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Spectrum Management and Telecommunications

Supplementary Procedure

Supplementary Procedure for Assessing Specific Absorption Rate (SAR) and Absorbed Power Density (APD) Compliance of Portable Devices in the 6 GHz Band (5925-7125 MHz)

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Canada

Preface

This Innovation, Science and Economic Development Canada compliance procedure describes the technical requirements and processes to be followed when demonstrating compliance with specific absorption rate (SAR) limits and absorbed power density (APD) limits for portable devices operating in the 6 GHz band (e.g. radio local area network (RLAN) device in the 5925-7125 MHz).

Issued under the authority of the Minister of Innovation, Science and Industry

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MARTIN PROULX
Director General
Engineering, Planning and Standards Branch

Contents

1. Scope

Supplementary Procedure SPR-APD, issue 1, for Radio Standards Specification RSS-102, *Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)*, sets out the general test methods to be followed when carrying out a specific absorption rate (SAR) and absorbed power density (APD) compliance assessment of portable devices overlapping the 6 GHz frequency band that are subject to RSS-248, *Radio Local Area Network (RLAN) Devices Operating in the 5925-7125 MHz Band*.

2. Certification requirements

All testing performed to demonstrate radio frequency (RF) exposure compliance of radio local area network (RLAN) devices operating in the 5925-7125 MHz band shall be carried out by an Innovation, Science and Economic Development Canada (ISED) recognized testing laboratory. To perform APD assessments, the testing laboratory shall have, at a minimum, the **RSS-102 (SAR)**^{MEAS} scope. To perform RF exposure assessments, the testing laboratory shall have, at a minimum, the **RSS-102 (RF Exp.)**^{MEAS} scope.

3. Normative references

The following documents shall be consulted for the application of SPR-APD. The most recent versions of these reference publications shall be used for showing compliance.

- Radio Standards Specification RSS-102, *Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)*
- International Electrotechnical Commission/Institute of Electrical and Electronics Engineers (IEC/IEEE) 62209-1528, *Measurement procedure for the assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-worn wireless communication devices - Human models, instrumentation and procedures (Frequency range of 4 MHz to 10 GHz)*
- Safety Code 6, *Limits of Human Exposure to Radiofrequency Electromagnetic Energy in the Frequency Range from 3 kHz to 300 GHz*
- Safety Code 6 Notice, *Localized human exposure limits for radiofrequency fields in the range of 6 GHz to 300 GHz*
- FCC KDB 248227 D01, SAR guidance for IEEE 802.11 (Wi-Fi) Transmitters

ISED may consider assessment methods not covered by SPR-APD or the referenced publications. Consult ISED's Certification and Engineering Bureau website to determine the acceptability of any alternative measurement methods, or send an inquiry by email with detailed information on the alternative assessment method(s).

4. Definitions and abbreviations

This section contains definitions for terms used throughout this document, as well as explanations for acronyms and abbreviations used herein.

4.1. Definitions

Absorbed power density (APD) evaluation: The method used to evaluate APD levels from a device by physical measurement. An APD evaluation is required for devices operating at a frequency greater than 6 GHz and if the separation distance between the user or bystanders and the device is less than or equal to 20 cm.

Averaging area: The area/volume on the evaluation surface over which the APD or SAR is averaged. For SAR assessments in the 6 GHz band, 1g or 10g tissue volume is used for head/neck/trunk and limbs respectively. For APD assessments in the 6 GHz band, the averaging area is defined as a 4 cm^2 square. This is equivalent to 8g tissue volume.

Peak spatial-average power density: The global maximum value of all spatial-average power density values defined on the evaluation surface.

Spatial peak power density: The global maximum value of the power density values defined on the evaluation surface.

Note: Unlike the peak spatial-average power density, this value is not averaged.

Specific absorption rate (SAR) evaluation: The method used to evaluate SAR levels from a device by physical measurement or computational modelling techniques. A SAR evaluation is required for devices operating at a frequency less than or equal to 6 GHz and if the separation distance between the user or bystander and the device is less than or equal to 20 cm.

4.2. Abbreviations and acronyms

This document uses the following abbreviations and acronyms:

APDabsorbed power density

DUTdevice under test

FCCFederal Communications Commission

IECInternational Electrotechnical Commission

IEEEInstitute of Electrical and Electronics Engineers

ISEDInnovation, Science and Economic Development Canada

KDBknowledge database

MEASmeasurement

PDpower density

pPDspatial peak power density (see definition in section 4.1)

psPD peak spatial-average power density (see definition in section 4.1)

RFradio frequency

RLANradio local area network

SARspecific absorption rate

SPLSR SAR to peak location separation ratio

TER total exposure ratio

UMPCultra-mobile personal computer

5. RF exposure compliance assessment approach

RF exposure compliance shall be demonstrated based on Health Canada's Safety Code 6 limits adopted in RSS-102. As set forth in RSS-102, RF exposure compliance of devices meant to be used less than or equal to 20 cm from a user and/or bystander shall be assessed against the basic restriction limits. Conversely, RF exposure compliance of devices meant to be used at distances greater than 20 cm shall be assessed by an RF exposure evaluation against the reference level limits.

For RLAN devices operating in the 5925 MHz to 7125 MHz band, the same requirements apply.

Devices operating less than or equal to 20 cm from a user and/or bystander:

- from 5925 MHz to 6000 MHz, RF exposure compliance shall be assessed against the SAR limits (basic restrictions) as defined in RSS-102
- above 6000 MHz, RF exposure compliance shall be assessed against APD limits defined by Health Canada's Safety Code 6 Notice adopted in RSS-102

- for frequency channels, which occupy bandwidth above and below 6000 MHz, both the SAR and APD limits apply

Devices operating at distances greater than 20 cm from a user and/or bystander:

- shall continue to be tested according to the requirements and procedures set forth in RSS-102

6. Preparation of the DUT

The preparation of the DUT, including the test positions and configurations shall be based on RSS-102 and its accepted test procedures incorporated by reference, including IEC/IEEE 62209-1528 and FCC KDB 248227 D01. Some requirements are introduced for the test frequencies and channels in the following sub-section.

6.1. Configurations to be tested

The configurations to be tested shall be based on FCC KDB 248227 D01.

The maximum output power, including tune-up tolerance, is used to determine the initial test configuration. When the same maximum power is specified for multiple transmission modes in a frequency band, the initial test configuration shall start with the largest channel bandwidth, lowest order modulation, lowest data rate. The subsequent test configurations, including the test reduction procedures, shall follow the aforementioned FCC KDB.

For APD, the following conversion factors apply for the threshold for test reductions:

- 0.4 W/kg is equivalent to 25% of the APD limits: 5 W/m^2
- 0.8 W/kg is equivalent to 50% of the APD limits: 10 W/m^2
- 1.2 W/kg is equivalent to 75% of the APD limits: 15 W/m^2

When other thresholds are specified in KDBs accepted by ISED, the SAR value in W/kg could be converted to an equivalent $APD_{threshold}$ following this equation:

$$APD_{threshold} = \frac{SAR_{threshold}}{SAR_{limit}} \cdot APD_{limit}$$

Using the methodology and formula in section 7.2.8 of IEC/IEEE 62209-1528, the minimum number of test frequencies shall be 5 provided the number of possible channels is greater than 5. In all cases and test positions, the channel with the highest power subject to SAR limits and the channel with the highest power subject to APD limits shall be tested. When any part of the lowest channel spans across 6000 MHz, compliance to both the SAR and APD limits shall be demonstrated.

An example of the application is shown in table 1. If the device operates using 80 MHz channels, there are 14 possible channels between 5925 and 7125 MHz. For the purposes of testing, a minimum of 5 test frequencies shall be used. The test frequencies should represent the entire frequency range and be evenly spaced representing the low, middle and high portion of the band.

Table 1: Minimum number of test frequencies required

Channel bandwidth (MHz)	Number possible channels	Minimum number of test frequencies
320	3	3
160	7	5
80	14	5
40	29	5
20	60	5

Situations where SAR compliance (as per IEC/IEEE 62209-1528 or other procedures accepted by ISED) are at a particular separation distance leading to test reduction shall be carefully examined and documented in the RF exposure technical brief. For instance, per FCC KDB 941225 D07, 1g SAR at 5 mm is required for devices classified as ultra-mobile personal computer (UMPC). Once compliance is demonstrated under these conditions, 10g SAR at 0 mm is exempted. However, such exemption does not exist for APD. To determine compliance, the DUT shall be assessed against the:

- APD limits at 0 mm
- 1g SAR at the prescribed distance of 5 mm

Both of these values shall be documented in the RF technical brief.

For the instance of UMPC described above, it is permitted to test the DUT against the 10g SAR at 0 mm for completeness; however, consistent with the test reduction principle, this value does not have to be reported.

In all cases, ISED notes the use of the test reduction for certification purposes does not in any way prevent ISED from employing enforcement measures for non-compliant readings reached outside of the test reduction principle for the purpose of compliance with Safety Code 6 limits adopted in RSS-102.

7. Measurements

While SAR assessments have been established for many years, APD assessments are relatively new. A scientific journal recently published that the APD may be derived from SAR measurements (see *Compliance Assessment of the Epithelial or Absorbed Power Density Below 10 GHz Using SAR Measurement Systems* (https://onlinelibrary.wiley.com/doi/abs/10.1002/bem.22355) for details). As a result, measurement systems capable of assessing SAR may be used to assess APD provided they implement algorithms (see section 7.1) allowing the conversion from SAR to APD.

7.1. Measurement system requirements

APD shall be assessed with a SAR measurement system, which complies with all the requirements in RSS-102 and the IEC/IEEE 62209-1528 international standard.

The APD shall be derived from the measured SAR values using the formulas in the *Compliance Assessment of the Epithelial or Absorbed Power Density Below 10 GHz Using SAR Measurement Systems* document.

The APD evaluation shall be based on the same measurement procedure as defined in RSS-102 and IEC/IEEE 62209-1528 for SAR but with modifications to the uncertainty evaluation (see section 7.3) to account for the conversion from SAR to APD.

7.2. System validation and system check

The system validation and system check shall continue to be performed as per IEC/IEEE 62209-1528. The numerical SAR target values found in table D.2 of that document shall continue to apply.

7.2.1. System check

For system check, it is acceptable to use the various SAR and APD values from the dipole calibration certificate.

7.2.2. System validation

For system validation, in addition to the target values found in table D.2 of IEC/IEEE 62209-1528, the following target values, as shown in table 2, shall be used for standard dipoles and flat phantoms.

Table 2: System validation target values

Frequency (MHz)	1g SAR (W/kg)	8g SAR (W/kg)	10g SAR (W/kg)	4 cm^2 APD (W/m^2)
6500	298.4	64.6	52.8	1290
7000	275.0	59.7	47.0	1190

Above 6000 MHz, for successful system validation, step a) of annex A.3.5 of the IEC/IEEE 62209-1528 shall be used for the 8g SAR values, which is equivalent to 4 cm^2. In situations where the measurement system does not report the 8g SAR value, validation may be performed directly against the 4 cm^2 APD target value.

The measured system validation and system check values shall be reported in the RF exposure technical brief.

7.3. SAR Correction

The 10g SAR correction coefficient found in section 7.8.2 of IEC/IEEE 62209-1528 can also be applied for the 8g SAR.

7.4. Uncertainty evaluation

Measurement equipment manufacturers shall provide all associated uncertainty components for the conversion of SAR to APD. They shall be added to the uncertainty budget table specified in section 8 of the IEC/IEEE 62209-1528. The updated uncertainty budget shall be provided in the RF exposure technical brief submitted to ISED in the certification filing.

7.5. Measurement of devices with multiple antennas or multiple transmitters

When an operational mode is capable of multiple simultaneous transmissions, operating in bands other than the 6 GHz frequency band, this operational mode shall also be tested using procedures outlined in RSS-102 and its associated SPRs.

A conservative way to assess compliance with the RF exposure limits is to evaluate the corresponding total exposure ratio (TER), which can be expressed as:

$$TER_{SAR-PD} = \sum_{n=1}^{N} ER_{SAR,n} + \sum_{m=1}^{M} ER_{PD,m} + \sum_{k=1}^{K} ER_{EH-SAR,k}$$

where:

- TER_{SAR-PD} is the SAR-PD based TER
- N is the total number of transmitters for which a SAR assessment has been performed
- $ER_{SAR,n}$ is the exposure ratio contribution from the n-th transmitter for which a SAR assessment has been performed
- M is the total number of transmitters for which a PD and/or APD assessment has been performed
- $ER_{PD,m}$ is the exposure ratio contribution from the m-th transmitter for which a PD and/or APD assessment has been performed
- K is the total number of transmitters for which an assessment against the SAR-based reference levels for the incident E- and H-fields has been performed
- $ER_{EH-SAR,k}$ is the exposure ratio contribution from the k-th transmitter for which an assessment against the SAR-based reference levels for the E- and H-fields has been performed

The exposure ratio resulting from a SAR assessment can be expressed as:

$$ER_{SAR,n} = \frac{SAR_n}{SAR_{limit}}$$

where:

- SAR_n is the SAR value for the n-th transmitter/test frequency
- SAR_{limit} is the basic restriction limit that is applicable to the n-th transmitter/test frequency

For transmitters operating above 6000 MHz, it is necessary to perform an assessment against the PD (basic restriction up to 10 GHz and reference levels beyond). The exposure ratio for the m-th transmitter is given by:

$$ER_{PD,m} = \begin{cases} max\left[\frac{SAR_m}{SAR_{limit}}, \frac{APD_m}{APD_{limit}}\right] & , \quad 5925\ \mathrm{M}Hz < f_m \leq 10\ GHz \\ \frac{psPD_m}{psPD_{limit,m}} & , \quad 10\ GHz < f_m \leq 30\ GHz \\ max\left[\frac{psPD_m}{psPD_{limit,m}}, \frac{pPD_m}{pPD_{limit,m}}\right], & \quad f_m > 30\ GHz \end{cases}$$

where:

- SAR_m is the SAR value for the n-th transmitter/test frequency
- SAR_{limit} is the basic restriction limit that is applicable to the n-th transmitter/test frequency
- APD_m is the APD value for the m-th transmitter/test frequency
- APD_{limit} is the basic restriction limit that is applicable for the m-th transmitter/test frequency
- $psPD_m$ is the psPD value for the m-th transmitter
- $psPD_{limit,m}$ is the applicable psPD reference level limit for the m-th transmitter
- f_m is the operating frequency of the m-th transmitter
- pPD_m is the pPD value for the m-th transmitter
- $pPD_{limit,m}$ is the applicable pPD reference level limit for the m-th transmitter

When taking into account contributions from transmitters operating below 10 MHz, it is necessary to perform an assessment against the SAR-based reference levels for the incident E- and/or H-fields. The corresponding exposure ratio is given as:

$$ER_{EH-SAR,k} = \begin{cases} \left(\frac{H_{SAR,k}}{H_{RL-SAR,k}}\right)^2 & , \quad 100\ kHz \leq f_k < f_{env} \\ \max\left[\left(\frac{E_{SAR,k}}{E_{RL-SAR,k}}\right)^2, \left(\frac{H_{SAR,k}}{H_{RL-SAR,k}}\right)^2\right], & \quad f_{env} \leq f_k < 10\ MHz \end{cases}$$

where:

- $H_{SAR,k}$ is the root-mean-square (RMS) incident H-field from the k-th transmitter, time-averaged in accordance with a SAR-based assessment

- $H_{RL-SAR,k}$ is the SAR-based reference level for the incident H-field which is applicable to the k-th transmitter
- f_k is the operating frequency of the k-th transmitter
- $E_{SAR,k}$ is the RMS incident E-field from the k-th transmitter, time-averaged in accordance with a SAR-based assessment
- $E_{RL-SAR,k}$ is the SAR-based reference level for the incident E-field that is applicable to the k-th transmitter
- f_{env} is 1.10 MHz when considering the limits for uncontrolled environments and 1.29 MHz when considering the limits for controlled environments, as per Health Canada's Safety Code 6

Compliance with the SAR-PD based RF exposure limits is achieved if $TER_{SAR-PD} \leq 1$. In the context of SPR-APD, ISED accepts the FCC's method based on the SAR to peak location separation ratio (SPLSR) as a method to determine test reduction for simultaneous transmission when $TER_{SAR-PD} > 1$.

$$SPLSR = \frac{\left(max\left[\frac{SAR_1}{SAR_{limit}}, \frac{APD_1}{APD_{limit}}\right] + max\left[\frac{SAR_2}{SAR_{limit}}, \frac{APD_2}{APD_{limit}}\right]\right)^{1.5}}{Distance}$$

where:

- SAR_1 and SAR_2 are the SAR value for the 1st and 2nd transmitter respectively
- SAR_{limit} is the applicable basic restriction limit
- APD_1 and APD_2 is the APD value for the 1st and 2nd transmitter respectively
- APD_{limit} is the applicable basic restriction limit
- $Distance$ is the separation distance between the peak exposure location of the 1st and 2nd transmitter in **mm**

Note: Simultaneously transmitting antenna combinations must be considered one pair at a time to determine SPLSR for test reduction consideration.

Simultaneous transmission testing may be exempted when the transmitters are considered to be spatially separated:

- SPLSR ≤ 0.02 for head, neck and trunk exposure conditions
- SPLSR ≤ 0.013 for limb exposure conditions

To apply SPLSR, ISED notes that the separation distance and configuration for each individual transmitter shall be the same. This may imply conducting additional SAR measurements on test conditions that are normally exempted through test reduction.

All other situations where the TER exceeds unity shall be reported to ISED. Alternative methods considering point-by-point evaluations may be considered on a case-by-case basis. The TER shall be documented in the RF exposure technical brief.

It is also important to demonstrate compliance with the exposure limits to prevent nerve stimulation. However, the assessment is performed separately and the resulting exposure ratios are not added to the TER_{SAR-PD}.

8. RF exposure technical brief

In addition to the requirements set forth in section 2.2 of RSS-102, the RF technical brief shall also include the:

- uncertainty budget calculations as defined in section 7.4
- system check values above 6 GHz
- system validation values above 6 GHz

Annex A: Bibliography

The following documents were consulted in the preparation of this supplementary procedure:

Samaras, T., Christ A., and Kuster, N. (2021). *Compliance Assessment of the Epithelial or Absorbed Power Density Below 10 GHz Using SAR Measurement Systems* Bioelectromagnetics (https://onlinelibrary.wiley.com/doi/abs/10.1002/bem.22355), online June 15, 2021

International Electrotechnical Commission, *Conversion Method of Specific Absorption Rate to Absorbed Power Density for the Assessment of Human Exposure to Radio Frequency Electromagnetic Fields from Wireless Devices in Close Proximity to the Head and Body – Frequency Range of 6 GHz to 10 GHz* (Draft)