8-4.1 Feed Sidelobe Illumination

When we feed a reflector with a narrow beam feed antenna, the narrow beam will under-illuminate the reflector causing reduce the amplitude taper efficiency while decreasing the feed power spilled past the rim of the reflector. However, the feed sidelobe illumination of the reflector will decrease phase error efficiency because the first sidelobe is 180° out of phase with respect to the main feed beam. The following analysis uses aperture theory on a circularly symmetric reflector fed by a feed with circular symmetry.

The feed uses a circular aperture excited by a circular Taylor distribution (Section 4-19) where the size has been adjusted to produce a suitable beam while making an adjustment due to the obliquity factor similar to the circular horn (Section 7-2). The obliquity factor also reduces the first sidelobe level and the Taylor distribution sidelobe level is adjusted to overcome the reduced the sidelobe. The Taylor distribution design procedure generates the first pattern null in U space and the aperture radius can be adjusted to produce a particular feed pattern null. We will track the additional loss as the null moves across the reflector aperture. Figure 8-4.1.1 shows the pattern of a feed with a pattern null at 60° off broadside.

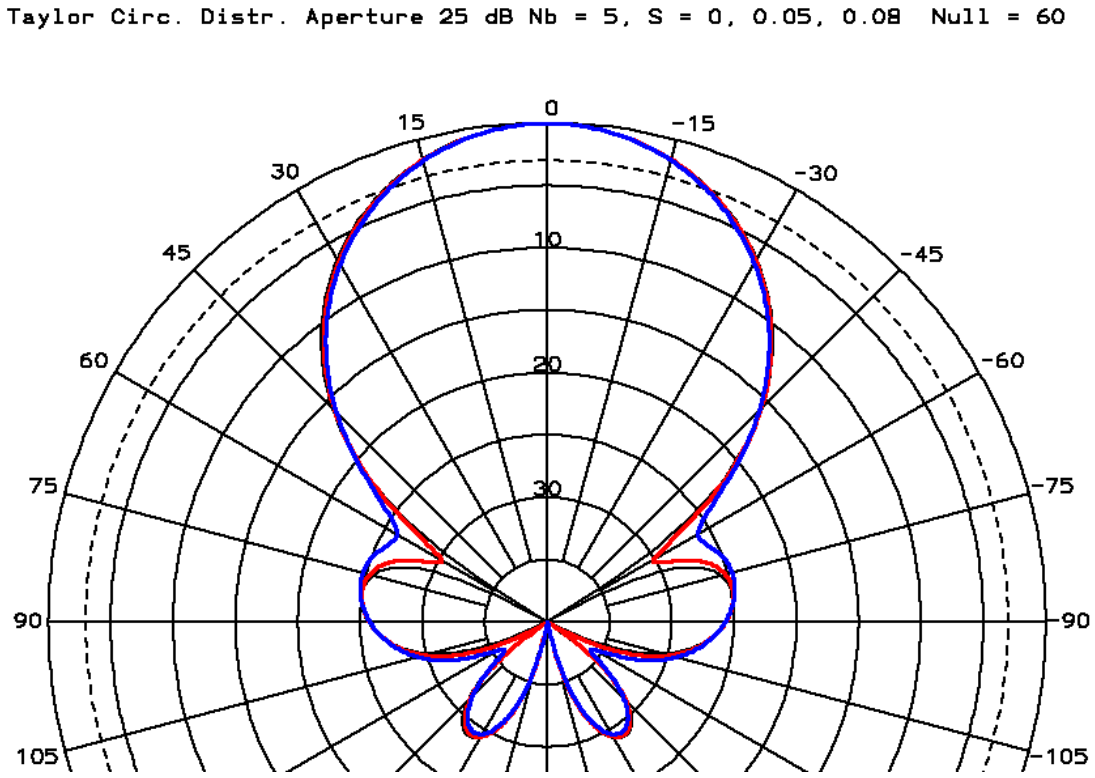

Figure 8-4.1.1 Reflector feed using Circular Taylor distribution aperture plus the obliquity pattern of the Huygens source to generate a pattern null 60° off broadside.

The figure illustrates the use of quadratic phase error (S) across the aperture to reduce the depth of the first pattern null. To achieve 25 dB sidelobes at the wide pattern angle, it was necessary to adjust the first sidelobe of the Taylor distribution: 16.1 dB (S = 0), 17.3 dB (S = 0.05), and 19.3 dB (S = 0.08). The aperture size has also been reduced to achieve a wide feed null: 0.629λ radius (S = 0), 0.655λ radius (S = 0.05), and 0.694λ radius (S = 0.08). The quadratic phase error also shifted the effective feed phase center into the aperture 0.044λ (S = 0.05) and 0.079λ (S = 0.08). The following analyses have adjusted the Taylor distribution sidelobe level, aperture radius, and the z-axis offset of the feed by its phase center for every case as the feed pattern null is varied.

We can use aperture theory and feed illumination loss analysis (Section 8-2) to compute the illumination losses. By adding the additional feed taper (Eq. 8-3) to the feed pattern, the k-space pattern can be generated given *f/D* for a generalized reflector independent of size by using the circular symmetric aperture analysis (Eq. 4-81). An initial analysis using a wide beam feed determines normal ATL and SPL to normalize the results to produce addition losses due to sidelobe illumination results.

Case 1 *f/D* = 0.433; 120° initial 10 dB Beam Feed 25 dB Sidelobes

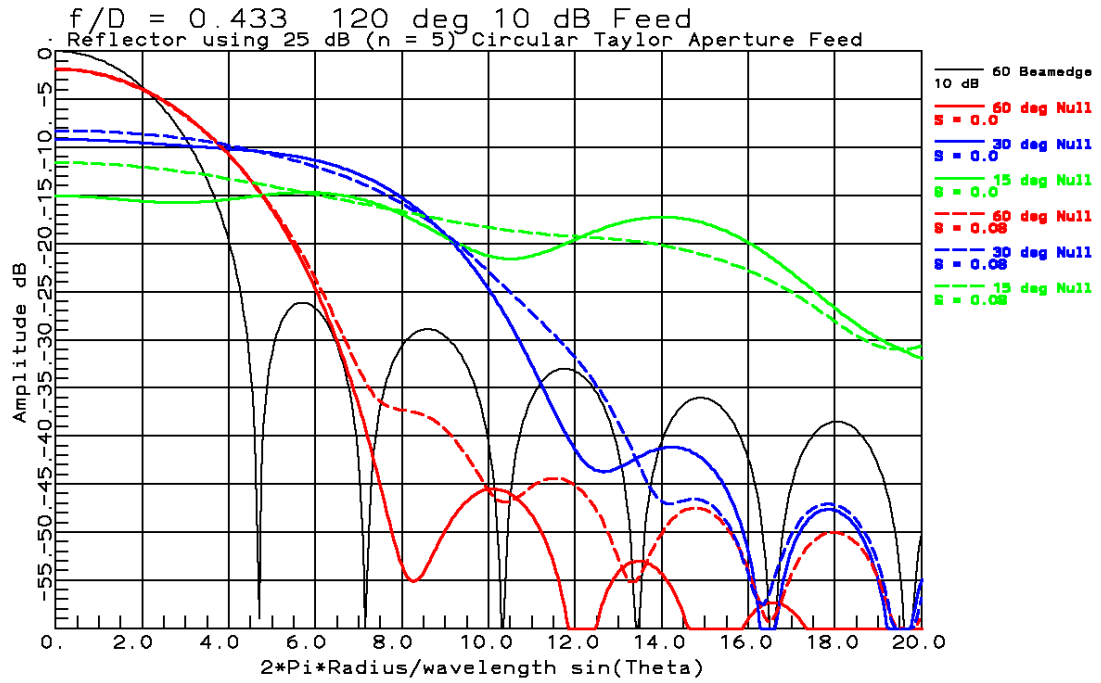

Figure 8-4.1.2 k-space pattern for *f/D* = 0.433 for pattern nulls at 60° (reflector rim), 30° and 15° compared to normal feed 25 dB first feed pattern sidelobe

Figure 8-4.1.3 plots the additional illumination loss due to sidelobe illumination versus the direction of the first pattern null of the feed. The dominate term is the combination of ATL and SPL. Of course, the spillover loss becomes less and less as the feed beamwidth is narrowed. When the first sidelobe starts illuminating the reflector for nulls less than 60° the phase error loss (PEL) becomes significant. Figure 8-4.1.2 illustrates how narrowing the feed pattern widens the reflector pattern because it is under-illuminated. The PEL has its first loss maximum for a feed pattern null about 36°. Figure 8-4.1.4 plots the feed pattern for a null at 30° and we see that the second sidelobe begins to illuminate the reflector as the first null moves inward on the reflector. The first sidelobe phase is 180° out-of-phase with respect to the main beam and the 2nd sidelobe has the same phase as the main beam. The illumination by the second sidelobe, as shown in Figure 8-4.1.4, increases the gain of the reflector as the first null angle of the feed decreases. Of course, the decreased main beam radiation angle increases the ATL. Lower feed sidelobes (Figures 8-4.1.12 and 8-4.1.16) show increased taper loss and decreased sidelobe PEL illumination effects.

Both Figure 8-4.1.2 and Figure 8-4.1.5 demonstrate that adding a quadratic phase across the feed aperture affects the normalized illumination losses. In some cases the quadratic phase improves the gain. Figure 8-4.1.2 shows that the inner nulls of the reflector pattern will be filled in when the null direction is close to the angle of the rim. This effect lessens when the sidelobe levels are less (Figure 8-4.1.14).

The 30 cases below show that *f/D* has a minor effect on results.

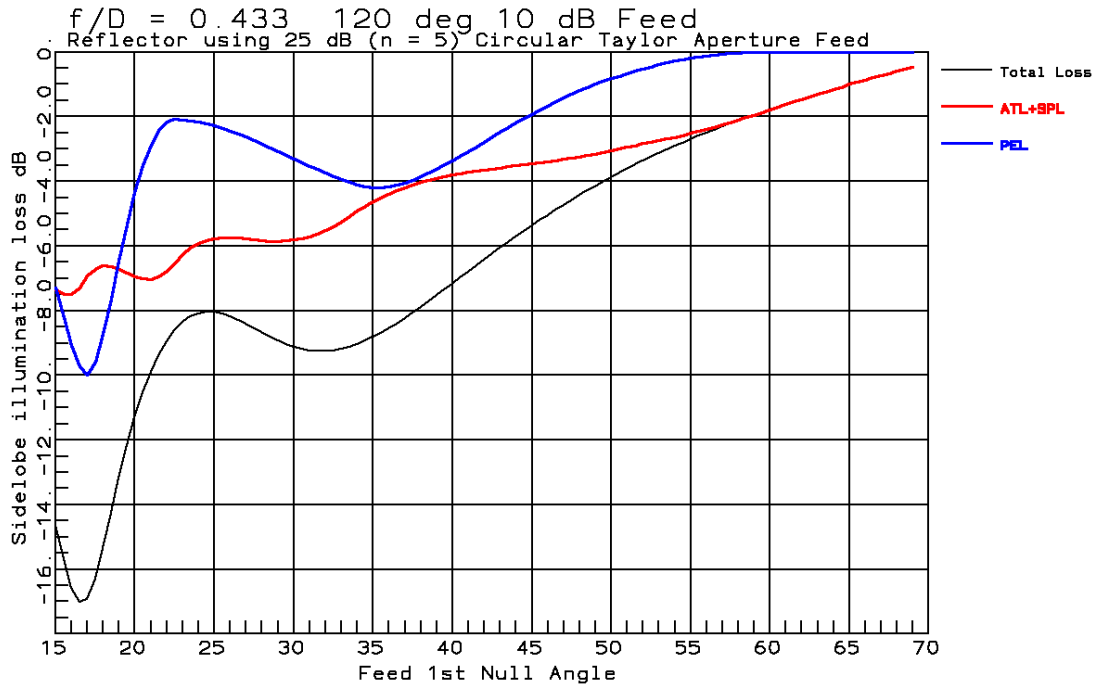

Figure 8-4.1.3 Illumination loss terms for *f/D* = 0.433 versus feed pattern null (60° reflector rim) (S = 0) compared to normal feed 25 dB feed sidelobes

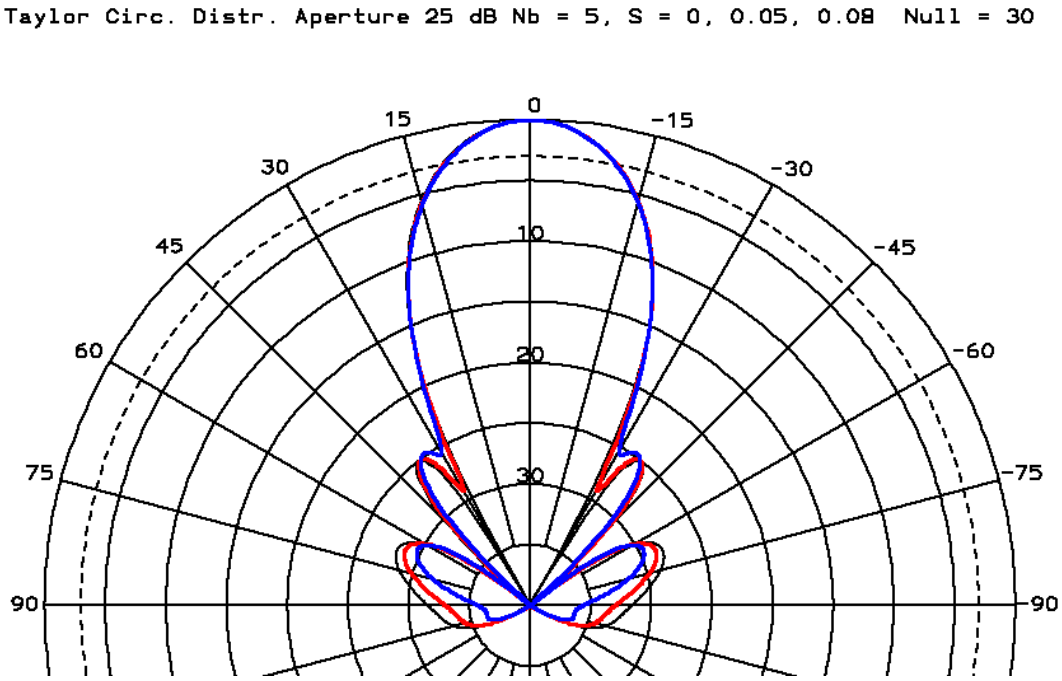

Figure 8-4.1.4 Reflector feed using Circular Taylor distribution aperture plus the obliquity pattern of the Huygens source to generate a pattern null 30° off broadside.

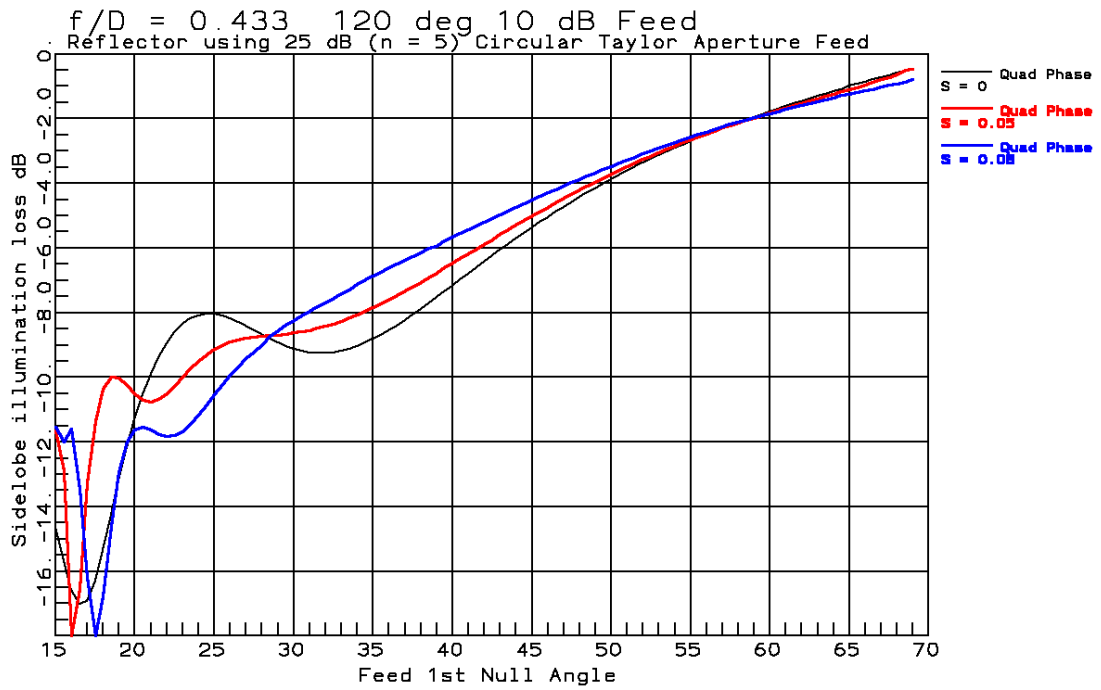

Figure 8-4.1.5 Illumination loss using various quadratic phase in the feed aperture for *f/D* = 0.433 versus feed pattern null (60° reflector rim) compared to normal feed with 25 dB sidelobes

Case 2 *f/D* = 0.433; 120° initial 10 dB Beam Feed 18 dB Sidelobes

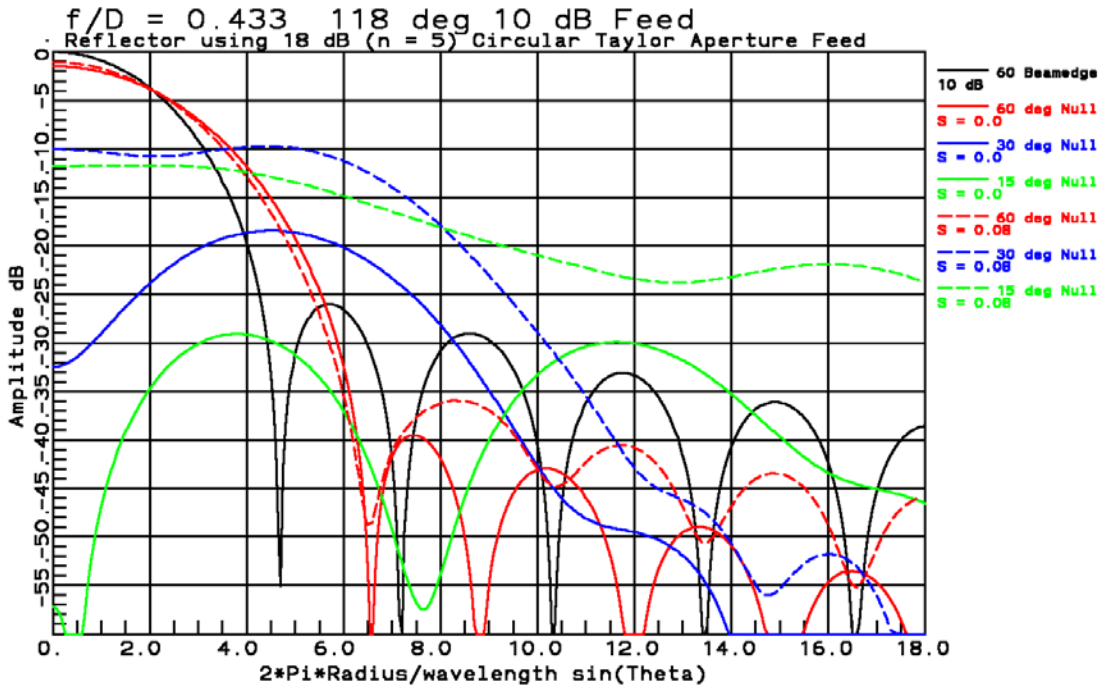

Figure 8-4.1.6 k-space pattern for *f/D* = 0.433 for pattern nulls at 60° (reflector rim), 30° and 15° compared to normal feed 18 dB first feed pattern sidelobe

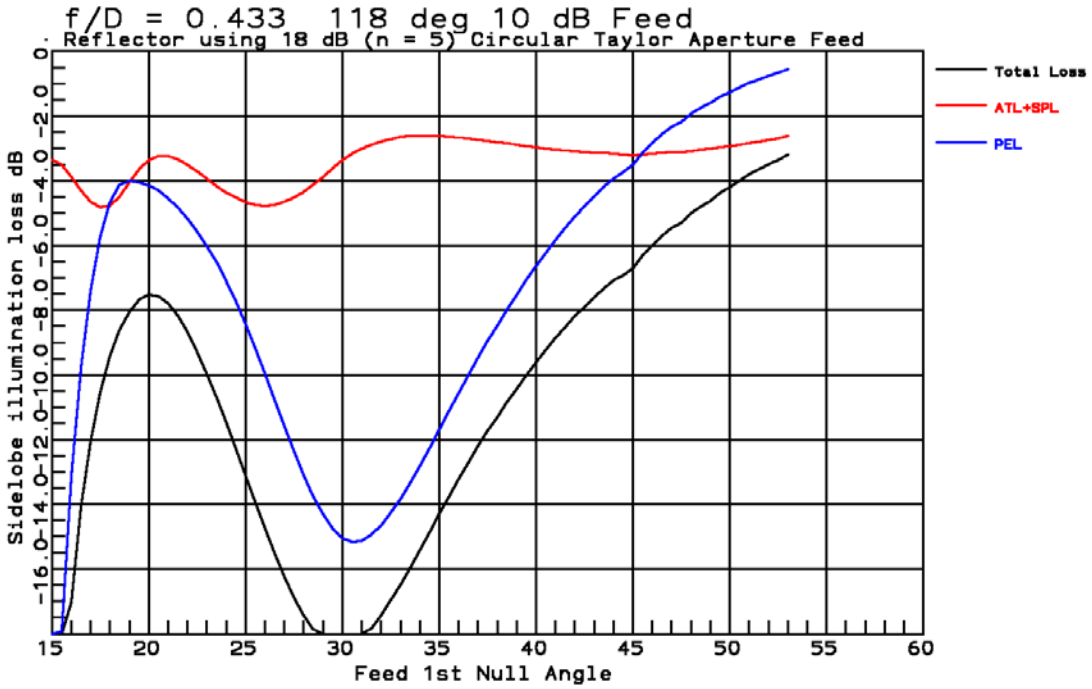

Figure 8-4.1.7 Illumination loss terms for *f/D* = 0.433 versus feed pattern null (60° reflector rim) (S = 0) compared to normal feed 30 dB feed sidelobes

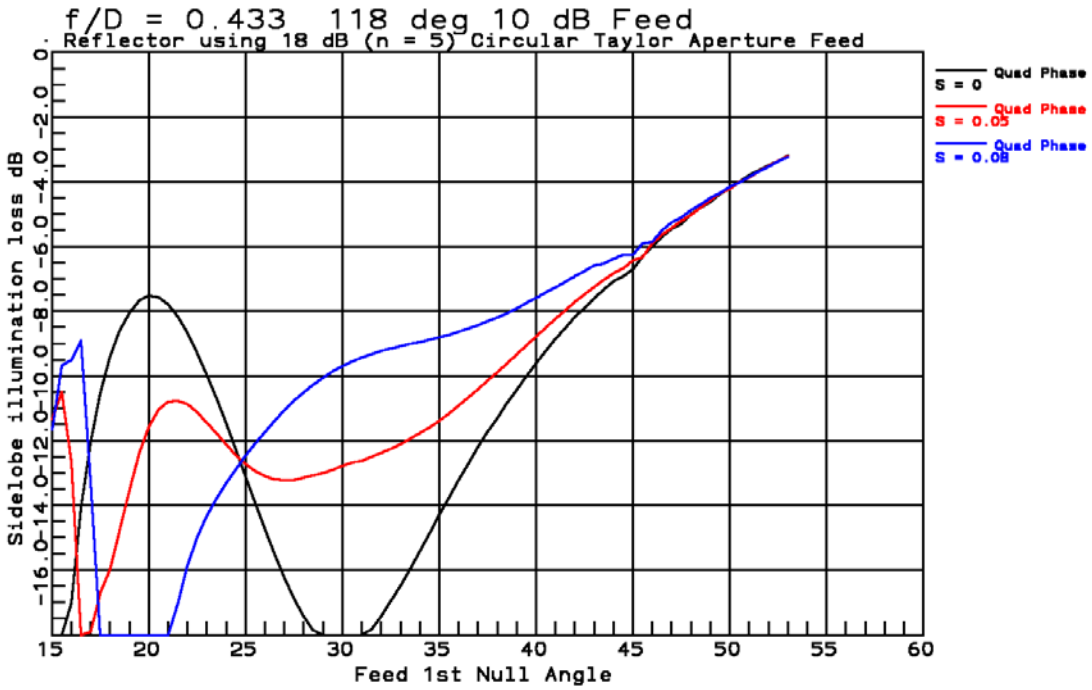

Figure 8-4.1.8 Illumination loss using various quadratic phase in the feed aperture for *f/D* = 0.433 versus feed pattern null (60° reflector rim) compared to normal feed with 18 dB sidelobes

Case 3 *f/D* = 0.433; 120° initial 10 dB Beam Feed 20 dB Sidelobes

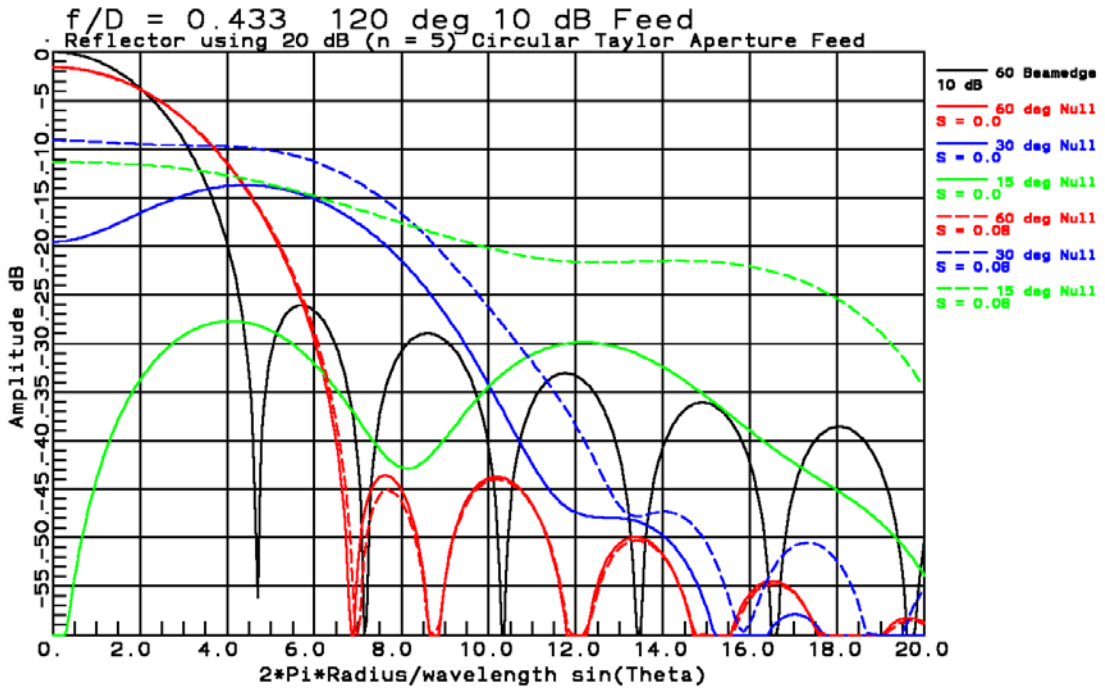

Figure 8-4.1.9 k-space pattern for *f/D* = 0.433 for pattern nulls at 60° (reflector rim), 30° and 15° compared to normal feed 20 dB first feed pattern sidelobe

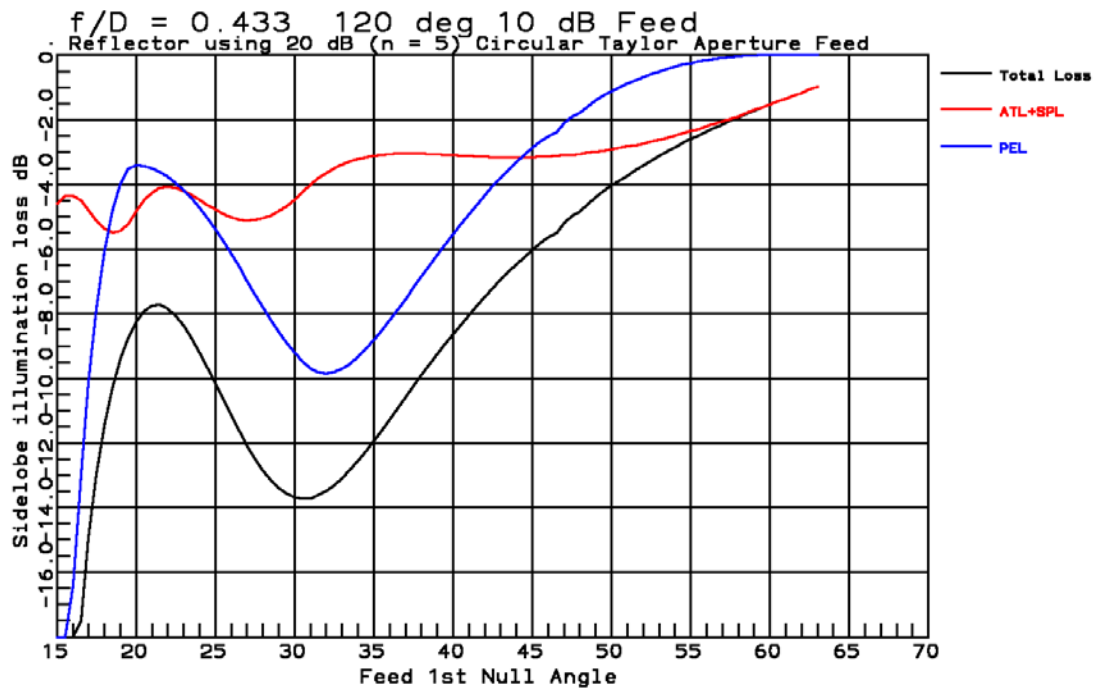

Figure 8-4.1.10 Illumination loss terms for *f/D* = 0.433 versus feed pattern null (60° reflector rim) (S = 0) compared to normal feed 20 dB feed sidelobes

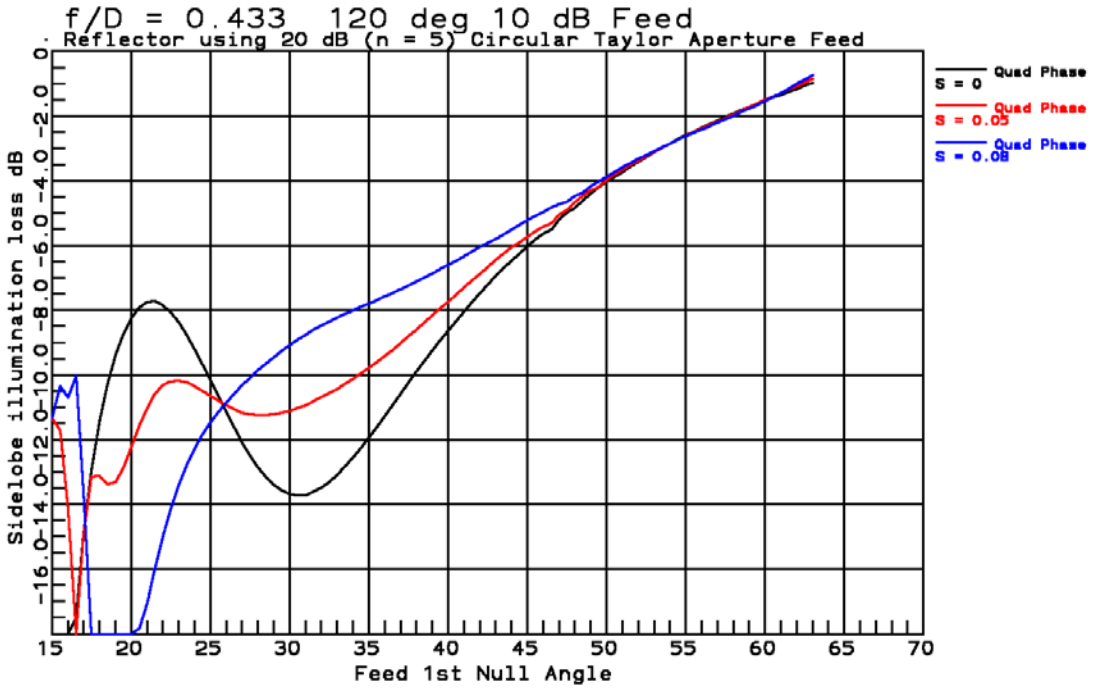

Figure 8-4.1.11 Illumination loss using various quadratic phase in the feed aperture for *f/D* = 0.433 versus feed pattern null (60° reflector rim) compared to normal feed with 20 dB sidelobes

Case 4 *f/D* = 0.433; 120° initial 10 dB Beam Feed 30 dB Sidelobes

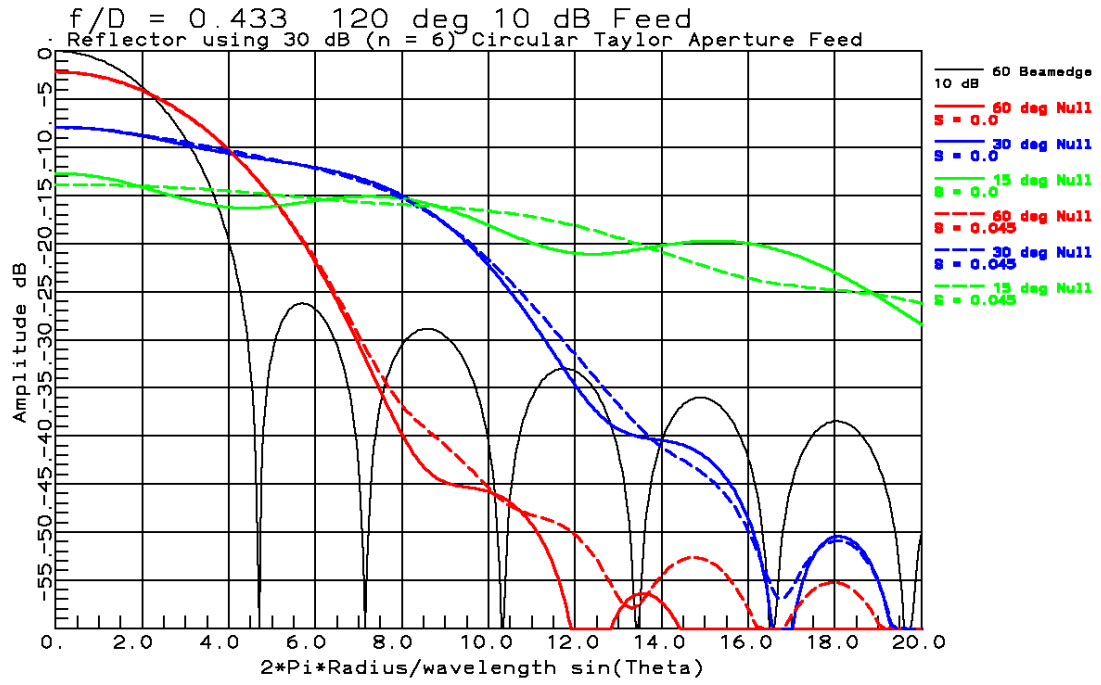

Figure 8-4.1.12 k-space pattern for *f/D* = 0.433 for pattern nulls at 60° (reflector rim), 30° and 15° compared to normal feed 30 dB first feed pattern sidelobe

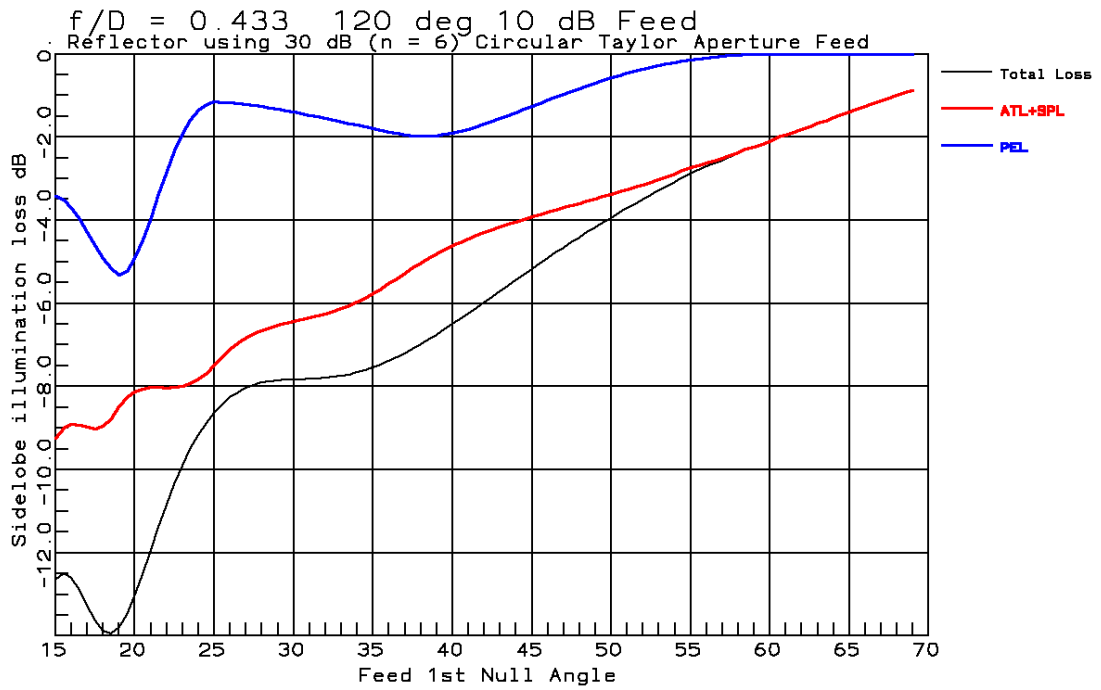

Figure 8-4.1.13 Illumination loss terms for *f/D* = 0.433 versus feed pattern null (60° reflector rim) (S = 0) compared to normal feed 30 dB feed sidelobes

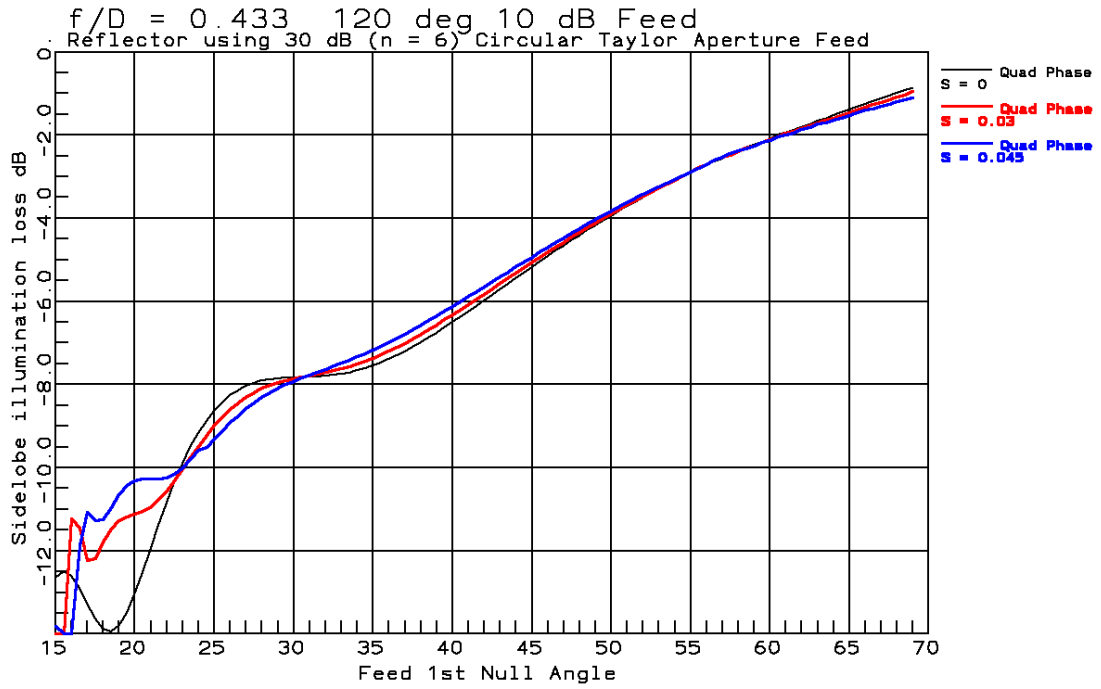

Figure 8-4.1.14 Illumination loss using various quadratic phase in the feed aperture for *f/D* = 0.433 versus feed pattern null (60° reflector rim) compared to normal feed with 30 dB sidelobes

Case 5 *f/D* = 0.433; 120° initial 10 dB Beam Feed 35 dB Sidelobes

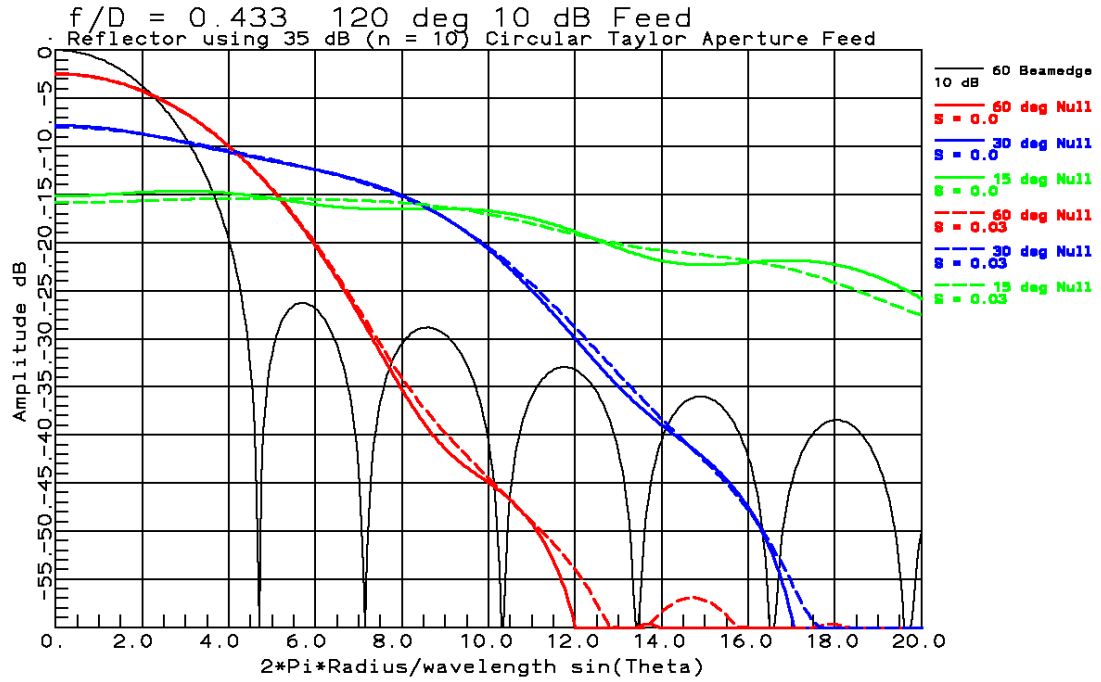

Figure 8-4.1.15 k-space pattern for *f/D* = 0.433 for pattern nulls at 60° (reflector rim), 30° and 15° compared to normal feed 35 dB first feed pattern sidelobe

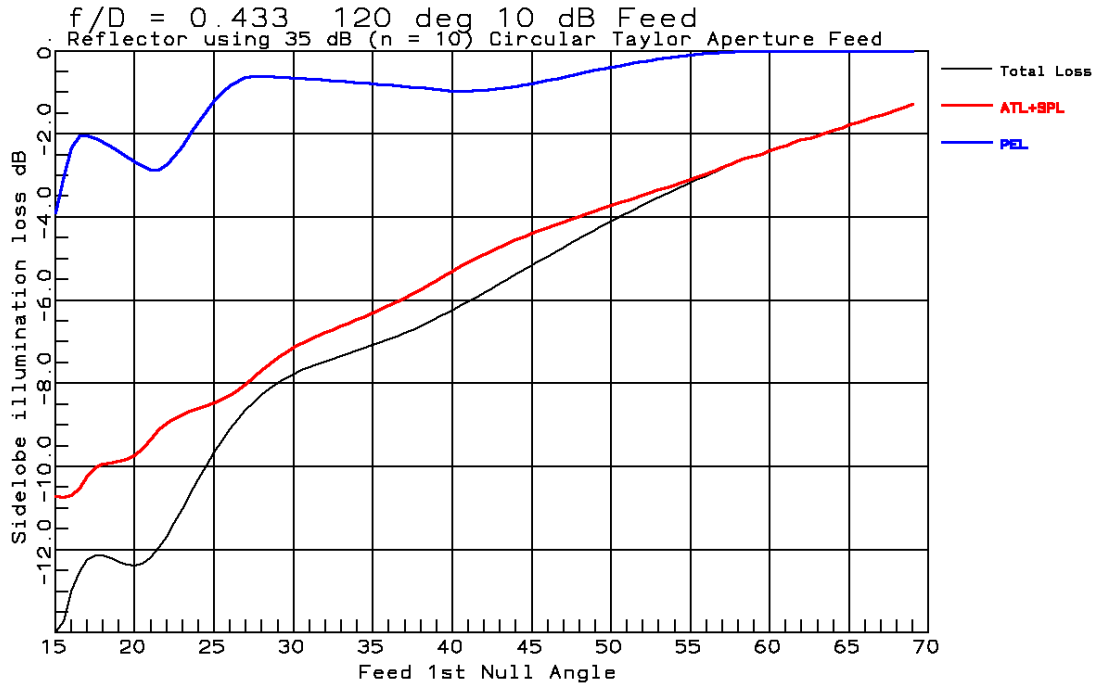

Figure 8-4.1.16 Illumination loss terms for *f/D* = 0.433 versus feed pattern null (60° reflector rim) (S = 0) compared to normal feed 35 dB feed sidelobes

Case 6 *f/D* = 0.536; 100° initial 10 dB Beam Feed 18 dB Sidelobes

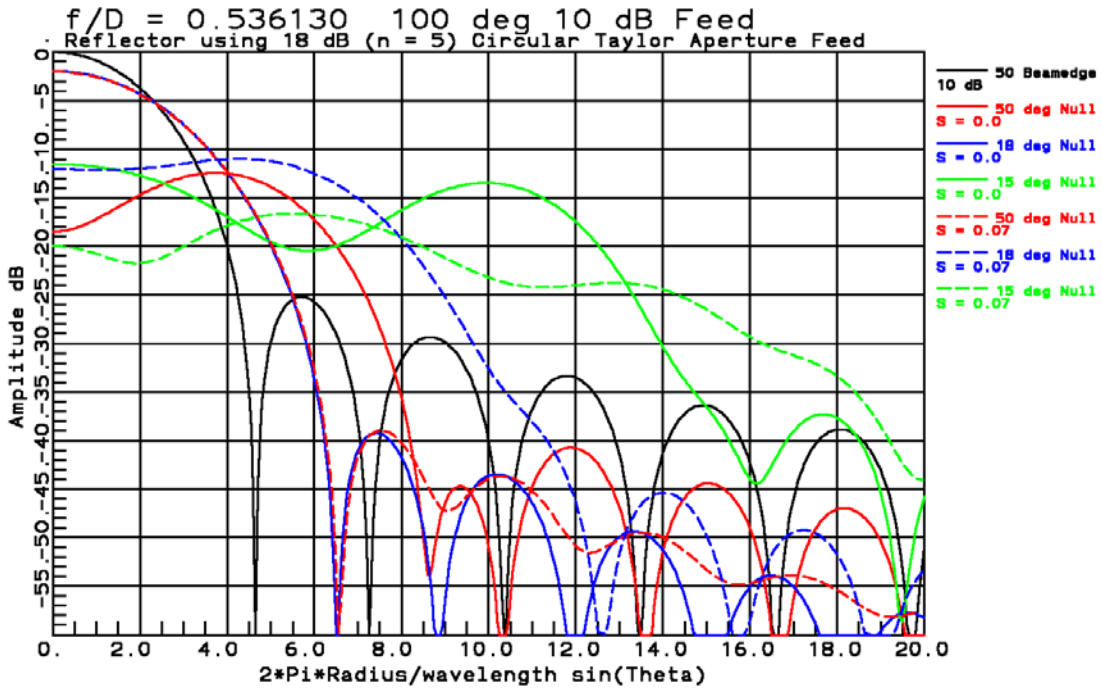

Figure 8-4.1.17 k-space pattern for *f/D* = 0.536 for pattern nulls at 50° (reflector rim), 25° and 15° compared to normal feed 18 dB first feed pattern sidelobe

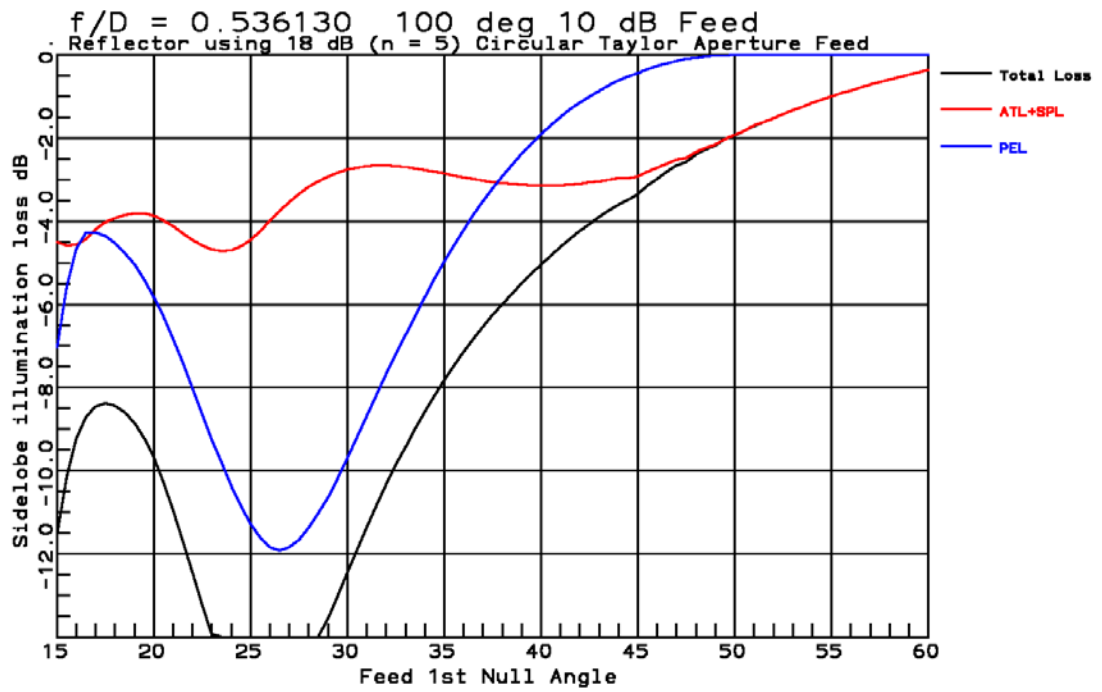

Figure 8-4.1.18 Illumination loss terms for *f/D* = 0.536 versus feed pattern null (50° reflector rim) (S = 0) compared to normal feed 18 dB feed sidelobes

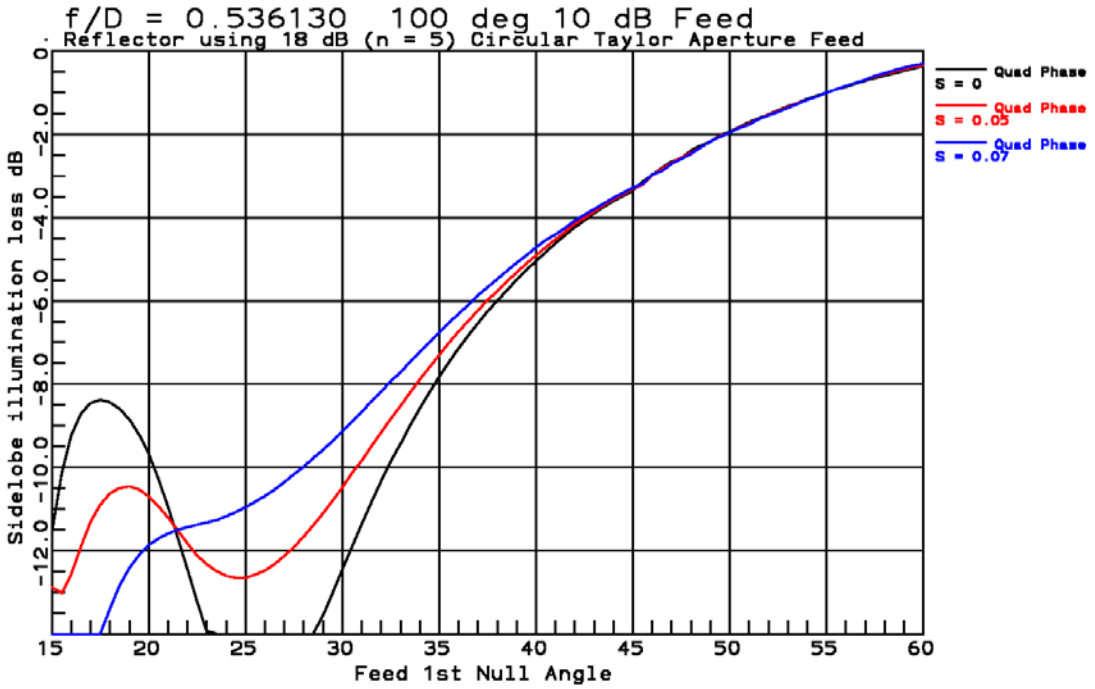

Figure 8-4.1.19 Illumination loss using various quadratic phase in the feed aperture for *f/D* = 0.536 versus feed pattern null (50° reflector rim) compared to normal feed with 18 dB sidelobes

Case 7 *f/D* = 0.536; 100° initial 10 dB Beam Feed 20 dB Sidelobes

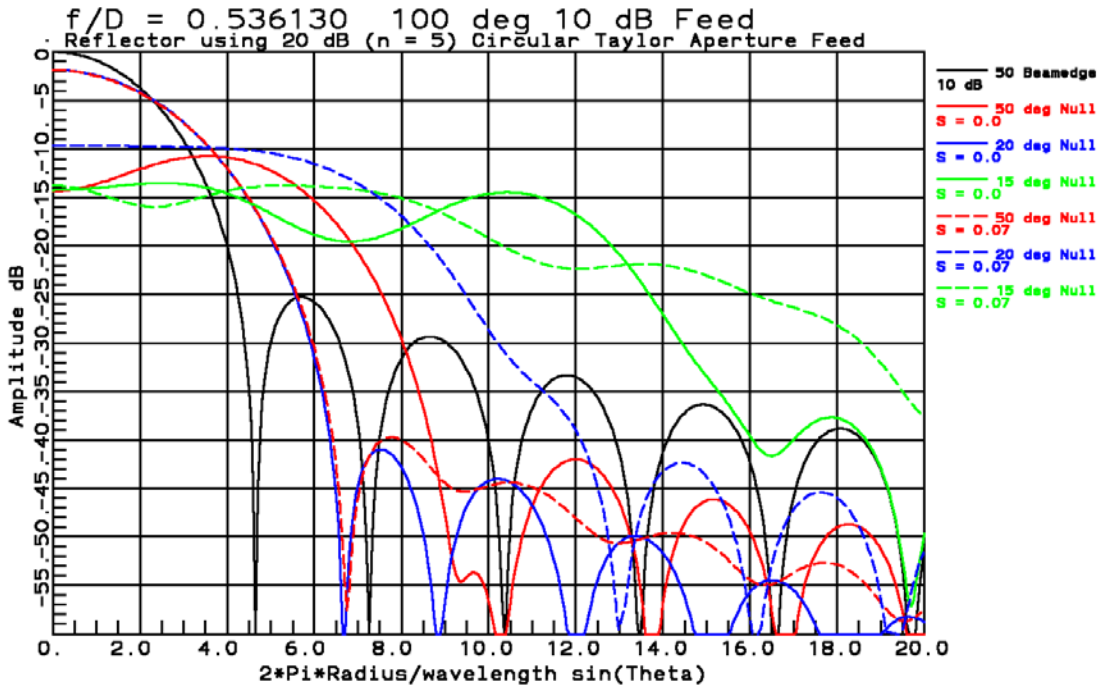

Figure 8-4.1.20 k-space pattern for *f/D* = 0.536 for pattern nulls at 50° (reflector rim), 25° and 15° compared to normal feed 20 dB first feed pattern sidelobe

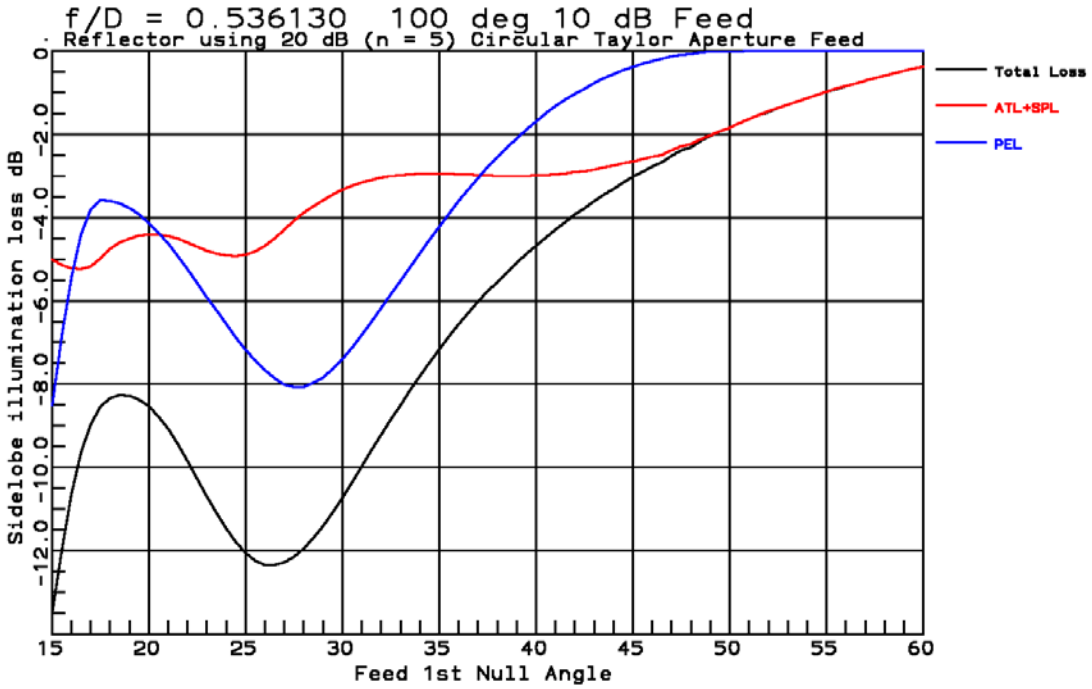

Figure 8-4.1.21 Illumination loss terms for *f/D* = 0.536 versus feed pattern null (50° reflector rim) (S = 0) compared to normal feed 20 dB feed sidelobes

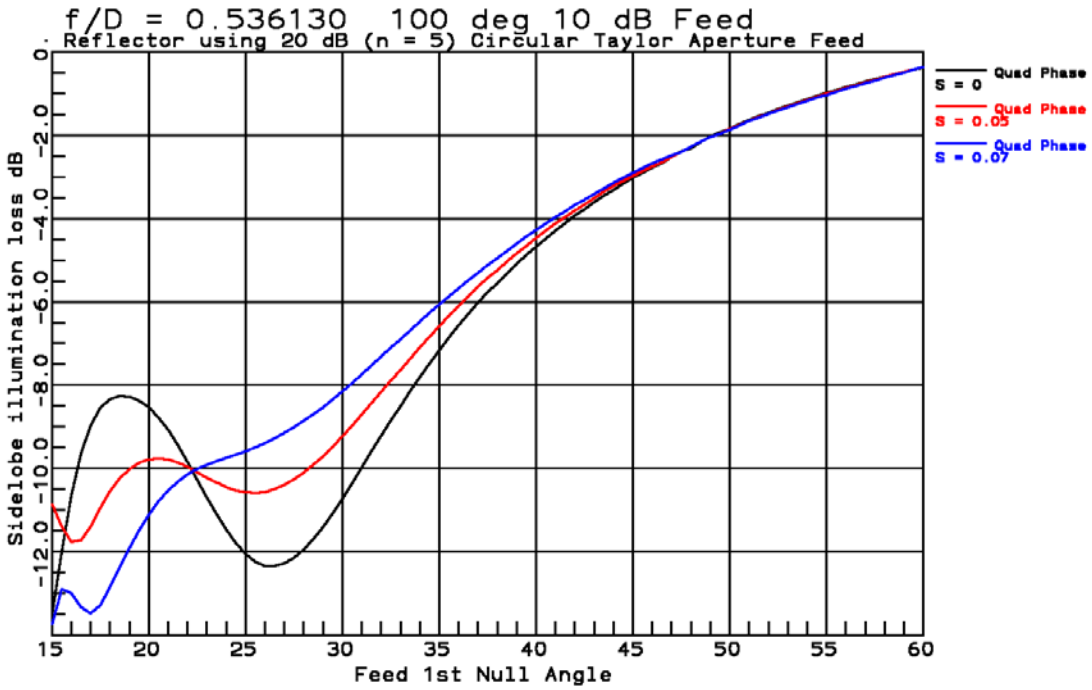

Figure 8-4.1.22 Illumination loss using various quadratic phase in the feed aperture for *f/D* = 0.536 versus feed pattern null (50° reflector rim) compared to normal feed with 20 dB sidelobes

Case 8 *f/D* = 0.536; 100° initial 10 dB Beam Feed 25 dB Sidelobes

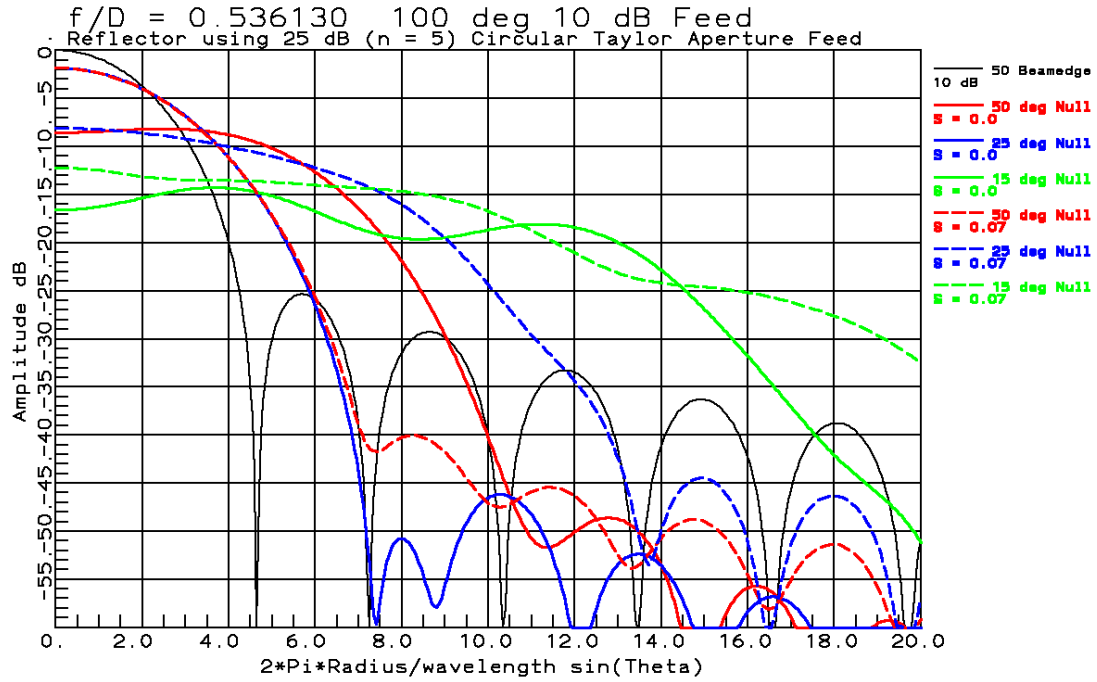

Figure 8-4.1.23 k-space pattern for *f/D* = 0.536 for pattern nulls at 50° (reflector rim), 25° and 15° compared to normal feed 25 dB first feed pattern sidelobe

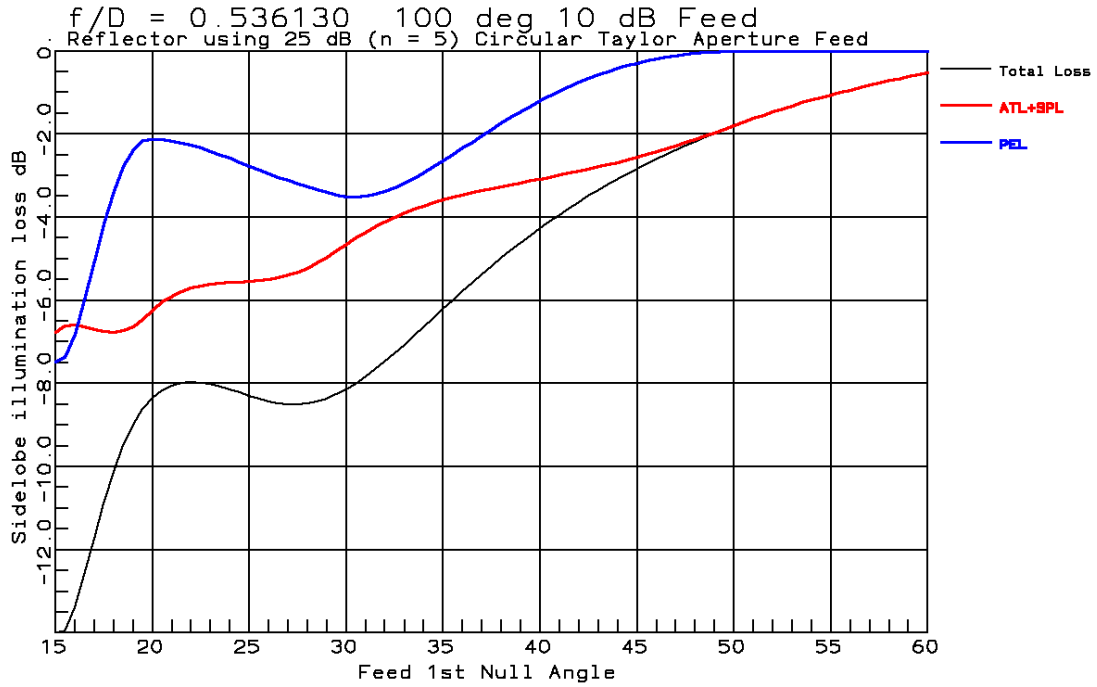

Figure 8-4.1.24 Illumination loss terms for *f/D* = 0.536 versus feed pattern null (50° reflector rim) (S = 0) compared to normal feed 25 dB feed sidelobes

Case 9 *f/D* = 0.536; 100° initial 10 dB Beam Feed 30 dB Sidelobes

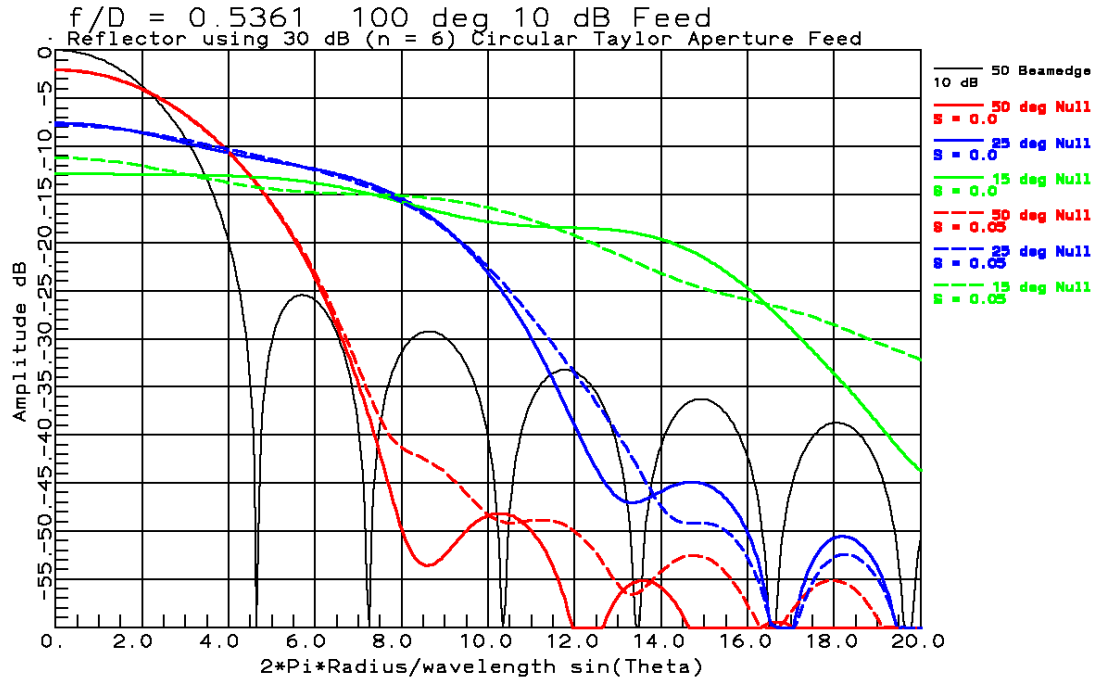

Figure 8-4.1.25 k-space pattern for *f/D* = 0.536 for pattern nulls at 50° (reflector rim), 25° and 15° compared to normal feed 30 dB first feed pattern sidelobe

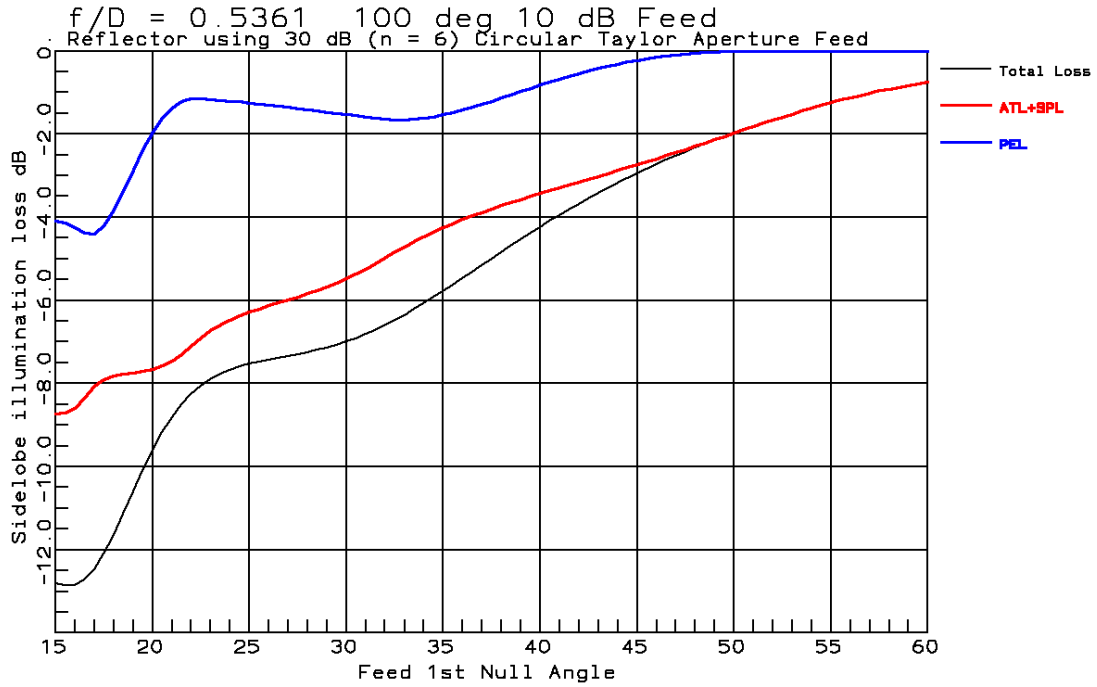

Figure 8-4.1.26 Illumination loss terms for *f/D* = 0.536 versus feed pattern null (50° reflector rim) (S = 0) compared to normal feed 30 dB feed sidelobes

Case 10 *f/D* = 0.536; 100° initial 10 dB Beam Feed 35 dB Sidelobes

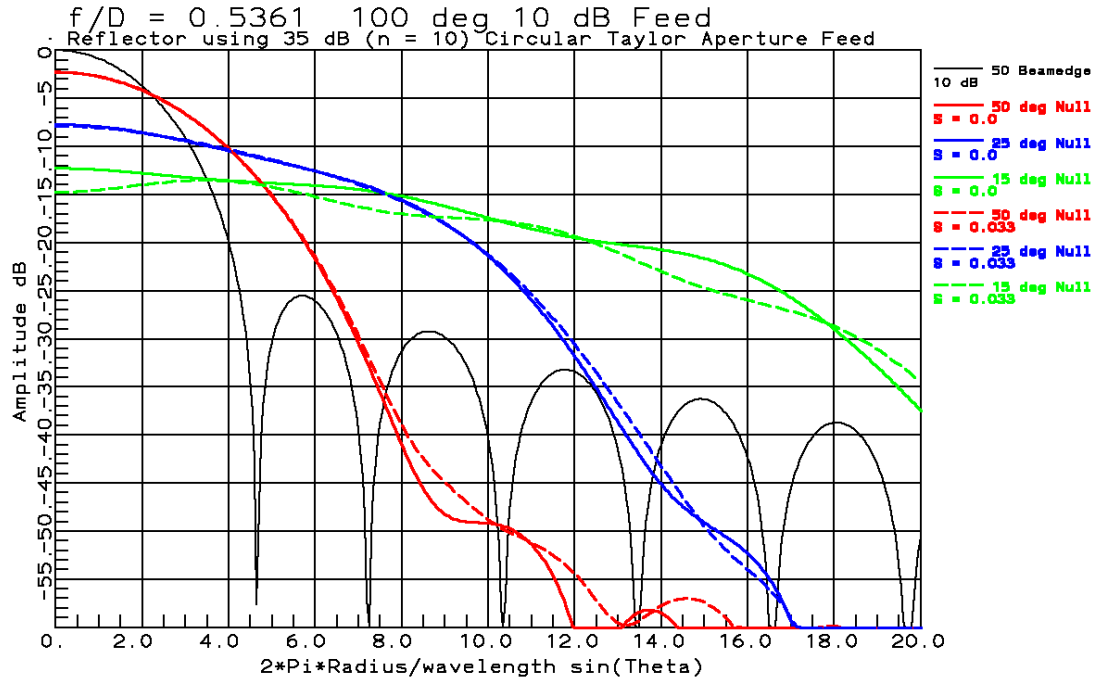

Figure 8-4.1.27 k-space pattern for *f/D* = 0.536 for pattern nulls at 50° (reflector rim), 25° and 15° compared to normal feed 35 dB first feed pattern sidelobe

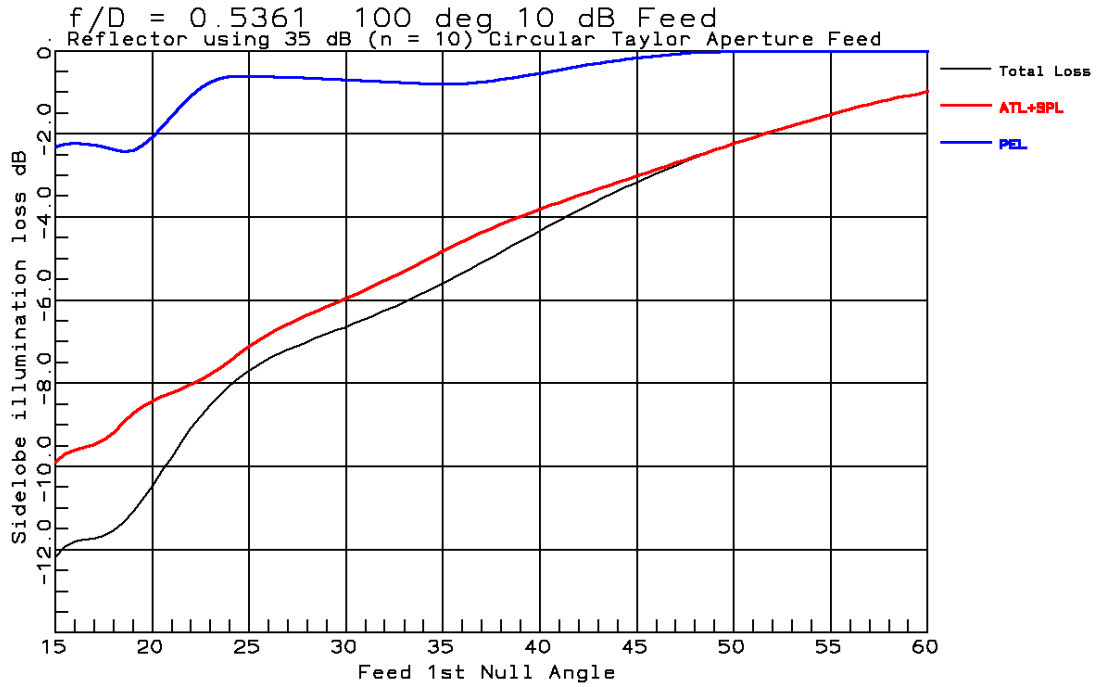

Figure 8-4.1.28 Illumination loss terms for *f/D* = 0.536 versus feed pattern null (50° reflector rim) (S = 0) compared to normal feed 35 dB feed sidelobes

Case 11 *f/D* = 0.687; 80° initial 10 dB Beam Feed 18 dB Sidelobes

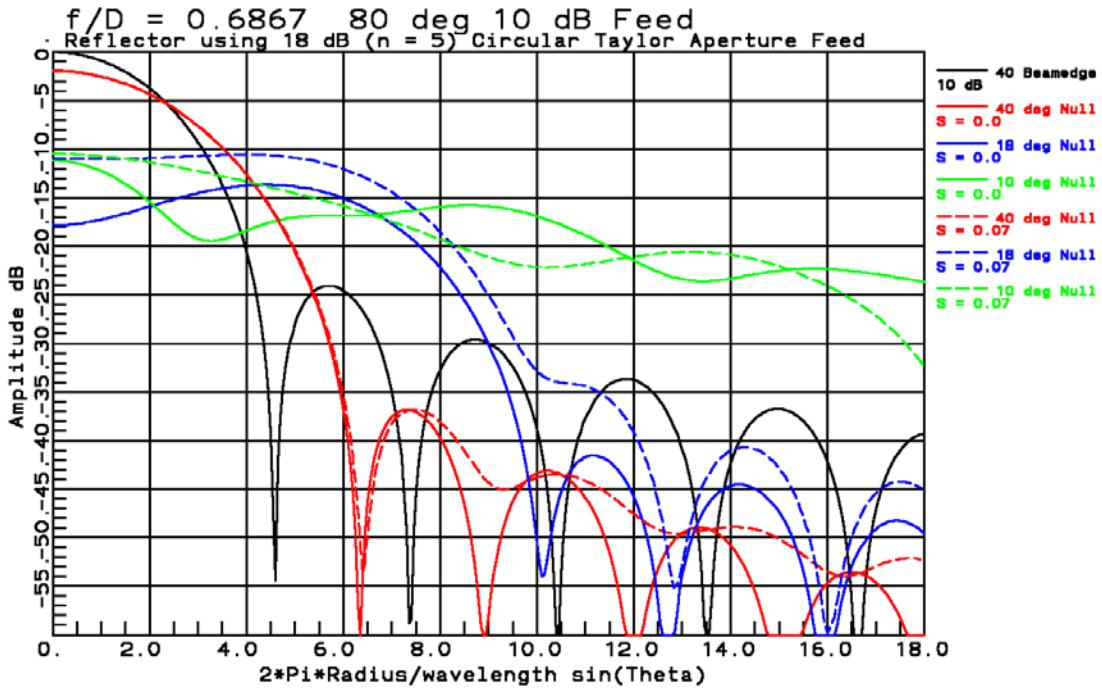

Figure 8-4.1.29 k-space pattern for *f/D* = 0.687 for pattern nulls at 40° (reflector rim), 20° and 10° compared to normal feed 18 dB first feed pattern sidelobe

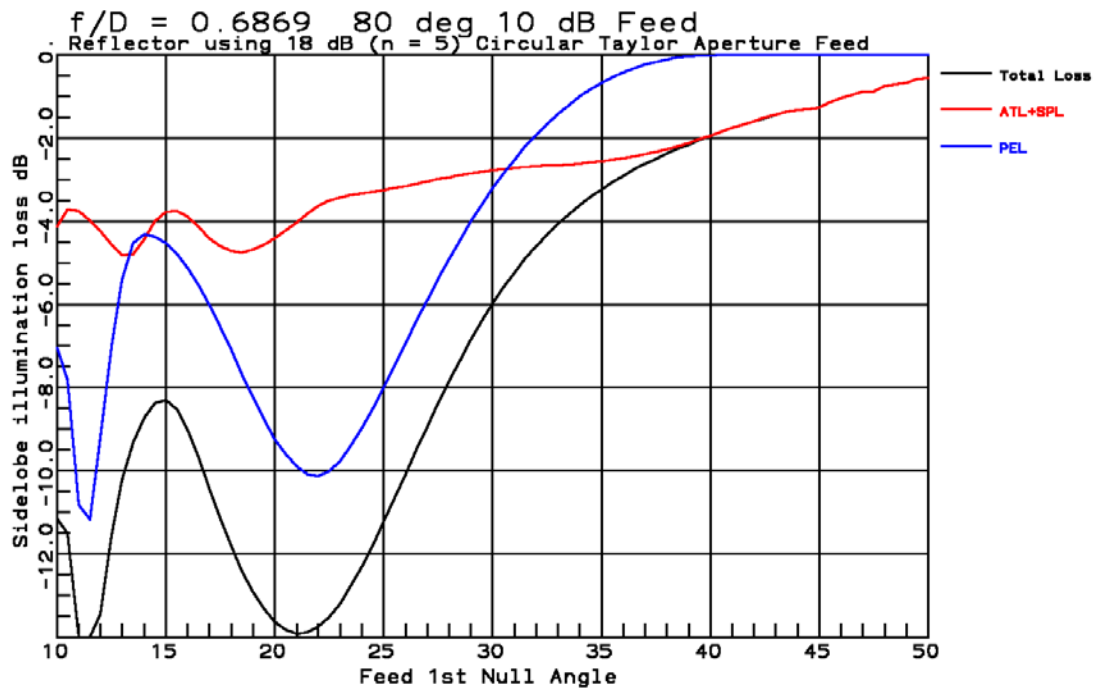

Figure 8-4.1.30 Illumination loss terms for *f/D* = 0.687 versus feed pattern null (40° reflector rim) (S = 0) compared to normal feed 18 dB feed sidelobes

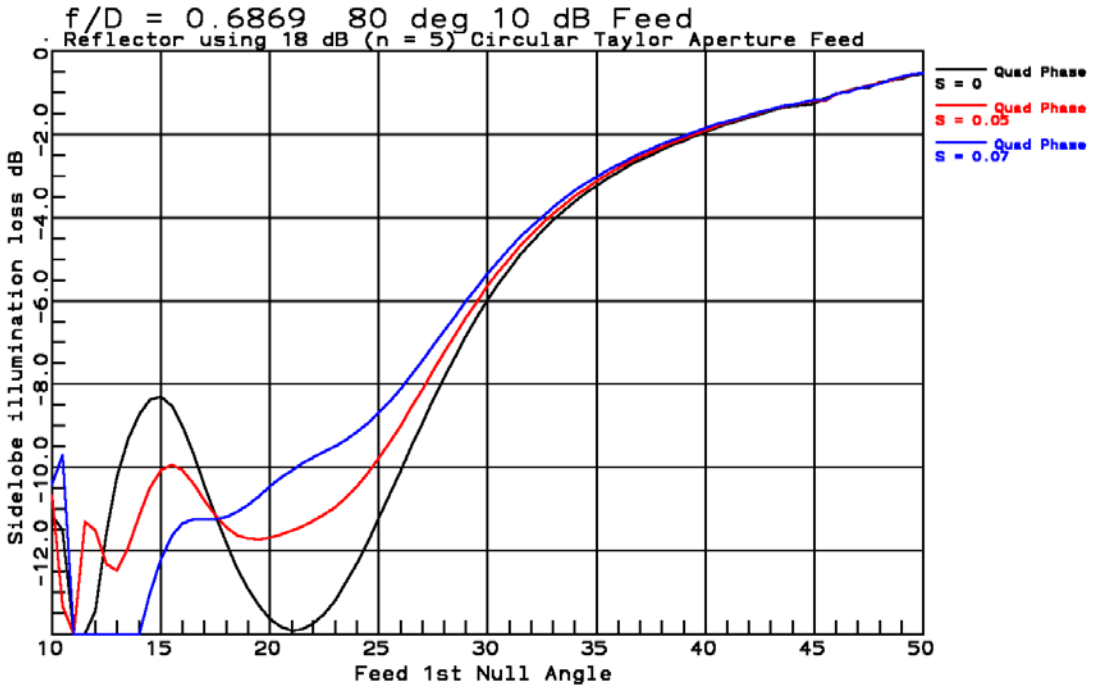

Figure 8-4.1.31 Illumination loss using various quadratic phase in the feed aperture for *f/D* = 0.687 versus feed pattern null (40° reflector rim) compared to normal feed with 18 dB sidelobes

Case 12 *f/D* = 0.687; 80° initial 10 dB Beam Feed 20 dB Sidelobes

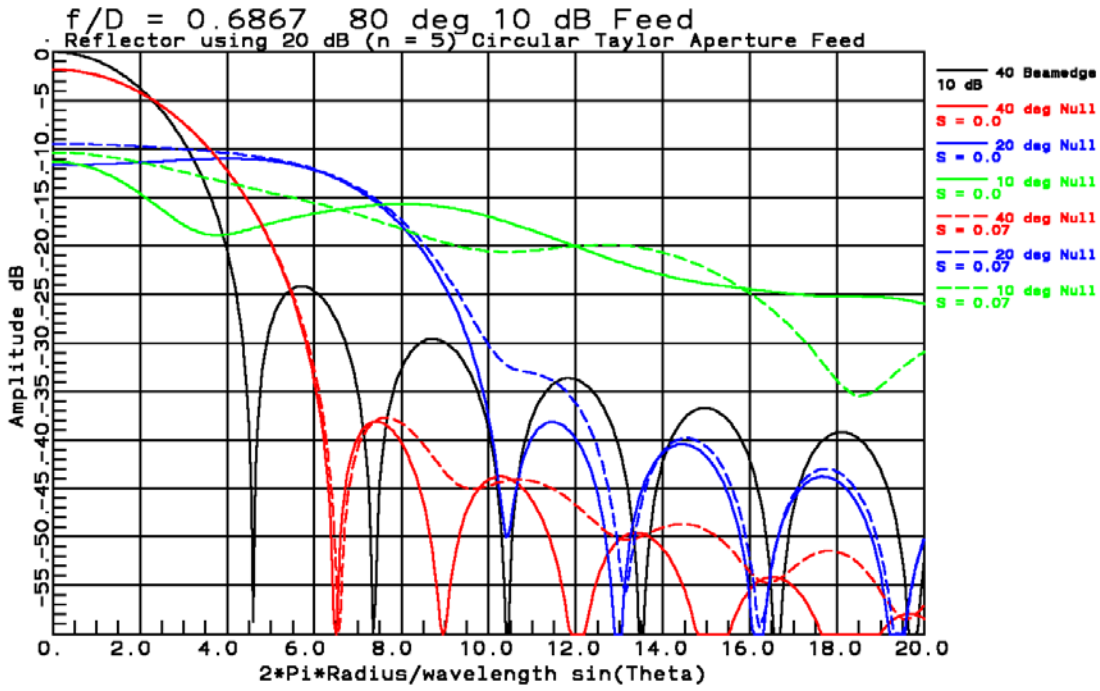

Figure 8-4.1.32 k-space pattern for *f/D* = 0.687 for pattern nulls at 40° (reflector rim), 20° and 10° compared to normal feed 20 dB first feed pattern sidelobe

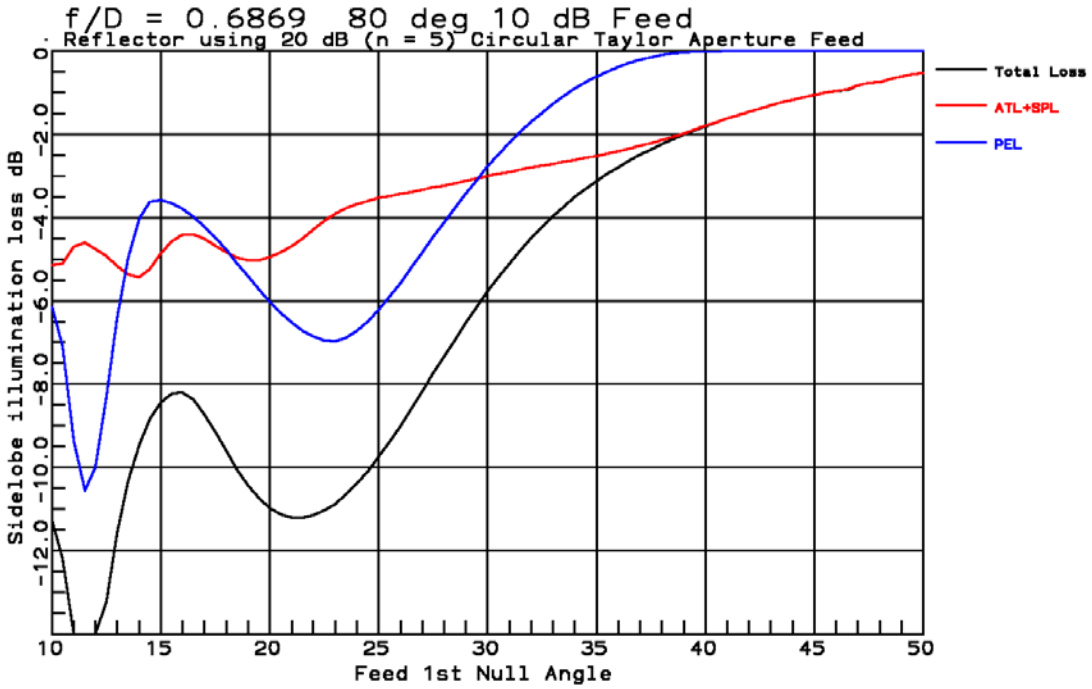

Figure 8-4.1.33 Illumination loss terms for *f/D* = 0.687 versus feed pattern null (40° reflector rim) (S = 0) compared to normal feed 20 dB feed sidelobes

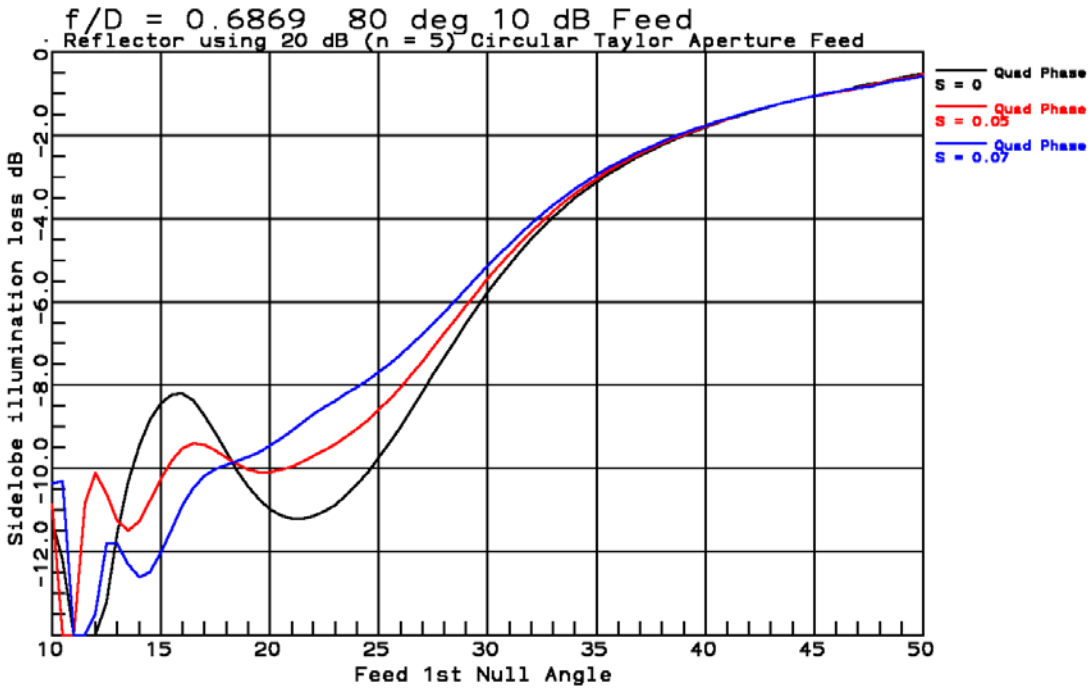

Figure 8-4.1.34 Illumination loss using various quadratic phase in the feed aperture for *f/D* = 0.687 versus feed pattern null (40° reflector rim) compared to normal feed with 20 dB sidelobes

Case 13 *f/D* = 0.687; 80° initial 10 dB Beam Feed 25 dB Sidelobes

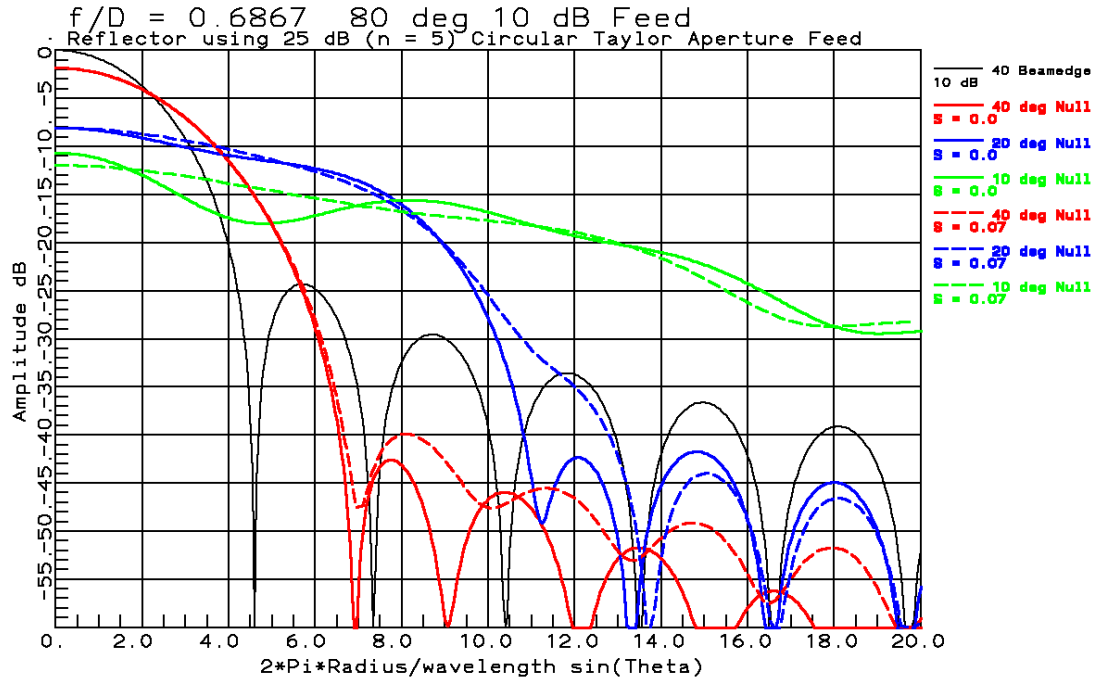

Figure 8-4.1.35 k-space pattern for *f/D* = 0.687 for pattern nulls at 40° (reflector rim), 20° and 10° compared to normal feed 25 dB first feed pattern sidelobe

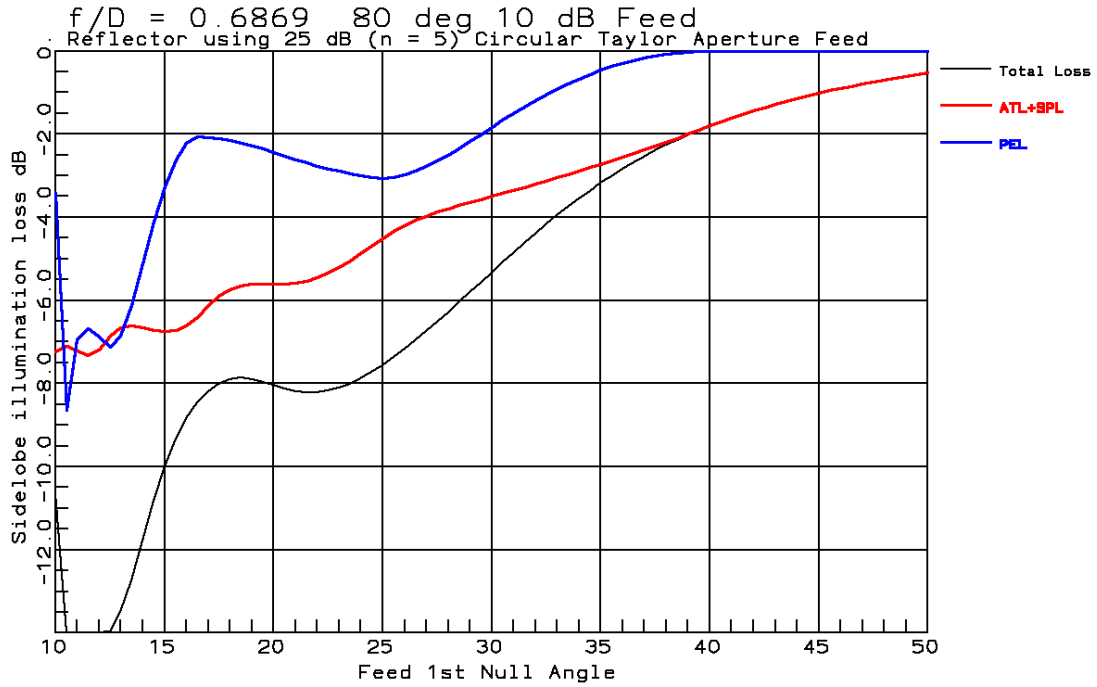

Figure 8-4.1.36 Illumination loss terms for *f/D* = 0.687 versus feed pattern null (40° reflector rim) (S = 0) compared to normal feed 25 dB feed sidelobes

Case 14 *f/D* = 0.687; 80° initial 10 dB Beam Feed 30 dB Sidelobes

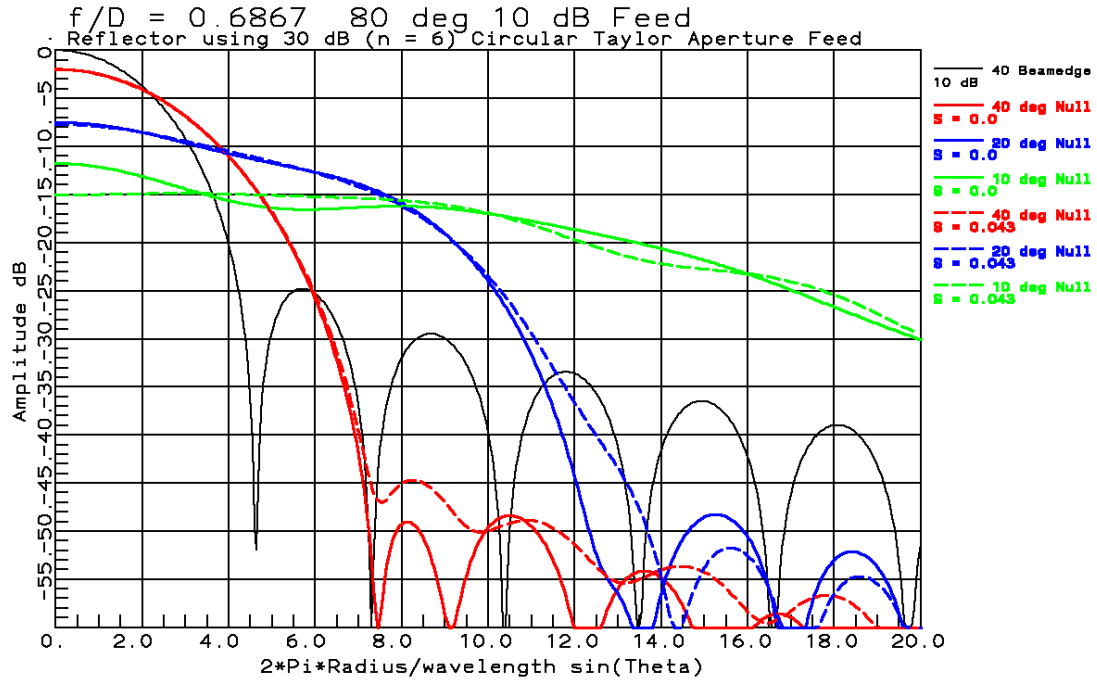

Figure 8-4.1.37 k-space pattern for *f/D* = 0.687 for pattern nulls at 40° (reflector rim), 20° and 10° compared to normal feed 30 dB first feed pattern sidelobe

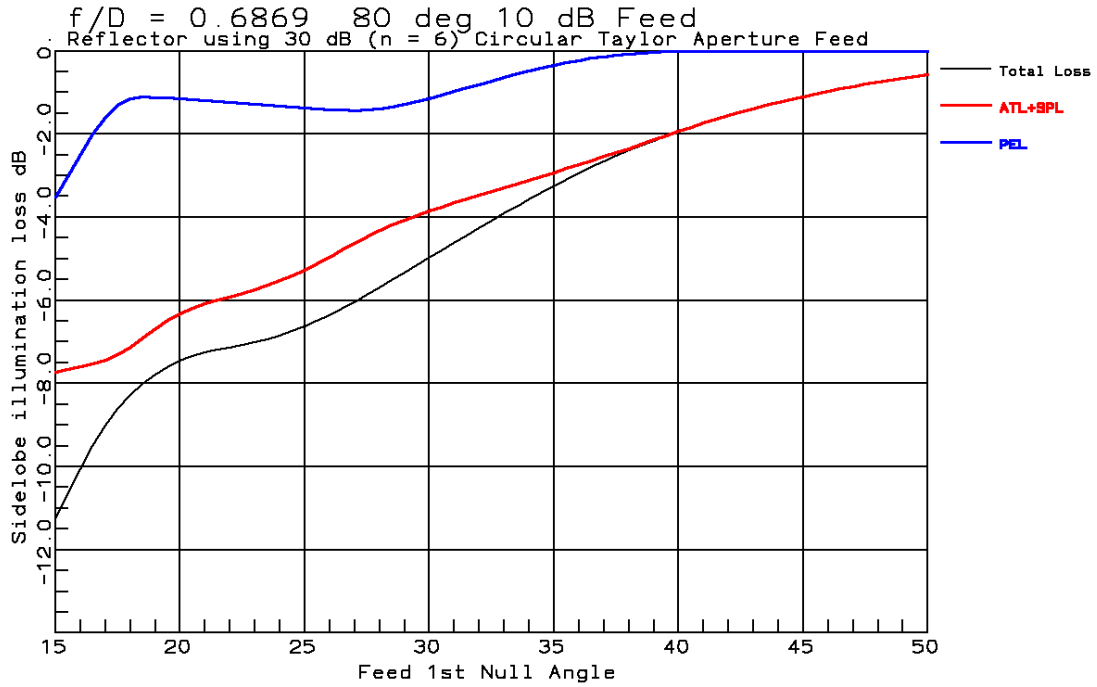

Figure 8-4.1.38 Illumination loss terms for *f/D* = 0.687 versus feed pattern null (40° reflector rim) (S = 0) compared to normal feed 30 dB feed sidelobes

Case 15 *f/D* = 0.687; 80° initial 10 dB Beam Feed 35 dB Sidelobes

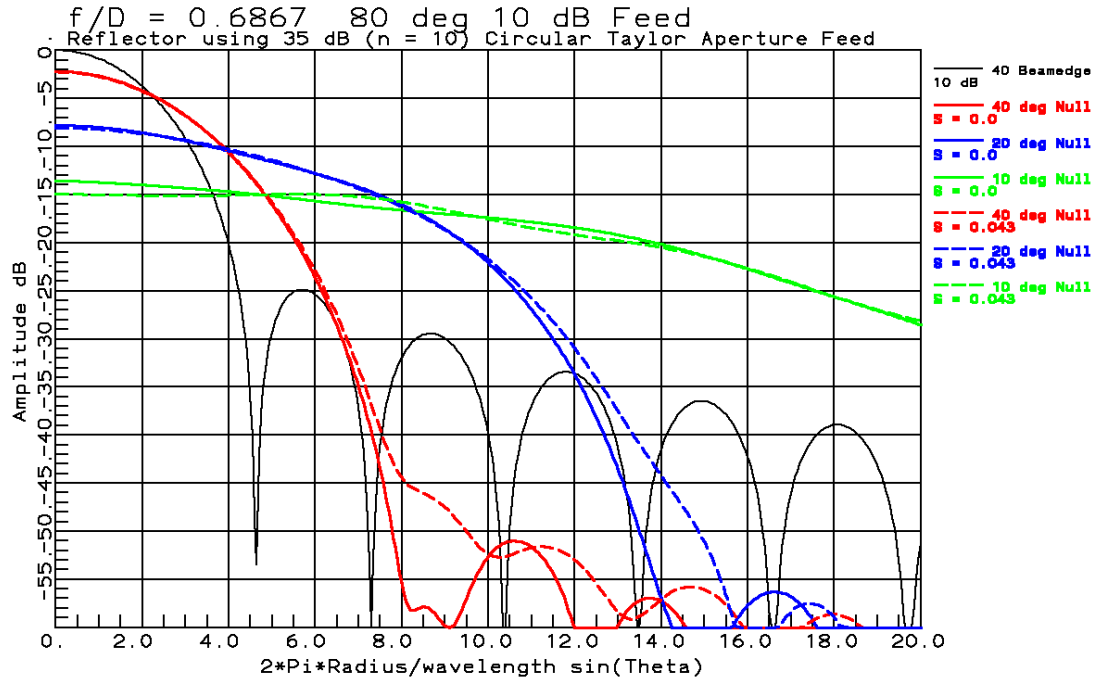

Figure 8-4.1.39 k-space pattern for *f/D* = 0.687 for pattern nulls at 40° (reflector rim), 20° and 10° compared to normal feed 35 dB first feed pattern sidelobe

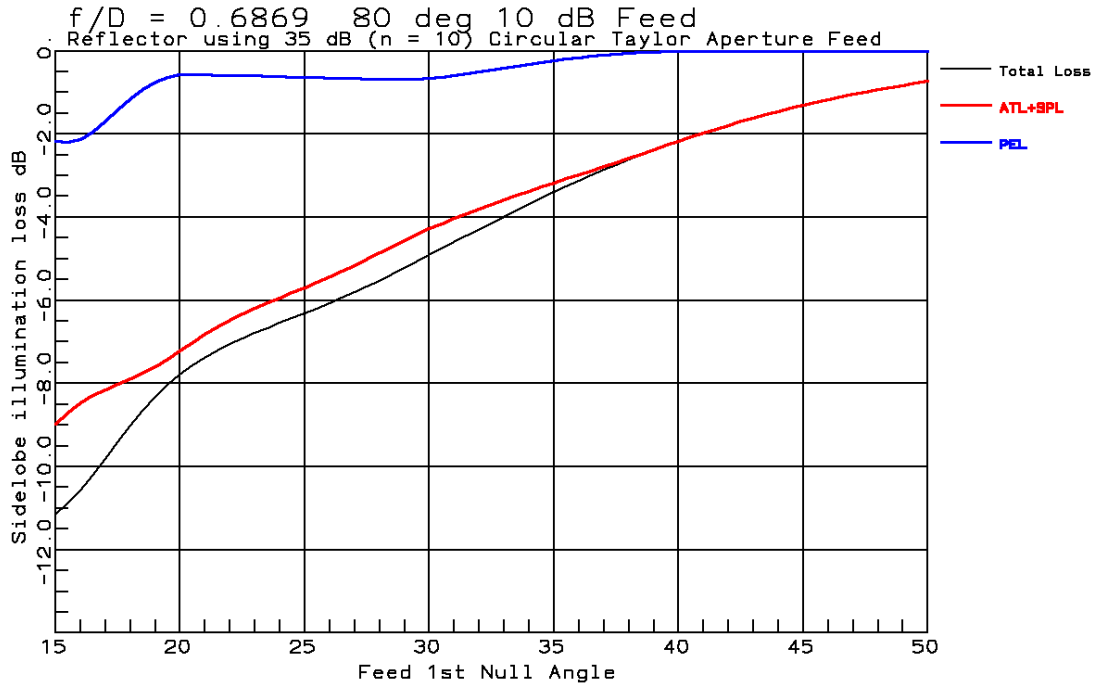

Figure 8-4.1.40 Illumination loss terms for *f/D* = 0.687 versus feed pattern null (40° reflector rim) (S = 0) compared to normal feed 35 dB feed sidelobes

Case 16 *f/D* = 0.933; 60° initial 10 dB Beam Feed 18 dB Sidelobes

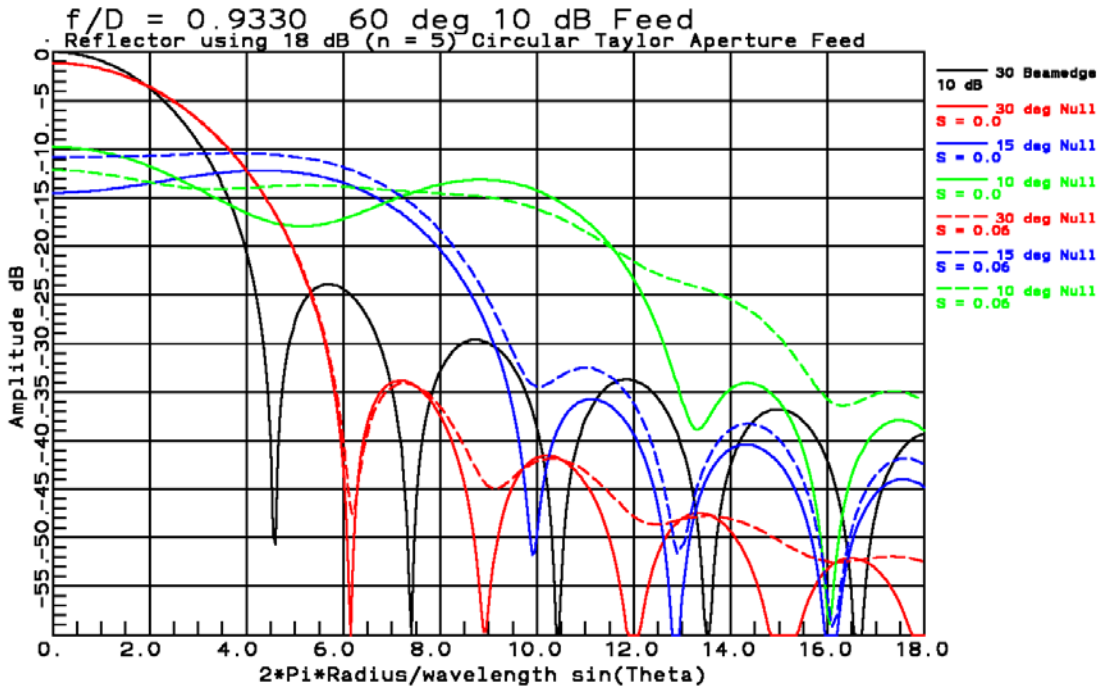

Figure 8-4.1.41 k-space pattern for *f/D* = 0.933 for pattern nulls at 30° (reflector rim), 15° and 10° compared to normal feed 18 dB first feed pattern sidelobe

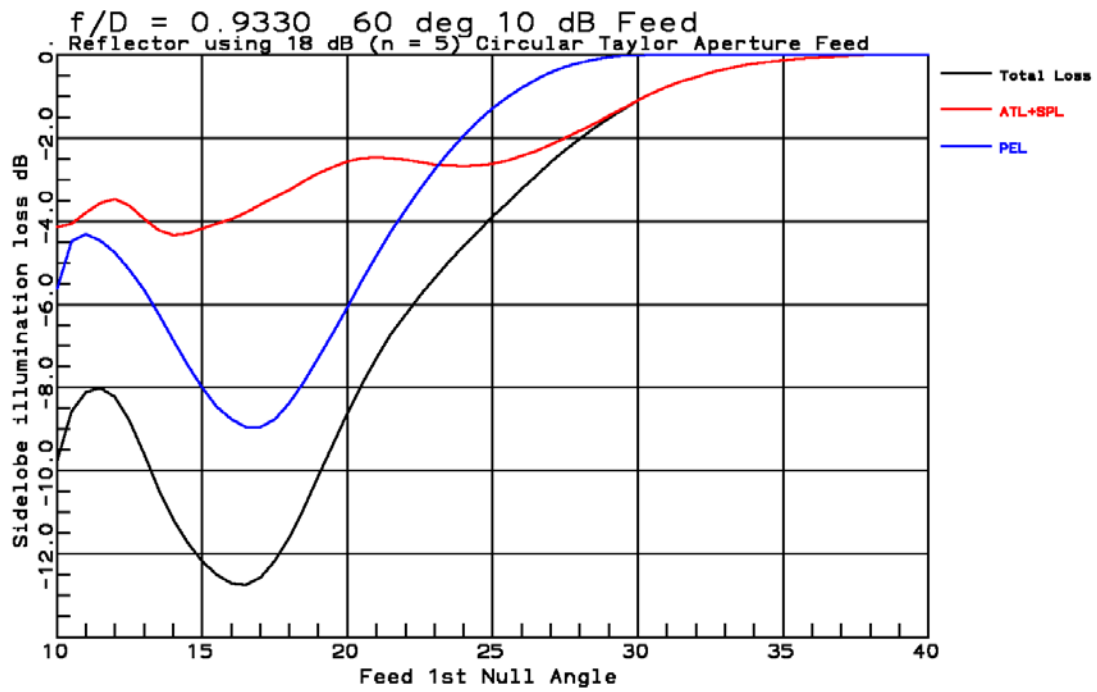

Figure 8-4.1.42 Illumination loss terms for *f/D* = 0.933 versus feed pattern null (30° reflector rim) (S = 0) compared to normal feed 18 dB feed sidelobes

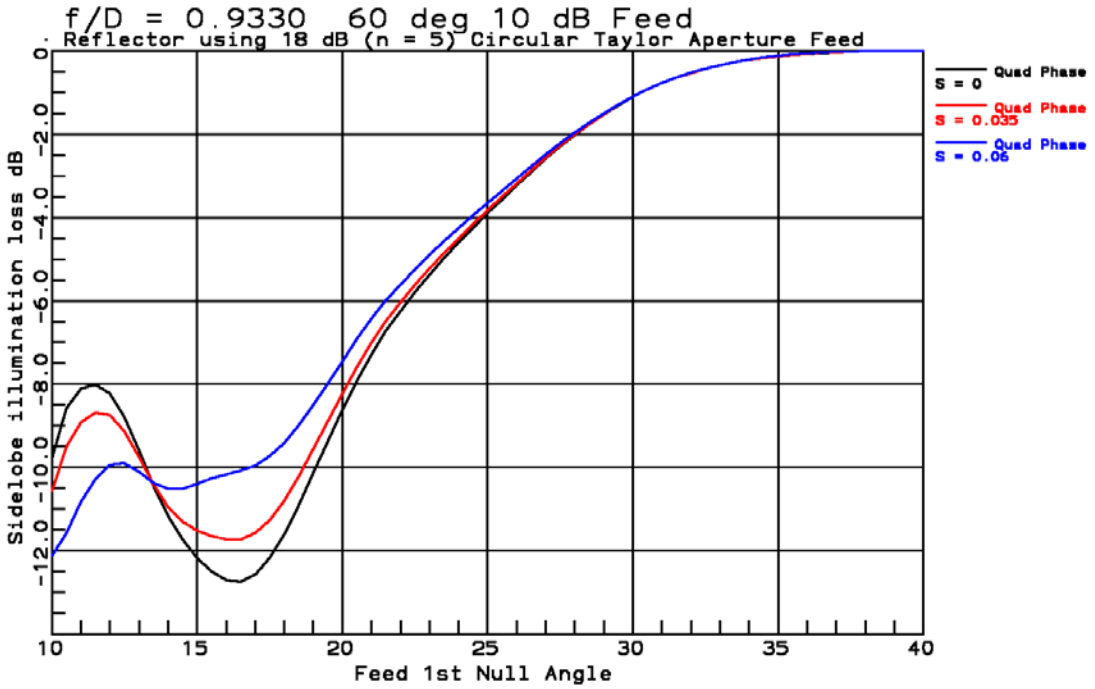

Figure 8-4.1.43 Illumination loss using various quadratic phase in the feed aperture for *f/D* = 0.933 versus feed pattern null (30° reflector rim) compared to normal feed with 18 dB sidelobes

Case 17 *f/D* = 0.933; 60° initial 10 dB Beam Feed 20 dB Sidelobes

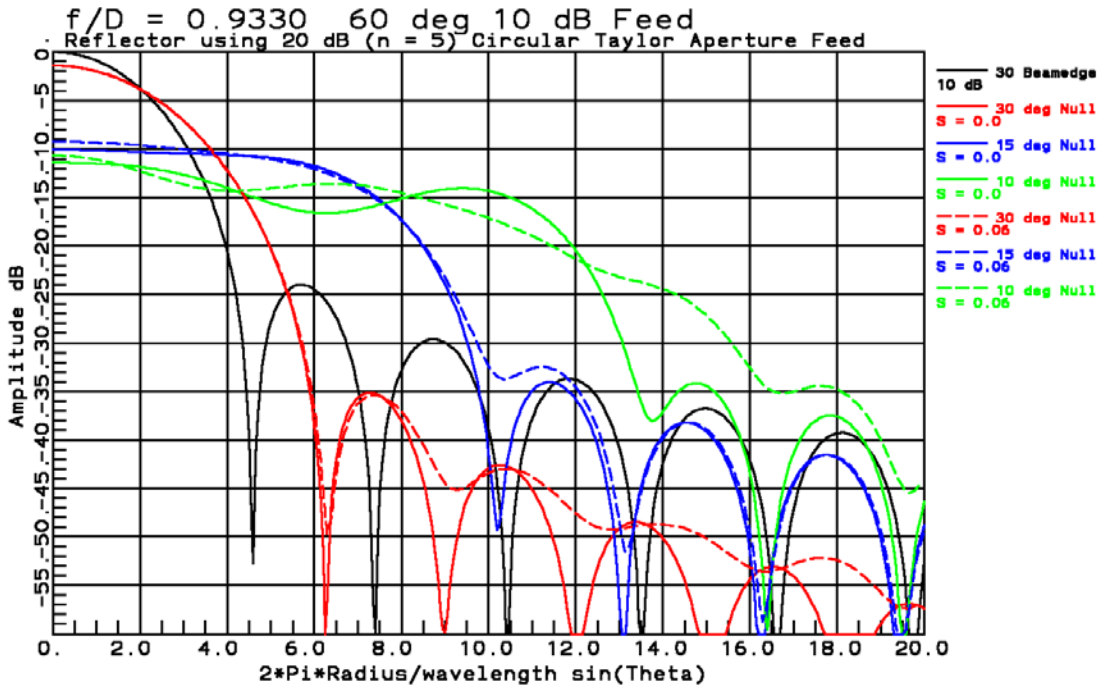

Figure 8-4.1.44 k-space pattern for *f/D* = 0.933 for pattern nulls at 30° (reflector rim), 15° and 10° compared to normal feed 20 dB first feed pattern sidelobe

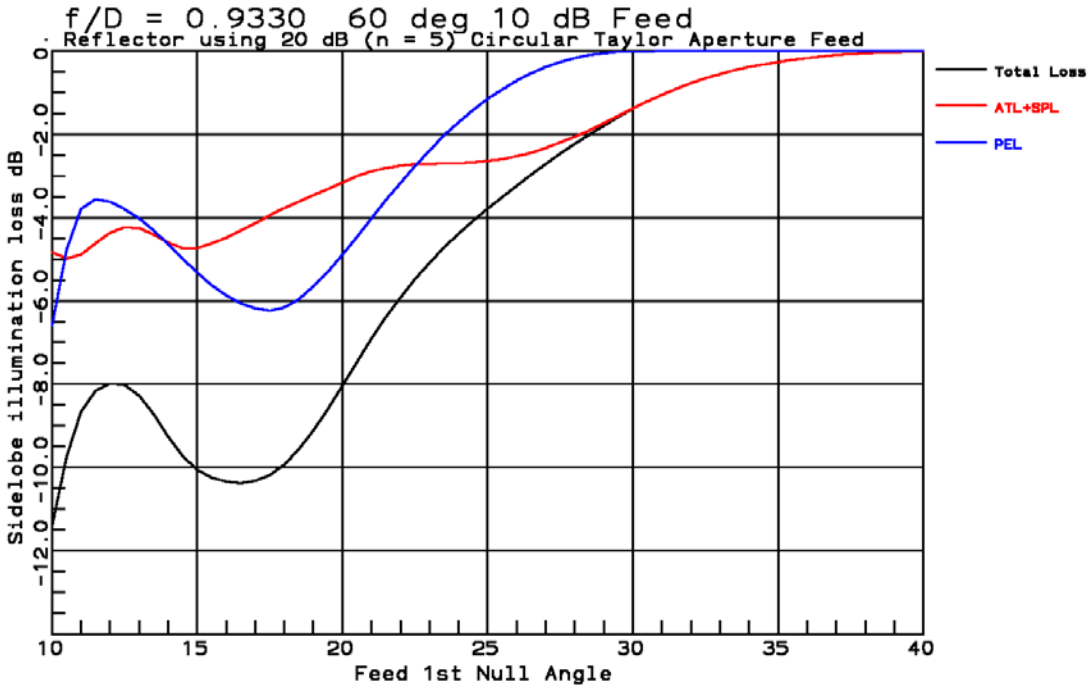

Figure 8-4.1.45 Illumination loss terms for *f/D* = 0.933 versus feed pattern null (30° reflector rim) (S = 0) compared to normal feed 18 dB feed sidelobes

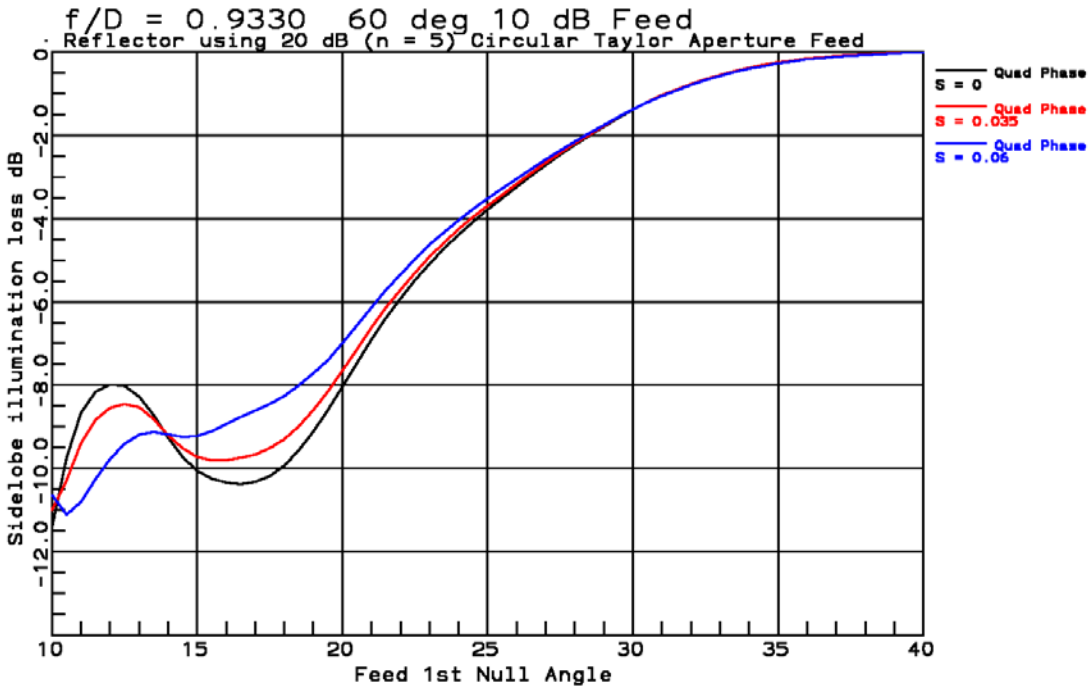

Figure 8-4.1.46 Illumination loss using various quadratic phase in the feed aperture for *f/D* = 0.933 versus feed pattern null (30° reflector rim) compared to normal feed with 20 dB sidelobes

Case 18 *f/D* = 0.933; 60° initial 10 dB Beam Feed 25 dB Sidelobes

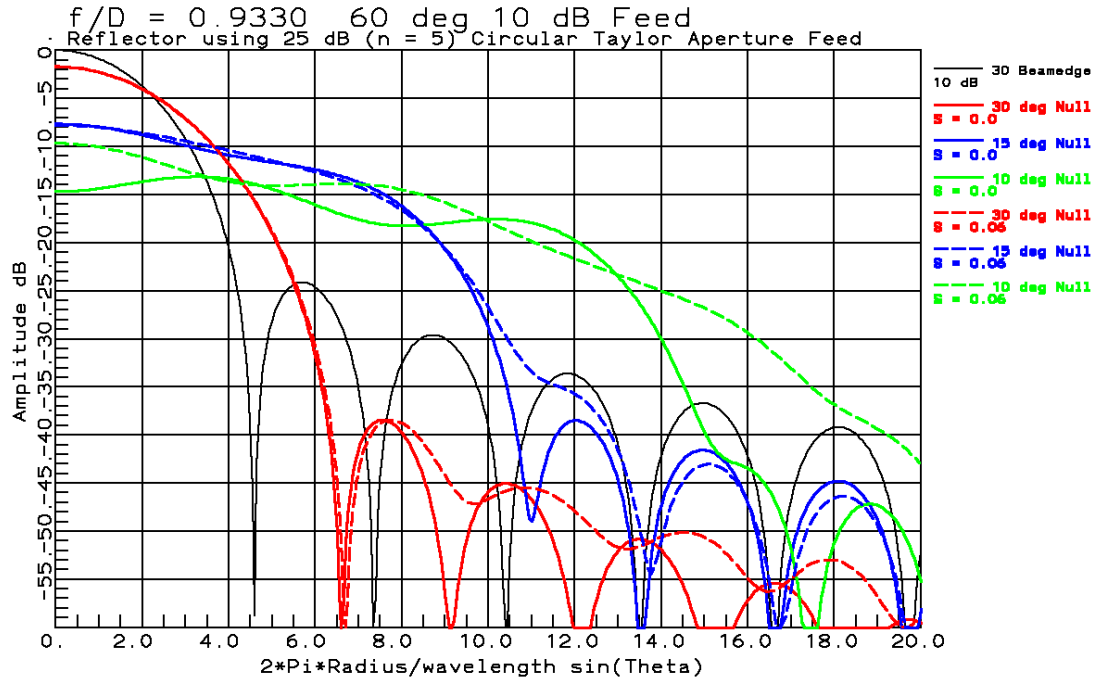

Figure 8-4.1.47 k-space pattern for *f/D* = 0.933 for pattern nulls at 30° (reflector rim), 15° and 10° compared to normal feed 25 dB first feed pattern sidelobe

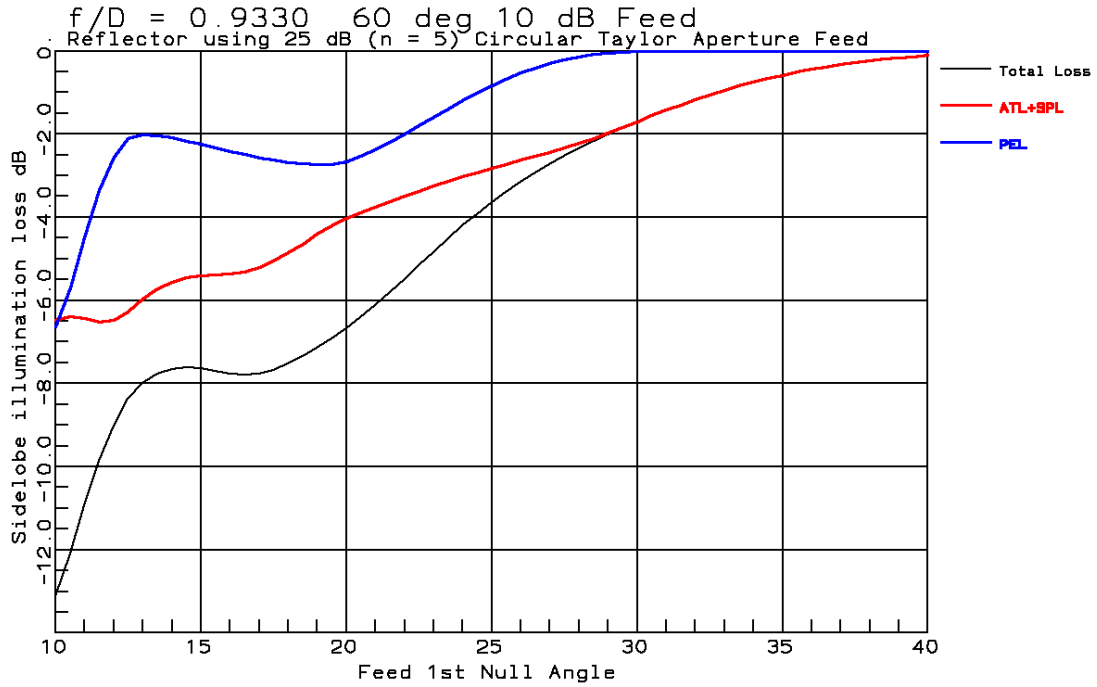

Figure 8-4.1.48 Illumination loss terms for *f/D* = 0.933 versus feed pattern null (30° reflector rim) (S = 0) compared to normal feed 25 dB feed sidelobes

Case 19 *f/D* = 0.933; 60° initial 10 dB Beam Feed 30 dB Sidelobes

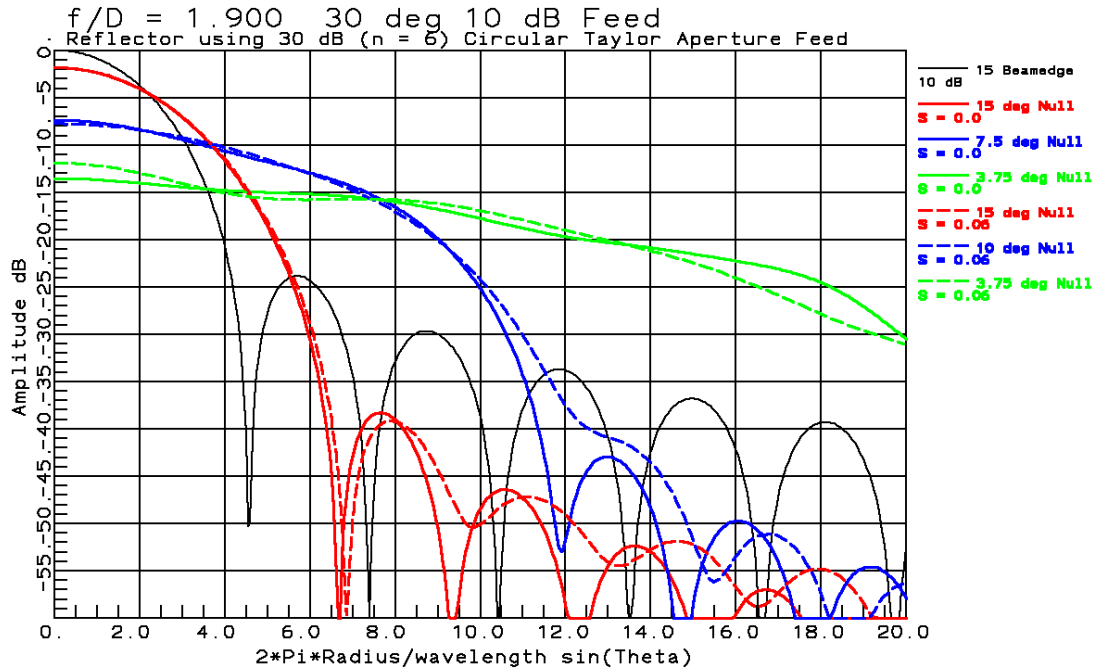

Figure 8-4.1.49 k-space pattern for *f/D* = 0.933 for pattern nulls at 30° (reflector rim), 15° and 10° compared to normal feed 30 dB first feed pattern sidelobe

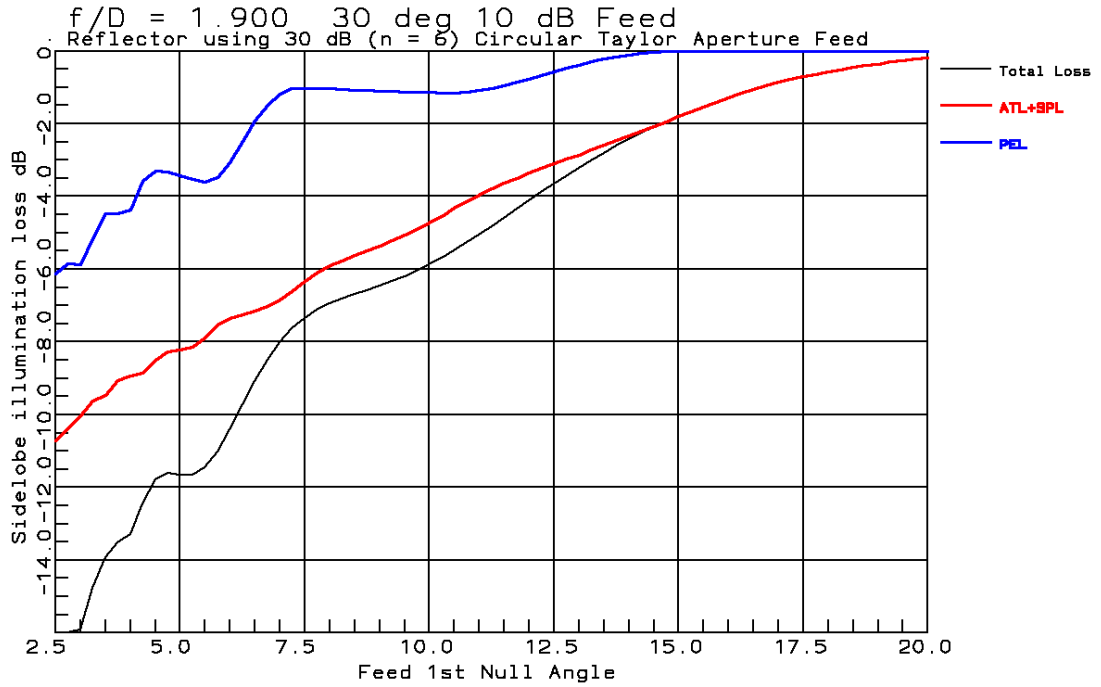

Figure 8-4.1.50 Illumination loss terms for *f/D* = 0.933 versus feed pattern null (30° reflector rim) (S = 0) compared to normal feed 30 dB feed sidelobes

Case 20 *f/D* = 0.933; 60° initial 10 dB Beam Feed 35 dB Sidelobes

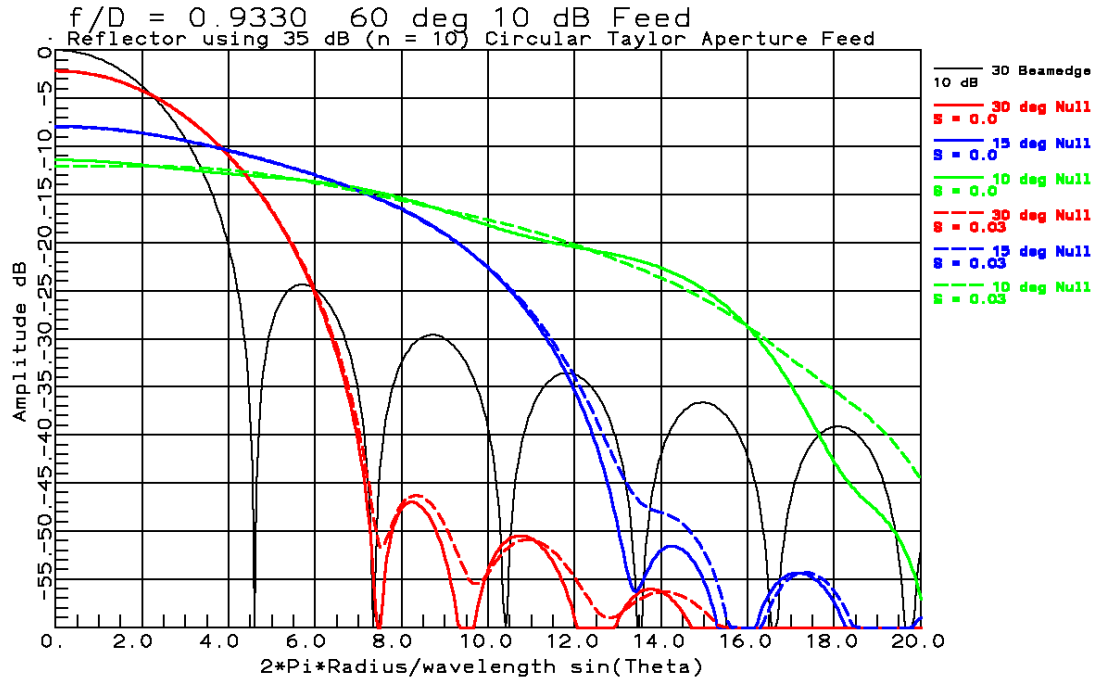

Figure 8-4.1.51 k-space pattern for *f/D* = 0.933 for pattern nulls at 30° (reflector rim), 15° and 10° compared to normal feed 35 dB first feed pattern sidelobe

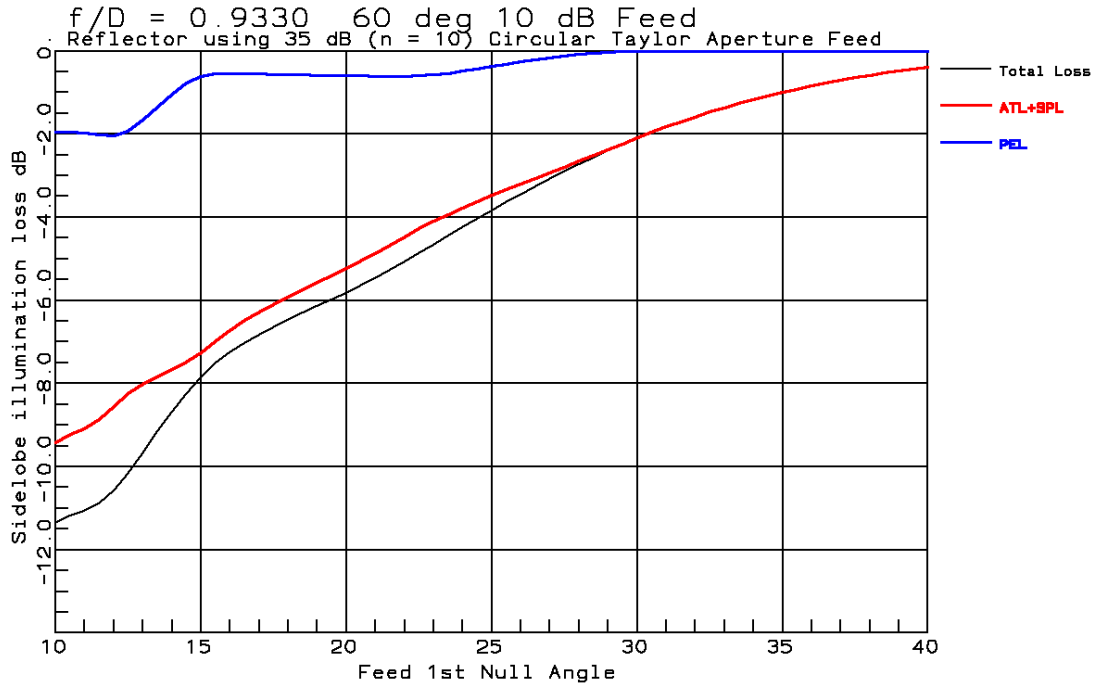

Figure 8-4.1.52 Illumination loss terms for *f/D* = 0.933 versus feed pattern null (30° reflector rim) (S = 0) compared to normal feed 35 dB feed sidelobes

Case 21 *f/D* = 1.418; 40° initial 10 dB Beam Feed 25 dB Sidelobes

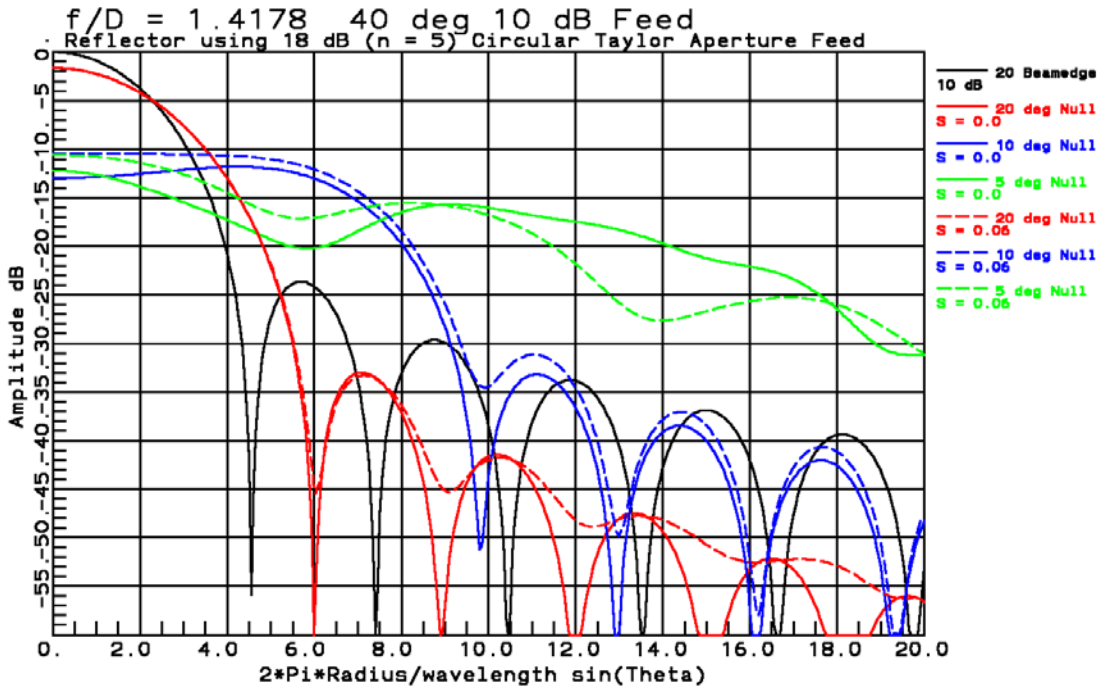

Figure 8-4.1.53 k-space pattern for *f/D* = 1.418 for pattern nulls at 20° (reflector rim), 10° and 5° compared to normal feed 18 dB first feed pattern sidelobe

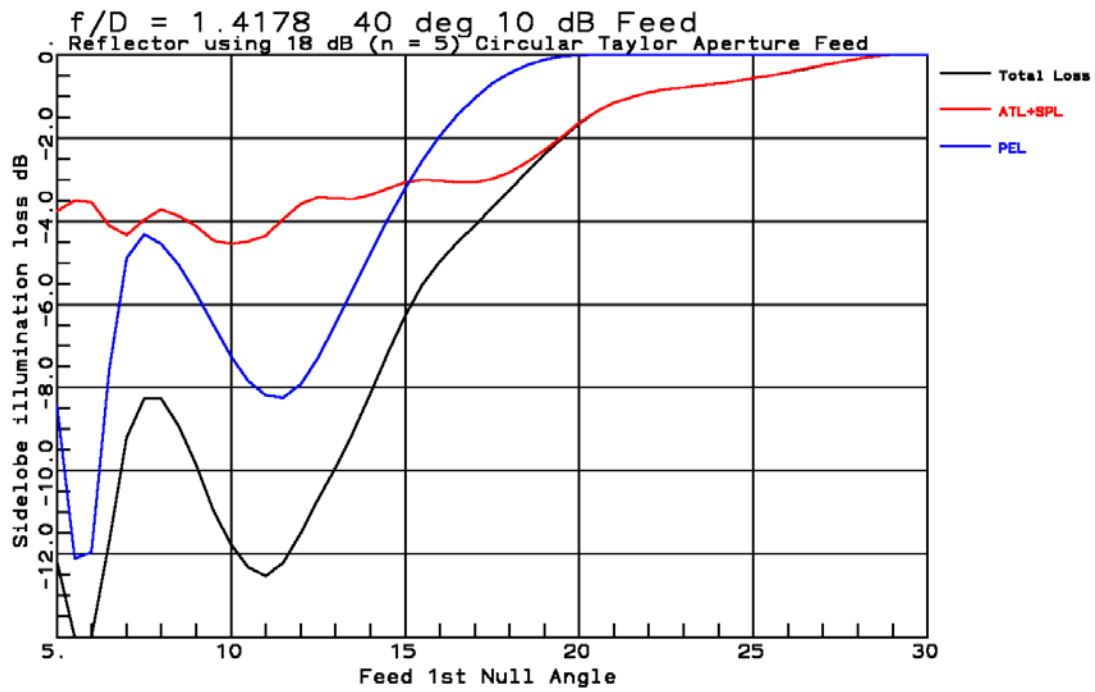

Figure 8-4.1.54 Illumination loss terms for *f/D* = 1.418 versus feed pattern null (20° reflector rim) (S = 0) compared to normal feed 18 dB feed sidelobes

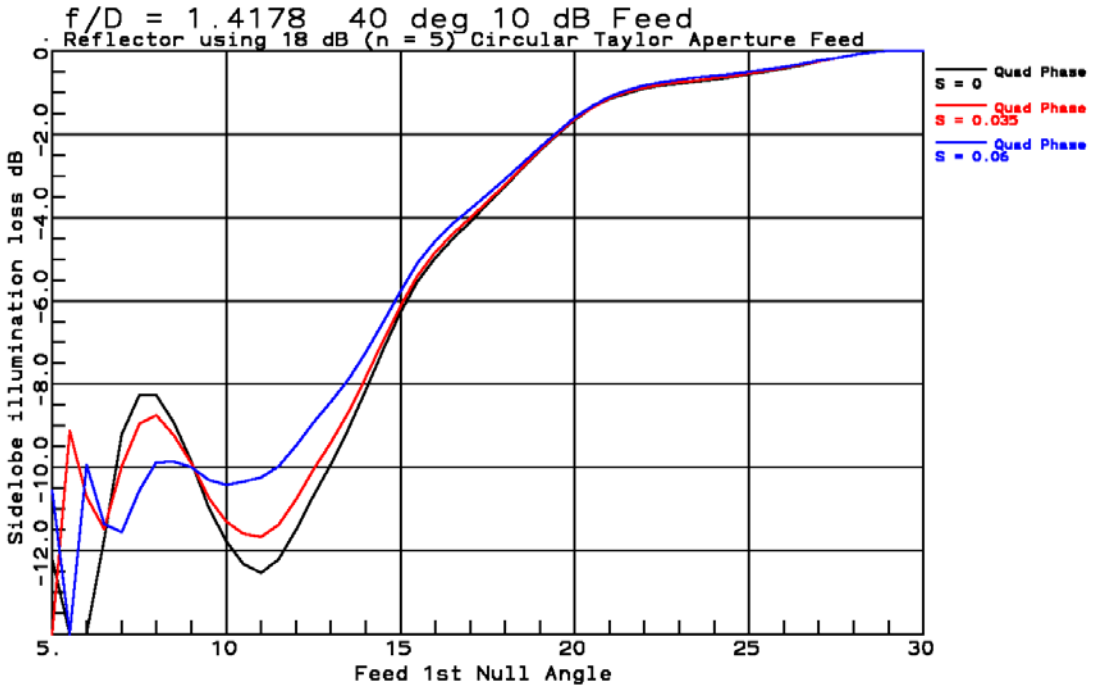

Figure 8-4.1.55 Illumination loss using various quadratic phase in the feed aperture for *f/D* = 1.418 versus feed pattern null (20° reflector rim) compared to normal feed with 18 dB sidelobes

Case 22 *f/D* = 1.418; 40° initial 10 dB Beam Feed 20 dB Sidelobes

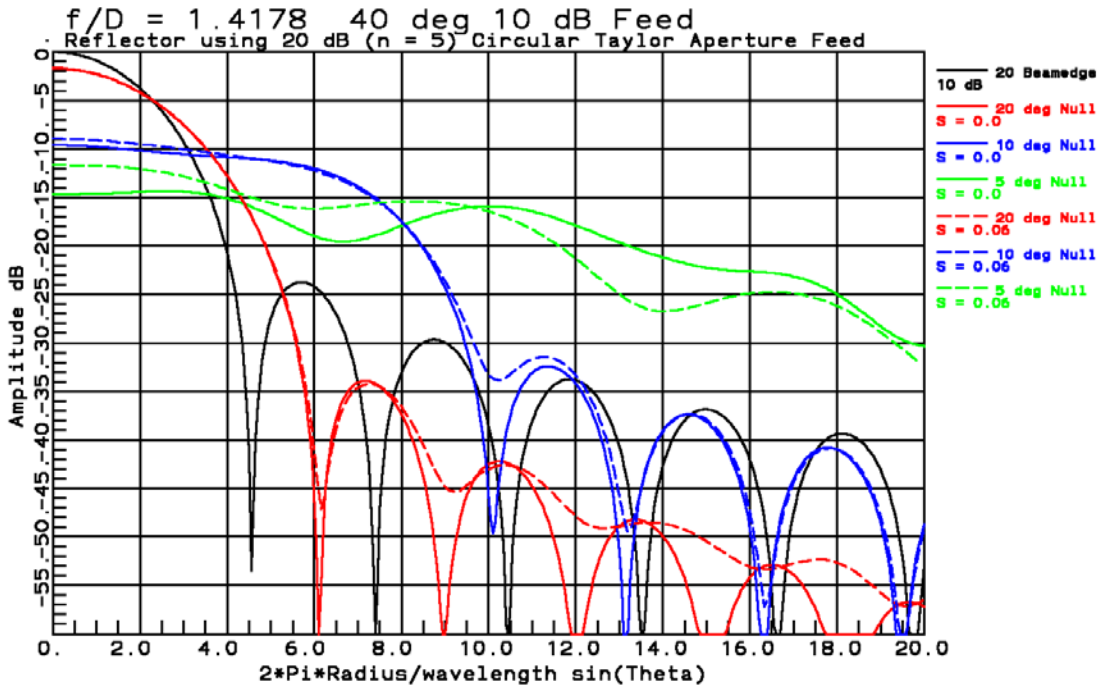

Figure 8-4.1.56 k-space pattern for *f/D* = 1.418 for pattern nulls at 20° (reflector rim), 10° and 5° compared to normal feed 20 dB first feed pattern sidelobe

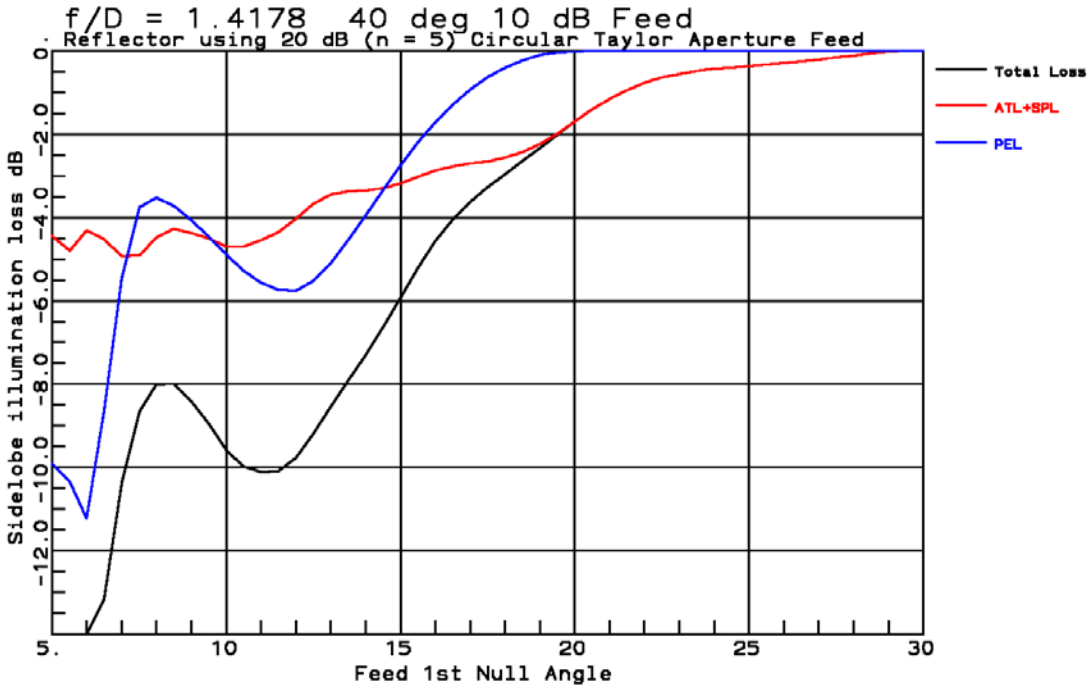

Figure 8-4.1.57 Illumination loss terms for *f/D* = 1.418 versus feed pattern null (20° reflector rim) (S = 0) compared to normal feed 20 dB feed sidelobes

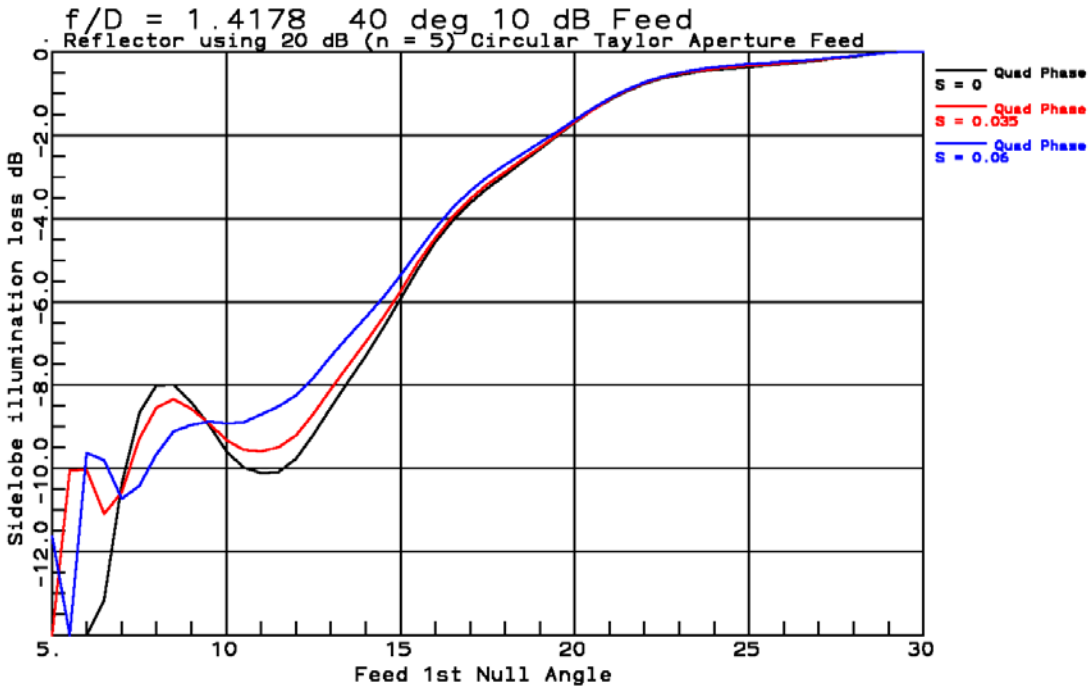

Figure 8-4.1.58 Illumination loss using various quadratic phase in the feed aperture for *f/D* = 1.418 versus feed pattern null (20° reflector rim) compared to normal feed with 20 dB sidelobes

Case 23 *f/D* = 1.418; 40° initial 10 dB Beam Feed 25 dB Sidelobes

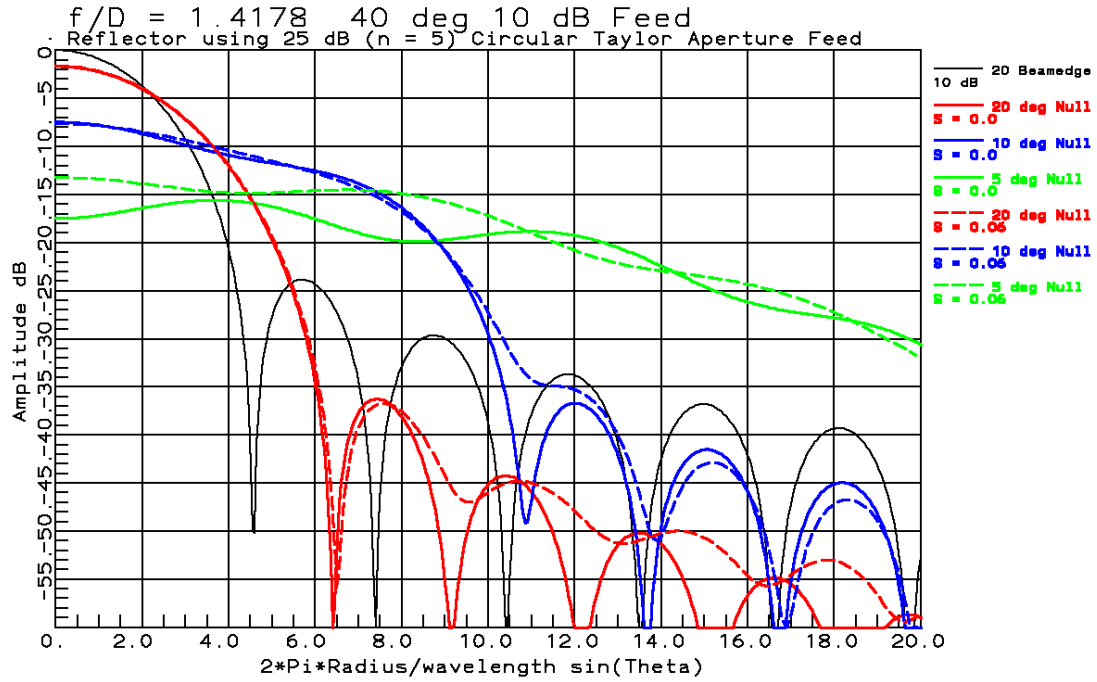

Figure 8-4.1.59 k-space pattern for *f/D* = 1.418 for pattern nulls at 20° (reflector rim), 10° and 5° compared to normal feed 25 dB first feed pattern sidelobe

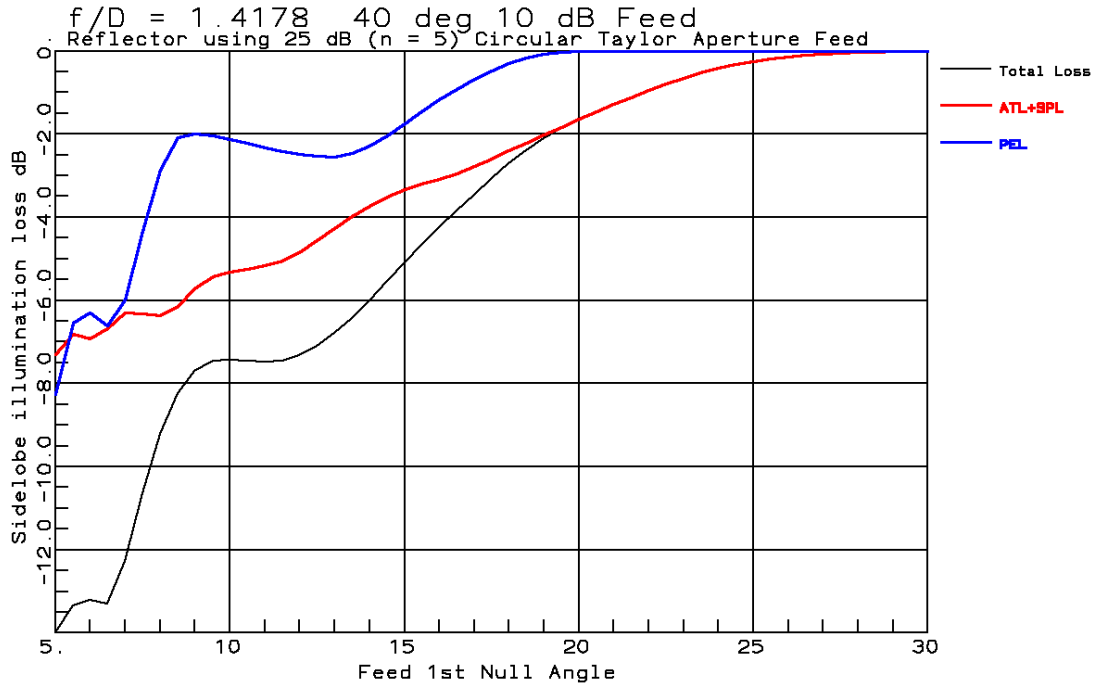

Figure 8-4.1.60 Illumination loss terms for *f/D* = 1.418 versus feed pattern null (20° reflector rim) (S = 0) compared to normal feed 25 dB feed sidelobes

Case 24 *f/D* = 1.418; 40° initial 10 dB Beam Feed 30 dB Sidelobes

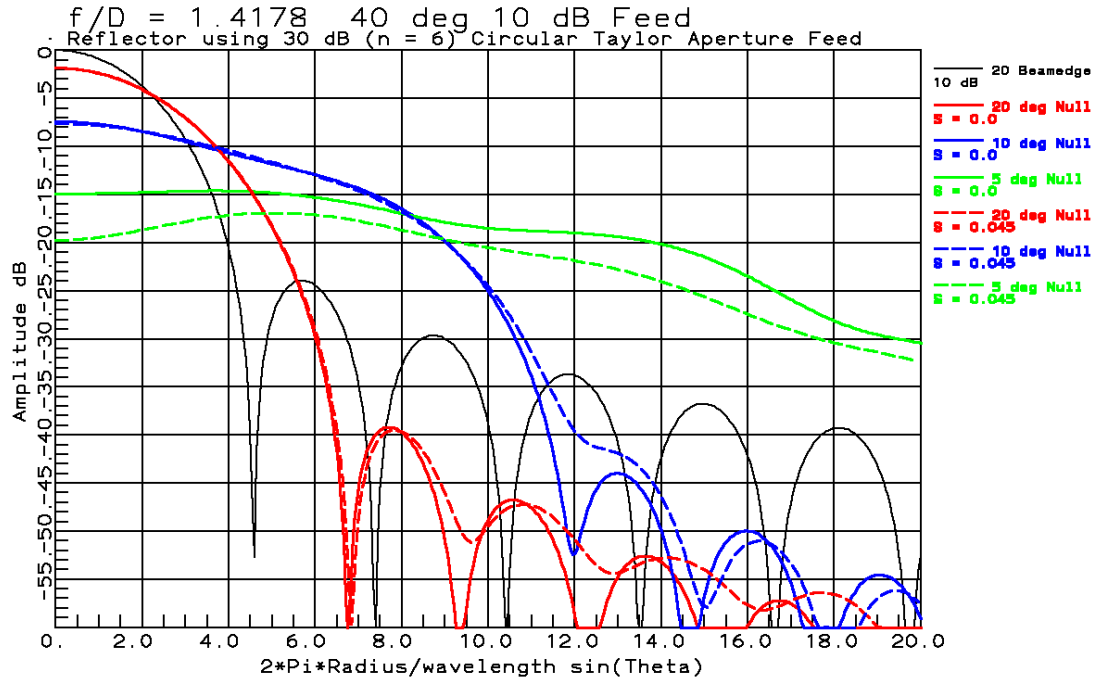

Figure 8-4.1.61 k-space pattern for *f/D* = 1.418 for pattern nulls at 20° (reflector rim), 10° and 5° compared to normal feed 30 dB first feed pattern sidelobe

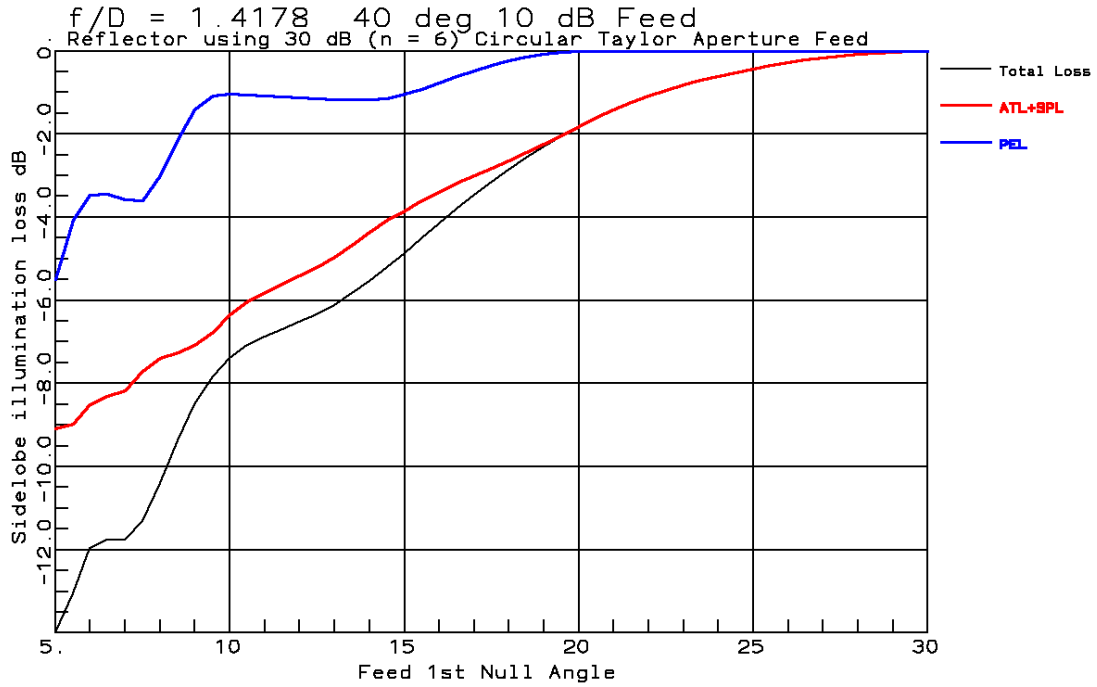

Figure 8-4.1.62 Illumination loss terms for *f/D* = 1.418 versus feed pattern null (20° reflector rim) (S = 0) compared to normal feed 30 dB feed sidelobes

Case 25 *f/D* = 1.418; 40° initial 10 dB Beam Feed 35 dB Sidelobes

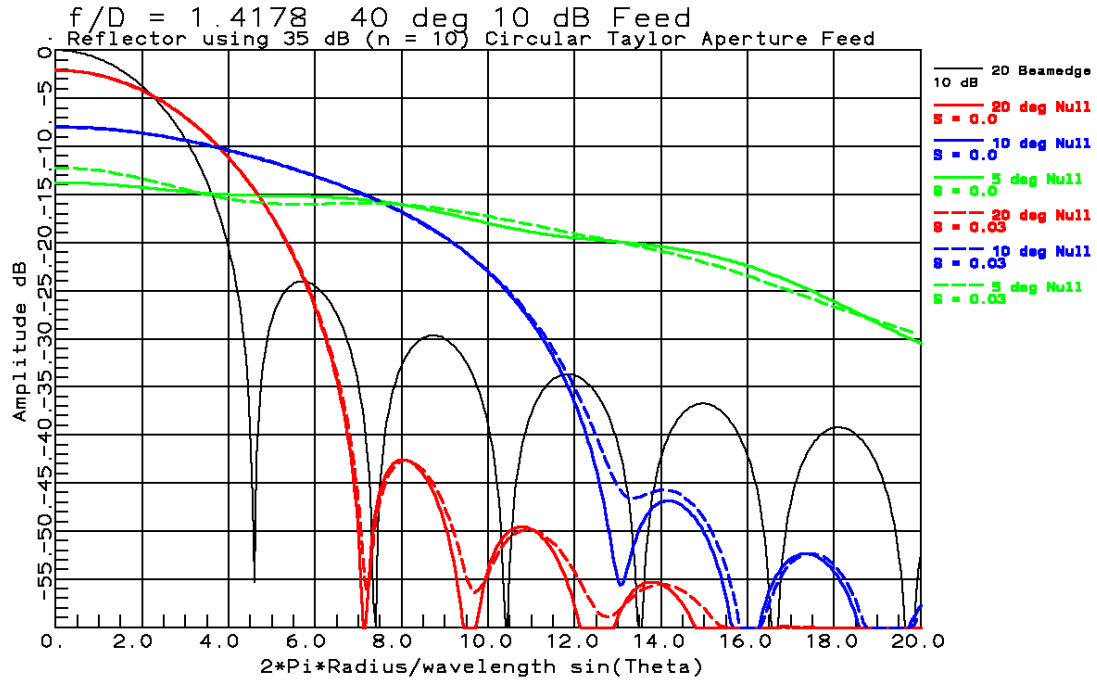

Figure 8-4.1.63 k-space pattern for *f/D* = 1.418 for pattern nulls at 20° (reflector rim), 10° and 5° compared to normal feed 35 dB first feed pattern sidelobe

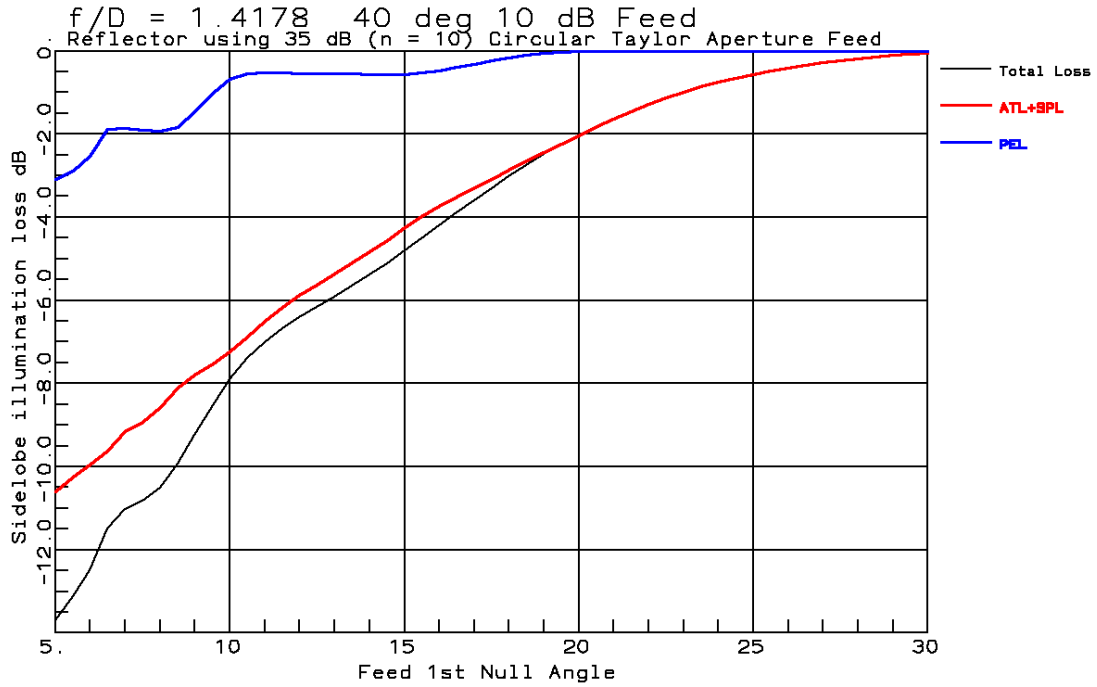

Figure 8-4.1.64 Illumination loss terms for *f/D* = 1.418 versus feed pattern null (20° reflector rim) (S = 0) compared to normal feed 35 dB feed sidelobes

Case 26 *f/D* = 1.900; 30° initial 10 dB Beam Feed 18 dB Sidelobes

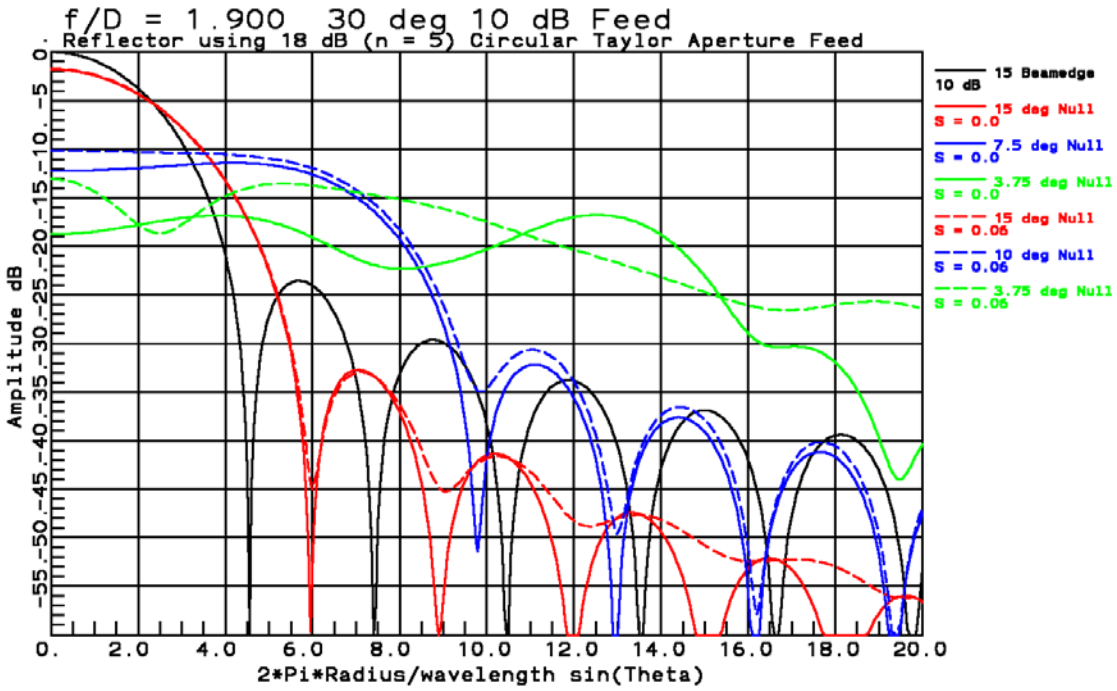

Figure 8-4.1.65 k-space pattern for *f/D* = 1.900 for pattern nulls at 15° (reflector rim), 7.5° and 3.75° compared to normal feed 18 dB first feed pattern sidelobe

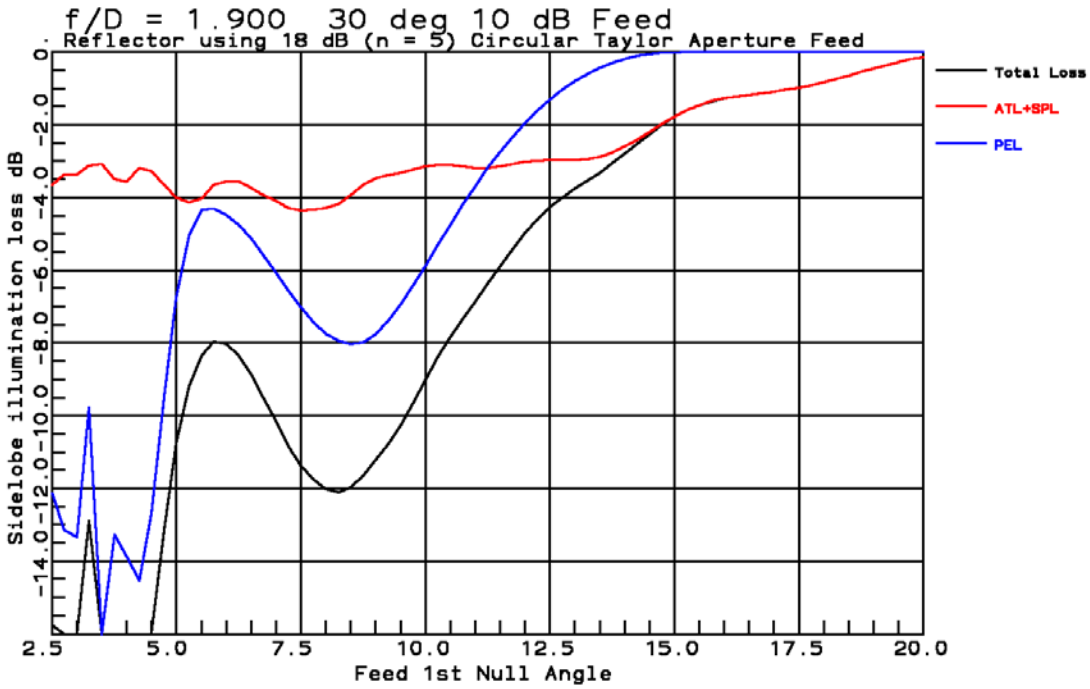

Figure 8-4.1.66 Illumination loss terms for *f/D* = 1.900 versus feed pattern null (15° reflector rim) (S = 0) compared to normal feed 18 dB feed sidelobes

Case 27 *f/D* = 1.900; 30° initial 10 dB Beam Feed 20 dB Sidelobes

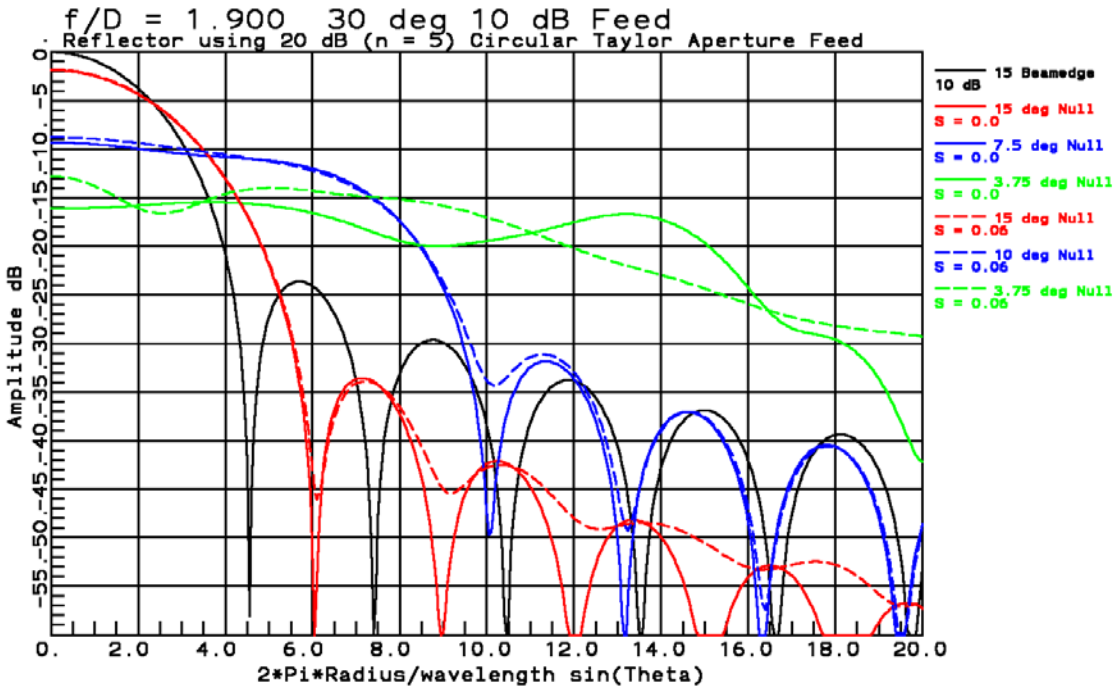

Figure 8-4.1.67 k-space pattern for *f/D* = 1.900 for pattern nulls at 15° (reflector rim), 7.5° and 3.75° compared to normal feed 20 dB first feed pattern sidelobe

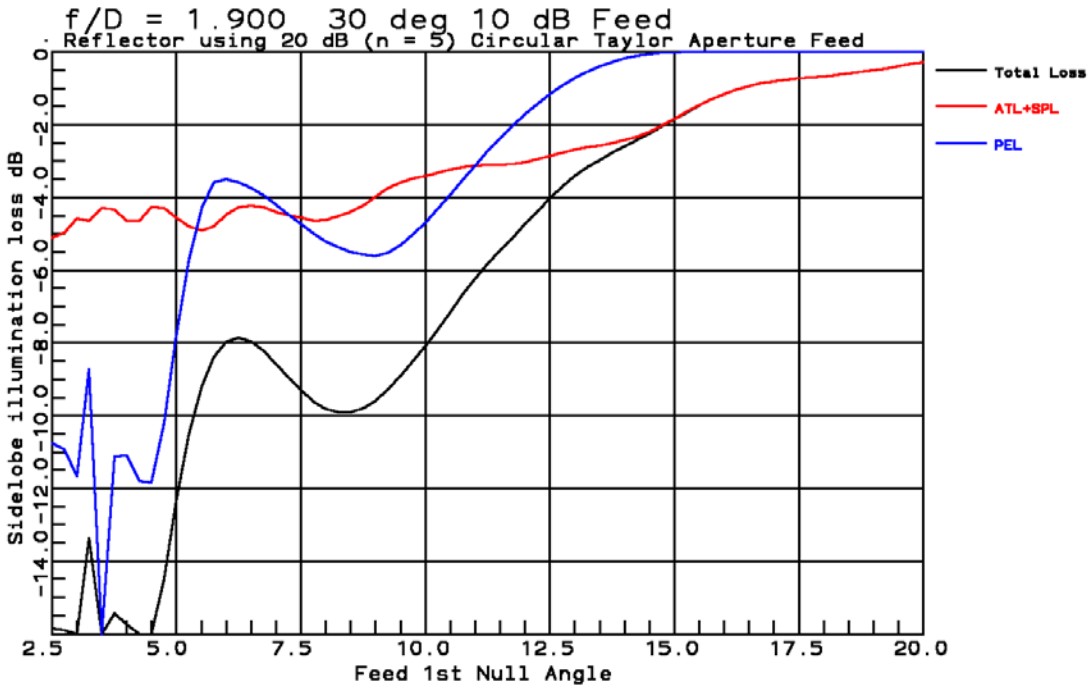

Figure 8-4.1.68 Illumination loss terms for *f/D* = 1.900 versus feed pattern null (15° reflector rim) (S = 0) compared to normal feed 20 dB feed sidelobes

Case 28 *f/D* = 1.900; 30° initial 10 dB Beam Feed 25 dB Sidelobes

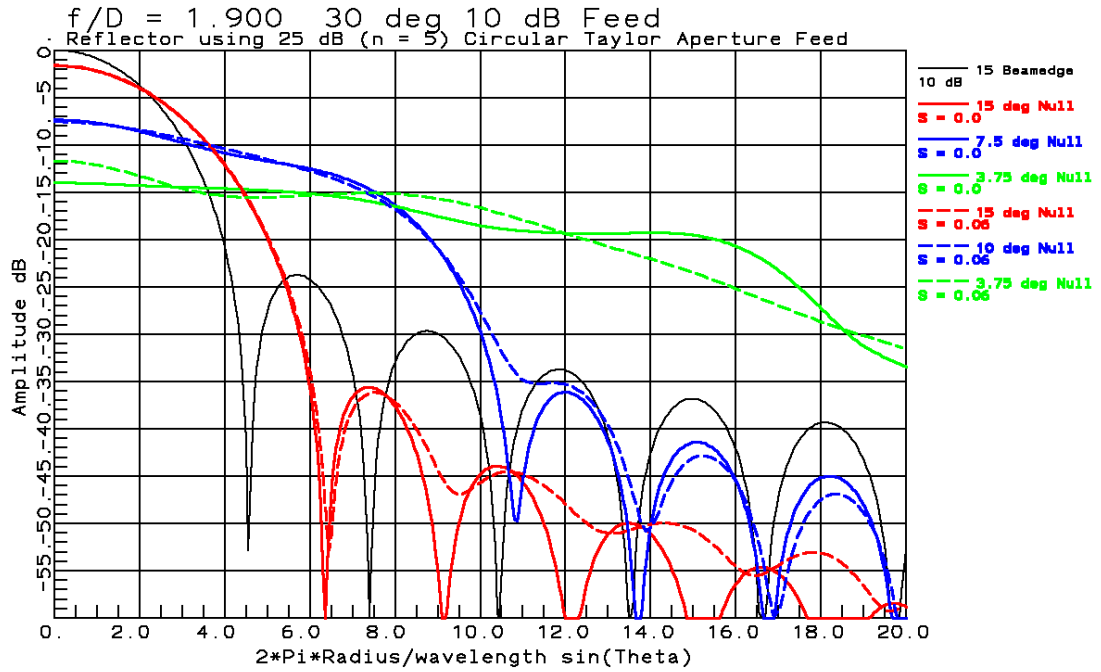

Figure 8-4.1.69 k-space pattern for *f/D* = 1.900 for pattern nulls at 15° (reflector rim), 7.5° and 3.75° compared to normal feed 25 dB first feed pattern sidelobe

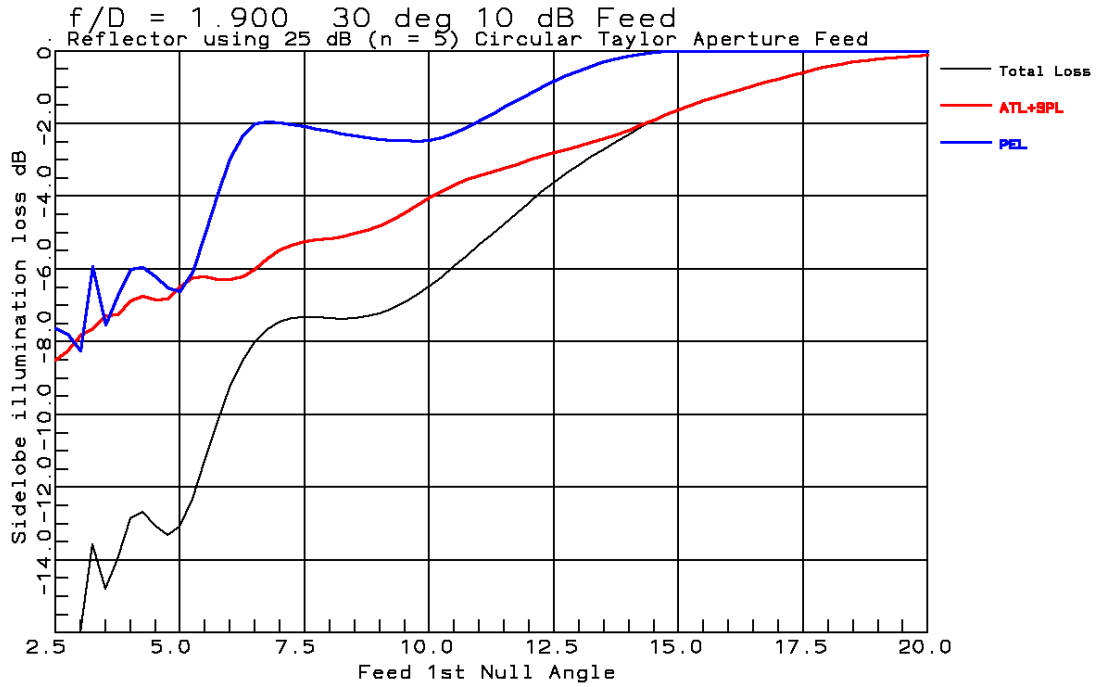

Figure 8-4.1.70 Illumination loss terms for *f/D* = 1.900 versus feed pattern null (15° reflector rim) (S = 0) compared to normal feed 25 dB feed sidelobes

Case 29 *f/D* = 1.900; 30° initial 10 dB Beam Feed 30 dB Sidelobes

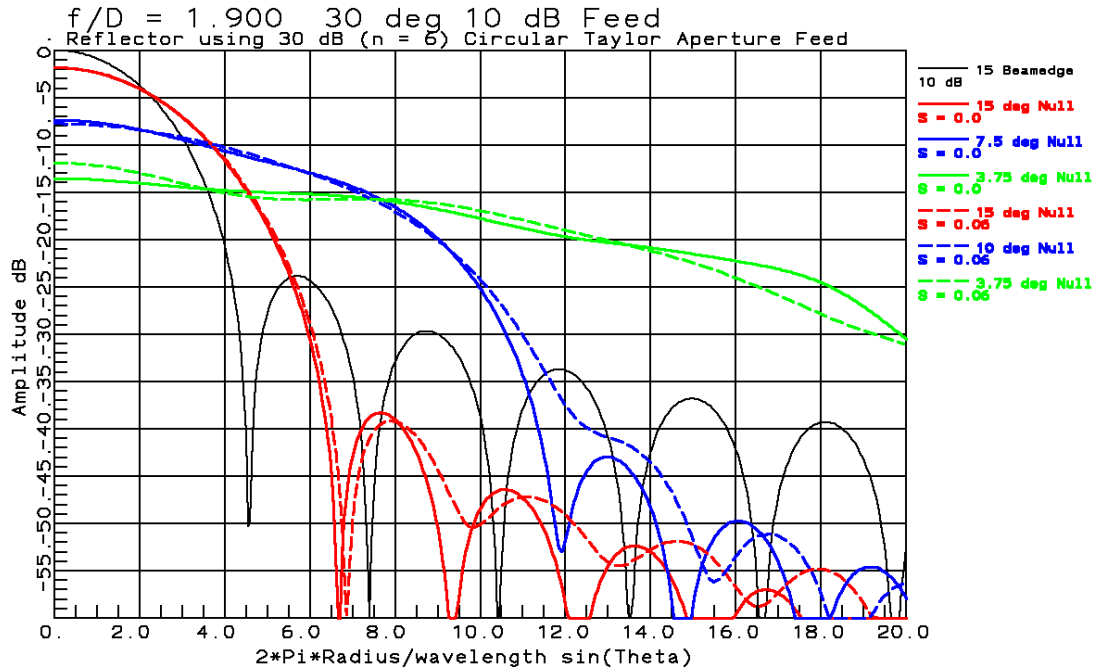

Figure 8-4.1.71 k-space pattern for *f/D* = 1.900 for pattern nulls at 15° (reflector rim), 7.5° and 3.75° compared to normal feed 30 dB first feed pattern sidelobe

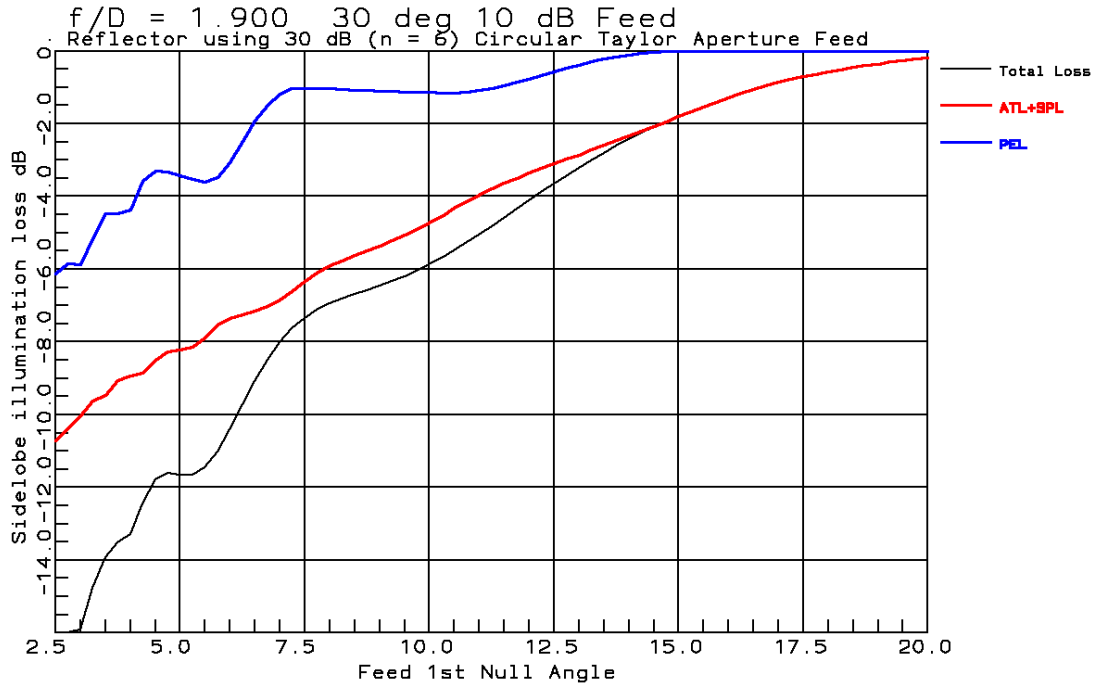

Figure 8-4.1.72 Illumination loss terms for *f/D* = 1.900 versus feed pattern null (15° reflector rim) (S = 0) compared to normal feed 30 dB feed sidelobes

Case 30 *f/D* = 1.900; 30° initial 10 dB Beam Feed 35 dB Sidelobes

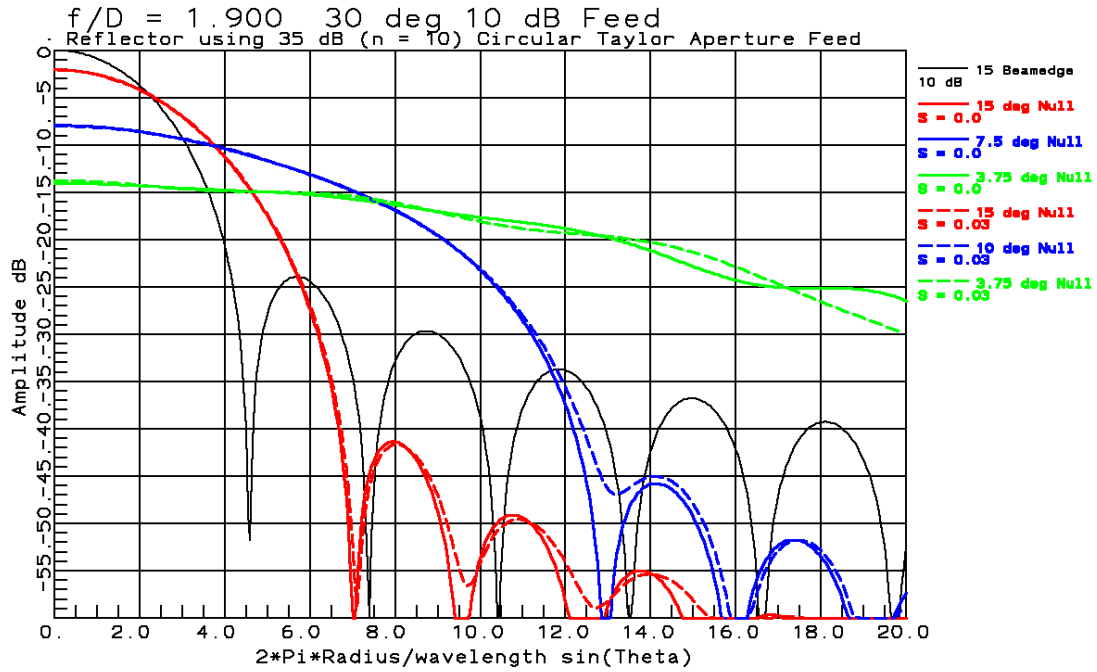

Figure 8-4.1.73 k-space pattern for *f/D* = 1.900 for pattern nulls at 15° (reflector rim), 7.5° and 3.75° compared to normal feed 35 dB first feed pattern sidelobe

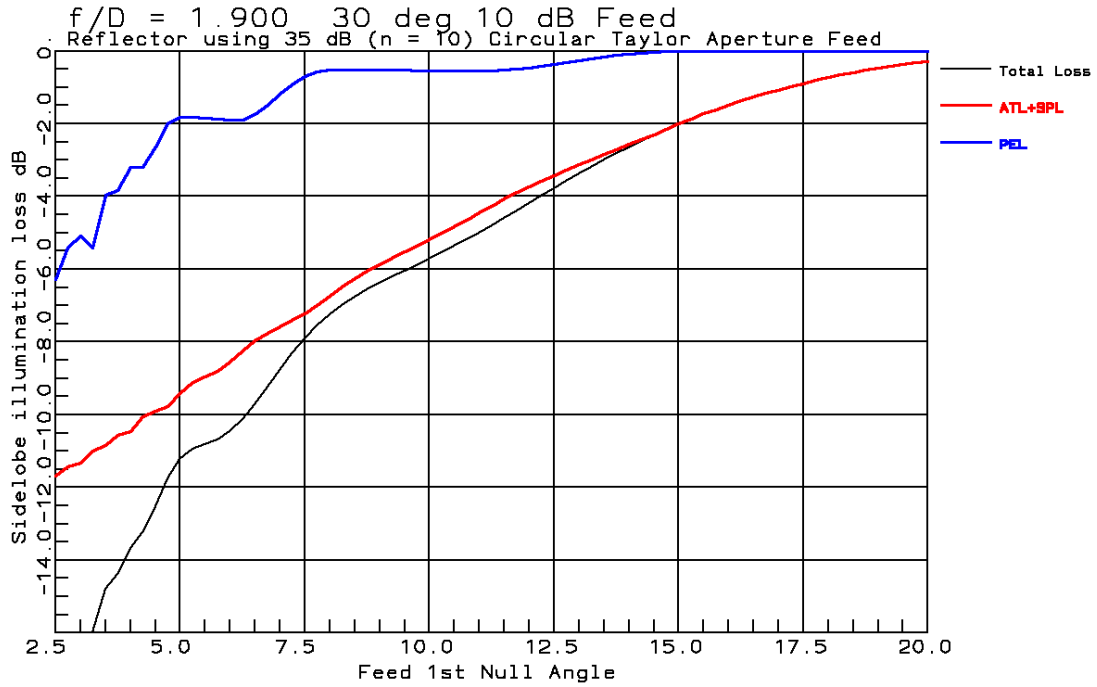

Figure 8-4.1.74 Illumination loss terms for *f/D* = 1.900 versus feed pattern null (15° reflector rim) (S = 0) compared to normal feed 35 dB feed sidelobes