



Operator Acceptance Values for Device Antenna Performance

Version 4.0

21 February 2019

This is a Non-binding Permanent Reference Document of the GSMA

Security Classification: Non-confidential

Access to and distribution of this document is restricted to the persons permitted by the security classification. This document is confidential to the Association and is subject to copyright protection. This document is to be used only for the purposes for which it has been supplied and information contained in it must not be disclosed or in any other way made available, in whole or in part, to persons other than those permitted under the security classification without the prior written approval of the Association.

Copyright Notice

Copyright © 2019 GSM Association

Disclaimer

The GSM Association ("Association") makes no representation, warranty or undertaking (express or implied) with respect to and does not accept any responsibility for, and hereby disclaims liability for the accuracy or completeness or timeliness of the information contained in this document. The information contained in this document may be subject to change without prior notice.

Antitrust Notice

The information contain herein is in full compliance with the GSM Association's antitrust compliance policy.

Table of Contents

1	Introduction	3
1.1	Overview	3
1.2	Scope	3
1.3	Definition of Terms	4
1.4	Document Cross-References	5
2	Antenna Performance Requirements	5
2.1	Antenna Performance Calculation Formula	6
2.2	Operator Antenna Performance Acceptance Values for 2G and 3G Bands	6
2.3	Operator Antenna Performance Acceptance Values for LTE Bands	7
3	Moving Forward	10
Annex A	Measured Values	11
A.1	RAG Status Tables	11
A.1.1	Test Methodology	11
A.1.2	Interpretation	12
A.1.3	Measured Results Tables	12
A.1.4	Further Analysis	14
A.2	Study on Wide Grip Hand	14
Annex B	Document Management	15
B.1	Document History	15
	Other Information	15

1 Introduction

1.1 Overview

Mobile handset design has changed significantly over the past few years. Antennas, which were external in many cases, moved inside the terminal and evolved to be light-weight and low-volume.

The increasing focus on design conflicts with radio performance of the antenna systems can lead to service disruption and increased dropped call rates impacting customer experience. Increasing network density is not an option as it may not be viable in many cases.

Whilst the 3GPP standards define the absolute global minimum OTA performance requirements to be met by devices, numerous operators are already requesting higher values in their own procurement activities to serve customer needs and network rollout plans.

However, the test methods used and antenna performance values requested by the various operators differ widely, leaving vendors with a fragmented requirements landscape.

To facilitate this alignment and agreement, the antenna experts of operators within the GSMA Terminal Steering Group have reviewed results of antenna performance tests (conducted within their own organisations as well as by the GSMA), and have aligned test methods and agreed on performance values to be used as guidelines for acceptable and achievable performance of antennas in Mobile devices. The values are supported by operators representing America, Europe and Asia.

Following the publication of version three in October 2015 [TS.24], the TSG operators have now aligned performance (2G/3G/LTE) also for devices with widths between 72 mm and 92 mm (same performance as for devices with widths between 56 mm and 72 mm).

1.2 Scope

This document defines the Operator Acceptance Values for Device Antenna Performance. The values are determined taking into consideration

- devices being held close to the head with left and right hand
- devices being held with one hand only for the purpose of Browsing
- devices being measured with the Free Space method

The requirements (which include measurement uncertainty) are relevant for mobile devices, including feature phones, smart phones, tablets and dongles. More details can be found in the relevant sections.

These GSMA Operator Acceptance Values for Device Antenna Performance are non-binding, and operators are free to request alternative values as required. It will be up to each individual operator to adopt and enforce the GSMA Operator OTA requirements.

These values serve to align, enhance and promote antenna performance requirements across the industry while seeking to improve device antenna performance and network interoperability.

Note 1: The alignment of the GSMA Operator Acceptance Values for Device Antenna Performance does not impact the test process; this will continue as it is the case today in Operator-Manufacturer bilateral agreements.

Each phase of the work carried out in updating TS.24 has also involved independent tests on commercially available Smartphones. The purpose of these tests was to benchmark the Acceptance Values defined in TS.24.

In this version of TS.24 we publish the results of these tests in the appendix.

1.3 Definition of Terms

Term	Description
3GPP	3 rd Generation Partnership Project
BHH	Beside Head and Hand
BHHL	Beside Head and Hand Left
BHHR	Beside Head and Hand Right
CCSA	China Communications Standards Association
CS	Circuit Switched (voice mode)
CTIA	Cellular Telecommunications & Internet Association
FDD	Frequency Division Duplex
FS	Free Space
GSM / E-GSM	Global System for Mobile Communication/ Extended-GSM
GSMA	GSM Association
HL	Browsing mode with Hand Left Only
HR	Browsing mode with Hand Right Only
LTE	Long Term Evolution
MIMO	Multiple Input Multiple Output
MS	Mobile Station
OEM	Original Equipment Manufacturer
OTA	Over The Air (without cable)
RAG	Red Amber Green
RB	Resource Block
RMC	Reference Measurement Channel
TDD	Time Division Duplex
TRP	Total Radiated Power
TRS (TIS)	Total Radiated (Isotropic) Sensitivity
TSG	Terminal Steering Group
TSGFM	Terminal Steering Group Full Members
UE	User Equipment
VoLTE	Voice over LTE

VoIP	Voice over Internet Protocol
WCDMA	Wideband Code Division Multiple Access

1.4 Document Cross-References

Ref	Document Number	Title
CTIA	3.8.1 or later	Test Plan for Wireless Device Over the Air Performance https://api.ctia.org/wp-content/uploads/2018/10/ctia-test-plan-for-wireless-device-over-the-air-performance-ver-3-8-1.pdf
3GPP	TS 25.144	User Equipment (UE) and Mobile Station (MS) over the air performance requirements

Table 1: Antenna Performance Calculation Formula

2 Antenna Performance Requirements

The following table serves as an internal guideline for mobile operators, who are encouraged to apply the required values in their bilateral agreements with their vendors.

Req ID	Requirement
TSG24_AP_01	For the scenario " Head and Hand " (BHH) and in line with CTIA, the terminal SHALL support an average value of the low, medium and high frequency channels, on both, the left (BHHL) and right (BHHR) hand-side, a performance equal to or above the GSMA performance requirements for that frequency band listed in table 1 and 2 in section 2.2 for 2G/3G and table 3 and 4 in section 2.3 for LTE bands.
TSG24_AP_02	For the scenario " Browsing " (HL or HR) and in line with CTIA, the terminal SHALL support an average value of the low, medium and high frequency channels, on both the left and right hand-side, a performance equal to or above the GSMA performance requirements for that frequency band listed in table 1 and 2 in section 2.2 for 2G/3G and table 3 and 4 in section 2.3 for LTE bands.
TSG24_AP_03	For the scenario " Free Space " (FS) and in line with CTIA, the terminal SHALL support an average value of the low, medium and high frequency channels a performance equal to or above the GSMA performance requirements for that frequency band listed in table 1 and 2 in section 2.2 for 2G/3G and table 3 and 4 in section 2.3 for LTE bands.
TSG24_AP_04	No measured channel SHALL be 1 dB worse than the performance values defined for that frequency band.
TSG24_AP_05	The CTIA/3GPP PDA hand SHALL be used for testing a device which is between 56 mm and 72 mm (inclusive) wide.
TSG24_AP_06	The CTIA Wide Grip hand SHALL be used for testing a device which exceeds 72 mm but does not exceed 92 mm in width.

2.1 Antenna Performance Calculation Formula

Note 2:

- a) The values include measurement uncertainty.
- b) Operators may accept alternative values for bands outside of their home market.
- c) BHH and Browsing acceptance values are the same for devices tested using the PDA and Wide Grip hand phantom.

2.2 Operator Antenna Performance Acceptance Values for 2G and 3G Bands

The following tables list the Operator Antenna Performance Values per test scenario and frequency band (2G and 3G).

Test scenario:

Head and Hand (BHH):

Relevant for devices that support voice and do not exceed the maximum dimensions specified for hand phantom (92 mm) [CTIA]. The values are defined considering head and hand and are relevant for left or right hand.

PDA hand is used for testing devices with widths 56 – 72 mm

Wide Grip hand is used for testing devices with widths >72 - 92 mm

Browsing (HL or HR):

Relevant for devices where the display is visible to the end user for data usage and where width ranges are between 56 mm and 92 mm [CTIA]. The values are defined considering one-hand only and are relevant for left or right hand. The 3G frequencies are measured, using a 12.2 Kbps reference measurement channel (RMC).

PDA hand is used for testing devices with widths 56 – 72 mm

Wide Grip hand is used for testing devices with widths >72 - 92 mm

Free Space:

Relevant for any device that embeds an antenna and that supports voice and/or data. The applicable measurement method is voice (CS) mode. The 3G frequencies are measured, using a 12.2 Kbps reference measurement channel (RMC).

These acceptance values include measurement uncertainty.

Frequency Band 2G/3G	GSMA Operator Acceptance Values for TRP [dBm]		
	BHH (Note 3)	Browsing	Free Space
GSM 850	20.0	24.0	27.0
EGSM 900	20.0	25.0	28.0

GSM 1800	21.0	23.0	26.0
GSM 1900	21.0	23.0	26.0
WCDMA Band 1	15.0	17.0	20.0
WCDMA Band 2	16.5	17.0	20.0
WCDMA Band 3	13.5	14.7	17.7
WCDMA Band 5	11.0	14.7	17.7
WCDMA Band 8	11.0	15.0	18.0
WCDMA Band 19	11.0	15.5	18.0

Table 2: GSMA Operator Acceptance Values for TRP for 2G and 3G bands

Frequency Band 2G/3G	GSMA Operator Acceptance Values for TRS [dBm]		
	BHH (Note 3)	Browsing	Free Space
GSM 850	-97.0	-99.0	-103.0
EGSM 900	-95.0	-99.0	-103.0
GSM 1800	-99.0	-100.0	-104.0
GSM 1900	-99.5	-100.0	-103.0
WCDMA Band 1	-101.0	-103.0	-106.0
WCDMA Band 2	-98.5	-101.0	-104.0
WCDMA Band 3	-98.5	-99.0	-102.0
WCDMA Band 5	-94.5	-100.0	-103.0
WCDMA Band 8	-96.0	-101.0	-104.0
WCDMA Band 19	-96.0	-102.0	-104.5

Table 3: GSMA Operator Acceptance Values for TRS for 2G and 3G bands

2.3 Operator Antenna Performance Acceptance Values for LTE Bands

The following tables list the Operator Antenna Performance Values per test scenario and frequency band (LTE).

Test scenario:

Head and Hand (BHH):

Relevant for devices that support voice (e.g. VoLTE, VoIP). The relevant hand phantom is to be used according to the device's width:

PDA hand is used for testing devices with widths 56 – 72 mm

Wide Grip hand is used for testing devices with widths >72 - 92 mm

The values are relevant for left or right hand.

Browsing (HL or HR):

Relevant for devices where the display is visible to the end user for data usage and relevant hand phantom to be used according to the devices width:

PDA hand is used for testing devices with widths 56 – 72 mm

Wide Grip hand is used for testing devices with widths >72 - 92 mm

The values are defined considering one-hand only and are relevant for left or right hand.

Free Space:

Relevant for any device that embeds an antenna and supports voice (e.g. VoLTE, VoIP) and /or data.

These acceptance values include measurement uncertainty.

Settings during testing**TRP:**

Single antenna transmitting

Uplink RB Allocation: 12

TRS:

All receivers/antennas active

Downlink RB Allocation: 50

Bandwidth: 10 MHz

Frequency Band LTE	GSMA Operator Acceptance Values for TRP [dBm]		
	BHH (Note 3)	Browsing	Free Space
FDD Band 1	13.5	15.5	18.5
FDD Band 2	13.5	15.5	18.5
FDD Band 3	13.5	15.5	18.5
FDD Band 4	13.5	15.5	18.5
FDD Band 5	9.8	14.3	18.0
FDD Band 7	13.5	15.5	18.5
FDD Band 8	9.8	14.3	18.0
FDD Band 11	11.5	14.5	18.0
FDD Band 12	9.8	14.3	18.0
FDD Band 13	9.8	14.3	18.0
FDD Band 17	9.8	14.3	18.0

FDD Band 18	9.8	14.3	18.0
FDD Band 19	9.8	14.3	18.0
FDD Band 20	9.8	14.3	18.0
FDD Band 21	11.5	14.5	18.0
FDD Band 25	13.5	15.5	18.5
FDD Band 26	9.8	14.3	18.0
FDD Band 28	9.8	14.3	18.0
TDD Band 38	13.5	15.5	18.5
TDD Band 39	13.5	15.5	18.5
TDD Band 40	13.5	15.5	18.5
TDD Band 41	13.5	15.5	18.5
TDD Band 42	13.5	15.5	18.5
TDD Band 43	13.5	15.5	18.5

Table 4: GSMA Operator Acceptance Values for TRP for the LTE Bands

Frequency Band LTE	GSMA Operator Acceptance Values for TRS [dBm]		
	BHH (Note 3)	Browsing	Free Space
FDD Band 1	-89.0	-91.0	-94.0
FDD Band 2	-89.0	-91.0	-94.0
FDD Band 3	-89.0	-91.0	-94.0
FDD Band 4	-89.0	-91.0	-94.0
FDD Band 5	-85.0	-89.5	-93.5
FDD Band 7	-89.0	-91.0	-94.0
FDD Band 8	-85.0	-89.5	-93.5
FDD Band 11	-87.0	-90.0	-93.5
FDD Band 12	-85.0	-89.5	-93.5
FDD Band 13	-85.0	-89.5	-93.5
FDD Band 17	-85.0	-89.5	-93.5
FDD Band 18	-85.0	-89.5	-93.5
FDD Band 19	-85.0	-89.5	-93.5
FDD Band 20	-85.0	-89.5	-93.5
FDD Band 21	-87.0	-90.0	-93.5
FDD Band 25	-89.0	-91.0	-94.0
FDD Band 26	-85.0	-89.5	-93.5
FDD Band 28	-85.0	-89.5	-93.5
TDD Band 38	-89.0	-91.0	-94.0
TDD Band 39	-89.0	-91.0	-94.0
TDD Band 40	-89.0	-91.0	-94.0

TDD Band 41	-89.0	-91.0	-94.0
TDD Band 42	-89.0	-91.0	-94.0
TDD Band 43	-89.0	-91.0	-94.0

Table 5 GSMA Operator Acceptance Values for TRS for the LTE Bands

Note 3: BHH and Browsing acceptance values are the same for PDA and Wide Grip hand phantom.

3 Moving Forward

As part of Phase 4, the GSMA operators will progress:

- Alignment of MIMO OTA test method and performance for LTE frequency bands

In addition, operators will continue to test antenna performance of market devices and actively monitor and/or engage in work driven in relevant industry bodies.

Annex A Measured Values

As part of the process to derive the harmonised Operator Acceptance Values published in this document the GSMA has, for each phase of the work, carried out independent tests on commercially available Smartphones. These devices are taken from consumer stock, and are not prototype or engineering samples provided by the OEM's.

In this appendix we have published the results from these tests.

The purpose of the tests was to benchmark the acceptance values defined in TS.24 and to ensure that they represent a realistic achievable target that manufacturers of devices can readily achieve.

All device results have been anonymised.

A.1 RAG Status Tables

The tables published in this appendix include a RAG (Red Amber Green) colour coding. This RAG status can be interpreted as follows:

Green = meets or surpasses the GSMA TS.24 acceptance value

Amber = within 2 dB of the GSMA TS.24 acceptance value

Red = fails to meet the GSMA TS.24 acceptance value by a value greater than 2 dB

The 2 dB margin used to define the Amber category reflects that the acceptance values published in this document are a harmonised average of the values contributed by operators who took part in this work.

It also recognises that some operators have a small tolerance in their acceptance values so that they do not block the launch of a device that marginally fails to meet their requirements. These tolerances are usually defined on a bilateral basis and are reviewed per device.

Because of the above the tables below try to reflect this reality through use of the 2 dB margin which defines values in Amber.

A.1.1 Test Methodology

Device selection was based on a random selection of commercially available devices at the time of measurement, typically these devices are from Tier 1 OEM's, and are their Flagship or high volume selling products.

The tests were carried out in an independent antenna lab, accredited by both CTIA (e.g. a CATL) and GCF (Global Certification Forum).

The specific test methodologies used, followed the recommendations issued by CTIA.

TRP [dBm]	Operator Acceptance	Device 1		Device 2		Device 3		Device 4		Device 5		Device 6		Device 7		Device 8		Device 9	
		BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL
LTE Frequency Band	BHH	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL
FDD Band 1	13,50	11,81	12,90			12,43	15,30									16,89	15,82	15,67	12,59
FDD Band 2	13,50					11,93	14,81												
FDD Band 3	13,50	13,60	13,26	12,52	13,83	13,36	16,21									15,18	13,16	14,92	12,90
FDD Band 4	13,50												16,95	12,81					
FDD Band 5	9,75	8,23	11,02			6,39	4,82												
FDD Band 7	13,50	10,98	12,79	14,50	9,62	11,74	17,45												
FDD Band 8	9,75	11,71	10,70			7,81	6,15												
FDD Band 11	11,50																		
FDD Band 12	9,75																		
FDD Band 13	9,75												10,96	11,24					
FDD Band 17	9,75																		
FDD Band 18	9,75																		
FDD Band 19	9,75															9,90	10,71	11,90	12,68
FDD Band 20	9,75	11,80	9,78	9,27	7,77	8,11	7,14												
FDD Band 21	11,50																		
FDD Band 25	13,50							15,59	16,02	14,98	13,30	13,33	11,48						
FDD Band 26	9,75							11,77	12,77	12,60	11,54	10,52	9,51						
FDD Band 28	9,75																		
TDD Band 38	13,50																		
TDD Band 39	13,50																		
TDD Band 40	13,50																		
TDD Band 41	13,50							12,24	16,65	13,70	15,87	13,63	4,31						
TDD Band 42	13,50																		
TDD Band 43	13,50																		

Table 8: TRP RAG status of tested devices in LTE bands for head & hand use case (status: 2015)

TRS [dBm]	Operator Acceptance	Device 1		Device 2		Device 3		Device 4		Device 5		Device 6		Device 7		Device 8		Device 9		
		BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	
LTE Frequency Band	BHH/Both Antennas Active	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	
FDD Band 1	-89,00	-87,73	-88,31			-89,36	-89,49									-91,51	-90,20	-87,82	-86,95	
FDD Band 2	-89,00					-90,35	-90,78													
FDD Band 3	-89,00	-91,37	-92,09	-89,03	-88,84	-88,79	-89,70													
FDD Band 4	-89,00												-91,74	-92,00						
FDD Band 5	-85,00	-85,87	-86,87			-82,61	-81,86													
FDD Band 7	-89,00	-92,46	-93,47	-88,88	-84,24	-86,69	-89,01													
FDD Band 8	-85,00	-85,72	-84,99			-85,01	-84,34													
FDD Band 11	-87,00																			
FDD Band 12	-85,00																			
FDD Band 13	-85,00												-86,65	-89,06						
FDD Band 17	-85,00																			
FDD Band 18	-85,00																			
FDD Band 19	-85,00																-86,17	-87,97	-86,25	-86,66
FDD Band 20	-85,00	-86,68	-87,19	-87,08	-86,30	-83,99	-82,84													
FDD Band 21	-87,00																			
FDD Band 25	-89,00							-91,09	-91,95	-92,40	-92,04	-89,17	-87,24							
FDD Band 26	-85,00							-85,76	-86,08	-87,45	-86,66	-86,97	-85,02							
FDD Band 28	-85,00																			
TDD Band 38	-89,00																			
TDD Band 39	-89,00																			
TDD Band 40	-89,00																			
TDD Band 41	-89,00							-88,89	-92,02	-87,74	-89,16	-90,48	-84,86							
TDD Band 42	-89,00																			
TDD Band 43	-89,00																			

Table 9: TRS RAG status of tested devices in LTE bands for head & hand use case (status: 2015)

A.1.4 Further Analysis

As part of the analysis it was noticed that there could be a perceived trend that demonstrates a difference between left hand and right hand performance. Further analysis of this trend is required to establish if this is a genuine trend or just an anomaly in the results. The TSGFM Group would like to draw attention to this as it was noted that accreditation in some regions is still limited to testing with the right hand, and therefore there could be a correlation between this and some products being optimized for performance in the right hand.

The sample of measured product is too small to establish if this trend is real, but it has been noted for further study during future measurement and test campaigns carried out by GSMA.

A.2 Study on Wide Grip Hand

More and more devices with big screens (including many flagship models) are introduced to the market and there are still no requirements on devices wider than 72 mm. Therefore **CCSA** (**C**hina **C**ommunications **S**tandards **A**ssociation) made a big study with many devices with widths between 72 – 92 mm using the CTIA Wide Grip hand phantom. TRP and TIS values in BHHR (“Talk” right) and HR (“Browsing” right) modes have been measured in 2G/3G/LTE bands used in China.

The study has shown an excellent correlation between GSMA BHH requirements for PDA hand phantom and results of devices tested with Wide Grip hand phantom. The values are selected so that 80% of the devices could pass the CCSA limit. The results show that there are no obvious differences for test results between devices with widths between 72 mm and 92 mm under CTIA Wide Grip hand phantom and devices with widths below 72 mm under PDA hand phantom. So the limit values can stay unchanged with the test of the PDA hand phantom.

Band(Test Scenario)	TRP(80%)	TRP(TS.24)	TIS(80%)	TIS(TS.24)
GSM 900 (BHHR)	17	20	-93	-95
GSM1800(BHHR)	19	21	-97	-99
WCDMA Band 1(BHHR)	13.5	15	-100	-101
LTE Band 3 (HR)	15.5	15.5	-91	-91
LTE Band 38 (HR)	15	15.5	-86	-91
LTE Band 39 (HR)	16	15.5	-88	-91
LTE Band 40 (HR)	15	15.5	-86	-91
LTE Band 41 (HR)	14.5	15.5	-85	-91

Table 10: Test results of devices with widths between 72 mm and 92 mm under CTIA Wide Grip hand phantom in comparison to TS.24 limits from the CCSA (status: 2017)

Annex B Document Management

B.1 Document History

Version	Date	Brief Description of Change	Approval Authority	Editor / Company
V1.0	14 May 2013	Published on GSM world	TSG	Katrin Jordan, DT
V2.0	Feb 2014	Updated scope, references, requirements and added performance values for Free Space and Browsing.	TSG	Katrin Jordan, DT
V3.0	Sept. 2015	Performance values for LTE and Annex A added	TSG	Xiaolong Zhou, China Unicom Abbas Alpaslan, Vodafone
V4.0	February 2019	Clarifying the requirements for devices wider than 72mm	TSG	Xiaolong Zhou, China Unicom Abbas Alpaslan, Vodafone Momar Goumballe, Orange

Other Information

Type	Description
Document Owner	This document is owned and approved by TSG Full Members

It is our intention to provide a quality product for your use. If you find any errors or omissions, please contact us with your comments. You may notify us at prd@gsma.com.

Your comments or suggestions & questions are always welcome.