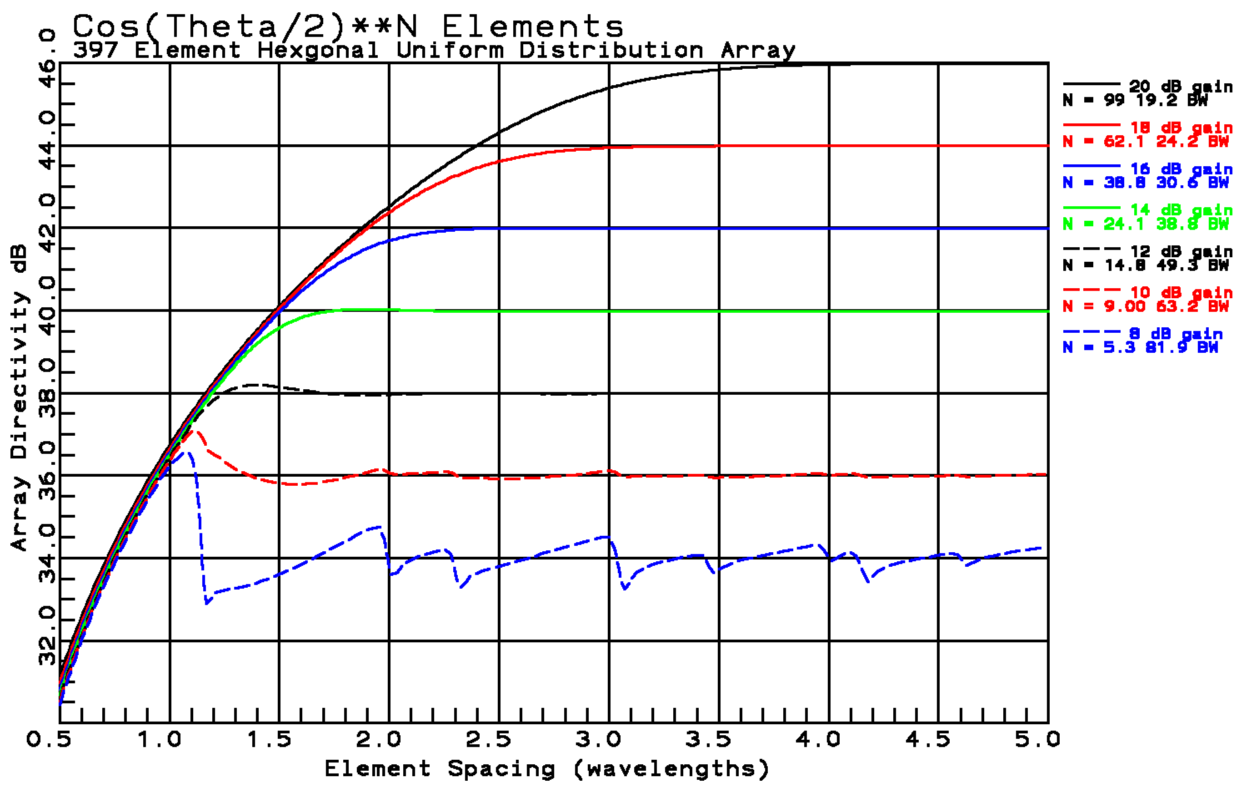
400 Element Square Array with 30 dB Dual Linear Taylor Distribution



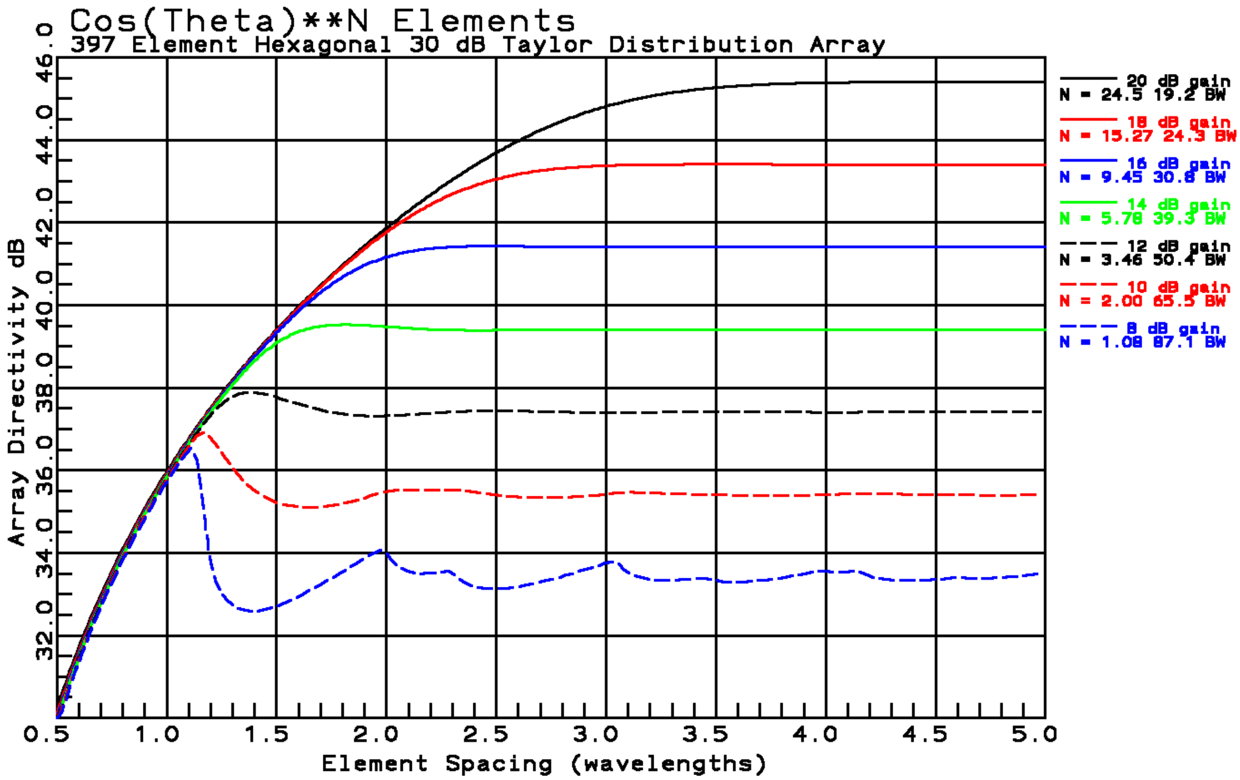
400 Element Square Array with 30 dB Dual Linear Taylor Distribution



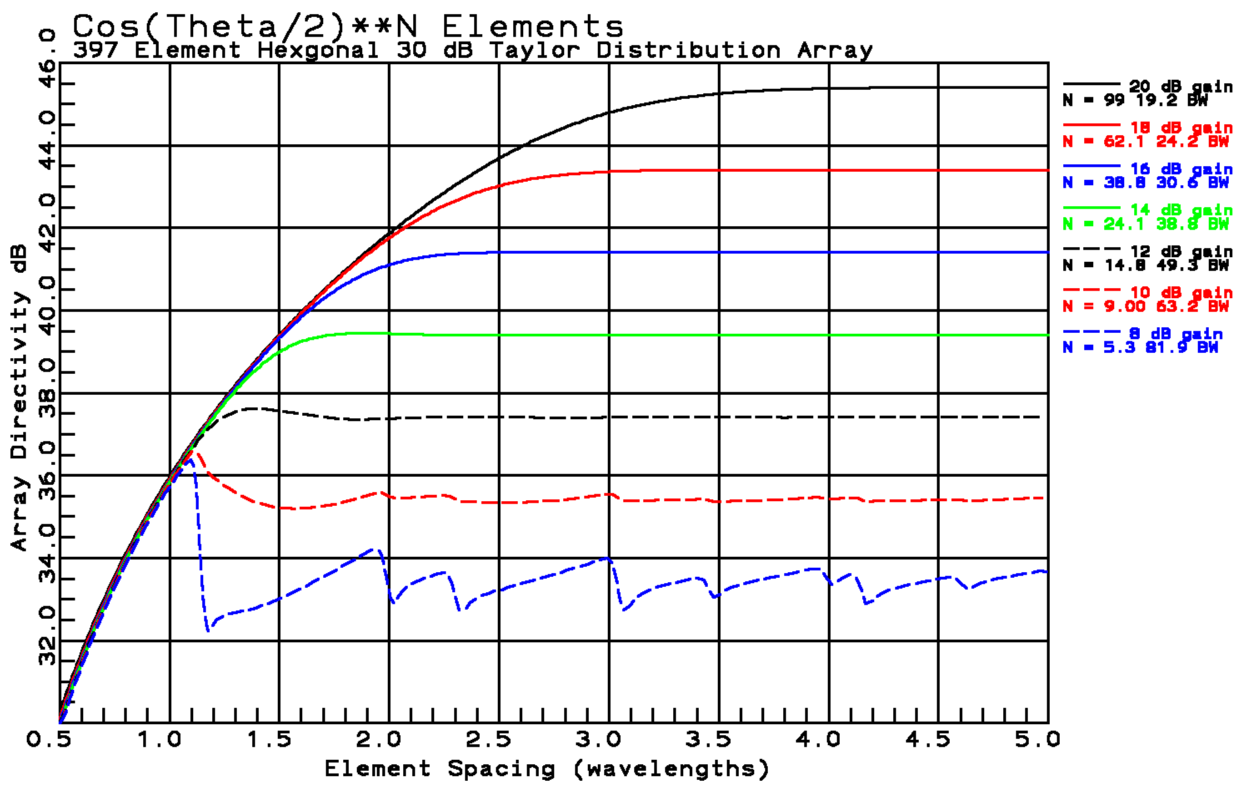
397 Element Hexagonal Array with Uniform Distribution



397 Element Hexagonal Array with Uniform Distribution



397 Element Hexagonal Array with 30 dB Circular Taylor Distribution



397 Element Hexagonal Array with 30 dB Circular Taylor Distribution