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Satellite Earth Stations (SES); Transmit/receive Very Small Aperture Terminals (VSATs) used for data communications operating in the Fixed Satellite Service (FSS) 11/12/14 GHz frequency bands

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Foreword

This European Telecommunication Standard (ETS) has been produced by the Satellite Earth Stations (SES) Technical Committee of the European Telecommunications Standards Institute (ETSI), and, has undergone the ETSI standards approval procedure in Public Enquiry 20 and Vote 25.

Every ETS prepared by ETSI is a voluntary standard. This ETS may contain text concerning type approval of the equipment to which it relates. This text should be considered as guidance only and does not make this ETS mandatory.

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1 Scope

This European Telecommunication Standard (ETS) provides specifications for the standardisation of the characteristics of transmit/receive Very Small Aperture Terminals (VSATs) operating as part of a satellite network used for the distribution and/or exchange of data between users.

In such a network a Centralised Control and Monitoring Function (CCMF) is responsible for the monitoring and control of remote VSATs.

These VSATs have the following characteristics:

- operating in the exclusive part of the Ku-band allocated to the Fixed Satellite Services (FSS), 14,00 to 14,25 GHz (Earth-Space), 12,50 to 12,75 GHz (Space-Earth), and in the shared parts of the Ku-band, allocated to the FSS and Fixed Services (FS), 14,25 to 14,50 GHz (Earth-Space) and 10,70 to 11,70 GHz (Space-Earth);

- in these frequency bands linear polarisation is normally used and the system operates through satellites at 3° spacing;

- designed for unattended operation;

- limited to the reception and transmission of baseband digital signals;

- equipped with one, or several terrestrial ports but the total aggregate information bit rate transmitted towards the satellite through these ports shall be limited to 2,048 Mbit/s;

- antenna diameter not exceeding 3,8 m, or equivalent corresponding aperture.

The equipment considered in this ETS comprises both the "outdoor unit", usually composed of the antenna subsystem and, associated power amplifier and Low Noise Block (LNB), and the "indoor unit" composed of the remaining part of the communication chain, including the cable between these two units.

This ETS does not contain any requirement, recommendation or information about the installation of the VSATs. Nor is this ETS intended to apply to VSAT network hub stations.

This ETS deals with two types of specification:

a) Essential normative requirements (indicated in Clause 4)

Requirements are specified in order to protect other users of the frequency spectrum, both satellite and terrestrial, from unacceptable interference. In addition, requirements are specified for the purposes of electrical safety, structural safety and solar radiation protection as well as protection from harmful interference.

The test and measurement procedures associated with the normative requirements detailed in Clause 4 of this ETS shall be performed and the criteria met in order to demonstrate compliance with this ETS.

b) Recommendations (indicated in Clause 5)

These are related to characteristics which contribute to the quality of reception by providing the VSAT with minimum interference protection from other radio systems.

The test and measurement procedures associated with the informative recommendations detailed in Clause 5 of this ETS are given for verification purposes only. The compliance with the recommendations will not be taken as a condition to comply with this ETS.

All tests related to the requirements shall be performed and the results shall be entered in the data sheet of the test report. The ability to comply with the recommendations shall also be noted in the data sheet of the test report.

2 Normative references

This ETS incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to, or revisions of, any of these publications apply to this ETS only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

[1] IEC 950 (1991): "Safety of information technology equipment including electrical business equipment".

[2] IEC 81(Co)6 (1981): "Standards for Lightning Protection of Structures".

[3] CISPR publication No.22 (1985): "Limits and methods of measurement of radio interference characteristics of information technology equipment".

[4] CISPR publication No.16 (1987): "Specifications for radio interference measuring apparatus and measurement methods".

[5] EN 55011 (1986): "Limits and methods of measurements of radio interference characteristics of industrial, scientific and medical (ISM) radio-frequency equipment".

[6] IEC 510-2-1 (1978): "Part 2: Measurements for sub-systems. Section one - General. Section Two - Antenna (including feed network)".

[7] IEC 510-1-2 (1984): "Part 1: Measurements common to sub-systems and combinations of sub-systems. Section Two - Measurements in the r.f. range".

[8] IEC 801-3 (1984): "Electromagnetic compatibility for industrial process measurement and control equipment Part 3: Radiated electromagnetic field requirement".

[9] ETS 300 160: "Satellite Earth Stations (SES); Control and monitoring functions at a VSAT".

[10] ETS 300 161: "Satellite Earth Stations (SES); Centralised control and monitoring functions for VSAT networks".

[11] CCIR Recommendation 732 (1990): "Method for statistical processing of Earth station antenna side-lobe peaks".

[12] Draft prETS 300 193: "Satellite Earth Stations (SES); General requirements for the connection of Very Small Aperture Terminals (VSATs) systems to terrestrial networks (DE/SES-3001)".

[13] Draft prETS 300 194: "Satellite Earth Stations (SES); The interconnection of Very Small Aperture Terminal (VSAT) systems to Packet Switched Public Data Networks (PSPDNs) (DE/SES-3002)".

[14] DE/SES-3003: "Standard for the interconnection of VSAT systems to CSPDNs".

[15] DE/SES-3007: "Standard for the interconnection of VSAT systems to ISDN".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of this ETS, the following definitions apply:

Outdoor unit: is the part of the terminal installed in a position within line of sight to the satellite and it is intended to be operated in outdoor environmental conditions.

It usually comprises three main parts:

1) the antenna sub-system which converts the incident radiation field into a guided wave and vice versa;

2) the LNB, which is a device that amplifies, with very low internal noise, the received signals in the Radio Frequency (RF) band and converts them to intermediate frequencies;

3) the power amplifier which amplifies the low level RF signals for transmission through the antenna subsystem.

NOTE: The installation equipment (means of attachment) is not included in this ETS. However, the antenna structures and other components directly mounted on the antenna and forming an integral part of it, are subject to the specifications of this ETS.

Indoor unit: is composed of the remaining part of the equipment. It is generally installed inside the buildings and is connected to the outdoor unit. The connection cable between the outdoor and indoor unit belongs to the indoor unit.

Nominated bandwidth: the bandwidth of the VSAT radio frequency transmission is nominated by the manufacturer. The nominated bandwidth shall encompass all close-in spectral elements of the transmission which have a density greater than the specified spurious levels. The nominated bandwidth shall be wide enough to take account of the transmit carrier frequency stability. The value of the nominated bandwidth shall be entered in the data sheet of the test report.

This parameter is to allow flexibility regarding adjacent channel interference levels which shall be taken into account by operational procedures depending on the exact transponder carrier assignment situation.

Spurious radiation: is any radiation outside the nominated bandwidth.

3.2 Abbreviations

For the purposes of this ETS, the following abbreviations apply:

CCMF	Centralised Control and Monitoring Functions
CSPDN	Circuit Switched Public Data Network
EIRP	Equivalent Isotropically Radiated Power
EUT	Equipment Under Test
FS	Fixed Service
FSS	Fixed Satellite Service
ISDN	Integrated Services Digital Network
LNB	Low Noise Block (low noise amplifier and down converter)
PSPDN	Packet Switched Public Data Network

RF Radio Frequency

VSAT Very Small Aperture Terminal

4 Requirements

4.1 Safety

4.1.1 Mechanical construction

Purpose:

Protection of operating personnel, the public and goods from insecure structures.

Specification:

This specification applies to the outdoor unit only.

The outdoor unit, including mounted and structural components, (but excluding the means of attachment) shall be designed to support the following main loads due to:

- the weight of the antenna and structural components;

- the wind speed.

Loading due to snow and ice is not considered.

At wind speeds up to 180 km/h, referred to standard atmosphere temperature and pressure (293 K and $1{,}013 \times 10^5$ Pa (1 013 mbar)) none of the components shall have been torn away.

Verification:

Two alternative methods are given for verification.

a) Wind tunnel testing.

A wind tunnel shall be used for the purpose of conformance testing. The wind tunnel tests shall be performed on the outdoor unit, or alternatively on a scale-model of the outdoor unit. The data obtained for the scale-model shall be computed in order to obtain data for the true antenna size.

b) Numerical analysis and simplified tests.

This method shall provide an alternative to the wind tunnel test. The effects of maximum wind load shall be first computed on the overall outdoor unit using a numerical analysis method, e.g. finite elements method by computer taking into account the intrinsic properties of the materials. In a second step, the computed loads shall be applied to the structure.
The purpose of the numerical analysis is twofold:

1) to show compliance with the specification under nominated conditions;

2) to compute equivalent static loads (force and torque) applied to the critical attachment points of the structure, e.g.:

- reflector - mounting legs fixing point;

- reflector - struts;

- struts - LNB.

Test procedure:

a) Wind tunnel.

The test object shall be mounted in such a way, that wind load can be applied from all horizontal directions in steps of 45°. The tests shall be carried out with the elevation angle of the antenna at its minimum and at its maximum in turn. The wind load shall be increased gradually in steps up to 180 km/h, each step lasting approximately one minute.

The tests may be performed at any atmosphere temperature and air pressure. If the atmospheric conditions differ from standard conditions (temperature = 293 K, air pressure = 1,013 x 10^5 Pa), then the test velocity shall be determined according to the formula:

$$V_T = V_S \sqrt{((1{,}013 \times 10^5) / P_T) \times (T_T / 293)}$$

where: V_T = wind velocity in test
V_S = wind velocity in standard conditions
P_T = air pressure in test, (Pa)
T_T = temperature in test, (K)

During the load conditions the test object shall be observed and the distortions recorded.

The test report shall contain:

- a description of the test equipment;
- a description of the tests performed;
- results of the measurements or calculations on the mechanical loads transmitted from the outdoor unit to the attachment devices.

For the pointing stability (see subclause 4.3.1):

- results of the measurements of the deviation of the antenna position, and components with respect to each other.

b) Numerical analysis and tests.

The computations needed to derive the field of forces and torque and the equivalent static stresses shall be carried out for the same wind directions and elevation as specified in the wind tunnel test procedure a) above. Only the maximum 180 km/h shall be considered. The air related parameters, namely the kinematic viscosity used to calculate drags at the rims of the structure shall be calculated with the standard atmospheric environmental conditions given in a) above. It shall be verified with the simulated results that break point limits are not exceeded for any self-contained element. During the practical test the calculated equivalent static loads shall be applied at any critical fixing point of the assembly.

During the load conditions, the outdoor unit shall be observed, and any distortion recorded.

The test report shall contain:

- the computation method used;
- a description of the test equipment;
- a description of the tests performed;
- results of the safety margin calculation;
- results of the measurements or calculations on the mechanical loads transmitted from the outdoor unit to the attachment devices.

For the pointing stability (see subclause 4.3.1):

- results of the measurements or mechanical distortions.

4.1.2 Electrical safety

4.1.2.1 Power voltages

Purpose:

Protection of operating personnel and the public from electric shock.

Specification:

The electrical safety of the equipment shall be in accordance with the introduction and Clauses 1 to 3 of IEC 950 [1]. These Clauses deal with fundamental design requirements, wiring, connections and supply.

Verification:

Conformance shall be determined according to IEC 950 [1], verification methods.

4.1.2.2 Lightning

Purpose:

To avoid dangerous potential differences between the outdoor unit and any other conductive structure.

Specification:

Means shall be provided to permit the attachment of bonding conductors of dimension indicated in table 7 of IEC 81(Co)6 [2].

Verification:

Conformance shall be determined by inspection.

4.1.3 Radio frequency radiation protection

Purpose:

Protection of operating personnel and the public from radio frequency radiation hazards.

Specification:

The equipment shall be fitted with a warning notice in a clearly visible position, indicating the region in which a radio frequency radiation level in excess of 10 W/m^2 may occur.

Verification:

By visual inspection.

4.1.4 Solar radiation protection

Purpose:

Protection of operating personnel and the public from solar radiation focusing effects.

Specification:

If, in conditions of sunshine, solar radiation is focused near the feed such that burning may occur, the equipment shall be fitted with a warning notice in a clearly visible position.

Verification:

A statement shall be provided to indicate that the surface of the antenna has been treated to avoid the situation, or otherwise by visual inspection to confirm the presence of warning notice.

4.2 Radio frequency

4.2.1 Spurious radiation

Purpose:

To limit the level of interference to terrestrial and satellite radio services.

Specification:

1) The VSAT shall satisfy the limits for radiated interference field strength specified in CISPR Publication No. 22 [3] over the frequency range from 30 MHz to 960 MHz.

Frequency range (MHz)	Quasi-peak limits (dBµV/m)
30 to 230	30
230 to 960	37

The lower limits shall apply at the transition frequency.

The applicable class A (test distance 30 m) or B (test distance 10 m) shall be designated by the manufacturer and indicated in the data sheet of the test report.

2) For the carrier-off case, the off-axis spurious Equivalent Isotropically Radiated Power (EIRP) from the VSAT, in any 100 kHz band, shall be below the following limits, for all off-axis angles greater than 7°:

960,0 MHz to 10,7 GHz 48 dBpW
10,7 GHz to 21,2 GHz 54 dBpW **1)**
21,2 GHz to 40,0 GHz 60 dBpW

The lower limits shall apply at the transition frequency.

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1) Prior to 1st January 1994, a limit of 63 dBpW shall be applied in the frequency range 13,6 to 14,9 GHz.

3) For the carrier-on case, the off-axis spurious EIRP from the VSAT, shall be below the following limits, for all off-axis angles greater than 7°:

49 dBpW	in any	100	kHz band in the range	960,0 MHz to 3,4	GHz;
55 dBpW	in any	100	kHz band in the range	3,4 GHz to 10,7	GHz;
61 dBpW	in any	100	kHz band in the range	10,7 GHz to 13,6	GHz;
78 dBpW[2)]	in any	20	MHz band in the range	13,6 GHz to 14,9	GHz;
61 dBpW	in any	100	kHz band in the range	14,9 GHz to 21,2	GHz;
67 dBpW	in any	100	kHz band in the range	21,2 GHz to 28,0	GHz;
78 dBpW[2)]	in any	20	MHz band in the range	28,0 GHz to 29,0	GHz;
67 dBpW	in any	100	kHz band in the range	29,0 GHz to 40,0	GHz;

The lower limits shall apply at the transition frequency.

4) These limits are applicable to the complete VSAT equipment, comprising the indoor and outdoor units and at least 10 m of connection cable between them.

Verification:

Measurement of spurious radiation generated by a VSAT terminal under operation.

Test procedure:

The full system shall be tested according to the test procedure given in Annex A.

The environmental conditions of the test laboratory shall be within the range of those for which the indoor unit is designed to operate.

4.2.2 On axis spurious radiation

Purpose:

To limit the level of interference to satellite radio services.

Specification:

In the 14,0 GHz to 14,5 GHz band the EIRP spectral density of the spurious radiation excluding intermodulation products and excluding the nominated bandwidth shall not exceed 4 - 10 log N dBW in any 100 kHz band with the carrier on.

The on axis spurious radiations, outside the 14,0 GHz to 14,5 GHz band, are limited in subclause 4.2.1 by taking into account the on axis antenna gain.

N is the maximum number of VSATs which are expected to transmit simultaneously in the same carrier frequency band. This number shall be indicated by the manufacturer.

When the carrier is off, the EIRP spectral density of the spurious radiation in the 14,0 GHz to 14,5 GHz band shall not exceed - 21 dBW in any 100 kHz band.

NOTE 1: Intermodulation limits inside the band 14,0 GHz to 14,5 GHz are to be determined by system design, subject to satellite operator specifications.

Verification:

Conformance shall be determined by direct measurement.

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2) Prior to 1st January 1994, a limit of 88 dBpW shall be applied.

Test procedure:

The measurement shall be performed by the following method.

The power of the spurious radiations at the interface point between the antenna and the remaining outdoor unit shall be measured according to the measurement method in IEC 510-1-2 [7], Clause 2, paragraph 5.2.2. The antenna on-axis gain shall be measured using one of the methods of IEC 510-2-1 [6], Clause 8, or any other method, that can be proved to give the same results. The EIRP of the spurious radiation shall be calculated from the above two measurements. The environmental conditions of the test laboratory shall be those for which the indoor unit is designed to operate.

NOTE 2: Definitions and methods of measurement for integrated equipment are under study.

4.2.3 Transmit carrier centre frequency stability

Purpose:

Protection of transmissions on the same satellite.

Specification:

The transmitted carrier centre frequency shall not deviate from its nominal value by more than an amount which allows the carrier (and its close-in spectral components which have a spectral power density greater than the specified spurious levels) to remain within its nominated bandwidth. This frequency tolerance refers to the initial frequency adjustment plus long-term drift. Long-term drift shall be assumed to be at least one month.

Verification:

Conformance shall be determined from documentary evidence.

4.2.4 Off-axis EIRP emission density (co-polar and cross-polar) within the band 14,0 GHz to 14,5 GHz

Purpose:

Protection of other satellite (uplink) systems.

Specification:

The maximum EIRP in any 40 kHz band within the nominated bandwidth of the co-polarised component in any direction Φ degrees from the antenna main beam axis shall not exceed the following limits:

33 - 25 log Φ - 10 log N	dBW for 2,5°	$\leq \Phi \leq$	7°
12 - 10 log N	dBW for 7°	$<\Phi \leq$	9,2°
36 - 25 log Φ - 10 log N	dBW for 9,2°	$<\Phi \leq$	48°
-6 - 10 log N	dBW for	$\Phi >$	48°

In addition the cross-polarised component in any direction Φ degrees from the antenna main beam axis shall not exceed the following limits:

23 - 25 log Φ - 10 log N	dBW for 2,5°	$\leq \Phi \leq$	7°
2 - 10 log N	dBW for 7°	$<\Phi \leq$	9,2°

Where Φ is the angle, in degrees, between the main beam axis and the direction considered, and N is the maximum number of VSATs which may transmit simultaneously in the same carrier frequency band. This number shall be indicated by the manufacturer.

NOTE 1: For Φ > 70° the values given above may be increased to 4 - 10 log N dBW over the range of angles for which the particular feed system may give rise to relatively high levels of spillover.

NOTE 2: For antennas designed for minimum off-axis gain in the direction of the geostationary orbit, the specification for Φ between 2,5° and 20° need only be met within ± 3° of a plane bisected by the main beam axis.

This plane must be marked and identified on the antenna. There must be an axis of rotation along the main beam axis, with adjustment capability to an accuracy of 0,5°. The antenna must be capable of having the above plane aligned with the geostationary orbit plane.

Verification:

Conformance shall be determined from:

- measurement of maximum RF power density entering the antenna feed;

- measurement of the co-polar and cross-polar transmit gain patterns in four planes: the E- and H-planes and the two planes with an inclination of 45° relative to these.

Test procedure:

The measurement of the RF power density shall be made in accordance with IEC 510-1-2 [7], paragraph 5.2.2.2. The measurement of the transmit gain patterns shall be made in accordance to IEC 510-2-1 [6], Clause 8, or any other recognised method that can be proved to give the same results, at 14,005 GHz, 14,250 GHz and 14,495 GHz.

4.2.5 Transmit polarisation discrimination

Purpose:

Protection of signals on the orthogonal polarisation.

Specification:

The polarisation discrimination of the antenna system in the transmit frequency band shall exceed 25 dB.

NOTE: Some satellite operators may require a higher ratio.

Verification:

Conformance shall be determined by measurement according to IEC 510-2-1 [6], Clause 7, or any other recognised method that can be proved to give the same results.

The initial polarisation alignment shall be such that the cross-polarised component on the main axis is minimum. No other polarisation alignment shall be done during the measurement.

The test results shall consist of bi-dimensional plots of co-polar and cross-polar antenna gain versus angles from boresight to the 1 dB contour of the main beam for the frequencies 14,005 GHz, 14,250 GHz and 14,495 GHz.

4.2.6 Carrier on-off

Purpose:

To allow for the satisfactory suppression of transmissions of a VSAT terminal by the CCMF.

Specification:

When the VSAT terminal is in suppressed transmission mode it shall transmit an EIRP density no more than 4 dBW in any 4 kHz band within the nominated bandwidth.

Verification:

Conformance shall be determined from practical tests as specified in subclause 4.2.2 of this ETS.

4.2.7 Electromagnetic immunity

Purpose:

Protection of the VSAT against interfering electromagnetic fields up to 2 000 MHz caused by other equipment. Beyond 2 000 MHz, a recommendation is given in subclause 5.5 of this ETS.

Specification:

The VSAT shall have an adequate level of intrinsic immunity to enable it to operate as intended, when it is exposed to the following electrical field strengths:

- 1 V/m in the frequency range 150 kHz to 50 MHz;
- 3 V/m in the frequency range 50 MHz to 2 000 Mhz.

Verification:

Conformance shall be determined by measurement according to IEC 801-3 [8], Clauses 6 to 9. The Equipment Under Test (EUT) shall be as in Annex A, Clause A.3. For the test set-up see also Annex A, Clause A.5, second paragraph. For operating mode signal generation see Annex A, Clause A.4.

The VSAT shall be considered to satisfy the electromagnetic immunity specification if the following conditions are met when the disturbing field is applied:

a) the quality of transmission observed is equal, or better than the lowest acceptable quality of transmission declared by the manufacturer;

b) under these conditions the VSAT transmission must be able to be suppressed by the CCMF or any CCMF simulator and it must not restart without being enabled from the CCMF;

c) when the VSAT is in the carrier-off state, there shall be no change in the signal level;

d) when the VSAT is in the carrier-on state, there shall be no change in the signal level and frequency.

4.3 Mechanical

4.3.1 Pointing stability

Purpose:

To prevent interference to adjacent satellites during severe wind conditions.

Specification:

Under the condition of 100 km/h maximum wind speed, with gusts of 130 km/h lasting 3 seconds, the installation shall not show any sign of permanent distortion and shall not need repointing after the application of the wind load.

Verification and test procedure:

The verification tests shall be carried out at the same time as those for mechanical construction requirements. The methodology and procedures shall be the same as those specified in subclause 4.1.1 of this ETS.

4.3.2 Antenna pointing accuracy capability

Purpose:

To make possible precise antenna pointing in order to avoid interference to adjacent satellites.

Specification:

The antenna mount shall allow the position of the antenna transmit main beam axis to be fixed with an accuracy of better than 0,3˚ along the geostationary orbit.

Verification:

By documentary evidence provided by the manufacturer.

4.3.3 Polarisation angle alignment capability

Purpose:

To make possible precise antenna linear polarisation alignment in order to avoid interference to adjacent satellites.

Specification 1:

The polarisation angle shall be continuously adjustable in a range of at least 180°.

Specification 2:

It shall be possible to fix the transmit antenna polarisation angle with an accuracy of at least 1°.

Verification:

By documentary evidence provided by the manufacturer.

5 Recommendations

5.1 Antenna transmit gain pattern (co-polar and cross-polar)

Purpose:

Protection of other satellite (uplink) systems and terrestrial services.

Specification 1: Protection of terrestrial services.

The gain G (Φ) in dB relative to an isotropic antenna of the main lobe and of at least 90 % of the side-lobe peaks should not exceed the following limits:

$$\begin{array}{lll} 29 - 25 \log \Phi & \text{for} & 2{,}5^\circ \leq \Phi \leq 7^\circ \\ 8 & \text{for} & 7^\circ < \Phi \leq 9{,}2^\circ \\ 32 - 25 \log \Phi & \text{for} & 9{,}2^\circ < \Phi \leq 48^\circ \\ -10 & \text{for} & \Phi > 48^\circ \end{array}$$

Additionally, the cross-polar gain G (Φ) in dB relative to an isotropic antenna of at least 90 % of the peaks should not exceed the following limits:

19 - 25 log Φ	for	$2,5^\circ < \Phi \leq 7^\circ$
- 2	for	$7^\circ < \Phi \leq 9,2^\circ$

Where Φ is the angle, in degrees, between the main beam axis and the direction considered.

NOTE 1: For Φ > 70° the values given above may be increased to 0 dBi over the range of angles for which the particular feed system may give rise to relatively high levels of spillover.

NOTE 2: The method of statistical processing of side-lobe peaks and the definition of a peak is dealt with in Annex II of CCIR Recommendation 732 [11].

Specification 2: Protection of adjacent satellites.

Specification 1 should be met for Φ between 2,5° and 20°.

NOTE 3: For antennas designed for minimum off-axis gain in the direction of the geostationary orbit, the specification for Φ between $2,5^\circ$ and 20° need only be met within $\pm 3^\circ$ of a plane bisected by the main beam axis.

This plane must be marked and identified on the antenna. There must be an axis of rotation along the main beam axis, with adjustment capability to an accuracy of $0,5^\circ$. The antenna must be capable of having the above plane aligned with the geostationary orbit plane.

Verification:

Conformance shall be determined by measurement of the co-polar and cross-polar transmit gain patterns in four planes: the E- and H-planes and the two planes with an inclination of 45° relative to these.

The measurement shall be made in accordance to IEC 510-2-1 [6], Clause 8, or any other recognised method that can be proved to give the same results for the frequencies 14,005 GHz, 14,250 GHz and 14,495 GHz.

5.2 Antenna receive gain pattern (co-polar and cross-polar)

Purpose:

Protection of the wanted signals from interference from terrestrial services and from adjacent satellites.

Specification 1: Protection from terrestrial services:

The gain G (Φ) in dB relative to an isotropic antenna of the main lobe and of at least 90 % of the side-lobe peaks should not exceed the following limits:

29 - 25 log Φ	for	$2,8^\circ \leq \Phi \leq 7^\circ$
8	for	$7^\circ < \Phi \leq 9,2^\circ$
32 - 25 log Φ	for	$9,2^\circ < \Phi \leq 48^\circ$
- 10	for	$\Phi > 48^\circ$

Additionally, the cross-polar gain G (Φ) in dB relative to an isotropic antenna of at least 90 % of the peaks should not exceed the following limits:

19 - 25 log Φ	for	$2,8^\circ < \Phi \leq 7,0^\circ$
-2	for	$7,0^\circ < \Phi \leq 9,2^\circ$

Where Φ is the angle, in degrees, between the main beam axis and the direction considered.

NOTE 1: For $\Phi > 70°$ the values given above may be increased to 0 dBi over the range of angles for which the particular feed system may give rise to relatively high levels of spillover.

NOTE 2: The method of statistical processing of side-lobe peaks and the definition of a peak is dealt with in Annex II of CCIR Recommendation 732 [11].

Specification 2: Protection from adjacent satellites.

Specification 1 should be met for Φ between 2,8° and 20°.

NOTE 3: For antennas designed for minimum off-axis gain in the direction of the geostationary orbit, the specification for Φ between $2,8^\circ$ and 20° need only be met within $\pm 3^\circ$ of a plane bisected by the main beam axis.

This plane must be marked and identified on the antenna. There must be an axis of rotation along the main beam axis, with adjustment capability to an accuracy of $0,5^\circ$. The antenna must be capable of having the above plane aligned with the geostationary orbit plane.

Verification:

Conformance shall be determined by measurement of the co-polar and cross-polar receive gain patterns in four planes: the E- and H-planes and the two planes with an inclination of 45° relative to these.

The measurement shall be made in accordance to IEC 510-2-1 [6], Clause 8, or any other recognised method that can be proved to give the same results. For VSATs operating in the 12,50 to 12,75 GHz frequency band the measurements shall be made for the frequencies 12,505 GHz, 12,625 GHz and 12,745 GHz. For VSATs operating also in the 10,7 to 11,7 GHz frequency band the measurements shall be made at the frequencies 10,705 GHz, 11,200 GHz and 11,675 GHz.

5.3 Transmit polarisation discrimination

Purpose:

Protection of signals on the orthogonal polarisation.

Specification:

The polarisation discrimination of the antenna system in the transmit frequency band should exceed 30 dB within the 1 dB contour of the main beam.

Verification:

Conformance shall be determined by measurement according to IEC 510-2-1 [6], Clause 7, or any other recognised method that can be proved to give the same results.

The initial polarisation alignment shall be such that the cross-polarised component on the main axis is minimum. No other polarisation alignment shall be done during the measurement.

The test results shall consist of bi-dimensional plots of co-polar and cross-polar antenna gain versus angles from boresight to the 1 dB contour of the main beam for the frequencies 14,005 GHz, 14,250 GHz and 14,495 GHz.

5.4 Receive polarisation discrimination

Purpose:

To provide protection of the wanted signals from signals on the orthogonal polarisation.

Specification:

The polarisation discrimination of the antenna system in the receive frequency bands should exceed 27 dB, within the 1 dB contour of the main beam.

NOTE: Some satellite operators may require a higher ratio.

Verification:

Conformance shall be determined by measurement according to IEC 510-2-1 [6], Clause 7, or any other recognised method that can be proved to give the same results.

The initial polarisation alignment shall be such that the cross-polarised component on the main axis is minimum. No other polarisation alignment shall be done during the measurement.

The test results shall consist of bi-dimensional plots of co-polar and cross-polar antenna gain versus angles from boresight to the 1 dB contour of the main beam. For VSATs operating in the 12,50 to 12,75 GHz frequency band the measurements shall be made for the frequencies 12,505 GHz, 12,625 GHz and 12,745 GHz. For VSATs operating also in the 10,7 to 11,7 GHz frequency band the measurements shall be made at the frequencies 10,705 GHz, 11,200 GHz and 11,675 GHz.

5.5 Electromagnetic immunity

Purpose:

Protection of the VSAT against interfering electromagnetic fields between 2 000 MHz and 3 000 MHz caused by other equipment.

Specification:

The VSAT should have an adequate level of intrinsic immunity to enable it to operate as intended, when it is exposed to the following electrical field strengths:

3 V/m in the frequency range 2 000 MHz to 3 000 MHz

Verification:

As specified in subclause 4.2.7.

6 Terrestrial interfaces

Information is contained in relevant ETSs.

Current ETSs addressing the issue are prETS 300 193 [12], covering general requirements for terrestrial interfacing and prETS 300 194 [13] covering the interconnection of VSATs to PSPDNs. Draft ETS DE/SES-3003 [14] will cover the interconnection of VSATs to Circuit Switched Public Data Networks (CSPDNs) and draft ETS DE/SES-3007 [15] will cover the interconnection of VSATs to Integrated Services Digital Networks (ISDNs).

7 Control and monitoring

Relevant information is contained in ETS 300 160 [9] and ETS 300 161 [10].

Annex A (normative): Spurious radiation outside main-beam - test procedure

A.1 Introduction

This annex addresses the measurement procedure of spurious radiation from 30 MHz to 40 GHz generated by a VSAT terminal under operation. The radiations considered are those which are not only generated at the focal point of the antenna subsystem and are thus radiated in random directions around the terminal. Since these emissions are most likely to interfere with any type of equipment, the measurement shall be done at ground level and at several locations surrounding the EUT.

For purpose of the test, the VSAT terminal includes:

- the outdoor unit;
- the indoor unit;
- a connection cable between indoor and outdoor unit;
- the necessary power supply cables and any other cable ensuring a proper functioning of the terminal.

The test procedure is based on already existing international standards and more specifically CISPR Publication No. 22 [3] and EN 55011 [5].

A.2 Measuring method

a) Below 960 MHz, the measurement method of CISPR Publication No.22 [3] applies.

b) For frequencies above 960 MHz, the European Standard EN 55011 [5] shall apply.

The amplitude-frequency response of any antenna and associated amplification system used for the measurement shall remain within ± 1 dB of its calibration curve across the measurement frequency range considered for this antenna.

The use of a spectrum analyser with sweep time variation capability is recommended. The analyser response to a constant amplitude sine wave signal shall remain within ± 1 dB across the frequency range of interest.

The screening performance of the spectrum analyser shall be in conformity with Clause 6 of CISPR Publication No.16 [4].

The measurement shall be executed in two stages:

The first stage is just to identify frequencies of spurious radiation. This stage should be carried out in an anechoic chamber with the measuring antenna close to the EUT.

The second stage could be carried out on an open air test site for each frequency identified in the first stage. The test set-up shall be as in Clause A.5. The measuring procedure given in Clause A.6 shall be applied.

Above the cut-off frequency of the waveguide connected to the VSAT antenna the off-axis spurious EIRP shall be estimated by measuring the input power at the antenna flange and using the maximum antenna gain for off-axis angles greater than 7°. The maximum antenna gain shall be determined from the antenna gain patterns measured under the provisions of subclause 4.2.4.

NOTE: Definitions and methods of measurement for integrated equipment are under study.

A.3 Equipment under test

The EUT is the VSAT terminal which consists of:

- the outdoor unit;

- the indoor unit terminated with a matched impedance at the terrestrial ports;

- at least 10 m of cable to connect the indoor and outdoor units. This cable shall be the same as one of those recommended by the manufacturer in his installation manual. The type of cable used shall be noted in the test report;

- the necessary power supply cables and any other cable ensuring a proper functioning of the system.

A.4 Operating mode signal generation

In order to measure the system radiation and electromagnetic immunity under operational conditions, proper arrangement has to be provided (by the manufacturer) to put the VSAT terminal in its normal operating mode. A receive signal shall be provided to emulate the operational conditions of reception.

For radiation measurement in carrier-on mode, the VSAT shall be put in a continuous transmit mode. The VSAT shall be operated at the maximum operational EIRP.

A.5 Test site and test set-up

The test site shall be on a reasonable level surface or ground and it shall be free from reflecting objects so that the measurement results are not unduly affected.

The indoor and outdoor units shall be installed with a separation of about 2 m. Between the two, at least 10 m of the connection cable shall be installed. The height of the cable shall be between 0,5 m and 1 m. The cable shall be maintained in that position by non-metallic means. The outdoor unit shall be normally set on the ground with its mounting structure. The indoor unit shall be set on a non-metallic table at a height between 0,5 m and 1 m.

The measuring antenna shall be installed at a distance of 10 m from the boundary of the EUT and outside the nearfield energy flow of the VSAT antenna as well as outside the 7° off axis cone around the main beam direction. The boundary is defined in CISPR Publication No.22 [3], Clause 10.

The main beam of the VSAT antenna shall have an elevation of at least 7°.

For measurement below the cut-off frequency of the waveguide connected to the antenna, the antenna feed horn may be replaced by a dummy load.

A.6 Measuring procedure below cut-off frequency

The following procedures shall be put in operation:

- measuring bandwidth: 100 kHz;

- measuring angular step: in the horizontal plane around the EUT in steps of 10°;

- main beam elevation angle: 7°;

- measuring aerial polarisation and azimuth shall be varied during the measurements to find the maximum field strength.

History

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