

AS 1417:2023



Receiving antennas for radio and television in the VHF and UHF broadcast bands — Design, manufacture and performance of outdoor terrestrial television antennas



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Receiving antennas for radio and television in the VHF and UHF broadcast bands — Design, manufacture and performance of outdoor terrestrial television antennas

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Preface

This Standard was prepared by the Standards Australia Committee CT-002, Broadcasting and Related Services, to supersede AS 1417:2015.

The objective of this document is to specify requirements for the design and manufacture of outdoor antennas for the reception of digital terrestrial television and DAB Radio transmitted in the high VHF and UHF bands and to provide the necessary performance specification and recommended values for manufacturers to make products suitable for the Australian environment.

The major changes in this edition are as follows:

- (a) The antenna patterns in [Clause 2.4.4](#) have been changed. Figures have been updated and additional figures added.
- (b) Wind loading references have been updated.
- (c) Corrosion resistance parameters have been changed.
- (d) Referenced standards have been updated to current versions.

The terms “normative” and “informative” are used in Standards to define the application of the appendix to which they apply. A “normative” appendix is an integral part of a Standard, whereas an “informative” appendix is only for information and guidance.

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NOTES

Australian Standard®

Receiving antennas for radio and television in the VHF and UHF broadcast bands — Design, manufacture and performance of outdoor terrestrial television antennas

Section 1 Scope and general

1.1 Scope

This document specifies requirements for outdoor terrestrial TV antennas for the reception of digital television. It provides specifications for minimum electrical performance and aspects of mechanical design for reception of terrestrial digital television broadcasts.

This document also provides a number of alternate measurement techniques that may be used to determine the performance of the antenna, along with information and guidance on their use.

Requirements for the reception of analogue television transmissions are not specified in this document, as analogue terrestrial television transmissions in Australia have ceased.

This document only considers receiving antennas suitable for Australian digital terrestrial television (DTT) services that operate in VHF Band III (174 MHz to 230 MHz), and UHF Bands (519 MHz to 694 MHz). This document does not include Band I or Band II reception capabilities that are not required for Australian DTT. Band II reception for FM radio is not covered by this document.

This document is applicable to outdoor television antennas capable of receiving Australian digital television signals. This includes various types of antennas, such as Yagi, phased-array and log-periodic designs which can operate over VHF Band III and UHF frequency bands.

NOTE 1 For a list of Australian RF channel numbers and frequencies, see [Appendix C](#).

This document can be applied to the use of VHF Band III antennas that are installed vertically polarized for the specific and sole use of the reception of vertically polarized DAB+ Radio.

This document does not directly consider specific design features, such as corner reflector rear directors, horizontal or vertical stacking to improve directivity, or length-to-diameter (L/D) ratios.

Although indoor antennas are not covered, some of the principles and specification requirements that are included could apply to indoor antenna performance.

Minimum antenna performance specifications are provided for a range of reception conditions, based on the Australian coverage planning requirements for adequate DTT reception.

NOTE 2 Digital radio (DAB+) in Australia has been assigned operating frequencies in VHF Band III and consequently could use digital television receiving Band III antennas, although transmission polarization for all DAB transmissions is vertical polarization.

NOTE 3 [Appendix A](#) gives information and guidance on antenna parameter measurements for a range of signal conditions and different antenna types.

NOTE 4 [Appendix D](#) gives further information about expected signal levels and failure mechanisms of digital TV reception.

NOTE 5 For details of how an antenna output should be distributed to multiple outlets as is required in single and multi-dwelling installations, refer to the latest edition of AS/NZS 1367.

NOTE 6 Additional ancillary requirements may include (integral) filters for rejection of interference from devices using an adjacent spectrum, such as mobile broadband services.

1.2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document.

NOTE Documents referenced for informative purposes are listed in the Bibliography.

AS 2331.1.1, *Methods of test for metallic and related coatings, Method 1.1: Local thickness tests—Micrographic examination of cross-sections*

AS 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60068-2-52, *Environmental testing – Part 2-52: Tests – Test Kb: Salt mist, cyclic (sodium chloride solution)*

ITU-R Recommendation BT.419-3, *Directivity and polarization discrimination of antennas in the reception of television broadcasting*

ACMA. Technical Planning Parameters and Methods for Terrestrial Broadcasting

1.3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

1.4.1

analogue

system in which a signal is continuous and varies in magnitude and frequency as a copy of the source signal

Note 1 to entry: Analogue is commonly used in conjunction with the type of transmission. See *digital* ([1.4.17](#)).

1.4.2

antenna

device used for transmission or reception of radio frequency signals that acts to convert the power between (to or from) radiated electromagnetic waves and electrical signals across a medium

Note 1 to entry: Also known as an aerial (for terrestrial reception) or a dish (for satellite reception).

1.4.3

antenna gain

ability of an antenna to concentrate the radiated power in a given direction, or conversely to effectively absorb incident power from that direction, relative to a reference antenna

Note 1 to entry: In this document a theoretical isotropic antenna is the reference antenna.

1.4.4

antenna pattern

plot of antenna's radiation intensity over a 360° rotation, usually shown on a polar plot with a logarithmic or linear scale

1.4.5

attenuator

passive device that reduces the signal power level

Note 1 to entry: Typically, an attenuator or pad is in the form of an in-line device with male and female connectors.

1.4.6

additive white Gaussian noise

AWGN

generated RF test signal used in engineering testing

1.4.7**balun**

type of electrical transformer that can convert electrical signals carried on two wire feeds that are balanced to signals that are unbalanced (one conductor connected to system earth) and vice versa

Note 1 to entry: Baluns are also often used to change impedance, particularly from around the 300 ohms of a folded dipole antenna to 75 ohms suitable for coaxial feed cable.

1.4.8**bandwidth**

difference, expressed in hertz (Hz), between the highest and lowest frequencies of that range of spectrum interest

Note 1 to entry: This definition may apply to the bandwidth of an antenna, the range of frequency of operation of an amplifier or other components, or the spectral width of a transmission channel.

1.4.9**channel**

frequency division of the bandwidth of the terrestrial broadcast spectrum or a similar division in a cabled distribution system

Note 1 to entry: Terrestrial broadcast channel width used in Australia for DVB-T digital television is 7 MHz in the VHF and UHF bands. An RF channel division should not be confused with logical channel numbers (LCNs) used by broadcasters to identify their various program services.

1.4.10**characteristic impedance**

ratio of voltage level to current flow at the measurement point, as determined by the physical dimensions and characteristics

1.4.11**coaxial cable**

dual conductor cable in which a centre conductor is surrounded by, but does not contact, a concentric cylindrical outer conductor

Note 1 to entry: The outer conductor may be a solid tube ("hardline" or semi-rigid cable). Flexible cable may have a braid of many wires or a thin aluminium foil, or layers of foil and braid such as that found in quad-shield cable.

Note 2 to entry: The preferred coaxial cable for terrestrial digital television antenna connection and distribution is a quad-shield type with a single-centre conductor type RG-6 (approximately 7 mm diameter), or for long runs or trunk distribution, RG-11 (approximately 10 mm diameter).

1.4.12**COFDM****coded orthogonal frequency division multiplexing**

type of modulation used for terrestrial broadcasting transmission

1.4.13**cross polarization**

orientation of linear polarized signals at 90° to the desired plane.

Note 1 to entry: A horizontal polarized antenna has rejection of vertical polarized signals.

1.4.14**DAB+****digital audio broadcasting plus.**

digital radio system based upon Eureka 147 DAB with COFDM modulation that was extended (+) using high efficiency advanced audio coding (HE AAC) and an extra level of error correction (RS) and is as used in Australia on VHF Band III with 1.5 MHz "ensembles"

1.4.15**dBd**

antenna's gain relative to a theoretical dipole antenna, expressed in a logarithmic ratio as a value

Note 1 to entry: dBi is the ratio in dB of received power from an antenna in a uniform electromagnetic field at a given frequency relative to the power received in the same field by a theoretical dipole antenna set to that frequency.

1.4.16**dBi**

antenna's gain relative to a theoretical isotropic antenna expressed in a logarithmic ratio as a value

Note 1 to entry: Antenna gain expressed in dBi is theoretically 2.15 dB greater than if it is referenced to a dipole (dBd) — usually rounded to 2 dB. This document recommends the use of dBi.

1.4.17**digital**

sampling and coding of analogue signals into discrete “bits” of information, i.e. ones and zeros

Note 1 to entry: Digital may also refer to digital modulated transmission based on, for example, DVB-C, DVB-S, DVB-S2 or DVB-T.

1.4.18**directivity**

ratio of concentrated radiated (or received) power, in the direction of maximum radiation, to the average radiated (or received) power over all directions

Note 1 to entry: The directivity is related to the gain by the antenna efficiency: gain (dBi) = directivity – internal antenna loss.

1.4.19**F-type connector****F-connector**

type of coaxial RF connector commonly used for terrestrial television and cable television, and universally used for satellite television and cable modems

Note 1 to entry: Quality approved types with designated cable may have satisfactory characteristics beyond 1 GHz.

Note 2 to entry: The solid centre wire conductor of the specified types of coaxial cable is used as the pin of the male connector.

Note 3 to entry: Some connector types can have very good protection against moisture ingress.

1.4.20**frequency bands**

small sections of the spectrum of radio communication frequencies in which channels are usually used or set aside for the same purpose

1.4.21**fringe area**

area where broadcast signal reception is weak and prone to interference or a low carrier-to-noise ratio

1.4.22**half-wave dipole**

antenna composed of two in-line sections, each one quarter wavelength in length at the frequency of operation

Note 1 to entry: The overall length will be less than the free-space half wavelength as the antenna will have a lower velocity of propagation of the EM wave than the free space velocity of light.

1.4.23**horizontal polarization**

transmissions received by an antenna with its elements in a horizontal plane

Note 1 to entry: The electric field is horizontal in a horizontally polarized signal.

1.4.24**isotropic**

uniform in all directions

1.4.25**may**

indicates the existence of an option

1.4.26**phased array**

array of antennas (including dipoles) arranged and phased for a particular directional performance

1.4.27**receiving antenna**

part of a radio receiving system that converts intercepted electromagnetic waves into guided radio frequency currents or fields in an associated transmission line

Note 1 to entry: This definition will normally include any impedance-matching devices, baluns and integral active equipment.

1.4.28**return loss****RL**

loss suffered by the incident signal in being returned, or reflected, from a termination, normally expressed in decibels

Note 1 to entry: If Z_0 is the characteristic impedance of the cable and Z_1 is the impedance of the termination, the

$$RL = 20 \log \left\{ \left(Z_1 + Z_0 \right) / \left(Z_1 - Z_0 \right) \right\}.$$

Note 2 to entry: The return loss is related to the VSWR (voltage standing wave ratio) by the expression

$$RL = 20 \log \left\{ \left(VSWR + 1 \right) / \left(VSWR - 1 \right) \right\}.$$

1.4.29**shall**

indicates that a statement is mandatory

1.4.30**should**

indicates a recommendation

1.4.31**ultra-high frequency****UHF**

frequency that is nominally 300 MHz to 3 000 MHz but for television reception includes Bands IV and V

Note 1 to entry: For DVB-T broadcasting in Australia, the UHF band from 526 MHz to 694 MHz is split into four "blocks" of six 7 MHz channels known as Blocks B, C, D and E.

1.4.32**vertical polarization**

transmissions received by an antenna with its elements in a vertical plane

Note 1 to entry: The electric field is vertical in a vertically polarized signal.

1.4.33**very high frequency****VHF**

frequency that is nominally 30 MHz to 300 MHz but for FM radio includes Band II at 88 MHz to 108 MHz and for television and DAB+ includes Band III from 174 MHz to 230 MHz known as Block A

1.4.34**voltage standing wave ratio****VSWR**

ratio of the maximum to the minimum voltage on a transmission line of characteristic impedance Z_0

Note 1 to entry: VSWR is related to the return loss as indicated in the definition for return loss.

1.4.35**Yagi**

antenna consisting of a dipole and additional parasitic elements comprising one or more rear reflectors and several forward placed directors

Note 1 to entry: Also known as “Yagi-Uda” after its inventors, Hidetsuga Yagi and Shintaro Uda.

Section 2 Electrical specifications

2.1 General

Required antenna performance parameters are detailed in this section. These should be detailed in the antenna specification sheet, as indicated in [Section 4](#).

NOTE An example of a completed antenna specification sheet is given in [Appendix B](#) Table B.1.

The term “specification” is used in this normative section to signify that (within the operating range) the antenna parameters to which it refers are manufactured to or guaranteed to operate to at least the performance or design parameter value given by the manufacturer or supplier.

Specifications may be published as expanded information suitable for a printed or electronic catalogue, or as summarized information included with the antenna as distributed.

Details of preferred format of specification data are given in [Section 4](#) and [Table 4.1](#).

2.2 Antenna suitability for given reception areas

Antennas should be designated according to their design, including suitability for various reception conditions such as prime (urban and suburban) or fringe (rural) reception.

NOTE 1 See [Appendix D](#) for more information.

To ensure reliable DTT reception on all required channels, an antenna should be selected that will provide more than a sufficient margin (level and quality) above the minimum to decode the service, and that will tolerate variations over time, such as between seasons, in rain, reflections from aircraft (including Doppler echo), impulsive noise, etc. For further information, see [Clause D.10](#).

The antenna type may also need to be selected for specific reception difficulties. For example, antennas with a narrow beamwidth are generally more suitable for receive locations that are subject to high levels of multiple reflections. This could include single frequency network (SFN) reception areas where the coverage is extended by two or more same frequency (re)transmit sites. A narrow beamwidth antenna could maximize reception from the best site and reduce pickup from other sites.

In areas covered by multiple transmit towers, receive locations relatively close to the towers, where the signals originate from different directions, may need an antenna with a wider beamwidth.

Such factors may determine the suitability of design types such as Yagi, log-periodic, or phased-array for particular reception scenarios.

NOTE 2 Further advice may be found in *Digital TV Antenna Systems*, published by the Australian Building Codes Board.

2.3 Operating frequency range or bandwidth

2.3.1 General

The published information provided by the manufacturer or supplier, specifying an antenna's operating frequency range or bandwidth, shall be the frequency range over which the antenna parameters are equal to or are better than the specified figures given in this document for gain, directivity, return loss (RL) and cross polarization discrimination.

NOTE Details of television channel frequencies and other services in the Australian frequency bands are given in [Appendix C](#) Table C.1.

2.3.2 Channel block plan

Australian DTT services in the frequency band from 694 MHz to 820 MHz in all areas have been restacked into VHF or UHF channels below 694 MHz. In most broadcast licence areas, the transmissions of all networks in an area are allocated within a six channel block.

These six channel blocks are as designated in [Table 2.1](#).

Table 2.1 — Channel blocks with frequencies

Block	Channels	Frequency range, MHz
A	6–12	174–230
B	28–33	526–568
C	34–39	568–610
D	40–45	610–652
E	46–51	652–694
NOTE Channels 9 and 9A are normally used for DAB but may be used for DVB-T at some locations.		

2.3.3 Use of channel blocks and exceptions

In many locations, most reception installations will only require an antenna to operate across one of these frequency blocks. This is not to imply that antennas should be limited to receive only across a single block.

There are some broadcast licence area exceptions with transmissions spread over wider spectrum allocations. These include service overlap areas with typically eight network transmissions spread over two blocks (such as along the Australian east coast) and some regional and remote areas that are allocated to non-contiguous channels.

Most premises in main capital cities will access their main services on VHF Band III requiring Block A antennas. Areas covered by repeaters usually only require UHF antenna reception capability.

NOTE RF channel assignments for each television service area are available on the Australian Communications and Media Authority (ACMA) website (<http://www.acma.gov.au>).

2.3.4 Rejection of out-of-band signals

Antennas suitable for digital television services in Australia need to only receive the signals broadcast within a limited frequency range in a given reception area. There is an increasing presence of other radio frequency emissions close in frequency to the television band edges, at VHF below 174 MHz and above 230 MHz, at UHF below 519 MHz and especially above 694 MHz. Such emissions may cause difficulties to DTT receiving systems if the receiving system is not optimized.

Reduction of out-of-band signals may be achieved by selecting a more suitable antenna, changing its location, and including filters to reject out-of-band signals, including those from mobile telephony, data and mobile broadband services equipment operating above 694 MHz.

2.4 Antenna gain

2.4.1 Gain specification

The antenna gain shall be stated over the specified operating frequency range that is limited by the (RL) bandwidth (see [Clause 2.6.3](#)). For recommended antenna gains in various reception conditions and environments, see [Tables 2.2, 2.3 and 2.4](#).

For the recommended specification sheet format, see [Table 4.1](#).

Note that the gain of an antenna may be compared to either a theoretical omnidirectional isotropic antenna with notional gain of 0 dBi or a half-wave dipole at a given operating frequency with a gain of 2 dBi.

NOTE This is rounded from 2.15 dBi to 2 dBi.

Any antenna gain figure referenced to an isotropic antenna should be labelled as dBi; but if referenced to a half-wave dipole, the figure should be labelled in dBd. The conversion is as follows:

$$\text{dBi} = \text{dBd} + 2 \text{ dB}$$

The use of “dB” alone for gain is not recommended as it promotes uncertainty and confusion.

The antenna gain shall be published in specifications as dBi and labelled as such.

The gain shall be measured at the antenna’s output F-type connector.

The antenna gain figure shall not include any amplification. If the antenna has an integral amplifier, then the antenna gain, the amplifier’s gain and noise figure should each be published.

The published gain value shall include the following details:

- (a) The operating frequency range (MHz).
- (b) The forward gains at the lowest, mid-range and highest frequencies.

Graphs of the antenna gain over its specified frequency bands should also be published.

2.4.2 Beamwidth (3 dB)

The 3 dB beamwidth, also known as the half-power beamwidth, is an angle in degrees between the two directions on either side of the major lobe where the gain is 3 dB less than the maximum gain value in the intended direction and polarization of reception. The range of beamwidths of an antenna shall be published, noting the applicable frequencies of operation. This could also be displayed on a polar pattern.

2.4.3 Front-to-back ratio

The front-to-back (F/B) ratio of an antenna, expressed in dB, is the ratio of the maximum gain in the forward direction (referenced as 0°) to the maximum gain in the rear direction over the range centred 180° ± 20°. This shall be specified over the operating frequency range and intended polarization of the antenna.

2.4.4 Antenna patterns (Directivity)

Directivity is the ability of an antenna to discriminate between signals arriving from different directions. The published antenna specification at minimum shall include the 3 dB beamwidth and the (F/B) ratio, as indicated in [Clauses 2.4.2](#) and [2.4.3](#).

Preferably, an antenna’s E-plane and H-plane patterns should be published as a graph covering 360° where the maximum gain orientation is taken to be at 0°. As a minimum, such a pattern should be measured at the mid-frequency point of each band that the antenna is specified for.

NOTE 1 Directivity should be understood as the ability of an antenna to discriminate between signals arriving from different directions. Such discrimination was important for analogue television to reduce the visibility of the effects of multipath reception on the picture. However, for digital television reception, some multipath (within the “guard interval”) may be acceptable, despite reducing the reception margin. A wider beamwidth may be useful for reception in areas (usually urban) with television transmitter towers located in different directions.

NOTE 2 Not directly specified is the reception of reflected signals arriving from above or below the reception plane such as a horizontal polarized antenna receiving interfering reflected signals from an aircraft passing overhead or reflected signals arriving by atmospheric high ducting phenomena. Corner rear reflectors or vertical dipole stacking may reduce this effect.

The directivity performance of receiving antennas for planning purposes is derived from ITU-R Recommendation BT.419-3 and ACMA's *Technical Planning Parameters and Methods for Terrestrial Broadcasting* and is shown in [Figures 2.1, 2.2](#) and [2.3](#).

The nominal antenna directivity response used for TV planning is shown in [Figures 2.1](#) and [2.2](#).

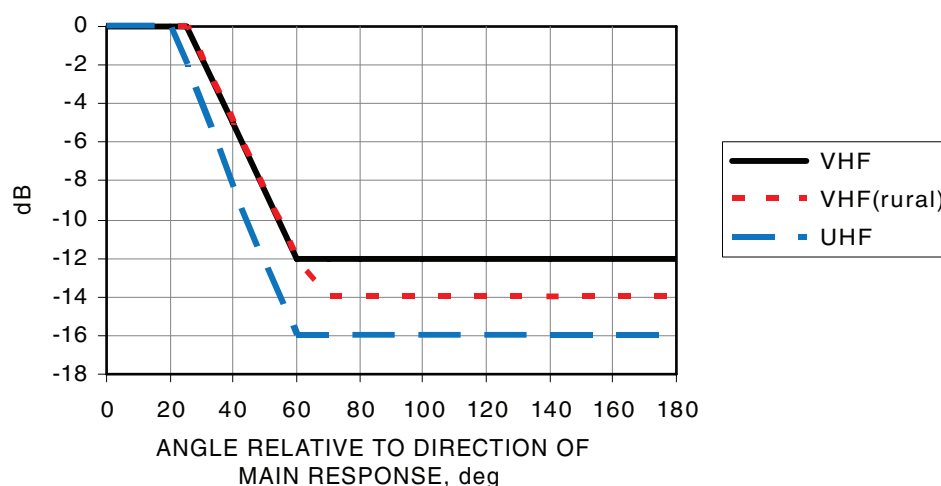


Figure 2.1 — Directivity Response — Angle relative to direction of main response in degrees

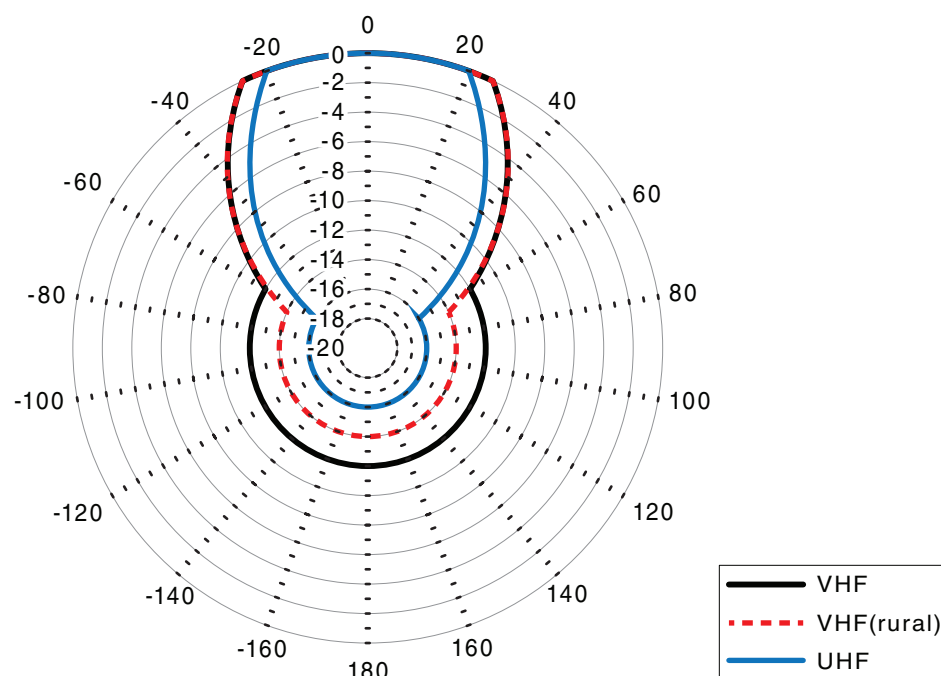


Figure 2.2 — Directivity response — Antenna gain (dB) relative to angle of main response in degrees

2.4.5 Front-to-sidelobe ratio

The front-to-sidelobe ratio of an antenna, expressed in dB, is the ratio of the maximum gain in the forward direction (referenced as 0°) to the highest gain measured between 90° and -90° but excluding 160° to -160°. This should be specified over the operating frequency range and intended polarization of the antenna.

2.5 Cross-polarization discrimination

The cross-polarization protection ratio, in dB, is the ratio of the power received from a signal that is linearly polarized in the desired plane of the antenna's polarization and a stated direction to the power received from an orthogonally polarized signal of the same amplitude and the same direction.

The antenna measurement for the cross-polarization protection ratio is referred to as cross-polarization discrimination.

The cross-polarization discrimination performance of receiving antennas for planning purposes is derived from ITU-R Recommendation BT.419-3 and ACMA's *Technical Planning Parameters and Methods for Terrestrial Broadcasting* and is shown in [Figure 2.3](#).

Antennas that meet the cross-polarization discrimination shown in [Figure 2.3](#) may be better able to reduce interfering signals.

In [Figure 2.3](#), the y-axis values are the ratio of cross-polar power at a given angle to the co-polar power received in the forward direction.

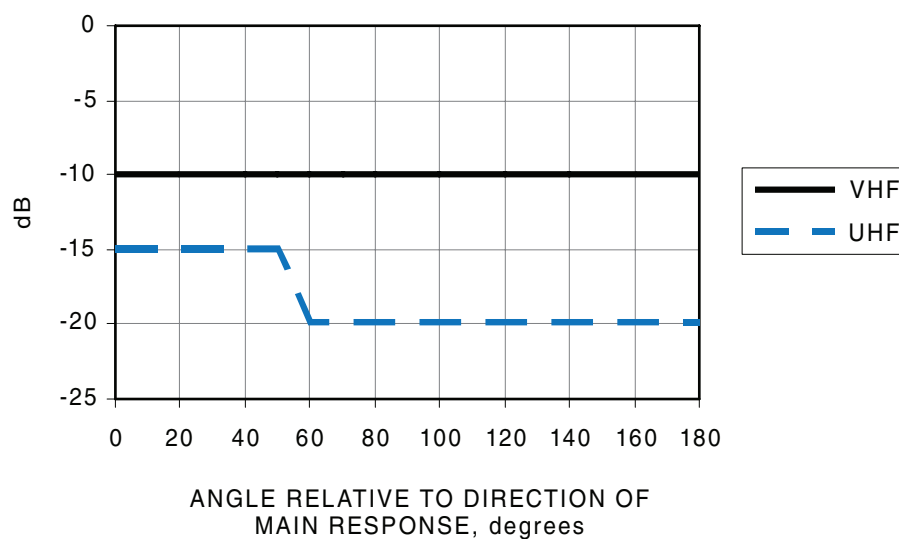


Figure 2.3 — Cross-polarization discrimination — Angle relative to direction of main response in degrees

2.6 Antenna interface characteristics

2.6.1 Antenna output connector

The antenna output connector shall be a female F-type connector designed to feed a 75 Ω coaxial cable. See [Clause 3.8.3](#) for requirements for the sealing or encapsulation of the enclosure to ensure that moisture ingress over the antenna's lifetime does not lead to corrosion of the centre connector.

A "saddle and clamp" coaxial or 300 Ω connection shall not be used.

NOTE 1 A female F-type connector is also known as F-connector.