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**Source:** Huawei

**Title:** TP to TR 37.941: Test uncertainty annexes

**Agenda Item:** 8.19

**Document for:** Approval

# Introduction

The external TR for OTA BS testing consolidates all the MU tables from the 3 internal TR’s. The generation of the TR is being used to review and correct all the MU calculations and tables and associated measurement uncertainty descriptions.

The measurement uncertainty descriptions are currently concentrated in the annexes of TR 37.842 and repeated I the annexes of TR 37.843, TR 38.817-02 reference the other 2 TR’s and adds a few new definitions in the text or in the notes of the tables.

The table sand the additional entries have been consolidated in the annexes for the new external TR.

Annex A contains the measurement uncertainty descriptions for the transmitter measurement methods

Annex B contains the measurement uncertainty descriptions for the receiver measurement methods

Annex C contains information on the test equipment common to all chamber types, it contains the uncertainty values plus the following added sections:

- the measurement uncertainty descriptions for the test equipment (note these have been moved from annex A and B where they were repeated many times under each chamber type with sometimes differencing descriptions, as we use the same uncertainty for the TE across all chamber types it makes sense that they have common descriptions)

- A new sub-clause has been added with the descriptions and calculations for the MU values derived from the conducted measurement MU values

Note yellow highlighted text indicates text copied for the donor TR’s which does not seem to be used, if it is not needed it can be deleted after review.

# Updates after 1st round

Ericsson:

• Regarding the yellow highlighted text. This can be removed if we do not use it. However, as the majority of the descriptions relate to the TE it should be placed with the common TE description – this was missed when the discussion on the TE uncertainty came to. For example A5-7 should move to be in associated section of the common TE uncertainty.

**Action:** Agree Yellow text deleted, common TE description in TE section.

• Reference to Internal TR in (A2-13)

**Action:** corrected to reference from this list (A2-4)

• The background for having different MU for EIRP pointing error for BS power and TRP, is that for BS power and some TRP requirements pointing error is low, while for some emission methods pointing error can be very large. This should be captured somewhere.

**Action:** This is case for CATR, we have different pointing errors for EIRP (A2-1) and TRP (A2-18) for other TE types the values are the same. Some text added to A2-18 in line with above.

Nokia: ACLR/OBUE MU are changed; propose to remove some unused MU elements; contains many untracked changes.

**Action:** Removed Unused elements in C.3, re-aligned numbering (in spreadsheet also). All text is new so it’s all under track changes – in retrospect this makes it hard tp see where the original text comes from apologies

**In addition**

* Entries were added to C.3 for the IMD and co-lcoation blocking incertainties.

TP to TR 37.941 v0.1.0

**--- Start of changes ---**

Annex A (informative):
Radiated TX measurement error contribution descriptions

# A.1 Indoor Anechoic Chamber

**A1-1 Positioning misalignment between the AAS BS and the reference antenna**

This contribution originates from the misalignment of the manufacturer declared coordinate system reference point of the AAS BS and the phase centre of the reference antenna. The uncertainty makes the space propagation loss between the AAS BS and the receiving antenna at the AAS BS measurement stage (i.e. Stage 2) different from the space propagation loss between the reference antenna and the receiving antenna at the calibration stage (i.e. Stage 1).

**A1-2 Pointing misalignment between the AAS BS and the receiving antenna**

This contribution originates from the misalignment of the testing direction and the *beam peak direction* of the receiving antenna due to imperfect rotation operation. The pointing misalignment may happen in both azimuth and vertical directions and the effect of the misalignment depends highly on the beamwidth of the beam under test. The same level of misalignment results in a larger measurement error for a narrower beam.

**A1-3 Quality of quiet zone**

This contribution originates from a reflectivity level of an anechoic chamber. The reflectivity level is determined from the average standard deviation of the electric field in the quiet zone. By repeating a free space VSWR measurement in 15° grid in elevation and azimuth, 264 standard deviation values in both polarizations are determined. From these values an average standard deviation of electric field in the quiet zone can be calculated from the equation:

 

Where:

  is the number of angular intervals in elevation,

  is the number of angular intervals in azimuth, and

  is elevation of single measurement .

If an efficiency calibration with omni-directional calibration antenna is performed, the effect of reflectivity level decreases in Stage 1 (i.e. calibration measurement) and  may be divided by factor 2. This is due to correcting impact of data averaging in this type of calibration. Efficiency calibration done with sampling step ≤ 30°, can be considered to have at least four independent samples.  may be divided by factor 2 also in Stage 2 (i.e. AAS BS measurement) for the same reason.

It's likely that asymmetry of the field probe will have a very small impact on this measurement uncertainty contributor, however, an upper bound to probe symmetry should be considered.

**A1-4 Polarization mismatch between the AAS BS (a) / reference antenna (b) and the receiving antenna**

This contribution originates from the misaligned polarization between the AAS BS/reference antenna and the receiving antenna.

**A1-5 Mutual coupling between the AAS BS/reference antenna and the receiving antenna**

This contribution originates from mutual coupling between the AAS BS/reference antenna and the receiving antenna. Mutual coupling degrades not just the antenna efficiency, i. e. the EIRP value, but it can alter the antenna's radiation pattern as well. For indoor anechoic chamber, usually the spacing between the AAS BS/reference antenna and the receiving antennas is large enough so that the level of mutual coupling might be negligible.

**A1-6 Phase curvature**

This contribution originates from the finite far field measurement distance, which causes phase curvature across the antenna of AAS BS/reference antenna.

**A1-7 Impedance mismatch in the receiving chain**

This contribution originates from multiple reflections between the receiving antenna and the power measurement equipment. The multiple reflections can produce an overall reflection that depends not only upon the individual reflections of each part but their reflective interactions as well. The combination loss by the overall reflection can be higher or lower than individual loss by multiple reflections. The combination loss is called the mismatch error and leads to the measurement uncertainty.

**A1-8 Random uncertainty**

The random uncertainty characterizes the undefined and miscellaneous effects which cannot be forecasted. One can estimate this type of uncertainty with a repeatability test by making a series of repeated measurement with a reference AAS BS without changing anything in the measurement set-up.

**A1-9 Impedance mismatch between the receiving antenna and the network analyzer**

This contribution originates from multiple reflections between the receiving antenna and the network analyzer. After appropriate calibration, the network analyzer may not introduce impedance mismatch error, but the error still happens between the receiving antenna feed cable and the receiving antenna.

**A1-10 Positioning and pointing misalignment between the reference antenna and the receiving antenna**

This contribution originates from reference antenna alignment and pointing error. In this measurement if the maximum gain directions of the reference antenna and the receiving antenna are aligned to each other, this contribution can be considered negligible and therefore set to zero.

**A1-11 Impedance mismatch between the reference antenna and the network analyzer**

This contribution originates from multiple reflections between the reference antenna and the network analyzer. After appropriate calibration, the network analyzer may not introduce impedance mismatch error, but the error still happens between the reference antenna feed cable and the reference antenna.

**A1-12 Influence of the reference antenna feed cable**

In the calibration Stage 1, the influence of the calibration antenna feed cable is assessed by measurements. A measurement for calibration may be repeated with a reasonably differing routing of the feed cable. Largest difference among the results is entered to the uncertainty budget with a rectangular distribution.

**A1-13 Reference antenna feed cable loss measurement uncertainty**

Before performing the calibration, the reference antenna feed cable loss have to be measured. The measurement can be done with a network analyzer to measure its S21 and uncertainty is introduced.

**A1-14 Influence of the receiving antenna feed cable**

If the probe antenna is directional (i.e. peak gain >+5 dBi, e.g. horn, LPDA, etc.) and the same probe antenna cable configuration is used for both stages, the uncertainty is considered systematic and constant 🡺 0.00 dB value.

In other cases a technical study should be done.

**A1-15 Uncertainty of the absolute gain of the receiving antenna**

The uncertainty appears in both stages and it is thus considered systematic and constant 🡺 0.00 dB value.

**A1-16 Frequency flatness**

This uncertainty contribution to account for the frequency interpolation error caused by a finite frequency resolution during the calibration stage.

**A1-17 Quality of quiet zone (extreme)**

This contribution is related to the ambient quality of the quiet zone (C1-3, 3GPP TR 37.842 [4]) which originates from a reflectivity level of an anechoic chamber. The reflectivity level is determined from the average standard deviation of the electric field in the quiet zone. As the environmental enclosure is larger than the DUT and the material of the environmental chamber may cause some reflection and refraction the quite zone flatness will be effected. The quality of the quiet zone for the extreme test is therefore larger tan that for the ambient due to the environmental enclosures effect.

**A1-18 Wet radome loss variation**

The environmental chamber radome will be an ineffective thermal isolator and will have extreme temperatures on the inside and the OTA chamber ambient temperature on the outside. In such conditions condensation is inevitable. This uncertainty is due to the variation in the radome loss due to condensation on the environmental chamber radome.

**A1-19 Radome loss variation**

The environmental chamber radome will affect the path between the DUT and the test antenna due to both its insertion loss and also reflection and refraction from the materials surface. The loss is dependent on the material as well as its proximity to the DUT. The uncertainty is the residual uncertainly of the total loss after calibration

**A1-20 Change in absorber behaviour**

The environmental chamber will contain RF absorptive material to prevent reflections within the chamber. This RF absorptive material will be subjected to the extreme temperatures inside the environmental chamber and hence its properties will change. This uncertainty accounts for the effect of that change in behavior.

**A1-21** **Uncertainty of the LNA**

To maintain a low noise figure for the measurement system (possibly considering the addition of a down conversion mixer for high frequencies) and LNA may be required. The variation in the gain of the LNA after the calibration procedure is accounted for in this uncertainty contribution

**A1-22** **Uncertainty of the Mixer**

Higher frequency emissions beyond the upper frequency range of the measurement equipment require down converting prior to measurement. The uncertainty introduced by the down conversion is accounted for in this uncertainty contribution.

# A.2 Compact Antenna Test Range

**A2-1 Misalignment DUT (a) /calibration antenna (b) & pointing error**

This contribution denotes uncertainty in DUT/calibration antenna alignment and DUT/calibration antenna pointing error. In this measurement the DUT/calibration antenna is aligned to maximum, also allowing for a zero contribution for polarization mismatch uncertainty. By adjusting for maximums to align, this contribution can be a small contribution. The calibration antenna's phase centre and polarization purity changes slightly according to the frequency. Therefore, there should be some uncertainty reserved for this. To ensure that the point error is at a minimal, this contribution should be captured using the antenna pattern cut which is broadest (in the case of the DUT this would most likely be in the azimuth domain).

**A2-2 Standing wave between DUT (a) / calibration antenna (b) and test range antenna**

This value is extracting the uncertainty value and standard deviation of gain ripple coming from standing waves between DUT and test range antenna. This value can be captured by moving the DUT towards the test range antenna as the standing waves go in and out of phase causing a ripple in measured gain.

**A2-3 RF leakage (SGH connector terminated & test range antenna connector cable terminated)**

This contribution denotes noise leaking in to connector and cable(s) between test range antenna and receiving equipment. The contribution also includes the noise leakage between the connector and cable(s) between SGH/reference antenna and transmitting equipment.

**A2-4 QZ ripple DUT (a) /calibration antenna (b)**

This is the quiet zone (QZ) ripple experienced by the AAS BS/calibration antenna during the measurement or calibration phase. The purpose of this component is to capture the contributions that the reflections from the walls, roof and floor that will add to the EIRP measurement. The sum of all these reflections from the walls, range reflector (if applicable), roof and floor will give the overall value for the QZ ripple. In other words, the uncertainty component from the wall will not be separated from the roof or the floor. The purpose of this uncertainty component is to capture the overall reflections from the chamber walls experienced by the AAS BS/calibration antenna. To capture the full effect of the QZ ripple a distance of 1λ should be measured from each of the AAS BS/calibration antenna physical aperture edges, i.e. total QZ distance = physical aperture length +2 λ, to ensure the full volume of the QZ is captured in the uncertainty measurement.

**A2-5 Mismatch of receiver chain (i.e. between receiving antenna and measurement receiver (a) / low power receiver (b))**

This uncertainty is the residual uncertainty contribution coming from multiple reflections between the receiving antenna and the test receiver equipment. This value can be captured through measurement by measuring the S11 towards the receive antenna and also towards the test receiver. The mismatch between the antenna reflection and the receiver reflection can also be calculated. If the same cable is used for calibration Stage 1, this can be considered systematic and negligible.

**A2-6 Insertion loss of receiver chain**

This uncertainty is the residual uncertainty contribution coming from introducing an antenna at the end of the cable. If this cable does not change/move between the calibration Stage 1 and the measurement Stage 2, the uncertainty is assumed to be systematic and negligible during the measurement stage. Alternatively, the insertion loss can also be calculated by taking the measurement of the cable where port 2 is the end of the cable connected to the AAS BS or calibration antenna.

 IL = -20log10|S21| dB

**A2-7 Influence of the calibration antenna feed cable**

**a) Flexing cables, adapters, attenuators, extra pathloss cable & connector repeatability.**

During the calibration phase this cable is used to feed the calibration antenna and any influence it may have upon the measurements is captured. This is assessed by repeated measurements while flexing the cables and rotary joints. The largest difference between the results is recorded as the uncertainty.

**A2-8 Misalignment positioning system**

This contribution originates from uncertainty in sliding position and turn table angle accuracy. If the calibration antenna is aligned to maximum this contribution can be considered negligible and therefore set to zero.

**A2-9 Rotary Joints**

If applicable the contribution of this uncertainty the accuracy in changing from azimuth to vertical measurements.

**A2-10 Miscellaneous Uncertainty**

The term 'miscellaneous uncertainty' is used to define all the unknown, unquantifiable, etc. uncertainties associated with EIRP measurements. This term should include truly random effects as well as systematic uncertainties, such as that arising from dissimilarity between the patterns of the reference antenna (SGH) and the DUT.

**A2-11 Switching Uncertainty**

The purpose of the switching unit is to switch electromechanically different RF path to different measurement instruments of different measurement modes. The electromechanical switching clearly reduces the errors arising from manual switching work. Switching is also used to measure the path loss values of each polarization component. Even though the electromechanical switching is preferable during path loss and antenna performance measurements, some minor uncertainties can occur when the switch states are programmed to change their polarity.

**A2-12 Frequency flatness**

This uncertainty contribution to account for the frequency interpolation error caused by a finite frequency resolution during the calibration stage.

**A2-13 Quality of quiet zone (extreme)**

This contribution is related to the ambient quality of the quiet zone (A2-4) which originates from a reflectivity level of an anechoic chamber. The reflectivity level is determined from the average standard deviation of the electric field in the quiet zone. As the environmental enclosure is larger than the DUT and the material of the environmental chamber may cause some reflection and refraction the quite zone flatness will be effected. The quality of the quiet zone for the extreme test is therefore larger tan that for the ambient due to the environmental enclosures effect.

**A2-14 Wet radome loss variation**

The environmental chamber radome will be an ineffective thermal isolator and will have extreme temperatures on the inside and the OTA chamber ambient temperature on the outside. In such conditions condensation is inevitable. This uncertainty is due to the variation in the radome loss due to condensation on the environmental chamber radome.

**A2-15 Radome loss variation**

The environmental chamber radome will affect the path between the DUT and the test antenna due to both its insertion loss and also reflection and refraction from the materials surface. The loss is dependent on the material as well as its proximity to the DUT. The uncertainty is the residual uncertainly of the total loss after calibration

**A2-16 Change in absorber behaviour**

The environmental chamber will contain RF absorptive material to prevent reflections within the chamber. This RF absorptive material will be subjected to the extreme temperatures inside the environmental chamber and hence its properties will change. This uncertainty accounts for the effect of that change in behavior.

**A2-17 Measurement system dynamic range uncertainty**

Uncertainty associated with the addition of each of the directional power measurements to calculate the TRP due to the limited dynamic range of the OTA test system causing an overestimation.

**A2-18 Misalignment DUT (a) /calibration antenna (b) & pointing error for TRP**

This contribution denotes uncertainty in DUT/calibration antenna alignment and DUT/calibration antenna pointing error and its effect on the TRP calculation. The pointing error for TRP emissions measurement is larger than for EIRP (A2-1)**A2-19** **Uncertainty of the LNA**

To maintain a low noise figure for the measurement system (possibly considering the addition of a down conversion mixer for high frequencies) and LNA may be required. The variation in the gain of the LNA after the calibration procedure is accounted for in this uncertainty contribution

**A2-20** **Uncertainty of the Mixer**

Higher frequency emissions beyond the upper frequency range of the measurement equipment require down converting prior to measurement. The uncertainty introduced by the down conversion is accounted for in this uncertainty contribution.

**A2-21** **Miscellaneous uncertainty**

The term 'miscellaneous uncertainty' is used to define all the unknown, unquantifiable, etc. uncertainties associated with EIRP measurements. This term should include truly random effects as well as systematic uncertainties, such as that arising from dissimilarity between the patterns of the reference antenna and the DUT.

# A.3 Near Field Test Range

**A3-1 Axes Intersection**

This is a mechanical uncertainty term and aim to find the uncertainty related with the lateral displacement between the horizontal and vertical axes of the AAS BS positioner. This can result in sampling the field on a non-ideal sphere. This uncertainty is assumed to have a Gaussian distribution.

**A3-2 Axes Orthogonality**

The difference from 90° of the angle between the horizontal and vertical axes also results in sampling the field on a non-ideal sphere. This uncertainty is assumed to have a Gaussian distribution.

**A3-3 Horizontal Pointing**

The horizontal mispointing of the horizontal axis to the probe reference point for Theta=0° also results in sampling the field on a non-ideal sphere. This uncertainty is assumed to have a Gaussian distribution.

**A3-4 Probe Vertical position**

The vertical displacement of the probe reference point from the horizontal axis results in sampling the field on a non-ideal sphere. This uncertainty is assumed to have a Gaussian distribution.

**A3-5 Probe Horizontal/Vertical pointing**

The horizontal or vertical mispointing of the probe z-axis from the intersection point of the horizontal/vertical axis. This uncertainty is assumed to have a Gaussian distribution.

**A3-6 Measurement distance**

This is the knowledge of the distance between the intersection point of the horizontal and vertical axis and probe reference point. This uncertainty is assumed to have a Gaussian distribution.

**A3-7 Amplitude and phase drift**

The system drift due to temperature variations the signal at AAS BS location to drift in amplitude and phase. This uncertainty is assumed to have a Gaussian distribution.

**A3-8 Amplitude and phase noise**

This uncertainty is due to the noise level of the test range so that the S/N ratio should be determined or measured at the AAS BS location. The noise level is usually measured with a Spectrum Analyzer. This uncertainty is assumed to have a Gaussian distribution.

**A3-9 Leakage and Crosstalk**

This uncertainty can be addressed by measurements on the actual system setup. The leakage and crosstalk cannot be separated from the random amplitude and phase errors so that the relative importance should be determined. This uncertainty is assumed to have a Gaussian distribution.

**A3-10 Amplitude non-Linearity**

This uncertainty is the linearity of the receiver used for the measurement. It can be taken from the data sheet of the receiver.

**A3-11 Amplitude and phase shift in rotary joint**

This uncertainty is due to the variation of the rotary joint. It can be measured and is assumed to have a Gaussian distribution.

**A3-12 Channel balance amplitude and phase**

This uncertainty is relevant for systems which are using dual polarized probes and polarization switches. The amplitude and phase difference between two signal channels of the receiver includes the difference between the probe ports, difference between the channels of the polarization switch, connecting cables and reflection coefficients. This uncertainty is assumed to have a Gaussian distribution.

**A3-13 Probe polarization amplitude and phase**

The amplitude and phase of the probe polarization coefficients should be measured. This uncertainty is assumed to have a Gaussian distribution.

**A3-14 Probe pattern knowledge**

The probe(s) pattern(s) is assumed to be known so that the AAS BS measurement in near field can be corrected when performing the near field to far field transform. There is no direct dependence between the AAS BS pattern and the probe pattern in near field measurements. This uncertainty is assumed to have a Gaussian distribution.

**A3-15 Multiple reflections**

The multiple reflections occur when a portion of the transmitted signal is reflected form the receiving antenna back to the transmitting antenna and re-reflected by the transmitting antenna back to the receiving antenna. This uncertainty can be determined by multiple measurements of the AAS BS when at different distance from the probes. This uncertainty is assumed to have a Gaussian distribution.

**A3-16 Room scattering**

As for the multiple reflections, a portion of the transmitted signal is reflected by either the absorbers or other structures in the measurement anechoic chamber before being received by the receiving antenna. This effect can be isolated from the multiple reflections by testing the AAS BS in different positions, separated by λ/4 with respect to the anechoic chamber and comparing these measurements with the reference. This uncertainty is assumed to have a Gaussian distribution.

**A3-17 DUT support scattering**

This is the uncertainty due to the AAS BS supporting structure on the signal level. This uncertainty is assumed to have a Gaussian distribution.

**A3-18 Scan area truncation**

This uncertainty does affect this near field measurement. It can be addressed by comparing the measurement result when scanning the full area. This uncertainty is assumed to have a Gaussian distribution.

**A3-19 Sampling point offset**

This uncertainty has an influence in near field and far field. It is assumed to have a Gaussian distribution.

**A3-20 Spherical mode truncation**

The measured near field is expanded using a finite set of spherical modes. The number of modes is linked to number of samples. The filtering effect generated by the finite number of modes can improve measurement results by removing signals from outside the physical area of the AAS BS. Care should be taken in order to make sure the removed signals are not from the AAS BS itself. This uncertainty is usually negligible.

**A3-21 Positioning**

The relative position of the probe array is not ideal. This uncertainty is assumed to have a rectangular distribution.

**A3-22 Probe array uniformity**

This is the uncertainty due to the fact that different probes are used for each physical position. Different probes have different radiation patterns. Generally, the probe array is calibrated so that the uniformity of the probes is achieved.

**A3-23 Mismatch of receiver chain**

If the same chain configuration (including the measurement receiver; the probe antenna and other elements) is used in both stages, the uncertainty is considered systematic and constant 🡺 0.00 dB value.

If it is not the case, this uncertainty contribution has to be taken into account and should be measured or determined by the method described in [14]. This uncertainty is assumed to have a U-shaped distribution

**A3-24 Insertion loss of receiver chain**

It is composed of the following:

- Insertion loss of the probe antenna cable.

- Insertion loss of the probe antenna attenuator (if used).

- Insertion loss of RF relays (if used).

If the same chain configuration is used for measurement and calibration, the uncertainty due to the above components is considered systematic and constant 🡺 0.00 dB value. This uncertainty is assumed to have a Gaussian distribution.

**A3-25 Uncertainty of the absolute gain of the probe antenna**

This uncertainty appears in the both stages and it is thus considered systematic and constant🡺 0.00 dB value.

**A3-26 Measurement Repeatability - Positioning Repeatability**

This uncertainty is due to the repositioning of the AAS BS in the test setup. It can be addressed by repeating the corresponding measurement 5 times. Calculate the standard deviation of the metric obtained and use that as the measurement uncertainty. For tests that require multiple setups, the worst-case standard deviation is used. This uncertainty is assumed to have a Gaussian distribution.

**A3-27 Mismatch of receiver chain**

If the same chain configuration (including the measurement receiver; the probe antenna and other elements) is used in both stages, the uncertainty is considered systematic and constant 🡺 0.00 dB value.

If it is not the case, each uncertainty contribution has to be taken into account and should be measured or determined and then taking the total of all non-zero mismatch uncertainty contribution from all parts by root-sum-squares (RSS) method. This uncertainty is assumed to have a Gaussian distribution.

**A3-28 Insertion loss of receiver chain**

If the same chain configuration is used for measurement and calibration, the uncertainty due to the above components is considered systematic and constant 🡺 0.00 dB value. This uncertainty is assumed to have a Gaussian distribution.

**A3-29 Mismatch in the connection of the calibration antenna**

This is the uncertainty from the mismatch in the connection between the system coax cable and the calibration antenna. This uncertainty is from the mismatch between the cable and the reference antenna that is used for calibration. It is determined by the S11 of the reference antenna and the S11 of the cable to which the antenna is connected i.e. if using an SGH antenna for calibration and 10dB pad is inserted on the cable connecting to the antenna this uncertainty contribution can be considered negligible. This uncertainty is assumed to have a U-shaped distribution.

**A3-30 Influence of the calibration antenna feed cable**

This uncertainty is due to the impact of the feeding cable on the radiation properties of the calibration antenna. In case of using either a standard horn or standard gain horn, the impact of the cable is to be considered negligible thus the uncertainty 🡺 0.00 dB value. In case of using a dipole-like antenna, the uncertainty should be addressed by measuring this impact. This uncertainty is assumed to have a Gaussian distribution.

**A3-31 Influence of the probe antenna cable**

If the same chain configuration is used for measurement and calibration, the uncertainty due to the above components is considered systematic and constant 🡺 0.00 dB value. This uncertainty is assumed to have a Gaussian distribution.

**A3-32 Short term repeatability**

It can be addressed by performing a repeatability test of the calibration antenna. This uncertainty is assumed to have a Gaussian distribution.

**A3-33 Frequency flatness**

This uncertainty contribution to account for the frequency interpolation error caused by a finite frequency resolution during the calibration stage.

# A.4 One Dimensional Compact Range

**A4-1 Misalignment DUT and pointing error**

This contribution denotes uncertainty in DUT alignment and DUT pointing error. In this measurement the DUT is aligned to maximum, also allowing for a zero contribution for polarization mismatch uncertainty. By adjusting for maximums to align, this contribution can be a small contribution. The reference antenna´s phase centre and polarization purity changes slightly according to the frequency. Therefore, there should be some uncertainty reserved for this. To ensure that the pointing error is at a minimal, this contribution should be captured using the antenna pattern cut which is broadest (in the case of the DUT this would most likely be in the azimuth domain).

**A4-2 Standing wave between DUT (a) / reference antenna (b) and test range antenna**

This value is extracting the uncertainty value and standard deviation of gain ripple coming from standing waves between DUT and test range antenna. This value can be captured by moving the DUT towards the test range antenna as the standing waves go in and out of phase causing a ripple in measured gain.

**A4-3 Quiet zone ripple DUT (a) / reference antenna (b)**

This is the quiet zone (QZ) ripple experienced by the DUT/reference antenna during the measurement phase. The purpose of this component is to capture the contributions that the reflections from the walls, roof and floor that will add to the EIRP measurement. The sum of all these reflections from the walls, range reflector (if applicable), roof and floor will give the overall value for the QZ ripple. In other words, the uncertainty component from the wall will not be separated from the roof or the floor. The purpose of this uncertainty component is to capture the overall reflections from the chamber walls experienced by the DUT/reference antenna. To capture the full effect of the QZ ripple a distance of 1λ must be measured from each of the DUT/reference antenna physical aperture edges, i.e. total QZ distance = physical aperture length + 2 λ, to ensure the full volume of the QZ is captured in the uncertainty measurement.

**A4-4 Phase curvature**

This contribution originates from the finite far field measurement distance, which causes phase curvature across the antenna of AAS BS (a) / reference antenna (b).

**A4-5 Polarization mismatch between DUT (a) / reference antenna (b) and receiving antenna**

This contribution originates from the misaligned polarization between the DUT/reference antenna and the receiving antenna.

**A4-6 Mutual coupling between DUT (a) / reference antenna (b) and receiving antenna**

This contribution originates from mutual coupling between the DUT/reference antenna and the receiving antenna. Mutual coupling degrades not just the antenna efficiency, i. e. the EIRP value, but it can alter the antenna’s radiation pattern as well. For compact range chamber, usually the spacing between the DUT/reference antenna and the receiving antennas is large enough so that the level of mutual coupling might be negligible.

**A4-7 Impedance mismatch in receiving chain**

This contribution originates from multiple reflections between the receiving antenna and the measurement equipment. The multiple reflections can produce an overall reflection that depends not only upon the individual reflections of each part but their reflective interactions as well. The combination loss by the overall reflection can be higher or lower than individual loss by multiple reflections. The combination loss is called the mismatch error and leads to the measurement uncertainty.

**A4-8 RF leakage (DUT (a) / SGH (b) connector terminated and test range antenna connector cable terminated)**

This contribution denotes noise leaking into connector and cable(s) between test range antenna and receiving equipment. The contribution also includes the noise leakage between the connector and cable(s) between SGH/reference antenna and transmitting equipment.

**A4-9 Misalignment positioning system**

This contribution originates from uncertainty in sliding position and turn table angle accuracy. If the calibration antenna is aligned to maximum this contribution can be considered negligible and therefore set to zero.

**A4-10 Pointing error between reference antenna and test range antenna**

This contribution originates from the misalignment of the testing direction and the *beam peak direction* of the receiving antenna due to imperfect rotation operation. The pointing misalignment may happen in both azimuth and vertical directions and the effect of the misalignment depends highly on the beamwidth of the beam under test. The same level of misalignment results in a larger measurement error for a narrower beam.

**A4-11 Impedance mismatch in path to reference antenna**

This contribution originates from multiple reflections between the reference antenna and the measurement equipment. After appropriate calibration, the measurement equipment may not introduce impedance mismatch error, but the error still happens between the reference antenna feed cable and the reference antenna.

**A4-12 Impedance mismatch in path to compact probe**

This contribution originates from multiple reflections between the receiving antenna and the measurement equipment. After appropriate calibration, the measurement equipment may not introduce impedance mismatch error, but the error still happens between the receiving antenna feed cable and the receiving antenna.

**A4-13 Influence of reference antenna feed cable (flexing cables, adapters, attenuators, connector repeatability)**

During the calibration phase this cable is used to feed the reference antenna and any influence it may have upon the measurements is captured. This is assessed by repeated measurements while flexing the cables and rotary joints. The largest difference between the results is recorded as the uncertainty.

**A4-14 Mismatch of receiver chain (i.e. between receiving antenna and measurement equipment)**

This uncertainty is the residual uncertainty contribution coming from multiple reflections between the receiving antenna and the test receiver equipment. This value can be captured through measurement by measuring the S11 towards the receive antenna and also towards the test receiver. The mismatch between the antenna reflection and the receiver reflection can also be calculated. If the same cable is used for calibration stage, this can be considered systematic and negligible.

**A4-15 Insertion loss of receiver chain**

This uncertainty is the residual uncertainty contribution coming from introducing an antenna at the end of the cable. If this cable does not change/move between the calibration and the measurement stage, the uncertainty is assumed to be systematic and negligible during the measurement stage. Alternatively, the insertion loss can also be calculated by taking the measurement of the cable where port 2 is the end of the cable connected to the DUT or reference antenna.

IL = -20log10|S21| dB

# A. 5 General Chamber

This subclause describes the uncertainties for a general wide band chamber.

**A5-1 Positioning misalignment between the AAS BS and the reference antenna**

This contribution originates from the misalignment of the manufacturer declared coordinate system reference point of the AAS BS and the phase centre of the reference antenna. The uncertainty makes the space propagation loss between the AAS BS and the receiving antenna at the AAS BS measurement stage (i.e. Stage 2) different from the space propagation loss between the reference antenna and the receiving antenna at the calibration stage (i.e. Stage 1).

**A5-2 Pointing misalignment between the AAS BS and the receiving antenna**

This contribution originates from the misalignment of the testing direction and the *beam peak direction* of the receiving antenna due to imperfect rotation operation. The pointing misalignment may happen in both azimuth and vertical directions and the effect of the misalignment depends highly on the beamwidth of the beam under test. The same level of misalignment results in a larger measurement error for a narrower beam.

**A5-3 Quality of quiet zone**

This contribution originates from a reflectivity level of an anechoic chamber. The reflectivity level is determined from the average standard deviation of the electric field in the quiet zone. By repeating a free space VSWR measurement in 15° grid in elevation and azimuth, 264 standard deviation values in both polarizations are determined. From these values an average standard deviation of electric field in the quiet zone can be calculated from the equation:

 

Where:

  is the number of angular intervals in elevation,

  is the number of angular intervals in azimuth, and

  is elevation of single measurement .

If an efficiency calibration with omni-directional calibration antenna is performed, the effect of reflectivity level decreases in Stage 1 (i.e. calibration measurement) and  may be divided by factor 2. This is due to correcting impact of data averaging in this type of calibration. Efficiency calibration done with sampling step ≤ 30°, can be considered to have at least four independent samples.  may be divided by factor 2 also in Stage 2 (i.e. AAS BS measurement) for the same reason.

It's likely that asymmetry of the field probe will have a very small impact on this measurement uncertainty contributor, however, an upper bound to probe symmetry should be considered.

**A5-4 Polarization mismatch between the AAS BS (a) /reference antenna (b) and the receiving** antenna

This contribution originates from the misaligned polarization between the AAS BS/reference antenna and the receiving antenna.

**A5-5 Mutual coupling between the AAS BS (a) /reference antenna (b) and the receiving antenna**

This contribution originates from mutual coupling between the AAS BS/reference antenna and the receiving antenna. Mutual coupling degrades not just the antenna efficiency, i. e. the EIRP value, but it can alter the antenna's radiation pattern as well. For indoor anechoic chamber, usually the spacing between the AAS BS/reference antenna and the receiving antennas is large enough so that the level of mutual coupling might be negligible.

**A5-6 Phase curvature**

This contribution originates from the finite far field measurement distance, which causes phase curvature across the antenna of AAS BS **(a)** /reference antenna **(b)**.

**A5-7 Impedance mismatch in the receiving chain**

This contribution originates from multiple reflections between the receiving antenna and the power measurement equipment. The multiple reflections can produce an overall reflection that depends not only upon the individual reflections of each part but their reflective interactions as well. The combination loss by the overall reflection can be higher or lower than individual loss by multiple reflections. The combination loss is called the mismatch error and leads to the measurement uncertainty.

**A5-8 Random uncertainty**

The random uncertainty characterizes the undefined and miscellaneous effects which cannot be forecasted. One can estimate this type of uncertainty with a repeatability test by making a series of repeated measurement with a reference AAS BS without changing anything in the measurement set-up.

**A5-9 Impedance mismatch between the receiving antenna and the network analyzer**

This contribution originates from multiple reflections between the receiving antenna and the network analyzer. After appropriate calibration, the network analyzer may not introduce impedance mismatch error, but the error still happens between the receiving antenna feed cable and the receiving antenna.

**A5-10 Positioning and pointing misalignment between the reference antenna and the receiving antenna**

This contribution originates from reference antenna alignment and pointing error. In this measurement if the maximum gain directions of the reference antenna and the receiving antenna are aligned to each other, this contribution can be considered negligible and therefore set to zero.

**A5-11 Impedance mismatch between the reference antenna and the network analyzer**

This contribution originates from multiple reflections between the reference antenna and the network analyzer. After appropriate calibration, the network analyzer may not introduce impedance mismatch error, but the error still happens between the reference antenna feed cable and the reference antenna.

**A5-12 Influence of the reference antenna feed cable**

In the calibration Stage 1, the influence of the calibration antenna feed cable is assessed by measurements. A measurement for calibration may be repeated with a reasonably differing routing of the feed cable. Largest difference among the results is entered to the uncertainty budget with a rectangular distribution.

**A5-13 Reference antenna feed cable loss measurement uncertainty**

Before performing the calibration, the reference antenna feed cable loss have to be measured. The measurement can be done with a network analyzer to measure its S21 and uncertainty is introduced.

**A5-14 Influence of the receiving antenna feed cable**

If the probe antenna is directional (i.e. peak gain >+5 dBi, e.g. horn, LPDA, etc.) and the same probe antenna cable configuration is used for both stages, the uncertainty is considered systematic and constant 🡺 0.00 dB value.

In other cases a technical study should be done.

**A5-15 Uncertainty of the absolute gain of the receiving antenna**

The uncertainty appears in both stages and it is thus considered systematic and constant 🡺 0.00 dB value.

**A5-16 Frequency flatness**

This uncertainty contribution to account for the frequency interpolation error caused by a finite frequency resolution during the calibration stage.

**A5-17 Measurement antenna frequency variation**

For wide band measurement the measurement antenna gain will vary considerably over frequency. The gain can be calibrated however variation may still remain between calibration frequency steps. This uncertainty accounts for the variation between the calibrated steps.

**A5-18 FSPL estimation error**

For wide band measurement the measurement free space path loss in the chamber will vary with frequency. The loss can be calibrated however this uncertainty accounts for the variation between the calibrated steps.

**A5-19 Measurement system dynamic range uncertainty**

Uncertainty associated with the addition of each of the directional power measurements to calculate the TRP due to the limited dynamic range of the OTA test system causing an overestimation.

**A5-20 - Reflections in anechoic chamber**

Uncertainty associated with the reflections in the chamber changing the coupling between the BS and the CLTA.

# A.6 Reverberation Chamber

**A6-1 Impedance mismatch in the receiving chain**

This contribution originates from multiple reflections between the receiving antenna and the power measurement equipment. The multiple reflections can produce an overall reflection that depends not only upon the individual reflections of each part but their reflective interactions as well. The combination loss by the overall reflection can be higher or lower than individual loss by multiple reflections. The combination loss is called the mismatch error and leads to the measurement uncertainty.

**A6-2 Random uncertainty**

The random uncertainty characterizes the undefined and miscellaneous effects which cannot be forecasted. One can estimate this type of uncertainty with a repeatability test by making a series of repeated measurement with a reference EUT without changing anything in the measurement set-up.

**A6-3 Reference antenna radiation efficiency**

This contribution is a residue of uncertainty of reference antenna radiation efficiency after calibration.

**A6-4 Mean value estimation of reference antenna mismatch efficiency**

This contribution originates from the error of the estimated mean related to the use of a finite number of samples in the measurement of the reference antenna mismatch efficiency. The mean value estimation is calculated as where is the standard deviation of the series of measured values.

**A6-5 Influence of the reference antenna feed cable**

Before performing the calibration, the reference antenna feed cable loss has to be measured. The measurement can be done with a network analyzer to measure its S21 and uncertainty is introduced.

**A6-6 Mean value estimation of transfer function**

This contribution originates from the error of the estimated mean related to the use of a finite number of samples in the measurement of the transfer function. The mean value estimation is calculated as where is the standard deviation of the series of measured values.

**A6-7 Uniformity of transfer function**

Standard deviation over EUT positions and rotations of the transfer function . This uncertainty expresses the variations of measured TRP values with respect to translations and rotations of the EUT. Ideally, the TRP does neither depend on translations nor rotations of the EUT.

# A.7 Plane Wave Synthesizer

**A7-1 Misalignment DUT (a) /calibration antenna (b) & pointing error**

This contribution denotes uncertainty in DUT/calibration antenna alignment and DUT/calibration antenna pointing error. In this measurement the DUT/calibration antenna is aligned to maximum, also allowing for a zero contribution for polarization mismatch uncertainty. By adjusting for maximums to align, this contribution can be a small contribution. The calibration antenna's phase centre and polarization purity changes slightly according to the frequency. Therefore, there should be some uncertainty reserved for this. To ensure that the point error is at a minimal, this contribution should be captured using the antenna pattern cut which is broadest (in the case of the DUT this would most likely be in the azimuth domain).

**A7-2 Longitudinal position uncertainty (i.e. standing wave and imperfect field synthesis) for DUT (a) /calibration antenna (b)**

This value covers the effect of standing wave between DUT or calibration antenna and the test range antenna, but also counts for the PWS imperfect field synthesis over distance. This value can be captured by moving the DUT or calibration antenna towards the test range antenna.

**A7-3 RF leakage**

This contribution denotes noise leaking in to connector and cable(s) between test range antenna and receiving equipment. The contribution also includes the noise leakage between the connector and cable(s) between reference antenna and transmitting equipment.

**A7-4** **QZ ripple with DUT (a) /calibration antenna (b)**

This is the quiet zone (QZ) ripple experienced by the DUT/reference antenna during the measurement phase. The purpose of this component is to capture the contributions that the reflections from the walls, roof and floor that will add to measurements. The sum of all these reflections from the walls, roof and floor will give the overall value for the QZ ripple. In other words, the uncertainty component from the wall will not be separated from the roof or the floor. The purpose of this uncertainty component is to capture the overall reflections from the chamber walls experienced by the DUT/reference antenna.

**A7-5 Miscellaneous Uncertainty**

The term 'miscellaneous uncertainty' is used to define all the unknown, unquantifiable, etc. uncertainties associated with EIRP measurements. This term should include truly random effects as well as systematic uncertainties, such as that arising from dissimilarity between the patterns of the reference antenna and the DUT.

**A7-6 Mismatch**

This uncertainty is the residual uncertainty contribution coming from multiple reflections between the receiving antenna and the test receiver equipment. This value can be captured through measurement by measuring the S11 towards the receive antenna and also towards the test receiver. The mismatch between the antenna reflection and the receiver reflection can also be calculated. If the same cable is used for calibration Stage 1, this can be considered systematic and negligible.

**A7-7 Insertion loss variation**

This uncertainty is the residual uncertainty contribution coming from introducing an antenna at the end of the cable. If this cable does not change/move between the calibration Stage 1 and the measurement Stage 2, the uncertainty is assumed to be systematic and negligible during the measurement stage. Alternatively, the insertion loss can also be calculated by taking the measurement of the cable where port 2 is the end of the cable connected to the AAS BS or calibration antenna.

 IL = -20log10|S21| dB

**A7-8 Influence of the calibration antenna feed cable**

**a) Flexing cables, adapters, attenuators, extra pathloss cable & connector repeatability.**

During the calibration phase this cable is used to feed the calibration antenna and any influence it may have upon the measurements is captured. This is assessed by repeated measurements while flexing the cables and rotary joints. The largest difference between the results is recorded as the uncertainty.

**A7-9 Misalignment of positioning system**

This contribution originates from uncertainty in sliding position and turn table angle accuracy. If the calibration antenna is aligned to maximum this contribution can be considered negligible and therefore set to zero.

**A7-10 Rotary Joints**

If applicable, this uncertainty term corresponds to the accuracy in changing from azimuth to vertical measurements.

**A7-11 Switching Uncertainty**

The purpose of the switching unit is to switch electromechanically different RF path to different measurement instruments of different measurement modes. The electromechanical switching clearly reduces the errors arising from manual switching work. Switching is also used to measure the path loss values of each polarization component. Even though the electromechanical switching is preferable during path loss and antenna performance measurements, some minor uncertainties can occur when the switch states are programmed to change their polarity.

**A7-12 Field repeatability**

Each execution of field calibration of the measurement antenna array to find the PWS settings provides a slightly different set of settings for the RF components for each antenna path. This results in variation of the synthesized plane wave in the QZ and variation of PWS antenna to reference antenna coupling. This variation is described by field repeatability term.

**A7-13 Frequency flatness**

This uncertainty contribution to account for the frequency interpolation error caused by a finite frequency resolution during the calibration stage.

**A7-14 System non-linearity**

This uncertainty term is calculated as RSS of the following items, assuming a rectangular distribution:

- System non-linearity in time. This is assessed by repeated measurements over a period of time (e.g. 60 minutes) for the same reference power transmitted by the reference antenna. The largest difference between the results is recorded as the uncertainty.

- System non-linearity in power. This is assessed by repeated measurements over a range of transmitted powers. The largest delta between the increments on the receiving side versus the transmitting side is recorded as the uncertainty.

Annex B:
Radiated RX measurement error contribution descriptions

# B.1 Indoor Anechoic Chamber

**B1-1 Positioning misalignment between the AAS BS and the reference antenna**

This contribution originates from the misalignment of the manufacturer declared coordinate system reference point of the AAS BS and the phase centre of the reference antenna. The uncertainty makes the space propagation loss between the AAS BS and the transmitting antenna at the DUT measurement stage (i.e. Stage 2) different from the space propagation loss between the reference antenna and the transmitting antenna at the calibration stage (i.e. Stage 1).

**B1-2 Pointing misalignment between the AAS BS and the transmitting antenna**

This contribution originates from the misalignment of the testing direction and the *beam peak direction* of the transmitting antenna due to imperfect rotation operation. The pointing misalignment may happen in both azimuth and vertical directions and the effect of the misalignment depends highly on the beamwidth of the beam under test. The same level of misalignment results in a larger measurement error for a narrower beam.

**B1-3 Quality of quiet zone**

This contribution originates from a reflectivity level of an anechoic chamber. The reflectivity level is determined from the average standard deviation of the electric field in the quiet zone. By repeating a free space VSWR measurement in 15-degree grid in elevation and azimuth, 264 standard deviation values in both polarizations are determined. From these values an average standard deviation of electric field in the quiet zone can be calculated from the equation:

 

where:

  is the number of angular intervals in elevation,

  is the number of angular intervals in azimuth, and

  is elevation of single measurement .

If an efficiency calibration with omni-directional calibration antenna is performed, the effect of reflectivity level decreases in Stage 1 (i.e. calibration measurement) and  may be divided by factor 2. This is due to correcting impact of data averaging in this type of calibration. Efficiency calibration done with sampling step ≤ 30°, can be considered to have at least four independent samples.  may be divided by factor 2 also in stage 2 (i.e. DUT measurement) for the same reason.

It's likely that asymmetry of the field probe will have a very small impact on this measurement uncertainty contributor, however, an upper bound to probe symmetry should be considered.

**B1-4 Polarization mismatch between the AAS BS (a) / reference antenna (b) and the transmitting antenna**

This contribution originates from the misaligned polarization between the AAS BS (a) /reference antenna (b) and the transmitting antenna.

**B1-5 Mutual coupling between the AAS BS (a) /reference antenna (b) and the transmitting antenna**

This contribution originates from mutual coupling between the AAS BS (a) /reference antenna (b) and the transmitting antenna. Mutual coupling degrades not just the antenna efficiency, but it can alter the antenna's radiation pattern as well. For indoor anechoic chamber, usually the spacing between the transmitting antenna and the AAS BS/reference antenna is large enough so that the level of mutual coupling might be negligible.

**B1-6 Phase curvature**

This contribution originates from the finite far-field measurement distance, which causes phase curvature across the antenna of the AAS BS/reference antenna.

**B1-7 Impedance mismatch in the transmitting chain**

This contribution originates from multiple reflections between the transmitting antenna and the signal generator. The multiple reflections can produce an overall reflection that depends not only upon the individual reflections of each part but their reflective interactions as well. The combination loss by the overall reflection can be higher or lower than individual loss by multiple reflections. The combination loss is called the mismatch error and leads to the measurement uncertainty.

**B1-8 Random uncertainty**

The random uncertainty characterizes the undefined and miscellaneous effects which cannot be forecasted. One can estimate this type of uncertainty with a repeatability test by making a series of repeated measurement with a reference DUT without changing anything in the measurement set-up.

**B1-9 Impedance mismatch between the transmitting antenna and the network analyzer**

This contribution originates from multiple reflections between the transmitting antenna and the network analyzer. After appropriate calibration, the network analyzer may not introduce impedance mismatch error, but the error still happens between the transmitting antenna feed cable and the transmitting antenna.

**B1-10 Positioning and pointing misalignment between the reference antenna and the transmitting antenna**

This contribution originates from reference antenna alignment and pointing error. In this measurement if the maximum gain direction of the reference antenna and the transmitting antenna are aligned to each other, this contribution can be considered negligible and therefore set to zero.

**B1-11 Impedance mismatch between the reference antenna and the network analyzer**

This contribution originates from multiple reflections between the reference antenna and the network analyzer. After appropriate calibration, the network analyzer may not introduce impedance mismatch error, but the error still happens between the transmitting antenna feed cable and the transmitting antenna.

**B1-12 Influence of the reference antenna feed cable**

In the calibration Stage 1, the influence of the calibration antenna feed cable is assessed by measurements. A measurement for calibration may be repeated with a reasonably differing routing of the feed cable. Largest difference among the results is entered to the uncertainty budget with a rectangular distribution.

**B1-13 Reference antenna feed cable loss measurement uncertainty**

Before performing the calibration, the reference antenna feed cable loss have to be measured. The measurement can be done with a network analyzer to measure its S21 and uncertainty is introduced.

**B1-14 Influence of the transmitting antenna feed cable**

If the probe antenna is directional (i.e. peak gain >+5 dBi e.g. horn, LPDA, etc.) and the same probe antenna cable configuration is used for both stages, the uncertainty is considered systematic and constant 🡺 0.00 dB value.

**B1-15 Uncertainty of the absolute gain of the transmitting antenna**

The uncertainty appears in both stages and it is thus considered systematic and constant 🡺 0.00 dB value.

# B.2 Compact Antenna Test Range

**B2-1 Misalignment DUT (a) /calibration antenna (b) & pointing error**

This contribution denotes uncertainty in DUT (a) /calibration antenna (b) alignment and DUT (a) /calibration antenna (b) pointing error. In this measurement the DUT (a) /calibration antenna (b) is aligned to maximum, also allowing for a zero contribution for polarization mismatch uncertainty. By adjusting for maximums to align, this contribution can be a small contribution. The calibration antenna's phase centre and polarization purity changes slightly according to the frequency. Therefore, there should be some uncertainty reserved for this. To ensure that the point error is at a minimal, this contribution should be captured using the antenna pattern cut which is broadest (in the case of the DUT this would most likely be in the azimuth domain).

**B2-2 Standing wave between DUT and test range antenna**

This value is extracting the uncertainty value and standard deviation of gain ripple coming from standing waves between DUT and test range antenna. This value can be captured by moving the DUT towards the test range antenna as the standing waves go in and out of phase causing a ripple in measured gain.

**B2-3 RF leakage & dynamic range, test range antenna cable connector terminated.**

This contribute denotes noise leaking in to connectors and cables between test range antenna and receiving equipment.

**B2-4 QZ ripple DUT (a) /calibration antenna (b)**

This is the quiet zone ripple experienced by the DUT (a) /calibration antenna (b) during the measurement phase. The purpose of this component is to capture the contributions that the reflections from the walls, roof and floor that will add to the EIS measurement. The sum of all these reflections from the walls, roof and floor will give the overall value for the QZ ripple. In other words, the uncertainty component from the wall will not be separated from the roof or the floor. The purpose of this uncertainty component is to capture the overall reflections from the chamber walls experienced by the DUT (a) /calibration antenna (b). To capture the full effect of the QZ ripple a distance of 1λ should be measured from each of the DUT (a) /calibration antenna (b) physical aperture edges, i.e. total QZ distance = physical aperture length + 2 λ, to ensure the full volume of the QZ is captured in the uncertainty measurement.

**B2-5 Mismatch of transmit chain (i.e. between transmitting measurement antenna and DUT)**

This uncertainty is the residual uncertainty contribution coming from multiple reflections between the transmitting antenna and the signal generation equipment. This value can be captured through measurement by measuring the S11 towards the transmit antenna and also towards the test signal generator equipment. The mismatch between the antenna reflection and the transmit reflection can also be calculated.

**B2-6 Insertion loss of transmit chain**

This uncertainty is the residual uncertainty contribution coming from introducing an antenna at the end of the cable. If this cable does not change/move between the calibration Stage 1 and the DUT measurement Stage 2, the uncertainty is assumed to be systematic. Alternatively, the insertion loss can also be calculated by taking the measurement of the cable where port 2 is the end of the cable connected to the measurement antenna.

 IL = -20log10|S21| dB

**B2-7 RF leakage (SGH connector terminated & test range antenna connector terminated)**

This contribution denotes noise leaking in to connector and cable(s) between test range antenna and receiving equipment. The contribution also includes the noise leakage between the connector and cable(s) between SGH/reference antenna and transmitting equipment.

**B2-8 Influence of the calibration antenna feed cable**

a) Flexing cables, adapters, attenuators & connector repeatability.

During the calibration phase this cable is used to feed the calibration antenna and any influence it may have upon the measurements is captured. This is assessed by repeated measurements while flexing the cables and rotary joints. The largest difference between the results is recorded as the uncertainty.

**B2-9 Uncertainty due to antenna mounting apparatus or rotary joints**

If applicable the contribution of this uncertainty the accuracy in changing from azimuth to vertical measurements.

**B2-10 Miscellaneous uncertainty**

The term 'miscellaneous uncertainty' is used to define all the unknown, unquantifiable, etc. uncertainties associated with EIRP measurements. This term should include truly random effects as well as systematic uncertainties, such as that arising from dissimilarity between the patterns of the reference antenna (SGH) and the DUT.

**B2-11 Rotary Joints**

If applicable the contribution of this uncertainty is the accuracy in changing from azimuth to vertical measurements.

**B2-12 Misalignment positioning system**

This contribution originates from uncertainty in sliding position and turn table angle accuracy. If the calibration antenna is aligned to the maximum then this contribution can be considered negligible and therefore set to zero.

**B2-15 Standing wave between DUT and test range antenna**

This value is extracting the uncertainty value and standard deviation of gain ripple coming from standing waves between DUT and test range antenna. This value can be captured by moving the DUT towards the test range antenna as the standing waves go in and out of phase causing a ripple in measured gain.

**B2-17 Switching Uncertainty**

The purpose of the switching unit is to switch electromechanically different RF path to different measurement instruments of different measurement modes. The electromechanical switching clearly reduces the errors arising from manual switching work. Switching is also used to measure the path loss values of each polarization component. Even though the electromechanical switching is preferable during path loss and antenna performance measurements, some minor uncertainties can occur when the switch states are programmed to change their polarity.

# B.3 Near Field Test Range

**B3-1 Axes Intersection**

This is a mechanical uncertainty term and aim to find the uncertainty related with the lateral displacement between the horizontal and vertical axes of the DUT positioner. This can result in sampling the field on a non-ideal sphere. This uncertainty is assumed to have a Gaussian distribution.

**B3-2 Axes Orthogonality**

The difference from 90° of the angle between the horizontal and vertical axes also results in sampling the field on a non ideal sphere. This uncertainty is assumed to have a Gaussian distribution.

**B3-3 Horizontal Pointing**

The horizontal mispointing of the horizontal axis to the probe reference point for Theta=0° also results in sampling the field on a non-ideal sphere. This uncertainty is assumed to have a Gaussian distribution.

**B3-4 Probe Vertical position**

The vertical displacement of the probe reference point from the horizontal axis results in sampling the field on a non ideal sphere. This uncertainty is assumed to have a Gaussian distribution.

**B3-5 Probe Horizontal/Vertical pointing**

The horizontal or vertical mispointing of the probe z-axis from the intersection point of the horizontal/vertical axis. This uncertainty is assumed to have a Gaussian distribution.

**B3-6 Measurement distance**

This is the knowledge of the distance between the intersection point of the horizontal and vertical axis and probe reference point. This uncertainty is assumed to have a Gaussian distribution.

**B3-7 Amplitude and phase drift**

The system drift due to temperature variations causes the signal at DUT location to drift in amplitude and phase. This uncertainty is assumed to have a Gaussian distribution.

**B3-8 Amplitude and phase noise**

This uncertainty is due to the noise level of the test range so that the S/N ratio should be determined or measured at the DUT location. The noise level is usually measured with a spectrum analyzer. This uncertainty is assumed to have a Gaussian distribution.

**B3-9 Leakage and Crosstalk**

This uncertainty can be addressed by measurements on the actual system setup. The leakage and crosstalk cannot be separated from the random amplitude and phase errors so that the relative importance should be determined. This uncertainty is assumed to have a Gaussian distribution.

**B3-10 Amplitude non-linearity**

This uncertainty is the linearity of the receiver used for the measurement. It can be taken from the data sheet of the receiver.

**B3-11 Amplitude and phase shift in rotary joint**

This uncertainty is due to the variation of the rotary joint. It can be measured and is assumed to have a Gaussian distribution.

**B3-12 Channel balance amplitude and phase**

This uncertainty is relevant for systems which are using dual polarized probes and polarization switches. The amplitude and phase difference between two signal channels of the receiver includes the difference between the probe ports, difference between the channels of the polarization switch, connecting cables and reflection coefficients. This uncertainty is assumed to have a Gaussian distribution.

**B3-13 Probe polarization amplitude and phase**

The amplitude and phase of the probe polarization coefficients should be measured. This uncertainty is assumed to have a Gaussian distribution.

**B3-14 Probe pattern knowledge**

The probe(s) pattern(s) is assumed to be known so that the DUT measurement in near field can be corrected when performing the near field to far field transform. There is no direct dependence between the DUT pattern and the probe pattern in near field measurements. This uncertainty is assumed to have a Gaussian distribution.

**B3-15 Multiple reflections**

The multiple reflections occur when a portion of the transmitted signal is reflected form the receiving antenna back to the transmitting antenna and re-reflected by the transmitting antenna back to the receiving antenna. This uncertainty can be determined by multiple measurements of the DUT when at different distance from the probes. This uncertainty is assumed to have a Gaussian distribution.

**B3-16 Room scattering**

As for the multiple reflections, a portion of the transmitted signal is reflected by either the absorbers or other structures in the measurement anechoic chamber before being received by the receiving antenna. This effect can be isolated from the multiple reflections by testing the DUT in different positions, separated by λ/4 with respect to the anechoic chamber and comparing these measurements with the reference. This uncertainty is assumed to have a Gaussian distribution.

**B3-17 DUT support scattering**

This is the uncertainty due to the DUT supporting structure on the signal level. This uncertainty is assumed to have a Gaussian distribution.

**B3-18 Scan area truncation**

This uncertainty does affect the near field measurement. It can be addressed by comparing the measurement result when scanning the full area. This uncertainty is assumed to have a Gaussian distribution.

**B3-19 Sampling point offset**

This uncertainty has an influence in near field and far field. It is assumed to have a Gaussian distribution.

**B3-20 Mode truncation**

The measured near field is expanded using a finite set of spherical modes. The number of modes is linked to number of samples. The filtering effect generated by the finite number of modes can improve measurement results by removing signals from outside the physical area of the AAS BS. Care should be taken in order to make sure the removed signals are not from the AAS BS itself. This uncertainty is usually negligible.

**B3-21 Positioning**

The relative position of the probe array is not ideal. This uncertainty is assumed to have a rectangular distribution.

**B3-22 Probe array uniformity**

This is the uncertainty due to the fact that different probes are used for each physical position. Different probes have different radiation patterns. This uncertainty is assumed to have a Gaussian distribution.

**B3-23 Mismatch of transmitter chain**

If the same chain configuration (including the vector signal generator; the probe antenna and other elements) is used in both stages, the uncertainty is considered systematic and constant 🡺 0.00 dB value.

If it is not the case, this uncertainty contribution has to be taken into account and should be measured or determined by the method described in 3GPP TR 25.914 [14]. This uncertainty is assumed to have a U-shaped distribution.

**B3-24 Insertion loss of transmitter chain**

It is composed of the following:

- Insertion loss of the probe antenna cable.

- Insertion loss of the probe antenna attenuator (if used).

- Insertion loss of RF relays (if used).

If the same chain configuration is used for measurement and calibration, the uncertainty due to the above components is considered systematic and constant 🡺 0.00 dB value. This uncertainty is assumed to have a Gaussian distribution.

**B3-25 Uncertainty of the absolute gain of the probe antenna**

This uncertainty appears in the both stages and it is thus considered systematic and constant🡺 0.00 dB value.

**B3-26 Measurement Repeatability - Positioning Repeatability**

This uncertainty is due to the repositioning of the DUT in the test setup. It can be addressed by repeating the corresponding measurement 10 times. Calculate the standard deviation of the metric obtained and use that as the measurement uncertainty. For tests that require multiple setups, the worst-case standard deviation is used. This uncertainty is assumed to have a Gaussian distribution.

**B3-27 Mismatch of transmitter chain**

If the same chain configuration (including the measurement receiver; the probe antenna and other elements) is used in both stages, the uncertainty is considered systematic and constant 🡺 0.00 dB value.

If it is not the case, this uncertainty contribution has to be taken into account and should be measured or determined by the method described in 3GPP TR 25.914 [14]. This uncertainty is assumed to have a Gaussian distribution.

**B3-28 Insertion loss of transmitter chain**

If the same chain configuration is used for measurement and calibration, the uncertainty due to the above components is considered systematic and constant 🡺 0.00 dB value. This uncertainty is assumed to have a Gaussian distribution.

**B3-29 Mismatch in the connection of the calibration antenna**

This is the uncertainty from the mismatch in the connection between the system coax cable and the calibration antenna. It should be measured or determined by the method described in 3GPP TR 25.914 [14]. This uncertainty is assumed to have a U-shaped distribution.

**B3-30 Influence of the calibration antenna feed cable**

This uncertainty is due to the impact of the feeding cable on the radiation properties of the calibration antenna. In case of using either a standard horn or standard gain horn, the impact of the cable is to be considered negligible thus the uncertainty 🡺 0.00 dB value. In case of using a dipole-like antenna, the uncertainty should be addressed by measuring this impact. This uncertainty is assumed to have a Gaussian distribution.

**B3-31 Influence of the probe antenna cable**

If the same chain configuration is used for measurement and calibration, the uncertainty due to the above components is considered systematic and constant 🡺 0.00 dB value. This uncertainty is assumed to have a Gaussian distribution.

**B3-32 Short term repeatability**

It can be addressed by performing a repeatability test of the calibration antenna. This uncertainty is assumed to have a Gaussian distribution.

# B.4 One Dimensional Compact Range

**B4-1 Misalignment DUT and pointing error**

This contribution denotes uncertainty in DUT alignment and DUT pointing error. In this measurement the DUT is aligned to maximum, also allowing for a zero contribution for polarization mismatch uncertainty. By adjusting for maximums to align, this contribution can be a small contribution. The reference antenna´s phase centre and polarization purity changes slightly according to the frequency. Therefore, there should be some uncertainty reserved for this. To ensure that the pointing error is at a minimal, this contribution should be captured using the antenna pattern cut which is broadest (in the case of the DUT this would most likely be in the azimuth domain).

**B4-2 Standing wave between DUT (a) /reference antenna (b) and test range antenna**

This value is extracting the uncertainty value and standard deviation of gain ripple coming from standing waves between DUT/reference antenna and test range antenna. This value can be captured by moving the DUT (a) /reference antenna (b) towards the test range antenna as the standing waves go in and out of phase causing a ripple in measured gain.

**B4-3 Quiet zone ripple DUT (a) /reference antenna (b)**

This is the quiet zone (QZ) ripple experienced by the DUT (a) / reference antenna (b) during the measurement phase. The purpose of this component is to capture the contributions that the reflections from the walls, roof and floor that will add to the EIS measurement. The sum of all these reflections from the walls, roof and floor will give the overall value for the QZ ripple. In other words, the uncertainty component from the wall will not be separated from the roof or the floor. The purpose of this uncertainty component is to capture the overall reflections from the chamber walls experienced by the DUT (a) / reference antenna (b). To capture the full effect of the QZ ripple a distance of 1λ must be measured from each of the DUT (a) / reference antenna (b) physical aperture edges, i.e. total QZ distance = physical aperture length + 2 λ, to ensure the full volume of the QZ is captured in the uncertainty measurement.

**B4-4 Phase curvature**

This contribution originates from the finite far-field measurement distance, which causes phase curvature across the antenna of the DUT/reference antenna.

**B4-5 Polarization mismatch between DUT (a) /reference antenna (b) and transmitting antenna**

This contribution originates from the misaligned polarization between the DUT (a) /reference antenna (b) and the transmitting antenna.

**B4-6 Mutual coupling between DUT (a) /reference antenna (b) and transmitting antenna**

This contribution originates from mutual coupling between the DUT (a) /reference antenna (b) and the transmitting antenna. Mutual coupling degrades not just the antenna efficiency, but it can alter the antenna’s radiation pattern as well. For compact range chamber, usually the spacing between the transmitting antenna and the DUT (a) /reference antenna (b) is large enough so that the level of mutual coupling might be negligible.

**B4-7 Impedance mismatch in transmitting chain**

This contribution originates from multiple reflections between the transmitting antenna and the signal generator. The multiple reflections can produce an overall reflection that depends not only upon the individual reflections of each part but their reflective interactions as well. The combination loss by the overall reflection can be higher or lower than individual loss by multiple reflections. The combination loss is called the mismatch error and leads to the measurement uncertainty.

**B4-8 RF leakage and dynamic range**

This contribute denotes noise leaking into connectors and cables between test range antenna and receiving equipment.

**B4-9 Misalignment positioning system**

This contribution originates from uncertainty in sliding position and turn table angle accuracy. If the reference antenna is aligned to the maximum then this contribution can be considered negligible and therefore set to zero.

**B4-10 Pointing error between reference antenna and test range antenna**

This contribution originates from the misalignment of the testing direction and the *beam peak direction* of the transmitting antenna due to imperfect rotation operation. The pointing misalignment may happen in both azimuth and vertical directions and the effect of the misalignment depends highly on the beamwidth of the beam under test. The same level of misalignment results in a larger measurement error for a narrower beam.

**B4-11 Impedance mismatch in path to reference antenna**

This contribution originates from multiple reflections between the reference antenna and the measurement equipment. After appropriate calibration, the measurement equipment may not introduce impedance mismatch error, but the error still happens between the reference antenna feed cable and the reference antenna.

**B4-12 Impedance mismatch in path to compact probe**

This contribution originates from multiple reflections between the transmitting antenna and the measurement equipment. After appropriate calibration, the measurement equipment may not introduce impedance mismatch error, but the error still happens between the transmitting antenna feed cable and the transmitting antenna.

**B4-13 Influence of reference antenna feed cable (flexing cables, adapters, attenuators and connector repeatability)**

During the calibration phase this cable is used to feed the reference antenna and any influence it may have upon the measurements is captured. This is assessed by repeated measurements while flexing the cables and rotary joints. The largest difference between the results is recorded as the uncertainty.

**B4-14 Mismatch of transmitter chain (i.e. between transmitting measurement antenna and DUT)**

This uncertainty is the residual uncertainty contribution coming from multiple reflections between the transmitting antenna and the signal generation equipment. This value can be captured through measurement by measuring the S11 towards the transmit antenna and also towards the test signal generator equipment. The mismatch between the antenna reflection and the transmit reflection can also be calculated.

**B4-15 Insertion loss of transmitter chain**

This uncertainty is the residual uncertainty contribution coming from introducing an antenna at the end of the cable. If this cable does not change/move between the calibration and the DUT measurement stage, the uncertainty is assumed to be systematic. Alternatively, the insertion loss can be calculated by taking the measurement of the cable where port 2 is the end of the cable connected to the measurement antenna.

IL = -20log10|S21| dB

**B4-16 RF leakage (SGH connector terminated and test range antenna connector terminated)**

This contribution denotes noise leaking into connector and cable(s) between test range antenna and receiving equipment. The contribution also includes the noise leakage between the connector and cable(s) between SGH/reference antenna and transmitting equipment.

# B.5 Plane Wave Synthesizer

**B5-1 Misalignment DUT (a) /calibration antenna (b) & pointing error**

This contribution denotes uncertainty in DUT/calibration antenna alignment and DUT/calibration antenna pointing error. In this measurement the DUT/calibration antenna is aligned to maximum, also allowing for a zero contribution for polarization mismatch uncertainty. By adjusting for maximums to align, this contribution can be a small contribution. The calibration antenna's phase centre and polarization purity changes slightly according to the frequency. Therefore, there should be some uncertainty reserved for this. To ensure that the point error is at a minimal, this contribution should be captured using the antenna pattern cut which is broadest (in the case of the DUT this would most likely be in the azimuth domain).

**B5-2 Longitudinal position uncertainty (i.e. standing wave and imperfect field synthesis) for DUT (a) /calibration antenna (b)**

This value covers the effect of standing wave between DUT or calibration antenna and the test range antenna, but also counts for the PWS imperfect field synthesis over distance. This value can be captured by moving the DUT or calibration antenna towards the test range antenna.

**B5-3 RF leakage**

This contribution denotes noise leaking in to connector and cable(s) between test range antenna and receiving equipment. The contribution also includes the noise leakage between the connector and cable(s) between reference antenna and transmitting equipment.

**B5-4** **QZ ripple with DUT (a) /calibration antenna (b)**

This is the quiet zone (QZ) ripple experienced by the DUT/reference antenna during the measurement phase. The purpose of this component is to capture the contributions that the reflections from the walls, roof and floor that will add to measurements. The sum of all these reflections from the walls, roof and floor will give the overall value for the QZ ripple. In other words, the uncertainty component from the wall will not be separated from the roof or the floor. The purpose of this uncertainty component is to capture the overall reflections from the chamber walls experienced by the DUT/reference antenna.

**B5-5 Miscellaneous Uncertainty**

The term 'miscellaneous uncertainty' is used to define all the unknown, unquantifiable, etc. uncertainties associated with EIRP measurements. This term should include truly random effects as well as systematic uncertainties, such as that arising from dissimilarity between the patterns of the reference antenna and the DUT.

**B5-6 Mismatch**

This uncertainty is the residual uncertainty contribution coming from multiple reflections between the receiving antenna and the test receiver equipment. This value can be captured through measurement by measuring the S11 towards the receive antenna and also towards the test receiver. The mismatch between the antenna reflection and the receiver reflection can also be calculated. If the same cable is used for calibration Stage 1, this can be considered systematic and negligible.

**B5-7 Insertion loss variation**

This uncertainty is the residual uncertainty contribution coming from introducing an antenna at the end of the cable. If this cable does not change/move between the calibration Stage 1 and the measurement Stage 2, the uncertainty is assumed to be systematic and negligible during the measurement stage. Alternatively, the insertion loss can also be calculated by taking the measurement of the cable where port 2 is the end of the cable connected to the AAS BS or calibration antenna.

 IL = -20log10|S21| dB

**B5-8 Influence of the calibration antenna feed cable**

**a) Flexing cables, adapters, attenuators, extra pathloss cable & connector repeatability.**

During the calibration phase this cable is used to feed the calibration antenna and any influence it may have upon the measurements is captured. This is assessed by repeated measurements while flexing the cables and rotary joints. The largest difference between the results is recorded as the uncertainty.

**B5-9 Misalignment of positioning system**

This contribution originates from uncertainty in sliding position and turn table angle accuracy. If the calibration antenna is aligned to maximum this contribution can be considered negligible and therefore set to zero.

**B5-10 Rotary Joints**

If applicable, this uncertainty term corresponds to the accuracy in changing from azimuth to vertical measurements.

**B5-11 Switching Uncertainty**

The purpose of the switching unit is to switch electromechanically different RF path to different measurement instruments of different measurement modes. The electromechanical switching clearly reduces the errors arising from manual switching work. Switching is also used to measure the path loss values of each polarization component. Even though the electromechanical switching is preferable during path loss and antenna performance measurements, some minor uncertainties can occur when the switch states are programmed to change their polarity.

**B5-12 Field repeatability**

Each execution of field calibration of the measurement antenna array to find the PWS settings provides a slightly different set of settings for the RF components for each antenna path. This results in variation of the synthesized plane wave in the QZ and variation of PWS antenna to reference antenna coupling. This variation is described by field repeatability term.

**B5-13 Frequency flatness**

This uncertainty contribution to account for the frequency interpolation error caused by a finite frequency resolution during the calibration stage.

**B5-14 System non-linearity**

This uncertainty term is calculated as RSS of the following items, assuming a rectangular distribution:

- System non-linearity in time. This is assessed by repeated measurements over a period of time (e.g. 60 minutes) for the same reference power transmitted by the reference antenna. The largest difference between the results is recorded as the uncertainty.

- System non-linearity in power. This is assessed by repeated measurements over a range of transmitted powers. The largest delta between the increments on the receiving side versus the transmitting side is recorded as the uncertainty.

Annex C (informative):Test equipment uncertainty values

# C.1 Test equipment measurement error contribution descriptions

**C1-1 Uncertainty of the RF power measurement equipment (e.g. spectrum analyzer, power meter)**

The receiving device used to measure the received signal level in the EIRP tests either as an absolute level or as a relative level. These receiving devices to name a few are spectrum analyzers, network analyzers or power meter. These devices will have an uncertainty contribution of their own; this value declared by the test gear vendor should be recorded as this uncertainty contribution. If a power meter is used then both measurement uncertainty and out of band noise is considered as part of the contribution. This uncertainty value can be found in table C2-1 and was a result of compromised value in order to align all test methods having this uncertainty contribution.

**C1-2 Uncertainty of the RF signal generator**

The use of this signal generator introduces an uncertainty on the absolute output level. The uncertainty value will be indicated in the manufacturer's data sheet in logs. This uncertainty value can be found in Annex C2-1 and was a result of compromised value in order to align all test methods having this uncertainty contribution.

**C1-3 Uncertainty of the network analyzer**

**a) drift (temp, oscillators, filters, etc.) start-to-end time of measurements.**

This uncertainty includes all the uncertainties involved in the S21 measurement (including drift and frequency flatness) with a network analyzer, and will be calculated from the manufacturer's data in logs. This uncertainty also includes analyzer uncertainty for multi-polarization (2 or more ports) measured simultaneously. This uncertainty value can be found in table C2-1 and was a result of compromised value in order to align all test methods having this uncertainty contribution.

**C1-4 Uncertainty of the absolute gain of the reference antenna**

This uncertainty consists of the uncertainty of the gain value associated with the gain value denoted from the antenna calibration. This uncertainty value can be found in table C.2-1 and was a result of compromised value in order to align all test methods having this uncertainty contribution.

# C.2 Measurement Equipment uncertainty values

The following uncertainty distribution and standard uncertainty (σ) values proposed by test vendors are adopted for the RF power measurement equipment, RF signal generator, and network analyzer to calculate the uncertainty budget.

Table C.2-1: Test equipment uncertainty values

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Instrument | Use case | Measurement Uncertainty type | Standard uncertainty σ (dB) | Probability distribution |
| f ≦ 3 GHz | 3 GHz < f ≦ 4.2 GHz |
| RF power measurement equipment (e.g. spectrum analyzer, power meter) | EIRP measurement stage | Total amplitude accuracy (with input levels down to ‑70 dBm) | 0.14 | 0.26 | Gaussian |
| RF signal generator | EIS measurement stage | Level error  | 0.46 | 0.46 | Gaussian |
| Network analyzer | Calibration stage | Accuracy of transmission measurements  | 0.13 | 0.20 | Gaussian |
| NOTE: Standard uncertainty values were derived from datasheets of mid-tier to high-end RF signal generators, spectrum analyzers, and VNAs. Standard uncertainty values of power measurement equipment were derived from datasheet of spectrum analyzers. |

The following uncertainty distribution and standard uncertainty (σ) value for the reference antenna derived as the maximum of companies' proposals are adopted in all test methods to calculate the uncertainty budget.

Table C.2-2: Reference antenna uncertainty value

|  |  |  |  |
| --- | --- | --- | --- |
| Instrument | Use case | Standard uncertainty σ (dB) | Probability distribution |
| f ≦ 3GHz | 3GHz < f ≦ 4.2 GHz |
| Reference antenna | Calibration stage | 0.29 | 0.25 | Rectangular |

# C.3 MU of TE derived from conducted specification

For a number of test cases the conducted measurement uncertainty used in TS 36.141 [22] is used to estimate the uncertainty contributing of the conducted part (filters, limiters, switches etc.) of the OTA test set up.

Where appropriate the mismatch uncertainty is removed from the conducted uncertainty so that it is not included twice in the calculation.

**C3-1 DL-RS MU derived from conducted spec**

Conducted MU (1.96σ) from TS 36.141 [22]: ±0.8 dB, f ≤ 3.0 GHz, ±1.1 dB, 3.0 GHz < f ≤ 4.2 GHz

Conducted contribution for OTA MU budget (1σ): ±0.41 dB, f ≤ 3.0 GHz, ±0.56 dB, 3.0 GHz < f ≤ 4.2 GHz

**C3-2 Total power dynamic range conducted uncertainty**

Conducted MU (1.96σ) from TS 36.141 [22]: ±0.4 dB

Conducted contribution for OTA MU budget (1σ): ±0.2 dB

**C3-3 Transmitter mandatory spurious emissions**

Conducted MU (1.96σ) from TS 36.141 [22]: 9 kHz < f ≤ 4 GHz: ±2.0 dB, 4 GHz < f ≤ 19 GHz: ±4.0 dB

Conducted contribution for OTA MU budget (1σ): 9 kHz < f ≤ 4 GHz: ±1.0 dB, 4 GHz < f ≤ 19 GHz: ±2.0 dB

**C3-4 Receiver spurious emissions**

Conducted MU (1.96σ) from TS 36.141 [22]: 30M Hz < f ≤ 4 GHz: ±2.0 dB, 4 GHz < f ≤ 19 GHz: ±4.0 dB

Conducted contribution for OTA MU budget (1σ): 9 kHz < f ≤ 4 GHz: ±1.0 dB, 4 GHz < f ≤ 19 GHz: ±2.0 dB

**C3-5 Additional (co-existence) spurious emissions**

Conducted MU (1.96σ) from TS 36.141 [22]: ±2.0 dB for > -60dBm, f ≤ 3.0GHz, ±2.5 dB, 3.0GHz < f ≤ 4.2GHz,

±3.0 dB, 4.2GHz < f ≤ 6.0GHz

Conducted contribution for OTA MU budget (1σ): ±1.0 dB for > -60dBm, f ≤ 3.0GHz, ±1.28 dB, 3.0GHz < f ≤ 4.2GHz,±1.53 dB, 4.2GHz < f ≤ 6.0GHz

**C3-6 TX IMD - conducted measurement uncertainty**

Conducted MU (1.96σ) from TS 36.141 [22]: ±1.0 dB

Conducted contribution for OTA MU budget (1σ): ±1.0 dB, f ≤ 3.0GHz, ±1.1 dB, 3.0 GHz < f ≤ 4.2 GHz, ± 1.2 dB, 4.2 GHz < f ≤ 6.0 GHz

**C3-5 Colocation blocking - conducted measurement uncertainty**

Conducted accuracy of the co-location blocking interferer is the same as the TX IMD interferer.

Table C.3-1: MU derived from the conducted specification

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| UID | Requirement | Use case | Standard uncertainty σ (dB) | Probability distribution |
| f ≦ 3GHz | 3GHz < f ≦ 4.2 GHz | **4.2GHz < f ≦ 6 GHz** | **6GHz < f ≦ 26 GHz** |  |
| C3-1 | DL-RS MU derived from conducted spec | Measurement stage | 0.41 | 0.56 | 0.56 | N/A | Gaussian |
| C3-2 | Total power dynamic range conducted uncertainty | Measurement stage | 0.2 | 0.2 | 0.2 | N/A | Gaussian |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
| C3-3 | Transmitter mandatory spurious emissions | Measurement stage | 1.0 | 2.0 | Gaussian |
| C3-4 | Receiver spurious emissions | Measurement stage | 1.0 | 2.0 | Gaussian |
| C3-5 | Additional (co-existence) spurious emissions | Measurement stage | 1.02 | 1.28 | 1.53 | N/A | Gaussian |
| C3-6 | TX IMD - conducted measurement uncertainty | Measurement stage | 1 | 1.1 | 1.2 | N/A | Gaussian |
| C3-7 | Colocation blocking - conducted measurement uncertainty | Measurement stage | 1 | 1.1 | 1.2 | N/A | Gaussian |