

REPORT 814-2

FACTORS TO BE CONSIDERED IN THE CHOICE OF POLARIZATION FOR PLANNING THE BROADCASTING-SATELLITE SERVICE

(Question 1/10 and 11, Study Programme 1A/10 and 11)

(1978-1982-1986)

1. Introduction

For purposes of planning the broadcasting-satellite service in the band 11.7-12.5 GHz in Region 1 and 11.7-12.2 GHz in Region 3, right- and left-hand circular polarization was adopted. Similarly, in Region 2, right- and left-hand circular polarization was selected for the Plan for the broadcasting-satellite service in the band 12.2-12.7 GHz as well as for the associated feeder-link Plan in the band 17.3-17.8 GHz. Furthermore, at the WARC ORB-85 the frequency bands 14.5-14.8 GHz (for countries outside Europe and for Malta) and 17.3-18.1 GHz were selected for the planning of feeder links for the broadcasting-satellite service in Regions 1 and 3. It was assumed that circular polarization will be used for planning. Alternatively linear polarization could be used, subject to the agreement of all administrations sharing the given orbital position.

This Report presents a summary of the factors that were considered in making this choice, both for the record, and for the planning of future systems in other bands that are, or may be, allocated to the broadcasting-satellite service. It is also suggested that the data in this Report be periodically updated.

2. Comparison between linear and circular polarization

The comparative advantages and disadvantages of linear and circular polarization for use in the broadcasting-satellite service are summarized in Table I. The symbols in the last two columns of the Table indicate for each factor which type of polarization, linear (L) or circular (C), is considered to have the advantage. In evaluating these comparative advantages and disadvantages, it must of course be recognized that the different factors are not all of equal practical importance and that their relative importance is also a matter of engineering judgement.

To aid in evaluating the importance of satellite antenna orientation on the choice of polarization (item 3 in Table I), a short, quantitative discussion of the effects of system geometry on linear polarization is given in Annex I.

The choice between linear and circular polarization for planning the BSS is governed by two major factors:

- the effect of rain attenuation and depolarization on C/N and C/I ;
- the effect on interference of the misalignment between the reference linear polarization vectors and of the misalignment of earth station and satellite polarizers.

Rain affects both the C/N and C/I of linearly and circularly polarized waves for small percentages of time. On the other hand, the misalignment between linearly polarized signals of interfering networks and the misalignment between transmitters and receivers has:

- no effect on C/N of linearly and circularly polarized networks,
- no effect on C/I of circularly polarized networks,
- little effect on co-polar C/I of linearly polarized networks, but
- has a strong effect on the cross-polar C/I of linearly polarized networks.

This is significant since linear polarization is normally used to improve C/I during rain but, as a consequence of the misalignment, it may decrease C/I far below the maximum possible discrimination capability of the satellite and earth-station antennas.

It was found that even for high rainfall zones, the effect of rain on co-polar and cross-polar C/I is small for all but 1% of the worst month. For smaller percentages of time, the effect of rain becomes more important and its effect on cross-polar C/I depends on the type of polarization and on the reference vectors for linear polarization.

There are two main reference systems that can be used to define linear polarization:

- *canted linear polarization*: *Vertical polarization* is defined so that the polarization vector is perpendicular to the satellite antenna beam axis and lies in the plane defined by the satellite antenna beam axis and the local vertical. *Horizontal polarization* is defined so that the polarization vector is perpendicular to the satellite antenna beam axis and is contained in the local horizontal plane. These vectors will be in the direction closest to the local horizontal or local vertical at the boresight of the satellite antenna;
- *equatorial linear polarization*: *Polar polarization* is defined so that the polarization vector is perpendicular to the satellite antenna beam axis and lies in the plane defined by the satellite antenna beam axis and a line parallel to the Earth's polar axis. *Equatorial polarization* is defined so that the polarization vector is perpendicular to the satellite antenna beam axis and parallel to the equatorial plane.

In general, the better performance that would be available from linear polarization requires two conditions which are, in most cases, incompatible. On the one hand, the best performance of linear polarization is obtained when the signal is received vertically polarized. On the other hand, the orthogonally-polarized interfering signals must be received exactly at 90° from the wanted signal. Because of the geometry of the problem these two conditions cannot be met simultaneously.

A slightly better performance can be obtained with linear polarization when the reference vector is defined perpendicular to the equatorial plane, and if the receiver misalignment does not exceed 3° for all co-polar systems. This implies that the polarization is not received vertically, and therefore does not meet the first condition. Since this improvement is considered marginal considering the additional constraint imposed on the receiver polarizer alignment, circular polarization is therefore suggested for planning of the broadcasting-satellite service.

Information on depolarization due to rain is given in Reports 722 and 564.

3. Experimental results

A study was performed in Canada on the choice between linear and circular polarization for the BSS down links. The cross-polar discrimination capability of the earth-station antenna XPI_{ES} is assumed to be in the range of 20 to 25 dB and the XPI_{SAT} of the satellite antenna in the range of 27 to 33 dB for both linear and circular polarization.

The effect of rain attenuation and depolarization on the down link C/I has been studied for rain climatic zones E, K and N using the rain model of Report 564. The results have shown that for all but 1% of the worst month, the effect of rain attenuation and depolarization on co-polar and cross-polar C/I is very small. For smaller percentages of time, the effect of rain attenuation and depolarization on cross-polar C/I depends on the type of polarization and on the reference vectors for linear polarization. Figure 1 gives the results of the availability of cross-polar C/I between homogeneous satellite down-link beams (2° diameter) using canted linear or equatorial linear or circular polarization.