B—6—3 PRIMARY-FEEDS FOR CROSS-POLARISATION SUPPRESSION IN OFFSET REFLECTOR ANTENNAS

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Summary

The principal advantages of the offset parabolic reflector antenna are well known. Avoidance of aperture-blocking effects, by ensuring that the primary-feed hardware does not protrude into the optical path of the reflected waves, provides a means of achieving high values of aperture efficiency combined with good sidelobe suppression. The fully offset configuration, which is illustrated in Fig 1, also leads to low reflector reaction and thus provides excellent electrical isolation between the primary-feed and the reflector itself.(1, 2, 3)

The offset parabolic reflector antenna does have a major disadvantage, however, which can be attributed to its geometric asymmetry. When illuminated by a conventional linearly-polarised primary-feed horn, the offset reflector exhibits an undesirable depolarising property. The reflector generates two cross-polarised lobes with peak values occurring in one of the principal planes of the antenna, at far-field angles coinciding approximately with the -6dB contour of the main co-polarised beam. A typical measured radiation pattern is shown in Fig 2, with the offset reflector fed by a conventional primary-feed horn. For practical (compact) reflector geometries the cross-polar lobes may have peak values of only -20dB and, with conventional primary-feeds, these fields can only be reduced to below -30dB by utilising reflector structures with large focal-length-to-diameter ratios. When illuminated by a conventional circularly-polarised primary-feed the offset reflector asymmetry does not depolarise the antenna radiation, but a small beam-squinting effect is introduced, which displaces the main-beam of the antenna from the boresight axis. The magnitude of the squint is proportional to the sine of the reflector offset angle, while its direction is dependent upon the hand of circular polarisation.(1, 2, 4)

In a recent publication the concept of a class of 'matched' feeds for offset parabolic reflectors was introduced (5). With this technique the tangential electric fields in the radiating aperture of the feed are designed to provide a conjugate match to the vector fields at the focus of the asymmetric reflector. It can be shown that, when this matching condition is satisfied, the primary-feed will compensate for the depolarisation introduced by the reflector asymmetry. It was proposed that the focal-plane field-matching be achieved by the use of higher-order waveguide modes in the mouth of the primary-feed horn. Employing a prototype multi-mode conical horn, of compact design, it was demonstrated that a given offset-reflector cross-polar lobes could be suppressed from the -23dB level to below -38dB. It was also indicated that suppression to levels below -40dB were theoretically feasible. Fig 3 shows the measured radiation-pattern of an offset reflector when fed by a rectangular aperture matched-feed device. The offset reflector is identical to that of Fig 2. The cross-polar radiation-pattern bandwidth and the vswr for this combination are shown in Figs 4 and 5. Later publications have described a successful application of the matched-feed concept to alleviate the problem of 'boresight jitter' which occurs when monopulse tracking feeds are used in conjunction with offset reflectors.(6, 7)

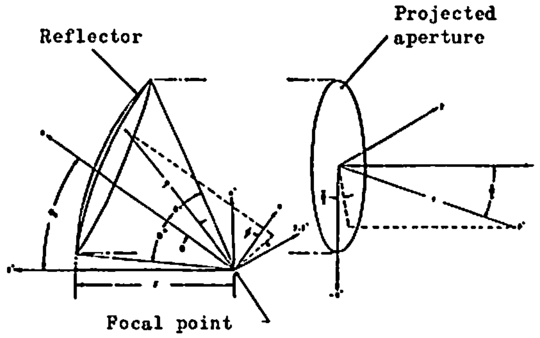

Fig 1: Offset reflector geometry

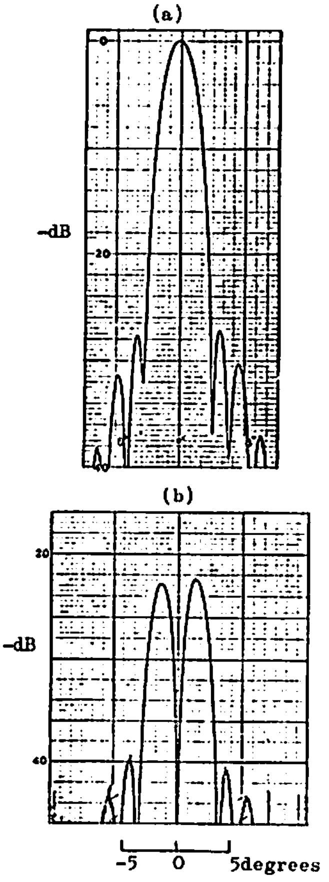

Fig 2: Measured co-polarised (a) and cross-polarised (b) radiation in $\Phi = \pi/2$ plane, from precision offset reflector ($\theta_0 = 44^\circ$, $\theta^* = 30^\circ$) fed by rectangular horn without higher order modes.

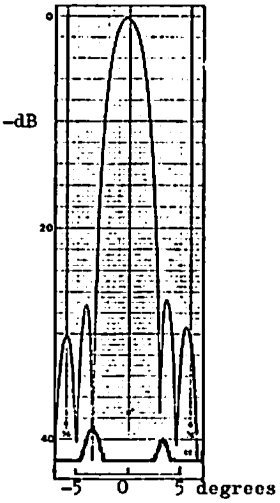

Fig 3: Measured co- and cross-polarised radiation in $\Phi = \pi/2$ plane with optimised rectangular matched feed (ie with higher order modes)

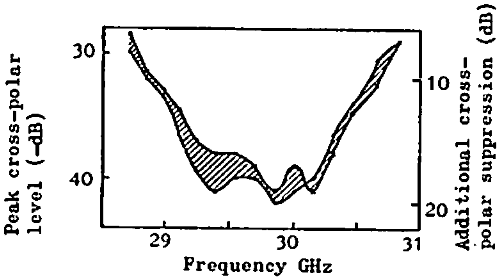

Fig 4: Peak levels of cross-polar lobes either side of boresight as a function of frequency

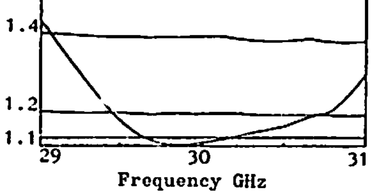

Fig 5: VSWR of prototype matched feed against frequency

The present paper reviews the progress made with the application of the matched-feed technique for both satellite communications and radar antennas. Mathematical modelling techniques have been utilised to model the vector radiation from the matched-feed elements and to predict the overall vector radiation when the feed is used in conjunction with an offset parabolic reflector. The theoretical studies performed have included dual-polarised multiple-beam systems, shaped (offset) reflector antennas and monopulse radar antennas. Experimental data to be presented includes measurements made on matched-feeds with cylindrical and rectangular geometries, constructed for operation in K-band. The data presented will include co-polar and cross-polar radiation and vswr measurements, made on the feeds themselves, and when used to feed accurately-profiled offset parabolic reflectors.

References

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