EMF COMPLIANCE ASSESSMENT of WIRLESS COMMUNICATION DEVICES

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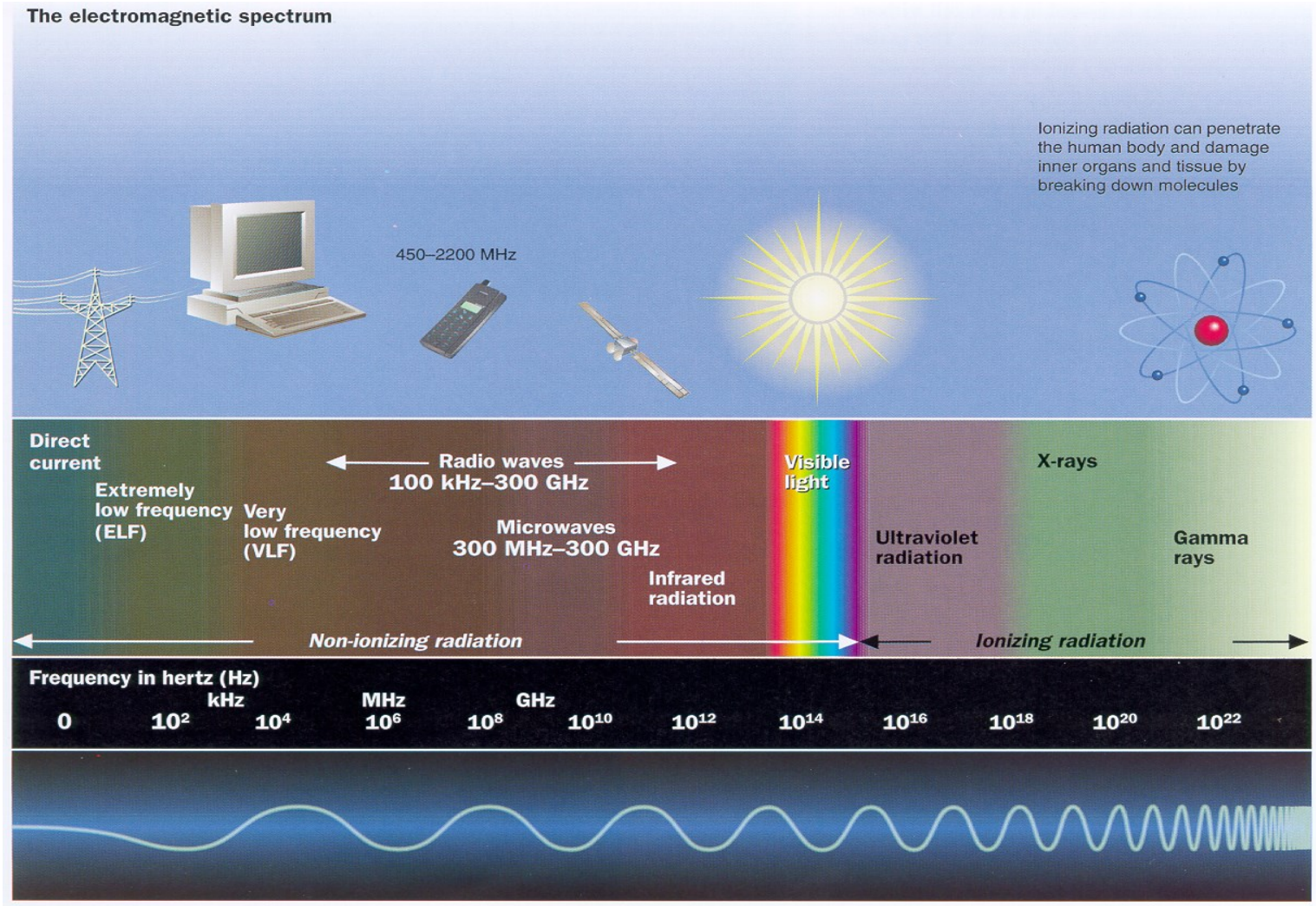
IEC MT1, IEC 62209-I & IEC 62209-II)

OUTLINE

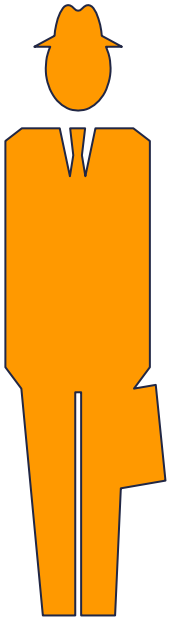
- EMF exposure standards
- Why to develop RF compliance standards
- Scientific rationale behind RF expsoure and measurement standards.
- RF measurement/assessment standards in International Electro-technical Commission (IEC)
- Future of IEC wireless devices compliance standards


The electromagnetic spectrum
Ionizing radiation can penetrate the human body and damage inner organs and tissue by breaking down molecules
450–2200 MHz
Direct current
Extremely low frequency (ELF)
Very low frequency (VLF)
Radio waves
100 kHz–300 GHz
Microwaves
300 MHz–300 GHz
Infrared radiation
Visible light
Ultraviolet radiation
X-rays
Gamma rays
Non-ionizing radiation
Ionizing radiation
Frequency in hertz (Hz)
kHz
MHz
GHz
0
10²
10⁴
10⁶
10⁸
10¹⁰
10¹²
10¹⁴
10¹⁶
10¹⁸
10²⁰
10²²

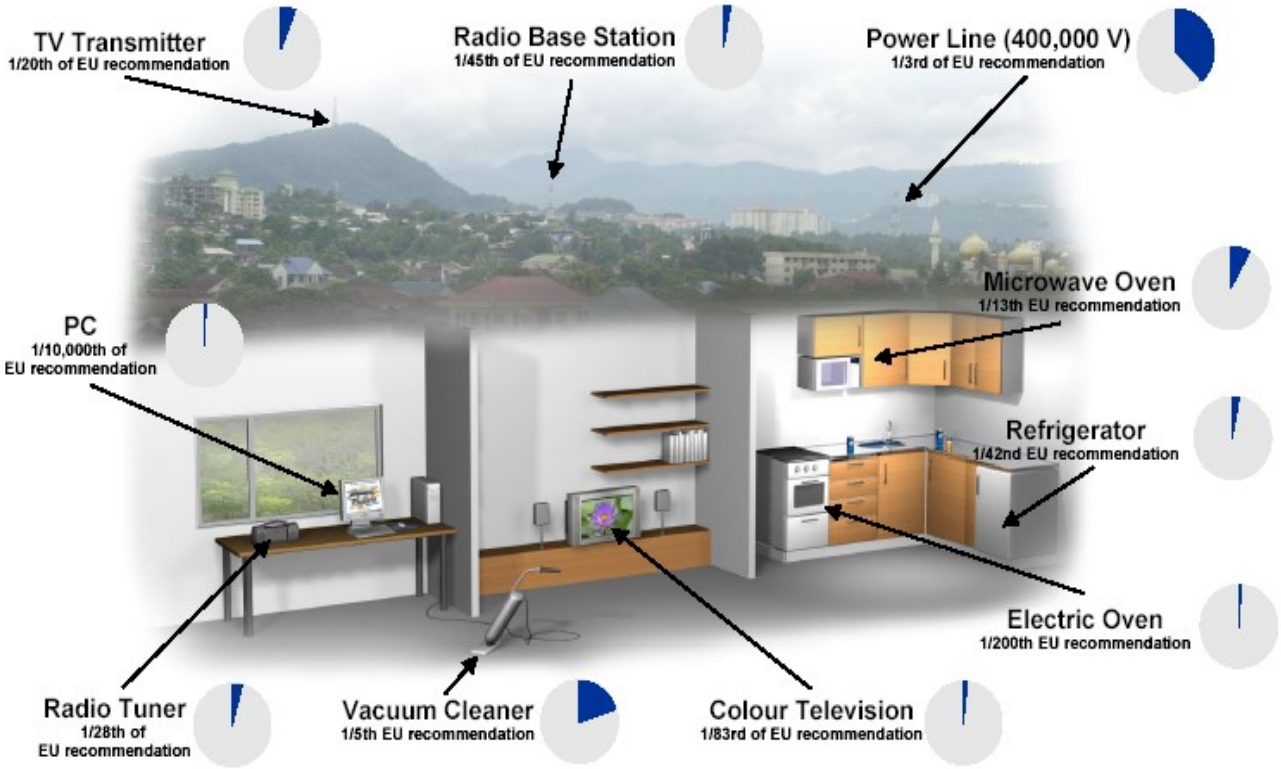
FREQUENCY RANGE

- Wirless communication devices operates at frequencies 100-6000 MHz.
- Wireless communication devices operate at a variety of frequencies between about 300 and 6000 MHz.
- Computer monitors emit a broad range of EMR from 30 Hz up to 300 GHz.

Wireless technology RF Sources



EXPOSURE TO COMMON EMF SOURCES



Realistic Power levels of wirless communication devices

Taking power regulation, DTX and 6 minutes time averaging into account, the real output power is

more than 10dB below maximum for 3G/WCDMA terminals,
around 4dB below maximum for GSM terminals, and
3dB below maximum for LTE terminals for 90% or more of the time.

This also adds an extra amount of conservativeness of between 3dB and 10dB depending on the wireless technology. This is also supported by the research of Kuehn et al (2013)

Persson et. al., Output Power Distributions of Terminals in a 3G Mobile Communication Network, Bioelectromagnetics 2011 DOI 10.1002/bem.20710

Wiart et.al. Analysis of the Influence of the Power Control and Discontinos Transmission on RF exposure with GSM Mobile Phones, IEEE Trans Electromagn Compatibility 2000;42(4):376–385.

Gati et.al. Exposure induced by WCDMA Mobile Phones in Operating Networks, IEEE Trans Wireless Commun 2009;8:5723–5727

Vrijheid et. al., Determinants of mobile phone output power in a multinational study implications for exposure assessment, Occup Environm Med 2009;66:664-671

How to quantify RF energy absorption, SAR

The power absorbed per unit mass of tissue is referred to as Specific Absorption Rate (SAR). For sinusoidal EM fields, the time rate of energy deposited in a small volume is defined as ***Specific Absorption Rate:***

$$SAR = (\sigma + \omega\varepsilon')\frac{E^2}{\rho} \quad (W/kg)$$

σ and ε’ indicate how much energy will be absorbed by the material

INTRODUCTION: MEASUREMENT AND COMPUTATIONAL STANDARDS

- All portable wireless devices have to comply with RF exposure limits before putting them in the market.
- Compliances standards for the portable RF wireless devices were developed by International Electrotechnical Commission IEC and IEEE mainly relevant to the mobile phones [IEC-62209-1 2005, IEEE-1528, 2003].
- The merge of new technologies and different usage positions of the mobile devices led to development of relevant compliance standard to cover the exposure evaluation of the other parts of the body other than the head [IEC-62209-2, 2010].
- Although the SAR was established at the highest certified level, the actual SAR level for the mobile phone during use is generally much lower than the maximum values. In fact, since mobile phones are designed to operate at many different power levels, they only use the minimum level of power required to provide a connection to the network. In theory, the closer you are to a base station antenna, the lower the power level required by the mobile phone.

RF compliance assessment standards

- Compliance can be assessed through measurements or calculations.
- There is no meaning for existence of exposure Guidelines/standards if it is not possible to measure it.
- Practically it is not possible to measure the energy absorption in the body of living humans!
- In order to assess the exposure limits there has to be standardized procedures to evaluate those limits.

➔ There is a need to develop phantoms head/body phantoms

- Advanced instrumentation is needed for this purpose
- Accurate procedure with well defined and quantified uncertainty is needed.

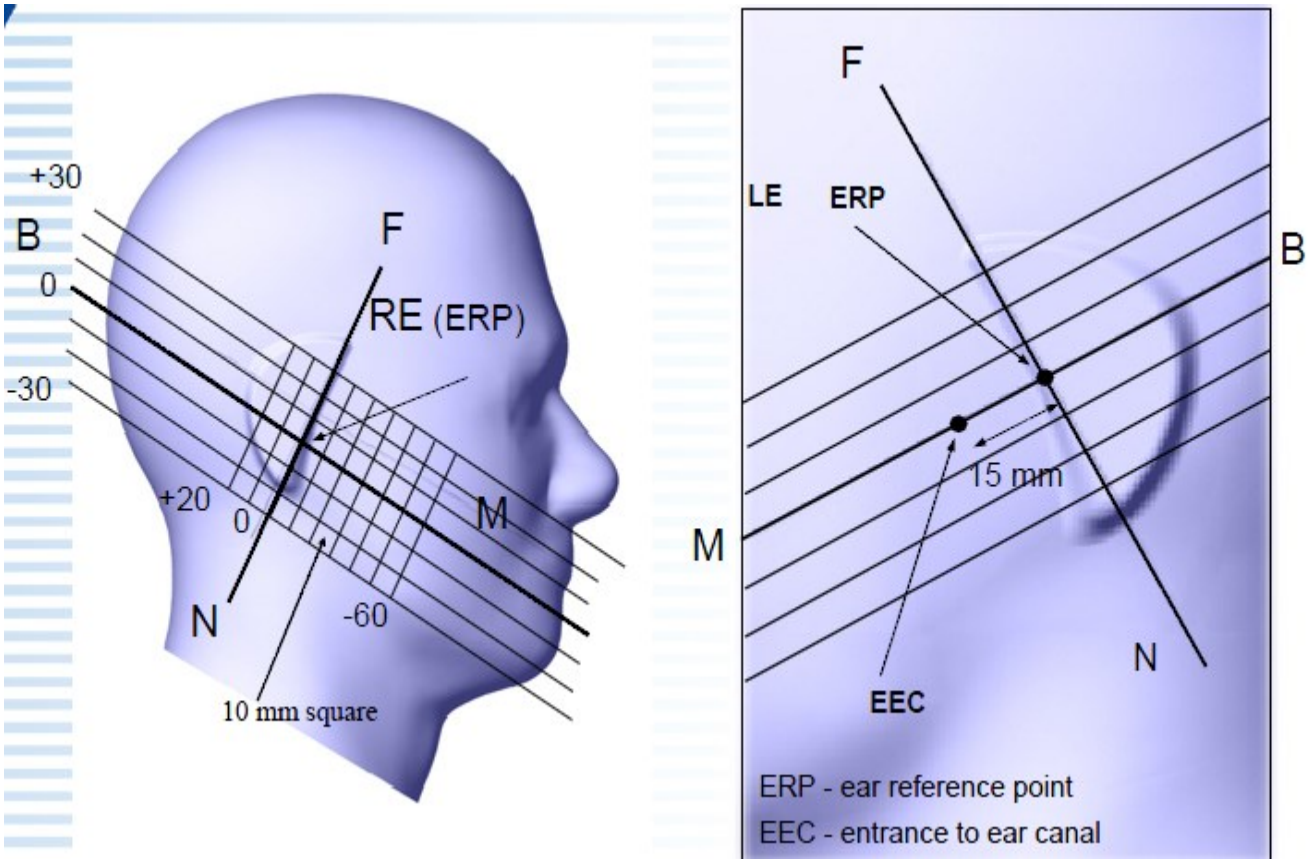
International Electro-technical Commission (IEC) Wireless devices RF Assessment Standards

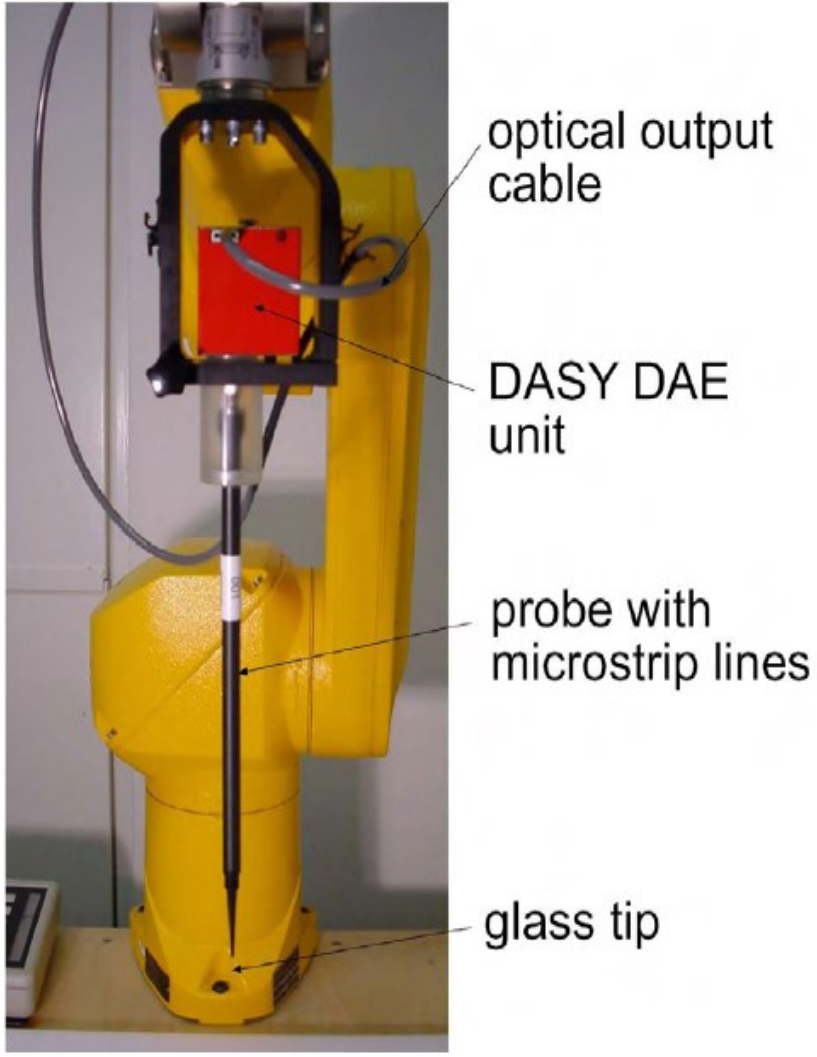
- IEC MT62209,
  - Part 1, SAR for handsets. To revise the standard IEC62209-1: “Procedure to Measure the Specific Absorption Rate (SAR) for Hand-Held Mobile Telephones in the Frequency Range of 300 MHz to 3 GHz” by the end of 2011.
  - Part 2, SAR for other handheld and body worn devices. To revise the IEC62209-2: “Procedure to determine the specific absorption rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz) standard by 2013.
  - To unify IEC62209 part 1 & 2 standards by 2013.

Standard Anthropomorphic head Model (SAM)

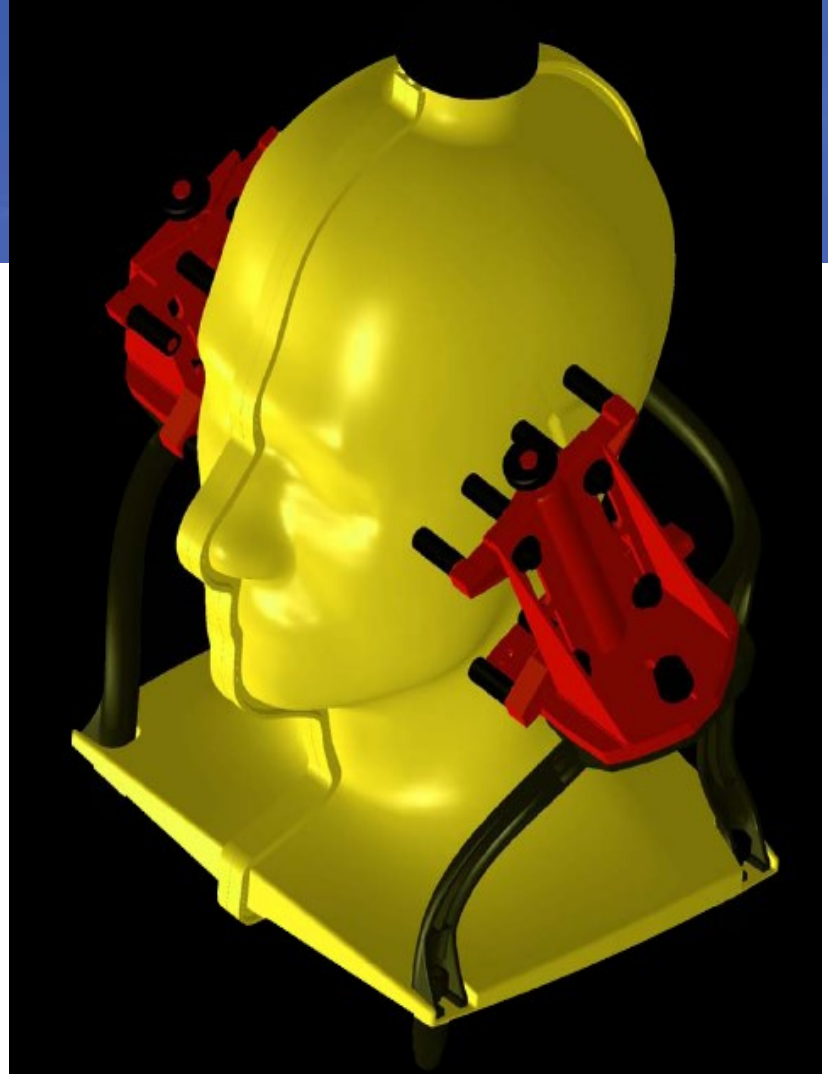
- the Standard Anthropomorphic Model - is a head shell phantom intended primarily for use in the measurement of exposure from mobile phones (or other hand-held transmitters)
- SAM is defined as standard phantom allowing a conservative measure of the radio exposure of people of all origins and all ages. The ear region is defined with reference points and planes to facilitate reproducible positioning of telecommunications devices.
- The dimensions of a 90th percentile male head were selected for the phantom.
- IEC, CENELEC, and IEEE have developed standard procedures for assessing exposures from mobile phones which specify the use of a SAM phantom.

SAR phantom definitions



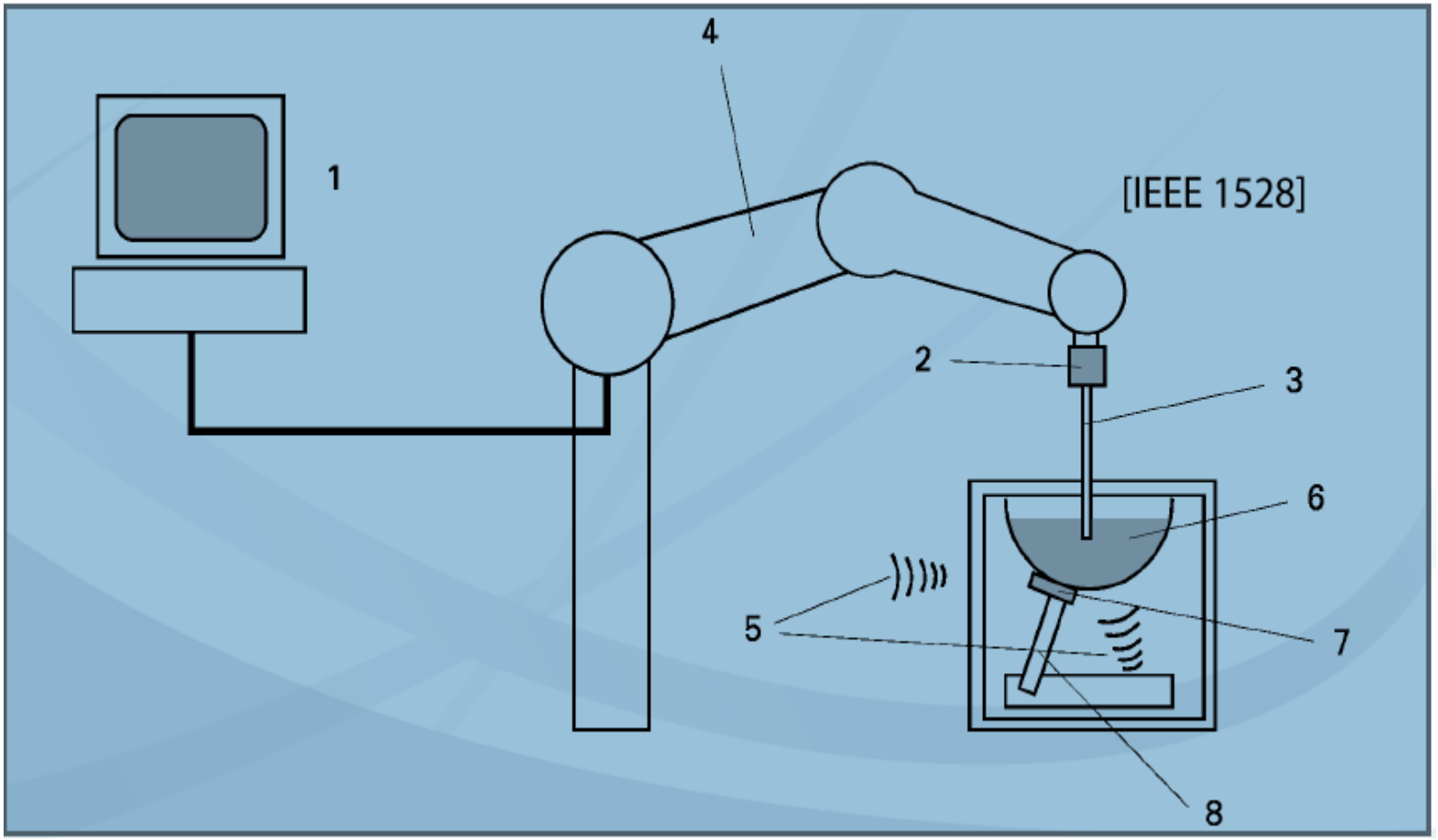


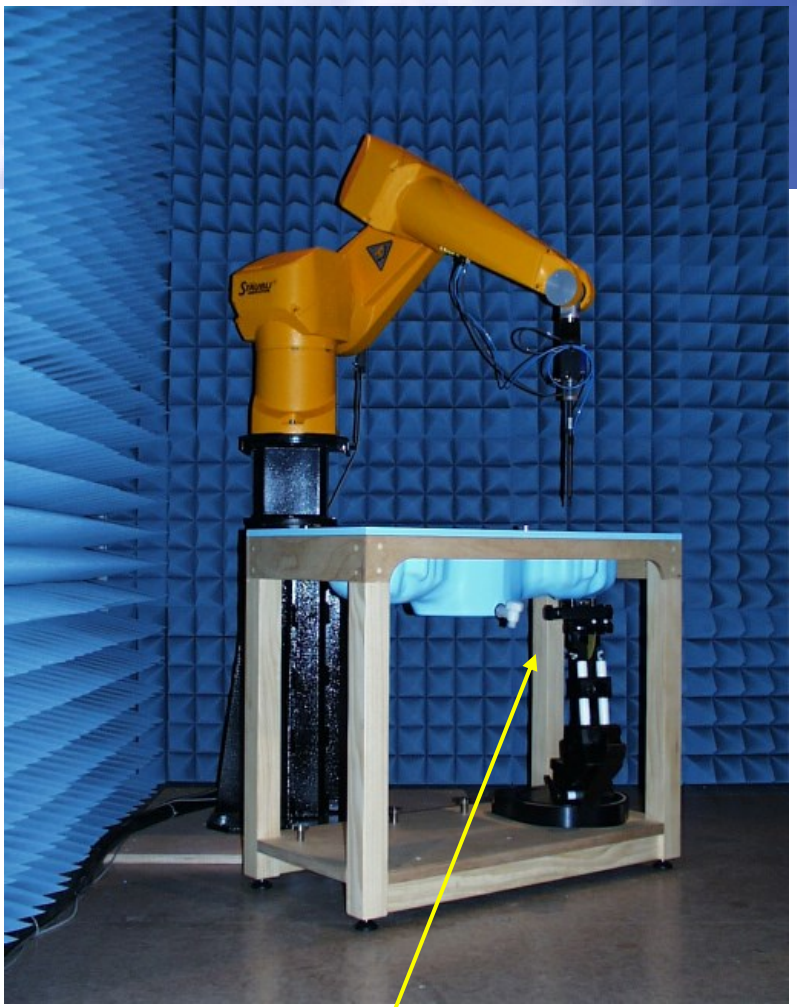
Field measurement unit

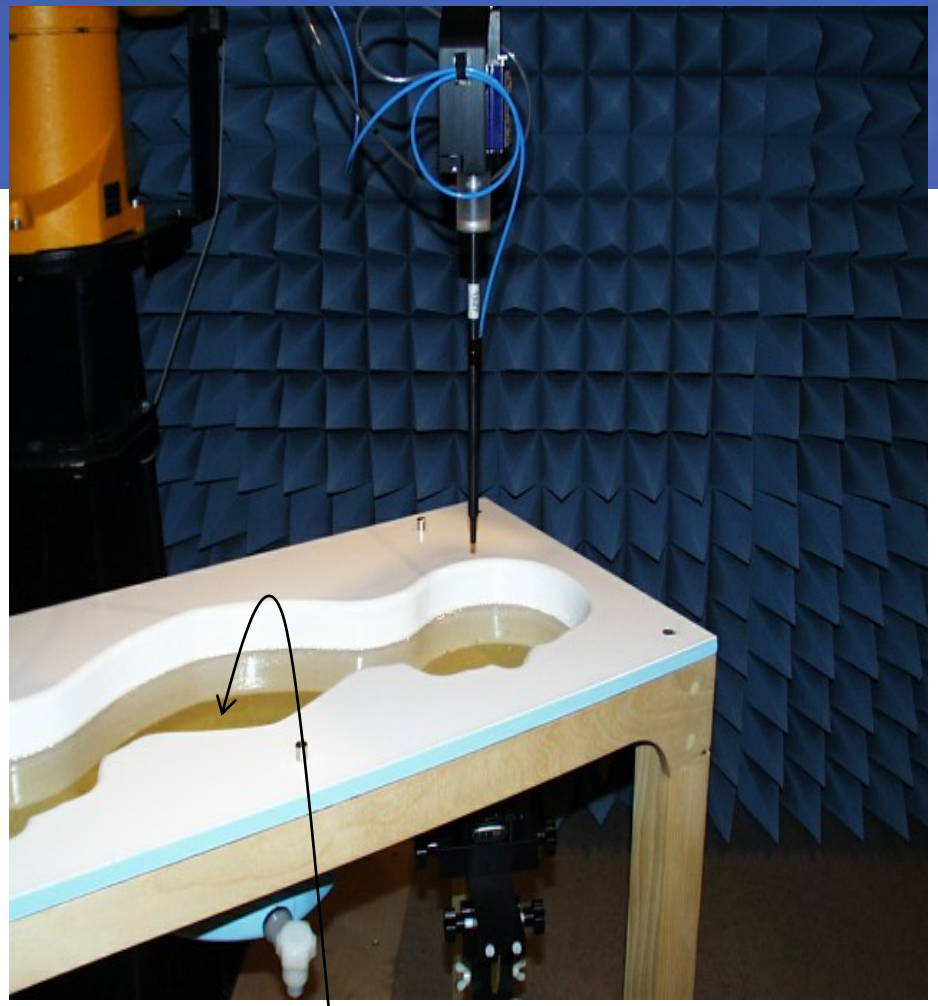


SAM
Head phantom

Principal of near field SAR measurement







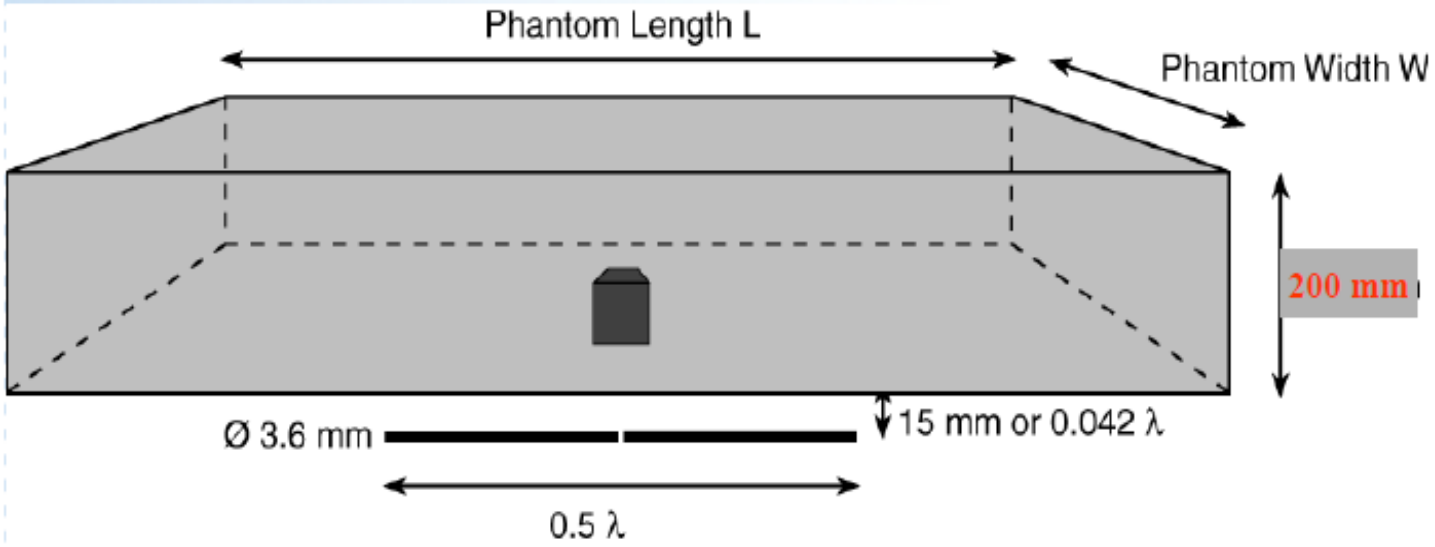
Device under test

Tissue simulating liquid

Wireless Communication Devices Exposure Assessment

Flat Phantom Specifications

- shell thickness
  - bottom:
    - > 800 MHz - 2.0 ± 0.2 mm with < 1% sagging (of λ_{air})
    - ≤ 800 MHz - < 6.5 ± 0.2 mm with < 0.5% sagging (of λ_{air})
  - other regions: unspecified
- length and width: ≥ 0.6 λ
- liquid depth: 15.0 ± 0.5 cm
- shell material: ε_r < 5.0 and loss tangent < 0.05



Tissue dielectric properties
5% measurement uncertainty required

Target Frequency	Head		Body	
(MHz)	ε_r	σ (S/m)	ε_r	σ (S/m)
150	52.3	0.76	61.9	0.80
300	45.3	0.87	58.2	0.92
450	43.5	0.87	56.7	0.94
835	41.5	0.90	55.2	0.97
900	41.5	0.97	55.0	1.05
915	41.5	0.98	55.0	1.06
1450	40.5	1.20	54.0	1.30
1610	40.3	1.29	53.8	1.40
1800 – 2000	40.0	1.40	53.3	1.52
2450	39.2	1.80	52.7	1.95
3000	38.5	2.40	52.0	2.73
5800	35.3	5.27	48.2	6.00

(ε_r = relative permittivity, σ = conductivity and $\rho = 1000$ kg/m^3)

Typical test configurations

- SAR is typically tested on high, middle & low channels
- Handsets are usually tested
  - on the left and right side of the SAM phantom
  - in cheek touching and 15º tilt positions
  - with antenna extended and retracted, as appropriate
  - tests are repeated for all operating modes and frequency bands with certain exceptions
- Other configurations are generally tested on high, middle & low channels with the device positioned at a appropriate distance from a flat phantom

SAR SCAN PROCEDURE

- Area scan to determine peak SAR locations
  - peak SAR mostly near surface of homogeneous phantoms
  - probe boundary effects error requires probe tip location
    - > ½ probe diameter distance from phantom surface
  - typical scan resolution
    - 1-2 cm at < 3 GHz and ≤ 1 cm at > 3 GHz
    - measured values are interpolated to identify peak locations
- zoom scan to determine volume averaged SAR
  - typical scan configurations
    - 5 x 5 x 7 points in 3 x 3 x 3 cm^3 volume at < 3 GHz
    - 7 x 7 x 7 or more points at 3-6 GHz
  - 1-g SAR is computed by
    - extrapolating measured values to the phantom surface
    - interpolating and then integrating with respect to a 1 cm^3

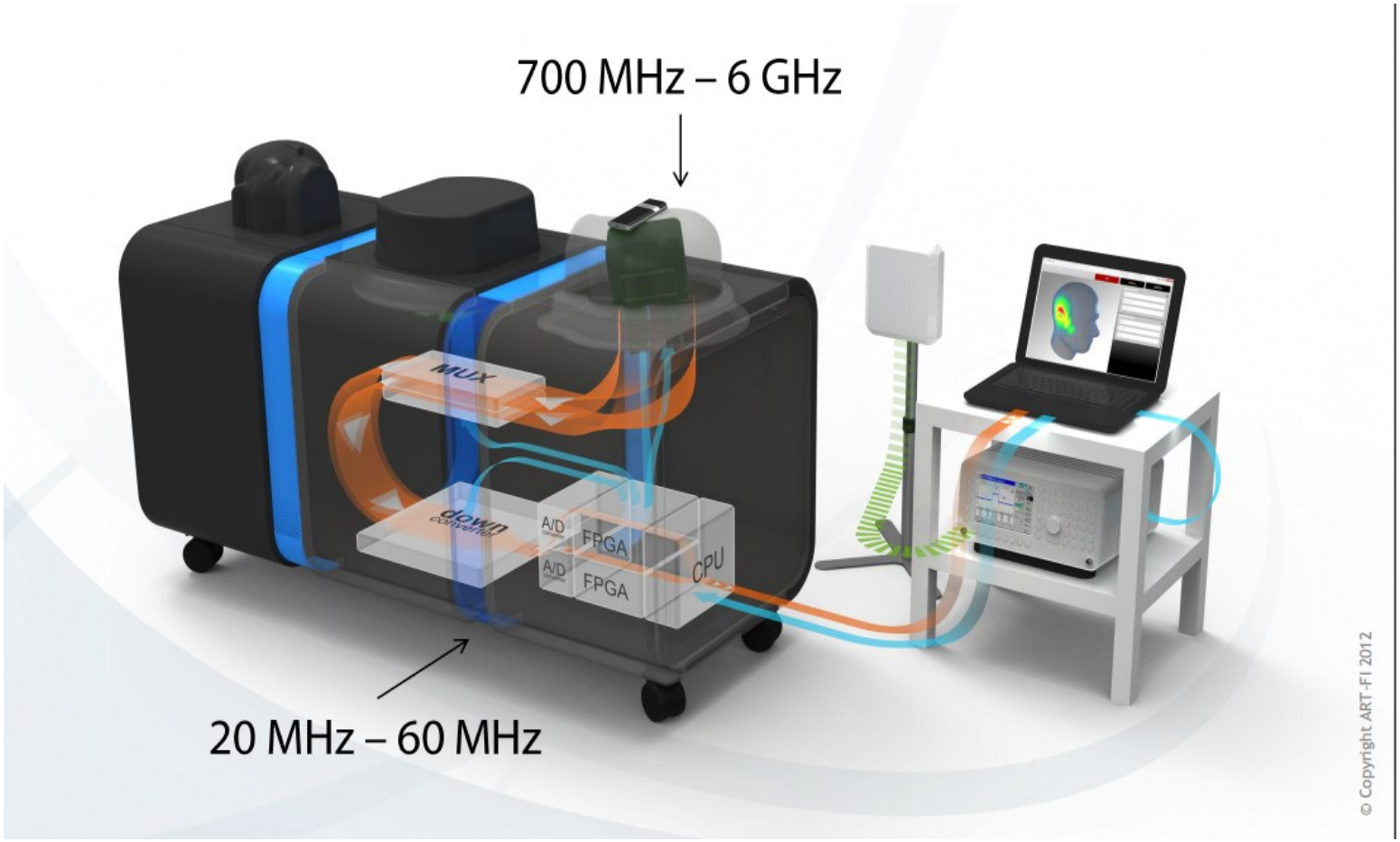
SAR Mesaurement Uncertainty

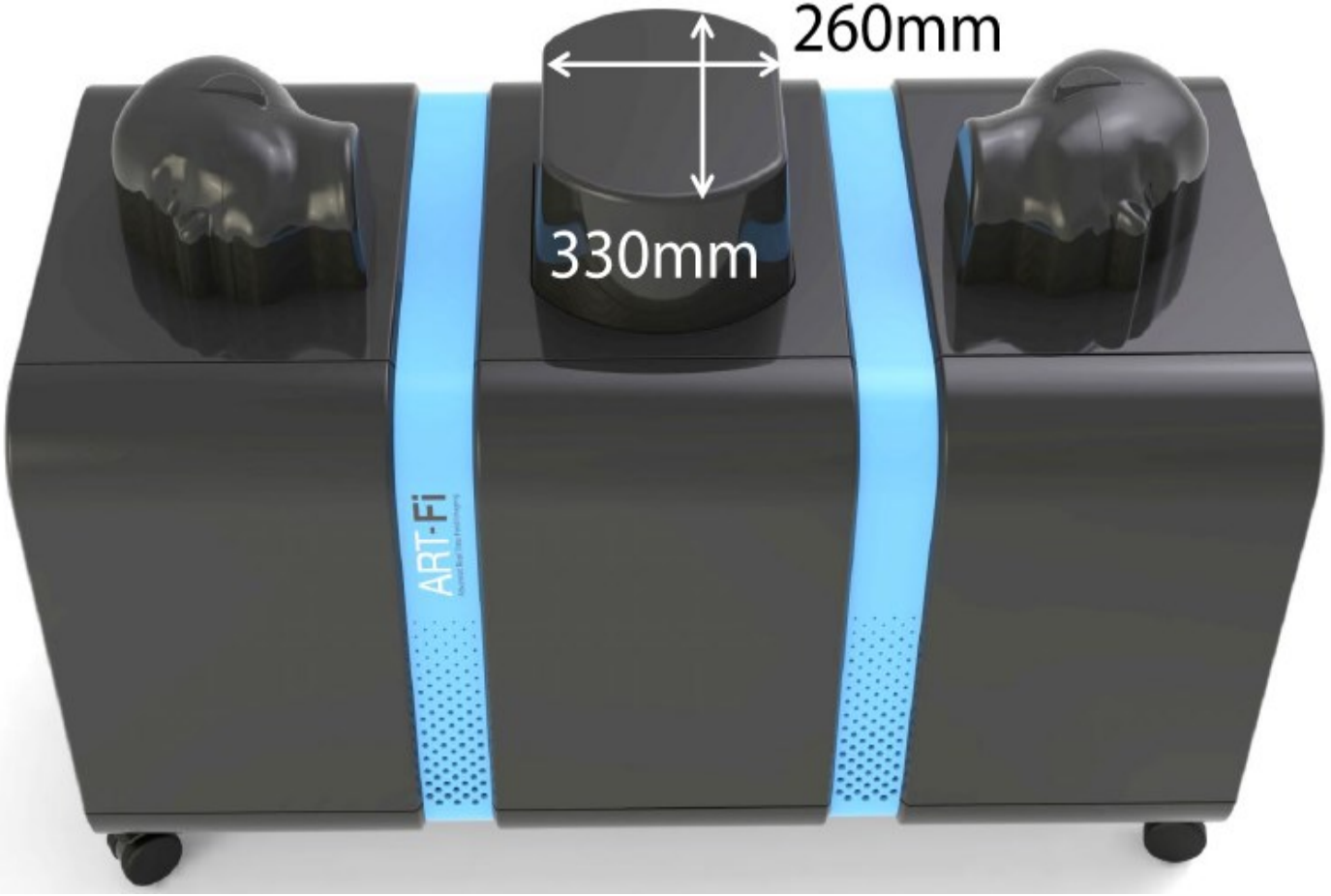
- Identifies the probability of a measured value from its true value
- Standard uncertainty of an uncertainty component
  - type A - statistical analysis of a series of observations
    - estimating the standard deviation
  - type B - other than statistical analysis
    - based on scientific judgement - reference data and specifications
- Combined standard uncertainty
  - estimate the standard deviation by combining standard uncertainties using the "root-sum-squares" method
- Expanded uncertainty
  - multiplied the combined uncertainty by a coverage factor
  - defines the probability of the measured result in an interval where the true value is believed to be

Uncertainty reporting

- Determine compliance according to measured SAR, if uncertainty is too large determine cause and take appropriate actions.
- During equipment certification, compliance is determined according to the measured values provided the expanded measurement uncertainty is less than 30% (IEC 62209-1)
- Device fails if measured value > SAR limit + uncertainty

Emerging SAR Measurement Technologies




260mm
330mm
ART-Fi

Thank you!

Questions?