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Federal Communications Commission
Office of Engineering and Technology
Laboratory Division

**RF Exposure Procedures and Equipment Authorization Policies
for Mobile and Portable Devices**

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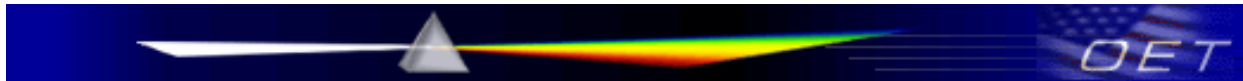
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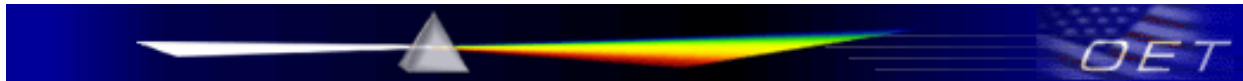
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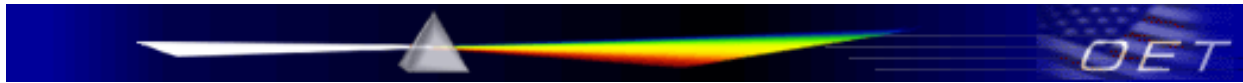
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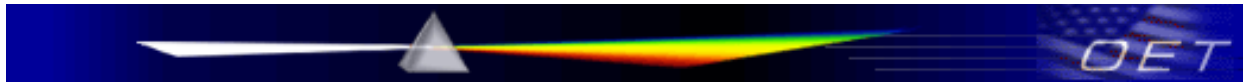
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1 GENERAL CONSIDERATIONS, POLICIES, AND REQUIREMENTS

1.1 Documentation on RF Exposure Procedures

This document provides RF exposure procedures and equipment authorization policies for compliance evaluations and demonstrations of mobile and portable devices to FCC exposure rules. The procedures and policies cover intentional-radiator and transmitter *RF sources*, and unintentional-radiator *RF sources* operating under Part 15 and Part 18. For fixed *RF sources* and transmitter sites, policies and procedures for RF exposure compliance evaluations and demonstrations are provided in FCC's OET Bulletin 65 [Reference]. The document is arranged with Section 1 through Section 6 covering the main topics, Appendix A through Appendix E on additional details, and Glossary explaining terms and definitions and special notations used in this document.

This guidance document KDB Pub. 447498 D01 describes the general RF exposure evaluation requirements and serves as an entry point for the more specific RF exposure guidance described in the collection of KDB publications on RF exposure procedures [Reference].¹

1.2 RF Exposure Requirements for Equipment Authorization

In general, KDB publications are applied in conjunction with other FCC rules, policies, and procedures to prepare devices for equipment authorization. Guidance in the most recent revision of the KDB publications and TCB workshop updates,² whichever is the latest at the time when device testing begins, must be applied.

The guidance in this document, as well as in any other applicable KDB publications, must be followed for equipment approval, unless further guidance is provided by the FCC. When the published KDB procedures are not fully applied, equipment authorization is allowed only with prior approval from the FCC obtained through KDB inquiries.

For some cases, especially for new technologies and emerging products, or devices that require substantial FCC evaluation, the equipment approval is subject to PAG procedures, as defined in KDB Pub. 388624 D01. For the devices and conditions that are on the PAG List (KDB Pub. 388624 D02), a PAG is required before equipment approval. Further clarifications can be obtained from the FCC Laboratory by submitting inquiries to the KDB system.

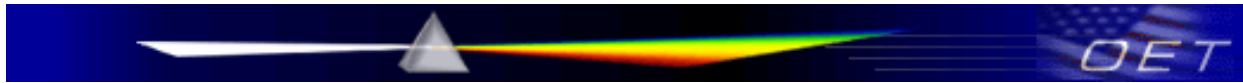
The FCC shall also be contacted to determine if existing test guidance is sufficient for evaluating new and evolving products and technologies. In some cases, e.g., when new test procedures are under development, interim test guidance may be provided through TCB Conference presentations, before KDB procedures are published.

1.3 Relation to the New FCC RF Exposure Rules

The FCC RF exposure rules were amended and revised by the *Second Report and Order* portion (referred to herein as the *Order*) of FCC 19-126, ET Docket No. 03-137, released December 4,

¹ Guidance for RF exposure evaluation is available from the [FCC website](https://www.fcc.gov/labhelp) through Knowledge Database Publications (KDB) at www.fcc.gov/labhelp. These publications provide RF exposure test and evaluation support for specific products, wireless technologies, test methodologies, and equipment approval policies.

² See FCC OET Laboratory Division Telecommunication Certification Body (TCB) Equipment Authorization Presentations, (<https://www.fcc.gov/oet/ea/presentations>).



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2019. Under the preceding rules, *Routine Evaluation* [[Glossary](#)] for RF exposure compliance demonstration was required only for a list of specific radio services and operations, while others not in that list were exempt from this requirement.

Under the new rules, all radio services and operations are subject to *Routine Evaluation* [§§ 1.1307(b)(1), 2.1033(f), etc.], unless shown to qualify under the exemptions provided in the rules and OET Lab policies for equipment authorization.

As part of the rule changes adopted by the *Order*, and the *First Report and Order* of docket no. 03-137 (FCC 13-39), §§ 1.1310(d)(4) and 2.1093(d)(3) were amended to reference KDB publications for acceptable RF exposure measurement procedures, rather than industry standards such as IEEE/IEC 62209-1528:2020, for mobile and portable devices equipment authorization purposes.

Uniform guidance and procedures for RF exposure compliance testing are given in KDB Pub. 865664 Attachment D01 for SAR, and in OET Bulletin 65 [[Reference](#)] for general MPE and fixed-site RF sources. KDB Pub. 865664 Attachment D02 specifies minimum requirements for uniform reporting of RF exposure compliance technical information in equipment authorization applications.

This document includes summaries of the exposure rules related to equipment authorization, primarily for mobile and portable devices, as well as additional policies and guidance for equipment authorization. In addition to basic changes from the rulemaking Order, in this document many of the underlying specific requirements and conditions and procedures remain unchanged from previous revisions, however some content re-organization has been introduced for clarification purposes.

1.4 Basic Concepts and Definitions

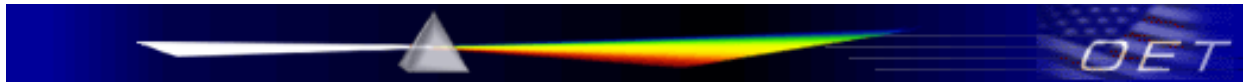
1.4.1 RF Exposure Limits

The RF exposure guidelines adopted by the FCC are based on SAR and MPE limits. The basic restrictions for human exposure are defined by SAR limits. MPE limits are derived from the SAR limits, in terms of free-space field strength and power density. SAR compliance is determined using tissue-equivalent media, at the applicable test frequencies.

1.4.2 Mobile and Portable Devices

For devices that operate at larger distances from persons, where there are minimal RF coupling interactions between a device and the user or nearby persons, the more complex SAR evaluation can be avoided by evaluating RF exposure compliance using MPE limits. The RF exposure evaluation requirements of § 2.1091 for mobile device exposure conditions subject to MPE limits, and § 2.1093 for portable device exposure conditions subject to SAR limits are different. Portable devices transmitting at frequencies above 6 GHz (e.g., Part 15 U-NII 6 GHz band) are subject to the MPE incident power density limits of § 1.1310.³ The RF exposure evaluation policies and procedures for portable devices in this document are applicable only where SAR

³ MPE compliance for portable devices above 6 GHz is evaluated at the minimum separation distance applicable to the operating configurations and exposure conditions of a device; the general-population/uncontrolled limit is 1 mW/cm² power density determined from the total field, averaged over 4 cm².



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evaluation is allowed; guidance for portable devices requiring MPE power density evaluation is provided in other OET documents.⁴

When both mobile device and portable device exposure conditions apply, compliance is determined according to the rules and policies established for each exposure condition.

A synopsis of the applicable limits for the mobile and portable device categories is shown in Table 1.

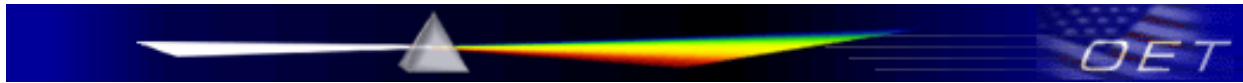
Table 1 – Synopsis of FCC RF Exposure Limits for Mobile and Portable Devices

Frequency f		FCC RF Exposure Limits
$f \leq 100$ kHz		All devices assessed case-by-case (guidelines for wireless power transfer devices are provided KDB Pub. 680106)
100 kHz $< f \leq 300$ kHz		SAR limits in § 1.1310 (b), (c), (d)
300 kHz $< f \leq 6$ GHz	Portable device	SAR limits in § 1.1310 (b), (c), (d)
	Mobile device	Per § 2.1093(d) SAR limits in § 1.1310 (b), (c), (d) OR Per § 1.1310(d)(2) MPE limits in § 1.1310(e)(1) - Table 1
$f > 6$ GHz		For all devices, MPE limits in § 1.1310(e)(1) - Table 1

1.4.3 Test Exemptions and Test Reductions

Devices that are not exempted from RF exposure testing, according to §§ 1.1307(b)(3), 2.1091(c), and 2.1093(c), need to follow the procedures in this document, and in other KDB publications referenced herein, to demonstrate compliance required for equipment authorization. When § 2.1091(d)(4) applies, i.e., there the possibility for a device be to be operated under portable exposure conditions (more conservative than mobile device exposure), the SAR test exemption provisions shall be considered, as applicable.

⁴ Guidance for portable devices requiring MPE power density evaluation is provided in the most recent TCB workshop presentations and references therein (<https://www.fcc.gov/general/equipment-authorization-presentations>), and per case-by-case basis in KDB inquiries. Per TCB workshop guidance, while industry development of test methods and test systems is ongoing, and until further notice, OET accepts SAR test data (supplemented with other measured and derived PD results), for interim compliance purposes of portable devices in the 5.925-7.125 GHz band.



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For devices that do not qualify for RF exposure test exemption, the RF exposure test reduction provisions in Section 3 of this document shall be applied to verify compliance, typically related to worst-case (from an RF exposure perspective) configurations.⁵

1.4.4 Standalone vs. Simultaneous Transmission

Standalone and simultaneous transmission use conditions for mobile device and portable device exposure conditions must be determined according to the host platform and product operating configuration requirements.

Transmitters approved only for use in standalone operations cannot be used in simultaneous transmission operations without further evaluation; this is typically accomplished through the test exemption provisions or specific testing required for equipment approval. Except for transmitters that cannot operate in standalone configurations, when SAR measurement is required for simultaneous transmission conditions, approval for standalone use is required for each individual transmitter (more details in Section 2.2).

For devices that do not support standalone transmission, there is no measured standalone SAR result to determine simultaneous transmission SAR test exemption. The standalone SAR may be then estimated according to procedures in Section 2.1 to determine simultaneous transmission SAR test exemption. In the alternative, the enhanced zoom scan measurement and volume scan post-processing procedures in KDB Pub. 865664 D01 must be applied to determine SAR compliance.

1.5 Application to Modules

1.5.1 Host Device Exposure Conditions

Transmitter modules [[Glossary](#)] shall be authorized according to the applicable host device exposure conditions, as described in this section, which refer to the module configurations tested or evaluated for equipment authorization when incorporated in qualified host products.

The *host platform exposure condition(s)* [[Glossary](#)] must be identified in the test reports and equipment certification records.

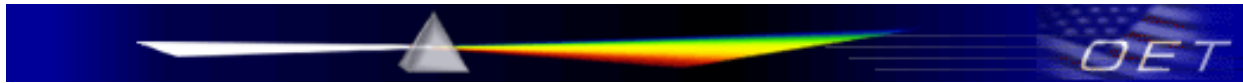
When transmitter modules are incorporated in host devices that qualify for RF exposure test exemption, and no other testing or equipment approval is required, the standalone and simultaneous transmission configurations and test exemption conditions must be fully documented by both the grantee and host integrator, according to Class I permissive change requirements.

1.5.2 Mobile Device Exposure Configurations

Mobile exposure host platform evaluation procedures can be applied only if all transmitters in the host devices support mobile device exposure conditions.

Transmitters and modules approved only for use in a mobile device *exposure host* platform are not approved to operate in the more restrictive portable device exposure conditions.

⁵ In some cases, the FCC may require RF exposure testing or analysis to be performed, based on the provisions of §§ 1.1307 (c) and (d) [§§ 2.1091(c)(2), 2.1093(c)(3)].



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1.5.3 Portable Device Exposure Configurations

The portable device *exposure host* platform, or the *mixed mobile and portable device exposure* platform is required to support portable device exposure conditions in qualified host configurations. Portable device *exposure host* platform evaluation procedures can be applied only if all transmitters in the host devices support portable exposure conditions.

Transmitters and modules approved for use in the *portable device exposure host* platform may be used for standalone operations in *mobile device exposure host* platforms, without further equipment approval, only when the same identical transmitter and antenna required for portable device exposure conditions are used.

Any transmitter or antenna changes required to support mobile device exposure host platform use configurations must also satisfy portable device exposure host platform requirements, and be addressed accordingly through Class II permissive changes. Alternatively, the mixed mobile and portable device exposure host platform shall be applied.

1.5.4 Mixed (Mobile and Portable Device) Exposure Configurations

The *mixed mobile and portable exposure host* platform enables host devices to incorporate transmitters in qualified mobile device and portable device exposure conditions, for standalone and simultaneous transmission operations, by applying the required KDB publication(s) applicable for the host product to address RF exposure compliance (e.g., KDB Pubs. 616217, 248227).

Transmitters and modules approved for use in *mixed mobile and portable exposure host* platform may be used for standalone and simultaneous transmission operations when integrated in host devices. In this case, use in either mobile or portable device exposure conditions in qualified host configurations shall be supported by the required test results and test exemption conditions.

When the simultaneous transmission test exemption provisions for mobile device exposure in Section 2.2 applies, a transmitter or module approved for use in the *portable exposure host* platform may be used for simultaneous transmission operations in the *mixed mobile and portable exposure host* platform according to Class I permissive change requirements without further equipment approval.

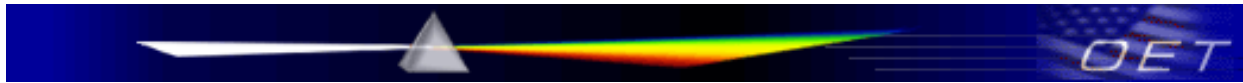
When tests are required to support additional antenna or host configurations, the results must be sufficiently conservative to demonstrate compliance for all standalone and simultaneous transmission operations required by the hosts and product configurations through subsequent Class II permissive changes.

1.6 General Population vs. Occupational Exposure Environments

1.6.1 General Population Exposure Environment

Transmitters operating in consumer products must comply with the general population exposure limits required for mobile device and/or portable device RF exposure conditions, as applicable.⁶ In general, the test configurations used to qualify for test exemption, or for compliance must be sufficiently conservative for all required operations. Accordingly, the devices and accessories shall be tested for normal use without requiring specific user intervention to maintain compliance.

⁶ See §§ 1.1310(e)(3) and 2.1093(d)(6).



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All device operating instructions and installation requirements must be consistent with the chosen test configurations and results that are presented for compliance purposes. It is unacceptable to provide instructions as a substitute to actual test data. Cautionary statements or warning labels are only acceptable for alerting users to avoid exposures in certain unintended use conditions that are not required for normal operations.

1.6.2 Occupational Exposure Environment

As defined in the FCC rules, occupational exposure limits only apply to “*work-related*” use conditions. Users must be “*fully aware of*” and be able to “*exercise control over*” their exposure through acceptable training to qualify for the higher occupational exposure limits.

Mandatory RF exposure training is required for workers to qualify devices for occupational exposure limits. Detailed training instructions incorporated in user manuals, in conjunction with conspicuous permanent labeling on the device, may be considered as acceptable training to qualify workers to operate a device according to occupational exposure limits. Supporting information shall demonstrate that users are required to adhere to the training instructions and are able to mitigate compliance concerns by applying the instructions. The training information must be included in the equipment authorization application.

Occupational exposure limits do not apply to consumer devices and radio services intended for supporting public networks, or to Part 15 unlicensed operations.

When general population and occupational limits are required for different transmitters within a host device, due to radio service rules, or when the use is not specified, each transmitter shall refer to the exposure limit that applies to its corresponding use conditions.

For instance, TX1, a transmitter designed for occupational exposure environment, may be integrated with TX2, transmitter that is authorized for general population use. The integrated device shall be then certified in reference to occupational exposure when TX1 is active (that includes the case of simultaneous TX1 and TX2 operation), and for general population limits when only TX2 is active.

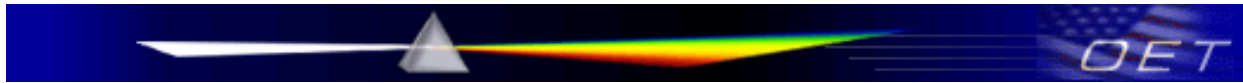
When devices are authorized in accordance with the general population exposure limits, additional equipment approval is not required to satisfy occupational exposure requirements (since they are less restrictive).

1.7 RF Exposure Considerations related to Installation and Operation Instructions

This sub-section provides general guidelines for the type of information that needs to be included for installation and operations of all RF devices, regardless of whether they are modular transmitter grants or not. The instructions required for standalone products and modular transmitters are generally different due to varying host configurations; therefore, different considerations shall be given to ensure RF exposure compliance for both standalone and simultaneous transmission operations.

As required by §§ 2.1033(b)(3) and 2.1033(c)(3), the required operating and installation instructions shall be furnished to all persons who require such information to ensure or maintain compliance and, as appropriate (such as users and installers). These shall be reviewed for acceptance during equipment authorization process.

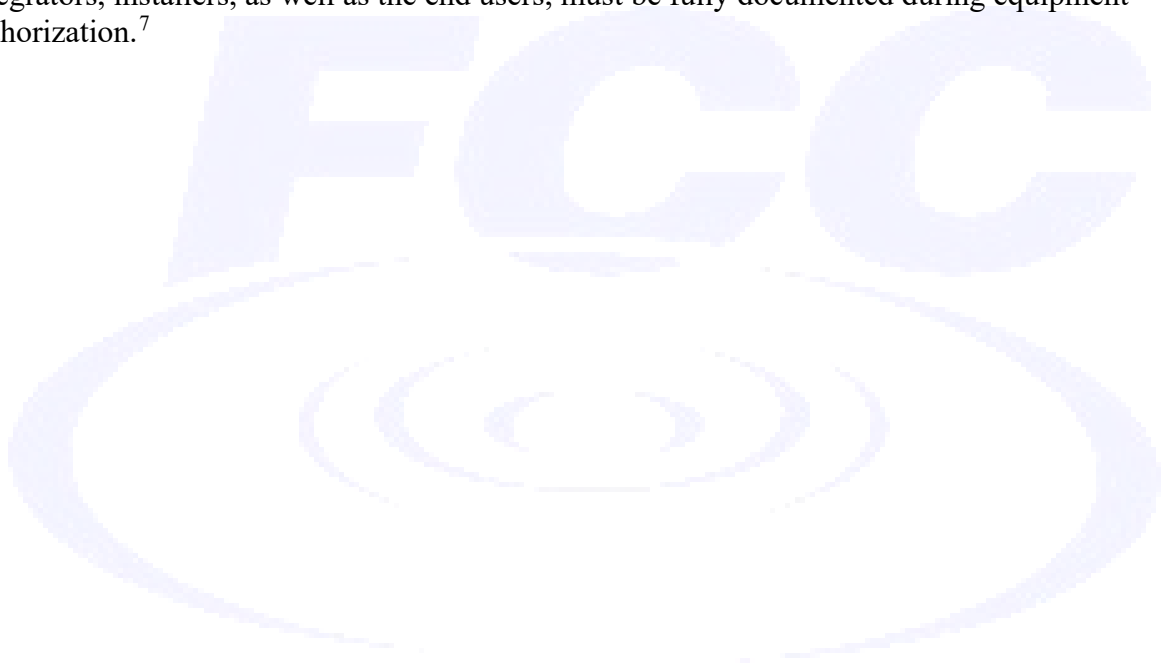
The acceptable host platform configurations, exposure conditions, and any restrictions, approved for a *modular transmitter*, must be fully described in the equipment approval and required OEM integration instructions.



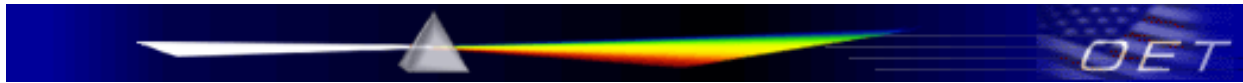
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User instructions for installation, OEM integration, or assembly by a third-party must be sufficiently clear and consistent for the target audience, whether it is limited to trained professionals, or to general consumers who are generally not professionally trained to install and operate the equipment, including specific requirements to ensuring RF exposure compliance. The entity that is granted the equipment authorization for a given equipment, typically the manufacturer, is responsible for ensuring the installers and integrators have a clear understanding of the compliance requirements by including the required instructions and documentation with the product and, if necessary, to provide further support to fulfill grantee responsibilities for ensuring compliance.

The installers and integrators must be fully informed of their obligations, and verify the resolution of any issues and concerns with each transmitter manufacturer or grantee. For transmitter modules, the different disclosures required for the entire supply chain to ensure compliance, including grantees of individual transmitters, host manufacturers, and OEM/ODM integrators, installers, as well as the end users, must be fully documented during equipment authorization.⁷



⁷ User manuals, product integration or installation instructions and general disclosure conditions normally do not qualify for confidentiality. The rules of confidentiality typically apply to product design details that are considered as trade secrets. When applicable, such information may be included separately in the equipment approval and must be properly referenced in the non-confidential documents.



2 GENERAL RF EXPOSURE TEST EXEMPTION GUIDANCE

2.1 RF Exposure Test Exemptions for Single Source

2.1.1 General RF Exposure Test Exemption Considerations

RF exposure test exemptions provide means to obtain certification without the need of showing data (measurements, or analytical/numerical modeling) to demonstrate compliance. Hereafter, in this context, an RF source is referred to as “*exempt RF device*” [Glossary] in the sense that it is not required to show data demonstrating compliance to RF exposure limits.

Test exemptions apply for devices used in general population/uncontrolled exposure environments, according to the SAR-based, or MPE-based exemption thresholds.⁸ However, it is always possible, especially when the potential for exposure cannot be easily determined, that an RF exposure evaluation may become required according §§ 1.1307(c) and (d).

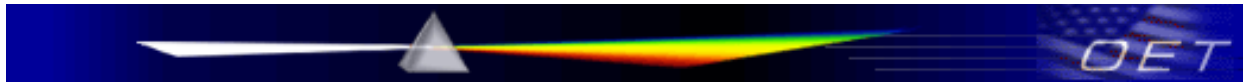
As detailed in Section 2.1.2, the 1-mW and SAR-based test exemption conditions are in terms of source-based available maximum time-averaged (matched conducted) output power for all operating configurations, adjusted for tune-up tolerance, and at the minimum *test separation distance* [Glossary] required for the particular RF exposure scenario under consideration. This minimum *test separation distance* is determined by the smallest distance from the antenna and radiating structures or outer surface of the device, according to the host form factor, exposure conditions and platform requirements, to any part of the body or extremity of a user or bystander. To qualify for SAR test exemption, the *test separation distances* applied must be fully explained and justified (typically in the SAR measurement, or SAR analysis report, according to KDB Pub. 865664) by showing the actual operating configurations and exposure conditions of the transmitter, and applicable host platform requirements (e.g., KDB Pubs. 648474, 616217, 941225)

When no other RF exposure testing or reporting is required, a statement of justification and compliance must be included in the equipment approval, in lieu of the SAR report, to qualify for SAR test exemption.

If RF exposure testing requirements for a specific device are covered in a KDB publication, those requirements must be satisfied before applying any SAR test exemption provisions. For example, this is the case for handheld PTT two-way radios, handsets, laptops, and tablets, etc.⁹ Finally, when 10-g extremity SAR applies, SAR test exemption may be considered by applying a factor of 2.5 to the SAR-based exemption thresholds.

⁸ Specific test exemption thresholds for operations under occupational/controlled limits are not established.

⁹ When SAR evaluation is required by the hotspot mode or UMPC mini-tablet procedures, that is, where an antenna is ≤ 2.5 cm from a surface or edge, the *test separation distance* from the phantom to the antenna or device enclosure, as appropriate, shall be applied to determine SAR test exemption for such configurations, according to the criteria in this document. For that case, the *test separation distance* cannot be determined from the distance of the antenna to the device surface or edge.



2.1.2 1-mW Test Exemption

Per § 1.1307(b)(3)(i)(A), a single RF source is *exempt RF device* (from the requirement to show data demonstrating compliance to RF exposure limits, as previously mentioned) if the available maximum time-averaged power is no more than 1 mW, regardless of separation distance.

This exemption applies to all operating configurations and exposure conditions, for the frequency range 100 kHz to 100 GHz, regardless of fixed, mobile, or portable device exposure conditions. This is a standalone exemption, and it cannot be applied in conjunction with any other test exemption.

2.1.3 SAR-Based Exemption

A more comprehensive exemption, considering a variable power threshold that depends on both the *separation distance* and power, is provided in § 1.1307(b)(3)(i)(B). This exemption is applicable to the frequency range between 300 MHz and 6 GHz, with *test separation distances* between 0.5 cm and 40 cm, and for all RF sources in fixed, mobile, and portable device exposure conditions.

Accordingly, a RF source is considered an *RF exempt device* if its available maximum time-averaged (matched conducted) power or its effective radiated power (ERP), whichever is greater, are below a specified threshold. This exemption threshold was derived based on general population 1-g SAR requirements and is detailed in Appendix C.

2.1.4 MPE-Based Exemption

An alternative to the SAR-based exemption is provided in § 1.1307(b)(3)(i)(C), for a much wider frequency range, from 300 kHz to 100 GHz, applicable for separation distances greater or equal to $\lambda/2\pi$, where λ is the free-space operating wavelength in meters. The MPE-based test exemption condition is in terms of ERP, defined as the product of the maximum antenna gain and the delivered maximum time-averaged power.¹⁰ For this case, a RF source is an *RF exempt device* if its ERP (watts) is no more than a frequency-dependent value, as detailed tabular form in Appendix B. These limits have been derived based on the basic specifications on Maximum Permissible Exposure (MPE) considered for the FCC rules in § 1.1310(e)(1).

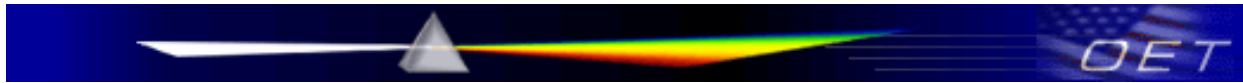
2.2 RF Exposure Test Exemptions for Simultaneous Transmission Sources

2.2.1 1-mW Test Exemption for Multiple Sources

As discussed in § 1.1307(b)(3)(ii)(A), the 1-mW exemption intended for single transmitters may be also applied to simultaneous transmission conditions, within the same host device, according one of the following criteria:

- a) When maximum available power each individual transmitting antenna within the same time averaging period is ≤ 1 mW, and the nearest parts of the antenna structures of the simultaneously operating transmitters are separated by at least 2 cm.

¹⁰ If the ERP of a single RF source is not easily obtained, then the available maximum (source-based) time-averaged power may be used in lieu of ERP if the physical dimensions in terms of wavelength of the device antenna(s) or radiating structure(s) do not exceed a length of $\lambda/4$ or if gain is less than the gain of a half-wave dipole (1.64 linear value).



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- b) When the aggregate maximum available power of all transmitting antennas is ≤ 1 mW in the same time-averaging period.

This exemption may not be combined with any other exemption.

2.2.2 Simultaneous Transmission with both SAR-based and MPE-Based Test Exemptions

This case is described in detail in § 1.1307(b)(3)(ii)(B) and covers the situations where both SAR-based and MPE-based exemption may be considered for test exemption in fixed, mobile, or portable device exposure conditions. For these cases, a device with multiple RF sources transmitting simultaneously will be considered an *RF exempt device* if the condition of Formula (1) is satisfied.

$$\sum_{i=1}^a \frac{P_i}{P_{th,i}} + \sum_{j=1}^b \frac{ERP_j}{ERP_{th,j}} + \sum_{k=1}^c \frac{Evaluated_k}{Exposure\ Limit_k} \leq 1 \quad (1)$$

Appendix C provides additional details.

For these test exemptions to apply, the maximum output power, duty factor, and other applicable parameters used in the standalone ERP determination tests, must be the same, or corresponding to a more conservative choice, than those required for simultaneous transmission.

The power level of the standalone SAR used to qualify for SAR test exemption, or additional test exemption, must be clearly explained in the SAR report. When simultaneous transmission SAR-based test exemptions, or when the *SPLSR* test exemption [Section 2.2.3] cannot be applied, *enlarged zoom scan* [Glossary] SAR measurements must be performed at the maximum output power required for the applicable simultaneous transmission scenarios. This power level shall account for the *tune-up tolerance* [Glossary] requirements of all transmitters, but not more than 2 dB lower than the maximum tune-up tolerance limit.

2.2.3 Test Exemption Based on the SAR to Peak Location Separation Ratio

When the ERP-based condition in the previous section does not apply, a test exemption may be still applicable based on the *SAR to peak location separation ratio (SPLSR)* [Glossary] procedure, discussed in more detail in Appendix E.

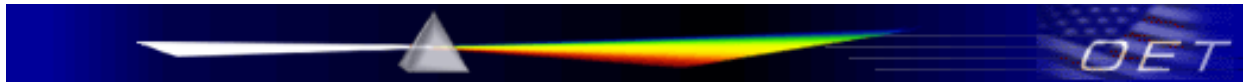
In this case, the simultaneously transmitting antennas in each operating mode and exposure condition combination must be considered one pair at a time to determine the *SPLSR* that qualifies for the additional test exemption.

This ratio is defined as $SPLSR = (SAR_1 + SAR_2)^{1.5}/R_i$, where SAR_1 and SAR_2 are the highest reported SAR or estimated SAR [Glossary] values for the two sources in the pair i , and R_i is their distance in millimeters.

When $SPLSR \leq 0.04$ (rounded to two decimal digits), for all antenna pairs in the configuration, then the device qualifies for 1-g SAR test exemption.

When 10-g SAR applies, the corresponding test exemption condition is $SPLSR \leq 0.10$.

If any antenna pair does not qualify for simultaneous transmission SAR test exemption, then the device must be tested for SAR compliance, according to the *enlarged zoom scan* [Glossary] and volume scan post-processing procedures in KDB Pub. 865664 D01.



3 GENERAL RF EXPOSURE TEST AND TEST REDUCTION GUIDANCE

3.1 RF Exposure Testing Parameters

3.1.1 General Setup

The general test methodologies described in KDB Pub. 865664 shall be applied to perform SAR measurements. Best EMC engineering practices shall be used for SAR or MPE evaluations, to ensure that the measurement setup does not perturb the antennas and radiating structures of the test device.

For example, field perturbations may occur due to fixtures (such as clamps, holders, etc.) used to secure very small test devices, such as USB dongles, or to thin edges of devices, or due to field scattering from nearby objects. In such cases, a device shall be secured with lossless foam material to provide sufficient separation from any conducting structures, and from materials with electromagnetic characteristics significantly different from that of vacuum, so as to minimize field perturbations.¹¹

3.1.2 Output Power Considerations

As required by §§ 2.1091(d)(1) and 2.1093(d)(1), RF exposure compliance must be determined at the maximum time-averaged power level, according to source-based time-averaging requirements (based on duty factor, as discussed in Section 5.3) to determine compliance for general population exposure conditions. On the other hand, time-averaging based on active power control, or similar implementations, is considered on a case-by-case basis and under PAG, as specified in KDB Pub. 388624.

Time-averaged maximum conducted output power applies to SAR and, as required by § 2.1091(c), time-averaged effective radiated power applies to MPE. These requirements also apply to test exemption considerations, as discussed in Section 2.1.1.

When an antenna port is not available on the device to support conducted power measurement, such as for Family Radio Service (FRS) Part 95 devices, and some Part 15 transmitters with built-in integral antennas, the available maximum output power or ERP, whichever is larger, and tolerance allowed for production units shall be used to determine RF exposure test exemption and compliance.

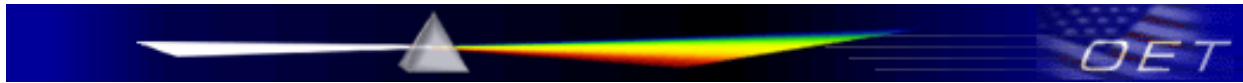
When an antenna port is not available on the device to support conducted power measurement and test software is used to establish transmitter power levels, the power level must be demonstrated and verified separately, according to design and component specifications and product development information. Otherwise, a KDB inquiry is necessary.

3.1.3 Tolerances in RF Exposure Test Methodologies

Device samples used for compliance testing must have the same physical, mechanical, and thermal characteristics, and operational tolerances as for production units.

All devices must be tested within the tune-up tolerance specification range. More specifically, each device must be evaluated for SAR or MPE compliance in the required operating modes and

¹¹ The “multi-meter” mode available in some SAR systems may be used to quickly determine if influences due to test device positioning, field perturbations, or external objects are introducing noticeable SAR variations.



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test configurations, at the maximum rated output power, and within the tune-up tolerance range specified for the product, but not more than 2 dB lower than the maximum *tune-up tolerance limit* [Glossary].

When tune-up tolerance is not required to be reported for equipment approval, RF exposure compliance must be determined using similar testing criteria, according to the highest maximum output power and tolerance allowed for production units.

The maximum output power of production units shall be within the tune-up tolerance range specified for the equipment certification. When the maximum output power of production units is lowered by widening the tune-up tolerance, additional testing may be necessary for the original test results to support compliance.

3.1.4 Power Scaling

When SAR or MPE is not measured at the maximum power level allowed for production units, the results must be scaled to the maximum tune-up tolerance limit, according to the power applied to the individual channels tested to determine compliance.

Some SAR measurement systems may have “power scaling” provisions to compute the 1-g SAR at a higher output power level, from measured results at a lower one.

When SAR or MPE is measured at or scaled to the maximum tune-up tolerance limit, the results are referred to as *reported SAR* or *reported MPE* [Glossary].

At least, the highest *reported SAR* or *MPE* results in each frequency band, and all *reported SAR* or *MPE* results that are either greater than 1.5 W/kg, or within 5% of the applicable MPE limits, respectively, must be clearly documented in the test reports.^{12,13} The highest *reported SAR* results are identified on the grant of equipment authorization according to procedures in KDB Pub. 690783 D01.

3.1.5 Test Separation Distances for SAR Testing

The *test separation distances* [Glossary] required for a device to demonstrate SAR or MPE compliance must be sufficiently conservative to support the *operational separation distances* [Glossary] required by the device and its antennas and radiating structures.

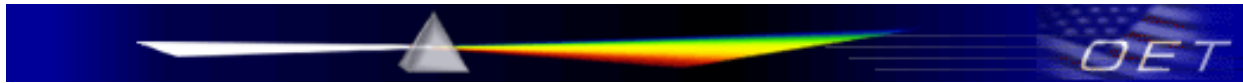
The general method to determine the *test separation distances* required for SAR test reduction, exemption, and measurements, is to consider the smallest distance between the outer surface of the device and the user.¹⁴ This is the case for devices such as tablets and transmitters embedded in keyboard sections of laptop computers that are typically used in close proximity to users.

For larger devices, the antenna *operational separation distance* may increase to where the SAR characteristics of the device and its antennas are no longer significantly influenced by the proximity the user. In practice this may occur when the *operational separation distance* is in the far field of the antenna; antennas along the top and upper side edges of laptop computer displays are sometimes in these conditions. For these cases, after obtaining FCC approval via KDB

¹² When different tune-up tolerances are specified for different wireless modes, and operating configurations, compliance must be determined separately according to the highest scaled results for each condition in each frequency band. This applies also to simultaneous transmissions.

¹³ See also KDB Pub. 865664 D01.

¹⁴ See Section 3.3.2 for body-worn accessory SAR test configurations used by cellphones.



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Inquiry submission, the *test separation distance* may be considered as the closest separation between the antenna and the user.

For *peripheral transmitters* [\[Glossary\]](#) and modules where the final host configuration is not known, the antenna-to-user separation distance shall be applied to determine the SAR measurement and test exemption requirements.

3.1.6 Determination of the Frequencies for SAR Testing

The number of required test channels for SAR testing is determined based on an even spread across the transmission frequency band of each transmitter.¹⁵ Accordingly, the number of test channels is given by Formula (2):

$$N_c = \text{Round} \left\{ \left[100 \times (f_{\text{high}} - f_{\text{low}}) / f_c \right]^{0.5} \times (f_c / 100)^{0.2} \right\} \quad (2)$$

where

- N_c is the number of test channels, rounded to the nearest integer,
- f_{high} and f_{low} are the highest and lowest channel frequencies within the transmission band,
- $f_c = (f_{\text{high}} + f_{\text{low}}) / 2$ is the mid-band channel frequency
- all frequencies are expressed in MHz.

SAR testing shall be performed at the center frequency for each channel, where the channel bandwidth is computed as $B_{\text{channel}} = (f_{\text{high}} - f_{\text{low}}) / N_c$.

3.1.7 Accounting for Antenna Gain with Portable Devices

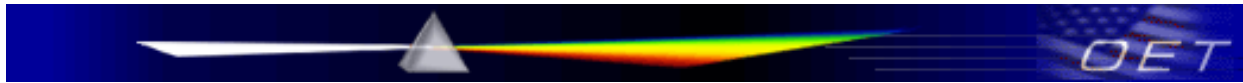
Depending on the operating frequency and on the required antenna *test separation distance*, there may be cases related to portable device exposure conditions where the antenna gain does not significantly impact the SAR measurement results.

This occurs, as it is in most practical cases, when the SAR exposure conditions are determined by the near-field pattern. Near-field patterns are highly dependent on the RF current distribution on antennas and nearby structures, and impacted by host device configurations, but are not directly related to the antenna gain. The antenna gain is defined based on the far-field distribution, and does not account for mutual coupling effects between the device radiating structures and surrounding objects (such as, in the case of portable devices considered here, a human body or test phantom).

Therefore, in general, it would be inappropriate to assume that lower gain antennas always produce lower SAR, and that SAR testing is not required for that reason. Accordingly, for transmitter designs with more than one antenna option, SAR compliance must be demonstrated independently for each antenna that the transmitter can be equipped with.

An exception can be made when the highest *reported SAR* [\[Glossary\]](#) for the original antenna is < 0.8 W/kg; in this case a KDB inquiry is required to show that the applicable field pattern characteristics of specific similar antennas are the same, within acceptable tolerances, as for the original antenna for which SAR was measured. Based on that information, the FCC may allow to show compliance of the additional antennas via referencing to the data of the original antenna.

¹⁵ Any further reduction in test channels must be confirmed through KDB inquiries to qualify for equipment approval.



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3.1.8 SAR for Simultaneous Transmission Scenarios

SAR compliance for simultaneous transmission must be considered when the maximum duration of overlapping transmissions, including network hand-offs, is greater than 30 seconds.

When simultaneous transmission SAR evaluation is required to determine compliance the *enlarged zoom* [Glossary] scan measurement, volume scan post-processing procedures, and associated considerations described in KDB Pub. 865664 D01 must be applied.

When simultaneous transmission applies, unless the SAR system has provisions to scale each *enlarged zoom* [Glossary] scan separately to account for maximum tune-up tolerance before the volume scan post-processing, the measured aggregate SAR must be scaled as follows: first, the differences between the maximum tune-up tolerance and actual power used to test each transmitter are computed. Then, the scaling factor is set as the sum of all these differences.¹⁶

When general population and occupational limits are applicable for different transmitters within a host device and test exemption applies for any of the transmitters subject to general population limits, SAR compliance for simultaneous transmission is determined according to the sum of the ratios of the corresponding exposures and the applicable limits. When simultaneous transmission measurement is necessary for such a host device, the measured data points shall be converted to exposure ratios before summing the ratios across multiple SAR distributions, to determine compliance with respect to the sum of the ratios.

Lastly, there are special conditions where a KDB inquiry is required to get approval for manufacturer-proposed procedures to measure simultaneous transmission SAR, as follows:

- a) When *coherent signals* [Glossary] are involved in the simultaneous transmission, such as certain phased array, beam-forming, or similar configurations.¹⁷
- b) When SAR is measured with MIMO chains, or other multiple antennas transmitting simultaneously in a single measurement and the difference in maximum output power across MIMO chains is > 1 dB
- c) When SAR is measured with MIMO chains, or other multiple antennas transmitting simultaneously in a single measurement, and there are not suitable procedures for testing the specific MIMO transmission or antenna configurations.
- d) When there is more than 1 dB variation in maximum output power across all channels in a wireless mode or frequency band.¹⁸

3.2 SAR Test Reduction Guidance

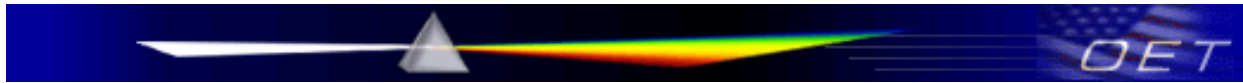
3.2.1 General Considerations

SAR test reduction procedures [Glossary] allow using a particular set of test data as representative of other, similar, test conditions. This may be applied for data within different test

¹⁶ Scaling is applied to the measured data points in each enlarged zoom scan, before interpolation and extrapolation are applied, to determine the adjusted SAR distribution before further volume scan post-processing.

¹⁷ SAR and EMC measurement issues for coherent and correlated signals are different, and generally must be considered separately; generally KDB Pub. 662911 applies for EMC purposes, while IEC TR 62630 generally applies for SAR.

¹⁸ All channels include those that are not required for testing. Maximum output power variations may be determined by combinations of measurements, design specifications, and other analyses, etc.



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positions (e.g. body, head, extremity), wireless modes (e.g. Wi-Fi, cellular), and frequency bands.

This test reduction process provides for the use of test data for one specific channel, while referencing to those data for demonstrating compliance in other required channels for each test position of an exposure condition, within the operating mode of a frequency band. This is limited specifically to when the reported 1-g or 10-g SAR for the mid-band or highest output power channel meets any of the following conditions:¹⁹

- a) $SAR \leq 0.8$ W/kg for 1-g, or $SAR \leq 2.0$ W/kg for 10-g, when the transmission band span is ≤ 100 MHz
- b) $SAR \leq 0.6$ W/kg for 1-g, or $SAR \leq 1.5$ W/kg for 10-g, when the transmission band span is between 100 MHz and 200 MHz
- c) $SAR \leq 0.4$ W/kg for 1-g, or $SAR \leq 1.0$ W/kg for 10-g, when the transmission band span is ≥ 200 MHz

3.2.2 1-g SAR Estimates Based on Area Scans

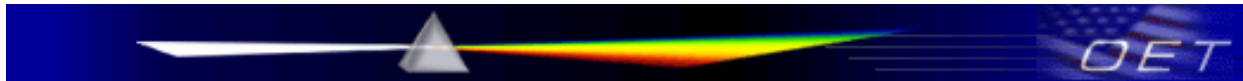
Some SAR evaluation systems have the provision to estimate 1-g SAR based on the interpolated (from coarse-grid points) and extrapolated results (from surface to volumetric distribution) of a normally required complete area scan (per KDB 865664 D01). Earlier implementations were based on polynomial fit algorithms; however, more complex algorithms are used in recent implementations.

When 1-g SAR is estimated using all results from a normally required area scan, and the estimated $SAR \leq 1.0$ W/kg, then zoom scan measurement is not required for that test condition. Use of this provision requires that the SAR estimation method implemented by a test system has been validated by the system manufacturer to obtain estimated SAR with an accuracy of $\pm 10\%$ from the nominal value as measured using a normally required zoom scan. When all measured SAR for a frequency band, wireless mode and exposure test position combination are based on estimated SAR; i.e., maximum estimated SAR is ≤ 1.0 W/kg, a zoom scan is required for the highest estimated SAR test configuration. When unclear, users should contact the SAR system manufacturer to determine if a specific implementation fully satisfies the preceding requirement. For purposes of applying the *SPLSR* [[Glossary](#)] required for simultaneous transmission SAR test exemption, the peak location shall be assumed to be at the phantom surface corresponding to the transverse position indicated by the area scan.

For the estimated 1-g SAR to be acceptable there shall be no warning messages from the SAR measurement system during the scan. Warning conditions can happen, for example, when the system detects excessive noise in the measurements, SAR peaks too close to scan boundary, SAR peaks too sharp, or spatial resolution too low.

For occupational exposure, zoom scan measurements are not required when the *estimated 1-g SAR* is less than or equal to 6.0 W/kg. When supported by the SAR measuring system, the 1-g SAR estimation procedures may be also used for 10-g SAR measurements by scaling the results according to the ratio of general population to occupational SAR limit.

¹⁹ SAR measurement standards such as IEEE Std 1528-2013 requires the middle channel to be tested first. This generally applies to wireless devices that are designed to operate in technologies with tight tolerances for maximum output power variations across channels in the band. When the maximum output power variation across the required test channels is $> \frac{1}{2}$ dB, instead of the middle channel, the highest output power channel must be used.



3.3 SAR Test Requirements for Typical Exposure Conditions

3.3.1 Head Exposure Conditions

Devices that are designed to transmit next to the ear, and operate according to the handset procedures in KDB Pub. 648474, must be tested using the *SAM phantom* [\[Glossary\]](#) defined in IEEE and IEC SAR measurement standards.

When antennas are near the bottom of a handset and the peak SAR location found per the area scan occurs in regions of the SAM phantom where SAR probe access can be limited, a rotated SAM phantom, or procedures in KDB Pub. 648474 D04, must be applied.

Other head exposure conditions, for example, in-front-of the face, shall be tested using a flat phantom according to the applicable KDB publication (e.g., 643646). Unless specifically authorized through a KDB inquiry, the SAM (head) phantom is generally unacceptable for testing the SAR of other head and body exposure conditions. For example, testing headsets at the SAM phantom ear location is generally unacceptable.

3.3.2 Body-worn Accessory Exposure Conditions

3.3.2.1 General Considerations

Devices that support transmission while used with body-worn accessories must be tested for SAR compliance related to each body-worn condition of use. SAR evaluation is required for body-worn accessories supplied with the device they are attached to.

The general informing principle is that the selected test configurations must conservatively capture the various body-worn accessory use conditions expected by users. For instance, devices that are designed to operate on the body of users using lanyards and straps, or without requiring additional body-worn accessories, must be tested for SAR compliance using a conservative minimum *test separation distance* not to exceed 5 mm for all use conditions required by the device.

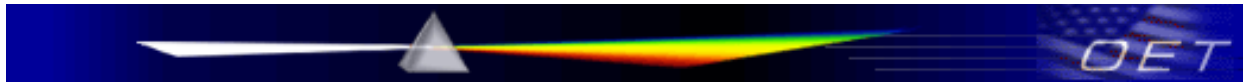
3.3.2.2 OEM Accessories

Body-worn accessories that do not contain metallic or conductive components shall be tested according to worst-case exposure configurations selected among all the different devices that the accessory can attach to, per the manufacturer's specification. For body-worn accessories with similar operating and exposure characteristics, the test can be performed for the accessory that provides the smallest *test separation distance*.

All body-worn accessories containing metallic components, either supplied with the product or available as an option from the device manufacturer, must be tested individually (e.g. not as a representative of a group of similar ones) in conjunction with their attached host device to demonstrate compliance.

Body-worn accessory SAR compliance must be based on a single minimum *test separation distance*, selected for

- all wireless and operating modes
- applicable to each body-worn accessory used by the attached device, and
- according to the relevant voice and/or data mode transmissions and operations.



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For instance, if a body-worn accessory supports voice only operations in its normal and expected use conditions (for example, belt-clips and holsters for cellphones), testing of data mode for body-worn compliance is not required. The voice and data transmission requirements must be determined according to the wireless technologies and operating characteristics of the individual device, and must be clearly explained in test reports to support the SAR results.

3.3.2.3 Non-OEM Accessories

A conservative minimum *test separation distance* for supporting non-OEM body-worn accessories that may be acquired by users of consumer handsets shall be used to test for body-worn accessory SAR compliance.

This distance is determined by the handset manufacturer according to the typical body-worn accessories users may acquire at the time of equipment certification (and must be clearly explained in the SAR report to support the body-worn accessory test configurations) but it cannot be more than 2.5 cm, to enable users to suitably purchase aftermarket body-worn accessories. Specific information must be included in the operating manuals to enable users to select body-worn accessories that meet the minimum *test separation distance* requirements. Users that acquire the required body-worn accessories must be fully informed, in a way that the typical user can easily understand of the operating requirements and restrictions to maintain compliance. Instructions on how to place and orient a device in body-worn accessories, in accordance with the test results, shall also be included in the user instructions. All supported body-worn accessory operating configurations must be clearly disclosed to users, through conspicuous instructions in the user guide and user manual, to ensure that unsupported operations are avoided.

All body-worn accessories containing metallic components must be tested for compliance and clearly identified in the operating manual. The instructions must inform users to avoid using other body-worn accessories containing metallic components not specifically tested, to ensure RF exposure compliance.

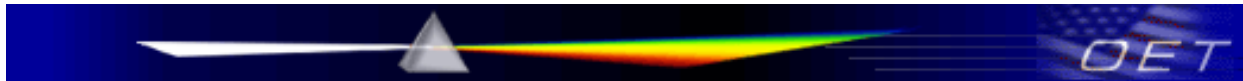
3.3.3 Extremity Exposure Conditions

Devices that are designed or intended for use on extremities (i.e., hands, wrists, feet and ankles), or mainly operated in extremity-only exposure conditions, may require extremity SAR evaluation. However, when the device also operates in close proximity to the user's body, SAR compliance for the body is also required.²⁰

The 1-g body and 10-g extremity test exemption thresholds in Section 2.1 shall be applied to determine SAR test requirements. When extremity SAR testing is required, a flat phantom is typically used. When that leads to more conservative exposure conditions than the actual use conditions, a KDB inquiry is required to determine the applicability of alternative phantoms (for example, wrist or limb phantoms) and related test requirements.

Body SAR compliance is also tested with a flat phantom. For devices with irregular shapes or form factors that do not conform to a flat phantom, and/or unusual operating configurations and exposure conditions, a KDB inquiry is also required to determine the appropriate SAR measurement procedures.

²⁰ Cellphones (handsets) are not normally designed to be used or operated in extremity only exposure conditions. The maximum output power levels of cellphones generally do not require extremity SAR testing to show compliance because the test conditions required for head and body SAR are more conservative



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Unless otherwise specified in a KDB Publication, when simultaneous transmission applies to extremity exposure, the simultaneous transmission SAR test exemption provisions in Section 2.2 shall be applied. When simultaneous transmission SAR measurement is required, the enlarged zoom scan and volume scan post-processing procedures in KDB Pub. 865664 D01 shall be applied.

3.3.4 Transmitters Implanted in the Body of a User

As discussed in Section 2.1.2, when the aggregate of the maximum power available at the antenna port and radiating structures of an implanted transmitter, under all operating circumstances, is less than or equal to 1.0 mW, a SAR test exemption applies. Otherwise, a KDB inquiry is required to determine the appropriate SAR measurement or numerical simulation procedures, or both.

3.4 SAR Evaluation Using Numerical Simulation

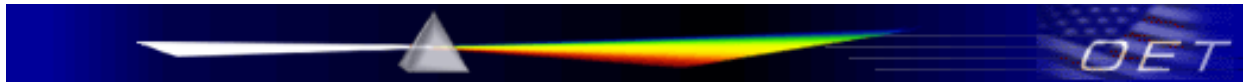
SAR simulations may be used to demonstrate compliance. Requirements described in the IEC/IEEE 62704 series were mostly related to the Finite Difference Time Domain (FDTD) technique, and for the frequency range of 30 MHz to 6 GHz. However, SAR simulations using the Finite Element Method (IEC/IEEE 62704-4 [Reference]), and simulations of power density above 6 GHz and for mm-wave frequencies are available.

When numerical computation methods other than FDTD are used, the equivalent considerations as required for the FDTD method must be applied, as specified in FDTD reporting guidelines in KDB Pub. 865664 D02 and similar to IEC/IEEE 62704-1 [Reference]. When these methods are used, a KDB inquiry is required to establish if the proposed methodology may be used, and for the specific exposure conditions under consideration.

This KDB inquiry, and, if approved, the subsequent SAR report exhibit filed for compliance, shall describe the validation of the numerical algorithm and of its implementation, and provide SAR-specific details such as gram-averaging requirements, tissue dielectric parameters, anatomical models with complex exposure configurations, and models for head and body tissue dielectric parameters.²¹

Furthermore, due to the complexity of modeling transmitters, and anatomically equivalent human models, it is necessary to show in the KDB Inquiry data that validate both transmitter and human models against experimental measurements of field strength and/or SAR measurement, for test benchmark configurations.

²¹ <http://transition.fcc.gov/oet/rfsafety/dielectric.html>; a KDB inquiry is required to determine tissue-equivalent dielectric parameters for frequencies not available at this link.



4 RF EXPOSURE GUIDANCE FOR TRANSMITTERS OPERATING IN HOST DEVICES

4.1 RF Exposure Considerations for Transmitter Integrations in Host Devices

4.1.1 Modules vs. Other Transmitters

This section applies to all FCC authorized transmitters that operate while installed on a different end-use product (referred to as a host, host product, or host device). Typically, these are transmitters (including those with a modular grant, i.e., “modules”),²² and *peripheral transmitters* [Glossary] that are approved for either standalone operations only, or for standalone and simultaneous transmission with other transmitters in a host.

As discussed in KDB Pub. 996369, when modules are used, module grantees are required to make available comprehensive instructions that specify and illustrate conditions and limitations for authorized uses under the module grant. However, the host manufacturer has the responsibility to ensure that transmitters operating in a host device remain compliant in all transmission scenarios supported by all host configurations, thus including both standalone and simultaneous transmission operations.

Additional equipment approval may be required for modules (e.g., changes in grant conditions, in some cases using permissive change rules [§ 2.1043]) due to the additive effects of RF emissions for some host product operations. Section 4.1.2 describes other host product considerations.

4.1.2 Host Form Factor Considerations

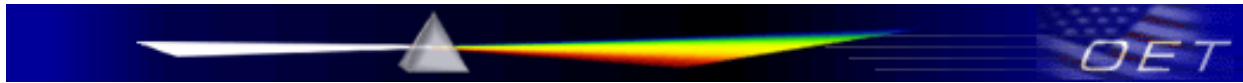
One example of host product form factor considerations is a modular transmitter with its antenna added in the display of a laptop computer. This may have little or no impact on the overall total SAR that includes other existing transmitters in the host when all antennas are installed sufficiently far apart from each other.

However, if the same module is incorporated in a smaller form factor host device, a re-evaluation of the transmitting features supported by host may be necessary to demonstrate SAR compliance. Similarly, transmitters installed in certain host products characterized by a smaller form factor,²³ such as cellphones, cannot be approved as modules because the close proximity of antennas within the device and to the user.

In general, when high SAR values may be expected for any device due to close proximity between antennas and users, the related transmitters may not be approved as modules because of difficulties to ensure compliance for all possible host configurations. Therefore, the proper approach for such compact and highly integrated (host) devices is to perform SAR testing with all transmitters that can be in operation at the same time in place, without relying on components having modular grants.

²² As defined in Section I of 996369 D01 Module Equip Auth Guide v02.

²³ In reference to the electrical length of the characteristic linear dimension, for the smallest wavelength of operation, and considering typical use conditions (e.g., held with one hand near the ear).



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4.1.3 Certification Strategies

When equipment approval is required for changes related to test data of transmitter modules (such as additional hosts, or antenna configurations), in some cases compliance may be addressed through Class II permissive changes submitted by the module grantee.²⁴

The most rigorous approach is to always address compliance of all transmitters in a host using a new equipment certification filing submitted by the host manufacturer, where a new FCC ID is issued for the host product.

Alternatively, the host device manufacturer may choose to file for a change of FCC ID for transmitter modules that require additional approval, or for any other transmitter module that may be deemed most critical for compliance purposes (*e.g.* with the highest maximum output power). At that point, any subsequent approval issue (such as permissive changes) are under the responsibility of the host manufacturer.²⁵

The host manufacturer may also consider a *modular* and *dedicated host mixed approach*. For example, as described in KDB Pub. 616217 D04, this approach allows the integrator to address compliance for transmitters with higher output power and SAR in dedicated host configurations, and to apply the modular approach to certain low power transmitters that have low SAR, or that do not require any SAR testing.

This also simplifies the host integration of low power transmitters by taking into consideration their impact on overall RF exposure during the SAR testing of the higher power transmitters, thus without requiring separate assessment for each low power transmitter in the host device. The grantee of a dedicated host, and/or the grantees of the individual modular transmitter(s) incorporated in the host, are all responsible for coordinating and ensuring the final implementations are compliant.

In general, modular transmitters are approved according to the operating configurations and exposure conditions tested for compliance to support a variety of possible (*i.e.*, “qualified”) host device configurations. The qualified installation and use conditions must be clearly identified in the equipment approval and OEM integration requirements, including all restrictions.

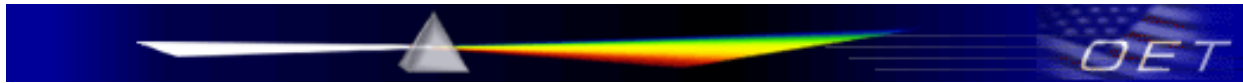
For instance, for modules integrated in hosts that are designed to operate as *portable* devices, the module grants shall consider applications in portable-device scenarios, as well as intended or expected conditions involving simultaneous transmitter operations. Accordingly, the equipment certification records shall clearly outline the operating conditions and limitations.

Any restrictions on host platform configurations and operating requirements must also be identified.²⁶ In general, all grant conditions must be supported by the test results and test exemption conditions. Similar considerations can be applied to modular transmitters approved for use in a *mixed mobile and portable exposure host* platform.

²⁴ See also KDB Pub. 178919 D01, Permissive Change Policies.

²⁵ Change of ID (§ 2.931) filings require coordination between an original grantee and the third-party applicant.

²⁶ Placement of a standalone module used in certain host configurations may also need restrictions; for example, modules inserted in a host device with small form factor can influence the SAR characteristics of adjacent transmitters due to impacts on the field pattern and mutual coupling effects, even when they are not transmitting simultaneously.



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4.2 Transmitters Operating Standalone with Host Products

4.2.1 General Requirements

A wide variety of consumer electronics equipment are capable to function as host products with integrated or attached transmitters. This often poses challenges for ensuring RF exposure compliance due to the lack of well-specified host product RF exposure conditions. When applicable, the SAR test exemption provisions of Section 2.1 may streamline test requirements for standalone operations.

When certain types of components, operating parameters, or control functions that manage the operation of a transmitter are not fully contained within an approved module or peripheral transmitter, the SAR characteristics of the transmitter and antenna can be affected by how these external functions are implemented in individual host devices.²⁷ When operation and control functions are shared or provided by a host product or through other mechanisms, SAR compliance and equipment approval shall be limited to a dedicated particular host device.²⁸ The following Sections describe cases of integration or attachment of modules and peripheral transmitters while operating in a standalone mode with host products, *i.e.*, while no other transmitter in the host product is transmitting simultaneously. The basic consideration being addressed is that physical structures in a host product may alter the SAR test results relative to those as obtained with the transmitter operating standalone.

4.2.2 Test Separation Distance for RF Exposure Measurements

For host compliance applicability, SAR evaluation shall always be performed according to the following conditions:

- Refer to the most conservative exposure conditions applicable to the host(s) attributes.²⁹
- Determine SAR compliance according to the minimum *test separation distance* required for all applicable operating configurations of the host platform. A *test separation distance* not exceeding 5 mm shall be applied to determine SAR-based test exemption or SAR values.³⁰

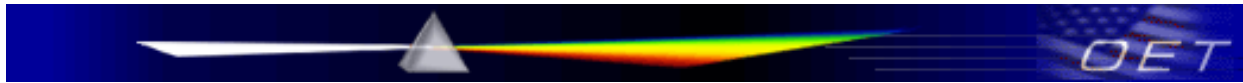
Separation distance considerations for incorporating transmitters into host devices are described in Section 3.1.5. For modules with built-in integral antennas embedded within self-contained outer housings, the *test separation distance* is measured from the outer housing to the user. For all other configurations, the *test separation distance* is considered from the antenna outer edge to the user.

²⁷ These types of operations include certain power reduction and proximity sensor functions, or motion detection functions implemented or provided by host devices. Approval policies for these types of operations in different host platforms (for example, handsets and tablets) may vary due to operating requirements and other RF coupling and exposure concerns. See also KDB Pub. 594280 D01 and D02 for software security requirements.

²⁸ See also, for example, considerations on module manufacturer and host product manufacturer responsibilities described in KDB Pubs. 616217 D04 and 996369 D04. In addition, the Commission has initiated a rulemaking including various considerations on end products incorporating certified modular transmitters in ET Docket No. 15-170 (FCC 15-92, 30 FCC Rcd 7747, paras. 60 et seq.); further updates to test and compliance guidance and requirements will be determined after the final rules are adopted.

²⁹ See footnote 30 (*A test distance of up to ...*).

³⁰ A test distance of up to 10 mm may be applied if prior approval from the FCC is confirmed via a KDB inquiry that smaller distances are not possible for normal operation of host devices in a platform.



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When a peripheral transmitter, such as a USB dongle, must be connected to the host through an external cable or adapter, a *test separation distance* ≤ 15 mm may be applied to test the required device orientations, only if it can be demonstrated that smaller separation distances are not applicable for normal operations. The same consideration also applies when a cable, adapter, or accessory antenna is available for a peripheral transmitter to offer alternative connection and use conditions.

The test distance must be fully justified in the SAR report. All required operating restrictions must be clearly explained in test reports to support the test setup and results. When applicable, these conditions for incorporation into host devices must be clearly identified in the equipment certification and in all required OEM integration and installation instructions.

4.2.3 Transmitter Integration for Standalone Operations in non-Specific Host Products

A transmitter, both OEM installed, and in user-accessible external peripherals, can be operated in a standalone mode (i.e., without any other host-product transmitter operating simultaneously) with host products that are not specifically identified,³¹ as long as:

- SAR testing is not required due to the standalone SAR test exemption of Section 2.1, or
- the transmitter highest 1-g *reported SAR* is ≤ 0.4 W/kg AND the *energy coupling enhancement condition* [Glossary] of Appendix E is satisfied, and the 1-g *reported SAR* required by the *energy coupling enhancement* test is ≤ 0.45 W/kg.

4.2.4 Transmitter Integration for Standalone Operations for Specific Set of Host Products

A transmitter, both OEM installed and user accessible external peripherals, can be operated in standalone mode in a specific set of host products, when the highest 1-g *reported SAR* is greater than 0.4 W/kg and less than or equal to 0.8 W/kg.³²

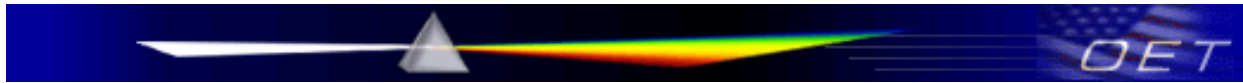
To qualify for this SAR compliance integration scheme, the transmitter may be approved for multiple host products either in the initial filing, and more host products may be added via Class II permissive changes. All subsequent Class II permissive changes must be within the scope of the defined host product configurations and exposure conditions of the original equipment approval

4.2.5 Transmitter Integration for Standalone Operations for Specific Single Host Product with Permissive Change Provision

A transmitter, both OEM installed and user accessible external peripherals, can be operated in specific single host when the highest 1-g *reported SAR* is greater than 0.8 W/kg and less than or equal to 1.2 W/kg. Other hosts may be added via Class II permissive change filings. All

³¹ Transmitters and antennas in devices with small form factors can influence the SAR characteristics of adjacent transmitters and antennas due to close proximity even when they are not transmitting simultaneously. Accordingly, KDB Pubs. 648474 and 616217 provide further testing requirements for standalone transmitters and antennas to qualify for collocation in host products.

³² Different hosts within the allowed set of hosts shall be tested independently when SAR characteristics are expected to change due to different operating configurations.



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subsequent Class II permissive change filings must be within the scope of the defined host configuration and exposure conditions of the original equipment approval.

4.2.6 Transmitter Integration for Standalone Operations Only for a Single Specific Host

When the highest 1-g *reported SAR* is greater than 1.2 W/kg, transmitters shall be limited to operate internally within the dedicated host product configurations tested for compliance.

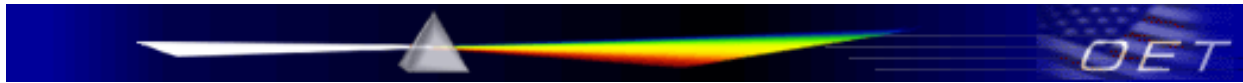
In these cases, special consideration may be given following a KDB inquiry for devices with highest 1-g *reported SAR* greater than 1.2 W/kg but less or equal than 1.4 W/kg.

When the highest 1-g *reported SAR* is > 1.4 W/kg, equipment approval requires a PAG for case-by-case consideration.

4.3 Transmitter Integration for Simultaneous Transmission Operations in Host Products

The procedures of Sections 2.2, 3.1.8, and Appendix E shall be applied to evaluate SAR compliance for simultaneous-transmission operations of multiple transmitters operating with host products.





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5 SAR TEST GUIDANCE FOR UNIQUE HOSTS AND EXPOSURE CONDITIONS

5.1 Handheld Push-to-Talk Two-way Radios

5.1.1 General

Generally, the operating configurations of handheld Push-to-Talk (PTT) two-way radios require SAR testing for exposure conditions that consider positioning both in front of the operator's face and with a body-worn accessory (such as a holster).

A *test separation distance* up to 25 mm must be applied for any in-front-of the face SAR test (for both compliance and exemption).

5.1.2 Duty Factor Considerations

For radios that operate with a mechanical PTT button, in consideration of typical average use conditions, a duty factor of 50% shall be applied to determine compliance. However, for radios where typical use conditions lead to operations at higher duty factors, compliance shall be shown under the maximum duty factor (up to 100%) that reflects the most conservative conditions.

For PTT radios with Bluetooth or voice activated transmission capabilities a duty factor of 75% shall be applied, as a conservative use-case estimate of an uneven transmit-receive pattern in the communication between two operators. When Time-Division Multiple Access (TDMA) technology is used, a duty factor consistent with the time slot partitioning shall be taken into consideration.

For PTT radios operating in the 100 MHz to 1 GHz range, according to general population exposure requirements as discussed in Section 1.6.1, properly justified duty factor conditions applied to the maximum conducted output power for a given time-averaging window, may lead to reduction of the effective power and qualify for a SAR test exemption. For portable PTT two-way radios operating above 1 GHz, a KDB inquiry must be submitted to obtain FCC approval for the SAR test procedure.

5.1.3 Test Conditions with Body-Worn Accessories

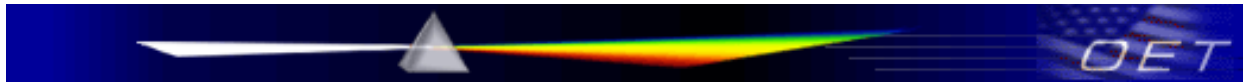
For manufacturer-provided body worn accessories, the actual separation distance between the antenna and the operator body can be considered, but only up to 25 mm.

When a body-worn accessory is not supplied by the PTT radio manufacturer, a *test separation distance* up to 5 mm (consistently with what is prescribed for other portable handsets), can be considered to determine body-worn accessory SAR test exemption while including the duty factor. This distance is chosen, conservatively, to account for a variety of typical device shape design.

When body-worn accessory SAR testing is required, the requirements in Section 3.3.2 shall be applied.

PTT two-way radios that support held-to-ear operating mode must also be tested according to the exposure configurations required for handsets in KDB Pub. 648474 D04.

This does not apply to cellular phones with PTT options, since cellular phones must be tested in more conservative configurations that include SAR compliance at 100% duty factor.



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When occupational exposure limits qualify, the procedures in KDB Pub. 643646 D01 are required.

5.2 Wristwatch and Wrist-Worn Transmitters

5.2.1 SAR Evaluation

Transmitters that are built-in within a wristwatch, or similar wrist-worn devices, typically operate in “speakerphone mode” for voice communication, with the device worn on the wrist and positioned next to the mouth. Operations next to the mouth requires 1-g SAR measurement, while the wrist-worn condition requires 10-g extremity SAR measurement.³³

SAR test exemptions for 10-g extremity with the wrist and 1-g with face exposure condition may be applied. When SAR evaluation is required, next-to-mouth use is evaluated with the front of the device positioned at 10 mm from a flat phantom to measure head SAR. The wrist bands shall be strapped together to represent normal use conditions.

SAR for wrist exposure is evaluated with the back of the device positioned in direct contact against a flat phantom filled with body tissue-equivalent medium. The wrist bands shall be unstrapped and touching the phantom. The space introduced between the transmitter and the flat phantom must be representative of actual use conditions.

5.2.2 Conditions that Require KDB Inquiry to Obtain Procedural FCC Approval

A KDB inquiry must be submitted to obtain FCC approval for the device positioning and related SAR probe access issues when any variation of the KDB published test procedures is being considered. For this particular discussion, FCC approval is required for use of:

- neck, or a curved head region of the SAM phantom
- alternative phantoms that are designed for testing specific product and associated exposure conditions for example, a wrist or limb phantom.
- other device positioning; for example, devices with rigid wrist bands or electronic circuitry and/or antenna(s) incorporated in the wrist bands.

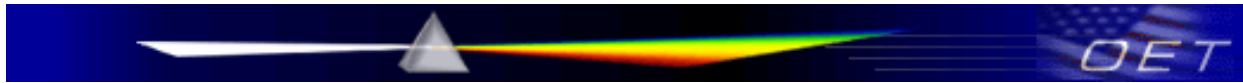
These test configurations are applicable only to devices that are worn on the wrist and cannot support other use conditions. Accordingly, it is a compliance requirement that the operating restrictions must be fully demonstrated in both the test reports and user manuals.

5.3 Low Duty Factor Transmitters

Voice-mode communication generally does not qualify for low duty factor considerations; however, exceptions may be considered for documented cases of very short (e.g. seconds) and infrequent transmissions. For these situations, a KDB inquiry is required to obtain FCC approval for the proposed evaluation methodology.

A more common case is devices without any voice support that transmit only intermittently in data mode, and for which the time-averaged RF exposure can be very low. These types of operations may include location trackers, emergency alert responders, point of sales (POS) devices, some black-and-white display e-readers, and devices supporting location-based services.

³³ It must be ensured that wrist operations are limited to the wrist only. Operations with a device worn on the arm above the wrist require 1-g SAR compliance. Other use conditions may require additional SAR testing.



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In these cases, the source-based time-averaging process for SAR evaluation can be applied, and possibly qualify for SAR test exemption, if the proper conditions (Section 2.1) are satisfied for both the duty factor adjusted maximum output power, and for the minimum *test separation distance* required for all applicable operating configurations.

Finally, when a defined transmission duty factor cannot be inherently associated with the device operations, the source-based time-averaging process for SAR evaluation can still be applied if an acceptable worst case (i.e. most conservative) transmission duty factor can be determined.

For all these cases, the supporting details for determining the duty factor, in reference to the full range of operating configurations and exposure conditions, must be fully documented in a SAR analysis report, according to KDB Pub. 865664 D02.

Once a duty factor has been established, if the SAR test exemption does not qualify and a SAR evaluation is required to demonstrate compliance, that duty factor may be applied to scale the measured SAR.³⁴

5.4 Accessories for RF Host Devices

5.4.1 General Remarks

RF devices equipped with transmitters (here referred to as “host devices”), such as handsets, music players, and other small consumer electronic devices, may be provided with accessories in the form of snap-on sleeves, plug-in components, attachments that contain built-in transmitters, or attachments that contain certain passive radiating structures or antenna elements.³⁵

In general, accessories that contain transmitters may support standalone and/or simultaneous transmission while operating independently or with a host device. Body-worn accessories may impact the SAR characteristics of the host device due to changes in the actual antenna-to-user *test separation distance*. While manufacturer-provided accessories can be considered in the original test compliance process, after-market accessories may change the operating characteristics of a device beyond the approved limits.

5.4.2 OEM Accessories without RF Transmitters

When a new accessory becomes available from the original equipment/host manufacturer (OEM, referring to the host device where the transmitter is located) and does not contain any transmitter, compliance of the host and accessory can be addressed according to Class I or Class II permissive change procedures.

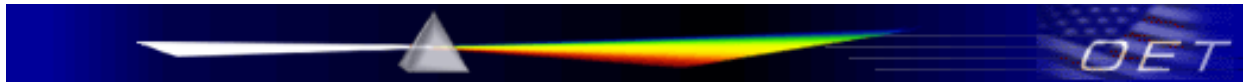
The SAR distribution and exposure conditions of the original host equipment authorization tested without the newly introduced accessory attached are generally not comparable or equivalent to the configurations tested with the accessory. Therefore, additional testing is required for determining whether there is SAR degradation.

5.4.3 Non-OEM Accessories without RF Transmitters

For third-party (non-OEM) accessories that do not contain transmitters, the accessory suppliers are encouraged to consult with the OEM to determine equipment authorization options for the accessory, such as Class I or Class II permissive change submitted by the host grantee. For

³⁴ Scaling for maximum tune-up tolerance must be considered separately.

³⁵ See also KDB Pub. 648474 D04 concerning after-market accessories, such as sleeves, used with cellphones.



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instance, an accessory that enables the use of a device in RF exposure conditions that are more restrictive than those granted, may lead to non-compliance situations.

In this process, a change of FCC ID followed by a Class II permissive change by the third-party accessory supplier may be also considered.³⁶

As described in KDB Pub. 178919, the assessment required to determine whether Class I or Class II permissive change is applicable may include preliminary measurements and analysis of relevant parameters such as SAR *test separation distance*, presence of metal structures in the accessory, changes to possible exposure conditions.

5.4.4 Accessories with RF Transmitters

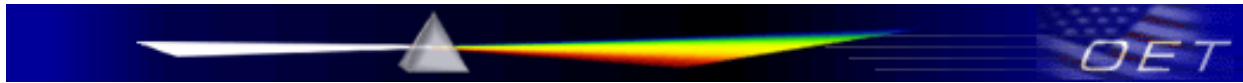
Separate equipment approval is required for accessories containing transmitter(s) that are available from the host manufacturer or third-party accessory suppliers.

If the transmitter in the accessory supports standalone operations, with or without the host equipment, both conditions must be evaluated for RF exposure compliance. When simultaneous transmission applies, all transmitter combinations must be addressed for the accessory alone and also with the accessory operating in conjunction with the host equipment.

Accessories with built-in transmitters that are designed to support host devices without transmitters do not require separate host authorization (this case does not strictly belong in the category of this Section but is mentioned for completeness).

In some instances, due to significant variations for the types of accessories and host use conditions, it may become difficult to determine the proper test configurations required for FCC authorization. In these cases, it is recommended to file a KDB inquiry to confirm the test plan and avoid conditions of non-compliance.

³⁶ Change of ID (§ 2.931) requires coordination between an original grantee and the third-party applicant.



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6 EVALUATION GUIDANCE FOR MOBILE DEVICE RF EXPOSURE CONDITIONS

6.1 Transmitters Used in Mobile Device Exposure Conditions for Standalone Operations

6.1.1 Mobile Devices

Devices operating in standalone mobile device exposure conditions may contain a single transmitter or multiple transmitters that do not transmit simultaneously. Mobile devices, as defined in § 2.1091 along with their applicable RF exposure limits, are characterized by the requirement of maintaining a minimum *test separation distance* ≥ 20 cm between any radiating structure of the device and nearby persons; to apply only mobile device (MPE) exposure limits. This *test separation distance* requirement must be defined for the most conservative exposure conditions, and must be fully supported for all the operating and installation configurations of the transmitter and its antenna(s), according to the source-based time-averaged maximum power requirements of § 2.1091(d)(2).

For situations as described in § 2.1091(d)(4), or in general when devices designed for mobile operations have the potential to operate in portable device (per § 2.1093) exposure conditions, compliance must be demonstrated for those specific portable conditions, since they represent the worst-case scenario from the RF exposure perspective.

6.1.2 Exemptions to Compliance Testing

The guidance of Section 2.1 is used to determine test exemptions for all fixed, mobile or portable devices, according to the underlying SAR or MPE criteria. More specifically, as applicable, the 1-mW test exemption (Section 2.1.2) as well as both SAR-based and MPE-based test exemption criteria (Section 2.1.3 and 2.1.4) may be used.

In cases where cable losses or other attenuations are applied to determine compliance, the most conservative operating configurations and exposure conditions must be evaluated.

When applying the test exemption provisions of § 2.1091(c), the minimum *test separation distance* [[Glossary](#)] is used to determine if the device qualifies. When a device does not qualify for those test exemptions, *routine evaluation* [[Glossary](#)] using MPE measurement or numerical simulation is required to determine compliance.

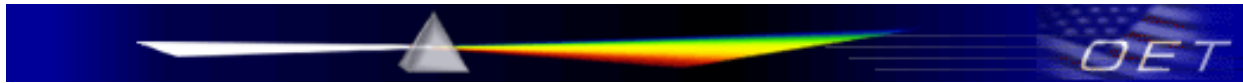
It is also to be noted that, when numerical simulation is used for MPE evaluation, a PAG is required, as described in KDB Pub. 388624.

6.1.3 Simplified MPE Estimate for Qualified Fixed Installations

For mobile devices operating in mostly stationary configurations (for example, on walls or ceiling), and when a sufficiently large separation distance is inherent in the installation conditions, a simplified procedure may be used for assessing compliance, following approval obtained via KDB.

Accordingly, for these cases, MPE estimates are provided according to a conservatively defined minimum *test separation distance* for estimating the far-field exposure conditions.³⁷ These

³⁷ While simple calculations may be acceptable for estimating the far-field exposure conditions of fixed transmitters (§ 1.1307), the distances estimated with similar calculations for mobile exposure conditions (§ 2.1091) are often not suitable or impractical for the installation conditions required for mobile devices. When routine evaluation is required for mobile exposure conditions, MPE estimates are unacceptable without prior FCC confirmation.



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estimates, if approved via KDB submission, may be acceptable for compliance instead of actual measurements or numerical simulation.

6.2 MPE Measurement Guidelines for Mobile Devices

6.2.1 Antenna Considerations

Except when certain sectors of an antenna are permanently blocked or restricted from access by the nature of the installation conditions, MPE compliance must be assessed in all directions surrounding the antenna and radiating structures of the device.

When symmetrical exposure conditions are expected, for example, from an omni-directional antenna, such conditions must be clearly demonstrated in test reports to avoid testing in all directions.

RF exposure evaluation equipment with isotropic sensors designed to measure the orthogonal field components is required to determine the total exposure field.³⁸ Either peak, or spatially averaged results may be applied to determine compliance.

As specified in § 1.1310, plane-wave equivalent power density limits can be considered for frequencies greater than or equal to 300 MHz, while electric and magnetic field strength limits are imposed for frequencies less than 300 MHz.

6.2.2 Spatial Averaging

For non-directional antennas, MPE evaluation points shall be along radials extending from the antenna (axis) that are no more than 30° apart. The direction of maximum exposure shall be aligned with one of the radials.

For exposures conditions referring to a standing person, spatial averaging of the MPE data along the vertical direction can be applied to determine the MPE to be used for compliance, using 1.8 m as the longest dimension of a typical adult. In this case spatial averaging is not required in horizontal planes.

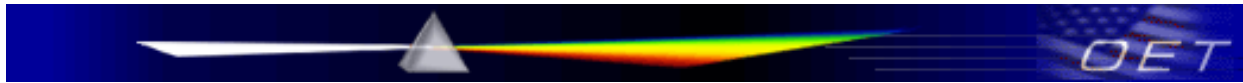
Similarly, spatial averaging along the horizontal planes can be applied for situations where the exposed person is aligned horizontally (e.g., patient in a medical facility). In general, spatial averaging can be applied along the longest dimension referred to the typical orientation of a person's body, for the given exposure scenarios under consideration.

For each specific exposure condition, the evaluation points along the longest dimension (e.g., vertical) shall use a spatial resolution of 10 cm or less, and shall extend at least 10 cm beyond the exposed portions of a person's body or until the evaluated results are less than 10% of the MPE limit. For exposures occurring next to the ground or next to a ground plane, the evaluation points shall be no closer than 10 cm from the ground.

6.2.3 Tests for Devices with Multiple Frequencies and Antennas

When the antenna of a device transmits in multiple frequency bands, the most restrictive *test separation distance* among all frequency bands is required to ensure compliance for the antenna installation.

³⁸ Additional information on test equipment is available in the most recent edition of OET Bulletin 65, its supplements, and references therein.



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When specific antennas are not identified in the installation requirements, for instance when different antennas or antennas with different gain requirements can be used, the maximum antenna gain allowed for each frequency band must be determined according to the most restrictive *test separation distance* required for all of the frequency bands.

The required antenna type, radiating characteristics, antenna gain, and the requirement of a unique minimum *test separation distance* must all be fully explained in the operating and installation instructions. Installers should be cautioned that failure to comply with the specific antenna requirements can result in operations that exceed FCC RF exposure limits.

6.3 Transmitters Used in Mobile Device Exposure Conditions for Simultaneous Operations

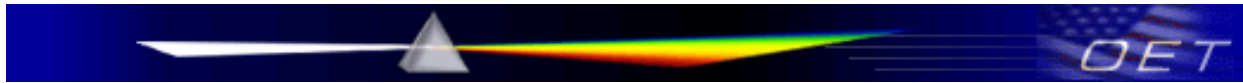
6.3.1 Exemptions to Compliance Testing

In order to determine if a mobile device with multiple transmitters qualifies for simultaneous transmission test exemption, the basic approach is to evaluate MPE compliance for each transmitter, either by measurement or computational modeling (the latter being subject to PAG). In this way one can assess if each transmitter qualifies for the standalone test exemptions of Section 2.1.

In alternative, a less restrictive approach is to use the simultaneous transmission test exemption procedure described in Section 2.2.

6.3.2 Modular Transmitters

The same considerations related to test exemptions that were previously discussed in Section 4 for modular transmitter authorized for portable configurations can be applied for mobile device configurations.



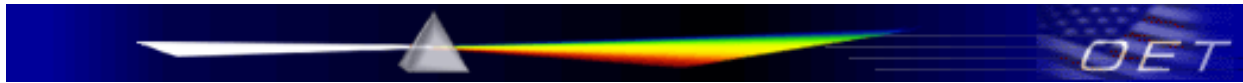
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Change Notice

10/23/2015: 447498 D01 General RF Exposure Guidance v06 replaces 447498 D01 General RF Exposure Guidance v05r02. Changes include update to reference latest IEEE Std 1528-2013, replacing PBA with PAG, updated certain text and added several footnotes for clarification, changing section numbering format and removing submitting approvals directly to the FCC (per FCC 14-208).

04/20/2021: 447498 D01 General RF Exposure Guidance v07 replaces 447498 D01 General RF Exposure Guidance v06. Changes include:

- overall editorial revisions and restructuring for readability and usability.
- former Secs. 1-3 consolidated and renumbered to Sec. 1, former Secs. 4-7 renumbered to Secs. 2-5.
- appendix with tables of exemption thresholds examples updated per FCC-19-126 rule changes.
- glossary and references appendices added.
- energy coupling enhancement (former Sec. 5.2.4) and simultaneous-transmit exemption SAR estimation (former 4.3.2) provisions moved to appendices.



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Appendix A

General Process to Determine RF Exposure Compliance

Frequency-dependent and distance-dependent power thresholds were adopted in Report and Order FCC 19-126. Appendix D of NPRM FCC 13-39 has the derivation of the frequency-dependent and distance-dependent time-averaged power thresholds, below which single portable RF sources operating in the frequency range of 300 MHz (0.3 GHz) to 6 GHz may be exempt from RF evaluation.

The previous power exclusion thresholds for mobile devices in § 2.1091(c) were 1.5 W ERP for transmitters operating at frequencies at or below 1.5 GHz, and 3 W ERP for transmitters operating at frequencies above 1.5 GHz. The new exemption criteria are similar to the previous power exclusion thresholds above 1.5 GHz between 20 cm and 40 cm but consider the potential for whole body resonance at frequencies below 1.5 GHz. The new exemption criteria are less restrictive than the previous power exclusion thresholds between 0.8 GHz and 1.5 GHz, and additionally support extension of these exclusion thresholds down to 0.3 GHz. The new exemption criteria can be used out to a separation distance of 40 cm for mobile and fixed RF sources operating between 300 MHz and 6 GHz. At 40 cm, the MPE-based exemption criteria and the SAR-based exemption criteria are equal.

Generally, the sequence to apply for single portable RF sources includes the following steps:

- 1) determination of 1 mW blanket exemption under § 1.1307(b)(3)(i)(A)
- 2) determination of exemption under the MPE-based § 1.1307(b)(3)(i)(C) if 1) is not met
- 3) determination of exemption under the SAR-based § 1.1307(b)(3)(i)(B) if both 1) and 2) are not met
- 4) streamlined test reduction procedures for evaluation by the FCC Laboratory which may reference current research based on bandwidth, etc. if 1), 2), and 3) are not met
- 5) evaluation by SAR measurement or computation if 1), 2), 3), and 4) are not met
- 6) Environmental Assessment (EA) if none of the previous are met (i.e., exposure limits would be exceeded)

This process is illustrated in the flowchart shown in Figure A.1.

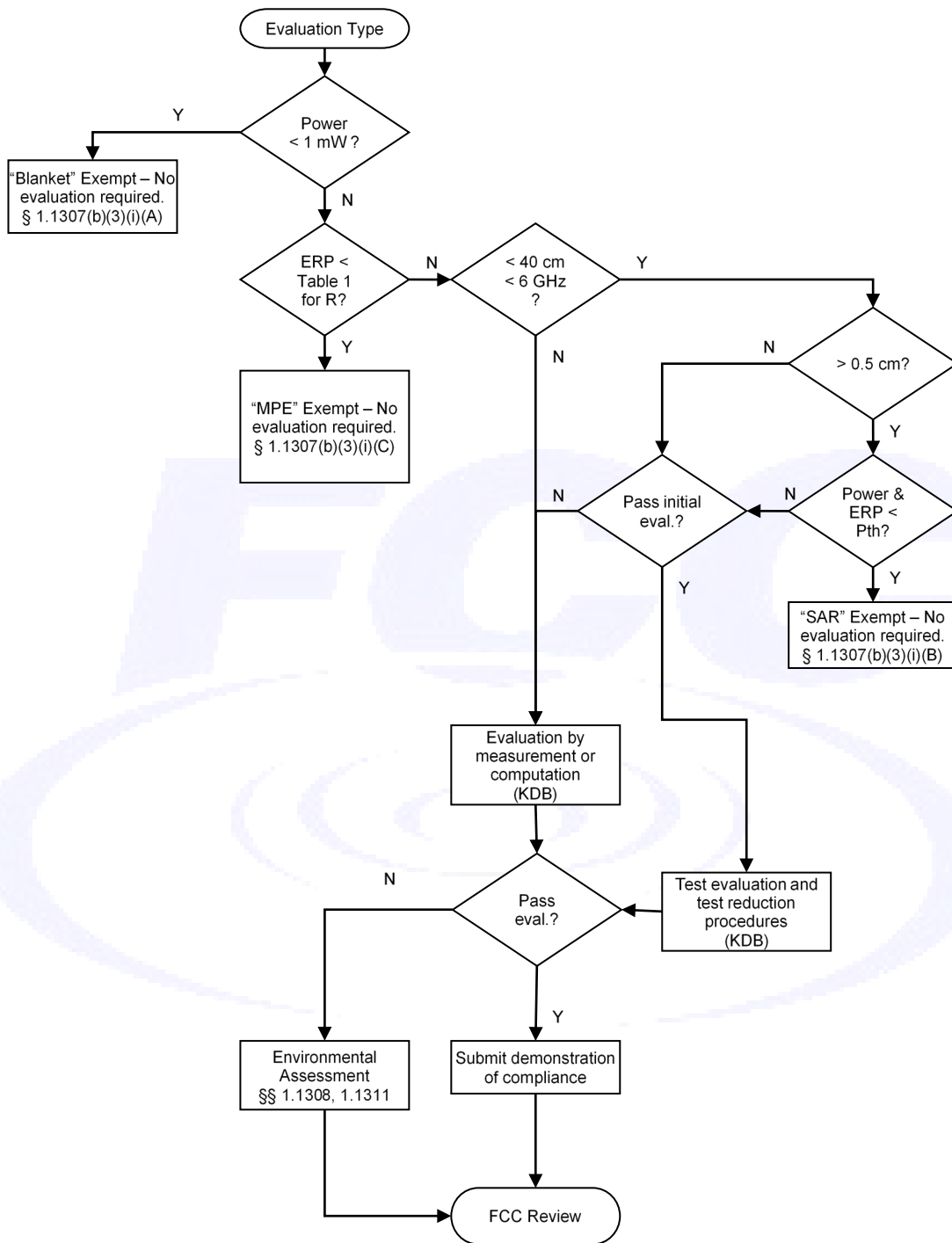
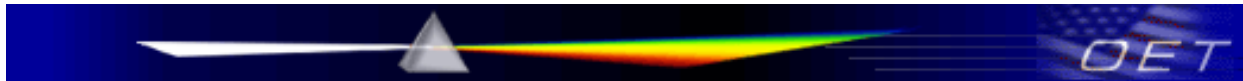


Figure A.1 – General Sequence for Determination of Procedure (exemption or evaluation) to Establish Compliance with Exposure Limits for a Single RF Source³⁹

³⁹ Figure A.1 is reproduced from Appendix D of FCC 13-39 (28 FCC Rcd 3633).



Appendix B Exemptions for Single RF Sources

B.1 General

This appendix provides the exemption criteria and summarizes relevant parameters and usage considerations based on descriptions in FCC 19-126.

B.2 Blanket 1 mW Blanket Exemption

The 1 mW Blanket Exemption of § 1.1307(b)(3)(i)(A) applies for single fixed, mobile, and portable RF sources with available maximum time-averaged power of no more than 1 mW, regardless of separation distance.

The 1 mW blanket exemption applies at separation distances less than 0.5 cm, including where there is no separation. This exemption shall not be used in conjunction with other exemption criteria other than those for multiple RF sources in paragraph § 1.1307(b)(3)(ii)(A).

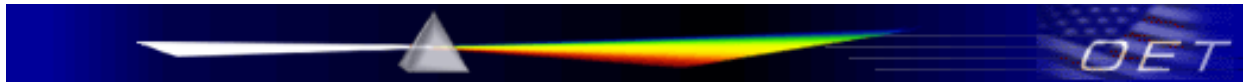
The 1 mW exemption is independent of service type and covers the full range of 100 kHz to 100 GHz, but it shall not be used in conjunction with other exemption criteria or in devices with higher-power transmitters operating in the same time-averaging period. Exposure from such higher-power transmitters would invalidate the underlying assumption that exposure from the lower-power transmitter is the only contributor to SAR in the relevant volume of tissue.

B.3 MPE-based Exemption

General frequency and separation-distance dependent MPE-based effective radiated power (ERP) thresholds are in Table B.1 [Table 1 of § 1.1307(b)(1)(i)(C)] to support an exemption from further evaluation from 300 kHz through 100 GHz.

TABLE B.1—THRESHOLDS FOR SINGLE RF SOURCES
SUBJECT TO ROUTINE ENVIRONMENTAL EVALUATION

RF Source Frequency			Minimum Distance			Threshold ERP
f_L MHz		f_H MHz	$\lambda_L / 2\pi$		$\lambda_H / 2\pi$	W
0.3	–	1.34	159 m	–	35.6 m	$1,920 R^2$
1.34	–	30	35.6 m	–	1.6 m	$3,450 R^2/f^2$
30	–	300	1.6 m	–	159 mm	$3.83 R^2$
300	–	1,500	159 mm	–	31.8 mm	$0.0128 R^2f$
1,500	–	100,000	31.8 mm	–	0.5 mm	$19.2R^2$
Subscripts L and H are low and high; λ is wavelength. From § 1.1307(b)(3)(i)(C), modified by adding Minimum Distance columns.						



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The table applies to any RF source (i.e., single fixed, mobile, and portable transmitters) and specifies power and distance criteria for each of the five frequency ranges used for the MPE limits. These criteria apply at separation distances from any part of the radiating structure of at least $\lambda/2\pi$. The thresholds are based on the general population MPE limits with a single perfect reflection, outside of the reactive near-field, and in the main beam of the radiator.

For mobile devices that are not exempt per Table B.1 [Table 1 of § 1.1307(b)(1)(i)(C)] at distances from 20 cm to 40 cm and in 0.3 GHz to 6 GHz, evaluation of compliance with the exposure limits in § 1.1310 is necessary if the ERP of the device is greater than $ERP_{20\text{cm}}$ in Formula (B.1) [repeated from § 2.1091(c)(1) and § 1.1307(b)(1)(i)(B)].

$$P_{\text{th}} \text{ (mW)} = ERP_{20 \text{ cm}} \text{ (mW)} = \begin{cases} 2040f & 0.3 \text{ GHz} \leq f < 1.5 \text{ GHz} \\ 3060 & 1.5 \text{ GHz} \leq f \leq 6 \text{ GHz} \end{cases} \quad (\text{B. 1})$$

If the ERP is not easily obtained, then the available maximum time-averaged power may be used (i.e., without consideration of ERP only if the physical dimensions of the radiating structure(s) do not exceed the electrical length of $\lambda/4$ or if the antenna gain is less than that of a half-wave dipole.

SAR-based exemptions are constant at separation distances between 20 cm and 40 cm to avoid discontinuities in the threshold when transitioning between SAR-based and MPE-based exemption criteria at 40 cm, considering the importance of reflections.

B.4 SAR-based Exemption

SAR-based thresholds are derived based on frequency, power, and separation distance of the RF source. The formula defines the thresholds in general for either available maximum time-averaged power or maximum time-averaged ERP, whichever is greater.

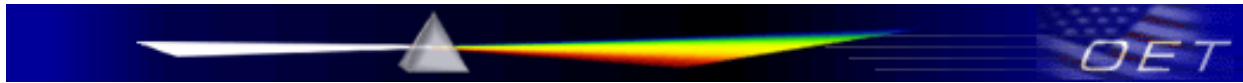
If the ERP of a device is not easily determined, such as for a portable device with a small form factor, the applicant may use the available maximum time-averaged power exclusively if the device antenna or radiating structure does not exceed an electrical length of $\lambda/4$.

As for devices with antennas of length greater than $\lambda/4$ where the gain is not well defined, but always less than that of a half-wave dipole (length $\lambda/2$), the available maximum time-averaged power generated by the device may be used in place of the maximum time-averaged ERP, where that value is not known.

The separation distance is the smallest distance from any part of the antenna or radiating structure for all persons, during operation at the applicable ERP. In the case of mobile or portable devices, the separation distance is from the outer housing of the device where it is closest to the antenna.

The SAR-based exemption formula of § 1.1307(b)(3)(i)(B), repeated here as Formula (B.2), applies for single fixed, mobile, and portable RF sources with available maximum time-averaged power or effective radiated power (ERP), whichever is greater, of less than or equal to the threshold P_{th} (mW).

This method shall only be used at separation distances from 0.5 cm to 40 cm and at frequencies from 0.3 GHz to 6 GHz (inclusive). P_{th} is given by Formula (B.2).



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$$P_{th} \text{ (mW)} = \begin{cases} ERP_{20 \text{ cm}}(d/20 \text{ cm})^x & d \leq 20 \text{ cm} \\ ERP_{20 \text{ cm}} & 20 \text{ cm} < d \leq 40 \text{ cm} \end{cases} \quad (\text{B. 2})$$

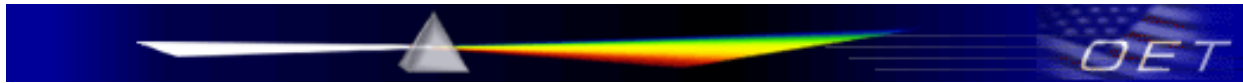
where

$$x = -\log_{10} \left(\frac{60}{ERP_{20 \text{ cm}} \sqrt{f}} \right)$$

and f is in GHz, d is the separation distance (cm), and $ERP_{20\text{cm}}$ is per Formula (B.1). The example values shown in Table B.2 are for illustration only.

Table B.2—Example Power Thresholds (mW)

Frequency (MHz)	Distance (mm)									
	5	10	15	20	25	30	35	40	45	50
300	39	65	88	110	129	148	166	184	201	217
450	22	44	67	89	112	135	158	180	203	226
835	9	25	44	66	90	116	145	175	207	240
1900	3	12	26	44	66	92	122	157	195	236
2450	3	10	22	38	59	83	111	143	179	219
3600	2	8	18	32	49	71	96	125	158	195
5800	1	6	14	25	40	58	80	106	136	169



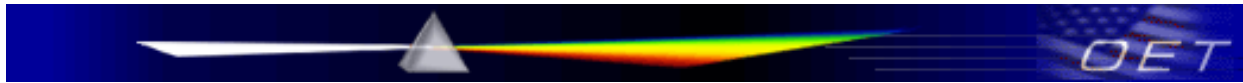
Appendix C
Simultaneous Transmission SAR Test Exemption
with Respect to Multiple Exemption Criteria

Either SAR-based or MPE-based exemption may be considered for test exemption for fixed, mobile, or portable device exposure conditions; therefore, the contributions from each exemption in conjunction with the measured SAR (*Evaluated_k* term) shall be used to determine exemption for simultaneous transmission according to Formula (C.1) [repeated from § 1.1307(b)(3)(ii)(B)].

$$\sum_{i=1}^a \frac{P_i}{P_{th,i}} + \sum_{j=1}^b \frac{ERP_j}{ERP_{th,j}} + \sum_{k=1}^c \frac{Evaluated_k}{Exposure\ Limit_k} \leq 1 \quad (C.1)$$

- a* number of fixed, mobile, or portable RF sources claiming exemption using the § 1.1307(b)(3)(i)(B) formula for P_{th} , including existing exempt transmitters and those being added.
- b* number of fixed, mobile, or portable RF sources claiming exemption using the applicable § 1.1307(b)(3)(i)(C) Table 1 formula for Threshold ERP, including existing exempt transmitters and those being added.
- c* number of existing fixed, mobile, or portable RF sources with known evaluation for the specified minimum distance.
- P_i the available maximum time-averaged power or the ERP, whichever is greater, for fixed, mobile, or portable RF source *i* at a distance between 0.5 cm and 40 cm (inclusive).
- $P_{th,i}$ the exemption threshold power (P_{th}) according to the § 1.1307(b)(3)(i)(B) formula for fixed, mobile, or portable RF source *i*.
- ERP_j the available maximum time-averaged power or the ERP, whichever is greater, of fixed, mobile, or portable RF source *j*.
- $ERP_{th,j}$ exemption threshold ERP for fixed, mobile, or portable RF source *j*, at a distance of at least $\lambda/2\pi$, according to the applicable § 1.1307(b)(3)(i)(C) Table 1 formula at the location in question.
- $Evaluated_k$ the maximum reported SAR or MPE of fixed, mobile, or portable RF source *k* either in the device or at the transmitter site from an existing evaluation.
- $Exposure\ Limit_k$ either the general population/uncontrolled maximum permissible exposure (MPE) or specific absorption rate (SAR) limit for each fixed, mobile, or portable sources, as applicable

The sum of the ratios of the applicable terms for SAR-based, MPE-based and measured SAR or MPE shall be less than 1, to determine simultaneous transmission exposure compliance.



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Appendix D

RF Energy Coupling Enhancement Condition

As described in Section 4.2.3, transmitters with $SAR \leq 0.4$ W/kg can be integrated in host platforms without further restrictions only if they also satisfy an additional condition referred to as test of the *RF energy coupling enhancement*.

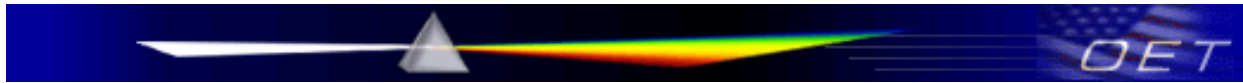
This condition is designed to verify that the low SAR value (*i.e.*, ≤ 0.4 W/kg) that was measured at the prescribed minimum test separation distance (≤ 5 mm) continues decreasing when the separation distance gets larger.

The SAR tests of the transmitter (typically applicable for modules) in general are repeated for each possible configuration in which the module is designed to operate (*e.g.*, different power levels, frequencies), and shall be performed according to the following steps.

- a) The highest *reported* SAR is determined via SAR zoom scan for each test configuration per Section 4.2.3.
- b) For each highest SAR condition of Step a), the tip of the SAR probe is positioned at the corresponding highest SAR (transverse) location of the zoom scan measured per 4.2.3 requirements, at a distance from the phantom surface less than or equal to half the probe tip diameter (or closest specified for the probe), rounded to the nearest mm.
- c) The EUT (*i.e.*, the transmitter/module) is initially positioned in direct contact with the phantom, then subsequently moved away from the phantom in 5 mm spacing increments.
- d) For each EUT position increment of Step c), single-point SAR (not gram-averaged), adjusted for tune-up tolerance, shall be recorded.⁴⁰

At least three repeated single-point (not zoom-scan gram-averaged) SAR results shall be measured at each EUT increment position. When there is more than 15% variation in the single-point measurements SAR results at each position, additional repeated measurements are required for that position, to ensure a representative high -range value is recorded.
- e) The process can be terminated when the measured single-point SAR falls below 50% of that recorded with the device in contact with the phantom.
- f) All the SAR measurements collected for the positions at 10 mm and beyond from the phantom are then examined to identify those points with SAR larger than 25% of the value measured at 5 mm.
- g) If there are positions identified in Step f), for the highest measured single-point SAR condition among all these positions a complete 1-g SAR evaluation is required.

⁴⁰ These single-point SAR measurements can generally be configured using the multi-meter or time-sweep modes available in most SAR systems to record the measured results.



Appendix E

SAR Estimations for Simultaneous Transmission Test Exemptions

E.1 Estimated SAR

When an antenna qualifies for test exemption in single transmitter/antenna mode, its actual SAR value may not be available, because it was not required to be measured. In this case, the SAR contribution of that antenna to simultaneous transmission must be estimated relative to the SAR or MPE based exemption criteria for the applicable terms in the equation of § 1.1307(b)(3)(ii)(B) (see also Appendix C), by multiplying the corresponding ratio by the SAR limit of 1.6 W/kg for 1-g SAR. This is referred to as *estimated SAR*.

For instance, a given antenna may qualify for a SAR-based exemption according to Section B.4, with $P_{ant} < P_{th}$, where P_{ant} is maximum time-averaged power or effective radiated power (ERP), whichever is greater, and P_{th} is defined in Formula (B.2). Then, per the preceding paragraph, the estimated SAR is computed as $SAR_{est} = 1.6 \cdot P_{ant} / P_{th}$ [W/kg].

When SAR is estimated, the peak SAR location is assumed to be at the feed-point or geometric center of the antenna, whichever provides a smaller antenna separation distance, and this location must be clearly identified in test reports. The estimated SAR is used only to determine simultaneous transmission SAR test exemption; it shall not be reported as the standalone SAR.

E.2 Using Standalone SAR Values

When SAR to peak location separation ratio test exemption is applied, the highest reported SAR for simultaneous transmission can be an estimated standalone SAR if the estimated SAR is the highest among all the simultaneously transmitting antennas (see also KDB Pub. 690783 D01 requirements for listing simultaneous-transmit SAR on grants).

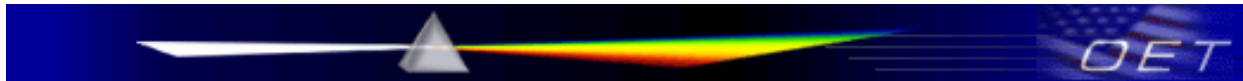
For situations where the estimated SAR is overly conservative, that is when using estimated SAR leads to non-compliance, then one can measure the actual value by performing can be determined using standalone SAR measurements, then measured SAR is used to determine simultaneous transmission SAR test exemption.

E.3 Peak Location Determination

When standalone SAR is measured, the peak location is determined by the x, y, z coordinates of the results reported by the zoom scan measurement, or area scan measurement when area scan based 1-g SAR estimation is applicable (these results in general way need extrapolation and/or interpolation to identify the actual peak locations).

Some SAR systems may have provisions to compute peak location separation distance automatically. however, it must be verified that the peak location separation distance is determined according to the correct 1-g peak SAR locations to avoid errors in noisy SAR distributions with several relative peaks near each other.

When SAR is estimated for both antennas considered in a pairwise *SPLSR* analysis, the peak location separation shall be determined by the closest physical separation of the antennas, according to the feed-point or geometric center of the antennas, whichever is more conservative.



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E.4 SAM Phantom Special Considerations

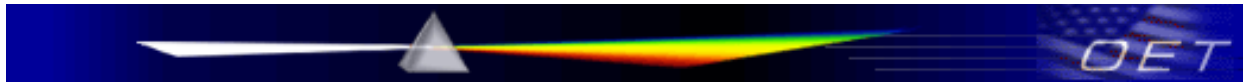
For the SAM phantom, the origin of the coordinates for data points reported by SAR systems is typically located at the *ear reference point*, on the inside surface of the phantom. This is also referred to as the *measurement grid reference point* by some systems.

Due to curvatures on the SAM phantom, when SAR is estimated for one of the antennas in an antenna pair the measured peak SAR location shall be translated onto the test device, to determine the peak location separation for the antenna pair.

The *ear reference point* location on the phantom is aligned with the location of the acoustic output on the handset, with 6 mm separation in the z coordinate due to the phantom ear spacer. A measured peak location can be translated onto the handset, with respect to the *ear reference point* location, by ignoring the 6 mm offset in the z coordinate.

The assumed peak location of the antenna for estimated SAR can also be determined with respect to the *ear reference point* location on the handset. The peak location separation distance is estimated by the x, y coordinates of the peaks, with respect to the *ear reference point* location. While flat phantoms are not expected to have these issues, the same peak translation approach shall be applied to determine peak location separation.

The coordinates of the peaks, whether measured or translated, shall be clearly identified in the SAR report. When necessary, plots or illustrations shall be included to support the distance applied to qualify for SAR test exemption.



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Glossary

Terms and definitions used in the published RF exposure KDBs are provided in this glossary.

A

Available Maximum Time-Averaged Power – Maximum available RF power (into a matched load) for an RF source, as averaged over a time-averaging period

C

Coherent Signals – Signals characterized by a fixed phase relationship.

Continuous Exposure – Maximum time-averaged exposure at a given location for an RF source and assumes that exposure may take place indefinitely. The exposure limits in § 1.1310 are used to establish the spatial regions where mitigation measures are necessary assuming continuous exposure as prescribed in § 1.1307(b)(4).

E

Effective Radiated Power (ERP) – The product of the maximum antenna gain which is the largest far-field power gain relative to a dipole in any direction for each transverse polarization component, and the maximum delivered time-averaged power which is the largest net power delivered or supplied to an antenna as averaged over a time-averaging period. ERP is summed over two polarizations, when present.

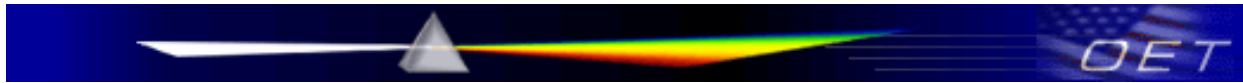
Energy Coupling Enhancement Condition – A condition designed to verify that the low SAR value that was measured at the prescribed minimum test separation distance continues to decrease decreasing when the separation distances gets larger.

Exempt RF Device – A source(s) is solely from the obligation to perform a routine environmental evaluation to demonstrate compliance with the RF exposure limits in § 1.1310; it is not exemption from the equipment authorization procedures described in 47 CFR Part 2, not exemption from general obligations of compliance with the RF exposure limits in § 1.1310 of this chapter, and not exemption from determination of whether there is no significant effect on the quality of the human environment under § 1.1306.

Enlarged Zoom Scan – A scan performed with a SAR evaluation system to provide higher resolution data points

Estimated SAR – See Appendix E

Exempt RF Device – RF source that is not the required to show data demonstrating compliance to RF exposure limits.



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F

Fixed RF Source – A RF source is one that is physically secured at one location, even temporarily, and is not able to be easily moved to another location while radiating;

H

Host Platform – A type or family of devices that can host transmitters (either modular or not)

Host Platform Exposure Condition – Any host exposure corresponding to mobile, portable exposure, or mixed mobile-portable categories

M

Modular Transmitters – Transmitters certified for use as a module.

Minimum Test Separation Distance – A *test separation distance* determined by the smallest distance from the antenna and radiating structures or outer surface of the device, according to the host form factor, exposure conditions and platform requirements, to any part of the body or extremity of a user or bystander.

O

Operational Separation Distance – Separation distance between the transmitter antenna (or radiating structure) and the user in typical conditions of operation

P

Peripheral Transmitter – A transmitter that requires a host product to support its operations and cannot operate independently by itself. Peripheral transmitters can be attached to hosts through user accessible external standard interface connections, or can be incorporated internally within a host device.

Plane-wave equivalent power density – The square of the root-mean-square (rms) electric field strength divided by the impedance of free space (377 ohms).

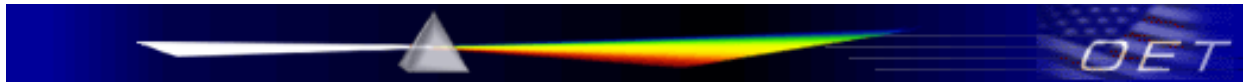
R

Reported SAR, Reported MPE – SAR measured at or scaled to the maximum tune-up tolerance limit

Routine (Environmental) Evaluation – Evaluation of the EM field, or EM power flux density in comparison with FCC limits set for RF exposure

Radiating Structure – An unshielded RF current-carrying conductor that generates an RF reactive near electric or magnetic field and/or radiates an RF electromagnetic wave. It is the component of an RF source that transmits, generates, or reradiates an RF fields, such as an antenna, aperture, coil, or plate.

RF source – FCC-regulated equipment that transmits or generates RF fields or waves, whether intentionally or unintentionally, via one or more radiating structure(s). Multiple RF sources may exist in a single device.



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S

SAM Phantom – Specific Anthropomorphic Mannequin phantom

SAR to Peak Location Separation Ratio (SPLSR) – See Section 2.2.3

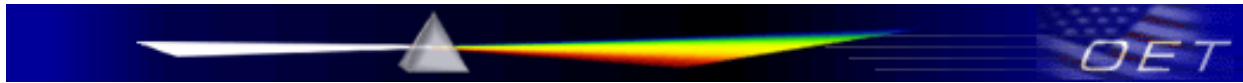
Source-Based Time Averaging – A time average of instantaneous exposure over a period that is based on an inherent property or duty-cycle of a device to ensure compliance with the continuous exposure limits.

T

Test Separation Distance – For RF exposure evaluations is the minimum distance in any direction from any part of a radiating structure and any part of the body of a nearby person exposed to the RF emission.

Tune-up Tolerance – The range of expected maximum output power variations from the rated nominal maximum output power specified for the product or wireless mode.





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References

OET Bulletin 65, “Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields,” (<https://www.fcc.gov/general/oet-bulletins-line>).

Related KDB Publications

a) Product related KDB publications:

- Mobile and Portable Devices (KDB 447498)
- USB Dongles (KDB 447498)
- Laptop/Notebook/Netbook & Tablet Devices (KDB 616217)
- Occupational PTT Two-Way Radios (KDB 643646)
- Handsets & Accessories (KDB 648474)
- UMPC Mini-Tablets (KDB 941225)

b) Wireless technology related KDB publications:

- 802.11 (KDB 248227)
- WiMax (KDB 615223)
- Wireless Power Transfer Applications (KDB 680106)
- 3GPP/3GPP2 Technologies (KDB 941225)
- Wireless Routers (KDB 941225)

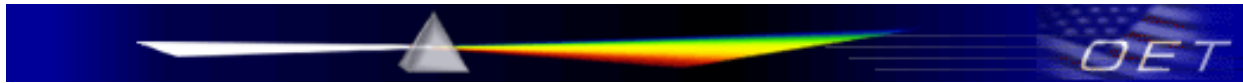
c) Test methodology related KDB publications:

- SAR Measurement and Reporting Requirements (KDB 865664)
- Mapping OET B 65 Supplement C to IEEE Std 1528-2013 (KDB 447498)

d) Equipment approval policy related KDB publications:

- Permissive Change Policies (KDB 178919)
- Pre-Approval Guidance (PAG) Procedures and PAG List (KDB 388624)
- Grant Frequency Listings (KDB 634817)
- SAR Numbers Grant Listings (KDB 690783)
- Modular Approval Policies (KDB 996369), etc.

DA 21-363; OFFICE OF ENGINEERING AND TECHNOLOGY ANNOUNCES MAY 3, 2021 AS THE EFFECTIVE DATE FOR RF EXPOSURE RULE CHANGES AND BEGINNING OF THE TWO-YEAR REVIEW PERIOD FOR EXISTING PARTIES; docket no. 19-226; Released: April 2, 2021; 86 FR 20456-20458, April 20, 2021



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FCC 19-126; Human Exposure to Radiofrequency Electromagnetic Fields and Reassessment of FCC Radiofrequency Exposure Limits and Policies; docket no. 03-137 and 13-84; final rule; 85 FR 18131-18151; Apr. 1, 2020

FCC 19-126, RESOLUTION OF NOTICE OF INQUIRY, SECOND REPORT AND ORDER, NOTICE OF PROPOSED RULEMAKING, AND MEMORANDUM OPINION AND ORDER; Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields, docket no. 03-137; Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies, docket no. 13-84; Targeted Changes to the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields, docket no. 19-226; Adopted: November 27, 2019; Released: December 4, 2019; 34 FCC Rcd (14) 11687-11855

FCC 13-39, FIRST REPORT AND ORDER, FURTHER NOTICE OF PROPOSED RULE MAKING, AND NOTICE OF INQUIRY; Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields, docket no. 03-137; Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies, docket no. 13-84; Adopted: March 27, 2013; Released: March 29, 2013; 28 FCC Rcd (4) 3498-3699

IEC/IEEE 62704-1, Determining the peak spatial-average specific absorption rate (SAR) in the human body from wireless communications devices, 30 MHz to 6 GHz – Part 1: General requirements for using the finite-difference time-domain (FDTD) method for SAR calculations

IEC/IEEE 62704-4, Determining the peak spatial-average specific absorption rate (SAR) in the human body from wireless communication devices, 30 MHz to 6 GHz – Part 4: General requirements for using the finite element method for SAR calculations