

RECOMMENDATION 80-3*

TRANSMITTING ANTENNAS IN HF BROADCASTING

(Question 44/10, Study Programme 44H/10)

(1951-1978-1986-1990)

The CCIR,

CONSIDERING

- (a) that a directional transmitting antenna should be used whenever appropriate, both to obtain adequate coverage of an intended service area and to minimize unwanted radiation, and potential interference, elsewhere;
- (b) that the design and installation of a wide variety of directional HF antenna types of improved performance are feasible using current technology;
- (c) that directional transmitting antennas can radiate significant power in unwanted directions;
- (d) that comprehensive and detailed information on the theoretical radiation characteristics of HF antennas is given in Part 1 of Annex I to Recommendation 705;
- (e) that information regarding the differences between the theoretical and practical performance of HF antennas is given in Part 2 of Annex I to Recommendation 705,

UNANIMOUSLY RECOMMENDS

1. that Annex I and Annex II should be used to give guidance on the choice of a suitable HF transmitting antenna;
2. that side-lobe radiation should be maintained at the lowest practical value;
3. that in practical operating conditions, for purposes of calculating interference, the field strength in other azimuths at angles of elevation corresponding to those of the main lobe, cannot be assumed to be less than 222.mV/m at a distance of 1 km for 1 kW of power supplied to the antenna, in the case of high gain antennas. A lower value of interfering field strength may need to be considered in the case of low gain antennas.
4. that Annex I to Recommendation 705 should be used as a source for more detailed information.

Note – The World Administrative Radio Conference for the Planning of HF Bands Allocated to the Broadcasting Service (WARC HFBC(1)), Geneva, 1987 has adopted for use, calculated values of minimum radiation which in some cases are lower than that given above (see Annex II).

ANNEX I**

1. The use of non-directional and directional antennas

In HF broadcasting the antenna is the means by which the radio-frequency energy is directed towards the required service area. The selection of the right type of antenna will enhance the signal in this area, while reducing radiation in unwanted directions. This will protect other users of the radio-frequency spectrum operating on the same channel or adjacent channels in another service area. The use of directional antennas with well defined radiation patterns is thus recommended as far as possible.

* Since the content of Reports 32-5 and 1062 have been modified and annexed to this Recommendation as Annexes I and II, respectively, Reports 32-5 (Dubrovnik, 1986) and 1062 (Dubrovnik, 1986) are hereby deleted.

** Nomenclature is explained in Annex I to Recommendation 705 and in Annex II to the present Recommendation.

Non-directional antennas can be used when the transmitter is located within the required service area. In this case the required service area as seen by the transmitter extends over an azimuthal angle greater than 180° .

Directional antennas serve a double purpose. The first is to prevent interference to other users of the spectrum by means of their directivity. The second is to provide sufficient field-strength for satisfactory reception by means of their power gains.

A chart in Fig. 1 gives some general guidelines for the choice of optimum antennas for a given type of service according to the required distance range. Two different categories are considered: short distance and medium/long-distance services.

A short distance service is understood here to have a range of up to about 2000 km. The corresponding area can be covered with either a non-directional or a directional antenna whose beamwidth can be selected according to the sector to be served. In the case of directional antennas, both horizontal dipole curtain and logarithmic-periodic antennas can be employed.

Medium and long distance services can be considered to reach distances greater than approximately 2000 km. Such coverage can be provided by antennas whose main lobe elevation angle is small (6° - 13°) and whose horizontal beamwidth — depending on the area to be served — is either wide between 65° and 95° (generally 70°) or narrow between 30° and 45° (generally 35°).

The value of the field strength in the reception area is influenced by the radiation characteristics of the antenna, which depends upon the type of array. Antennas of extremely narrow horizontal and vertical beamwidth should not be used because variations of the ionosphere could change the location of the coverage area.

Although rhombic antennas are used for broadcasting, their use should be discouraged because of the size and number of their sidelobes, which could create unnecessary interference.

2. Reduction of subsidiary lobes

For the purpose of avoiding interference in frequency sharing, the reduction of subsidiary lobes in high-frequency broadcasting directional antenna systems is of utmost importance. This interference is generally caused by the radiation pattern of the transmitting antenna having subsidiary lobes in unwanted directions, or by scatter of the energy of the main lobe, due to propagation anomalies. Reduction in intensity of the subsidiary lobes is possible by correct antenna design, while the propagation scatter in unwanted directions presents a complex problem, and its effect should be treated statistically.

HF curtain antennas constructed of horizontal dipole elements are made unidirectional by the addition of a reflector screen. This screen can be comprised of either:

- an identical array of dipoles tuned to provide an optimum front-to-back ratio over the range of operating frequencies. In general no power is applied to this type of reflector, which is known as either a “tuned dipole” or a “parasitic” reflector; or
- a screen consisting of horizontal wires which act as an untuned reflector. This type of reflector is known as an “aperiodic screen”.

The maximum slew values obtained in practice for different antenna types are given in Table I of Annex II.

While slewing does not appreciably affect the horizontal width of the main lobe of radiation, it does increase its asymmetry and at the same time produces a principal subsidiary lobe of considerable intensity. In slewing, the gain of main lobe decreases with the increase of the slewing angle and side lobe radiation increases. As a consequence the field strength created by the side lobes will substantially increase.

Practical experience in the People's Republic of China has confirmed the possibility of obtaining satisfactory slewing by using the value of current phase differences determined by a successive approximation method of calculation [CCIR, 1986-90a].

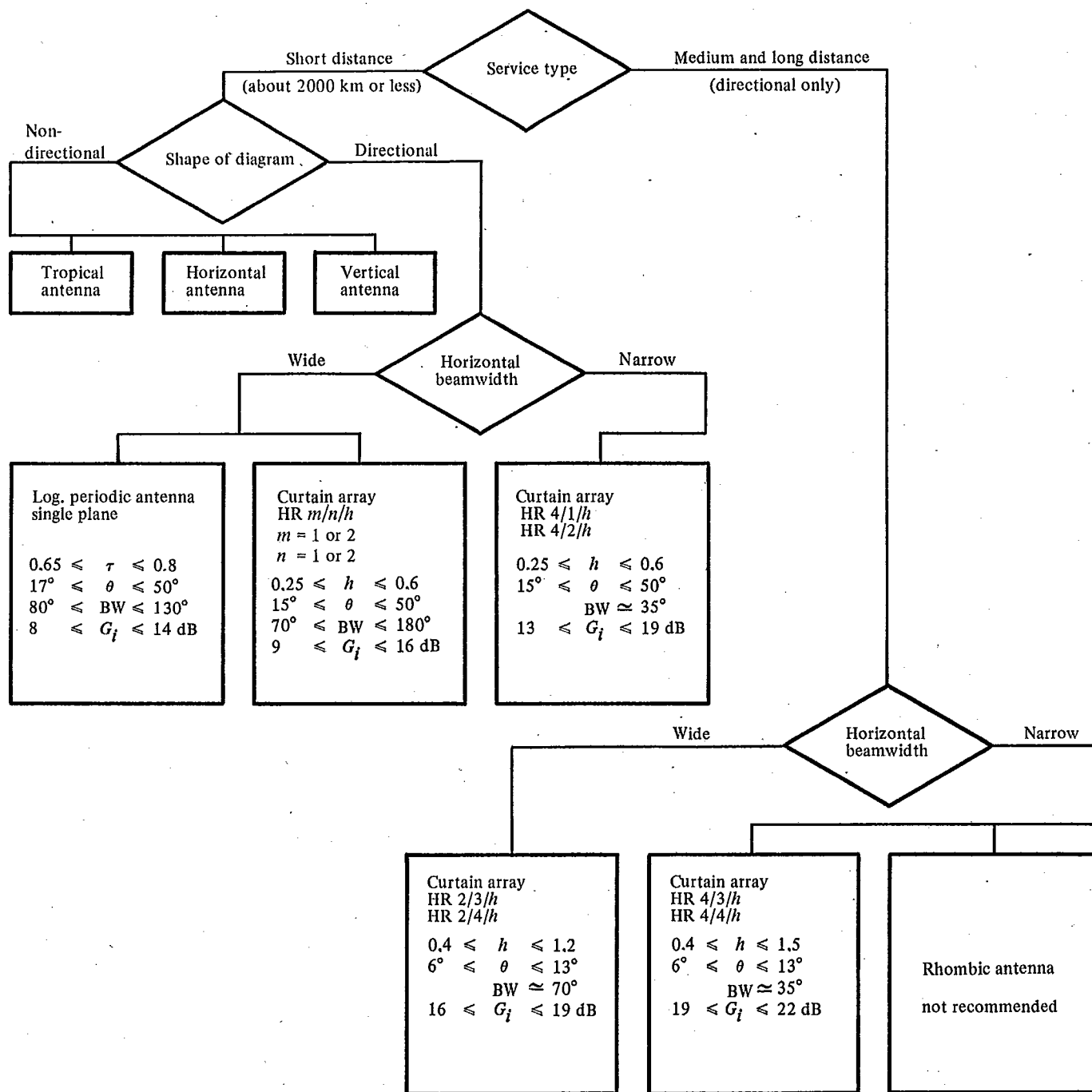


FIGURE 1 - Antenna selection chart

 θ : elevation angle G_i : gain (dB) relative to an isotropic antenna isolated in space G_d : gain (dB) relative to a half-wave dipole isolated in space ($G_i = G_d + 2.2 \text{ dB}$)BW: total horizontal beamwidth (-6 dB relative to maximum)

HR: horizontal dipole curtain antenna with reflector curtain

 m : number of half-wave elements in each row n : number of half-wave elements in each stack (one above the other) h : height above ground in full wavelengths of the bottom row of elements τ : taper ratio of log. periodic antenna

} of maximum radiation of the main beam

Tests in Italy [CCIR, 1963-66a] have shown that with an antenna of the type HRS 5/4/1.5 it is possible to reduce the amplitude of subsidiary lobes significantly when feeding the five stacks of dipoles separately. This property is maintained when the main beam is slewed.

A special feature of some type HR 4/4 antennas manufactured in France is that the reflector is fed, an arrangement which makes it possible to adjust accurately the current amplitudes and phases in the back and front of the arrays. Measurements of the pattern, using a helicopter, showed that it resembled the theoretical patterns very closely (nulls about 40 dB). Compared with systems with passive reflectors, the new arrays have a larger bandwidth and are more easily adjusted.

Calculations in France have also shown that, for multiband antennas of the type HR 2/ n / h extension of the frequency ratio to a value of f_{max}/f_{min} close to 3 would result in satisfactory theoretical radiation patterns without significant development of subsidiary lobes.

Although it is possible to achieve a substantial degree of suppression of side lobes for curtain arrays, the methods so far employed introduce mechanical difficulties and increase the cost.

3. Verification of radiation patterns

The RAI in Italy and the Vatican City State [CCIR, 1982-86a, 1986-90b] have made a series of field-strength measurements to investigate and verify the effective radiation pattern of a variety of types of HF antennas. The measurements have been performed by using airborne equipment. The results of these measurements on non-obstructed antennas confirm that the radiation patterns of the main beam are in good agreement with the theoretical values given by the CCIR special publication on Antenna Diagrams, 1984. Detailed studies by several administrations confirm the validity of these theoretical values. Details on these studies may be found in for example [CCIR, 1986-90c]. Furthermore it is shown that in the case of a practical horizontal dipole antenna with an aperiodic screen reflector the back radiation and that in the principal minimum in the forward direction is about 20 dB below the maximum of the main lobe. It can be concluded that the methodology of measuring antenna patterns by helicopter described in Part 2 of Annex I to Recommendation 705 is a reliable and valuable means of evaluating the performance of transmitting antennas.

4. Discrimination obtained in practice by directional antennas

Extensive measurement campaigns have been carried out in different countries, to evaluate the field strength of co-located transmitters and of transmitters on different transmitting sites using directional antennas directed to geographically separated service areas. These results were used to derive antenna discrimination values, that is, the reduction in field strength, relative to the main beam value, at angles of azimuth and elevation other than those of the main beam. The discrimination obtained in practice was consistent with the limiting value given in this Recommendation. The discrimination deduced from theoretical antenna considerations (see Part 1 of Annex I to Recommendation 705) would in most cases have been much higher than that actually measured. These measurement campaigns are reported by the United Kingdom in [CCIR, 1962, 1963, 1963-66b, 1970-74] and India [CCIR, 1974-78].

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[1970-74]: 10/180 (United Kingdom).

[1974-78]: 10/57 (India).

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ANNEX II

HF ANTENNA PATTERNS FOR SYSTEM DESIGN AND PLANNING

1. A set of reference antenna characteristics

The formulae and the associated software for the calculation of antenna patterns and values of maximum gain are given in Recommendation 705 for a wide range of HF antenna types. A limited set of reference HF antenna characteristics using the patterns of horizontal dipole antennas was adopted by WARC HFBC-87. Patterns of horizontal dipoles were used because it was found that these were the most commonly used antenna type. An examination of the variation in performance of this set of antennas forms a useful introduction to the range of antenna characteristics found in practice.

The principal characteristics of this reference set of patterns are summarized in Table I, containing 24 types of directional antenna together with a simplified pattern of a non-directional antenna (type 25). This set of antennas was selected so that a relatively wide range of characteristics is represented with only small changes between types. It also includes multiband operation and slewing.

The characteristics given in Table I apply to a design frequency of 10 MHz and ground of average conductivity. The characteristics for dual band and multiband antennas are frequency dependent. Information regarding typical expected changes in performance with frequency is given in § 3.

Information is given regarding:

- the maximum directivity gain of the main lobe of radiation in dB relative to an isotropic antenna;
- the elevation angle at which maximum radiation occurs;
- the azimuthal beamwidth to the –6 dB points;
- information regarding the practical slewing capabilities for the cases where the radiator/reflectors are one of the following:
 - (A): aperiodic screen reflector with centre-fed elements;
 - (T): tuned dipole reflector with centre-fed elements;
 - (TE): tuned dipole reflector with end-fed elements.

Types 1-6 are arrays having four collinear dipoles in each row, with from two to four parallel rows of dipoles stacked one above the other, and using one of the types of reflectors listed above, and have been extended to include multiband operation and slewing.