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Technical Specification

**Digital cellular telecommunications system (Phase 2+);
Universal Mobile Telecommunications System (UMTS);
LTE;
User Equipment (UE) / Mobile Station (MS)
Over The Air (OTA) antenna performance;
Conformance testing
(3GPP TS 34.114 version 8.0.0 Release 8)**

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Foreword

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Contents

Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

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1 Scope

The present document describes the test procedure for the radiated performances measurements of the 3G/2G user equipment/mobile stations (UE/MS) in active mode in both the up- and the downlink. The test procedure is based on the test method developed as a result of COST 273 Sub-Working Group (SWG) 2.2 members' contributions. Background work has also been made in the former COST259 project.

The measurement procedure explained in this document applies to UE/MS used under the "speech mode" conditions that correspond to predefined positions for voice application when the handset is held close to the user's head. This method is also applicable to free space measurements and for testing data applications.

The testing methodology applies to any single or multi-mode (GSM / UMTS) terminals.

The radio tests considered here are:

1. The measurement of the Total Radiated Power (TRP)
2. The measurement of the Total Radiated Sensitivity (TRS)

The test procedure described in this document measures the performance of the transmitter and the receiver, including the antenna and also the effects of the user.

The major parts of this test procedure are based on the 3-D pattern measurement method. It has been considered necessary to define some items and components in the test procedure in detail, such as test channels and phantom set-ups, in order to make the testing in different laboratories harmonized. The procedure is, however, not limited to some specific antenna chambers or positioners.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 25.914 Technical Specification 3rd Generation Partnership Project; Technical Specification Group Radio Access Networks; Measurements of Radio Performances for UMTS Terminals in Speech Mode

[2] 3GPP TS 25.101 Technical Specification 3rd Generation Partnership Project; Technical Specification Group Radio Access Networks; User Equipment (UE) radio transmission and reception (FDD)

[3] 3GPP 34.121, 3rd Generation Partnership Project; Technical Specification Group Terminals; Terminal conformance specification; Radio transmission and reception (FDD)

[4] ETSI TR 100 028, Paragraph D.1.3.6

[5] ETSI TR 102 273-1-2

[6] ETSI TR 102 273-1-1

[7] 3GPP TR 21.905 "Vocabulary for 3GPP Specifications"

[8] 3GPP TR 25.990 "Vocabulary"

[9] 3GPP TS 51.010-1 " Mobile Station (MS) conformance specification; Part 1: Conformance specification "

[10] 3GPP TS 34.108 "Common Test Environments for User Equipment (UE) Conformance Testing".

[11] 3GPP TS 34.109 "Terminal logical test interface; Special conformance testing functions

[12] 3GPP TS 25.144 "User Equipment (UE) and Mobile Station (MS) over the air performance requirements"

3 Definitions, symbols, abbreviations and equations

For the purposes of the present document, the terms and definitions given in 3GPP TR 21.905 [7], 3GPP TR 25.990 [8] and the following apply:

3.1 Symbols

For the purposes of the present document, the following symbols apply:

θ	Zenith angle in the spherical co-ordinate system
ϕ	Azimuth angle in the spherical co-ordinate system
Ω	Solid angle defined at the phase centre of the DUT
$G_{\psi}(\theta,\phi,f)$	Antenna gain pattern in the ψ-polarization as function of the spherical co-ordinates and the carrier frequency
F	Carrier frequency
P_{tr}	Transmitted power
$Q_{\psi}(\theta,\phi,f)$	Angular power distribution in the ψ-polarization as function of the spherical co-ordinates and the carrier frequency

dB	decibel
dBm	dB referenced to one milliwatt
m	meter
mm	millimeter
kbps	kilobit per second
ms	millisecond
MHz	megahertz

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

3G	3rd Generation
3GPP	3G Partnership Project
3-D	Three Dimensional
AAU	Aalborg University
APD	Angular Power Distribution
BS	Base Station
BT	Bluetooth
CN	Core Network
CPICH RSCP	Common Pilot Channel Received Signal Code Power
CRC	Cyclic Redundancy Check
DCH	Dedicated Channel
DL	Downlink
DPCH	Dedicated Physical Channel
DPDCH	Dedicated Physical Data Channel
DPCCH	Physical Control Channel
DTCH	Dedicated Traffic Channel
DUT	Device Under Test
ETSI	European Telecommunications Standards Institute
GPS	Global Positioning System
HUT	Helsinki University of Technology
MS	Mobile Station
NB	Node B
NSA	Normalised Site Attenuation
QoS	Quality of Service
QPSK	Quadrature Phase Shift Keying (modulation)
RAB	Radio Access Bearer
RB	Radio Bearer
RAN	Radio Access Network
RF	Radio Frequency
Rx	Receiver
SAM	Specific Anthropomorphic Mannequin
TFCI	Transport Format Combination Indicator
TRS	Total Radiated Sensitivity (also: Total Integrated Sensitivity)
Tx	Transmitter
TRP	Total Radiated Power
TRS	Total Radiated Sensitivity (see also: TRS)
XPD	Cross-Polar Discrimination of the antenna
XPR	Cross-Polarization ratio of the channel
UL	Uplink
UE	User Equipment
UMTS	Universal Mobile Telecommunications System

4 General

The present document describes test procedure for the radiated performances measurements of the 3G/2G user equipment/mobile stations (UE/MS) in active mode in both the up- and the downlink. The test procedure is based on 3GPP TR 25.914 [1].

4.1 Measurement frequencies

The radiation patterns of handset antennas can be expected to be frequency dependent, both in the size and, to smaller extent, in the shape of the pattern. TRP and TRS shall be measured in 3 channels in a frequency band, i.e. low, mid and high channels.

4.1.1 FDD frequency bands

UTRA/FDD is designed to operate in the following paired bands:

Table 4.1: UTRA FDD frequency bands

Operating Band	UL Frequencies UE transmit, Node B receive	DL frequencies UE receive, Node B transmit
I	1920 – 1980 MHz	2110 –2170 MHz
II	1850 –1910 MHz	1930 –1990 MHz
III	1710-1785 MHz	1805-1880 MHz
IV	1710-1755 MHz	2110-2155 MHz
V	824 – 849 MHz	869-894 MHz
VI	830-840 MHz	875-885 MHz
VII	2500-2570 MHz	2620-2690 MHz
VIII	880 – 915 MHz	925 – 960 MHz
IX X	1749.9-1784.9 MHz 1710 – 1770 MHz	1844.9-1879.9 MHz 2110 – 2170 MHz

Table 4.2: UTRA FDD Channels

Operating Band	UL Channels			DL Channels		
	Low	Mid	High	Low	Mid	High
I	9612	9750	9888	10562	10700	10838
II	9262	9400	9538	9662	9800	9938
III	937	1113	1288	1162	1338	1513
IV	1312	1450	1513	1537	1675	1738
V	4132	4175	4233	4357	4400	4458
VI	4162	4175	4188	4387	4400	4413
VII	2012	2175	2338	2237	2400	2563
VIII	2712	2788	2863	2937	3013	3088
IX	8762	8837	8912	9237	9312	9387
X	2888	3025	3162	3113	3250	3387

NOTE: Deployment in other frequency bands is not precluded.

4.1.2 GSM frequency bands

Table 4.3: GSM frequency bands

Operating Band	UL Frequencies MS transmit, BTS receive	DL frequencies MS receive, BTS transmit
GSM 850	824 – 849 MHz	869-894 MHz
P-GSM 900	890 – 915 MHz	935 – 960 MHz
E-GSM 900	880 – 915 MHz	925 – 960 MHz
DCS 1800	1710-1785 MHz	1805-1880 MHz
PCS 1900	1850 –1910 MHz	1930 –1990 MHz

Table 4.4: GSM Channels

Operating Band	Channels		
	Low	Mid	High
GSM 850	128	190	251
P-GSM 900	1	62	124
E-GSM 900	975	38	124
DCS 1800	512	699	885
PCS 1900	512	661	810

5 Transmitter Performance

5.1 General

This section specifies the test method and test requirements for the radiated power measurement.

5.1.1 DUT positioning

The measurements in this section are performed so that the DUT is placed against a SAM phantom. The characteristics of the SAM phantom are specified in Annex A.1. The DUT is attached to the SAM phantom in “cheek” position as defined in IEEE Std 1528. The DUT performance is measured on left and right side of the head.

5.1.2 Sampling grid

A 15°-sample grid in both azimuth and elevation can be considered sufficient for accurate measurements. Generally it can be said that since the radiating object has a limited size the gain pattern cannot change arbitrarily versus angle, and therefore only a limited number of samples are required to represent the gain pattern to a given accuracy.

Alternatively, different sampling patterns may be used, if they are able to ensure same or greater accuracy. The TRP can be calculated by interpolating the values to points on the regular grid. If an alternative sampling pattern is used number of measurement points should be greater than in the regular sampling grid.

5.2 Total Radiated Power (TRP) for FDD UE

5.2.1 Definition and applicability

The Total Radiated Power (TRP) is a measure of how much power the DUT actually radiates. The TRP is defined as the integral of the power transmitted in different directions over the entire radiation sphere:

$$TRP = \frac{1}{4\pi} \oint \left(EIRP_{\theta}(\Omega; f) + EIRP_{\varphi}(\Omega; f) \right) d\Omega$$

Where Ω is the solid angle describing the direction, f is frequency. θ and φ are the orthogonal polarizations. $EIRP_{\theta}$ and $EIRP_{\varphi}$ are the actually transmitted power-levels in corresponding polarizations.

Thus

$$TRP \approx \frac{\pi}{2NM} \sum_{n=0}^{N-1} \sum_{m=0}^{M-1} \left[EIRP_{\theta}(\theta_n, \varphi_m; f) + EIRP_{\varphi}(\theta_n, \varphi_m; f) \right] \sin(\theta_n)$$

In these formulas N and M are the number of sampling intervals for theta and phi. θ_n and φ_m are the measurement angles. The sampling intervals are discussed further in Section 5.1.2.

The requirements and this test apply to all types of UTRA for the FDD UE for Release 7 and later releases.

5.2.2 Minimum Requirements

The average TRP of low, mid and high channel in beside head position shall be higher than minimum performance requirements for roaming bands shown in Table 5.2.2.1. The averaging shall be done in linear scale for the TRP results of both right and left side of the phantom head.

$$TRP_{average} = 10\log\left[\frac{10^{P_{left\_low}/10} + 10^{P_{left\_mid}/10} + 10^{P_{left\_high}/10} + 10^{P_{right\_low}/10} + 10^{P_{right\_mid}/10} + 10^{P_{right\_high}/10}}{6} \right]$$

In addition the minimum TRP of each measured channel in beside head position shall be higher than minimum performance requirements shown in the columns “Min”.

$$TRP_{\min} = \min\left[P_{left\_low}, P_{left\_mid}, P_{left\_high}, P_{right\_low}, P_{right\_mid}, P_{right\_high} \right]$$

Table 5.2.1 TRP minimum performance requirement for FDD roaming bands in the speech position and the primary mechanical mode

Operating band	Power Class 1	Power Class 2	Power Class 3		Power Class 3bis		Power Class 4	
	Power (dBm)	Power (dBm)	Power (dBm)		Power (dBm)		Power (dBm)	
			Average	Min	Average	Min	Average	Min
I	-	-	+15	+13	-	-	+13	+11
II	-	-	+15	+13	-	-	+13	+11
III	-	-	+15	+13	-	-	+13	+11
IV	-	-	+15	+13	-	-	+13	+11
V	-	-	TBD	TBD	-	-	TBD	TBD
VI	-	-	TBD	TBD	-	-	TBD	TBD
VII	-	-	+15	+13	+15	+13	+13	+11
VIII	-	-	TBD	TBD	TBD	TBD	TBD	TBD
IX	-	-	+15	+13	-	-	+13	+11
NOTE: Applicable for dual-mode GSM/UMTS.								

The normative reference for this clause is TS25.144 section 6.1.1.1.

5.2.3 Test purpose

The purpose of this test is to verify that $TRP_{average}$ and $TRP_{\min}$ of the UE is not below specified values. A lower $TRP_{average}$ and $TRP_{\min}$ decrease the coverage area.

5.2.4 Method of test

5.2.4.1 Initial conditions

The output power is a measure of the maximum power the UE can transmit in a bandwidth of at least (1+ α) times the chip rate of the radio access mode, for more information see 3GPP TS 34.121 chapter 5.2. The period of measurement shall be at least one timeslot. Also care should be taken that the noise floor of the measurement receiver is not disturbing the power measurement.

Test environment: normal; see TS34.121-1 [3] clause G.2.1.

Frequencies to be tested: low range, mid range, high range; see TS34.121-1 [3] clause G.2.4.

1) Set the SS downlink physical channels according to settings in Table 5.2.2. Set the DPCH power such that there will not be transmission gaps due to too low signal strength thorughout the measurement.
2) Power on the UE.
3) A call is set up according to the Generic call setup procedure. The power control algorithm shall be set to Power Control Algorithm 2. Compressed mode shall be set to OFF.
4) Enter the UE into loopback test mode 2 and start the loopback test.

See TS 34.108 [10] and TS 34.109 [11] for details regarding generic call setup procedure and loopback test.

Table 5.2.2: Downlink Physical Channels transmitted during a connection

Physical Channel	Power
CPICH	CPICH_Ec / DPCH_Ec = 7 dB
P-CCPCH	P-CCPCH_Ec / DPCH_Ec = 5 dB
SCH	SCH_Ec / DPCH_Ec = 5 dB
PICH	PICH_Ec / DPCH_Ec = 2 dB
DPCH	Test dependent power

5.2.4.2 Procedure

1) Send continuously Up power control commands to the UE.
2) As the UE reaches maximum power, start sending PN15 data pattern.
3) Position the UE against the SAM phantom
4) Measure the $EIRP_\theta$ and $EIRP_\varphi$ with a sample step of 15° in theta (θ) and phi (ϕ) directions using a test system having characteristics as described in Annex A.
5) Calculate TRP using equations from chapter 5.2.1

NOTE 1: The measurement procedure is based on the measurement of the spherical radiation pattern of the DUT. The power radiated by the DUT is sampled in far field in a group of points located on a spherical surface enclosing the DUT. The EIRP samples are taken using a constant sample step of 15° both in theta (θ) and phi (ϕ) directions. In some cases a different sampling grid may be used to speed up the measurements (See Section 5.1.2). All the EIRP samples are taken with two orthogonal polarizations, θ - and φ - polarisations.

NOTE 2: The noise floor of the measurement receiver shall not disturb the power measurement.

NOTE 3: Non Standard settings: To speed up sensitivity measurements, power measurements may be done with non standard modulation. However to obtain TRP result the measured EIRP figures shall be normalized by

$$\Delta\overline{EIRP} = \frac{1}{n}\sum_{i=1}^{n}\left(EIRPstd_i - EIRPnstd_i\right)$$

where $EIRPstd_i$ is power measurement done with standard setting. $EIRPnstd_i$ is power measurement done with non standard modulation. n is amount of reference measurement points.

To ensure accuracy of TRP, the amount of reference points measured should be at least 4. It is recommended to spread the reference measurements equally during the measurement time.

5.2.5 Test requirements

The average TRP of low, mid and high channel in beside head position shall be higher than test performance requirements for roaming bands shown in Table 5.2.3. The averaging shall be done in linear scale for the TRP results of both right and left side of the phantom head.

$$TRP_{average} = 10\log\left[\frac{10^{P_{left\_low}/10} + 10^{P_{left\_mid}/10} + 10^{P_{left\_high}/10} + 10^{P_{right\_low}/10} + 10^{P_{right\_mid}/10} + 10^{P_{right\_high}/10}}{6}\right]$$

In addition the minimum TRP of each measured channel in beside head position shall be higher than minimum performance requirements shown in the columns "Min".

$$TRP_{\min} = \min\left[P_{left\_low}, P_{left\_mid}, P_{left\_high}, P_{right\_low}, P_{right\_mid}, P_{right\_high}\right]$$

Table 5.2.3 TRP test requirement for FDD roaming bands in the speech position and the primary mechanical mode

Operating band	Power Class 1	Power Class 2	Power Class 3		Power Class 3bis		Power Class 4	
	Power (dBm)	Power (dBm)	Power (dBm)		Power (dBm)		Power (dBm)	
			Average	Min	Average	Min	Average	Min
I	-	-	+14.3	+12.0	-	-	+12.3	+10.0
II	-	-	+14.3	+12.0	-	-	+12.3	+10.0
III	-	-	+14.3	+12.0	-	-	+12.3	+10.0
IV	-	-	+14.3	+12.0	-	-	+12.3	+10.0
V	-	-	TBD	TBD	-	-	TBD	TBD
VI	-	-	TBD	TBD	-	-	TBD	TBD
VII	-	-	+14.3	+12.0	+14.3	+12.0	+12.3	+10.0
VIII	-	-	TBD	TBD	TBD	TBD	TBD	TBD
IX	-	-	+14.3	+12.0	-	-	+12.3	+10.0
NOTE: Applicable for dual-mode GSM/UMTS.								

NOTE: If the above Test Requirement differs from the Minimum Requirement then the Test Tolerance applied for this test is non-zero. The Test Tolerance for this test is defined and the explanation of how the Minimum Requirement has been relaxed by the Test Tolerance is given in Annex D.

5.3 Total Radiated Power (TRP) for GSM MS

5.3.1 Definition and applicability

The Total Radiated Power (TRP) is a measure of how much power the DUT actually radiates. The TRP is defined as the integral of the power transmitted in different directions over the entire radiation sphere:

$$TRP = \frac{1}{4\pi}\oint\left(EIRP_\theta(\Omega; f) + EIRP_\varphi(\Omega; f)\right)d\Omega$$

Where Ω is the solid angle describing the direction, f is frequency. θ and φ are the orthogonal polarizations. $EIRP_\theta$ and $EIRP_\varphi$ are the actually transmitted power-levels in corresponding polarizations.

Thus

$$TRP \approx \frac{\pi}{2NM} \sum_{n=0}^{N-1} \sum_{m=0}^{M-1} \left[EIRP_\theta(\theta_n, \varphi_m; f) + EIRP_\varphi(\theta_n, \varphi_m; f) \right] \sin(\theta_n)$$

In these formulas N and M are the number of sampling intervals for theta and phi. θ_n and φ_m are the measurement angles. The sampling intervals are discussed further in Section 5.1.2.

The requirements and this test apply to all types of MS that support GSM for Release 7 and later releases.

5.3.2 Minimum Requirements

The minimum requirements are TBD.

Table 5.3.1 TRP minimum requirement for GSM roaming bands in the speech position and the primary mechanical mode

TBD

The normative reference for this clause is TS25.144 section 6.1.1.2.

5.3.3 Test purpose

The purpose of this test is to verify that $TRP_{average}$ and $TRP_{\min}$ of the UE is not below specified values. A lower $TRP_{average}$ and $TRP_{\min}$ decrease the coverage area.

5.3.4 Method of test

5.3.4.1 Initial conditions

A call is set up by the SS according to the generic call set up procedure on a channel with ARFCN in the Mid ARFCN range, power control level set to Max power. MS TXPWR_MAX_CCH is set to the maximum value supported by the Power Class of the Mobile under test.

The SS sends Standard Test Signal C1; see TS51.010-1 [9] Annex A5.2.

The downlink power is set such that there will not be transmission gaps due to too low signal strength throughout the measurement

Test environment: normal condition; see TS51.010-1 [9] Annex A1.2.2.

5.3.4.2 Procedure

1) Position the MS against the SAM phantom
2) Measure the $EIRP_\theta$ and $EIRP_\varphi$ with a sample step of 15° in theta (θ) and phi (ϕ) directions using a test system having characteristics as described in Annex A.
3) Calculate TRP using equations from chapter 5.3.1
4) Test steps 1 to 3 is repeated for ARFCN in the low and high range

NOTE 1: Measurement of normal burst transmitter output power. The SS takes power measurement samples evenly distributed over the duration of one burst with a sampling rate of at least 2/T, where T is the bit duration. The samples are identified in time with respect to the modulation on the burst. The SS identifies the centre of the useful 147 transmitted bits, i.e. the transition from bit 13 to bit 14 of the midamble, as the timing reference

NOTE 2: The measurement procedure is based on the measurement of the spherical radiation pattern of the DUT. The power radiated by the DUT is sampled in far field in a group of points located on a closed surface enclosing the DUT. The EIRP samples are taken using a constant sample step of 15° both in theta (θ) and phi (ϕ) directions. In some cases a different sampling grid can be used to speed up the measurements (See Section 5.1.2). All the EIRP samples are taken with two orthogonal polarizations, θ - and φ - polarisations.

NOTE 3: The noise floor of the measurement receiver shall not disturb the power measurement.

NOTE 4: Non Standard settings: To speed up sensitivity measurements, power measurements can be done with non standard modulation. However to obtain TRP result the measured EIRP figures shall be normalized by

$$\Delta\overline{EIRP} = \frac{1}{n}\sum_{i=1}^{n}\left(EIRPstd_i - EIRPnstd_i\right)$$

where $EIRPstd_i$ is power measurement done with standard setting. $EIRPnstd_i$ is power measurement done with non standard modulation. n is amount of reference measurement points.

To ensure accuracy of TRP, the amount of reference points measured should be at least 4. It is recommended to spread the reference measurements equally during the measurement time.

5.3.5 Test requirements

TBD

The average TRP of low, mid and high channel in beside head position shall be higher than test performance requirements for roaming bands shown in Table 5.2.3. The averaging shall be done in linear scale for the TRP results of both right and left side of the phantom head.

$$TRP_{average} = 10\log\left[\frac{10^{P_{left\_low}/10} + 10^{P_{left\_mid}/10} + 10^{P_{left\_high}/10} + 10^{P_{right\_low}/10} + 10^{P_{right\_mid}/10} + 10^{P_{right\_high}/10}}{6}\right]$$

In addition the minimum TRP of each measured channel in beside head position shall be higher than minimum performance requirements shown in the columns "Min".

$$TRP_{\min} = \min\left\lfloor P_{left\_low}, P_{left\_mid}, P_{left\_high}, P_{right\_low}, P_{right\_mid}, P_{right\_high}\right\rfloor$$

Table 5.2.3 TRP test requirement for GSM roaming bands in the speech position and the primary mechanical mode

TBD

NOTE: If the above Test Requirement differs from the Minimum Requirement then the Test Tolerance applied for this test is non-zero. The Test Tolerance for this test is defined and the explanation of how the Minimum Requirement has been relaxed by the Test Tolerance is given in Annex D.

6 Receiver Performance

6.1 General

This section describes the specifics of the radiated sensitivity measurement procedure.

The procedure for the measurement of the UE receiver performance is in principle equivalent to the transmitter performance measurement described in Annex A. The basic difference is that now the absolute sensitivity value at a predefined BER level is the parameter of interest in each measurement point. Note that the receiver and transmitter performances measurements may be done in parallel, at each position.

6.1.1 DUT Positioning

The measurements are performed so that the DUT is placed against a SAM phantom. The characteristics of the SAM phantom are specified in Annex A.1. The DUT is attached to the SAM phantom in "cheek" position as defined in IEEE Std 1528. The DUT performance is measured on both left and right side of the head.

6.1.2 Sampling grid

A 15°-sample grid in both azimuth and elevation can be considered sufficient for accurate measurements. Generally it can be said that since the radiating object has a limited size the gain pattern cannot change arbitrarily versus angle, and therefore only a limited number of samples are required to represent the gain pattern to a given accuracy consequently. A 30°-sample grid may be used taking also into account that there is a trade-off between the accuracy of the approximated TRS values and the total measurement time required to obtain a complete 3-D radiation pattern of the antenna.

Alternatively, different sampling patterns may be used, if they are able to ensure same or greater level of accuracy. The TRS can be calculated by interpolating the values to points on the regular grid. If an alternative sampling pattern is used number of measurement points should be greater than in the regular sampling grid.

6.2 Total Radiated Sensitivity (TRS) for FDD UE

6.2.1 Definition and applicability

The Total Radiated Sensitivity is defined as:

$$TRS = \frac{4\pi}{\oint \left[\frac{1}{EIS_{\theta}(\Omega; f)} + \frac{1}{EIS_{\varphi}(\Omega; f)} \right] d\Omega} \qquad (6.3)$$

Where the effective isotropic sensitivity (*EIS*) is defined as the power available at the antenna output such as the sensitivity threshold is achieved for each polarization. Ω is the solid angle describing the direction, f is frequency. θ and φ are the orthogonal polarizations.

$$TRS \approx \frac{2NM}{\pi \sum_{n=0}^{N-1} \sum_{m=0}^{M-1} \left[\frac{1}{EIS_{\theta}(\theta_n, \varphi_m; f)} + \frac{1}{EIS_{\varphi}(\theta_n, \varphi_m; f)} \right] \sin(\theta_n)} \qquad (6.4)$$

In these formulas N and M are the number of sampling intervals for theta and phi. θ_n and φ_m are the measurement angles. The sampling intervals are discussed further in Section 6.1.2.

The requirements and this test apply to all types of UTRA for the FDD UE for Release 7 and later releases.

6.2.2 Minimum requirements

The average TRS of low, mid and high channel in beside head position for 1% BER with 12.2kbps DL reference channel as defined in Annex C.3 of TS25.101 [2] shall be lower than minimum performance requirements for roaming bands shown in Table 6.2.2.1. The averaging shall be done in linear scale for the TRS results of both right and left side of the phantom head.

$$TRS_{average} = 10\log\left[6 \Big/ \left(\frac{1}{10^{P_{left\_low}/10}} + \frac{1}{10^{P_{left\_mid}/10}} + \frac{1}{10^{P_{left\_high}/10}} + \frac{1}{10^{P_{right\_low}/10}} + \frac{1}{10^{P_{right\_mid}/10}} + \frac{1}{10^{P_{right\_high}/10}}\right)\right]$$

In addition the minimum TRS of each measured channel in beside head position shall be better than minimum performance requirements for roaming bands shown in the columns "Min".

$$TRS_{\min} = 10\log\left[\max\left(10^{P_{left\_low}/10}, 10^{P_{left\_mid}/10}, 10^{P_{left\_high}/10}, 10^{P_{right\_low}/10}, 10^{P_{right\_mid}/10}, 10^{P_{right\_high}/10}\right)\right]$$

Table 6.2.1: TRS minimum requirements for FDD roaming bands in the speech position for the primary mechanical mode

Operating Band	Unit	<REFÎ$_{or}$>	
		Average	Max
I	dBm/3.84 MHz	-101	-98
II	dBm/3.84 MHz	-99	-96
III	dBm/3.84 MHz	-98	-95
IV	dBm/3.84 MHz	-101	-98
V	dBm/3.84 MHz	TBD	TBD
VI	dBm/3.84 MHz	TBD	TBD
VII	dBm/3.84 MHz	-99	-96
VIII	dBm/3.84 MHz	TBD	TBD
IX	dBm/3.84 MHz	-100	-97
NOTE 1 For Power Class 3, 3bis and 4 this shall be achieved at the maximum output power. NOTE 2 For the UE which supports both Band III and Band IX operating frequencies, the reference level of TDB dBm TRS <REFÎ$_{or}$> [average and min] shall apply for Band IX. NOTE 3: Applicable for dual-mode GSM/UMTS.			

The normative reference for this clause is TS25.144 section 7.2.1.

6.2.3 Test Purpose

The purpose of this test is to ensure that $TRS_{Average}$ and TRS_{Min} of the UE is above specified limit. The lack of the reception sensitivity decreases the coverage area at the far side from Node B.

6.2.4 Method of test

6.2.4.1 Initial conditions

Test environment: normal; see TS34.121-1 [3] clause G.2.1.

1) Set the SS downlink physical channels according to settings in Table 6.2.2.

2) Power on the UE.

3) A call is set up according to the Generic call setup procedure. The power control algorithm shall be set to Power Control Algorithm 2. Compressed mode shall be set to OFF.

4) Enter the UE into loopback test mode 2 and start the loopback test.

See TS 34.108 [10] and TS 34.109 [11] for details regarding generic call setup procedure and loopback test.

Table 6.2.2: Downlink Physical Channels transmitted during a connection

Physical Channel	Power	
CPICH	CPICH_Ec / DPCH_Ec	= 7 dB
P-CCPCH	P-CCPCH_Ec/ DPCH_Ec	= 5 dB
SCH	SCH_Ec / DPCH_Ec	= 5 dB
PICH	PICH_Ec / DPCH_Ec	= 2 dB
DPCH	Test dependent power	

6.2.4.2 Test procedure

1) Send continuously Up power control commands to the UE.

2) As the UE reaches maximum power, start sending PN15 data pattern.

3) Position the UE against the SAM phantom

4) Measure EIS from one measurement point. EIS is the power transmitted from one specific direction to the UE causing BER value of 1% ± 0.2% using 20000 or more bits, see Annex E.19.1.

   NOTE: To meet BER value target DL power level can be changed using user's freely selectable algorithm.

5) Measure the EIS for every direction of selected sampling gird using two orthogonal polarizations to obtain TRS.

6) Calculate TRS using equations from chapter 6.2.1

NOTE:

To speed up sensitivity measurements non standard setting (i.e. data speed, PCL, BER target) can be used in the measurements. However to obtain TRS result the measured EIS figures shall be normalized by

$$\Delta\overline{EIS} = \frac{1}{n}\sum_{i=1}^{n}\left(EISstd_i - EISnstd_i\right)$$

Where $EISstd_i$ is sensitivity measurement done with standard setting. $EISnstd_i$ is sensitivity measurement done with non standard settings. n is amount of reference measurement points.

To ensure accuracy of TRS, the amount of reference points measured should be at least 4. It is recommended to spread the reference measurements equally during the measurement time.

The measurement procedure is based on the measurement of the spherical sensitivity pattern of the DUT. The sensitivity values of the DUT at a predefined BER level are sampled in far field in a group of points located on a spherical surface enclosing the DUT. The EIS samples are taken using a constant sample step of 30° both in theta (θ) and phi (ϕ) directions. All the EIS samples are taken with two orthogonal polarizations, θ - and φ -polarisations. The Total Radiated Sensitivity is calculated from the measured data by equation in chapter 6.2.1.

6.2.5 Test requirements

The average TRS of low, mid and high channel in beside head position for 1% BER with 12.2kbps DL reference channel as defined in Annex C.3 of [2] shall be lower than test requirements for roaming bands shown in Table 6.2.3. The averaging shall be done in linear scale for the TRS results of both right and left side of the phantom head.

$$TRS_{average} = 10\log\left[6\Big/\left(\frac{1}{10^{P_{left\_low}/10}} + \frac{1}{10^{P_{left\_mid}/10}} + \frac{1}{10^{P_{left\_high}/10}} + \frac{1}{10^{P_{right\_low}/10}} + \frac{1}{10^{P_{right\_mid}/10}} + \frac{1}{10^{P_{right\_high}/10}}\right)\right]$$

In addition the minimum TRS of each measured channel in beside head position shall be better than minimum performance requirements for roaming bands shown in the columns "Min".

$$TRS_{\min} = 10\log\left[\max\left(10^{P_{left\_low}/10}, 10^{P_{left\_mid}/10}, 10^{P_{left\_high}/10}, 10^{P_{right\_low}/10}, 10^{P_{right\_mid}/10}, 10^{P_{right\_high}/10}\right)\right]$$

Table 6.2.3: TRS test requirements for FDD roaming bands in the speech position for the primary mechanical mode

Operating Band	Unit	<REF$\hat{I}_{or}$>	
		Average	Max
I	dBm/3.84 MHz	-100.1	-96.8
II	dBm/3.84 MHz	-98.1	-94.8
III	dBm/3.84 MHz	-97.1	-93.8
IV	dBm/3.84 MHz	-100.1	-96.8
V	dBm/3.84 MHz	TBD	TBD
VI	dBm/3.84 MHz	TBD	TBD
VII	dBm/3.84 MHz	-98.1	-94.8
VIII	dBm/3.84 MHz	TBD	TBD
IX	dBm/3.84 MHz	-99.1	-95.8
NOTE 1 For Power Class 3, 3bis and 4 this shall be achieved at the maximum output power. NOTE 2 For the UE which supports both Band III and Band IX operating frequencies, the reference level of TDB dBm TRS <REF$\hat{I}_{or}$> [average and min] shall apply for Band IX. NOTE3: Applicable for dual-mode GSM/UMTS.			

NOTE: If the above Test Requirement differs from the Minimum Requirement then the Test Tolerance applied for this test is non-zero. The Test Tolerance for this test is defined and the explanation of how the Minimum Requirement has been relaxed by the Test Tolerance is given in Annex D.

6.3 Total Radiated Sensitivity (TRS) for GSM MS

6.3.1 Definition and applicability

The Total Radiated Sensitivity is defined as:

$$TRS = \frac{4\pi}{\oint \left[\frac{1}{EIS_\theta(\Omega; f)} + \frac{1}{EIS_\varphi(\Omega; f)} \right] d\Omega}$$

Where the effective isotropic sensitivity (*EIS*) is defined as the power available at the antenna output such as the sensitivity threshold is achieved for each polarization. Ω is the solid angle describing the direction, f is frequency. θ and φ are the orthogonal polarizations.

$$TRS \approx \frac{2NM}{\pi \sum_{n=0}^{N-1} \sum_{m=0}^{M-1} \left[\frac{1}{EIS_\theta(\theta_n, \varphi_m; f)} + \frac{1}{EIS_\varphi(\theta_n, \varphi_m; f)} \right] \sin(\theta_n)}$$

In these formulas N and M are the number of sampling intervals for theta and phi. θ_n and φ_m are the measurement angles. The sampling intervals are discussed further in Section 6.1.3.

The requirements and this test apply to all types of MS that support GSM for Release 7 and later releases.

6.3.2 Minimum requirements

TBD

Table 6.3.1: TRS minimum requirements for GSM roaming bands in the speech position for the primary mechanical mode

The normative reference for this clause is TS25.144 section 7.2.2.

6.3.3 Test Purpose

The purpose of this test is to ensure that $TRS_{Average}$ and TRS_{Min} of the UE is above specified limit. The lack of the reception sensitivity decreases the coverage area at the far side from Node B.

6.3.4 Method of test

6.3.4.1 Initial conditions

Test environment: normal condition; see TS51.010-1 [9] Annex A1.2.2.

A call is set up according to the generic call set up procedure on a TCH/FS with an ARFCN in the Mid ARFCN range, power control level set to maximum power.

The SS transmits Standard Test Signal C1 on the traffic channel, see TS51.010-1 [9] Annex A5.2.

The SS commands the MS to create traffic channel loop back signalling erased frames, see TS44.014 [34] clause 5.1.2.

6.3.4.2 Test procedure

1) Position the UE against the SAM phantom

2) The SS compares the data of the signal that it sends to the MS with the signal which is looped back from the receiver after demodulation and decoding, and checks the frame erasure indication.

3) The SS determines the number of residual bit error events for the bits of class II, by examining sequences of at least the minimum number of samples of consecutive bits of class II. Bits are taken only from those frames not signalled as erased.

4) Measure EIS from one measurement point. EIS is the power transmitted from one specific direction to the UE causing RBERII value of 2.44% ± 0.2%, see Annex E.19.2

   NOTE: To meet BER value target DL power level can be changed using user's freely selectable algorithm.

5) Measure the EIS for every direction of selected sampling gird using two orthogonal polarizations to obtain TRS.

6) Calculate TRS using equations from chapter 6.2.1

7) Steps 1) to 6) are repeated for TCH/FS with ARFCNs in the Low ARFCN range and the High ARFCN range.

NOTE 2: Non standard settings:

To speed up sensitivity measurements non standard setting (i.e. data speed, PCL, BER target) can be used in the measurements. However to obtain TRS result the measured EIS figures shall be normalized by

$$\Delta\overline{EIS} = \frac{1}{n}\sum_{i=1}^{n}\left(EISstd_i - EISnstd_i\right)$$

Where $EISstd_i$ is sensitivity measurement done with standard setting. $EISnstd_i$ is sensitivity measurement done with non standard settings. n is amount of reference measurement points.

To ensure accuracy of TRS, the amount of reference points measured should be at least 4. It is recommended to spread the reference measurements equally during the measurement time.

The measurement procedure is based on the measurement of the spherical sensitivity pattern of the DUT. The sensitivity values of the DUT at a predefined BER level are sampled in far field in a group of points located on a closed surface enclosing the DUT. The EIS samples are taken using a constant sample step of 30° both in theta (θ) and phi (ϕ) directions. All the EIS samples are taken with two orthogonal polarizations, θ- and φ-polarisations. The Total Radiated Sensitivity is calculated from the measured data.

6.3.5 Test requirements

TBD

Table 6.3.2: TRS test requirements for GSM roaming bands in the speech position for the primary mechanical mode

NOTE: If the above Test Requirement differs from the Minimum Requirement then the Test Tolerance applied for this test is non-zero. The Test Tolerance for this test is defined and the explanation of how the Minimum Requirement has been relaxed by the Test Tolerance is given in Annex D.

Annex A (normative): Test system characterization

The main objective of this section is to define basic parameters of simulated user (phantom) and anechoic chamber.

A.1 Phantom specifications

A.1.1 Head Phantom

The Specific Anthropomorphic Mannequin (SAM) is used for radiated performance measurements without the shell thickness requirement in non-critical areas of SAM. The dielectric properties of used material shall be maintained within ±25% of target properties listed in table A.1. For other frequencies within the frequency range, linear interpolation method shall be used to obtain target dielectric properties.

Table A.1

Frequency (MHz)	Relative Dielectric Constant (ε_r)	Conductivity (σ) (S/m)
450	43,5	0,87
835	41,5	0,90
900	41,5	0,97
1450	40,5	1,20
1800	40,0	1,40
1900	40,0	1,40
1950	40,0	1,40
2000	40,0	1,40
2450	39,2	1,80
3000	38,5	2,40

Example of recipe for tissue simulating liquid is presented in annex F .

A.2 Anechoic chamber constraints

Testing shall be performed in an anechoic chamber fulfilling following requirements.

A.2.1 Positioner

The chamber should be equipped with a positioner making possible to perform full 3-D measurements for both Tx and Rx radiated performance. The centre of the rotation should be the phase centre of the antenna, in the case it is not possible to evaluate an estimation of the antenna centre should be used. Alternatively centre of the line between right and left ear reference points can be used as a centre of rotation. Theta (θ) and phi (ϕ) angles are specified in figure A.1.

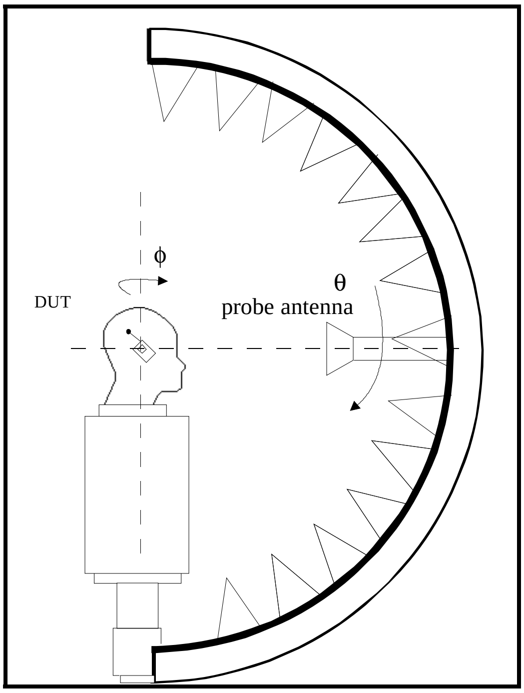

Figure A.1 The coordinate system used in the measurements

A.2.2 Measurement Antenna

The measurement antenna should be able to measure two orthogonal polarizations (typically linear theta (θ) and phi (ϕ) polarizations). Note that single-polarized linear measurement antenna can also be used by turning it 90 ° for every measurement point.

For far-field measurements, the distance *r* between the DUT and the measurement antenna should be

$$r > \max\left(\frac{2D^2}{\lambda}, 3D, 3\lambda\right)$$

where λ is the wavelength of the measurement frequency and *D* the maximum extension of the radiating structure. Then the phase- and amplitude uncertainty limits and the reactive near field limit are not exceeded. The influence of measurement distance is discussed in Appendix A - Estimation of Measurement Uncertainty

A.2.3 Quiet Zone

Reflectivity of the quiet zone shall be measured for frequencies used with method described in Appendix F. Measured reflectivity level is used in uncertainty calculations.

A.2.4 Shielding effectiveness of the chamber

The recommended level of the shielding effectiveness is -100 dB from 800 MHz to 4 GHz. See Appendix G for more details on shielding effectiveness validation.

Annex B (normative): Calibration

The relative power values of the measurement points will be transformed to absolute radiated power values (in dBm) by performing a calibration measurement. The calibration measurement is done by using a reference antenna with known efficiency or gain values. In the calibration measurement the reference antenna is measured in the same place as the DUT, and the attenuation of the complete transmission path (L_{total}) from the DUT to the measurement receiver/NB/BS simulator is calibrated out.

The gain and/or radiation efficiency of the reference antenna shall be known at the frequency bands in which the calibrations are performed. Recommended calibration antennas are monopole antennas or sleeve dipoles tuned for the each frequency band of interest. Alternatively, other methods may be used if they ensure an equal or greater level of accuracy. A network analyzer is recommended to be used to perform the calibration measurement. Also other devices can be used to measure the attenuation. The calibration is performed individually for the both orthogonal polarizations, all the transmission paths and all frequencies used in the testing.

The principle is based on the use of calibration/substitution antennas presenting an efficiency known with a sufficient accuracy in the measurement bandwidths. Such a calibration antenna is placed on the DUT positioner at the exact MS location used for TRP and TRS measurement. It is possible to use a mechanical piece to place the calibration antenna on the positioner. This mechanical piece should not present any electromagnetic properties, which could influence the frequency response and the radiation properties of the calibration antenna. Find hereafter, an illustration of the substitution configuration in Figure B.1.

B.1 Calibration Procedure

L_{total} is the attenuation between P and B, see figure B.1.

$$L_{total} = \left(L_{AB} - L_{AC} + E_{cal}\right)$$

Where L_{AC} is cable loss from A to C. The cable AC connecting the substitution antenna should be such that its influence upon radiation pattern measurements is minimal. L_{AB} is the attenuation between points A and B. In TRP and TRS measurements point B is connected to the calibrated input/output port of measurement receiver.

E_{cal} is the efficiency or gain of the calibration antenna at the frequency of interest.

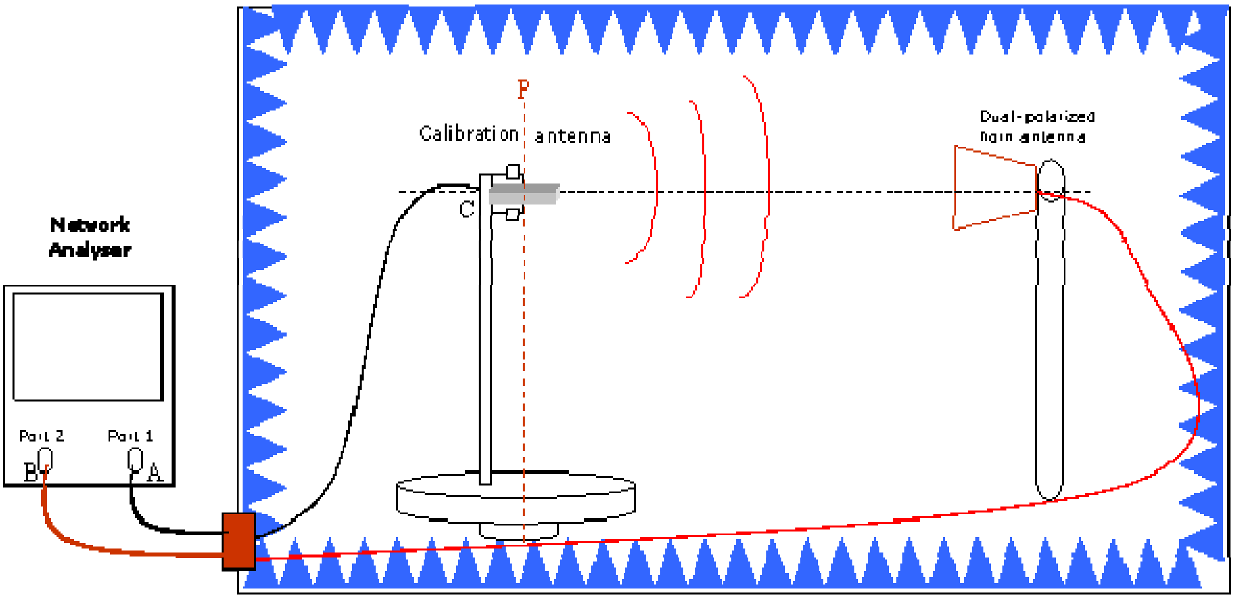

Figure B.1 Calibration/substitution procedures using a vector network analyzer.

If the calibration is based on known efficiency of the calibration antenna, a full spherical scanning is performed to determine L_{AB} . Unless the otherwise specified in the calibration antenna documentation, TRP sampling grid and equation for TRP in section 5.2.1 should be used.

This procedure has to be done at each frequency of interest.

To achieve measurements with an uncertainty as low as possible, it is absolutely necessary to exactly keep the same P to B configuration (cables, dual-polarized antenna and cables positions, etc).

Calibration shall be performed yearly or if any equipment in the measurement system is changed.

Annex C (normative): Measurement Test Report

Operational mode, model and serial number of the DUT shall be documented to the test report. Whether the DUT is positioned against the phantom head with a specific device holder or by other means should be described in the test report. A photograph of the test setup is recommended.

Test equipment list should be included in the test report.

$\overline{TRP}$ [dBm] and $\overline{TRS}$ [dBm] values shall be reported for each tested channel and for each side of the head and a frequency band average shall be calculated by using following equations.

$$\overline{TRP} = 10\log\left[\frac{10^{TRP_{low\_right}/10} + 10^{TRP_{mid\_right}/10} + 10^{TRP_{high\_right}/10} + 10^{TRP_{low\_left}/10} + 10^{TRP_{mid\_left}/10} + 10^{TRP_{high\_left}/10}}{6}\right]$$

$$\overline{TRS} = 10\log\left[\frac{6}{10^{-TRS_{low\_right}/10} + 10^{-TRS_{mid\_righ}/10} + 10^{-TRS_{high\_righ}/10} + 10^{-TRS_{low\_left}/10} + 10^{-TRS_{mid\_left}/10} + 10^{-TRS_{high\_left}/10}}\right]$$

The expanded measurement uncertainty, assessed according Annex E, shall be documented next to the corresponding TRP and TRS results. The uncertainty calculation shall be made available.

Annex D (normative): Maximum uncertainty of Test System and Test Tolerances

D.1 Maximum uncertainty of Test System

The maximum acceptable uncertainty of the Test System is specified below for each test. The Test System shall enable test to be measured with an uncertainty not exceeding the specified values. All uncertainties are absolute values and are valid for a confidence level of 95 %.

The estimation of measurement uncertainty is presented in more detail in Annex E.

Table D.1: Test system uncertainties for OTA tests

Clause	Maximum Test System Uncertainty	Derivation of Test System Uncertainty
5.2 TRP for FDD UE	±1.9 dB for single measurement	Detailed derivations of uncertainty can be found in Annex E
5.3 TRP for GSM MS	±1.9 dB for single measurement	Same as 5.2
6.2 TRS for FDD UE	±2.3 dB for single measurement	Detailed derivations of uncertainty can be found inAnnex E.
6.3 TRS for GSM MS	±2.3 dB for single measurement	Same as 6.2

D.2 Test tolerances (informative)

Test tolerances below are used to relax the Minimum Requirements in the present document to derive the Test Requirements.

Table D.2: Test tolerances for OTA tests

Clause	Test Tolerance
5.2 TRP for FDD UE	1.0 dB for minimum requirement 0.7 dB for average requirement
5.3 TRP for GSM MS	1.0 dB for minimum requirement 0.7 dB for average requirement
6.2 TRS for FDD UE	1.2 dB for maximum requirement 0.9 dB for average requirement
6.3 TRS for GSM MS	1.2 dB for maximum requirement 0.9 dB for average requirement

D.3 Derivation of Test Requirements (informative)

Table D.3: Derivation of test requirements for OTA tests

Clause	Minimum requirement in TS25.144	Test Tolerance (TT)	Test requirement in TS34.114
5.2 TRP for FDD UE	Single (minimum) requirement: Bands I,II,III,IV,VII,IX: 13 dBm Bands V,VI,VIII: TBD Average requirement: Bands I,II,III,IV,VII,IX: 15 dBm Bands V,VI,VIII: TBD	1.0 dB for single (minimum) requirement 0.7 dB for average requirement	Formula: Minimum Requirement - TT Bands I,II,III,IV,VII,IX: 12 dBm Bands V,VI,VIII: TBD Average requirement: Bands I,II,III,IV,VII,IX: 14.3 dBm Bands V,VI,VIII: TBD
5.3 TRP for GSM MS	TBD	1.0 dB for single (minimum) requirement 0.7 dB for average requirement	TBD
6.2 TRS for FDD UE	Single (Maximum) requirement: Bands I,IV: -98 dBm Bands II, VII: -96 dBm Band III: -95 dBm Band IX: -97 dBm Bands V,VI,VIII: TBD Average requirement: Bands I,IV: -101 dBm Bands II, VII: -99 dBm Band III: -98 dBm Band IX: -100 dBm Bands V,VI,VIII: TBD	1.2 dB for single (maximum) requirement 0.9 dB for average requirement	Formula: Minimum requirement + TT Single (Maximum) requirement: Bands I,IV: -96.8 dBm Bands II, VII: -94.8 dBm Band III: -93.8 dBm Band IX: -95.8 dBm Bands V,VI,VIII: TBD Average requirement: Bands I,IV: -100.1 dBm Bands II, VII: -98.1 dBm Band III: -97.1 dBm Band IX: -99.1 dBm Bands V,VI,VIII: TBD
6.3 TRS for GSM MS	TBD	1.2 dB for single (maximum) requirement 0.9 dB for average requirement	TBD

Annex E (normative): Estimation of Measurement Uncertainty

Individual uncertainty contributions in the TRP and TRS measurements are discussed and evaluated in this Appendix. A technique for calculating the total measurement uncertainty is also presented. More detailed discussion on the uncertainty contributions can be found from [4].

The TRP/TRS measurement procedure can be considered to include two stages. In Stage 1 the actual measurement of the 3-D pattern of the Device Under Test (DUT) is performed. In Stage 2 the calibration of the absolute level of the DUT measurement results is performed by means of using a calibration antenna whose absolute gain/radiation efficiency is known at the frequencies of interest. The uncertainty contributions related to TRP are listed in Table E.1 and the contributions related to TRS are in Table A.2. The uncertainty contributions are analyzed in the following paragraphs.

The calculation of the uncertainty contribution is based on the ISO Guide to the expression of uncertainty in measurement. Each individual uncertainty is expressed by its Standard Deviation (termed here as 'standard uncertainty') and represented by symbol U. The uncertainty contributions can be classified to two categories: Type-A uncertainties, which are statistically determined e.g. by repeated measurements, and Type-B uncertainties, which are derived from existing data e.g. data sheets. Several individual uncertainties are common in Stage 1 and Stage 2 and therefore cancel.

The procedure of forming the uncertainty budget in TRP measurement is:

1) Compile lists of individual uncertainty contributions for TRP measurement both in Stage 1 and Stage 2.
2) Determine the standard uncertainty of each contribution by
   a) Determining the distribution of the uncertainty (Gaussian, U-shaped, rectangular, etc.)
   b) Determining the maximum value of each uncertainty (unless the distributions is Gaussian)
   c) Calculating the standard uncertainty by dividing the uncertainty by $\sqrt{2}$ if the distribution is U-shaped, and by $\sqrt{3}$ if the distribution is rectangular.
3) Convert the units into decibel, if necessary.
4) Combine all the standard uncertainties by the Root of the Sum of the Squares (RSS) method.
5) Combine the total uncertainties in Stage 1 and Stage 2 also by the RSS method: $u_c = \sqrt{u^2_{c,DUT\ measurement} + u^2_{c,calibration\ measurement}}$.
6) Multiply the result by an expansion factor of 1.96 to derive expanded uncertainty at 95% confidence level: 1.96 * u_c.

Example uncertainty budgets are presented in Tables E.5 and E.6.

Table E.1 Uncertainty contributions in TRP measurement.

Description of uncertainty contribution	Details in paragraph
Stage 1, DUT measurement	
1) Mismatch of receiver chain (i.e. between probe antenna and measurement receiver)	E.1-E.2
2) Insertion loss of receiver chain	E.3-E.5
3) Influence of the probe antenna cable	E.6
4) Uncertainty of the absolute antenna gain of the probe antenna	E.7
5) Measurement Receiver: uncertainty of the absolute level	E.8
6) Measurement distance: a) offset of DUT phase center from axis(es) of rotation b) mutual coupling between the DUT and the probe antenna c) phase curvature across the DUT	E.9
7) Quality of quiet zone	E.10
8) DUT Tx-power drift	E.11
9) Uncertainty related to the use of the SAM phantom: a) uncertainty from using different types of SAM phantom b) simulated tissue liquid uncertainty c) effect of the DUT holder	E.12
10) Coarse sampling grid	E.13
11) Random uncertainty (repeatability, including positioning uncertainty of the DUT against the SAM phantom)	E.14
Stage 2 , Calibration measurement, network analyzer method, figure 7.5	
12) Uncertainty of network analyzer	E.15
13) Mismatch of receiver chain	E.1-E.2
14) Insertion loss of receiver chain	E.3-E.5
15) Mismatch in the connection of calibration antenna	E.1
16) Influence of the calibration antenna feed cable	E.6
17) Influence of the probe antenna cable	E.6
18) Uncertainty of the absolute gain of the probe antenna	E.7
19) Uncertainty of the absolute gain/ radiation efficiency of the calibration antenna	E.16
20) Measurement distance: a) Offset of calibration antenna's phase center from axis(es) of rotation b) Mutual coupling between the calibration antenna and the probe antenna c) Phase curvature across the calibration antenna	E.9
21) Quality of quiet zone	E.10

Table E.2 Uncertainty contributions in TRS measurement.

Description of uncertainty contribution	Details in paragraph
Stage 1, DUT measurement	
1) Mismatch of transmitter chain (i.e. between probe antenna and base station simulator)	E.1-E.2
2) Insertion loss of transmitter chain	E.3-E.5
3) Influence of the probe antenna cable	E.6
4) Uncertainty of the absolute antenna gain of the probe antenna	E.7
5) Base station simulator: uncertainty of the absolute output level	E.17
6) BER measurement: output level step resolution	E.18
7) Statistical uncertainty of BER measurement	E.19
8) BER data rate normalization	E.20
9) Measurement distance: a) offset of DUT phase center from axis(es) of rotation b) mutual coupling between the DUT and the probe antenna c) phase curvature across the DUT	E.9
10) Quality of quiet zone	E.10
11) DUT sensitivity drift	E.21
12) Uncertainty related to the use of the SAM phantom: a) uncertainty from using different types of SAM phantom b) simulated tissue liquid uncertainty c) effect of the DUT holder	E.12
13) Coarse sampling grid	E.13
14) Random uncertainty (repeatability) - positioning uncertainty of the DUT against the SAM	E.14
Stage 2 , Calibration measurement, network analyzer method, figure 7.5	
15) Uncertainty of network analyzer	E.15
16) Mismatch in the connection of transmitter chain (i.e. between probe antenna and NA)	E.1-E.2
17) Insertion loss of transmitter chain	E.3-E.5
18) Mismatch in the connection of calibration antenna	E.1
19) Influence of the calibration antenna feed cable	E.6
20) Influence of the probe antenna cable	E.6
21) Uncertainty of the absolute gain of the probe antenna	E.7
22) Uncertainty of the absolute gain/radiation efficiency of the calibration antenna	E.16
23) Measurement distance: a) Offset of calibration antenna's phase center from axis(es) of rotation b) Mutual coupling between the calibration antenna and the probe antenna c) Phase curvature across the calibration antenna	E.9
24) Quality of quiet zone	E.10

If a network analyzer is not available for calibration measurement and a spectrum analyzer or a power meter is used, Stage 2 errors in Tables 1 and 2 shall be replaced by Table 3.

Table E.3: Uncertainty contributions in Stage 2 (calibration measurement, spectrum analyzer method)

Description of uncertainty contribution	Details in paragraph
Stage 2, calibration measurement, spectrum analyser method, figure 7.4	
1) Cable loss measurement uncertainty	E.22
2) Uncertainty from impedance mismatch between the signal generator and the calibration antenna	E.1
3) Impedance mismatch uncertainty between the measurement receiver and the probe antenna	E.1
4) Signal generator: uncertainty of the absolute output level	E.23
5) Signal generator: output level stability	E.24
6) Influence of the calibration antenna feed cable	E.6
7) Influence of the probe antenna cable	E.6
8) Insertion loss of the calibration antenna feed cable	E.25
9) Insertion loss of the probe antenna cable	E.3
10) Mismatch uncertainty: between signal generator and calibration antenna (if antenna attenuator is used)	E.1
11) Mismatch uncertainty: between measurement receiver and probe antenna (if antenna attenuator is used)	E.1
12) Insertion loss of the calibration antenna attenuator (if used)	E.26
13) Insertion loss of the probe antenna attenuator (if used)	E.4
14) Uncertainty of the absolute level of the measurement receiver	E.8
15) Uncertainty of the absolute gain of the probe antenna	E.7
16) Uncertainty of the absolute gain of the calibration antenna	E.16
18) Measurement distance: a) Offset of calibration antenna's phase center from axis(es) of rotation b) Mutual coupling between the calibration antenna and the probe antenna c) Phase curvature across the calibration antenna	E.9
17) Quality of quiet zone	E.10

E.1 Mismatch uncertainty between measurement receiver and the probe antenna

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 ➔ 0.00dB 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 [1].

E.3 Insertion loss of the probe antenna cable

If the probe antenna cable does not move between the calibration and the DUT measurement stage, the uncertainty due to the insertion loss of the cable is assumed to be systematic. Moreover, this uncertainty is common and constant in both stages and that is why this leads to 0.00dB value.

If a different cable is used in the calibration measurement and in the DUT measurement, and the difference of the insertion loss is used in the calculations, then the overall combined standard uncertainty of the insertion loss measurement should be used in the uncertainty budget. The distribution of this uncertainty is assumed to be rectangular, in which case the standard uncertainty can be calculated as the maximum value/√3.

E.4 Insertion loss of the probe antenna attenuator (if used)

See Insertion loss of the probe antenna cable

If the probe antenna attenuator is used in both stages, the uncertainty is considered systematic and constant ➔ 0.00dB value.

E.5 Insertion loss of the RF relays (if used)

See Insertion loss of the probe antenna cable.

If the RF relay is used in both stages, the uncertainty is considered systematic and constant ➔ 0.00dB value.

E.6 Influence of the antenna cable

E.6.1 Probe antenna cable

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

In other cases a technical study should be done.

An ETSI technical report [4] gives a discussion on the results obtained by testing a vertically polarized biconical antenna over a ground plane with differing RF cable configurations.

E.6.2 Calibration antenna cable

If an efficiency calibration is performed, influence of the calibration antenna feed cable can be assumed to be negligible, due to data averaging.

In the case of gain calibration, the influence of the calibration antenna feed cable shall be assessed by measurements. A gain calibration measurement is repeated with a reasonably differing routing of the feed cable. Largest difference between the results is entered to the uncertainty budget with a rectangular distribution.

E.7 Absolute gain of the probe antenna

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

E.8 Measurement Receiver: uncertainty of absolute level

The receiving device is used to measure the received signal level in TRP tests either as an absolute level or as a relative level. Receiving device used is typically a Base Station Simulator (BSS), spectrum analyzer (SA), or power meter (PM). Generally there occurs an uncertainty contribution from limited absolute level accuracy and non-linearity.

E.9 Measurement distance

The uncertainty contribution from a finite measurement distance is estimated in three parts.

E.9.1 Offset of DUT phase centre from axis(es) of rotation

In all the measurements defined in this test procedure the DUT and phantom combination is rotated about the ear reference point of SAM phantom, which is also assumed to be the location of the phase center in both angular directions of the measurements.

For some turntables this may be practically impossible in which case a measurement uncertainty contribution can arise because the phase center will rotate on a non-zero radius about the center of rotation, thereby giving a variable measurement distance. Data averaging process may lead to a partial self-cancel of this uncertainty.

The following formula is used to estimate this uncertainty contribution in stage 1:

$U_{phase\_center\_limits}$ (dB) = $10\log(d \pm \Delta d)^2 + 10\log(d)^2$

If a gain calibration is performed in Stage 2, the uncertainty contribution of calibration antenna's displacement is estimated with the previous formula. Misalignment can be estimated with following formula,

$U_{misaligment}$ (dB) = $20\log(\cos\theta)$,

where θ is the misalignment angle between the calibration antenna and the probe antenna. The contribution shall be added to displacement error:

U_{cal} (dB) = $\sqrt{U^2_{phase\_center\_\Delta} + U^2_{misaligment}}$

For an efficiency calibration with an omnidirectional calibration antenna, the U_{cal} is calculated similary as for gain calibration but the uncertainty may be divided by factor 2. This is due to correcting impact of data averaging in this type of calibration.

E.9.2 Mutual coupling

In measurement of radio performances of UMTS mobile phones in speech mode, the mutual coupling uncertainty for this frequency band is a 0.00dB value (see annex A-2 in [5]).

The 0.00dB value can be extended for the GSM; DCS and PCS band frequencies.

E.9.3 Phase curvature

This uncertainty originates from the finite far-field measurement distance, which causes phase curvature across the DUT. If the measurement distance is > 10λ, this error is assumed to be negligible. At 2 GHz λ is 0.15 m, thus 10λ is 1.5 m.

E.10 Quality of quiet zone

The uncertainty contribution of the reflectivity level of the anechoic chamber 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 average standard deviation of electric field in the quiet zone can be calculated from the equation:

$$\overline{S_{freq}} = \frac{\frac{\pi}{2NM}\sum_{n=1}^{N}\sum_{m=1}^{M} s_{n,m,hor}\sin(\theta_n) + \frac{\pi}{2NM}\sum_{n=1}^{N}\sum_{m=1}^{M} s_{n,m,ver}\sin(\theta_n)}{2}$$

where

N is number of angular intervals in elevation,

M is number of angular intervals in azimuth and

θ_n is elevation of single measurement $s_{n,m,pol}$.

If an efficiency calibration with omnidirectional calibration antenna is performed, the effect of reflectivity level decreases in Stage 2 and $\overline{S_{freq}}$ 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. $\overline{S_{freq}}$ may be divided by factor 2 also in stage 1 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.

E.11 Tx-power drift of DUT

A single point power reference measurement in the beginning and at the end of the measurement procedure is recommended to monitor the power drift of the DUT. Based on TX-power drift measurements for typical 3G UE the determination of this contribution is performed by measuring the Tx-power drift and the value shall be included in the uncertainty budget.

In order to minimize Tx-power drift error it’s recommended to interleave sensitivity and power measurement of multiple channels. This spreads the measurements over a longer period, which helps to average the drift of the TX-power.

E.12 Uncertainty related to the use of SAM phantom

E.12.1 Uncertainty from using different types of SAM phantom

This uncertainty contribution originates from the fact that different laboratories may use the two different versions of SAM head: the SAM head phantom or the SAM phantom including the head and the shoulders. The standard SAM head is the specified phantom. However, the use of the other type of SAM is also allowed with the requirement that the resulting uncertainty contribution is taken into account in the uncertainty budget.

E.12.2 Simulated tissue liquid uncertainty

This uncertainty will occur, if the laboratory uses a liquid which has dielectric parameters deviating from the target parameters given in chapter Annex A. The relative dielectric constant (ε_r) and conductivity (σ) of used material shall be maintained within ±25% of target properties listed in Annex A. To convert electrical parameters of the tissue stimulant ε_r and σ to uncertainty values following equation shall be used:

$$U_{electrical} = 0.5dB \frac{\sqrt{\left(\frac{\varepsilon_r - \varepsilon_{r\_target}}{\varepsilon_{r\_target}}\right)^2 + \left(\frac{\sigma_r - \sigma_{r\_target}}{\sigma_{r\_target}}\right)^2}}{\sqrt{25\%^2 + 25\%^2}}$$

E.12.3 Device Holder

This uncertainty contribution originates from interaction of the Device Holder (the supporting structure of low-loss dielectric material that is used to hold the handset under-test in the desired position during measurement, as defined in the IEEE 1528) and the DUT. The Device Holder Uncertainty contribution depends on the different laboratories implementation and on the shape and manufacturing material. The Device Holder has an influence that varies with the relative position with respect to the DUT Antenna. Due to this the Device Holder should be designed to have maximum distance between Device Holder and DUT Antenna. The fixed value 0.2 dB is used to estimate the impact of device holder in uncertainty calculation. The determination of this contribution is performed by measuring the TRP and TRS with and without the holder.

E.13 Coarse sampling grid

Degreasing of sampling density to finite amount of samples affects the measurement uncertainty by two different errors. First is due to inadequate number of samples and second is a systematic discrimination approximation error in TRP and TRS equations.

The offset of systematic approximation error can be expressed by using formula

$$Offset = 10 \cdot \log 10\left(\frac{\pi}{2N}\sum_{n-1}^{N}\sin(\theta_n)\right).$$

where

N is number of angular intervals in elevation,

θ_n is elevation.

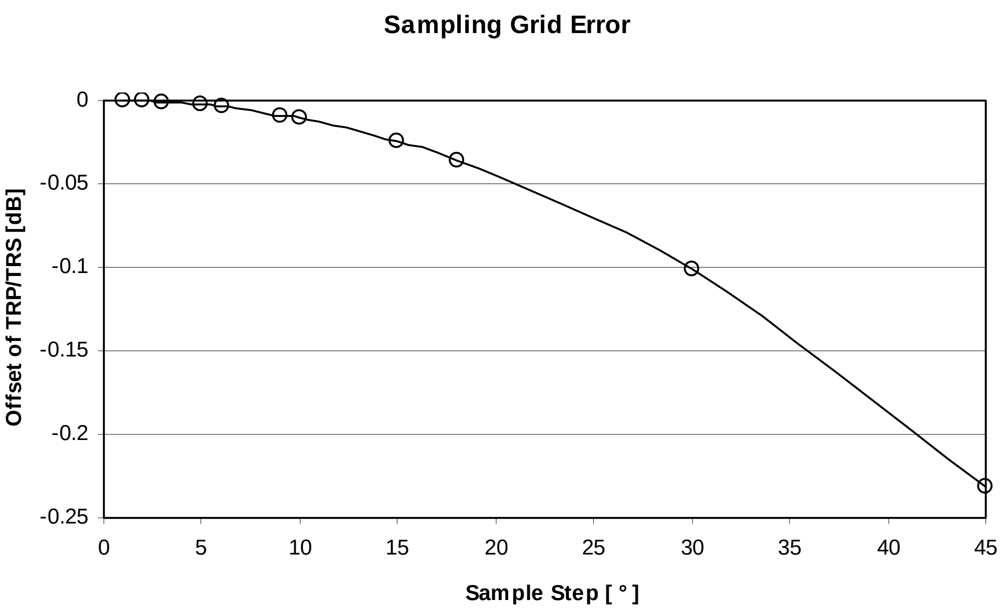

Figure E.7. Approximation error of TRP/TRS.

The 10° or 15° sampling grid used in TRP measurements has been shown to introduce only very small differences as compared to the results obtained with denser grids, so with that sampling grid the uncertainty contribution can assumed negligible.

When using sample step size of 15° - 30°, standard uncertainty of 0.15dB can be assumed to cover errors.

E.14 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.

To estimate this uncertainty, it is suggested to perform at least five evaluations of TRP/TRS for the cheek right position whereby the device shall be dismounted and newly positioned with a fully charged battery before each tests. This measurement set has to be carried out in mid channel of each frequency band, for at least three phones with different type of mechanical design. The values have to be normalized by the mean for each measurement set. As a result the uncertainty contribution entered to uncertainty budget is the difference between the maximum and minimum normalized value.

E.15 Uncertainty of network analyzer

This uncertainty includes the all uncertainties involved in the S21 measurement with a network analyzer, and will be calculated from the manufacturer's data in logs with a rectangular distribution, unless otherwise informed, (see clause 5.1.2 in [6]).

E.16 Uncertainty of the gain/efficiency of the calibration antenna

The calibration antenna only appears in Stage 2. Therefore, the gain/efficiency uncertainty has to be taken into account.

This uncertainty will be calculated from the manufacturer's data in logs with a rectangular distribution, unless otherwise informed (see clause 5.1.2 in [6]).

If the manufacturer's data do not give the information, the value has to be checked, see annex A-12 in [5]

E.17 Base station simulator: uncertainty of the absolute level

The transmitter device (typically a BS Simulator) is used to drive a signal to the horn antenna in sensitivity tests either as an absolute level or as a relative level. Receiving device used is typically a UE/MS. Generally there occurs uncertainty contribution from limited absolute level accuracy and non-linearity of the BS Simulator.

For practical reasons, the calibration measurement (Stage 2) should be only performed with the probe antenna as a receiver. Hence, the uncertainty on the absolute level of the transmitter device cannot be assumed as systematic. This uncertainty should be calculated from the manufacturer's data in logs with a rectangular distribution, unless otherwise informed (see clause 5.1.2 in [6]). Furthermore, the uncertainty of the non-linearity of the device is included in the absolute level uncertainty.

E.18 BER measurement: output level step resolution

When output power of the BS simulator is swept to reach the BER target, used power step resolution creates this uncertainty. Output power step used in the BER measurement is divided by factor 2 to obtain the uncertainty with rectangular distribution.

E.19 Statistical uncertainty of the BER measurement

To study statistical uncertainty of BER measurement, see ETSI document TR 100 028-1, section 6.6 [4].

For a full TRS measurement with a regular sampling grid, the statistical uncertainty can be approximated by using the following formula:

$$U_{fullTRS} = \frac{U_{SingleTRS}}{\sqrt{N/4}},$$

Where

$U_{SingleTRS}$ is the statistical uncertainty of single measurement,

N is the number of measurements.

E.19.1 WCDMA

For a BER target of 1%±0.2% using 20000 bits, uncertainty of 0.19 dB for a single measurement can be used. Using a BER target of 10%±2% with 20000 tested bits will lead to uncertainty of 0.46dB for a single measurement. If non standard settings are used to determine EIS the statistical error of the measurement should be estimated according to ETSI document TR 100 028-1.

E.19.2 GSM

For a BER target of 2.44%±0.1% using 10000 bits, uncertainty of 0.13 dB for a single measurement can be used. If non standard settings are used to determine EIS the statistical error of the measurement should be estimated according to ETSI document TR 100 028-1.

E.20 BER normalization uncertainty

This uncertainty occurs only when non standard settings are used to speed up TRS measurement. It can be calculated using following formula:

$$U_{norm} = \frac{\sqrt{\left(\frac{U_{SingleTRSref}}{2}\right)^2 + \left(\frac{U_{SingleTRSfast}}{2}\right)^2}}{\sqrt{N_{ref}}},$$

Where

$U_{SingleTRSref}$ is the statistical uncertainty of the used reference measurement,

$U_{SingleTRSfast}$ is the statistical uncertainty of the non standard measurement,

N_{ref} Is the number of measured reference points.

E.21 DUT sensitivity drift

Due to statistical uncertainty of BER measurement, drift in the TRS can not be monitored similary to TRP. An uncertainty value of 0.2dB can be used, or the TRS drift should be measured, with a setup corresponding to the actual TRS measurement.

E.22 Cable loss measurement uncertainty

Before performing the calibration, cable losses have to be measured. This measurement includes a standard uncertainty, which is composed of the mismatch, and the insertion loss uncertainties. In the calibration measurement, the transmitter part is composed with the calibration antenna, cables, and signal generator. The receiver part is composed with the probe antenna, cables, and measurement device.

The cable loss of transmitter and receiver parts should be measured separately. By this way, the cable losses will be compliant with the cable routing of the calibration stage. On the opposite, if the cable losses were measured together at the same time, the measured values would include errors from miscellaneous mismatch contributions, which do not appear in the cable routing of the calibration stage.

The cable loss measurement uncertainty is the result of the RSS of the uncertainty contributions listed in Table E.4.

Table E.4. Uncertainty contributions in the cable loss measurement.

Description of uncertainty contribution	Standard Uncertainty (dB)
Mismatch uncertainty of cable(s) receiver part	
Insertion loss of the cable(s) receiver part	
Measurement device: absolute level uncertainty	
Measurement device: linearity	
Mismatch uncertainty of cable(s) transmitter part	
Insertion loss of the cable(s) transmitter part	
Signal generator: absolute output level uncertainty	
Signal generator: output level stability uncertainty	
Cable loss measurement uncertainty (RSS)	

E.23 Signal generator: uncertainty of the absolute output level

The signal generator is only used at this stage. It substitutes the DUT by feeding the calibration antenna with a known power level. The use of this signal generator introduces an uncertainty on the absolute output level.

This uncertainty will be calculated from the manufacturer's data in logs with a rectangular distribution (see clause 5.1.2 in [6]).

E.24 Signal generator: output level stability

The uncertainty on the output level stability has to be taken into account only when the uncertainty of the absolute level is not considered.

This uncertainty will be calculated from the manufacturer's data in logs with a rectangular distribution (see clause 5.1.2 in [6]).

E.25 Insertion loss: Calibration antenna feed cable

The feed cable of the calibration antenna only appears in Stage 2. As a result, this uncertainty has to be taken into account.

This uncertainty will be measured or calculated from the manufacturer's data in logs with a rectangular distribution (see clause 5.1.2 in [6]).

E.26 Insertion loss: Calibration antenna attenuator (if used)

If a calibration antenna attenuator is used, it only appears in Stage 2. As a result, this uncertainty has to be taken into account.

This uncertainty will be calculated from the manufacturer's data in logs with a rectangular distribution (see clause 5.1.2 in [6]).

E.27 Examples of uncertainty budget calculations for TRP(Informative)

Table E.5: Example of uncertainty budget for TRP measurement

Uncertainty Source	Comment	Uncertainty Value [dB]	Prob Distr	Div	ci	Standard Uncertainty [dB]
STAGE 1 (DUT measurement)						
1) Mismatch of receiver chain	$\Gamma_{power\ meter}$ <0.05 $\Gamma_{probe\ antenna\ connection}$ <0.16	0.05	U	$\sqrt{2}$	1	0.04
2) Insertion loss of receiver chain	Systematic with Stage 2 (=> cancels)	0	R	$\sqrt{3}$	1	0
3) Influence of the probe antenna cable	Systematic with Stage 2 (=> cancels)	0	R	$\sqrt{3}$	1	0
4) Absolute antenna gain of the probe antenna	Systematic with Stage 2 (=> cancels)	0	R	$\sqrt{3}$	1	0
5) Measurement Receiver: uncertainty of the absolute level	Power Meter	0.06	R	$\sqrt{3}$	1	0.03
6) Measurement distance a) Offset of DUT phase center	Δd=0.05m	0.14	R	$\sqrt{3}$	1	0.08
7) Quality of quiet zone	Standard deviation of E-field in QZ measurement	0.5	N	1	1	0.5
8) DUT Tx-power drift	Drift	0.2	R	$\sqrt{3}$	1	0.12
9) a) Uncertainty related to the use of SAM phantom:	Standard SAM head with standard tissue simulant	0	R	$\sqrt{3}$	1	0
b) Simulated tissue liquid uncertainty	Maximum allowed error	0.5	R	$\sqrt{3}$	1	0.29
c) Effect of DUT holder	Fixed value	0.2	R	$\sqrt{3}$	1	0.12
10) Coarse sampling grid	Negligible, used Δ_θ = 15° and Δ_φ = 15°.	0	N	1	1	0
11) Repeatability	Monoblock, clamshell and slide design used for testing	0.4	R	$\sqrt{3}$	1	0.23
STAGE 2 (Calibration)						
12) Uncertainty of network analyzer	Manufacturer's uncertainty calculator, covers whole NA setup	0.5	R	$\sqrt{3}$	1	0.29
13) Mismatch of receiver chain	Taken in to account in NA setup uncertainty	0	U	$\sqrt{2}$	1	0
14) Insertion loss of receiver chain	Systematic with Stage 1 (=> cancels)	0	R	$\sqrt{3}$	1	0
15) Mismatch in the connection of calibration antenna	Taken in to account in NA setup uncertainty	0	U	$\sqrt{2}$	1	0
16) Influence of the feed cable of the calibration antenna	Gain calibration with a dipole	0.3	R	$\sqrt{3}$	1	0.17
17) Influence of the probe antenna cable	Systematic with Stage 1 (=> cancels)	0	R	$\sqrt{3}$	1	0
18) Uncertainty of the absolute gain of the probe antenna	Systematic with Stage 1 (=> cancels)	0	R	$\sqrt{3}$	1	0
19) Uncertainty of the absolute gain of the calibration antenna	Calibration certificate	0.5	R	$\sqrt{3}$	1	0.29
20) Measurement distance: - Calibration antenna's displacement and misalignment	d=3m, Δd=0.05m, θ=2°	0.29	R	$\sqrt{3}$	1	0.17

21) Quality of quiet zone	Standard deviation of e-field in QZ measurement, Gain calibration	0.5	N	1	1	0.5
Combined standard uncertainty	$u_c = \sqrt{\sum_{i=1}^{m} c_i^2 \cdot u_i^2}$					0.95
Expanded uncertainty (Confidence interval of 95 %)			$u_e = 1{,}96\, u_c$			1.86

E.28 Examples of uncertainty budget calculations for TRS(Informative)

Table E.6. Example of uncertainty budget for TRS measurement

Uncertainty Source	Comment	Uncertainty Value [dB]	Prob Distr	Div	ci	Standard Uncertainty [dB]
STAGE 1 (DUT measurement)						
1) Mismatch of transmitter chain	Γ_{BSS} <0.13 $\Gamma_{antenna\ connection}$ <0.03	0.02	N	1	1	0.02
2) Insertion loss of transmitter chain	Systematic with Stage 1 (=> cancels)	0	R	$\sqrt{3}$	1	0
3) Influence of the probe antenna cable	Systematic with Stage 2 (=> cancels)	0	R	$\sqrt{3}$	1	0
4) Absolute antenna gain of the probe antenna	Systematic with Stage 2 (=> cancels)	0	R	$\sqrt{3}$	1	0
5) Base station simulator: uncertainty of the absolute level		1	R	$\sqrt{3}$	1	0.58
6) BER measurement: output level step resolution	Step 0.1dB	0.05	R	$\sqrt{3}$	1	0.03
7) Statistical uncertainty of the BER measurement	BER target 10%±2% , 20000 tested bits , N=60	0.12	N	1	1	0.12
8) TRS data rate normalization	4 reference points measured	0.12	N	1	1	0.12
9) Measurement distance a) Offset of DUT phase center	Δd=0.05m	0.14	R	$\sqrt{3}$	1	0.08
10) Quality of quiet zone	Standard deviation of E-field in QZ measurement	0.5	N	1	1	0.5
11) DUT sensitivity drift	Drift measurement	0.2	R	$\sqrt{3}$	1	0.12
12) a) Uncertainty related to the use of SAM phantom:	Standard SAM with standard tissue simulant	0	R	$\sqrt{3}$	1	0
b) Simulated tissue liquid uncertainty	Maximum allowed error	0.5	R	$\sqrt{3}$	1	0.29
c) Effect of DUT holder	Fixed value	0.2	R	$\sqrt{3}$	1	0.12
13) Coarse sampling grid	Δ_θ = 30° and Δ_φ = 30°.	0.15	N	N	1	0.15
14) Repeatability	Monoblock, clamshell and slide design used for testing	0.5	R	$\sqrt{3}$	1	0.29
STAGE 2 (Calibration)						
15) Uncertainty of network analyzer	Manufacturer's uncertainty calculator, covers NA setup	0.5	R	$\sqrt{3}$	1	0.29
16) Mismatch of transmitter chain	Taken in to account in NA setup uncertainty	0	U	$\sqrt{2}$	1	0
17) Insertion loss of transmitter chain	Systematic with Stage 1 (=> cancels)	0	R	$\sqrt{3}$	1	0
18) Mismatch in the connection of calibration antenna	Taken in to account in NA setup uncertainty	0	R	$\sqrt{3}$	1	0
19) Influence of the feed cable of the calibration antenna	Gain calibration with dipole	0.3	R	$\sqrt{3}$	1	0.17
20) Influence of the probe antenna cable	Systematic with Stage 1 (=> cancels)	0	R	$\sqrt{3}$	1	0
21) Uncertainty of the absolute gain of the probe antenna	Systematic with Stage 1 (=> cancels)	0	R	$\sqrt{3}$	1	0

22) Uncertainty of the absolute gain of the calibration antenna	Calibration certificate	0.5	R	$\sqrt{3}$	1	0.29
23) Measurement distance: Calibration antenna's displacement and misalignment	d=3m, Δd=0.05m, θ=2°	0.29	R	$\sqrt{3}$	1	0.17
24) Quality of quiet zone	Standard deviation of E-field in QZ measurement	0.5	N	1	1	0.5
Combined standard uncertainty	$u_c = \sqrt{\sum_{i=1}^{m} c_i^2 \cdot u_i^2}$					1.17
Expanded uncertainty (Confidence interval of 95 %)			$u_e = 1{,}96\, u_c$			2.29

Annex F (informative): Suggested Recipes of Liquid to be used inside SAM Phantom

In Tables F.1 – F.2 are proposed two different recipes of the liquid to be used inside the SAM phantom.

Table F.1. Liquid recipe .

Component	Mass %
De-ionized Water	57.12
Tween 20	42.30
NaCl	0.58

Table F.2. Liquid recipe

Component	Mass %
De-ionized Water	54.9 %
Diethylene Glycol Butyl Ether (DGBE) (> 99 % pure)	44.92 %
NaCl	0.18 %

Annex G (informative): Anechoic Chamber Specifications and Validation Method

This Appendix presents the specifications for the shielded anechoic chamber and the validation methods.

G.1 Shielded anechoic chamber specifications

To avoid environmental perturbations the measurements shall be performed in a shielded enclosure, preserved from electromagnetic disturbances coming from electromagnetic environment (Radio and TV broadcast, cellular, ISM equipment, etc…). The shielding effectiveness shut be tested according to the EN 50 147-1 standard in the frequency range of 800 MHz up to 4 GHz.

The recommended level of the shielding effectiveness is -100 dB from 800 MHz to 4 GHz.

Testing of the shielding effectiveness can be performed either before or after the installation of absorbers.

G.2 Quiet Zone reflectivity level validation

The performance of anechoic chamber is typically evaluated from reflectivity level R_{level} in the quiet zone. Reflectivity level is defined as power ratio of <u>all</u> summed reflected signals P_r to direct signal P_d from antenna:

$$R_{level} = 10\log\frac{P_r}{P_d}\ .$$

To evaluate the quiet zone reflectivity level, the contribution of absorbing materials, the antenna positioning system and other constructions in the anechoic chamber should be measured.

To measure accurately quality of the quite zone in anechoic chamber an omni-directional antenna shall be used. Near omni-directional three axes field-probes are available with fibre optic connection thus minimizing cable effects. Because sensitivity of field probe is limited it shall be carefully checked that the field probe is operated at least 6dB above the noise floor of the probe.

Note: The quiet zone evaluation should be performed with the antenna positioning system in its place, in order to include its effect on the reflectivity level.

G.2.1 Description of a practical method for Quiet Zone characterization

In the following, a practical version of the Free Space VSWR method is presented.

In the Free Space VSWR method the quality of quite zone is measured from amplitude ripple caused by reflections inside the anechoic chamber. Phase variation of the direct signal and the reflected signals is obtained by moving a field-probe in the quiet zone. Amplitude ripple in the quiet zone is caused by this phase variation of reflected signals and the direct signal from antenna. The figure 2 below shows seven measuring positions.

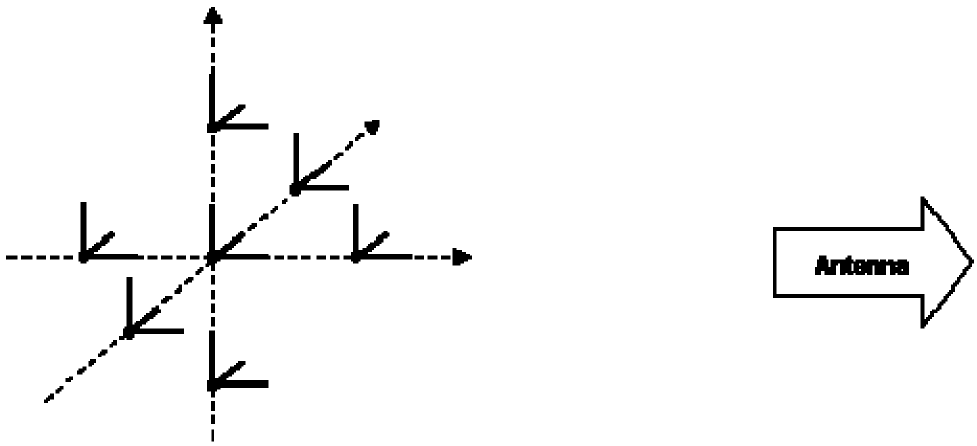

Figure G.2: Measurement positions with 150mm separation

In each of the seven-measurement position amplitude of power received by field-probe $P_{meas\,n}$ [dBm] is measured where n is index of measuring position. Variance of measurement distance to the antenna from field-probe in different measurement positions can be compensated by following equation:

$$P_n = P_{meas\,n} + 20\log(\frac{d_n}{l})$$

where,

d_n is distance to point n from the antenna,

l is distance to centre of quiet zone from the antenna

$P_{meas\,n}$ is uncorrected measurement value from point n.

The sample standard deviation of the electric field in the quiet zone can be calculated from these distance corrected values or directly from the measured values with the following equation:

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left(P_i - \overline{P}\right)^2}$$

where,

N is number of measurements positions

$\overline{P}$ is dB average of all P_n

P_i is P_n or P_{meas_n}

G.4 Standard deviation of electric field

To obtain more accurate picture of quality of quiet zone, measurement described in previous chapter can be done from multiple directions and polarizations. Doing free space VSWR measurement from different directions in 15-degree separation for elevation and azimuth we get 264 standard deviation values in both polarizations ($s_{\theta,\Phi,pol}$). From these values average sample standard deviation in electric field in quiet zone can be calculated from equation:

$$\overline{S_{freq}} = \frac{\frac{\pi}{2IJ}\sum_{i=1}^{I}\sum_{j=1}^{J} s_{i,j,hor}\sin(\Theta_i) + \frac{\pi}{2IJ}\sum_{i=1}^{I}\sum_{j=1}^{J} s_{i,j,ver}\sin(\Theta_i)}{2}$$

where,

I is number of angular intervals in elevation,

J is number of angular intervals in azimuth and

Θ_i is elevation of measurement $s_{i,j,pol}$.

This quiet zone quality measurement should be done at all the frequencies used in measurements, but can be sufficient on all the centre frequencies in the measurement bands but also in this case the Tx and Rx shall be measured separately.

Annex H (informative): Bibliography

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Annex I (informative): Change history

Meeting-1st-Level	Doc-1st-Level	CR	Rev	Subject	Cat	Version-Current	Version-New	Doc-2nd-Level
RP-37	RP-070665	-	-	TS 34.114 for information	-	-	1.0.0	R5-072420
RP-41	RP-080612	-	-	New version of 34.114	-	1.0.0	7.0.0	R5-083817
SP-42	-	-	-	New version of 34.114	-	7.0.0	8.0.0	-

History

Document history		
V8.0.0	January 2009	Publication