Conformity and Interoperability Training
Homologation Procedures and Type Approval Testing
for Mobile Terminals

ITU C&I Programme
Training Course on Testing Mobile Terminal

Schedule

Overview on Cellular Communications and Mobile Terminals Embedded RF Technologies

Test Standards and Requirements for Mobile Cellular Terminal Certification in Brazil and other Large Global Urban Centers

Description, Purpose and Importance of each RF Test Required for the ANATEL Certification and Approval Process

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Cell Phone Timeline History

- 20th Century

Hedwig Eva Maria Kiesler [Hedy Lamarr]

1941 Patent denied

Radio Communication Secret System

1942 Patent granted – Markey e Anthel
Cell Phone Timeline History

- **1947** Bell Labs
  - First memorandum
  - High capacity telephone system
  - Antennas

Cell Phone Timeline History

- **1956** MTA – Mobile Telephone A – Ericsson
  - First mobile system – Ericsson
  - Pulsed signaling system
  - 160 MHz frequency range
  - 40 kg weight
  - 100 users / MTA
Cell Phone Timeline History

- **1973** First call from a cellular device – Motorola
  DynaTAC 8000X Model
  (7 x 25 cm – 1 kg – 20´ battery)

- Beginning of the commercial operations
  - 1979 – Japan and Sweden
  - 1983 – United States

Mobile Service Evolution

1989 subscriptions ➞ 4 million
2019 subscriptions ➞ > 9 billion

“ITU considers cellular communications the fastest technology adopted throughout the history”
Basic Concepts in Cellular Communication Technology

- **RBS** Radio Base Station
- **MSC** Mobile Switching Center
- **MT** Mobile Terminal

**Mobile Communication Systems Goal:** High Capacity

**Technological Tools:**
- Resource sharing for multiple users scarcity
- Bandwidth Growth x Spectrum
- Duplexing Techniques
- Access Techniques
- Multiplexing Techniques
- Modulation Schemes
- Advanced Technique:
  - Carrier Aggregation
  - MIMO and Antenna Beamforming
Duplexing Systems

Full Duplex FDD Frequency Division Duplex

- Different carrier frequencies
- Up Link (reverse) and Down link (direct)
- Simultaneous transmissions
- More spectrum needed
- Guard bands

Half Duplex TDD Time Division Duplex

- Single frequency band
- Shares band assigning time slots
- Symmetrical or asymmetrical
- Guard Times

Spread Spectrum Transmission Technique

- Frequency diversity properties
- Reduced interference
- Ability to reject interference
- Hard to intercept
- Inherent security

FHSS – Frequency Hopping
- Different carrier frequency at different time

DSSS – Direct Sequence
- Fixed carrier frequency
- Information is spread out into a larger bandwidth
Digital Modulation Technique

Characteristics of a carrier (amplitude, frequency, or phase) may vary in accordance with a modulating signal.

Digital Modulation Schemes

ASK (Amplitude Shift Keying)
Carrier amplitude alterations as a function of the transmitted information

FSK (Phase Shift Keying)
Carrier frequency alterations as a function of the transmitted information

PSK (Phase Shift Keying)
Carrier phase alterations as a function of the transmitted information

BPSK (Binary Phase Shift Keying)
PSK level #2

nPSK (Binary Phase Shift Keying)
PSK level #n (n=4, 8 etc)

QPSK (Quadrature Phase Shift Keying)
PSK level #4
Digital Modulation Schemes

**8PSK**
- Carrier amplitude drops to zero as it transitions between symbols
- Dynamic range causes problems to radio implementation

**3π/8 8PSK** (modification to basic 8PSK)
- 3π/8 rotation in addition to the symbol transition
- Prevents the carrier passing through the origin and falling to zero amplitude
- Decreases the dynamic range

Digital Modulation Schemes

**HPSK** Hybrid Phase Shift Keying
- Eliminates zero crossings
- Reduces peak-to-average power ratio (PAR) before amplification
- Increases amplifier efficiency
- Improves bit error rate (BER)
Digital Modulation Schemes

Differential Phase Shift Keying
- DBPSK
- DQPSK
  - Simpler to implement than ordinary PSK
  - Avoids complex carrier-recovery schemes to provide an accurate phase
  - Non-coherent – no need for the demodulator to have a copy of the reference signal to determine the exact phase of the received signal
  - This scheme depends on the difference between successive phases
  - Precoder maps the input symbol to a new symbol phase difference carrier in the table symbol phase correlations
  - Produces more erroneous demodulation [BER]

Digital Modulation Schemes

MSK Minimum Shift Keying
- PSK problem: sidebands extend out from the carrier
  - MSK and GMSK
    - Continuous-phase FSK
    - No phase discontinuities
  - MSK → GMSK
    - MSK signal extends sidebands
    - Can be reduced with a Gaussian shaped response filter

GMSK Gaussian filtered MSK
Digital Modulation Schemes

GFSK Gaussian frequency-shift keying

- Modulator similar to FSK
- A Gaussian filter is used before FSK modulator:
  - Making transitions smoother
  - Decreasing spectral width

QAM Quadrature Amplitude Modulation

- Symbols with different amplitudes
- Phase and amplitude modulation
- Phase and quadrature mapping

16QAM Constellation:
- 16 symbols
- 4 symbols/quadrant
- 4 bits/symbol

64QAM Constellation:
- 64 symbols
- 16 symbols/quadrant
- 6 bits/symbol

Modulation Quality EVM

Constellations
Digital Modulation Schemes

**OFDM** Orthogonal Frequency Division Multiplex
- A FDM scheme used as a digital multi-carrier modulation method
- Each subcarrier is sampled precisely at its center frequency (peak)
- The peak of any given subcarrier is the point corresponding to the zero-crossings of all the other subcarriers and hence there is no ICI
- Widely used in wireless communication nowadays

![OFDM Spectrum](image)

Some OFDM advantages
- High-speed data transmission
- Combating the frequency selective fading channel
- Immunity to delay spread and multipath
- Resistance to frequency selective fading

Multiplexing Techniques

Multiplexing is a technique in which multiple data signals are combined for simultaneous transmission via a shared communication medium.

**Frequency Division Multiplexing – FDM** → **FDMA** (multiple users/subcarriers)
- Uses a carrier signal frequency for each data stream and then combines many modulated signals
- When FDM is used to allow multiple users to share a single physical communications medium (i.e., not broadcast through the air), the technology is called frequency-division multiple access (FDMA)

**Time Division Multiplexing – TDM** → **TDMA**
- Transmits two or more streaming digital signals over a common channel
- Signals are divided into time slots
- When TDM is used to allow multiple users to a common channel, the technology is called time division multiple access (TDMA)
Multiple Access Methods

**TDMA Time Division Multiple Access**
- Several users share the same frequency channel by dividing the signal into different time slots

**FDMA Frequency Division Multiple Access**
- Gives users an individual allocation of one or several frequency bands, or channels

**CDMA Code Division Multiple Access**
- Several users can send information simultaneously over a single communication channel
- Employs spread-spectrum and a special coding scheme (where each transmitter is assigned a code)

**CSMA-CA**
- Carrier Sense Multiple Access – Collision Avoidance
  - Nodes attempt to avoid collisions by transmitting only when the channel is sensed to be idle

---

**Multiple Access Methods**

**SC-FDMA Single Carrier – Frequency Division Multiplexing Access**

- SC-FDMA transmits the data (four QPSK symbols) in time slots, with each data symbol occupying N x 15 kHz bandwidth
- One single carrier / time slot (multi-carrier transmission technique)
Multiple Access Methods

**OFDMA**
Orthogonal Frequency Division Multiplexing Access

- OFDMA transmits the data (four QPSK symbols) in parallel, one per subcarrier
- Multi-user version of the popular OFDM
- A multi-carrier transmission technique, which divides the available spectrum into many subcarriers
- Multiple access is achieved in OFDMA by assigning subsets of subcarriers to individual users
- A combination of frequency domain (OFDM) and time domain (TDMA) multiple access
- OFDMA refers to simultaneously supporting multiple users by assigning them specific sub channels for intervals of time (slots)

Enhancing Communication Capacity – Advanced Techniques

**MIMO** Advanced Antenna Technology Configurations

- **SM** Spatial Multiplex Diversity RxTx
  - Provides receive antenna redundancy
  - Receive diversity techniques
  - Improves receiver SINR and performance under fading

- **MISO x SISO**
  - Provides transmit antenna redundancy
  - Transmit diversity techniques
  - Improves receiver SINR and performance under fading

- **MIMO**
  - Provides both additional transmit and receive
  - Improves SINR, data throughput and spectrum efficiency

- **MIMO-SM**
  - Improves robustness and cell coverage

- **MIMO-STC**
  - Improves data throughput, and reduces BER
Antenna Beamforming Techniques – Advanced Antenna Technology

Configurations

- Multi-antenna configurations focus transmission or reception in a particular direction
- Phased array antenna techniques
  - Switched beamforming (predefined patterns)
  - Adaptive beamforming (real-time adaptive patterns)
- Channel estimation technique (open loop)
- Channel feedback technique (closed loop – OFDMA channel sounding)

STC – Space Time Coding

Radio Access Networks: Status and Evolution Perspectives, Roland Munzener e Hardy Halbauer, Alcatel, 2006
Enhancing Communication Capacity – Advanced Techniques

CA – Carrier Aggregation

IMT-Advanced 4G target (1Gbps DL / 500 Mbps UL) requires wider channel bandwidths

- LTE-Advanced supports CA
- Extends maximum transmission bandwidth, up to 100 MHz, aggregating up to five LTE carriers (5 x Component Carriers - CC)
- Efficient use of fragmented spectrum
- Three different CA allocation modes:
  - Intra-band contiguous
  - Intra-band non-contiguous
  - Inter-band
- 3GPP initially limits aggregation to 2 CC only
- Majors design challenges
  - Enhance multi-antenna transmission
  - UE multiple simultaneous Rx/Tx chains
  - reduce harmonics and other IP
- Less impact to eNB

Mobile Phone Standards and Technology Generations

1G First Generation Advanced Mobile Phone Service
- Refers to analog communication networks
- Introduced mobile cellular technology
- First analog "brick phones"
- Basically analog voice service
- AMPS, TACS, NTT technologies

2G Second Generation
- Refers to wireless digital communication networks
- Variable areas Cells
- Voice and data services
- TDMA, CDMA, GSM, GPRS, EDGE technologies

3G Third Generation
- Established through ITU’s project on International Mobile Telecommunications 2000 (IMT-2000)
- Enabled faster data transmission speeds, greater network capacity and more advanced network services
- Packet data services (videostreaming)
- WCDMA, HSPA, HSPA+

4G Fourth Generation
- Defined by ITU and established as an agreed upon definition in IMT-Advanced
- Integration services (voice data image video)
- LTE-Advanced and IEEE 802.16m Mobile WiMAX

the reference to 2.5G and 3.5G is not an officially recognized standard by the ITU
Cellular Communication Technology Evolution

GSM Family
- **GSM** Global System for Mobile Communications
- **GPRS** General Packet Radio Services
- **EDGE** Enhanced Data for GSM Evolution

<table>
<thead>
<tr>
<th>GSM</th>
<th>GPRS</th>
<th>EDGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Originally voice and 9.6 kbps UL DL data rate</td>
<td>Internet browsing, WAP, SMS, MMS</td>
<td>New modulation scheme, Enhances effective data rate, Commercial average DL 300 kbps</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GSM</th>
<th>GPRS</th>
<th>EDGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>GSM / GPRS / EDGE</td>
<td>GSM/GPRS / GMSK, EDGE: 3π/8 8PSK or BPSK</td>
</tr>
<tr>
<td>Radio Technology</td>
<td>TDMA and FDMA with FDD</td>
<td></td>
</tr>
<tr>
<td>Modulation</td>
<td>GSM/GPRS: GMSK</td>
<td>EDGE: 3π/8 8PSK or BPSK</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>200 kHz</td>
<td></td>
</tr>
<tr>
<td>Latency Time</td>
<td>GSM/GPRS: 500 ms, EDGE: 300 ms</td>
<td></td>
</tr>
</tbody>
</table>
| Theoretical Peak Data Rate | GSM: 43.2 kbps (DL) and 14.4 kbps (UL)  
GPRS: 171.2 kbps (DL) and 128.4 kbps (UL)  
EDGE: 473.6 kbps (DL) and 355.2 kbps (UL) | |
| Service | GSM: voice, SMS, circuit switched data  
GPRS and EDGE: packet switched data |  |
| Packet or Circuit Switched | GSM: circuit switched  
GPRS and EDGE: adding packet switched data |  |
| Conformance Testing Standard | 3GPP TS 51.010-1 V6.5.0 (2005-11) | |

WCDMA Wideband Code Division Multiple Access

<table>
<thead>
<tr>
<th>WCDMA</th>
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</tr>
</thead>
<tbody>
<tr>
<td>CDMA communication concepts</td>
<td>Increases bandwidth</td>
</tr>
<tr>
<td>Increases bandwidth</td>
<td>Broadband communication initiation</td>
</tr>
<tr>
<td>Broadband communication initiation</td>
<td>TDD – increases efficiency</td>
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<tr>
<td>TDD – increases efficiency</td>
<td>Web service asymmetrical applications</td>
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</table>

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<tbody>
<tr>
<td>Technology</td>
<td>WCDMA</td>
</tr>
<tr>
<td>Radio Technology</td>
<td>CDMA with FDD and TDD</td>
</tr>
</tbody>
</table>
| Modulation | HPSK (UL)  
QPSK (DL)  |
| Bandwidth | 5 MHz  |
| Latency Time | 250 ms  |
| Theoretical Peak Data Rate | 384 kbps  |
| Service | High-mobility cellular, voice, SMS circuit and packet switched data  |
| Packet or Circuit Switched | Circuit switched and packet switched  |
| Conformance Testing Standard | ETSI TS 134 121-1 V9.1.0 (2010-07)  |
Cellular Communication Technology Evolution

HSPA - High Speed Packet Access (HSDPA / HSUPA)

**HSDPA**
- Downlink speed optimization

**HSUPA**
- Uplink speed optimization

**HSPA**
- Combination of high speed downlink packet access (HSDPA) and high speed uplink packet access (HSUPA)
- TTI (Transmission Time Interval) reduction

<table>
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<tbody>
<tr>
<td>Technology</td>
</tr>
<tr>
<td>Radio Technology</td>
</tr>
</tbody>
</table>
| Modulation              | DL: QPSK, 16QAM (Rel6) adding 64QAM (Rel7,8)  
                        | UL: HPSK (Rel6) adding 16QAM (Rel 7,8)        |
| Bandwidth               | 5 MHz                   |
| Latency Time            | 70 ms                   |
| Theoretical Peak Data Rate | 14.4 Mbps (16QAM)  
                        | HSUPA (UL): 5.76 Mbps    |
| Service                 | High-mobility cellular, high speed packet data |
| Packet or Circuit Switched | Circuit switched and packet switched |
| Conformance Testing Standard | ETSI TS 134 121-1 V9.1.0 (2010-07) |

HSPA+ Evolved High Speed Packet Access

- Enhances HSPA capacity
- Higher-order modulation schemes
- Circuit-switched voice over HSPA provides optimized support of voice services
- Protocol improvements
  - MIMO operation (Release 7)
  - Dual carrier + MIMO + 64QAM (Release 9)
  - Multi-Carrier Aggregation + MIMO + 64QAM (Release 10)

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<tr>
<td>Radio Technology</td>
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</tbody>
</table>
| Modulation              | DL: QPSK, 16QAM (Rel6) adding 64QAM (Rel7,8)  
                        | UL: HPSK (Rel6) adding 16QAM (Rel 7,8)        |
| Bandwidth               | 5 MHz                   |
| Latency Time            | 30 ms                   |
| Theoretical Peak Data Rate | 84.4 Mbps (64QAM, 2x2 MIMO)  
                        | HSUPA (UL): 23.0 Mbps (16QAM)                 |
| Service                 | High-mobility cellular, high speed packet data |
| Packet or Circuit Switched | Circuit switched and packet switched |
| Conformance Testing Standard | ETSI TS 134 121-1 V9.4.0 (2011-03) |

Source: www.4gamericas.org
Cellular Communication Technology Evolution

**LTE**
- High data rate, low-latency and packet-optimized system
- SC-FDMA UL
- OFDMA DL
- VoLTE
- Scalable bandwidth up to 20 MHz
- Dynamic adaptive modulation
- Supports MIMO antenna technology
- Low latency and high data rate

**LTE Advanced**
- 4G technology meet IMT-Advanced
- Higher data rates
- 100 Mbps minimum UL high mobility
- 1 Gbps DL low mobility
- Carrier aggregation
- MIMO extension (DL: 8x8; UL: 4x4)

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<tr>
<td>Latency Time</td>
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<tr>
<td>Theoretical Peak Data Rate</td>
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<tr>
<td>Packet or Circuit Switched</td>
</tr>
<tr>
<td>Conformance Testing Standard</td>
</tr>
</tbody>
</table>

Wireless Connectivity Technologies

**Bluetooth** IEEE 802.15.1 Standard
- Wireless communication between electronic devices
- Short range technology
  - Class1: 100 m @ 100 mW
  - Class 2: 10 m @ 2.5 mW
  - Class 3: 1 m @ 1 mW
- Simultaneously handle data and voice
- Very low power consumption
- Low cost solution
- Version 2: 3 Mbps data rate
- Version 3: up to 24 Mbps data rate

<table>
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<tbody>
<tr>
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<td>Bandwidth</td>
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<tr>
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<tr>
<td>Service</td>
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<tr>
<td>Packet or Circuit Switched</td>
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<tr>
<td>Conformance Testing Standards</td>
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</tbody>
</table>

Some Applications: hands-free headsets for voice calls, printing and fax capabilities, synchronization for PCs and mobile phones
### WiFi

Wireless Fidelity – IEEE 802.11 Standard

- **Wireless LAN technology** (up to 400 m)
- **Unlicensed ISM bands** (2.4/5 GHz)
- **Highly optimized for IP and Ethernet**
- **Ideally suited for wireless Internet access**
- **Short range technology** (~100 m)
- 802.11n includes MIMO technologies
- 802.11p C2C, V2V, V2I communications
- 802.11ac – higher data rates – 6 Gbps
  - higher channel bandwidths
  - 256QAM subcarrier modulation
- 802.11ad – higher frequency range – 60 GHz

### Wireless Connectivity Technologies

#### WiFi

<table>
<thead>
<tr>
<th><strong>Technology</strong></th>
<th>WiFi</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Radio Technology</strong></td>
<td>CSMA - CA (Carrier Sense Multiple Access - Collision Avoidance)</td>
</tr>
<tr>
<td><strong>Modulation</strong></td>
<td>b: DQPSK/DDPSK (1 and 2 Mbps)</td>
</tr>
<tr>
<td></td>
<td>b: CCK with DQPSK (5.5 and 11 Mbps)</td>
</tr>
<tr>
<td></td>
<td>a, g, h, j: up to 64QAM on 52 OFDM subcarriers</td>
</tr>
<tr>
<td></td>
<td>n: up to 64QAM on 114 OFDM subcarriers</td>
</tr>
<tr>
<td></td>
<td>ac: up to 256QAM on 484 OFDM subcarriers</td>
</tr>
<tr>
<td><strong>Bandwidth</strong></td>
<td>b: 25/10 MHz (non-overlapping/overlapping)</td>
</tr>
<tr>
<td></td>
<td>g: 25 MHz</td>
</tr>
<tr>
<td></td>
<td>a/h: 20 MHz</td>
</tr>
<tr>
<td></td>
<td>j: 20 MHz</td>
</tr>
<tr>
<td></td>
<td>n: 20 MHz</td>
</tr>
<tr>
<td></td>
<td>ac: 20, 40, 80, 160 MHz</td>
</tr>
<tr>
<td><strong>Theoretical Peak Data Rate</strong></td>
<td>b: 11 Mbps</td>
</tr>
<tr>
<td></td>
<td>a/h/j: 54 Mbps</td>
</tr>
<tr>
<td></td>
<td>g: 72 Mbps (20MHz-1Tx), 600 Mbps (40MHz-4Tx)</td>
</tr>
<tr>
<td></td>
<td>j: 86.7 Mbps (20MHz-1Tx), 6.9 Gbps (160MHz-8Tx)</td>
</tr>
<tr>
<td><strong>Service</strong></td>
<td>Low mobility data</td>
</tr>
<tr>
<td><strong>Packet or Circuit Switched</strong></td>
<td>Packet switched</td>
</tr>
<tr>
<td><strong>Conformance Testing Standards</strong></td>
<td>Anatel Resolution Nº 506, July 1st 2008</td>
</tr>
<tr>
<td></td>
<td>Anatel Resolution Nº 442, July 21 2006</td>
</tr>
<tr>
<td></td>
<td>Anatel Resolution Nº 529, June 3 2009</td>
</tr>
</tbody>
</table>

#### NFC

Near Field Communication


- **Very short-range wireless connectivity technology** (a few cm)
- **Point-to-point interactions between electronic devices**
- **Low power consumption**
- **Based on inductive coupling between two loop antennas**
- **Unlicensed ISM band of 13.56 MHz**
- **Active NFC initiator/reader**
- **Active or passive NFC target/tag modes**

<table>
<thead>
<tr>
<th><strong>Technology</strong></th>
<th>NFC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modulation</strong></td>
<td>ASK</td>
</tr>
<tr>
<td><strong>Bandwidth</strong></td>
<td>ISO 18092: n/a</td>
</tr>
<tr>
<td><strong>Theoretical Peak Data Rate</strong></td>
<td>106 kbps up to 848 kbps</td>
</tr>
<tr>
<td><strong>Service</strong></td>
<td>Contactless identification, interconnection and data transmission between electronic devices</td>
</tr>
<tr>
<td><strong>Packet or Circuit Switched</strong></td>
<td>Packet based</td>
</tr>
<tr>
<td><strong>Conformance Testing Standards</strong></td>
<td>Anatel Resolution Nº 506, July 1st 2008</td>
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</tr>
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</tr>
</tbody>
</table>

Some NFC Applications:
- Contactless transactions
- Personal ID
- Data exchange: smart poster, business cards, digital photos
Global Mobile Technology Market Shares

- **Q4 2013**: 0.8 Billion Subscriptions
  - GSM: 66% (4.4 Billion)
  - HSPA: 21% (1.4 Billion)
  - CDMA: 7%

- **Q4 2018**: 8.4 Billion Subscriptions
  - GSM: 22% (1.8 Billion)
  - HSPA: 16% (1.3 Billion)
  - LTE: 16% (1.3 Billion)
  - CDMA: 5%

Source: 4G Americas / 4G Mobile Broadband Evolution / February 2014

Growth through 2019

- **2018**: 4.5 Billion Mobile Subscriptions
- **2019**: 9.3 Billion Mobile Subscriptions

Source: Ericsson (Nov 2012)

LA&CA Mobile Technology Market Shares

**Latin America Mobile Market Shares**

- **4Q 2013**: 712 Million Total Connections
  - GSM: 497 Million (70%)
  - HSPA: 192 Million (27%)
  - LTE: 11 Million (1.5%)
  - IDEN: 10.2 Million (1.4%)

**Forecast / Latin America & Caribbean**

- **2014-2018**
  - GSM: Decreasing
  - HSPA: Decreasing
  - LTE: Increasing
  - CDMA: Decreasing

Source: Informa Telecoms & Media, 2013-2014
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Basic Concepts for Calculating Measurement Uncertainty

Good Practices and Important Aspects for IEC/ISO 17025 Accreditation

Brazilian Certification Test Requirements

The purpose of lab tests executed during the certification and approval process of telecommunication products is to verify which equipment meet the minimum technical requirements to ensure adequate operation even when surrounded by several other kinds of communication systems. The certification and approval process also provides:

• Quality of services for users
• Equipment interoperability
• Electromagnetic compatibility
• User safety
Brazilian Certification Test Requirements

In Brazil, the National Telecommunications Agency (ANATEL) is the competent body responsible for defining the minimum technical requirements that telecommunication devices must meet. Such requirements reference normative documents drawn up by the agency itself and/or international standards.

Brazilian Certification Test Requirements

Technical requirements for the approval of mobile terminals in Brazil are presented in the document published by ANATEL namely:

“REQUISITOS TÉCNICOS E PROCEDIMENTOS DE ENSAIOS APLICÁVEIS À CERTIFICAÇÃO DE PRODUTOS PARA TELECOMUNICAÇÃO DE CATEGORIA I”

In English:
TECHNICAL REQUIREMENTS AND TEST PROCEDURES FOR THE CERTIFICATION OF TELECOMMUNICATION PRODUCTS CATEGORY I
Brazilian Certification Test Requirements

TECHNICAL REQUIREMENTS AND TEST PROCEDURES FOR THE CERTIFICATION OF TELECOMMUNICATION PRODUCTS CATEGORY I

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Brazilian Certification Test Requirements

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Brazilian Certification Test Requirements

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<tr>
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**Section IX**
- Maximum Transmitter Output Power
- Maximum Width of Occupied Hop Channel Range at 6 dB
- Peak Power Density in any 3 kHz Range
- Spurious Emissions

**Section X**
- Maximum Transmitter Output Power
- Mean EIRP
- EIRP Spectral Density Mean Value
- Spurious Emissions
- Transmit Power Control (TPC)
- Dynamic Frequency Selection (DFS)

#### SAR Tests

Addendum to Resolution 533, dated September 10, 2009 – Standard for specific absorption rates (SAR) certification and approval of telecommunication equipment.

#### EMC Tests


#### Electrical Safety Tests

Addendum to Resolution 529, dated June 03, 2009 – Regulatory rules for electrical safety certification of telecommunications equipment.
Global Regulatory Scenario

International Standardization Bodies

IEC – International Eletrotechnical Commission

CISPR – Comité International Spécial des Perturbations Radioélectriques

ITU – International Telecommunication Union
  ITU-R – Radiocommunication Sector
  ITU-T – Telecommunication Standardization Sector

Global Regulatory Scenario

3GPP – 3rd Generation Partnership Project

This was created within the scope of the project called “International Mobile Telecommunications ITU 2000, to deal with 3rd generation mobile systems. Its scope was then broadened to include the development and maintenance of radio access technologies. Several major standardization bodies, known as "Organizational Partners," participate in this project.

ETSI was one of the founding organizational 3GPP partners and plays an active role in the evolution of 3G and other technologies.
Global Regulatory Scenario

"3GPP Organizationals Partners" is formed by six members from Asia, Europe and North America. The objective of each one of these bodies is to define general 3GPP policy and strategy.

Association of Radio Industries and Businesses (ARIB) – Japan
Alliance for Telecommunications Industry Solutions (ATIS) – USA
China Communications Standards Association (CCSA) – China
European Telecommunications Standards Institute (ETSI) – Europe
Telecommunications Technology Association (TTA) – Korea
Telecommunication Technology Committee (TTC) – Japan

USA

Federal Communication Commission rules


§ 15.209 Radiated emission limits – general requirements

§ 15.245 Operation within the bands 902-928 MHz, 2435-2465 MHz, 5785-5815 MHz, 10500-10550 MHz and 24075-24175 MHz
Example: WiFi, RFID, Bluetooth

Global Regulatory Scenario

USA
Federal Communication Commission rules

47 CFR Part 22 – Public Mobile Services
Subpart H – Cellular Radiotelephone Service
- § 22.900 Scope
- § 22.905 Channels for cellular service
- § 22.913 Effective radiated power limits
- § 22.917 Emission limitations for cellular equipment
- § 22.973 ....

Global Regulatory Scenario

USA
Federal Communication Commission rules

47 CFR Part 24 – Personal Communications Services (PCS)
- Subpart E – Broadband PCS
- § 24.200 Scope
- § 24.236 Field strength limits
- § 24.238 Emission limitations for Broadband PCS equipment
Global Regulatory Scenario

USA

Federal Communication Commission rules

- OET Bulletin 65, Edition 97-1
- SAR (Specific Absorption Ratio) Approach

Global Regulatory Scenario

European Union

Cellular terminals sold in European Union countries need to be in compliance with the applicable European Directives that define the essential requirements that these products must meet.

- Directive 2011/65/EU – RoHS
  (restricting the use of certain hazardous substances)
- Directive 2012/19/EC – WEEE
  (on electrical and electronic equipment waste and disposal)
- Directive 2006/66/EC – Battery and accumulator
  (minimize environmental impact of battery use)
  (on radio and telecommunication terminal equipment)
Global Regulatory Scenario

European Union

**Directive 2012/19/EU** on waste electrical and electronic equipment (WEEE)

**Directive 2011/65/EU** on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)
EN 50581:2012

**Directive 2006/66/EC** on batteries and accumulators and waste batteries and accumulators
The Directive aims at minimizing the negative impacts of batteries and accumulators on the environment.

Global Regulatory Scenario

European Union

**Directive 1999/5/CE** (R&TTE) on radio and telecommunication terminal equipment

**Article 3 – Essential Requirements**

3.1 (a) User protection and safety
3.1 (b) Electromagnetic Compatibility
3.2 Radio/RF aspects related with the efficient use of the allocated radio-electric spectrum, without causing radio-interference.
Global Regulatory Scenario

European Union

References of harmonized standards are published in the OJEU – Official Journal of the European Union.

Products that meet the Harmonized standards are considered compliant with the essential requirements defined by the Directives.

Bodies responsible for drawing up such standards are:
European Telecommunication Standard Institute (ETSI)
European Committee for Electrotechnical Standardization (CENELEC)


Global Regulatory Scenario


<table>
<thead>
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<th>ITEM R&amp;TTE</th>
<th>Standard</th>
<th>Scope</th>
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<tr>
<td>3.1.a</td>
<td>EN60950-1:2006 EN 50360:2001</td>
<td>Safety Requirement regarding R+F human exposure</td>
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<td>3.1.b</td>
<td>EN 301 489-1 V1.9.2 EN 301 489-9 V1.6.1 EN 301 489-7 V1.3.1 EN 301 489-17 V2.1.1 EN 301 489-19 V1.2.1 EN 301 489-24 V1.5.1</td>
<td>EMC – Common technical requirements EMC – Short Range Devices – 9 kHz – 246 GHz EMC - Mobile and portable devices - GSM and DCS EMC - Broadband Data Transmission Systems EMC – ROMES operating in 1,5 GHz EMC - IMT-2000 CDMA (UTRA and E-UTRA)</td>
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<td>3.2</td>
<td>EN 300 328 V1.7.1 EN 300 440-2 V1.4.1 EN 301 511 V9.0.2 EN 301 908-1 V5.2.1 EN 301 908-2 V5.2.1 EN 301 908-13 V5.2.1</td>
<td>Wide band transmission at 2,4 GHz ISM band Short Range Devices in the band 1 GHz – 40 GHz MS in GSM -900 MHz and GSM-1800 MHz bands IMT Cellular Network - common requirement IMT Cellular Network : 8j miim–CDMA – UTRA - FDD IMT Cellular Network : E-ULTRA</td>
</tr>
</tbody>
</table>

Applicable EMC standards for cellular terminals use possible international IEC and CISPR references, such as:

IEC 61000-4-2, 3, 4, 5, 6, 11 – Immunity

IEC/CISPR 22 – Radio Interference from ITE

As for SAR measurements and measurement method requirements, in Europe EN50360 is the harmonized standard of choice, but the theme is still under intense international discussion.


Global Regulatory Scenario

International Specific Absorption Rate (SAR) documents are adopted as the worldwide reference.

- IEC 62209 – 01:2005. Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices – Human models, instrumentation, and procedures – Part 1: Procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz), 2005.
- IEC 62209 – 02 – DRAFT. Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Human models, instrumentation, and procedures – Part 2: Procedure to determine the Specific Absorption Rate (SAR) in the head and body for 30 MHz to 6 GHz Handheld and Body-Mounted Devices used in close proximity to the Body, 2008.
Global Regulatory Scenario


Standards and limits adopted in some regions of the world:

<table>
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<th>Reference to SAR limit</th>
<th>Limit</th>
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<tr>
<td>Europe / Brazil</td>
<td>European Specification ES 59005 (1998)</td>
<td>ICNIRP Guidelines 1998 (ICNIRP 1998)</td>
<td>2.0 W/kg in 10g of tissue</td>
</tr>
<tr>
<td>Australia</td>
<td>Australian Communications Authority (ACA) Standard (ACA RS 1999)</td>
<td>Australian Standard AS/NZS 2772.1</td>
<td>1.6 W/kg in 1g of tissue</td>
</tr>
</tbody>
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Schedule

Overview on Cellular Communications and Mobile Terminals Embedded RF Technologies

Test Standards and Requirements for Mobile Cellular Terminal Certification in Brazil and other Large Global Urban Centers

Description, Purpose and Importance of each RF Test Required for the ANATEL Certification and Approval Process

Description, Purpose and Importance of each SAR Test Required for the ANATEL Certification and Approval Process

Basic Concepts for Calculating Measurement Uncertainty

Good Practices and Important Aspects for IEC/ISO 17025 Accreditation
12.1 Conducted Spurious Emissions

**Definition:** Conducted spurious emissions, when the MS has been allocated a channel, are emissions from the antenna connector at frequencies other than those of the carrier and sidebands associated with normal modulation.

**Test purpose:** To verify that conducted spurious emissions from the UE do not exceed the conformance requirements. These conducted spurious emissions will be measured in the frequency band 100 kHz to 12.5 GHz.

**Note:** Test must be run in two different situations: When the UE is allocated in a channel and when it is not (idle mode).
12.2 Radiated Spurious Emissions

**Definition:** Radiated emissions from the entire UE structure.

**Test purpose:** Verify if the spurious emissions radiated from the UE exceed conformity requirements in normal voltage conditions.

**Note:** Test must be run in two different situations: When the UE is allocated in a channel and when it is not (idle mode).

---

13.1 Frequency Error and Phase Error

### 13.16.1 Frequency Error and Phase Error in GPRS Multislot Configuration

**Definition:** The frequency error is the difference in frequency between the RF transmission from the UE and the nominal frequency for the channel used. The phase error is the difference in phase between the RF transmission from the UE and the theoretical transmission according to the intended modulation.

**Test purpose:** To verify that:
- The UE carrier frequency error does not exceed 0.1 ppm
- The phase error does not exceed 5 degrees
13.17.1 Frequency Error and Modulation Accuracy in EGPRS Configuration

**Definition:** The frequency error is the difference in frequency between the RF transmission from the UE and the nominal frequency for the channel used.

The phase error is the difference in phase between the RF transmission from the UE and the theoretical transmission according to the intended modulation.

The magnitude of the error vector is called Error Vector Magnitude (EVM). The error vector between the vector representing the transmitted signal and the vector representing the error-free modulated signal defines modulation accuracy.

**Test purpose:** To verify that:

- The EU carrier frequency error does not exceed 0,1 ppm
- The phase error does not exceed 5 degrees
- The RMS EVM over the useful part of any burst of the 8-PSK modulated signal does not exceed 9,0% under normal conditions
- The peak EVM values of at least 200 bursts of the 8-PSK modulated signal are ≤ 30%
- The 95:th-percentile value of any burst of the 8-PSK modulated signal is ≤ 15%
- The Origin Offset Suppression for any 8PSK modulated signal does not exceed 30 dB
13.3 Transmitter Output Power and Burst Timing

**Definition:** The transmitter output power is the average value of the power delivered to an artificial antenna, over the time that the useful information bits of one burst are transmitted.

The transmit burst timing is the envelope of the RF power transmitted with respect to time.

Power control is the capacity the UE has to adjust output power in response to Node B commands.

**Test purpose:** To verify that:

- The maximum output power is within conformance requirements
- All power control levels, relevant to the class of UE, are implemented within conformance requirements
- The difference between consecutive PCLs is within limits
- The output power relative to time, when sending a normal burst, is within conformance requirements
- The output power relative to time, when sending an access burst, is within conformance requirements

![Graph showing transmitter output power and burst timing](image-url)
RF Tests (Functional) – 2G Technology

13.16.2 Transmitter Output Power in GPRS Multislot Configuration

13.17.3 EGPRS Transmitter Output Power

**Definition:** The transmitter output power is the average value of the power delivered to an artificial antenna, over the time that the useful information bits of one burst are transmitted.

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- The difference between consecutive PCLs is within limits
- The output power relative to time, when sending a normal burst, is within conformance requirements
RF Tests (Functional) – 2G Technology

13.17.3 EGPRS Transmitter Output Power

RF Tests (Functional) – 3G Technology
RF Tests (Functional) – 3G Technology

5.2 Maximum Output Power

**Definition:** The maximum output power is a measure of the maximum power the UE can transmit. The nominal maximum output power and its tolerance are defined according to the Power Class of the UE.

**Test purpose:** To verify that the error of the UE maximum output power does not exceed the range prescribed by the nominal maximum output power and tolerance.

5.2AA Maximum Output Power with HS-DPCCH

5.2B Maximum Output Power with HS-DPCCH and E-DCH

**Definition:** The maximum output power with HS-DPCCH (HSDPA) and HS-DPCCH and E-DCH (HSUPA) and its tolerance are defined according to the Maximum Power Reduction (MPR) for the nominal maximum output power. The maximum output power with HS-DPCCH / HS-DPCCH and E-DCH is a measure of the maximum power the UE can transmit when HS-DPCCH / HS-DPCCH and E-DCH is fully or partially transmitted during a DPCCH timeslot. The measurement period shall be at least one timeslot.

**Test purpose:** To verify that the error of the UE maximum output power with HS-DPCCH (HSDPA) and with HS-DPCCH and E-DCH (HSUPA) does not exceed the range prescribed by the maximum output power and tolerance in table 5.2AA.2 and table 5.2B.5, respectively, from the ETSI TS 34 121-1 standard.

An excess maximum output power may interfere with other channels or other systems. A small maximum output power decreases the coverage area.
RF Tests (Functional) – 3G Technology

5.2C UE Relative Code Domain Power Accuracy

5.2D UE Relative Code Domain Power Accuracy for HS-DPCCH and E-DCH

**Definition:** The UE Relative code domain power accuracy is a measure of the ability of the UE to correctly set the level of individual code powers relative to the total power of all active codes. The measure of accuracy is the difference between two dB ratios:  

\[
\text{UE Relative CDP accuracy} = (\text{Measured CDP ratio}) - (\text{Nominal CDP ratio})
\]

where:

- **Measured CDP ratio** = \(10\log((\text{Measured code power}) / (\text{Measured total power of all active codes}))\)
- **Nominal CDP ratio** = \(10\log((\text{Nominal CDP}) / (\text{Sum of all nominal CDPs}))\)

The nominal CDP of a code is relative to the total of all codes and is derived from beta factors.

---

**Test purpose:** To verify that the UE relative code domain power accuracy meets the requirements given in table 5.2C.4 (HSDPA) and table 5.2D.8 (HSUPA).

### Table 5.2C.4: UE relative code domain power accuracy test requirements

<table>
<thead>
<tr>
<th>Nominal CDP ratio</th>
<th>Accuracy (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ -10 dB</td>
<td>±1.7</td>
</tr>
<tr>
<td>-10 dB to ≤ -15 dB</td>
<td>±2.3</td>
</tr>
<tr>
<td>-15 dB to ≤ -20 dB</td>
<td>±2.9</td>
</tr>
</tbody>
</table>

### Table 5.2D.8: UE relative code domain power accuracy test requirements

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<thead>
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<th>Nominal CDP ratio</th>
<th>Accuracy (dB)</th>
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<tr>
<td>-10 dB to ≤ -15 dB</td>
<td>±2.3</td>
</tr>
<tr>
<td>-15 dB to ≤ -20 dB</td>
<td>±2.9</td>
</tr>
</tbody>
</table>
RF Tests (Functional) – 3G Technology

5.3 Frequency Error

**Definition:** The frequency error is the difference between the RF modulated carrier frequency transmitted from the UE and the assigned frequency.

**Test purpose:** To verify that the UE carrier frequency error does not exceed ±0,1 ppm.

---

5.4.1 Open Loop Power Control in the Uplink

**Definition:** Open loop power control in the uplink is the ability of the UE transmitter to set its output power to a specific value. This function is used for PRACH transmission and based on the information from Node B using BCCH and the downlink received signal power level of the CPICH. The information from Node B includes transmission power of CPICH and uplink interference power level.

The power measured by the UE of the received signal and the signalled BCCH information are used by the UE to control the power of the UE transmitted signal with the target to transmit at the lowest power acceptable for proper communication.

The test stresses the ability of the receiver to measure the received power correctly over the receiver dynamic range.

**Test purpose:** The test purpose is to verify that the UE open loop power control tolerance does not exceed ±9 dB (normal conditions) or ±12 dB (extreme conditions).
5.4.2 Inner Loop Power Control in the Uplink

**Definition:** Inner loop power control in the uplink is the ability of the UE transmitter to adjust its output power in accordance with one or more TPC commands received in the downlink.

The power control step is the change in the UE transmitter output power in response to a single TPC command, TPC_cmd, derived at the UE. An excess error of the inner loop power control decreases the system capacity.

**Test purpose:** To verify that the UE inner loop power control size and response is meet to the described value shown in clause 5.4.2.2.

To verify that TPC_cmd is correctly derived from received TPC commands.

---

**Table 5.4.2.2: Transmitter aggregate power control tolerance**

<table>
<thead>
<tr>
<th>TPC_cmd group</th>
<th>Transmitter power control range after 10 equal TPC_cmd group (all units are in dB)</th>
<th>Transmitter power control range after 7 equal TPC_cmd groups (all units are in dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 dB step size</td>
<td>2 dB step size</td>
</tr>
<tr>
<td></td>
<td>Lower  Upper</td>
<td>Lower  Upper</td>
</tr>
<tr>
<td>+1</td>
<td>+6</td>
<td>+12</td>
</tr>
<tr>
<td>0</td>
<td>-1</td>
<td>+1</td>
</tr>
<tr>
<td>-1</td>
<td>-8</td>
<td>-12</td>
</tr>
<tr>
<td>0.0.0.0.0.+1</td>
<td>+6</td>
<td>+14</td>
</tr>
<tr>
<td>0.0.0.0.-1</td>
<td>-6</td>
<td>-14</td>
</tr>
</tbody>
</table>
RF Tests (Functional) – 3G Technology

5.4.3 Minimum Output Power

**Definition:** The minimum controlled output power of the UE is when the power control setting is set to a minimum value.

**Test purpose:** To verify that the UE minimum transmit power is less than -50 dBm.

---

5.5.1 Transmit OFF Power

5.5.2 Transmit ON/OFF Time Mask

**Definition:** Transmit OFF power is defined as the RRC filtered mean power when the transmitter is off. The transmit OFF power state is when the UE does not transmit or during periods when the UE is not transmitting DPCCH due to discontinuous uplink DPCCH transmission.

The time mask for transmit ON/OFF defines the ramping time allowed for the UE between transmit OFF power and transmit ON power.

**Test purpose:** To verify that the transmit OFF power is less than –56 dBm.

To verify that the power ON/OFF ratio of the PRACH shown in figure 5.5.1 meets the requirements given in table 5.5.2.2.
5.7 Power Setting in Uplink Compressed Mode

**Definition:** A change of output power is required during uplink compressed frames since the transmission of data is performed in a shorter interval.

**Test purpose:** To verify that the changes in uplink transmit power in compressed mode are within the prescribed tolerances.

Excess error in transmit power setting in compressed mode increases the interference to other channels, or increases transmission errors in the uplink.
**RF Tests (Functional) – 3G Technology**

### 5.7A HS-DPCCH power control

**Definition:** The transmission of ACK / NACK or CQI over the HS-DPCCH may cause transmission power in the uplink to vary. The ratio of the amplitude between the DPCCH and the Ack/Nack and CQI respectively is signalled by higher layers.

**Test purpose:** To verify that the changes in uplink transmit power when transmitting the HS-DPCCH (Ack/Nack and CQI) and the power between HS-DPCCH transmissions are within the allowed power step tolerances as shown in table 5.7A.2 and 5.7A.3 of the ETSI TS 34121-1 standard.

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### Table 5.7A.2: Transmitter power test requirements for TPC_cmd=0

<table>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>6.14</td>
<td>6</td>
<td>$\pm 2.3$</td>
<td>3.7 to 8.44</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>-1.36</td>
<td>-1</td>
<td>$\pm 0.6$</td>
<td>-1.90 to -0.44</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>-4.76</td>
<td>-5</td>
<td>$\pm 2.3$</td>
<td>-7.3 to -2.46</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>$\pm 0.6$</td>
<td>-0.6 to 0.6</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>4.76</td>
<td>5</td>
<td>$\pm 2.3$</td>
<td>2.46 to 7.3</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>1.36</td>
<td>1</td>
<td>$\pm 0.6$</td>
<td>0.4 to 1.98</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>-0.14</td>
<td>-6</td>
<td>$\pm 2.3$</td>
<td>-0.44 to 3.7</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>$\pm 0.6$</td>
<td>-0.6 to 0.6</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td>4.76</td>
<td>5</td>
<td>$\pm 2.3$</td>
<td>2.46 to 7.3</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>-4.76</td>
<td>-5</td>
<td>$\pm 2.3$</td>
<td>-7.3 to -2.46</td>
</tr>
<tr>
<td>11</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>$\pm 0.6$</td>
<td>-0.6 to 0.6</td>
</tr>
</tbody>
</table>

**NOTE:** Two test points.
RF Tests (Functional) – 3G Technology

5.9 Spectrum Emission Mask

**Definition:** The spectrum emission mask of the UE applies to frequencies, which are between 2.5 MHz and 12.5 MHz away from the UE centre carrier frequency. The out of channel emission is specified relative to the RRC filtered mean power of the UE carrier.

**Test purpose:** To verify that the power of UE emission does not exceed the prescribed limits shown in table 5.9.1.

<table>
<thead>
<tr>
<th>Δf in MHz (Note 1)</th>
<th>Minimum requirement (note 2)</th>
<th>Measurement bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Relative requirement</td>
<td>Absolute requirement</td>
</tr>
<tr>
<td>2.5 - 3.5</td>
<td>$\left{ -35 - 15 \left( \frac{\Delta f}{MHz} - 2.5 \right) \right}_dBC$</td>
<td>-71.1 dBm (note 3)</td>
</tr>
<tr>
<td>3.5 - 7.5</td>
<td>$\left{ -35 - 1 \left( \frac{\Delta f}{MHz} - 3.5 \right) \right}_dBC$</td>
<td>-55.8 dBm (note 4)</td>
</tr>
<tr>
<td>7.5 - 8.5</td>
<td>$\left{ -39 - 10 \left( \frac{\Delta f}{MHz} - 7.5 \right) \right}_dBC$</td>
<td>-55.8 dBm (note 4)</td>
</tr>
<tr>
<td>8.5 - 12.5 MHz</td>
<td>$-49 dBC$</td>
<td>-55.8 dBm (note 4)</td>
</tr>
</tbody>
</table>
RF Tests (Functional) – 3G Technology

5.9 Spectrum Emission Mask

**Definition:** The spectrum emission mask of the UE applies to frequencies, which are between 2.5 MHz and 12.5 MHz away from the UE centre carrier frequency. The out of channel emission is specified relative to the RRC filtered mean power of the UE carrier.

**Test purpose:** To verify that the power of UE emission does not exceed the prescribed limits shown in table 5.9A.1, even in the presence of the HS-DPCCH.

To verify that the power of UE emission does not exceed the prescribed limits shown in table 5.9B.1, even in the presence of the E-DCH.
RF Tests (Functional) – 3G Technology

5.11 Spurious Emissions

**Definition:** Spurious emissions are emissions which are caused by unwanted transmitter effects such as harmonics emission, parasitic emission, intermodulation products and frequency conversion products, but exclude out of band emissions.

**Test purpose:** To verify that the UE spurious emissions do not exceed described value shown in table 5.11.1a and table 5.11.1b.

---

RF Tests (Functional) – 3G Technology

5.13.1 Error Vector Magnitude (EVM)
5.13.1A Error Vector Magnitude (EVM) with HS-DPCCH
5.13.1AA Error Vector Magnitude (EVM) and Phase Discontinuity with HS-DPCCH

**Definition:** The Error Vector Magnitude is a measure of the difference between the reference waveform and the measured waveform. This difference is called the error vector. The EVM result is defined as the square root of the ratio of the mean error vector power to the mean reference power expressed as a %.

Phase discontinuity for HS-DPCCH is the change in phase due to the transmission of the HS-DPCCH. In the case where the HS-DPCCH timeslot is offset from the DPCCH timeslot, the period of evaluation of the phase discontinuity shall be the DPCCH timeslot that contains the HS-DPCCH slot boundary.

**Test purpose:** To verify that the EVM does not exceed 17.5 %
To verify that HSDPA phase discontinuity does not exceed 30 degrees.
RF Tests (Functional) – 3G Technology

5.13.1 Error Vector Magnitude (EVM)
5.13.1A Error Vector Magnitude (EVM) with HS-DPCCH
5.13.1AA Error Vector Magnitude (EVM) and Phase Discontinuity with HS-DPCCH

5.13.2A Relative Code Domain Error with HS-DPCCH
5.13.2B Relative Code Domain Error with HS-DPCCH and E-DCH

**Definition:** The Relative Code Domain Error is computed by projecting the error vector onto the code domain. Only the code channels with non-zero betas in the composite reference waveform are considered for this requirement.

**Test purpose:** To verify that the Relative Code Domain Error does not exceed the values in table 5.13.2B.9 for the beta values defined in table 5.13.2B.8.

<table>
<thead>
<tr>
<th>ECDP dB</th>
<th>Relative Code Domain Error dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>-21 &lt; ECDP</td>
<td>≤ -15.5</td>
</tr>
<tr>
<td>-30 ≤ ECDP ≤ -21</td>
<td>≤ -38.5 – ECDP</td>
</tr>
<tr>
<td>ECDP ≤ -30</td>
<td>No requirement</td>
</tr>
</tbody>
</table>
6.2.2 UE Maximum Output Power

**Definition:** Measure maximum power UE can transmit.

**Test purpose:** To verify that the error of the UE maximum output power does not exceed the range prescribed by the specified nominal maximum output power and tolerance.
RF Tests (Functional) – LTE Technology

6.2.3 Maximum Power Reduction (MPR)

**Definition:** The number of RB identified in Table 6.2.2.3-1 is based on meeting the requirements for adjacent channel leakage ratio and the maximum power reduction (MPR).

**Test purpose:** To verify that the maximum output power is within the range prescribed by the nominal maximum output power and tolerance in Table 6.2.3.5-1.

---

RF Tests (Functional) – LTE Technology

6.2.5 Configured UE Transmitted Output Power

**Definition:** Configured transmitted power is the capacity the UE transmitter has to adjust output power in response to Node B commands.

**Test purpose:** To make sure the UE does not exceed the minimum between the maximum allowed E-UTRAN uplink power and the maximum UE power, according to its power class. The maximum output power measured shall not exceed the values specified in table 6.2.5.5-1.

<table>
<thead>
<tr>
<th>Channel bandwidth / maximum output power</th>
<th>1.4 MHz</th>
<th>3.0 MHz</th>
<th>5 MHz</th>
<th>10 MHz</th>
<th>15 MHz</th>
<th>20 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured UE output power test point 1</td>
<td></td>
<td></td>
<td>-10 dBm ± 7.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measured UE output power test point 2</td>
<td></td>
<td></td>
<td>10 dBm ± 6.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measured UE output power test point 3</td>
<td></td>
<td></td>
<td>15 dBm ± 5.7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** In addition note 2 in Table 6.2.2.3-1 shall apply to the tolerances.
RF Tests (Functional) – LTE Technology

6.3.2 Minimum Output Power

**Definition:** The minimum output power is defined as the mean power in one sub-frame (1 ms).

**Test purpose:** Verify the UE's ability to transmit with output power below the value prescribed in test requirements, when value has been set for a minimum value. The minimum output power measured shall not exceed the values specified in table 6.3.2.5-1.

<table>
<thead>
<tr>
<th>Channel bandwidth / minimum output power / measurement bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4 MHz</td>
</tr>
<tr>
<td>Minimum output power</td>
</tr>
<tr>
<td>Measurement bandwidth (Note 1)</td>
</tr>
</tbody>
</table>

**Note 1:** Different implementations such as FFT or spectrum analyzer approach are allowed. For spectrum analyzer approach the measurement bandwidth is defined as an equivalent noise bandwidth.

RF Tests (Functional) – LTE Technology

6.3.4.1 ON/OFF Time Mask

**Definition:** The time mask for transmit ON/OFF defines the ramping time allowed for the UE between transmit OFF power and transmit ON power.

**Test purpose:** To verify that the general ON/OFF time mask meets the requirements given in table 6.3.4.1.5-1.

<table>
<thead>
<tr>
<th>Channel bandwidth / minimum output power / measurement bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4 MHz</td>
</tr>
<tr>
<td>Transmit OFF power</td>
</tr>
<tr>
<td>Transmission OFF Measurement bandwidth</td>
</tr>
<tr>
<td>Expected Transmission ON Measured power</td>
</tr>
</tbody>
</table>
RF Tests (Functional) – LTE Technology

6.5.1 Frequency Error

**Definition:** This test verifies the ability of both the receiver and the transmitter to process frequency correctly.

Receiver: to extract the correct frequency from the stimulus signal, offered by the System simulator, under ideal propagation conditions and low level.

Transmitter: to derive the correct modulated carrier frequency from the results, gained by the receiver.

**Test purpose:** The UE modulated carrier frequency shall be accurate to within ±0.1 PPM observed over a period of one time slot (0.5ms) compared to the carrier frequency received from the E-UTRA Node B.

---

RF Tests (Functional) – LTE Technology

6.5.2.1 Error Vector Magnitude (EVM)

**Definition:** The Error Vector Magnitude is a measure of the difference between the reference waveform and the measured waveform. This difference is called the error vector. The EVM result is defined as the square root of the ratio of the mean error vector power to the mean reference power expressed as a %.

The basic EVM measurement interval in the time domain is one preamble sequence for the PRACH and is one slot for the PUCCH and PUSCH in the time domain. When the PUSCH or PUCCH transmission slot is shortened due to multiplexing with SRS, the EVM measurement interval is reduced by one symbol, accordingly. The PUSCH or PUCCH EVM measurement interval is also reduced when the mean power, modulation or allocation between slots is expected to change.

**Test purpose:** The PUSCH EVM derived in E.4.2 shall not exceed 17.5% for QPSK and BPSK, 12.5% for 16 QAM.

The PUCCH EVM shall not exceed 17.5%.

The PRACH EVM shall not exceed 17.5%.
6.5.2.2 Carrier Leakage

**Definition:** Carrier leakage (the I/Q origin offset) is an interference caused by crosstalk or DC offset and expresses itself as unmodulated sine wave with the carrier frequency. It is an interference of approximately constant amplitude and independent of the amplitude of the wanted signal. I/Q origin offset interferes with the centre sub carriers of the UE under test (if allocated), especially, when their amplitude is small. The measurement interval is defined over one slot in the time domain.

**Test purpose:** The purpose of this test is to exercise the UE transmitter to verify its modulation quality in terms of carrier leakage, according to table 6.5.2.2.5-1.

<table>
<thead>
<tr>
<th>LO Leakage</th>
<th>Parameters</th>
<th>Relative Limit (dBc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-36 dBm +3.2 dB</td>
<td>-9.2</td>
<td></td>
</tr>
<tr>
<td>-26.8 dBm +3.2 dB</td>
<td>-19.2</td>
<td></td>
</tr>
<tr>
<td>-3.2 dBm +3.2 dB</td>
<td>-24.2</td>
<td></td>
</tr>
</tbody>
</table>

6.5.2.3 In-Band Emissions for Non Allocated RB

**Definition:** The in-band emissions are a measure of the interference falling into the non-allocated resources blocks. The in-band emission is defined as the average across 12 sub-carrier and as a function of the RB offset from the edge of the allocated UL transmission bandwidth. The in-band emission is measured as the ratio of the UE output power in a non-allocated RB to the UE output power in an allocated RB. The basic in-band emissions measurement interval is defined over one slot in the time domain.

**Test purpose:** To verify that the relative in-band emissions do not exceed the values specified in table 6.5.2.3.5-1.
6.5.2.3 In-Band Emissions for Non Allocated RB

**Definition:** Occupied bandwidth is a measure of the bandwidth containing 99% of the total integrated mean power of the transmitted spectrum on the assigned channel.

**Test purpose:** To verify that the UE occupied bandwidth for all transmission bandwidth configurations supported by the UE are less than their specific limits.

<table>
<thead>
<tr>
<th>Table 6.6.1.2-1: Occupied channel bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel bandwidth (MHz)</td>
</tr>
<tr>
<td>Occupied channel bandwidth / channel bandwidth</td>
</tr>
<tr>
<td>1.4 MHz</td>
</tr>
</tbody>
</table>
RF Tests (Functional) – LTE Technology

6.6.2.1 Spectrum Emission Mask

**Definition:** The spectrum emission mask of the UE applies to frequencies (ΔfOOB) starting from the edge of the assigned E-UTRA channel bandwidth. For frequencies greater than (ΔfOOB) as specified in Table 6.6.2.1.3-1 the spurious requirements in clause 6.6.3 are applicable.

**Test purpose:** To verify that the power of any UE emission shall not exceed specified lever for the specified channel bandwidth.

### Table 6.6.2.1.3-1: General E-UTRA spectrum emission mask

<table>
<thead>
<tr>
<th>ΔfOOB (MHz)</th>
<th>1.4 MHz</th>
<th>3.0 MHz</th>
<th>5 MHz</th>
<th>10 MHz</th>
<th>15 MHz</th>
<th>20 MHz</th>
<th>Measurement bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>± 0.1</td>
<td>-10</td>
<td>-13</td>
<td>-15</td>
<td>-18</td>
<td>-20</td>
<td>-21</td>
<td>30 kHz</td>
</tr>
<tr>
<td>± 1.25</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>1 MHz</td>
</tr>
<tr>
<td>± 2.5-2.8</td>
<td>-25</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>1 MHz</td>
</tr>
<tr>
<td>± 2.8-5</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>1 MHz</td>
</tr>
<tr>
<td>± 5-6</td>
<td>-25</td>
<td>-13</td>
<td>-13</td>
<td>-13</td>
<td>-13</td>
<td>-13</td>
<td>1 MHz</td>
</tr>
</tbody>
</table>

RF Tests (Functional) – LTE Technology

6.6.2.3 Adjacent Channel Leakage Power Ratio

**Definition:** ACLR is the ratio of the filtered mean power centred on the assigned channel frequency to the filtered mean power centred on an adjacent channel frequency at nominal channel spacing.

**Test purpose:** To verify that UE transmitter does not cause unacceptable interference to adjacent channels in terms of Adjacent Channel Leakage Power Ratio.
RF Tests (Functional) – LTE Technology

6.6.3.1 Transmitter Spurious Emissions

**Definition:** Spurious emissions are emissions which are caused by unwanted transmitter effects such as harmonics emission, parasitic emissions, intermodulation products and frequency conversion products, but exclude out of band emissions.

**Test purpose:** To verify that UE transmitter does not cause unacceptable interference to other channels or other systems in terms of transmitter spurious emissions, according to table 6.6.3.1.3-2.

<table>
<thead>
<tr>
<th>Frequency Range</th>
<th>Maximum Level</th>
<th>Measurement Bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 kHz ≤ f &lt; 150 kHz</td>
<td>-36 dBm</td>
<td>1 kHz</td>
</tr>
<tr>
<td>150 kHz ≤ f ≤ 30 MHz</td>
<td>-36 dBm</td>
<td>10 kHz</td>
</tr>
<tr>
<td>30 MHz ≤ f &lt; 1000 MHz</td>
<td>-36 dBm</td>
<td>100 kHz</td>
</tr>
<tr>
<td>1 GHz ≤ f ≤ 12.75 GHz</td>
<td>-30 dBm</td>
<td>1 MHz</td>
</tr>
</tbody>
</table>

RF Tests (Functional) – 3G Technology
RF Tests (Functional) – Wi-Fi Technology
2.400-2.483,5 MHz and 5.725-5.850 MHz

Maximum Transmitter Output Power

**Definition:** Maximum transmitter output power is the measurement of the maximum power the UE can transmit.

**Test purpose:** Verify, according to item II of article 41 in section IX, that maximum transmitter output power cannot exceed 1 Watt.

---

RF Tests (Functional) – Wi-Fi Technology
2.400-2.483,5 MHz and 5.725-5.850 MHz

Maximum Width of Occupied Hop Channel Range at 6 dB

**Definition:** Occupied bandwidth is a 6 db bandwidth measurement of the transmission peak signal in the assigned channel.

**Test purpose:** Verify, according to item I of article 41 in section IX that the bandwidth, at 6 db, must be at least 500 kHz.
RF Tests (Functional) – Wi-Fi Technology
2.400-2.483,5 MHz and 5.725-5.850 MHz

Peak Power Density in any 3 kHz Range

**Definition:** Spectral power density describes how the energy of a signal or a time series shall be distributed with the frequency.

**Test purpose:** Verify, according to item II of article 41 in section IX that the spectral power density peak, in any 3 kHz range, during any continuous transmission time interval, shall never exceed 8 dBm.

![Spectral density graph](image)

---

RF Tests (Functional) – Wi-Fi Technology
2.400-2.483,5 MHz and 5.725-5.850 MHz

Spurious Emissions

**Definition:** Spurious emissions are emissions which are caused by unwanted transmitter effects such as harmonics emission, parasitic emissions, intermodulation products and frequency conversion products.

**Test purpose:** Verify, according to item III of article 41 in section IX, that produced radiofrequency power, in any 100 kHz bandwidth outside any one of the bands in which the system is operating, must be at least 20 dB below the maximum power produced in a 100 kHz interval, within the operating range.
RF Tests (Functional) – Wi-Fi Technology
5.470-5.725 MHz

Maximum Transmitter Output Power

**Definition:** Maximum transmitter output power is the measurement of the maximum power the UE can transmit.

**Test purpose:** Verify, according to item I of article 47 in section X, that maximum transmitter output power cannot exceed 250 mW.

---

RF Tests (Functional) – Wi-Fi Technology
5.150-5.350 MHz and 5.470-5.725 MHz

Mean EIRP

**Definition:** Equivalent radiated isotropic power mean is the average of the arithmetic product of the power supplied to the antenna and its gain.

**Test purpose:** Verify, according to item II of articles 46 and 47 of section X, that the EIRP mean value is limited to a maximum 200 mW (for an operating range of 5.150-5.350 MHz) and 1 W (for an operating range of 5.470-5.725 MHz).
RF Tests (Functional) – Wi-Fi Technology
5.150-5.350 MHz and 5.470-5.725 MHz

7 – EIRP Spectral Density Mean Value

**Definition:** The EIRP spectral density describes the power contributed to the wave by a frequency, considering the gain of the transmitting antenna.

**Test purpose:** Verify, according to item III of articles 46 and 47 of section X, that the EIRP spectral mean value is limited to a maximum of 10 mW/MHz (for an operating range of 5,150-5,350 MHz) and 50 mW/MHz (for an operating range of 5,470-5,725 MHz).

---

RF Tests (Functional) – Wi-Fi Technology
5.150-5.350 MHz and 5.470-5.725 MHz

Spurious Emissions

**Definition:** Spurious emissions are emissions which are caused by unwanted transmitter effects such as harmonics emission, parasitic emissions, intermodulation products and frequency conversion products.

**Test purpose:** Verify, according to article 48 in section X, that spurious emissions or those outside any of the operating ranges shall be inferior to the EIRP limit of -27dBm/MHz.
RF Tests (Functional) – Wi-Fi Technology
5.150-5.350 MHz and 5.470-5.725 MHz

Transmit Power Control (TPC)

**Definition:** Equipment without the TPC mechanism shall be exceptionally allowed. In this case, the EIRP mean value shall be limited to 100 mW for equipment operating in the 5,150-5,350 MHz band and limited to 500 mW range for equipment operating in the 5,470-5,725 MHz band.

**Test purpose:** Verify, according to article 49 in section X, that the UE allows dynamic selection of transmission power and assures a mitigating factor of at least 3dB.

---

Dynamic Frequency Selection (DFS)

**Definition:** In the 5,250-5,725 MHz ranges, the Broadband Wireless Access System for Local Networks shall use the dynamic frequency selection mechanism. This frequency range is exclusively reserved for military radars, however, it can be used by Wi-Fi devices provided they have a device able to detect when a radar signal is operating in the same frequency.

**Test purpose:** Verify, according to article 50 in section X, that:

I - time taken to verify channel availability does not exceed 60 seconds and no transmission shall begin before channel availability has been verified;

II – one channel availability has been verified and its occupancy has been identified, this channel shall be subject to a 30-minute non-occupancy period;

III – for equipment operating at a maximum EIRP of less than 200 mW, the DFS mechanism shall be able to detect interfering signals below the –62 dBm threshold, calculated during an average interval of 1 microsecond;
RF Tests (Functional) – Wi-Fi Technology
5.150-5.350 MHz and 5.470-5.725 MHz

Dynamic Frequency Selection (DFS)

IV – for equipment operating at a maximum EIRP of between 200mW and 1 W, the DFS mechanism shall be able to detect interfering signals below the –64 dBm threshold, calculated during an average interval of 1 microsecond;

V – in case an interfering signal with a value above the DFS detection threshold, all transmissions on the channel in question shall stop within 10 seconds.

**NOTE:** The use of the DFS mechanism in the 5.150-5.250 MHz band, however, the use of this mechanism is not mandatory in this band.

---

**NOTE:**

- **Center Freq:** 5.260000000 GHz
- **Freq Toler:** ±100 kHz
- **Frec Span:** 20 MHz
- **Ref 0 dBm:** 30.68 dBm
- **Freq Offset:** 0 Hz
- **Sweep Time:** 15.00 s
- **Sweep type:** Linear
- **Ref Gain:** 20 dB
- **Ref Offset:** 0 dB
- **Ref Level:** 20 dBm
- **Ref Frequency:** 5.260000000 GHz
- **Ref Phase:** 0°
- **Ref Power:** 20 dBm
RF Tests (Functional) – Bluetooth Technology

Separating Carrier Frequencies in Hop Channels

**Definition**: Pseudo-random frequency hops separated by channels are used to minimize data transmission interference.

**Test purpose**: Verify, according to item I of article 40 in section IX, that the hop channel RF carriers are separated by a minimum 25 kHz or by the width of the hop channel at 20 dB, whichever value is greater.
RF Tests (Functional) – Bluetooth Technology

Maximum Transmitter Output Power Peak

**Definition:** Maximum transmitter output power is the measurement of the maximum power the UE can transmit.

**Test purpose:** Verify, according to item VII-d and VII-e of article 40 in section IX, that for systems utilizing less than 75 hop radiofrequencies, maximum transmitter output power peak is limited to 125 mW, and for systems using 75 or less radiofrequencies, maximum transmitter output power peak is limited to 1 Watt.

![Graph of Peak Power](image1)

RF Tests (Functional) – Bluetooth Technology

Hop Frequencies

**Definition:** Count hop frequency channels within the specified range.

**Test purpose:** Verify, according to item VII-a of article 40 in section IX, that the system is using at least 15 non-coinciding hop frequencies.
RF Tests (Functional) – Bluetooth Technology

Maximum Width of Occupied Hop Channel Range at 20 dB

**Definition:** Occupied hop channel bandwidth is a 20 dB bandwidth measurement of the transmission peak signal in the assigned channel.

**Test purpose:** Verify, according to item I of article 40 in section IX, the hop channel bandwidth at 20 dB.

---

RF Tests (Functional) – Bluetooth Technology

Mean Occupancy Time of Any Frequency

**Definition:** Measure hop channel mean occupancy time.

**Test purpose:** Verify, according to item VII-b of article 40 in section IX, that the mean occupancy time of any radiofrequency does not exceed 0.4 seconds in a 0.4 s interval multiplied by the number of hop channels utilized.
RF Tests (Functional) – Bluetooth Technology

Spurious Emissions

**Definition:** Spurious emissions are emissions which are caused by unwanted transmitter effects such as harmonics emission, parasitic emissions, intermodulation products and frequency conversion products.

**Test purpose:** Verify, according to article 44 in section IX, that produced radiofrequency power, in any 100 kHz bandwidth outside any one of the bands in which the system is operating, must be at least 20 dB below the maximum power produced in a 100 kHz interval, within the operating range.

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Schedule

- Overview on Cellular Communications and Mobile Terminals Embedded RF Technologies
- Test Standards and Requirements for Mobile Cellular Terminal Certification in Brazil and other Large Global Urban Centers
- Description, Purpose and Importance of each RF Test Required for the ANATEL Certification and Approval Process
- **Description, Purpose and Importance of each SAR Test Required for the ANATEL Certification and Approval Process**
- Basic Concepts for Calculating Measurement Uncertainty
- Good Practices and Important Aspects for IEC/ISO 17025 Accreditation
SAR Tests – Definitions

SAR – Specific Absorption Rate
SAR is defined as the incremental electromagnetic power absorbed by an incremental mass contained in a volume element of given density, averaged over a certain period of time (ANSI, 1982).

SAR is measured in W/kg, representing power absorbed by unit mass.

Normative limits for SAR tests are prescribed based on scientific studies regarding the effects of radiation to ensure that users’ health will not be affected in the short term. Therefore, this test is fundamental from the aspect of user safety.

\[
\text{SAR} = \frac{d}{dt}\left(\frac{dW}{dm}\right) = \frac{d}{dt}\left(\frac{dW}{\rho dV}\right)
\]

\[
SAR = \frac{c\Delta T}{\Delta t} \bigg|_{t=0}
\]

\[
SAR = \frac{\sigma|E|^2}{\rho}
\]

\(dW\) = Electromagnetic Energy
\(dm\) = Mass
\(dV\) = Volume
\(\rho\) = Density

\(c\) = Specific Heat
\(\Delta T\) = Temperature variation
\(\Delta t\) = Duration (time) of exposure

\(\sigma\) = Electrical conductivity
\(\mathbb{E}\) = RMS value of the electrical field vector
\(\rho\) = Middle density
SAR Tests – Measurement Techniques

Temperature Alterations
• Temperature measurement probes
  • Optical or electrical technology
  • Heat meters

Electrical Field Measurements
• Probes with dipoles and diodes
• Probes with optical sensors

Technology adopted by all standards
• Probes with dipoles and diodes
SAR Tests – Device Under Test

SAR tests must be run on portable radiofrequency telecommunication equipment that operate close to the human body. In Brazil, the Addendum to Resolution 533 defines that any portable terminal operating the range between 300 MHz and 6 GHz must be submitted to SAR tests.

Examples of portable telecommunication terminals:
- Cell phones
- Tablets
- Modems
- PTT
- Radios

SAR Tests – Basic Test Setup

1) Unit for data acquisition/control
2) Electronic transducer test probe
3) Electrical field dosimetric test probe
4) Robotic test probe positioner
5) Present electromagnetic fields
6) Phantom filled with simulating liquid
7) Equipment Under Test (EUT)
8) EUT positioner
SAR Tests – Environment Requirements

Reference Standards:
• IEEE 1528 – Item 6.6.1.1
• IEC 62.209 – Item 5.1

Room temperature: 18 to 25 °C
Maximum variation of liquid temperature: ± 2 °C
• Regarding temperature during characterization

EUT cannot connect to local network
RF Noise < 0.012 W/kg
• External noise
• Internal noise (reflections, internal RF transmitters, etc.)
• 3% of the probe’s minimum detection limit (0.4 W/kg)

SAR Tests – Environment Requirements

Using shielded room
Assumptions:
• Use of input filters for all cables
• To shield high frequency electromagnetic fields, use good conductor materials
• Above 10 MHz, losses by absorption predominate
• Top-quality shielding, no matter what plate is used
• Conductor and solid
• Very small thickness
SAR Tests – Basic Instrument Set

Measuring probe

Data Acquisition Engine (DAE)

Validation dipole

SAR Tests – Basic Instrument Set

Bi-sectioned phantom ("Twin Sam") and positioner
SAR Tests – Basic Instrument Set

Flat phantom (ELI)

SAR Tests – Basic Instrument Set

Validation setup

Dielectric Setup
SAR Tests – Basic Instrument Set

Simulating Liquid

Reference Standards:
- IEEE 1528: Item 5.3.1 and Addendum C
- IEC 62.209: Item 5.2.4 and Addendum I

Liquid with dielectric properties
- Equivalent to human tissue
- Homogeneous: Mean value of several human tissues
- Transparent and low viscosity
- Frequency-dependent

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Relative Permissiveness ($\varepsilon'$)</th>
<th>Conductivity (S/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>45.30</td>
<td>0.87</td>
</tr>
<tr>
<td>450</td>
<td>43.50</td>
<td>0.87</td>
</tr>
<tr>
<td>835</td>
<td>41.50</td>
<td>0.90</td>
</tr>
<tr>
<td>900</td>
<td>41.50</td>
<td>0.97</td>
</tr>
<tr>
<td>1,450</td>
<td>40.50</td>
<td>1.20</td>
</tr>
<tr>
<td>1,800/-2,000</td>
<td>40.00</td>
<td>1.40</td>
</tr>
<tr>
<td>2,450</td>
<td>39.20</td>
<td>1.80</td>
</tr>
<tr>
<td>3,000</td>
<td>38.50</td>
<td>2.40</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Relative Permissiveness ($\varepsilon'$)</th>
<th>Conductivity (S/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>[55.0]</td>
<td>[0.75]</td>
</tr>
<tr>
<td>150</td>
<td>[52.3]</td>
<td>[0.76]</td>
</tr>
<tr>
<td>4,000</td>
<td>38.00</td>
<td>3.50</td>
</tr>
<tr>
<td>5,000</td>
<td>36.20</td>
<td>4.40</td>
</tr>
<tr>
<td>5,200</td>
<td>36.00</td>
<td>4.70</td>
</tr>
<tr>
<td>5,400</td>
<td>35.80</td>
<td>4.90</td>
</tr>
<tr>
<td>6,000</td>
<td>35.30</td>
<td>5.30</td>
</tr>
</tbody>
</table>
**SAR Tests – Basic Instrument Set**

Liquid simulator – Ingredients

- Saccharine (sugar) (purity > 98%)
- Sodium Chloride (salt) (purity > 99%)
- Deionized water (Minimum resistivity) 16 MΩ.cm)
- Hydrolysis of cellulose (HEC)
- Bactericide
- Diethylene glycol butyl ether (DGBE) (purity > 99%)
- Triton X-100 - Polyethylene glycol mono [4-(1,1,3,3-tetramethylbutyl) phenyl ether] Ultra pure

**SAR Tests – Test Scenarios**

For running head SAR tests, we have:

- Bi-sectioned Twin SAM phantom

The bi-sectioned SAM phantom is used to run tests, simulating a user's head. Tests are run on the right and left side of the head in two different positions: touching the face and with a 15-degree inclination.
SAR Tests – Test Scenarios

The following is an illustration of the head phantom.

Legend:
- RE: Right Ear Reference Point (ERP)
- LE: Left Ear Reference Point (ERP)
- M: Mouth Reference Point
- F Line N – F: Last point on the face (this does not need to be marked on the SAM phantom).
- N Line N – F: Last point on the neck (this does not need to be marked on the SAM phantom).

This complete head model is just for purposes of illustration and is directly derived from the phantom kit.
SAR Tests – Test Scenarios

How the terminals are placed at a 15-degree angle from the bi-sectioned phantom head:

Legend:
<table>
<thead>
<tr>
<th>RE</th>
<th>Left Ear Reference Point (ERP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LE</td>
<td>Right Ear Reference Point (ERP)</td>
</tr>
<tr>
<td>M</td>
<td>Mouth Reference Point</td>
</tr>
</tbody>
</table>

This complete head model is just for purposes of illustration and is directly derived from the phantom kit.

SAR Tests – Test Scenarios

Body test must be run with the terminal facing frontwards and backwards, as shown in the image below:

Touching the phantom flat

If the manufacturer should inform the recommended distance between the terminal and the phantom, body tests shall be performed at the informed distance.
SAR Tests – Test Scenarios

Defining the terminal under test scan area.

Examples of phantom head placement:

- Cheek (Touching)
- Tilt (15° angle)
SAR Tests – Test Scenarios

Examples of terminal placement on flat phantom

Body with accessories

Body without accessories

If the terminal utilizes accessories such as wired headphones, cloth or leather cases, belt clips, and so forth, then body tests must be performed with and without these accessories.

Examples of Accessories:

- Leather case with belt clip.
- Wired headphones.
SAR Tests – Test Results

Example of the 10g cube on the head and body:

Head

Body

SAR Tests – Normative Limit for SAR Tests in Brazil

<table>
<thead>
<tr>
<th>Usage Area</th>
<th>Limits – 10g Cube</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>2W/kg</td>
</tr>
<tr>
<td>Head / Body</td>
<td>2W/kg</td>
</tr>
<tr>
<td>Body only / Other members</td>
<td>4W/kg</td>
</tr>
<tr>
<td>Facing the cheek</td>
<td>4W/kg</td>
</tr>
</tbody>
</table>
Overview on Cellular Communications and Mobile Terminals Embedded RF Technologies

Test Standards and Requirements for Mobile Cellular Terminal Certification in Brazil and other Large Global Urban Centers

Description, Purpose and Importance of each RF Test Required for the ANATEL Certification and Approval Process

Description, Purpose and Importance of each SAR Test Required for the ANATEL Certification and Approval Process

Basic Concepts for Calculating Measurement Uncertainty

Good Practices and Important Aspects for IEC/ISO 17025 Accreditation

**Basic Concepts for Calculating Measurement Uncertainty**

Mandatory for ISO IEC 17025 Compliance

General Requirements for the Competence of Testing and Calibration Laboratories
Basic Concepts for Calculating Measurement Uncertainty

EXISTING REFERENCES

Evaluation of measurement data – Guide to the expression of uncertainty in measurement (GUM) JCGM 100:2008

Evaluation of measurement data – An introduction to the "Guide to the expression of uncertainty in measurement" and related documents JCGM 104:2009

Evaluation of measurement data – Supplement 1 to the "Guide to the expression of uncertainty in measurement" – Propagation of distributions using a Monte Carlo method JCGM 101:2008

Evaluation of measurement data – Supplement 2 to the "Guide to the expression of uncertainty in measurement" – Extension to any number of output quantities JCGM 102:2011

Evaluation of measurement data – The role of measurement uncertainty in conformity assessment JCGM 106:2012


Basic Concepts for Calculating Measurement Uncertainty

EXISTING REFERENCES

International vocabulary of Metrology – Basic and General Concepts and Associated Terms (VIM) – 3rd edition

Several requirement standards and measurement methods today already include uncertainty concepts in tests. Ex.:

- CISPR 16.4.2 – Uncertainty in Standardized EMC Tests
- IEC 61000-4-2 – Testing Method for Immunity to Electrostatic Discharges
- IEC 61000-4-3 – Testing method for immunity to radiated fields
- IEC 61000-4-4 – Testing method for immunity to rapid transients
- IEC 61000-4-6 – Testing method for immunity to conducted RF
- IEC 62232 – Standard for measuring exposure to RF emitted by BTS

and others

TERMINOLOGY

**Measurement** (VIM 2.1): process of experimentally obtaining one or more quantity values that can reasonably be attributed to a **quantity**.

**Measurand** (VIM 2.3): **quantity** intended to be measured

**Measurement result** (VIM 2.9): set of quantity values being attributed to a measurand together with any other available relevant information.

**NOTE:** A measurement result is generally expressed as a single measured quantity value and a measurement uncertainty.
Basic Concepts for Calculating Measurement Uncertainty

True quantity value (VIM 2.11): quantity value consistent with the definition of a quantity.
1. Value obtained by a perfect measurement
2. True values are, by nature, indeterminate

Conventional quantity value (VIM 2.12): quantity value attributed by agreement to a quantity for a given purpose.

Example: Standard acceleration of free fall (formerly called “standard acceleration due to gravity”), \( a=9.80665 \, \text{m.s}^2 \)

Basic Concepts for Calculating Measurement Uncertainty

Measurement accuracy (VIM 2:13): closeness of agreement between a measured quantity value and a true quantity value of a measurand.

Note 1 – The concept ‘measurement accuracy’ is not a quantity and is not given a numerical quantity value. A measurement is said to be more accurate when it offers a smaller measurement error.

Note 2 – The term “measurement accuracy” should not be used for measurement trueness and the term “measurement precision” should not be used for ‘measurement accuracy’, which, however, is related to both these concepts.

Note 3 – Measurement accuracy’ is sometimes understood as closeness of agreement between measured quantity values that are being attributed to the measurand.
Basic Concepts for Calculating Measurement Uncertainty

**Measurement error (VIM 2.16):** measured quantity value minus a reference quantity value.

**Systematic measurement error (VIM 2.17):** component of measurement error that in replicate measurements remains constant or varies in a predictable manner.

---

**Note 1** – A reference quantity value for a systematic measurements remains constant or varies in a predictable manner.

**Note 2** – Systematic measurement error, and its causes, can be known or unknown. A correction can be applied to compensate for a known systematic measurement error.

**Note 3** – Systematic measurement error equals measurement error minus random measurement error.
Basic Concepts for Calculating Measurement Uncertainty

**Random measurement error (VIM 2.19):** component of measurement error that in replicate measurements varies in an unpredictable manner.

**Note 1** – A reference quantity value for a random measurement error is the average that would ensue from an infinite number of replicate measurements of the same measurand random measurement error.

**Note 2** – Random measurement errors of a set of replicate measurements form a distribution that can be summarized by its expectation, which is generally assumed to be zero, and its variance.

**Note 3** – Random measurement error equals measurement error minus systematic measurement error.

---

Basic Concepts for Calculating Measurement Uncertainty

**Measurement uncertainty (VIM 2.26):** non-negative parameter characterizing the dispersion of the quantity values being attributed to a measurand, based on the information used.

**Note 1** – Measurement uncertainty includes components arising from systematic effects, such as components associated with corrections and the assigned quantity values of measurement standards, as well as the definitional uncertainty. Sometimes estimated systematic effects are not corrected for but, instead, associated measurement uncertainty components are incorporated.

**Note 2** – The parameter may be, for example, a standard deviation called standard measurement uncertainty (or a specified multiple of it), or the half-width of an interval, having a stated coverage probability.
Basic Concepts for Calculating Measurement Uncertainty

Note 3 – Measurement uncertainty comprises, in general, many components. Some of these may be evaluated by Type A evaluation of measurement uncertainty from the statistical distribution of the quantity values from series of measurements and can be characterized by standard deviations. The other components, which may be evaluated by Type B evaluation of measurement uncertainty, can also be characterized by standard deviations, evaluated from probability density functions based on experience or other information.

Note 4 – In general, for a given set of information, it is understood that the measurement uncertainty is associated with a stated quantity value attributed to the measurand. A modification of this value results in a modification of the associated uncertainty.

Basic Concepts for Calculating Measurement Uncertainty

Standard measurement uncertainty (VIM 2.30): measurement uncertainty expressed as a standard deviation.

Combined standard measurement uncertainty (VIM 2.31): standard measurement uncertainty that is obtained using the individual standard measurement uncertainties associated with the input quantities in a measurement model

Expanded measurement uncertainty (VIM 35): product of a combined standard measurement uncertainty and a factor larger than the number one.

(This factor refers to a coverage factor.)
Basic Concepts for Calculating Measurement Uncertainty

The combined standard uncertainty is calculated by the following expression where \( u(x_i) \) is the standard uncertainty of a component and \( c_i \) is the sensitivity coefficient.

\[
u_c(y) = \sqrt{\sum_i c_i^2 u^2(x_i)}
\]

Thus the expanded uncertainty can be calculated by the following expression where the factor \( k_p \) is the coverage factor.

\[
U(y) = k_p u_c(y)
\]

Basic Concepts for Calculating Measurement Uncertainty

**Measurement repeatability:** measurement precision under a set of repeatability conditions of measurement.

Condition of measurement, out of a set of conditions that includes:
- the same measurement procedure
- same operators, same measuring system, same operating conditions and same location
- and replicate measurements on the same or similar objects over a short period of time.
Basic Concepts for Calculating Measurement Uncertainty

**Correction (VIM 2.53):** compensation for an estimated systematic effect.

The compensation can take different forms, such as an addend or a factor, or can be deduced from a table.

Components of measurement uncertainty should be grouped into two categories:

Type A evaluation of measurement uncertainty from the statistical distribution of the quantity values from series of measurements and can be characterized by standard deviations

Type B evaluation of measurement uncertainty, can also be characterized by standard deviations, evaluated from probability density functions based on experience or other information
Basic Concepts for Calculating Measurement Uncertainty

Instrumental measurement uncertainty (VIM 4.24): component of measurement uncertainty arising from a measuring instrument or measuring system in use.

Note 1 – Instrumental measurement uncertainty is obtained through calibration of a measuring instrument or measuring system, except for a primary measurement standard for which other means are used.

Note 2 – Instrumental measurement uncertainty is used in a Type B evaluation of measurement uncertainty.

Note 3 – Information relevant to instrumental measurement uncertainty may be given in the instrument specifications.

Standard Deviation

For a series of \( n \) measurements of the same measurand, the magnitude "s", characterizing the dispersion of the results is given by the formula:

\[
s = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \overline{x})^2}{n-1}}
\]

\( x_i \) represents the result of the "umpteenth" measurement.

\( \overline{x} \) represents the arithmetic mean of "n" results
Basic Concepts for Calculating Measurement Uncertainty

Type-A evaluation of measurement uncertainty (VIM 2.28): evaluation of a component of measurement uncertainty by a statistical analysis of measured quantity values obtained under defined measurement conditions. For various types of measurement conditions, see repeatability condition of measurement, intermediate precision condition of measurement, and reproducibility condition of measurement.

Basic Concepts for Calculating Measurement Uncertainty

**Type-A evaluation of measurement uncertainty**

For an input magnitude \( x_i \) determined by \( n \) repeated independent observations, we can say that the standard uncertainty of the mean is the standard experimental deviation of the mean.

\[
\begin{align*}
    u(x_i) &= s\left( \overline{x_i} \right) \\
    u(x) &= s\left( \overline{x} \right) = \frac{s(x)}{\sqrt{n}}
\end{align*}
\]

This is called type-A uncertainty standard, taking into consideration an adequate \( n \) number of observations.

For statistical reliability, \( n > 10 \).
As an example, we shall consider the CC voltage calibration of the ESD generator.

In this situation, a discharge is triggered, and the generator’s output capacitor is charged. Measurement is performed with a high impedance voltmeter: 20 GΩ.
Basic Concepts for Calculating Measurement Uncertainty

Type-B evaluation of measurement uncertainty (VIM 2.29): evaluation of a component of measurement uncertainty determined by means other than a Type A evaluation of measurement uncertainty.

EXAMPLES: Evaluation based on information:
- associated with authoritative published quantity values
- associated with the quantity value of a certified reference material
- obtained from a calibration certificate
- about drift
- obtained from limits deduced through personal experience

Basic Concepts for Calculating Measurement Uncertainty

Components related to type B uncertainty are related to instruments and accessories which usually need to be calibrated.

The uncertainty value presented in calibration certificates usually are expanded measurement uncertainty. Thus, we must divide its value by the corresponding coverage factor in order to calculate the combined uncertainty of the measurand.
Basic Concepts for Calculating Measurement Uncertainty

All type B values used in the calculation of combined standard uncertainty shall match a standard deviation. Therefore the values of the components must be divided by factors corresponding to the probability distribution assigned to them:

Normal = 1
Normal (expanded) = 2
Rectangular = $\sqrt{3}$
Triangular = $\sqrt{6}$
U-format = $\sqrt{2}$

So all components of uncertainty will have a confidence level of 68%

Basic Concepts for Calculating Measurement Uncertainty

The standard uncertainty $u(x_i)$ in dB and the sensibility uncertainty must be taken into consideration when evaluating the standard combined uncertainties $u_c(y)$ of the estimated value of the measurand through the expression:

$$u_c(y) = \sqrt{\sum_i c_i^2 u^2(x_i)}$$

Based on the combined uncertainty value above, the expanded uncertainty value can be calculated by multiplying it by the $k_p$ factor, which has to do with the degree of freedom of the variable.

$$U(y) = k_p \cdot u_c(y)$$
Basic Concepts for Calculating Measurement Uncertainty

To calculate the coverage factor $k_p$, the effective number of degrees of freedom is determined $V_{eff}$

$$V_{eff} = \frac{u_c^4}{\sum_{i=1}^{n} \frac{u_i^4}{v_i}}$$

Through the obtained value of $V_{eff}$ and the degree of confidence desired, for example 95%, the coverage factor $k_p$ is determined in the distribution table-$T$ (t-student):

<table>
<thead>
<tr>
<th>$V_{eff}$</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>Infinito</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T=k_p$</td>
<td>2.23</td>
<td>2.09</td>
<td>2.04</td>
<td>2.02</td>
<td>2</td>
</tr>
</tbody>
</table>

$T = t$-student coefficient

Basic Concepts for Calculating Measurement Uncertainty

RF disturbance emission tests usually only take instrumental uncertainties into consideration, which allows confrontation with the CISPR uncertainty.

Therefore, the $U_{lab}$ evaluation corresponds to the type-B component uncertainty evaluation, taking into consideration the impact caused by test location and measurement setup components:

The following example corresponds to a radiated emission test in the 30 - 300 MHz range, with a biconical antenna in horizontal polarization.
Example: Measurement in Anechoic Chamber according to CISPR

<table>
<thead>
<tr>
<th>Input quantity</th>
<th>Uncertainty of $x_i$ $u(x_i)$</th>
<th>$c_i$</th>
<th>$c_i u(x_i)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receiver reading</td>
<td>$\pm 0.1$ $k = 1$ dB</td>
<td>0.1</td>
<td>1 dB</td>
</tr>
<tr>
<td>Attenuation antenna-receiver</td>
<td>$\pm 0.2$ $k = 2$ dB</td>
<td>0.1</td>
<td>0.1 dB</td>
</tr>
<tr>
<td>Factor de antenna</td>
<td>$\pm 2.0$ $k = 2$ dB</td>
<td>1.0</td>
<td>1 dB</td>
</tr>
<tr>
<td>Receiver correction</td>
<td>$\pm 1.0$ $k = 2$ dB</td>
<td>0.5</td>
<td>0.5 dB</td>
</tr>
<tr>
<td>Sine wave voltage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulse amplitude response</td>
<td>$\pm 1.5$ rectangular dB</td>
<td>0.87</td>
<td>1 dB</td>
</tr>
<tr>
<td>Pulse repetition rate response</td>
<td>$\pm 1.5$ rectangular dB</td>
<td>0.87</td>
<td>1 dB</td>
</tr>
<tr>
<td>Noise floor proximity</td>
<td>$\pm 0.5$ rectangular dB</td>
<td>0.29</td>
<td>1 dB</td>
</tr>
<tr>
<td>Mismatch antenna-receiver</td>
<td>$+0.9-1.0$ U-shaped dB</td>
<td>0.67</td>
<td>1 dB</td>
</tr>
<tr>
<td>Antenna corrections</td>
<td>$\pm 0.3$ rectangular dB</td>
<td>0.17</td>
<td>1 dB</td>
</tr>
<tr>
<td>AF frequency interpolation</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Basic Concepts for Calculating Measurement Uncertainty
**Basic Concepts for Calculating Measurement Uncertainty**

**Example: Measurement uncertainty for radiated tests**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Uncertainty</th>
<th>Setup</th>
<th>( k )</th>
<th>( U_{cispr} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>AF variation with height</td>
<td>( \pm 1.0 )</td>
<td>rectangular</td>
<td>0.58</td>
<td>1.08</td>
</tr>
<tr>
<td>Directivity difference – ( d = 3 ) m</td>
<td>( \pm 0.0 )</td>
<td>0.00</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Directivity difference – ( d = 10 ) m</td>
<td>( \pm 0.0 )</td>
<td>0.00</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Directivity difference – ( d = 30 ) m</td>
<td>( \pm 0.0 )</td>
<td>0.00</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Cross-polarization</td>
<td>( \pm 0.0 )</td>
<td>0.00</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Balance</td>
<td>( \pm 0.3 )</td>
<td>rectangular</td>
<td>0.17</td>
<td>1.17</td>
</tr>
<tr>
<td>Site imperfections</td>
<td>( \pm 4.0 )</td>
<td>triangular</td>
<td>1.63</td>
<td>1.63</td>
</tr>
<tr>
<td>Separation distance</td>
<td>( d = 10 ) m</td>
<td>( \pm 0.1 )</td>
<td>rectangular</td>
<td>0.06</td>
</tr>
<tr>
<td>Table height</td>
<td>( d = 10 ) m</td>
<td>( \pm 0.1 )</td>
<td></td>
<td>0.05</td>
</tr>
</tbody>
</table>

\[
u_c(x) = \sqrt{(0.1)^2 + \left(\frac{0.2}{2}\right)^2 + \left(\frac{2}{2}\right)^2 + \left(\frac{2}{3}\right)^2 + \left(\frac{0.5}{3}\right)^2 + \left(\frac{0.5}{3}\right)^2 + \left(\frac{0.09}{2}\right)^2 + \left(\frac{0.3}{3}\right)^2 + \left(\frac{0.3}{3}\right)^2 + \left(\frac{0.0}{3}\right)^2 + \left(\frac{4}{6}\right)^2 + \left(\frac{0.1}{2}\right)^2} \]

\[u_c(x) = 2.52 \text{ dB} \quad U_E(x) = k_P \cdot u_c(x) = 2 \cdot 2.52 = 5.04 \text{ dB}\]

**Normalized EMC Test Uncertainties**

**CISPR 16-4-2**

The CISPR 16-4-2 document takes instrumentation uncertainty and aspects of the setup into consideration when dealing with RF disturbance measurements. The estimated calculated value is called \( U_{cispr} \).

<table>
<thead>
<tr>
<th>Measurement</th>
<th>( U_{cispr} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conducted disturbance at mains port using AMN</td>
<td>(9 kHz to 150 kHz)</td>
</tr>
<tr>
<td>Conducted disturbance at mains port using voltage probe</td>
<td>(9 kHz to 30 MHz)</td>
</tr>
<tr>
<td>Conducted disturbance at telecommunications port using AAN</td>
<td>(150 kHz to 30 MHz)</td>
</tr>
<tr>
<td>Conducted disturbance at telecommunications port using CVP</td>
<td>(150 kHz to 30 MHz)</td>
</tr>
<tr>
<td>Conducted disturbance at telecommunications port using CP</td>
<td>(150 kHz to 30 MHz)</td>
</tr>
<tr>
<td>Disturbance power</td>
<td>(30 MHz to 300 MHz)</td>
</tr>
<tr>
<td>Radiated disturbance (electric field strength at an OATS or in a SAC)</td>
<td>(30 MHz to 1000 MHz)</td>
</tr>
</tbody>
</table>
A very unique CISPR test criterion prescribes that:

**IF** $U_{lab}$ **is** less than or equal to $U_{cispr}$, **then** the test report **can** state the $U_{lab}$ value **or** state that $U_{lab}$ **is** less than $U_{cispr}$.

**If** $U_{lab}$ **is** greater than $U_{cispr}$, **than** the test report **must** state the actual lab $U_{lab}$ value (em dB). **In this case, the difference between** $U_{lab}$ **and** $U_{cispr}$ **must be subtracted from the limit in order to verify compliance with requirements.**
GOOD LAB PRACTICES


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  4.2 Management system
  4.3 Document control
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  4.5 Subcontracting of tests and calibrations
  4.6 Purchasing services and supplies
  4.7 Service to the customer
  4.8 Complaints

4.9 Control of nonconforming testing and/or calibration work
4.10 Improvement
4.11 Corrective action
4.12 Preventive action
4.13 Control of records
4.14 Internal audits
4.15 Management reviews


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5.5 Equipment
5.6 Measurement traceability
5.7 Sampling
5.8 Handling of test and calibration items
5.9 Assuring the quality of test and calibration results
5.10 Reporting the results

4.2 Management system

- The laboratory shall establish, implement and maintain a management system appropriate to the scope of its activities.
- The laboratory shall document its policies, systems, programmes, procedures and instructions to the extent necessary to assure the quality of the test and/or calibration results.
- The lab shall document its policies, systems, programs, procedures and instructions.
- The laboratory's management system policies related to quality, including a quality policy statement, shall be defined in a quality manual.
- The quality policy statement shall be issued under the authority of top management. It shall include at least the following:
  • the laboratory management's commitment to good professional practice and to the quality of its testing and calibration in servicing its customers
  • the laboratory management's commitment to comply with this International Standard and to continually improve the effectiveness of the management system
  • a requirement that all personnel concerned with testing and calibration activities within the laboratory familiarize themselves with the quality documentation


4.2 Management system (cont.)

- The roles and responsibilities of technical management and the quality manager
- Top management shall ensure that the integrity of the management system is maintained when changes to the management system are planned and implemented.

4.3 Document control

- The laboratory shall establish and maintain procedures to control all documents that form part of its management system.
- Invalid or obsolete documents are promptly removed.
- Management system documents generated by the laboratory shall be uniquely identified. Such identification shall include the date of issue and/or revision identification, page numbering, the total number of pages, and the issuing authority(ies).
- Changes to documents shall be reviewed and approved by the same function that performed the original review unless specifically designated otherwise.
- Where practicable, the altered or new text shall be identified in the document.
- Procedures shall be established to describe how changes in documents maintained in computerized systems are made and controlled.

4.4 Review of requests, tenders and contracts
- The laboratory shall establish and maintain procedures for the review of requests, tenders and contracts.
- Records of reviews, including any significant changes, shall be maintained.
- The customer shall be informed of any deviation from the contract.
- If a contract needs to be amended after work has commenced, the same contract review process shall be repeated and any amendments shall be communicated to all affected personnel.

4.5 Subcontracting of tests and calibrations
- The laboratory is responsible to the customer for the subcontractor’s work, except in the case where the customer or a regulatory authority specifies which subcontractor is to be used.
- The laboratory shall maintain a register of all subcontractors that it uses for tests and/or calibrations and a record of the evidence of compliance with this International Standard for the work in question.

4.6 Purchasing services and supplies
- The laboratory shall have a policy and procedure(s) for the selection and purchasing of services and supplies it uses that affect the quality of the tests and/or calibrations.


4.7 Service to the customer
- The laboratory shall be willing to cooperate with customers or their representatives in clarifying the customer's request and in monitoring the laboratory's performance in relation to the work performed, provided that the laboratory ensures confidentiality to other customers.
- The laboratory shall seek feedback, both positive and negative, from its customers.

4.8 Complaints
- The laboratory shall have a policy and procedure for the resolution of complaints received from customers or other parties.

4.9 Control of nonconforming testing and/or calibration work
- The laboratory shall have a policy and procedures that shall be implemented when any aspect of its testing and/or calibration work, or the results of this work, do not conform to its own procedures or the agreed requirements of the customer.

4.10 Improvement
- The laboratory shall continually improve the effectiveness of its management system.
4.11 Corrective action
- The laboratory shall establish a policy and a procedure and shall designate appropriate authorities for implementing corrective action when nonconforming work or departures from the policies and procedures in the management system or technical operations have been identified.
- The procedure for corrective action shall start with an investigation to determine the root cause(s) of the problem.
- Cause analysis is the key and sometimes the most difficult part in the corrective action procedure.
- The laboratory shall monitor the results to ensure that the corrective actions taken have been effective.

4.12 Preventive action
- Needed improvements and potential sources of nonconformities, either technical or concerning the management system, shall be identified.

4.13 Control of records
- The laboratory shall establish and maintain procedures for identification, collection, indexing, access, filing, storage, maintenance and disposal of quality and technical records.
- All records shall be legible and shall be stored and retained in such a way that they are readily retrievable in facilities that provide a suitable environment to prevent damage or deterioration and to prevent loss. Retention times of records shall be established.
- The laboratory shall have procedures to protect and back-up records stored electronically and to prevent unauthorized access to or amendment of these records.

4.14 Internal audits
- The laboratory shall periodically, and in accordance with a predetermined schedule and procedure, conduct internal audits of its activities to verify that its operations continue to comply with the requirements of the management system and this International Standard.
4.15 Management reviews

- In accordance with a predetermined schedule and procedure, the laboratory’s top management shall periodically conduct a review of the laboratory’s management system and testing and/or calibration activities to ensure their continuing suitability and effectiveness, and to introduce necessary changes or improvements.

Technical requirements

5.1 General

Many factors determine the correctness and reliability of the tests and/or calibrations performed by a laboratory:

- Human factors
- Accommodation and environmental conditions
- Test and calibration methods and method validation
- Adjustment of measurement equipment
- Measurement traceability
- Sampling
- The handling of test and calibration items

Technical requirements

5.2 Personnel

The management of the laboratory shall ensure the competence of all who:

- operate specific equipment;
- perform tests and/or calibrations;
- evaluate results;
- and sign test reports and calibration certificates.

The management of the laboratory shall formulate the goals with respect to the education, training and skills of the laboratory personnel.

The laboratory shall have a policy and procedures for identifying training needs and providing training of personnel.

The laboratory shall maintain current job descriptions for managerial, technical and key support personnel involved in tests and/or calibrations, including the responsibilities with respect to performing tests and/or calibrations, to the planning of tests and/or calibrations and evaluation of results, for reporting opinions and interpretations, and to method modification and development and validation of new methods.


Technical requirements

5.3 Accommodation and environmental conditions

- The laboratory shall ensure that the environmental conditions do not invalidate the results or adversely affect the required quality of any measurement.

- The laboratory shall monitor, control and record environmental conditions as required by the relevant specifications, methods and procedures or where they influence the quality of the results.

- Special care must be take to control and monitor environmental conditions.

- There shall be effective separation between neighboring areas in which there are incompatible activities.

- Access to and use of areas affecting the quality of the tests and/or calibrations shall be controlled.
Technical requirements

5.4 Test and calibration methods and method validation

- The laboratory shall use appropriate methods and procedures for all tests and/or calibrations within its scope, and, where appropriate, an estimation of the measurement uncertainty.
- The laboratory shall have instructions on the use and operation of all relevant equipment, and on the handling and preparation of items for testing and/or calibration, or both, where the absence of such instructions could jeopardize the results of tests and/or calibrations.
- Non-normalized methods shall be validated and agreed upon by the customer.
- Procedures are established and implemented for protecting the data; such procedures shall include, but not be limited to, integrity and confidentiality of data entry or collection, data storage, data transmission and data processing.
- Test data calculation and transfer must be submitted to due verification.
- Spreadsheets used for processing results must be validated.
- When data control involves the use of computers and automatic equipment, be sure to ensure integrity and reliability.


Technical requirements

5.5 Equipment

- Equipment and its software used for testing, calibration and sampling shall be capable of achieving the accuracy required and shall comply with specifications relevant to the tests and/or calibrations concerned.
- Equipment shall be operated by authorized personnel.
- Up-to-date instructions on the use, storage and maintenance of equipment shall be readily available for use by the appropriate laboratory personnel.
- Each item of equipment and its software used for testing and calibration and significant to the result shall, when practicable, be uniquely identified and present calibration status on their body.
- Records shall be maintained of each item of equipment: the manufacturer's name type identification, and serial number or other unique identification, results and copies of reports and certificates of all calibrations, adjustments, acceptance criteria, the due date of next calibration, the maintenance plan, where appropriate, and maintenance carried out to date.
Technical requirements
5.6 Measurement traceability

- All equipment used for tests and/or calibrations having a significant effect on the accuracy or validity of the result of the test shall be calibrated before being put into service.
- Calibrations must be performed by bodies that can provide traceability to the International System, using calibration labs accredited by a competent organism, for example, CGCRE in Brazil. In other countries, ILAC members can be used.
- The laboratory shall have an established programme and procedure for the calibration of its equipment.
- Certifications must have the information needed to verify traceability.
- Intermediary verifications must be performed.

Note: CGCRE – General INMETRO Accreditation Coordination
      ILAC - International Laboratory Accreditation Cooperation


Technical requirements
5.7 Sampling

The laboratory shall have a sampling plan and procedures for sampling when it carries out sampling of substances, materials or products for subsequent testing or calibration. The sampling plan as well as the sampling procedure shall be available at the location where sampling is undertaken. Sampling plans shall, whenever reasonable, be based on appropriate statistical methods. The sampling process shall address the factors to be controlled to ensure the validity of the test and calibration results.

Note: Not applicable for cellular terminals and EMC certification tests.

Technical requirements

5.8 Handling of test and calibration items

The laboratory:

- Shall have procedures for the transportation, receipt, handling, protection, storage, retention and/or disposal of test and/or calibration items, including all provisions necessary to protect the integrity of the test or calibration item.
- Shall have a system for identifying test and/or calibration items.
- Shall record abnormalities or departures from normal or specified conditions.
- Shall register customer requests.
- When items have to be stored or conditioned under specified environmental conditions, these conditions shall be maintained, monitored and recorded.


Technical requirements

5.9 Assuring the quality of test and calibration results

The laboratory shall have quality control procedures for monitoring the validity of tests and calibrations undertaken. This includes:

- Participation in proficiency-testing program.
- Replicate tests or calibrations using the same or different methods.
- Inter laboratory comparison.
- Regular use of certified reference materials.

Quality control data shall be analyzed and, where they are found to be outside pre-defined criteria and planned action shall be taken to correct the problem.
Technical requirements

5.9 Assuring the quality of test and calibration results

For radiated emission tests: preliminary test with known field source.


Technical requirements

5.10 Reporting the results

- The results of each test, calibration, or series of tests or calibrations carried out by the laboratory shall be reported accurately, clearly, unambiguously and objectively, and in accordance with any specific instructions in the test or calibration methods.
- Each test report shall include:
  - a title
  - the name and address of the laboratory
  - unique identification of the test report
  - on each page an identification in order to ensure that the page is recognized as a part of the test report
  - a clear identification of the end of the test report
  - the name and address of the customer
  - identification of the method used
  - a description of, the condition of, and unambiguous identification of the item(s) tested
  - the date of receipt of the test or calibration item(s)
  - all information needed for its analysis
  - the name(s), function(s) and signature(s) or equivalent identification of person(s) authorizing the test report
Thank You!

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