VD/GN BK/

CIRCULAR POLARIZED FEEDS

Notes to arrive at a specification for feeds for the NRAO 11 cm interferometer

The elements of the interferometer will be three 85-foot reflectors, combined in pairs. Each reflector has f/D = 0.4, and at the observing frequency of 2695 Mc/s (bandwidth ± 12 Mc/s) has a beamwidth of 20' arc.

The experiment I propose calls for feeds capable of receiving either hand of circular polarization, a subsequent switch selecting right- or left-hand at will. Since the polarization of most radio sources is only a small fraction of their total intensity (say 1 to 3%), the chief requirement is that the two outputs of each feed shall be very pure circular polarization: specifically, when the antenna is pointing directly at a source, the ellipse of polarization of each output shall have an axial ratio preferably less than 1.01:0.99, and certainly less than 1.02:0.98. The corresponding figures expressed as an isolation are $\geq$ 40 db preferred, $\geq$ 35 db (min).

It is desirable to preserve the purity of polarization over the beam of the antenna. The full 40 db should be preserved over the center 2-3' arc. Outside of this area the purity is less important, and it may suffice if the purity is 30 db or better over the main beam. Sidelobes outside the main beam are less important again, since signals received in them should be rejected in the interferometer analysis. Purity of 20 db or better will probably suffice.

There are other requirements besides the purity of the polarization, but in general these are probably less severe. (It may be noted that the experiment does not detect a signal in the form of a difference between the two modes.) The gain, the beamwidth and the direction of pointing should be closely equal for the two modes; furthermore, the performance must not be noticeably inferior in these respects to the performance of the existing linearly polarized feed:

Parameters of secondary pattern	Difference between two circular modes	Difference from existing linearly polarized mode
Gain	$\leq$ 1/2 db	$\leq$ 1 db
Beamwidth	$\leq$ 10%	$\leq$ 10%
Pointing errors	$\leq$ 10% of beamwidth	$\leq$ 10% of beamwidth

The outputs should each be matched to a VSWR of $\leq$ 1.1 over the band. The feed should not introduce appreciable noise ($\leq$ 15 °K, i.e. $\leq$ 0.2 db loss).

So far, the specification has been in terms of the secondary pattern (i.e. of the 85-foot reflectors) since this is how the system must finally be tested. The translation into characteristics of the primary feed pattern is not entirely straightforward, though this is presumably what a manufacturer will require. We may note the following: (1) The reflectors have circular symmetry and the feed support legs have four-fold symmetry. The reflectors work at λ 3 cm and hence must be well nigh perfect at λ 11 cm. Consequently little error should arise due to these components. (2) The purity of polarization will not be maintained if the switch which finally selects the required hand of polarization has crosstalk in excess of - 40 db. The polarization will not be switched faster than once per minute, and the switching can be performed if necessary by a coaxial relay having isolation in excess of this figure.

The on axis purity of polarization depends upon a mean value of the purity over the whole of the primary feed pattern, weighted most towards the peak of the pattern. Consequently the purity at the center of the primary pattern should be at least as good as, or better than, that required at the center of the secondary pattern. We therefore specify the axial ratio at the center of the primary pattern must not exceed 1.01:0.99 (≡ 40 dbs), and should preferably be less.

It may be necessary to build in some form of trimming control to achieve this specification. This would be acceptable. It seems that the only way satisfactorily to measure and/or adjust to this purity is to transmit and receive via two identical feeds, facing each other. Then a signal radiated as (say) LH polarization from one feed should be received at the LH port of the other feed 40 db down with respect to the RH port. This experiment must be repeated with one feed rotated in polarization with respect to the other by angles of up to 90°.

It is not clear what conditions the primary pattern must fulfill in order to reduce the cross-polarization to an acceptable level away from the center of the secondary beam. Presumably if the primary pattern is everywhere better than 30 db (axial ratio 1.03:0.97), this will suffice, but it may not be a necessary condition.

This criteria as to gain, bandwidth and beamsquint are presumably satisfied if one uses the existing 871 feeds, whose properties with one linear polarization are known. The chief requirement to be checked is that the electrical center for each circular mode shall lie on the rotation axis to ± 3 mm and at the same axial distance to ± 1 cm. The patterns for each circular mode shall be measured in two perpendicular planes as a check that no major unexpected phenomena occur.

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June 23, 1966