

Method of Measurements for Fixed-Satellite Earth-to-Space services Operating in Ka Band from 17.8 GHz to 30 GHz (with parabolic reflector antenna) Date of Issue: 15 September 2025

REVISION CONTROL LOG

This Revision Control Log is to be maintained for all revisions of this document.

PAGE NUMBERS	REVISION LEVEL	DATE REVISED	APPROVAL SIGN-OFFS	
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All (New issue)	1.0	N/A	JMG	09/15/2025
Change summary: None. New release.				

1.0 PURPOSE

This document defines temporary alternative methods of measurement for Fixed-Satellite Earth-to-Space services operating in the Ka Band from 17.8 GHz to 30 GHz, in support of Japan Radio Testing and MIC Type Certification (according to Ministry of Internal Affairs and Communications Notice No. 88, Paragraph 2, dated December 1, 2017).

2.0 SCOPE

This procedure applies to the SpaceX Gateway, which features a parabolic reflector antenna operating in Ka-Band (17.8 GHz to 30 GHz).

3.0 TECHNICAL REQUIREMENTS SPECIFICATIONS

3.1 Environmental and Power Requirements

The technical requirements of the present document apply under the environmental profile for operation of the equipment, which shall be in accordance with its intended use. The equipment shall always comply with all the technical requirements of the present document when operating within the boundary limits of the operational environmental profile defined by its intended use.

Tests defined in this document shall be carried out at representative points within the boundary limits of the operational environmental profile, as defined by its intended use.

SpaceX declared/intended use operational environmental profile and frequency stability:

Temperature:	-40°C to +50 °C
Humidity:	0 % to 100 % (condensing) with IP55, NEMA 3R enclosure.
Frequency Stability:	+/-150 ppm
Power requirements:	200 to 240 VAC / 50-60 Hz single phase, 33 Amps (Verify the nominal voltage +/-10 % or if the EUT has a wide voltage range, the highest and lowest rated voltage at +10 % and -10 % respectively)

3.2 Operating configurations

For the purposes of verifying that the EUT complies with all the occupied bandwidth and other transmissions parameters of the transmitted signal, the manufacturer may declare the worst-case combination of transmission parameters. When the equipment can transmit more than 4 channels, a representative sampling of the low/mid/high channels should be sufficient proof of compliance. The following specifications apply to the EUT for each occupied bandwidth and other transmission parameters.

All operational parameters, including the maximum EIRP, EIRP densities in use, modulation, occupied bandwidth, channels, and polarization, shall be provided for the EUT testing.

The manufacturer shall declare the number of channels and emitters of the EUT that may be used simultaneously. The specifications in this clause shall apply to the configuration as declared by the manufacturer.

3.3 EUT requirements for testing purposes

The manufacturer shall submit one or more samples of the equipment as appropriate for testing.

Additionally, technical documentation and operating manuals, sufficient to allow testing to be performed, shall be supplied.

The performance of the EUT submitted for testing shall be representative of the performance of the corresponding production model. The manufacturer shall offer equipment complete with any auxiliary equipment needed for testing.

The manufacturer shall declare the frequency range(s), the range of operation conditions and power requirements, preheating as applicable, to establish the appropriate test conditions.

3.4 Measurement Equipment

Unless otherwise specified and documented, all testing should be carried out with ISO 17025-accredited and calibrated equipment, specifying the associated error/uncertainties for each related test setup.

4.0 TEST METHODS FOR FIXED-SATELLITE EARTH-TO-SPACE SERVICES Ka-BAND

4.1 General requirements

This clause outlines the general requirements for confirming that EUT's performance meets the specified criteria. Performance test methods are detailed in later clauses. The manufacturer must keep records of essential radio test results. The documentary evidence must include at least:

- test setup (configurations, test equipment, and calibration status);
- test conditions (environmental and operational parameters);
- method of testing;
- results of measurements, measurement resolution, and uncertainty; and
- statement of compliance with the technical specifications of the present document.

The test conditions for each test shall be representative of the intended operational environment and be noted in the test report where it has a significant effect on the measurement results.

The type, termination, and length of each cable used shall be representative of the intended installation and recorded in the test report. For maximum cable lengths exceeding 10 m, as declared by the manufacturer, tests shall be conducted with cables at least 10 m long.

4.2 Off-axis spurious radiation

4.2.1 Test method

4.2.1.1 General

The tests for the specification shall be limited to the "Carrier-on" radio state. The tests shall be undertaken with the transmitter operating at EIRP_{max}. An EUT with antenna is a ST with its antenna comprising both the indoor and outdoor units interconnected by 10 m of cable. An EUT without antenna is a ST with the removable antenna removed. It comprises both the indoor and outdoor units, up to the antenna flange, interconnected by 10 m of cable. The connecting cable between the indoor and the outdoor units shall be of the same type as specified by the applicant in the installation manual. The type of cable used shall be entered in the test report. The EUT shall be terminated with matched impedance at the terrestrial ports if recommended by the applicant in the user documentation and if there is no associated equipment connected to each port.

For frequencies up to 80 MHz the measuring antenna shall be a balanced dipole with a length equal to the 80 MHz resonant length and shall be matched to the feeder by a suitable balanced transforming device. Measurements with broad band antennas are also possible provided that the test site has been validated according to CISPR 16-1-4 [2]. For frequencies between 80 MHz and 1 000 MHz the measuring antenna shall be a balanced dipole which shall be resonant in length. Measurements with broad band antennas are also possible provided that the test site has been validated according to CISPR 16-1-4 [2].

For frequencies above 1 000 MHz the antenna shall be a horn radiator of known gain/frequency characteristics. When used for reception the antenna and any associated amplification system shall have an amplitude/frequency response within ± 2 dB of the combined calibration curves across the measurement frequency range considered for the antenna. The antenna is mounted on a support capable of allowing the antenna to be used in either horizontal or vertical polarization and at the specified height.

4.2.1.2 Multi-carrier operation

For STs designed to transmit simultaneously several carriers the verification up to 1 000 MHz shall be performed with one or more carriers and the verification above 1 000 MHz shall be repeated for each combination of carriers declared by the applicant. For each combination of carriers the applicant shall declare the carriers' centre frequencies and characteristics, the maximum value of the total on-axis e.i.r.p. of the carriers and the relative levels of the carriers (in dBs) at the input or output of the HPA or antenna. In the case of combinations of carriers with identical characteristics and when the power at the input of the HPA does not exceed the maximum input power with two carriers (i.e. when the Global Input Back-Off of the HPA is greater than the minimum Global Input Back-Off with two carriers), the verification may be limited to the case with two carriers and with the maximum frequency separation between them. In any other case, the number of configurations to be verified above may be limited to cases which can be proven by the applicant, by documentary evidence or demonstration, to generate the maximum e.i.r.p. density level of the out-of-band emissions due to inter-modulation products.

4.2.2 Up to 1 000 MHz

The test shall be performed either in an open area test site, a semi-anechoic chamber or an anechoic chamber. Ambient noise levels shall be at least 6 dB below the applicable unwanted emissions limit.

The open area test site shall be flat, free of overhead wires and nearby reflecting structures, sufficiently large to permit aerial placement at the specified measuring distance and provide adequate separation between aerial, test unit and reflecting structures, according to CISPR 16-1-4 [2].

For both the open area test site and the semi-anechoic chamber a metal ground plane shall be inserted on the natural ground plane and it shall extend at least 1 m beyond the perimeter of the EUT at one end and at least 1 m beyond the measurement antenna at the other end.

The distance between the EUT and measuring antenna should be 10 m. For measurements at a different distance an inverse proportionality factor of 20 dB per decade shall be used to normalize the measured data to the specified distance for determining compliance. Care should be taken in measurement of large test units at 3 m at frequencies near 30 MHz due to near field effects.

Procedure:

- a) The EUT shall be an EUT with antenna or, preferably, without antenna but with the antenna flange terminated by a dummy load.
- b) The EUT shall be in the "Carrier-on" radio state.
- c) The EUT shall be rotated through 360° and, except in an anechoic chamber, the measuring antenna shall be rotated and height varied from 1 m to 4 m above the ground plane to determine the maximum emission.
- d) All identified spurious radiation shall be measured and noted in frequency and level.

4.2.3 Above 1 000 MHz:

The spectrum analyser resolution bandwidth shall be set to the specified measuring bandwidth or as close as possible. If the resolution bandwidth is different from the specified measuring bandwidth, bandwidth correction shall be performed for the noise-like wideband spurious.

For an EUT with antenna the tests shall be performed in two stages for both the "Carrier-on" and "Carrier-off" radio states:

- Procedure a): Identification of the significant frequencies of spurious radiation.
- Procedure b): Measurement of radiated power levels of identified spurious radiation.

For an EUT without antenna the tests shall be performed in three stages for both the "Carrier-on" and "Carrier-off" radio states:

- Procedure a): Identification of the significant frequencies of spurious radiation.
- Procedure b): Measurement of radiated power levels of identified spurious radiation.
- Procedure c): Measurement of conducted spurious radiation radiated through the antenna flange

4.2.3.1 Test Site

The identification of frequencies emitting from the EUT shall be performed either in an anechoic chamber, an open area test site or a semi-anechoic chamber with the test antenna close to the EUT and at the same height as the volume centre of the EUT.

Procedure:

- a) The EUT shall be in the "Carrier-off" radio state.
- b) For an EUT with antenna the main beam of the antenna shall have an angle of elevation of 7°, and, for an EUT without antenna the antenna flange shall be terminated by a dummy load.
- c) The receivers shall scan the frequency band while the EUT revolves.
- d) The EUT shall be rotated through 360° and the frequency of any spurious signals noted for further investigation.
- e) For an EUT with antenna the test shall be repeated with the test antenna being in the opposite polarization.
- f) The test shall be repeated in the "Carrier-on" radio state while transmitting one modulated carrier at maximum power.

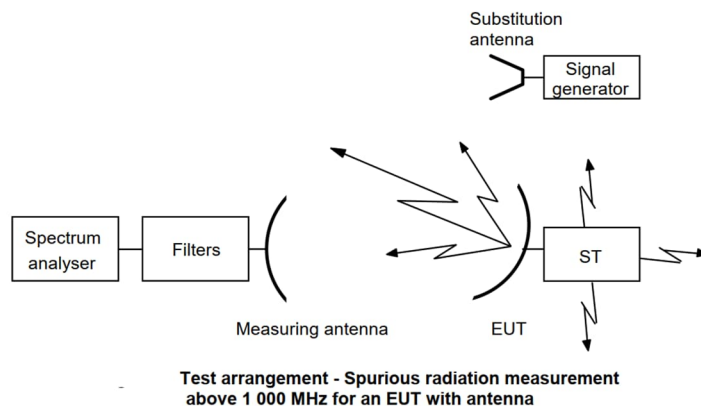


Figure 1

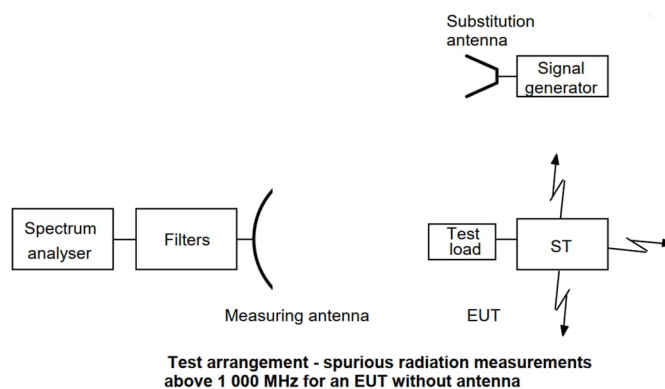


Figure 2

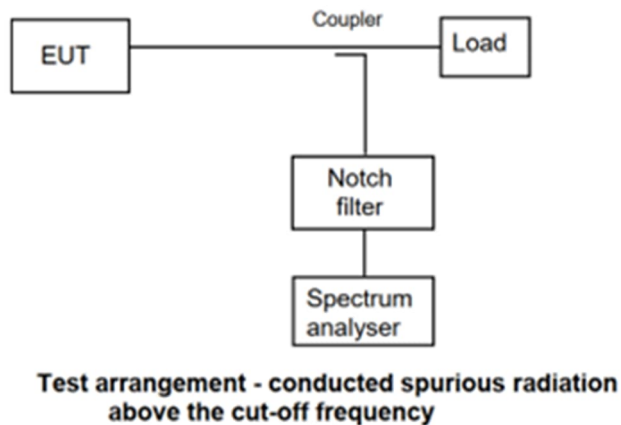


Figure 3

4.3 On-axis spurious radiation

4.3.1 Test method

The tests shall be undertaken with the transmitter operating at EIRP_{max}. There are no requirements for the test site to be used for this test.

4.3.2 Method of measurement

For ST equipment for which measurements at the antenna flange are possible and agreed by the applicant, the measurements shall be performed at the antenna flange. For ST equipment for which measurements at the antenna flange are not possible or not agreed by the applicant, the measurements shall be performed with a test antenna. The EUT is the ST with its antenna comprising both the indoor and outdoor units interconnected by 10 m of cable.

4.3.3 Method of measurement at the antenna flange

- a) The test arrangement shall be as shown in figure 3 with the notch filter being optional. In order to protect the spectrum analyser while ensuring the necessary measurement accuracy, particularly close to the carrier, if a notch filter is used it shall be tuned to the transmit carrier frequency.
- b) The EUT shall transmit one modulated carrier continuously, or at its maximum burst rate where applicable, centred on a frequency as close to the lower limit of the operating frequency band of the EUT as possible. The EUT shall be operated at EIRP_{max}. The frequency range 27,50 GHz to 29,50 GHz and range 29,50 GHz to 30,00 GHz shall be investigated.
- c) Due to the proximity of the carrier the spectrum analyser resolution bandwidth shall be set to a measurement bandwidth of 3 kHz, or as close as possible. If the measurement bandwidth is different from the specified measurement bandwidth, bandwidth correction shall be performed for noise-like wideband spurious radiation.
- d) To obtain the on-axis spurious e.i.r.p., the antenna transmit gain shall be added to any figure obtained in the above measurement and any correction or calibration factor summated with the result. The antenna gain shall be as measured or receive the measurements from the manufacturer at the closest frequency to the spurious frequency.
- e) The tests in b) to e) shall be repeated with a transmit frequency in the centre of the operating frequency band.
- f) The tests in b) to e) shall be repeated with a transmit frequency as close to the upper limit of the operating frequency band of the EUT as possible.
- g) The tests in b) to f) shall be repeated in the "Carrier-off" radio state.

4.3.4 Method of measurement for an EUT with antenna

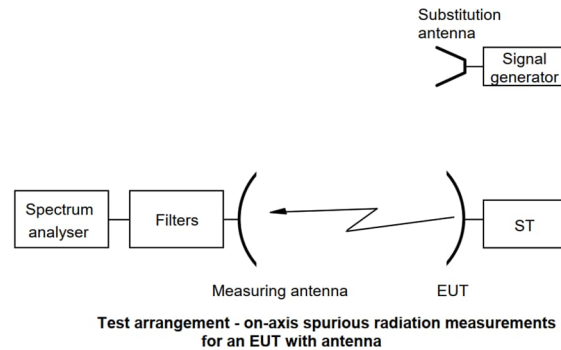


Figure 4

- a) The test arrangement shall be as shown in figure above with the notch filter being optional.
- b) The EUT shall be installed such that the units are separated by about 1 m to 2 m with the indoor unit at a height between 0,5 m and 1,0 m on a turntable. The interconnection cable shall be supported by non-metallic means at a height between 0,5 m and 1,0 m.
- c) The spectrum analyzer resolution bandwidth shall be set to the specified measuring bandwidth or as close as possible. If the resolution bandwidth is different from the specified measuring bandwidth, bandwidth correction shall be performed for noise-like wideband spurious radiation.
- d) The EUT shall transmit one modulated carrier continuously, or at its maximum burst rate where applicable, centered on a frequency as close to the lower limit of the operating frequency band of the EUT as possible. The EUT shall be operated at $EIRP_{max}$. The frequency range 27,50 GHz to 29,50 GHz and 29,50 GHz to 30,00 GHz shall be investigated and each spurious frequency shall be noted.
- e) Due to the proximity of the carrier the spectrum analyzer resolution bandwidth shall be set to a measurement bandwidth of 3 kHz, or lower. If the measurement bandwidth is different from the specified measurement bandwidth, bandwidth correction shall be performed for noise-like wideband spurious radiation.
- f) The measuring antenna shall be positioned at a distance from the EUT (e.g. 3 m, 5 m, 10 m) relevant to the applied test site and shall be aligned with the EUT antenna for the transmit frequency. The measuring antenna shall be adjusted in height, while the EUT is in the appropriate carrier condition, for a maximum response on the associated spectrum analyzer at each spurious frequency previously identified, this response level shall be noted. The adjustment in height of the measuring antenna does not apply when an anechoic chamber is being used.
- g) The EUT shall be replaced by a representative substitution antenna to which a signal generator is connected. The main beam axes of the measuring and substitution antennas shall be aligned. The distance between these antennas shall be the distance determined under test f).
- h) The substitution and measuring antennas shall be aligned to that polarization which produced the largest response between the EUT and the test antenna.

- i) The output of the generator shall be adjusted so that the received level is identical to that of the previously noted largest spurious radiation.
- j) The output level of the signal generator shall be noted. The e.i.r.p. of the on-axis spurious radiation is the sum, in dB, of the signal generator output plus the substitution antenna isotropic gain minus the interconnection cable loss.
- k) The tests in d) to k) shall be repeated with a transmit frequency in the centre of the operating frequency band.
- l) The tests in d) to k) shall be repeated with a transmit frequency as close to the upper limit of the operating frequency band of the EUT as possible.
- m) The tests in b) to l) shall be repeated in the "Carrier-off" radio state.

4.4 Off-axis e.i.r.p. emission density within the band

4.4.1 Test Method

The measurement shall be made (or provided by the applicant) in the operational configuration(s) (occupied bandwidth, $EIRP_{nom}$) producing the highest emission density in the frequency band. The selected configuration(s) shall be recorded in the test report. All of the e.i.r.p. emission density measurement shall be performed at $EIRP_{nom}$.

If the test is to be carried out with an STE, then the STE shall provide all the signals needed by the STs under normal operation (e.g. a radio beacon if it is expected to be received by the satellite).

For STs with uplink power density control capability the compliance of the ST during fading conditions shall be demonstrated by documentary evidence from the applicant. The e.i.r.p. density is determined from the measurements of the antenna co-polar and cross polar gain patterns, and of the power density at the antenna flange. The e.i.r.p. density shall be compared to the specified mask, taking into account the applicant declared pointing accuracy $\delta\phi$, if applicable. To ascertain the off-axis e.i.r.p. it is necessary to know the transmit power density and antenna transmit radiation pattern. To ascertain the radiation pattern it is necessary to know the antenna transmit gain.

The following three measurement procedures shall be performed:

- a) transmit output power density (dBW/40 kHz);
- b) antenna transmit gain (dBi);
- c) antenna transmit radiation patterns (dBi).

4.5 Carrier suppression

- a) The test can be performed by conducted or radiated measurements.
- b) The EUT shall transmit one modulated carrier continuously, or at its maximum burst rate where applicable, centered on 28,50 GHz for 27,5 GHz to 29,5 GHz frequency bands and centered on 29,750 GHz for 29,5 GHz to 30,0 GHz frequency bands.
- c) The resolution bandwidth of the spectrum analyzer shall be set to 100 kHz.
- d) The "Carrier-off" radio state shall be obtained by use of the STE.
- e) For conducted measurements the maximum residual carrier power density within the nominated bandwidth shall be measured and added to the antenna on-axis gain.

f) For radiated measurements the maximum residual e.i.r.p. density within the nominated bandwidth shall be measured and recorded.

4.6 Pointing stability methodology

This test based on a numerical analysis should be performed in two stages.

In the first stage the effects of maximum wind speed should be computed on the outdoor unit using a numerical analysis method (finite elements method by computer) taking into account the intrinsic properties of the materials. In the second stage the computed loads should be applied to the structure.

The purpose of the numerical analysis is twofold:

- 1) to show that the torque and the fields of force applied to the outdoor unit structure under nominated conditions do not reach the breakpoint limit of any element of the structure;
- 2) to compute equivalent static loads (force and torque) applied to the critical attachment points of the structures, for example:
 - reflector - mounting legs fixing point;
 - reflector - struts;
 - LNB - struts.

Numerical analysis and load applications procedure:

- 1) The air related parameters, namely the kinetic viscosity used to calculate drags at the rims of the structure should be calculated with the standard atmospheric environmental conditions (temperature = 293 K, air pressure = $1,013 \times 10^5$ Pascal).
- 2) The computations needed to derive the field of force and torque and the equivalent static stresses should be carried out for each of the following variables:
 - elevation angle: maximum and minimum;
 - wind direction: in steps of 45° around the outdoor unit;
 - wind speed: 160 km/h.
- 3) It should be verified with the simulated results that break point limits are not exceeded for any self-contained element.
- 4) The calculated equivalent static loads should be applied at any identified critical fixing point of the assembly.
- 5) While the loads are applied the outdoor unit should be observed and any distortion noted.
- 6) The test report should contain the following information:
 - the computation method used;
 - description of the test equipment;
 - description of the tests performed;
 - results of the safety margin test;

- any signs of distortion observed;
- results of the measurements of the deviation of the antenna position;
- component deviation with respect to each other.

4.7 Antenna pointing accuracy

4.7.1 Method of measurement

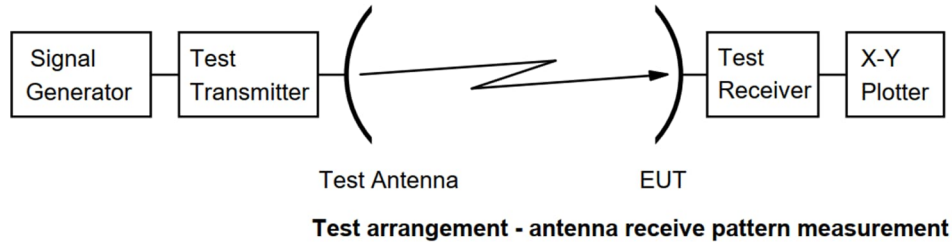


Figure 5

- The test arrangement shall be as shown in figure 13 with the EUT connected to the test receiver.
- A signal proportional to the angular position from the servo mechanism shall be applied to the X-axis and the signal level from the test receiver shall be applied to the Y-axis of the plotter.
- The test frequencies shall be the centre frequency of each applicable frequency range. The E-plane shall be vertical.
- The EUT shall be aligned to maximize the received signal level and the X-Y plotter shall be adjusted to give the maximum reading on the chart.
- The EUT shall be driven in azimuth through 180°.
- The pattern measurement is then obtained by driving the EUT in azimuth through 360° with the plotter recording the results.
- The tests in b) to e) shall be repeated with the frequency changed to the lower limit of the applicable band as declared by the manufacturer.
- The tests in b) to e) shall be repeated with the frequency changed to the upper limit of the applicable band as declared by the manufacturer.
- The tests in b) to h) shall be repeated with the frequencies changed to the others specified if the design of the equipment is such that operation is possible, but not necessarily simultaneously, in all bands.
- The tests in b) to h) shall be repeated with the test signal being transmitted in the H-plane instead of the E-plane.
- The tests in b) to h) shall be repeated with the test signal being transmitted in a plane at 45° to the H-plane.
- The tests in b) to h) shall be repeated with the test signal being transmitted in a plane at 90° to that in k).
- The tests in b) to l) shall be repeated between the angles of ϕ_r and 7° with the EUT rotated through 90°, or the test antenna or the polarization subsystem of the EUT rotated by 90°, to give the cross-polar measurement.

4.7.2 Computation

The computation of results shall be carried out by producing a "mask" to the specified limits with the reference level being equal to the gain of the antenna. This reference shall then be placed on the maximum point of the plot obtained.

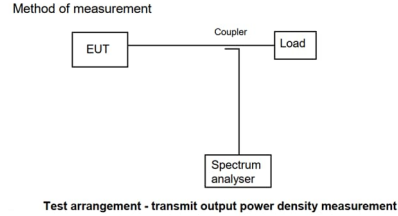
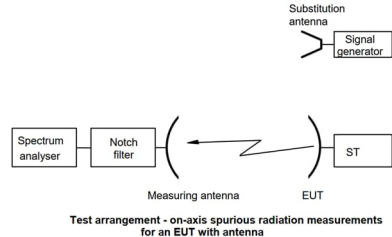
5.0 CONFORMANCE REQUIREMENTS

Test	Justification	Specification	Conformance tests																														
Off-axis spurious radiation	To limit the level of interference to terrestrial and satellite radio services	1) The ST shall not exceed the limits for radiated interference field strength over the frequency range from 30 MHz to 1 000 MHz specified in table 1b. Table 1b: Limits of radiated field strength at a test distance of 10 m in a 120 kHz bandwidth <table><tr><th>Frequency range</th><th>Quasi-peak limits</th></tr><tr><td>30 MHz to 230 MHz</td><td>30 dBµV/m</td></tr><tr><td>230 MHz to 1 000 MHz</td><td>37 dBµV/m</td></tr></table>	Frequency range	Quasi-peak limits	30 MHz to 230 MHz	30 dBµV/m	230 MHz to 1 000 MHz	37 dBµV/m																									
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		2) When the ST is in the "Emissions disabled" radio state, the off-axis Equivalent Isotropically Radiated Power (e.i.r.p.) of spurious radiation from the ST, in any 100 kHz band, shall not exceed the limits in table 2, for all off-axis angles greater than 7°. Table 2: Limits of spurious radiation - "Emissions disabled" radio state <table><tr><th>Frequency band</th><th>e.i.r.p. limit</th></tr><tr><td>1.0 GHz to 2.0 GHz</td><td>42 dBpW</td></tr><tr><td>2.0 GHz to 10.7 GHz</td><td>48 dBpW</td></tr><tr><td>10.7 GHz to 21.2 GHz</td><td>54 dBpW</td></tr><tr><td>21.2 GHz to 40 GHz</td><td>60 dBpW</td></tr></table>	Frequency band	e.i.r.p. limit	1.0 GHz to 2.0 GHz	42 dBpW	2.0 GHz to 10.7 GHz	48 dBpW	10.7 GHz to 21.2 GHz	54 dBpW	21.2 GHz to 40 GHz	60 dBpW	a) The EUT shall be an EUT with antenna or, preferably, without antenna but with the antenna flange terminated by a dummy load. b) The EUT shall be in the "Carrier-on" radio state. c) For Radiated test Method: The EUT shall be rotated through 360° and, except in an anechoic chamber, the measuring antenna shall be rotated and height varied from 1 m to 4 m above the ground plane to determine the maximum emission. d)For conducted method: The test arrangement shall be as shown in figure 3 with the notch filter being optional. In order to protect the spectrum analyser while ensuring the necessary measurement accuracy, particularly close to the carrier, if a notch filter is used it shall be tuned to the transmit carrier frequency e) All identified spurious radiation shall be measured and noted in frequency and level.																				
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		3) The present document applies outside the nominated bandwidth. For both the "Carrier-on" and "Carrier-off" radio states, the off-axis e.i.r.p. of spurious radiation in the specified measurement bandwidth from the ST, shall not exceed the limits in table 3, for all off-axis angles greater than 7°. Table 3: Limits of spurious radiation - "Carrier-on" and "Carrier-off" radio states <table><tr><th>Frequency band</th><th>e.i.r.p. limit (dBpW)</th><th>Measurement bandwidth</th></tr><tr><td>1.0 GHz to 2.0 GHz</td><td>43</td><td>100 kHz</td></tr><tr><td>2.0 GHz to 3.4 GHz</td><td>49</td><td>100 kHz</td></tr><tr><td>3.4 GHz to 10.7 GHz</td><td>55</td><td>100 kHz</td></tr><tr><td>10.7 GHz to 21.2 GHz</td><td>61</td><td>100 kHz</td></tr><tr><td>21.2 GHz to 27.35 GHz</td><td>67</td><td>100 kHz</td></tr><tr><td>27.35 GHz to 27.50 GHz</td><td>85 (see note 1)</td><td>1 MHz</td></tr><tr><td>27.50 GHz to 29.50 GHz</td><td>85 (see notes 1 and 2)</td><td>1 MHz</td></tr><tr><td>30.00 GHz to 30.15 GHz</td><td>85 (see note 1)</td><td>1 MHz</td></tr><tr><td>30.15 GHz to 40.00 GHz</td><td>67</td><td>100 kHz</td></tr></table> NOTE 1: This limit may be exceeded in a frequency band which shall not exceed 50 MHz, centred on the carrier frequency, provided that the on-axis e.i.r.p. density measured in 100 kHz at the frequency of the considered spurious is 50 dB below the maximum on-axis e.i.r.p. density of the signal measured in 100 kHz. NOTE 2: This limit may not apply in frequency bands exclusively designated to FSS in regions where those bands have been adopted. The lower limits shall apply at the transition frequency. When operating in the 27,5 GHz to 29,5 GHz and 29,5 GHz to 30,0 GHz frequency bands: In the frequency band of 21,2 GHz to 2,9,35 GHz, for any 20 MHz band within which one or more spurious signals exceeding 67 dBpW/100 kHz are present, then the power of each of those signals exceeding the limit shall be added in Watts, and the sum shall not exceed 75 dBpW. For STs designed to transmit simultaneously several carriers (multicarrier operation), the above limits apply to any combination of carriers declared by the applicant and outside the smallest continuous bandwidth encompassing the nominated bandwidths of the carriers. Each combination of carriers shall be characterized by the carriers' centre frequencies and characteristics, the maximum value of the total on-axis e.i.r.p. of the carriers and the relative levels of the carriers (in dBs) at the input or output of the HPA or antenna. These limits are applicable to the complete ST equipment, comprising of the indoor and outdoor units with at least 10 m of cable connecting them.	Frequency band	e.i.r.p. limit (dBpW)	Measurement bandwidth	1.0 GHz to 2.0 GHz	43	100 kHz	2.0 GHz to 3.4 GHz	49	100 kHz	3.4 GHz to 10.7 GHz	55	100 kHz	10.7 GHz to 21.2 GHz	61	100 kHz	21.2 GHz to 27.35 GHz	67	100 kHz	27.35 GHz to 27.50 GHz	85 (see note 1)	1 MHz	27.50 GHz to 29.50 GHz	85 (see notes 1 and 2)	1 MHz	30.00 GHz to 30.15 GHz	85 (see note 1)	1 MHz	30.15 GHz to 40.00 GHz	67	100 kHz	
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30.00 GHz to 30.15 GHz	85 (see note 1)	1 MHz																															
30.15 GHz to 40.00 GHz	67	100 kHz																															

On-axis spurious radiation	To limit the level of interference to satellite radio services	1) "Carrier-on" radio state The following specification applies to the ST transmitting at e.i.r.p. values up to EIRP_{nom}. For EIRPs above EIRP_{nom}(when uplink power control is implemented) the limits below may be exceeded by the difference in dB between the current e.i.r.p. and EIRP_{nom}. In the 27,5 GHz to 29,5 GHz band and in the 29,5 GHz to 30,0 GHz band the e.i.r.p. spectral density of the spurious radiation outside the nominated bandwidth shall not exceed 4 - 10 log M dBW in any 100 kHz band. This limit may be exceeded provided that for any 20 MHz band within which one or more spurious signals exceeding 4 dBW/100 kHz are present, then the power of each of those signals exceeding the limit shall be added in Watts, and the sum shall not exceed 10 dBW. NOTE 1: In order to avoid harmful interference to radio services using the same satellite or collocated satellites, the satellite operator or the satellite network operator may require more stringent limits e.g. depending on the size of the network and the size of the satellite coverage. The above limit may be exceeded in a bandwidth of 5 times the occupied bandwidth centred on the carrier centre frequency, in which case the e.i.r.p. spectral density of the spurious radiation outside the nominated bandwidth, shall not exceed 18 - 10 log M dBW in any 100 kHz band. M is the maximum number of STs which are expected to transmit simultaneously in the same carrier frequency band. This number shall not be exceeded for more than 0,01 % of the time. The value of M and the operational conditions of the system shall be declared by the applicant. NOTE 2: The on-axis spurious radiation, outside the 27,5 GHz to 29,5 GHz band, is indirectly limited by clause 4.2.2.2. Consequently no specification is needed. NOTE 3: Intermodulation limits inside the band 27,5 GHz to 29,5 GHz are to be determined by system design and are subject to satellite operator specifications. For ST designed to transmit simultaneously several different carriers (multicarrier operation), the above limits only apply to each individual carrier when transmitted alone. For ST designed to transmit simultaneously several different carriers (multicarrier operation), the above limits only apply to each individual carrier when transmitted alone. 2) "Carrier-off" and "Emissions disabled" radio states The following specification applies for a ST in the "Carrier-off" and "Emissions disabled" radio states. In the 27,5 GHz to 29,5 GHz band and the 29,5 GHz to 30,0 GHz band the e.i.r.p. spectral density of the spurious radiation outside the nominated bandwidth shall not exceed -21 dBW in any 100 kHz band. NOTE: In order to avoid harmful interference to radio services using the same satellite or collocated satellites, the satellite operator or the satellite network operator may require more stringent limits e.g. depending on the size of the network and the size of the satellite coverage.	a)For Radiated Method: The EUT shall be an EUT with antenna or, preferably, without antenna but with the antenna flange terminated by a dummy load. The tests shall be undertaken with the transmitter operating at EIRP_{max}. b))For conducted method: The test arrangement shall be as shown in figure 3 with the notch filter being optional. In order to protect the spectrum analyser while ensuring the necessary measurement accuracy, particularly close to the carrier, if a notch filter is used it shall be tuned to the transmit carrier frequency c) The EUT shall be in the "Carrier-on" radio state and "Carrier-off" radio state. d) All identified spurious radiation shall be measured and noted in frequency and level.
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Off-axis e.i.r.p. emission density within the band	Protection of other satellite (uplink) systems.	The following specifications apply to the ST transmitting at e.i.r.p. values up to EIRPmax. The maximum e.i.r.p. in any 40 kHz band within the nominated bandwidth for each of the co-polarized components in any direction ϕ degrees from the antenna main beam axis shall not exceed the following limits: <table><tr><td>$19 - 25 \log \phi - 10 \log N$</td><td>dBW</td><td>for</td><td>$1,8^\circ$</td><td>$\leq$</td><td>$\phi \leq 7,0^\circ$;</td></tr><tr><td>$-2 - 10 \log N$</td><td>dBW</td><td>for</td><td>$7,0^\circ$</td><td>$<$</td><td>$\phi \leq 9,2^\circ$;</td></tr><tr><td>$22 - 25 \log \phi - 10 \log N$</td><td>dBW</td><td>for</td><td>$9,2^\circ$</td><td>$<$</td><td>$\phi \leq 48^\circ$;</td></tr><tr><td>$-10 - 10 \log N$</td><td>dBW</td><td>for</td><td></td><td></td><td>$\phi > 48^\circ$.</td></tr></table> Where ϕ is the angle, in degrees, between the main beam axis and the direction considered. For systems in which more than one ST is expected to transmit simultaneously in the same 40 kHz band, e.g. for systems employing CDMA, the maximum e.i.r.p. values above are decreased by 10 log N dB, where N is the number of STs in the receive beam of the satellite to which these STs are communicating and which are expected to transmit simultaneously in the same 40 kHz band within that beam. The number N shall be declared by the applicant. NOTE 1: N = 1 for TDMA carriers with occupied bandwidth greater than 40 kHz. N > 1 may apply for FDMA or TDMA carriers with a lower occupied bandwidth In addition the maximum e.i.r.p. in any 40 kHz band within the nominated bandwidth of each of the cross-polarized components in any direction ϕ degrees from the antenna main beam axis shall not exceed the following limits: <table><tr><td>$9 - 25 \log \phi - 10 \log N$</td><td>dBW</td><td>for</td><td>$1,8^\circ$</td><td>$\leq$</td><td>$\phi \leq 7,0^\circ$;</td></tr><tr><td>$-12 - 10 \log N$</td><td>dBW</td><td>for</td><td>$7,0^\circ$</td><td>$<$</td><td>$\phi \leq 9,2^\circ$;</td></tr></table> where ϕ and N are as defined above. For non-continuous transmission, the above limits may not apply for a specific portion of each burst as declared by the applicant. This excluded portion shall not exceed 50 μ sec or 10 % of the burst, whichever is the smaller. The excluded portion shall have characteristics similar to the remaining part of the burst: - same symbol rate and modulation; and - same or lower maximum amplitude. In the case of STs employing uplink power density control, the above limits, for co-polar and cross-polar components, shall apply under clear-sky conditions and these limits include all additional margins above the minimum clear-sky level necessary for the implementations of uplink power density control. For STs implementing uplink power density control, the above limits may be exceeded by up to A dB during fade conditions, where A is the attenuation of the transmit signal relative to clear sky conditions. The above limits shall not be exceeded by more than 13 dB in the 27,5 GHz to 29,5 GHz band and by more than 20 dB in the 29,5 GHz to 30,0 GHz. In the case of STs employing transmission parameter modification (e.g. FEC, modulation, symbol rate) of the transmitted signal as part of uplink power density control, the above limits shall apply to all combinations of occupied bandwidth and transmission parameters as declared by the applicant. a) Tx EIRP Spectral Density will be provided by the applicant.	$19 - 25 \log \phi - 10 \log N$	dBW	for	$1,8^\circ$	$\leq$	$\phi \leq 7,0^\circ$;	$-2 - 10 \log N$	dBW	for	$7,0^\circ$	$<$	$\phi \leq 9,2^\circ$;	$22 - 25 \log \phi - 10 \log N$	dBW	for	$9,2^\circ$	$<$	$\phi \leq 48^\circ$;	$-10 - 10 \log N$	dBW	for			$\phi > 48^\circ$.	$9 - 25 \log \phi - 10 \log N$	dBW	for	$1,8^\circ$	$\leq$	$\phi \leq 7,0^\circ$;	$-12 - 10 \log N$	dBW	for	$7,0^\circ$	$<$	$\phi \leq 9,2^\circ$;
$19 - 25 \log \phi - 10 \log N$	dBW	for	$1,8^\circ$	$\leq$	$\phi \leq 7,0^\circ$;																																	
$-2 - 10 \log N$	dBW	for	$7,0^\circ$	$<$	$\phi \leq 9,2^\circ$;																																	
$22 - 25 \log \phi - 10 \log N$	dBW	for	$9,2^\circ$	$<$	$\phi \leq 48^\circ$;																																	
$-10 - 10 \log N$	dBW	for			$\phi > 48^\circ$.																																	
$9 - 25 \log \phi - 10 \log N$	dBW	for	$1,8^\circ$	$\leq$	$\phi \leq 7,0^\circ$;																																	
$-12 - 10 \log N$	dBW	for	$7,0^\circ$	$<$	$\phi \leq 9,2^\circ$;																																	

		Any antenna off-axis direction may be defined by a pair of values (α, ϕ) where ϕ is the off-axis angle of that direction with the antenna main beam axis and α is the angle of the plane defined by that direction and the antenna main beam axis with an arbitrary reference plane containing the antenna main beam axis. The range of values of ϕ and α is from 0° to 180° for ϕ, and from -180° to $+180^\circ$ for α. The above limits apply to any off-axis direction (α, ϕ) within $\pm 3^\circ$ of the visible part of the GSO and may be exceeded up to 3 dB in any other direction. The above limits may also be exceeded by up to 3 dB for ϕ greater than 10° and within $\pm 3^\circ$ of the visible part of the GSO provided that the total angular range over which this occurs does not exceed 20° when measured along both sides of the geostationary orbit. The concerned off-axis direction (α, ϕ) within $\pm 3^\circ$ of the visible part of the GSO under all operational conditions declared by the applicant shall be any direction within the (α, ϕ) domain unless it can be demonstrated by documentary evidence that only a limited subset of the (α, ϕ) domain is concerned. Outside this subset the +3 dB relaxation applies. When documentary evidence is provided to demonstrate that only a limited subset of the (α, ϕ) domain is concerned, the determination of the (α, ϕ) subset shall take into account the operational conditions for which the ST is designed, as declared by the applicant or indicated within the user documentation. These conditions shall include: •the range of latitudes of the ST; •the minimum elevation pointing angle; •the type of antenna mount (e.g. with azimuth and elevation axes or equatorial); •the range of adjustment for the major axis of the antenna for antennas with asymmetric main beam; •the method of alignment of the antenna major axis with the GSO for antennas with asymmetric main beam; •the maximum static and dynamic alignment errors of the antenna mount axes; •the maximum static and dynamic alignment errors of the antenna major axis with respect to the GSO arc for antennas with asymmetric main beam; •the range of directions of the electric field radiated by the satellite(s) with respect to the Earth's axis for which the equipment is designed, when the electric field is used for the antenna alignment. The alignment errors shall not exceed the declared maximum values when applying the alignment method declared by the applicant or indicated within the user documentation. NOTE 2: ETSI TR 102 375 [i.1] gives guidance for the determination of the concerned subset within the (α, ϕ) domain.	
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Carrier suppression	To allow for the satisfactory suppression of transmissions of a ST in the "Emissions disabled" radio state (e.g. when requested by the NCF or a fault condition is detected).	When the ST is in the "Emissions disabled" radio state the on-axis e.i.r.p. shall not exceed 4 dBW in any 100 kHz band within the nominated bandwidth.	a) The test arrangement for conducted measurements shall be as shown in the figure below:  b) The test arrangement for radiated measurements shall be as shown in the figure below: 
Antenna pointing accuracy	Protection of signals to and from the same and adjacent satellites.	a) Pointing stability: 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. b) Pointing accuracy capability: The applicant shall declare the usage area in terms of the range of latitude and longitude relative to the satellite orbital position where the alignments specified below are possible. Specification 1: Main beam pointing accuracy. The antenna sub-system alignment facilities shall enable the main beam axis to be adjusted and fixed with a pointing accuracy ($\delta\phi$) of either: 1) 0,1°; or 2) a greater value declared by the applicant, subject to the following restrictions: - the pointing accuracy ($\delta\phi$) shall not exceed 30 % of the antenna transmit main beam half power beamwidth; - the off-axis e.i.r.p. emission density pattern remains within the mask specified in clause 4.2.4.2 when shifted by an angle of $\pm(\delta\phi - 0,1^\circ)$.	a) Pointing stability: As it is considered impracticable to perform the test on pointing stability no test is given. The test methodology described in section 4.6 may be used to show compliance with the specification for pointing stability. b) Pointing accuracy capability: Specification 1: Main beam pointing accuracy - The EUT shall be inspected to ascertain whether fine adjustment facilities are available for the azimuth axis (coarse adjustment is usually provided by the positioning of the means of attachment). - The adjustment facilities shall be examined to determine both the angular movement possible and the means of securing that movement. - The securing facility shall be examined to determine its permanency. - The test shall be repeated for the elevation axis. Specification 2: Alignment with the Geostationary Satellite Orbit

		Specification 2: Alignment with the geostationary satellite orbit. For antennas with asymmetric main beam, the antenna shall be capable of having the plane defined by the antenna main beam axis and its major axis aligned with the tangent to the geostationary orbit in accordance with the method declared by the applicant. c) Polarization angle alignment capability for linear polarization: The polarization angle shall be continuously adjustable within the operational range as declared by the applicant. It shall be possible to fix the transmit antenna polarization angle with an accuracy of at least 1°. When linear polarization is used for both transmission and reception, the angle between the receive and corresponding transmit polarization planes shall not deviate by more than 1° from the nominal value declared by the applicant.	- The EUT shall be inspected to ascertain whether adjustment facilities are available to align the plane or range of planes defined in clause 4.2.4.2 with the geostationary arc with the specified accuracy. - The adjustment facilities shall be examined to determine both the angular movement possible and the means of securing that movement. - The securing facility shall be examined to determine its permanency. c) Polarization angle alignment capability (linear polarization only): - The adjustment facilities shall be examined to determine both the angular movement possible and the means of securing that movement. - The securing facility shall be examined to determine its permanency.										
Receive Antenna off-axis gain pattern	To protect the wanted signals from interference from terrestrial services and from other satellite services.	The maximum antenna gain of each of the co-polarized components in any direction ϕ degrees from the antenna main beam axis shall not exceed the following limits: $\begin{array}{lll} G & = 32 - 25 \log \phi & \text{dBi} \quad \text{for } \phi_{min} \leq \phi < 48^\circ \\ G & = -10 & \text{dBi} \quad \text{for } 48^\circ \leq \phi \leq 85^\circ \\ G & = 0 & \text{dBi} \quad \text{for } 85^\circ \leq \phi \leq 180^\circ \end{array}$ where: $\phi_{min} = 1^\circ \text{ or } 100 \lambda/D \text{ degrees, whichever is the greater, for } D/\lambda \geq 50.$ $\phi_{min} = 2^\circ \text{ or } 114 (D/\lambda)^{-1.09} \text{ degrees, whichever is the greater, for } D/\lambda < 50.$ D is the nominal diameter of the antenna. In addition the maximum antenna gain of each of the cross-polarized components in any direction ϕ degrees from the antenna main beam axis shall not exceed the following limits: $G_x(\phi) = 23 - 20 \log \phi \quad \text{dBi} \quad \text{for } \phi_p \leq \phi \leq 7^\circ$ where ϕ_p is equal to 1° or 100 λ/D, whichever is greater.	This test shall be performed on either an outdoor far field test site or compact test range. However if the near field scanner technology to convert near field measurements to far field results is proven and sufficiently accurate by reference to tests taken in both regions then antenna measurements may be taken in the near field. Fully automated systems can be used for these tests providing that the results can be proven to be as accurate as if they were done according to the specified method.										
Occupied Channel Bandwidth	The Occupied Channel Bandwidth is the bandwidth that contains 99 % of the power of the signal when considering a single frequency.	1) In the “Carrier-on” radio state, measure at least the lowest, center and highest channel (or one per polarization if applicable). 2) Transmit at EIRP max. 3) Measure each modulation of the system. 4) When available, the 99 % occupied BW function of the Spectrum analyzer may be used for measurements. 5) Measurement system diagram Signal Generator DUT Attenuator Spectrum Analyzer Computer (The diagram shows the setup: Signal Generator (if necessary) → DUT → Attenuator (if necessary) → Spectrum Analyzer →computer (may be connected for control and analysis). Connection tools may include various waveguide adapters and conversion connectors.	The test arrangement shall be as shown in the measurement system diagram. <table><tr><td>Resolution bandwidth</td><td>Approximately 1 % OBW</td></tr><tr><td>Video bandwidth</td><td>1 to 3*RBW</td></tr><tr><td>Frequency span</td><td>2*OBW</td></tr><tr><td>Detector mode</td><td>Peak</td></tr><tr><td>Trace mode</td><td>Max Hold</td></tr></table>	Resolution bandwidth	Approximately 1 % OBW	Video bandwidth	1 to 3*RBW	Frequency span	2*OBW	Detector mode	Peak	Trace mode	Max Hold
Resolution bandwidth	Approximately 1 % OBW												
Video bandwidth	1 to 3*RBW												
Frequency span	2*OBW												
Detector mode	Peak												
Trace mode	Max Hold												

epfd Limits	For the protection of GSO satellite networks.	The EIRP density of each ESOMP operating in the frequency bands 27,5 GHz to 28,6 GHz and 29,5 GHz to 30 GHz shall be determined by the NCF to ensure the compliance with the epfd limit of -162 (dB(W/m ²)) in a reference bandwidth of 40 kHz at any point in the GSO as specified in No 22.5D of the ITU Radio Regulations.	The applicant shall declare the methodology used to test and verify compliance with the requirements for epfd limits.
Frequency Tolerance	To determine the Frequency accuracy vs the declared frequency channels	1) Set the EUT in the "Carrier-on" radio state in the 3 representative channels (or one per polarization if applicable). 2) If allowed, set the radio signal in CW 3) Record the FL (Frequency low) and FH (Frequency High) using the OBW function of the spectrum Analyzer. 4) Apply the following formula: (FL+FH)/2 5) Compare results vs the Channel frequencies.	The frequency tolerance should be +/-50 ppm or 0.02 × Channel Spacing (MHz), whichever is more stringent. Same settings as OBW
Environmental Conditions + Power variation	To verify the operating frequency and frequency determination circuitry when exposed to changes in temperature and humidity.	1) Set the EUT in the "Carrier-off" radio state, let it stabilize in the minimum and maximum declared temperature range; Allow 1 hour to stabilize the min/max temperature across the EUT circuitry. 2) Set the EUT in the "Carrier-on" radio state in the 3 representative channels (or one per polarization if applicable). 3) Measure the frequency deviation (ppm) for both Min and Max temperatures. 4) Set the EUT in the "Carrier-off" radio state, let it stabilize at room temperature or 35°C and at the max declared humidity or 95 % if not specified/declared; Allow at least 1 hour to stabilize the temperature/humidity across the EUT circuitry. 5) Set the EUT in the "Carrier-on" radio state in the 3 representative channels (or one per polarization if applicable). 6) Measure the frequency deviation (ppm) for room and humidity testing. 7) Set the EUT in the "Carrier-on" radio state in the 3 representative channels (or one per polarization if applicable), first at the normal voltage at any frequency (e.g., 200 VAC / 60 Hz), then vary the voltage +/-10 %, allowing at least 20 minutes in each voltage to stabilize the circuitry. 8) Measure the frequency deviation (ppm) for +/- 10 % voltage variation	+/-100 ppm from the reference levels Measurement using the spectrum analyzer by using markers at the max peak of the signal level. The equation used to calculate the ppm is: $ppm = \left(\frac{CH \text{ frequency} - \text{Measured } CH \text{ frequency}}{CH \text{ frequency}} \right) * 1000000$

6.0 TERMS AND ABBREVIATIONS

6.1 For the purpose of this document the following terminology applies:

ATPC: Automatic Transmit Power Control.

EIRP: Equivalent Isotropically Radiated Power.

EIRP_{max}: Maximum EIRP capability of the WBES as declared by the manufacturer

EIRP_{nom}: either

a) when uplink power control is not implemented EIRP_{max}; or

b) when uplink power control is implemented, the maximum required e.i.r.p. of the ST under clear sky condition as declared by the applicant.

NOTE: The applicant may declare different values of EIRP_{max} and EIRP_{nom} for each combination of occupied bandwidth and transmission parameters

EUT: Equipment Under Test.

epfd: equivalent power flux-density

ESOMP: Earth Station On Mobile Platform

HPA: High Power Amplifier

Integral antenna: an antenna which may not be removed during the tests according to the manufacturer's declaration.

NCF: Network Control Facility, net of functional entities that, at system level, monitor and control the correct operation of the ESOMP and, if appropriate, all of the ESOMPs in a network

ST: Satellite Terminal

STE: Special Test Equipment

7.0 RESPONSIBILITIES

7.1 Lab Manager or designate is responsible for:

- approving, using, enforcing, and supporting this procedure.
- ensuring that this procedure meets and supports NEMKO goals and objectives.
- providing adequate time, tools, and funds for implementation.
- providing adequate training to all applicable personnel.
- reviewing this procedure (If necessary)

7.2 Quality Manager or designate is responsible for:

- approving this procedure and further revisions.
- making sure that personnel are being trained.



8.0 APPROVALS

The individuals below, having read and accepted their responsibilities as listed above, hereby approve this procedure.

A blue ink signature of Vina Kerai, written in a cursive style.

Vina Kerai, Certification Manager, TCB

Date: 15 / 9 / 2025

Day / Month / Year

A blue ink signature of Juan Manuel González, written in a cursive style.

Juan Manuel González, Director of Global Operations

Date: 15 / 9 / 2025

Day / Month / Year