RE-740

49.20

MIC requirements for certification

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1 History

Revision	Section number	Page number	Date	remark(s)	Issued by
2			01-06-2011	Second release (Including Category VV, UV, carrier sensing, dwell => retention time, carriers in 1 MHz) + TSF 057-01_1 Lichtsterkte (Lux)	WJJ
3		all	23-06-2022	Logo exchanged in header.	AG

Issued/modified by : Axel Gase
Function : Quality manager
Revision : 3
Date : 23-06-2022

Verified by : Willem Jan Jong
Function : Manager Product Certification
Date : 25-06-2022

Released by : Axel Gase
Function : Quality assurance manager
Date of release : 25-06-2022

2 GENERAL: Definition Radio equipment

Radio equipment, submitted for certification shall satisfy the following basic requirements:

1. Equipment has an antenna part, a high frequency part, modulation part, auxiliary equipment (indicator, etc) and a control part (power supply equipment, etc). The control part can include external equipment that is supposed to be connected to the control part under certain interface conditions.

2. At the time of entering into market, all parts are completely installed in the equipment.

3. If the equipment is supposed to be connected in or installed to external devices when it is used, the construction of the equipment need to be as follows; easily disconnected from the external equipment with a connector and obviously identified as specified radio equipment.

A “radio part” without antenna or control part is not considered as “radio equipment”, therefore it can’t be certified. It is necessary to list the available in- and external antenna’s for “radio equipment” and to check that all combinations satisfy the relevant EIRP requirements, for example the maximum EIRP power (density) and spurious emissions.

3 Article 49.20. Overview low power data communications systems.

(*<u>Part of Section 4.17</u> Radio Equipment of Radio Stations of a low Power Data Communication System*)

All requirements can be related to the antenna connector (as a principle), so that a conducted measurement can be applied. If the requirement is based upon an EIRP based requirement, the maximum gain of the available antenna(s) shall be taken into account for evaluation of the EIRP limit. If there is no antenna connector available, measurements shall be carried out with a suitable test-fixture or in a full anechoic room, based upon a full EIRP approach.

In all situations, the **antenna characteristics shall be measured for the relevant operational frequencies**, especially with regard to the half power beam width and the maximum gain for a directional antenna. These results shall be included in the report.

Description	**Article and Category**	
In the 2.4GHz band, 2400 – 2483.5 MHz (e.g. WLAN 802.11b/g/n), *<u>Indoor/outdoor use.</u>* <u>Modulation:</u> OFDM or DSSS or other digital modulation (like frequency hopping) or a combination. <u>Density limited</u> up to 10 mW/MHz (if the occupied bandwidth is smaller than 26 MHz) or 5 mW/*MHz for 40 MHz channel spacing* and 3 mW/MHz for *hopping* systems using (or part of) the frequency range from 2427 – 2470.75 MHz. <u>Power limited</u> up to 10 mW for other modulations / systems (single carrier)	**Article 2 item (19)** *(For radio controlled models for outdoor use,* *the category is **UV**)*	**WW**
In the 2.4GHz band, 2471 – 2497 MHz, *<u>Indoor/outdoor use</u>.* <u>Modulation:</u> DSSS or other digital modulation (like frequency hopping) or a combination. *OFDM is not allowed.* <u>Density limited</u> up to 10 mW/MHz.	**Article 2 item (19)-2** *(For radio controlled models for outdoor use,* *the category is VV)*	**GZ**

In the 5.2, 5.3GHz band, WLAN 802.11a/n, channels like 5180, up to 5320 MHz (or 5180 up to 5240 MHz in an aircraft) with a channel spacing of 20 or 40 MHz. *Only Indoor use.* Modulation: OFDM or DSSS Density limited up to 10 mW/MHz up for 20 MHz channel spacing or less and up to 5 mW/MHz for 40 MHz channel spacing Power limited up to 10 mW for other modulations: like AM, FM, pulse modulation (single carrier)	**Article 2 item (19)-3**	**XW**
In the band, from 5.470 up to 5.740 GHz, channels like 5500 up to 5700 MHz with a channel spacing of 20 or 40 MHz. *Indoor use, outdoor is allowed with special marking warning to avoid interference.* Modulation: OFDM or DSSS Density limited up to 10 mW/MHz up for 20 MHz channel spacing or less and up 5 mW/MHz for systems with 40 MHz channel spacing Power limited up to 10 mW for other modulations: like AM, FM, pulse modulation (single carrier systems)	**Article 2 item (19)-3-2**	**YW**

4 Test: Availability antenna terminal

Reference: Article 2, Item (19) Notice 88, Appendix 43, B-1 (1) & (2)

Requirement: Applicable for equipment with an antenna terminal, including testing terminals)
If an antenna connector is available, all relevant tests will be carried out conducted. If not, tests will be carried out in an anechoic room or with a suitable test-fixture.

Result: An antenna terminal is available (Yes/No)

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5 Test: Environmental conditions during testing.

Reference: Article 2, Item (19) Notice 88, Appendix 43, A-1, JIS Z8703

Requirement: All measurements shall be carried out under the following conditions:

- Temperature between 5 and 35 ^{0}C
- Humidity between 45 and 85 %

Result: Confirmation that these conditions are satisfied (Yes / No)

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6 Test: Supply conditions during testing - 1.

Reference: Article 2, Item (19) Notice 88, Appendix 43, A-2- (1)

Requirement: All measurements shall be carried out with a regulated (stabilized) power supply, so that the same supply condition is maintained.

Result: A regulated power supply has been used (Yes / No)

Test exec: A regulated power supply must be used to maintain the same condition(s) during all testing, so that the results are traceable.

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7 Test: Supply conditions during testing - 2

Reference: Article 2, Item (19) Notice 88, Appendix 43, A-2- (2)

Requirement: All measurements shall be carried out with three different supply voltages: the <u>Rated</u> nominal value, - 10 % and + 10 %. This supply variation is applicable for the DIRECT supply voltage. See for example equipment hosted by other equipment (Like an USB device in a PC; this USB device shall be tested with 5 V nominal and a variation of 0.5 V)

However, if the device uses an *internal* voltage regulator, supplying power to all critical parts of the radio circuitry, it is acceptable to restrict the measurements to the nominal supply voltage value under the condition that the regulator is capable to reduce the voltage variation to a value smaller than 1 % (if the input is varied with 10%)

Result: Internal regulator is present, and satisfies the 1 % criterion
Yes / No

Note: If an *internal radio module* is specified with a restricted supply range, (smaller than 10%), it can be accepted only for certification, if the hosting environment is defined as well. It should be clear that the host will reduce the 10% variation of its own voltage supply to the specified voltage supply value of the module - or better. If so, testing shall occur at the specified supply limits of the radio module. These supply limits shall be expressed clearly in the test report.

Test-exec.: *If a regulator is used, the input voltage is varied with 10% under max. load conditions and the output voltage(s) of the regulator are recorded. If these satisfies the 1% criterion, present the measurement results, with 10% input variation and the max. output voltage variation.*

Important is to check the different circuits, being served by the regulator and directly from the (unregulated) supply. If a critical circuit is supplied directly, the 1 % rule can't be applied.

Another possibility is to use the manufacturers specification of the regulator. If the specs of the regulator are available and acceptable, present a reference to this document and the stated minimum performance of the regulator (e.g. output voltage stabilization better than x % at the max. load condition, if x < 1)

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8 Test: Testing frequency.

Reference: Article 2, Item (19) Notice 88, Appendix 43, A-3

Requirement: If the EUT can be set to 3 of more different (carrier) frequencies in 1 allocated band, testing shall be performed using the Lowest, Middle and the Highest frequency (L,M and H). If there are 2 or fewer frequencies, testing shall be performed with the available frequencies.

Result: Testing has been performed with the following frequencies: (common: L, M, H)

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9 Test: Preheating time.

Reference: Article 2, Item (19) Notice 88, Appendix 43, A-5

Requirement: If no preheating time is indicated in the operating manual, all requirements shall be fulfilled immediately after switching-on. If a preheating time is specified, this time shall be taken into account before testing.

Result: Preheating time is indicated (Yes/No, according to operating manual)

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10 Test: Selected equipment characteristics for testing

Reference: Article 2, Item (19) Notice 88, Appendix 43, B-1 (2)

Requirement: If the equipment has the possibility to switch its characteristics, an appropriate selection will be made depending upon the test. Changes in the code sequence, code length and frequency can influence the measurement results and therefore the coding characteristics shall be recorded <u>*so that traceability is maintained*</u>.

The same is applicable for the <u>modulations</u>, as far this can be selected. If nothing is specified, a choice shall be made, <u>so that the worst-case situation is realized</u> taking into account the nature of the requirement (e.g. spreading rate).

Hopping systems,
If <u>A</u>daptive <u>F</u>requency <u>H</u>opping (AFH) is available, the measurements for the spreading bandwidth and the power output shall be carried out with the maximum and the minimum amount of the available channels (carrier-frequencies)

Test-Tool
A software tool or a built-in test-mode needs to be reported with the parameter settings for creating the appropriate selection of characteristics.

Result: Overview of equipment' characteristics and the specific equipment "state" applied for testing (like frequency throughput/coding/modulation/ channels) and the corresponding parameter settings of the test-software

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Test-exec.: The test-tool should have the following functionalities:

- *facility to transmit without having a communicating party*
- *to select specific frequencies for transmitting (LMH)*
- *facility to transmit at a selected frequency continuously or in a periodic burst mode*
- *facility to set the modulation*
- *facilities to set the spreading code and to stop it*

- *to use standardized test-signals (MLS 2^9-1 up to 2^{23}-1 according to ITU-T Rec. O.150):*

The software settings shall be reported because of the traceability requirement of the measurements. The settings are depending upon the IEEE standard & mode and the applied modulation. Most common settings are:

- *for 802.11b, bit rate 1 Mb/s, modulation DSSS: DBPSK, DQPSK, CCK Symbol rate 1.375 Mbaud.*
- *for 802.11g, bit rate 6 Mb/s, modulation DSSS: DBPSK, DQPSK, CCK; OFDM: BPSK, QPSK, 16QAM, 64QAM, Symbol rate 6.75 Mbaud.*
- *for 802.11a, bit rate 54 Mb/s, modulation DSSS: DBPSK, DQPSK, CCK; OFDM: BPSK, QPSK, 16QAM, 64QAM Symbol rate 6.75 Mbaud.*
- *for 802.11n (20 MHz) 54 Mb/s, modulation OFDM: BPSK, QPSK, 16QAM, 64QAM*
- *for 802.11n (40 MHz) 108 Mb/s, modulation OFDM: BPSK, QPSK, 16QAM, 64QAM*

The settings for Bluetooth will be influenced by the throughput and the modulation. Most important characteristics to take into account for testing:

- *Bluetooth 2.0 has the AFH (Adaptive Frequency Hopping) facility, so that channels are disabled which cause interference and a minimum set of channels shall be used (normally 20)*
- *Bluetooth 2.0 + EDR: bit rate 1-3 Mb/s, 3 different modulations: GFSK, pi/4 DQPSK, 8DPSK*

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11 Test: Frequency deviation.

Reference: Article 2, Item (19) Notice 88 Appendix 43, C-2

Requirement: The deviation of the carrier frequencies from the nominal value is depending upon the assigned frequency band:
-For the 2.4 GHz bands (WW and GZ) it shall be better than 50 ppm under the operational conditions
-For the 5 GHz bands (XW and YW) it shall be better than 20 ppm under the operational conditions

Result: Carrier frequencies in MHz or GHz units and the deviation from the nominal frequency in ppm. If the EUT has more than 1 transmit antenna terminal, the measurements shall be carried out for the each terminal.

Test-execution.:

Test equipment

(1) Generally, use a counter or a spectrum analyzer as the frequency meter.
(2) The measurement accuracy value of the frequency meter shall be –at least- 10 times smaller than the allowable deviation (i.e. 5 ppm for 2.4 GHz)
(3) Set the attenuation of the attenuator at a suitable level for the frequency meter to avoid the effect of amplitude fluctuations in the tested frequencies.
(4) Use the pulse measurement function of the counter to measure bursts and set the value of the gate ‘open time’ to measure the burst completely

Preamble:
(1) Set EUT to transmit a single frequency.
(2) Stop modulation (and stop spreading) and continuous transmit a non-modulated signal. If this is not possible, “continuous transmit bursts of non-modulated frequency” or choose the modulation mode in order to emit characteristic spectral frequencies (i.e. 1 subcarrier wave etc.) that can be measured using a spectrum analyzer.

Test procedure

(1) In the case of non-modulated frequencies (consecutive or repeated periodic bursts), conduct direct measurements using the counter.
(2) In the case of burst frequencies, the measurement time should be long enough for sufficient accuracy and set the average value as the measured value.
(3) If test modes are used, (emitting characteristic spectral frequencies), measure the spectral frequency using the spectrum analyzer.
(4) Generally, if frequencies corresponding to direct testing frequencies are not measured with the methods as specified here before, the results shall be obtained by suitable calculations.
5 Recording of measurement results
List the largest differences in MHz or GHz units and the largest deviation from the nominal frequency in ppm for each antenna terminal.

Special Conditions
When conducting tests with modulation, frequencies can be measured by using a combination with a signal generator. If the signal from the signal generator and a testing signal are observed simultaneously (or switched) by the spectrum analyzer, match the frequency of the signal generator with the location of the dips on the screen and use the frequency of the signal generator as the measured value.

12 Test: Interference prevention capability

Reference: Article 2, Item (19) Notice 88 Appendix 43, 44, 45
Requirement: The EUT shall have the capability to transmit or to receive the MAC identification automatically, so that sender and receiver shall exclude other equipment.

Result: Verification of the capability to transmit and receive the identification

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Test-execution.: Use adequate test-software to create a communication link with another EUT. This link shall be protected by using the MAC identifications of both devices. The protection capability is tested by *changing respectively the ID's* of both devices and observing the resulting disconnection and error messaging.

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13 Test: "Not easily to open"

Reference: Article 2, Item (19) Notice 88 Appendix 43, 44, 45
Requirement: The EUT shall be constructed in such a way that the RF parts, (like modulation and oscillator parts) cannot be reached easily by the user. If the device is using a cabinet for protection it shall be fixed by tamper screws (like Torx) and/or by glue. If the device has no cabinet but is constructed as a PCI board, the RF and modulation parts (including the pins) shall be covered by soldered metal caps or glue or by other mechanical covers. If the covers are fixed with screws, these shall be not the common type(s) like a Phillips, but tamper screws like Torx, so that the user cannot open the device with common tools.
Result: Verification of the requirement by showing the mechanical protection.

Note: The standard crystal oscillator for TX/RX frequency generation is regarded as part of the RF circuit and the ID (Identification) number storage parts are regarded as a part of the modulation circuit .

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14 Test: Transmission burst length

Reference: Article 2, Item (19) –2-3 Notice 88 Appendix, 45, applicable for equipment using the 5 GHz bands (XW and YW)
Requirement: The EUT shall limit its burst length to a maximum value of 4 ms.

Result: Verification of the capability to transmit and receive the identification

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Test-execution.: *Use adequate test-software to create a communication link with another EUT and measure the duration of the transmit bursts. The transmit burst can be* *measured by using a simple AM demodulator (or crystal detector) and an oscilloscope. The RC time shall be less than 0.1 ms. The burst length shall be measured for the different modes and available modulations.*

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15 Test: Occupied Bandwidth

Reference: Article 6, Radio Legislation, Table No.2 Notice 88, Appendix 43, 44, 45 A-4

Requirement: - 1. Occupied Bandwidth requirement for DSSS & OFDM equipment

Carrier frequencies from 2,400MHz to 2,483.5MHz or from 2,471MHz to 2,497MHz, for all equipment except for 40 MHz channel separation:
Max. occupied Bandwidth: 26 MHz (Note: For GZ the OFDM modulation is not allowed)

W52: carrier frequencies of 5,180MHz, 5,200MHz, 5,220MHz, 5,240MHz, (can be used also in aircrafts) and
W53; carrier frequencies of 5,260MHz, 5,280MHz, 5,300MHz or 5,320MHz
Max. occupied Bandwidth:
19 MHz for OFDM systems and 18 MHz for other modulations.

W56; carrier frequencies of 5,500MHz, 5,520MHz, 5,540MHz, 5,560MHz, 5,580MHz, 5,600MHz, 5,620MHz, 5,640MHz, 5,660MHz, 5,680MHz, or 5,700MHz:
Max. occupied Bandwidth: 19.7 MHz

For OFDM equipment with 40 MHz channel separation in all frequency bands as stated above except for the band from 2,471MHz to 2,497MHz (GZ):
Max. occupied Bandwidth: 38 MHz

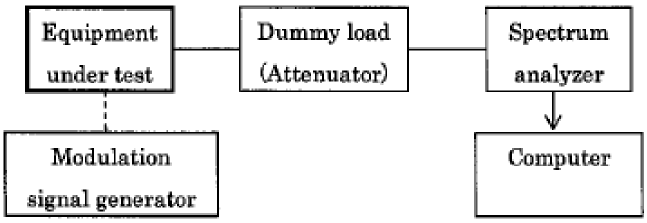
- 2. Equipment using frequency hopping from 2,400MHz to 2,483.5MHz, or in a mix with DSSS or a combined version of frequency hopping with orthogonal frequency division multiplexing:
Max. occupied Bandwidth: 83.5 MHz

Result: Overview of the occupied bandwidth measurements, related to mode, modulation and frequency (L, M and H)

Test-exec: *Applicable for both Occupied Bandwidth and Spread Bandwidth*

1 Measurement Schematic Diagram

Block diagram of measuring system



2 Conditions of the Measuring Devices
(1) The settings of the spectrum analyzer are as follows:
Central Frequency: Testing frequencies
Sweep Bandwidth: 2-3.5 times the acceptable value
Resolution Bandwidth: Less than 3% of the acceptable *(Limit*) value
Video Bandwidth: Comparable to resolution bandwidth.
Y-Axis Scale: 10 dB/Div
Input Level Carrier wave level: sufficiently higher than spectrum analyzer noise
Sweep Time: Minimum amount of time to ensure measurement accuracy (in the case of burst waves, 1 burst per sample)
Data Points: Over 400 points
Sweep Mode: Continuous sweep
Detection Mode: Positive peak
Display Mode: Max hold
In case of OFDM modulation, set the spectrum analyzer as follows:
Average number of processing 10 times: In a burst transmission, Max. Hold
Detection mode Sample, In a burst, positive peak.

(2) Process the measured values of the spectrum analyzer using an external or internal computer.

3 Status of Testing Equipment
Set to testing frequency and modulate using standard encoding test signals. For OFDM and burst transmission, it shall be modulated so that sub-carriers (short preamble) are minimized in time.

4 Operating Procedures for Measurements
(1) Configure the settings of the spectrum analyzer to 2(1).
(2) After repeating sweeps until no display changes are found, import the values of all the data points as array variables of the computer.
(3) Convert the dB value into the antilog of the power dimension (i.e. mW) for all data.
(4) Find the total power of all the data and record as "Total Power" in mW.
(5) Add power to the minimum frequency data in order and find the value of the limiting data point that is 0.5%
(5% in the case of spread bandwidth) of the "Total Power". Convert the limiting point into a frequency and record as the "*lower limit" frequency*.
(6) Add power to the maximum frequency data in order and find the value of the limiting data point that is 0.5% (5% in the case of spread bandwidth) of the "Total Power".
Convert the limiting point into a frequency and record as the "*upper limit" frequency*.

5 Recording Methods of Test Results
- Find the occupied bandwidth and spread bandwidth as the difference between the “upper limit” frequency and “lower limit” frequency and list in MHz units.
- If the EUT has more antenna terminals than one, tests shall be done for each antenna terminal and indicate the largest one of the values measured.

6. Other Conditions
(1) If the EUT has more than one antenna terminal but does not simultaneously transmit from all antenna terminals (diversity technology in the antenna selecting system), measure the occupied bandwidth only at the active antenna terminals. However, if the selecting circuit of the antennas has a *non-linear element*, measure the occupied bandwidth *at all antenna terminals*.
(2) If the EUT has more than one antenna terminals and the measured value at each antenna terminal exceeds the value derived from the limit value minus 100 kHz, measure the occupied bandwidth at each antenna terminal under the condition that *all antenna terminals are connected with the couple*r and indicate the combined result together with the measured value at each antenna terminal.
The EUT will be configured so that the total antenna power is maximised.

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16 Test: Diffusion (*spreading*) bandwidth.

Reference: Article 49.20 1);h /I and 3);i Notice 88, Appendix 43, 44, 45 A-4

Requirement: The minimal diffusion bandwidth is 500 kHz.
The requirement is only applicable for:

1. Regular DSSS & OFDM equipment with frequencies from 2,400MHz to 2,483.5MHz & from 2,471MHz to 2,497MHz (*Only DSSS*) & 5,180 MHz to 5,320 MHz and from 5470-5725 MHz.

Note:
For systems using *frequency hopping* from 2,400MHz to 2,483.5MHz without any spreading technology, there are no spreading bandwidth restrictions (only the occupied bandwidth is restricted). However, it is necessary to measure the spreading bandwidth, in order to calculate the observation time for measuring the retention time and the power density.
It shall be measured in the extreme hopping modes with the *maximum* amount of available channels and the *minimum* (If AFH is applicable). As far as possible, the operational channels shall be clustered for the measurement of the minimal (spreading) bandwidth.

If clustering is not possible, the *minimal spreading bandwidth* can be approximated by:
- smallest spreading bandwidth of a single channel (L, M, H) + 0.9 x [(n-1) x channel separation]
- (n = *minimum amount of channels*)

Result: Table of spreading (diffusion) bandwidth results, depending upon IEEE standard/modulation/throughput

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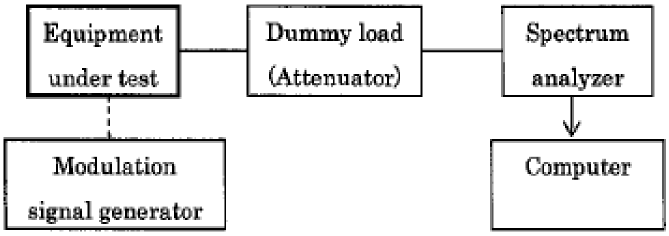
Test-execution: *Occupied Bandwidth and Spreading Bandwidth*

1
Block diagram of measuring system



2 Conditions of the Measuring Devices
(1) The settings of the digital spectrum analyzer are as follows:
Central Frequency: Testing frequencies
Sweep Bandwidth: 2-3.5 times the acceptable value
Resolution Bandwidth: Less than 3% of the acceptable *(Limit)* value
Video Bandwidth: Comparable to resolution bandwidth.
Y-Axis Scale: 10 dB/Div
Input Level Carrier wave level: sufficiently higher than spectrum analyzer noise
Sweep Time: Minimum amount of time to ensure measurement accuracy
(in the case of burst waves, 1 burst per sample)
Data Points: Over 400 points
Sweep Mode: Continuous sweep
Detection Mode: Positive peak
Display Mode: Max hold
(2) Process the measured values of the spectrum analyzer using an external or internal computer.

3 Status of Testing Equipment
Set to testing frequency and modulate using *standard encoding test signals*.

4 Operating Procedures for Measurements
(1) Configure the settings of the spectrum analyzer to 2(1).
(2) After repeating sweeps until no display changes are found, import the values of all the data points as array variables of the computer.
(3) Convert the dB value into the antilog of the power dimension for all the data.
(4) Find the total power of all the data and record as “Total Power”.
(5) Add power to the minimum frequency data in order and find the value of the limiting data point that is 0.5% (5% in the case of spread bandwidth) of the “Total Power”. Convert the limiting point into a frequency and record as the “lower limit frequency”.
(6) Add power to the maximum frequency data in order and find the value of the limiting data point that is 0.5% (5% in the case of spread bandwidth) of the “Total Power”. Convert the limiting point into a frequency and record as the “upper limit frequency”.

5 Recording Methods of Test Results
Find the occupied bandwidth and spread bandwidth as the difference between the “upper limit frequency” and “lower limit frequency” and list in MHz units.

17 Test: Antenna Power (*Conducted*)

Reference: Article 2, Item (19) – (1+2+3) 49.20 1);e (1), (2) / 2) d / 3) f (1), (2) Notice 88, Appendix 43, F

Requirement: The conducted power shall satisfy the requirements as stated in the table below. These requirements are "absolute", i.e. it is not allowed to have a higher value. Related to the Rated power –as defined by the approval holder separately- there is also a second requirement, related to the deviation of the actual power from the rated power. For the deviation from the rated power, the following tolerance requirement is applicable:

For the 2.4 GHz bands & 5 GHz W52+W53: +20% and –80%
For the 5 GHz W56 band: +50% and –50%

Note: *This means that for the 2.4 GHz band with a Rated power of 8.33 mW/MHz, it is allowed to cover the range from 1.67 mW/MHz up to the absolute limit of 10 mW/MHz and for the 5 GHz W56 band a Rated Power of 6,67 mW/MHz the range from 3.34 mW/MHz up to 10 mW/MHz*

For the absolute values of the power density (or total power) the following requirements are applicable:

WW: For the 2.4GHz band, 2400 – 2483.5 MHz (e.g. WLAN 802.11b/g/n, ZigBee, Z-Wave) Modulation: OFDM or DSSS or other digital modulation (like frequency hopping) or a combination. Power Density limited up to 10 mW/MHz or 5 mW/MHz *for 40 MHz channel spacing* and 3 mW/MHz for *hopping* systems if these are using *a part* of the frequency range from 2427.00 – 2470.75 MHz. If both descriptions above are not applicable, the system is *power limited* Power limited up to 10 mW (total transmit power) for other modulations /systems
GZ: For the 2.4GHz band 2471 – 2497 MHz (e.g. WLAN 802.11b) Modulation: DSSS or other digital modulation (like frequency hopping) or a combination. OFDM is not allowed Power Density limited up to 10 mW/MHz.
XW: For the W52 band, channels from 5180 up to 5240 MHz (can be used in an aircraft) with a channel spacing of 20 or 40 MHz (e.g. WLAN 802.11a/n)

<u>Modulation:</u> OFDM or DSSS systems
<u>Density limited</u> up to 10 mW/MHz for 20 MHz channel spacing or less and up to 5 mW/MHz for 40 MHz channel spacing

For the W53 band, channels <u>from 5260 up to 5320 MHz</u> with a channel spacing of 20 or 40 MHz (e.g. WLAN 802.11a/n)
<u>Modulation:</u> OFDM or DSSS.
<u>Density limited</u> up to 10 mW/MHz up for 20 MHz channel spacing or less and up to 5 mW/MHz for 40 MHz channel spacing

<u>YW</u>: For the W56 band, channels <u>from 5500 up to 5700 MHz</u> with a channel spacing of 10, 20 or 40 MHz.
<u>Modulation:</u> OFDM or DSSS
<u>Density limited</u> up to 10 mW/MHz up for 20 MHz channel spacing or less and up 5 mW/MHz for systems with 40 MHz channel spacing

<u>Power limited</u> up to 10 mW for other modulations: like AM, FM, pulse modulation (single carrier)

Result: Conducted Power (density), depending upon the different frequencies (e.g. L, M, H) of the specified transmit-band and worst-case parameter settings (e.g. coding scheme, modulation, throughput and software-power setting)

Test-execution: *For <u>density limited</u> systems the modulation and throughput is selected so that the transmitter realizes the highest output density. For <u>power limited</u> systems, the modulation and throughput will be chosen so that the highest output is realized.*

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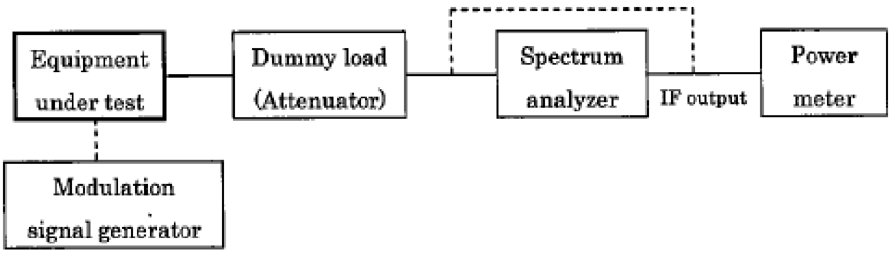

Note 1: The power meter is directly connected to the dummy load output for measuring total power in a system other than orthogonal frequency division multiplexing system and spectrum spreading system using direct sequence spreading.

1

Note 1 The direct high frequency power meter is connected to the output of the attenuator when measuring the total power of systems other than spectral spread systems.
Note 2 Computers are used when measuring spread bandwidth.

Conditions of the Measuring Devices
(1) Measure the equivalent noise bandwidth (NWB) of the 1 MHz resolution bandwidth in the set-up as stated above; to be used for correction of the output reading.
Correction = [RBW / NWB]
If the *spreading bandwidth* is less than 1 MHz, and
"spreading bandwidth (MHz) / NWB (MHz)" exceeds 1, the RBW must be reduced.
(2) Set the attenuation of the attenuator to values that provides acceptable input levels to the spectrum analyzer for optimal functioning (middle of the linear part of the mixer)
(3) The settings of the spectrum analyzer when searching for frequencies that provide maximum antenna power are as follows:
Central Frequency : Middle frequencies of the applied frequency bands.
Sweep Bandwidth: 50 MHz
Resolution Bandwidth: 1 MHz
Video Bandwidth: About 3 times the resolution bandwidth
Y-Axis Scale: 10 dB/Div
Sweep Time: Minimum amount of time to ensure measurement accuracy
(in the case of burst waves, 1 burst per sample)
Trigger Conditions: Free run
Data Points: Over 400 points
Sweep Mode: Continuous sweep
Detection Mode: Positive peak
Display Mode: Max hold
(4) The settings of the spectrum analyzer when measuring antenna power are as follows for the direct spread systems:
In this case, calibrate the indicator of the high frequency power meter while the high frequency power meter is connected to the IF output of the spectrum analyzer (using a calibrated generator connected to the spectrum analyzer input, set at the EUT frequency providing a maximum power density. Afterwards replace the generator by the EUT.
Central Frequency: Frequencies providing maximum power density (acquired frequencies during search)
Sweep Bandwidth: 0 Hz
Resolution Bandwidth: 1 MHz
Video Bandwidth: Comparable to resolution bandwidth.
Sweep Mode: Continuous sweep

Status of Equipment under test
(1) No frequency hopping systems:
a. Configure the settings of the spectrum analyzer to 2(3).
b. After repeating sweeps (until no display changes are found), measure the maximum power frequency per MHz.
c. Connect the high frequency power meter to the IF output of the spectrum analysers.
d. Configure the settings of the spectrum analyzer to 2(4).
e. Set the antenna power as follows:
- Continuous waves: value indicated on the high frequency power meter, corrected according to 2(1).

- Burst waves: value similarly corrected in the case of continuous waves and value calculated from the *average power within bursts* from rates of transmission times (i.e. correction on the duty-cycle, to find the average within the transmit burst)

(2) Frequency hopping system or combined systems of direct spread and frequency hopping:
a. Connect the high frequency power meter to the output of the attenuator
and measure the total power (without bandwidth limitation)
b. Divide the total power by the spread bandwidth to find the "average" power per MHz.
c. Confirm that frequency distribution of the hopping frequencies is homogeneous according to the supporting data. If frequency distribution of the frequencies is not homogeneous, consider other measurement or correction methods based on the supporting data.
d. Set the antenna power as follows:

- Continuous waves: value in b.
- Burst waves: value in b. and value calculated from the average power within bursts from rates of transmission times (i.e. correction on the duty-cycle, to find the average *within the transmit burst*)

Recording Methods of Test Results
List the absolute value of the antenna power in **mW/MHz** units for spreading and hopping systems and in **mW** units for other systems. List the deviation of the rated antenna power (listed in operating specifications) in % units with the (+) or (-) symbol.

Note
For defining the Rated Power, it is recommended to use the following recipe:

1. Find the minimum and maximum measured value, independent of the modulation; just for all channels in operation (L,M and H).
2. For 2.4 GHz systems & for 5 GHz W52 and W53 this recipe can only be used if the ratio between maximum and minimum measured value is < 6. For the 5 GHz W56 band, this ratio shall be less than 3.
3. Determine the average value.
4. For 2.4 GHz and 5 GHz W52+W53: Divide average result by 0.7

Effectively: Rated Power = [highest + lowest measured value] / 1.4
If using this Rated Power value, the tolerance margin for the lowest measured value with regard to the 20% limit (-80%) is equal to the tolerance margin for the highest measured value with regard to the 120% limit.

5. Check that this result is lower than the realistic limit and convert to this limit if the result was higher.

For 2.4 GHz & for 5 GHz W52 and W53 the realistic limit is 8.33 mW/MHz (Limit 10 mW/MHz) or 4.16 mW/MHz (Limit 5 mW/MHz). For hopping systems like Bluetooth the realistic limit is 2.5 mW/MHz

For 5 GHz W56 the realistic limit is 6.66 mW/MHz (or 3.33 mW/MHz if the absolute limit is 5 mW/MHz)

If AFH is applicable (for hopping systems), it is recommended to distinguish between the operational use with AFH and without and to define 2 different values for the Rated Power density. That makes it easier to satisfy the requirement in 2.

If you apply this recipe, you are certain that you are ALWAYS satisfying the -80% and +20% tolerance limits, as long as the ratio between highest value/lowest value is **smaller than 6**
(= 120 / 20) . So you don't need to calculate the deviation percentage if you apply this recipe.

18 Test: EIRP power (density) limit and gain of the Antenna

Reference: Article 2 , Item (19) (1+2+ 3), paragraph 1, 49.20 1);f (1), (2) / 2) d / 3) f (1), (2) Notice 88, Appendix 43, F

Requirement:

WW: For the 2.4GHz band, 2400 – 2483.5 MHz

1. - POWER DENSITY limited system:
(like DSSS or OFDM)

The EIRP is limited to 12.14 dBm/MHz for an Omni-directional antenna (like a dipole).
For a directional antenna, the EIRP is limited to 22.14 dBm/MHz.

2. - POWER DENSITY limits for a HOPPING system:
The EIRP is limited to 6.91 dBm/MHz for an Omni-directional antenna (like a dipole).
For a directional antenna, the EIRP is limited to 16.91 dBm/MHz.

3. - POWER limited system:
The EIRP is limited to 12.14 dBm for an omnidirectional antenna (like a dipole). For a directional antenna the max. EIRP is limited to 22.14 dBm.

COMPENSATION (1)
It is allowed to compensate for effective gain and conducted power as long as the max. EIRP value of 22.14 dBm /(MHz) is respected (for a directional antenna) or 12.14 dBm/(MHz) for an Omni directional antenna (like a dipole).
For a *directional* antenna, the EIRP is limited to 22.14 dBm /(MHz) if the effective antenna beam width (Half Power Beam Width; HPBW) is smaller than 36º. For any EIRP between 12.14 and 22.14 dBm /(MHz), the **HPBW limit** is calculated as follows:

- *calculate* ***A = antilog [(EIRP – 12.14)/10]***
A = 10 = Limit value*,*
if A is higher the output power shall be reduced. Minimum value A = 1 (by definition; if the EIRP < 12.14 dBm /(MHz),
- *calculate HPBW limit = [360 / A] º*
This HPBW limit shall be checked, considering the real / measured characteristics of the directional antenna. Therefore these antenna

characteristics shall be available (in 3 perpendicular planes) for E and H. **COMPENSATION (2), for hopping systems** It is allowed to compensate for effective gain and conducted power as long as the max. EIRP value of 16.91 /MHz is respected or 6.91 dBm(/MHz) for an omni directional antenna (like a dipole). For a *directional* antenna, the EIRP is limited to 16.91 dBm /MHz) if the effective antenna beam width (Half Power Beam Width; HPBW) is smaller than 36º. For any EIRP between 6.91and 16.91 dBm /MHz, the **HPBW limit** is calculated as follows: - *calculate* ***A = antilog [(EIRP – 6.91)/10]*** ***A = 10 = Limit value***, *if A is higher, the output power shall be reduced. Minimum value A = 1 (by definition; if the EIRP < 6.91 dBm (/MHz),* - calculate **HPBW limit = [360 / A] º** **COMPENSATION (3), for 40 MHz systems allowed (only OFDM)** It is allowed to compensate for effective gain and conducted power as long as the max. EIRP value of 19.14 dBm/(MHz) is respected or 9.14 dBm /(MHz) for an Omni directional antenna (like a dipole). For a *directional* antenna, the EIRP is limited to 19.14 dBm /MHz if the effective antenna beam width (Half Power Beam Width; HPBW) is smaller than 36º. For any EIRP between 9.14 and 19.14 dBm /(MHz), the **HPBW limit** is calculated as follows: - *calculate* ***A = antilog [(EIRP – 9.14)/10]*** ***A = 10 = Limit value***, *if A is higher, the output power shall be reduced. Minimum value A = 1 (by definition; if the EIRP < 9.14 dBm (/MHz),* - calculate **HPBW limit = [360 / A] º** This HPBW limit shall be checked, considering the real / measured characteristics of the directional antenna. Therefore these antenna characteristics shall be available (in 3 perpendicular planes) for E and H.
GZ: For the 2.4GHz band 2471 – 2497 MHz: only DSSS and hopping systems allowed *A trade-off between conducted power and max. gain is possible, as long*

as the EIRP is limited to 12.14 dBm/MHz. The radiation pattern is not specified, only the max. Gain figure is important. There are no possibilities for a beam angle compensation using the HPBW.
XW: **1. For the 5.2 GHz band, (W52)** channels from 5180 up to 5240 MHz **TPC (-3 dB power reduction facility) and DFS is optional** Modulation: DSSS or OFDM. For 40 MHz systems only OFDM allowed Density limited: EIRP up to 10 mW/MHz for 20 MHz channel spacing and up to 5 mW/MHz for 40 MHz channel spacing Single carrier systems: Power limited EIRP up to 10 mW for other systems/modulations: like AM, FM, pulse modulation (single carrier) The radiation pattern is not restricted, only the max. Gain figure is important (taking into account the EIRP). There are no possibilities for a beam angle compensation using the HPBW. ----------------------------------- **2. For the 5.3GHz band, (W53)** channels from 5260 up to 5320 MHz TPC (-3 dB power reduction facility) and DFS are required for a master station. Modulation: DSSS or OFDM. For 40 MHz systems only OFDM allowed Density limited: EIRP up to 10 mW/MHz for 20 MHz channel spacing and up to 5 MHz for 40 MHz channel spacing Single carrier systems *Power limited EIRP up to 10 mW for other systems/modulations: like AM, FM, pulse modulation (single carrier)* The radiation pattern is not specified, only the max. Gain figure is important (taking into account the max. EIRP). There are no possibilities for a beam angle compensation using the HPBW.
YW, For the band, from 5.47 up to 5.725 GHz, (W56) channels like 5500, up to 5700 MHz, with a channel spacing of 20 or 40 MHz. TPC (-3 dB power reduction facility) and DFS are required for a master station. Modulation: OFDM /DS ; For 40 MHz systems only OFDM allowed Density limited

EIRP up to 50 mW/MHz for 20 MHz channel spacing or less and up to 25 mW/MHz for OFDM systems with 40 MHz channel spacing Other systems/modulations/single carrier *Power limited EIRP up to 10 mW for other systems/modulations: like AM, FM, pulse modulation (single carrier)* The radiation pattern is not specified, only the max. EIRP figure is important. A max. gain of 7 dBi is possible if the conducted power is equal to the limit value of 10 mW/MHz. There are no possibilities for a beam angle compensation using the HPBW.

NOTE: The use of 5 GHz equipment is restricted to indoor, with the exception of W56 (YW). Article 49 Clause 20-3 (In 2000: Old Ministerial Notice No. 157-1) for 5GHz low power data communications system states: " The guideline describing that 5GHz is for indoor use only **must be indicated** on the easily viewable part of wireless equipment." It is allowed to use W56 equipment outdoors, if measures are taken to restrict the radiation, to avoid interference with similar systems. This can be accomplished by directional antennas, so that the equipment covers a defined area. It is required to put a statement on the equipment, declaring the necessary precautions for the user. This shall be done on a visible place on the outside. For XW a statement like: "*For indoor use only*" will be sufficient. For YW the statement could be: *For indoor use. Outdoor use is allowed only if measures have been taken, so that the covered area is restricted to avoid interference with other systems.*

Result: List the EIRP power and antenna Gain depending upon IEEE mode, modulation frequency (L,M and H)

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19 Test: Channel Leakage Ratio (CLR)

Reference: Article 2, Item (19) – (3) 49.20 Notice 88, Appendix 45,

Requirement: These requirements are applicable for the 5 GHz bands (XW and YW) and are specified for the adjacent channels and for the alternate channels, based upon a channel spacing of 20 MHz. The channel leakage ratio shall satisfy the requirements as stated below. These requirements are relative i.e. it is required to determine the relation of the power within the "empty" channel with respect to the transmitting channel. The power in the adjacent / alternate channel shall be measured within a band of ± 9 MHz distance from the nominal carrier (i.e. a band of 18 MHz)

Adjacent channels (20 MHz distance)	Leakage ratio 25 dB
Alternate channels (40 MHz distance)	Leakage ratio 40 dB

**) The* Adjacent Channel Leakage Ratio- is called ACLR or more common Adjacent Channel Power Ratio; ACPR.

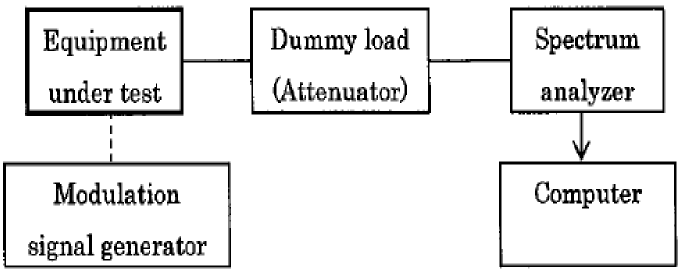
Result: List CLR values (in dBrc) depending upon IEEE mode, modulation, channel / carrier frequency (L, M and H)

Test-execution: For <u>density limited</u> systems the modulation and throughput is selected so that the transmitter realizes the highest output density. For <u>power limited</u> systems, the modulation and throughput will be chosen so that the highest output is realized.

Conditions of the Measuring Devices
(1) The settings of the spectrum analyzer when measuring the adjacent channel leakage power are as follows:

1. Measurement Schematic Diagram

. **Block diagram of measuring system**



Note 1: The computer is used for calculating the mean value of amplitude levels.
(*Comparable with Occupied Bandwidth measurement)*

2. Conditions of the Measuring Devices
(1) The settings of the spectrum analyzer are as follows:
Central Frequency: Testing frequencies, main carrier, main carrier $\pm$ 20 MHz, main carrier $\pm$ 40 MHz
Sweep Bandwidth: approximately 18 MHz (0.9 x channel spacing)
Resolution Bandwidth: Less than 5% of the acceptable *(Limit*) value
Video Bandwidth: Comparable to resolution bandwidth.
Y-Axis Scale: 10 dB/Div
Input Level Carrier wave level: sufficiently higher than spectrum analyzer noise
Sweep Time: Minimum amount of time to ensure measurement accuracy (in the case of burst waves, 1 burst per sample)
Data Points: Over 400 points
Sweep Mode: Continuous sweep
Detection Mode: Positive peak
Display Mode: Max hold
(2) Process the measured values of the spectrum analyzer using an external or internal computer.

3 Status of Testing Equipment
Set to testing frequency and modulate using standard encoding test signals.

4 Operating Procedures for Measurements
(1) Configure the settings of the spectrum analyzer to 2(1).
(2) After repeating sweeps until no display changes are found, import the values of all the data points as array variables to the computer.
(3) Convert the dB value into the antilog of the power dimension (i.e. mW) for all the data.
(4) Find the total power of all the data and record as "Total Power" in mW.
(5) Repeat the measurement for the adjacent channel(s) and the alternate channels(s)
(6) Calculate the relative differences between alternate/adjacent channels and the main channel to find the CLR values.
(7) Present the worst-case value for alternate and adjacent channel in dBrc.
(8) Repeat the measurement with another frequency for the main carrier (L.M,H)

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20 Test: Amount of carriers in 1 MHz

Reference: Article 2, Item (19) 49.20 1) g / 49.20 3) h Notice 88 Appendix 43, 44, 45
Requirement: If OFDM is applied, the amount of carriers within 1 MHz shall be 1 or more.

Result: Verification of the distance in MHz between the carriers.

Test-execution.: See occupied bandwidth measurement.

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21 Test : Spreading Rate, (effective broadening)

Reference: Article 2, Item (19) 49.20 1) i / 49.20 2) g / 49.20 3) i
Notice 88, Appendix 43, A-4, Appendix 44, A-4, Appendix 45, A-4,
Requirement: Only applicable for DSSS equipment with frequencies from 2,400MHz to 2,483.5MHz & from 2,471MHz to 2,497MHz & from 5,180 MHz to 5,320 MHz and from 5470-5725 MHz.
The requirements for the spreading factor are:

For XW > 5,
For GZ > 10
For XW > 5
For YW > 5

Note: For OFDM & hopping systems, there are no spreading rate limitations. However, it is necessary to measure the spreading rate for hopping systems, in order to calculate the observation time for measuring the retention time

Result: List spreading rate, depending upon (present table)

Test-exec.: *See occupied bandwidth and spread bandwidth measurement. The spreading rate for the purposes of evaluating wideband DSSS data transmission systems, operating in the 2400-2483.5MHz and 2471-2497 MHz is based on the 90% signal bandwidth and the transmission rate of the modulation signal. The spreading rate is calculated by dividing the spreading bandwidth by the frequency equivalent of the transmission rate (or symbol rate) of the modulation signal. For example, the throughput for Bluetooth is always 1 Mbaud, irrespective of the modulation. The coding scheme, modulation and effective throughput are selected so that the effective spreading rate is as small as possible.*

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22 Test: Spurious Emissions and out-band leakage power

Reference: Article 7, Table 3; Article 2, Item (19) 49.20(1);h /I Notice 88, Appendix 43, A-4

Requirement: Applicable for DSSS & OFDM equipment with frequencies from 2,400MHz to 2,483.5MHz (WW), from 2,471MHz to 2,497MHz (GZ), from 5,180 MHz to 5,320 MHz (XW) and from 5470 - 5740MHz (YW). Spurious emissions shall be evaluated from 30 MHz up to a frequency equal to 5x the highest carrier frequency. The requirements are defining the max. *average power* in a bandwidth of 1 MHz:

Conducted values of the spurious emissions:

For WW and UV

1. (General)

Frequency band	Permissible average power at 1MHz band - width of spurious emission
Lower than 2,387 MHz and higher than 2,496.5MHz	Lower than 2.5 µW
Higher than 2,387 MHz, lower than 2400MHz, and higher than 2,483.5 and lower than 2,496.5 MHz.	Lower than 25 µW

Exclusion bands:
In case of the frequency hopping systems and a combination of hopping and other modulation method(s), the range from 2,374 MHz to 2,5095 MHz is excluded. For other modulation methods, the range from 2,400 MHz to 2,483.5 MHz is excluded.

For GZ and VV:

Frequency band	Permissible value of average power of spurious emission
Lower than 2,458 MHz, and higher than 2.510 MHz	Lower than 2.5 µW
Higher than 2,458 MHz and lower than	Lower than 25 µW

2,471MHz, and higher than 2,497MHz and lower than 2,510 MHz	

For XW:

1. General

Frequency band	Permissible value of average power of spurious emission
Lower than 5,140MHz and higher than 5,360MHz	Lower than 2.5µW

For YW:

1. General

Frequency band	Permissible value of average power of spurious emission
Lower than 5,460MHz and higher than 5,740MHz	Lower than 2.5µW

Permissible value of the of average power of spurious emission refers to the peak envelope power for the transmitting equipment of each modulated frequency supplied to the feeder; (i.e. conducted measurement) except for those defined differently like the EIRP requirements as stated below.

EIRP values of out-band emissions, (*depending upon the applied antenna*):

2. 49.20 3) k (1)

When using emissions of a frequency of 5,180 MHz, 5,200 MHz, 5,220 MHz, or 5,240 MHz:

Technical standard for out-band leakage power (5180 - 5240MHz)

Frequency band	Deviation frequency (f) from 5240 MHz	EIRP
5140 – 5142 MHz	98- 100 MHz	2.5µW/MHz or less
5142 – 5150 MHz	90 – 98 MHz	15µW/MHz or less
5250 – 5251 MHz	10 – 11 MHz	$10^{1-(f-9)}$ mW/MHz or less
5251 – 5260 MHz	11 – 20 MHz	$10^{-1-(8/90)(f-20)}$ mW/MHz or less
5260 - 5266.7 MHz	20 - 26.7 MHz	$10^{-1.8-(6/50)(f-20)}$ mW/MHz or less
5266.7 – 5360 MHz	26.7 – 120 MHz	2.5µW/MHz or less

3. 49.20 3) k (2)

When using emissions of a frequency of 5260 MHz, 5280 MHz, 5300 MHz, or

5320 MHz:

Technical standard for out-band leakage power (5260 – 5320 MHz)

Frequency band	Deviation frequency (f) from 5260MHz	EIRP
5140 - 5233.3 MHz	26.7 – 120 MHz	2.5µW/MHz or less
5233.3 – 5240 MHz	20 - 26.7 MHz	$10^{-1.8-(6/50)(f-20)}$ mW/MHz or less
5240 – 5249 MHz	11 – 20 MHz	$10^{-1-(8/90)(f-11)}$ mW/MHz or less
5249 – 5250 MHz	10 – 11 MHz	$10^{1-(f-9)}$ mW/MHz or less
5350 – 5360 MHz	90 – 100 MHz	2.5µW/MHz or less

4. 49.
When using emissions of a frequency of 5500 MHz, 5520 MHz, 5540 MHz, 5560 MHz, 5580 MHz, 5600 MHz, 5620 MHz, 5640 MHz, 5660 MHz, 5580 MHz or 5700 MHz:

Technical standard for out-band leakage power (5470 – 5740 MHz)

Frequency band	EIRP
5460 - 5470 MHz	12.5 µW/MHz or less
5725 – 5740 MHz	12.5 µW/MHz or less

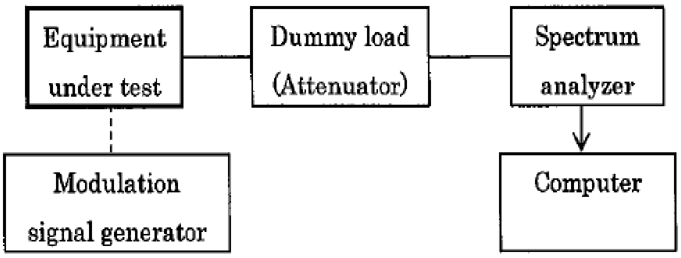
These out-of-band requirements are applicable **between** the W52 and W53 bands.

Note the difference on the edges of the specified bands (5140 and 5360 MHz), whereby the limit value (2.5µW/MHz) changes from EIRP value to conducted value.

Result: List the different modes/modulations and frequency ranges according to the manufacturer and determine for each the spurious emissions. The table reflects the selected transmit frequencies (L,M and H), coding scheme and throughput (worst case selections).

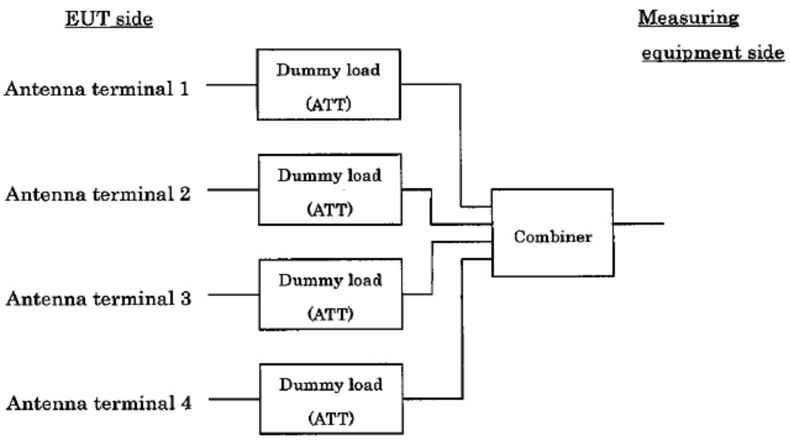
Test-execution:

. **Block diagram of measuring system**



1 **Note 1: The computer is used for calculating the mean value of amplitude levels.**

If the spurious limit is specified with the EIRP value, the max. figure for the antenna(s) gain shall be taken into account for the (conductive) measurement procedure. If multiple antenna ports are used, these shall be combined as follows:



In this case the coupling attenuation shall be taken into account (For example from terminal 1 to terminal 2) since this will reduce the combined output power. A check shall be done by using a calibrated source (generator) to be connected to the terminal(s) and measuring its output.

2 Conditions of the Measuring Devices

(1) The settings of the spectrum analyzer during spurious searches are as follows:

- Sweep Bandwidth Starts spurious searches from the smallest possible frequencies to more than 5 times the carrier frequencies (for example from 30 MHz up to 12.5 GHz for a 2.4 GHz system).
- Resolution Bandwidth 1 MHz
- Video Bandwidth 1 MHz
- Y-Axis Scale 10 dB/Div
- Input Level: Maximum dynamic range value
- Sweep Time: Minimum amount of time to ensure measurement accuracy.
- Sweep Mode: normally single sweep , however for *Frequency Hopping Systems* the continuous mode
- In the case of burst transmission, the sweep time shall exceed a duration of:
- *[Burst period (s) x (frequency of the sweep (in MHz)) / RWB (in MHz)] in (s)*

- *Note that the measurement result can be reduced by 3 dB as a maximum.*
- Data Points Over 400 points
- Detection Mode: Positive peak
- Display mode: Maximum hold

(2) The settings of the spectrum analyzer while conducting spurious amplitude measurements are as follows:

- Central Frequency: Acquired spurious frequencies in (1)
- Sweep Frequency 0 Hz
- Resolution Bandwidth 1 MHz
- Video Bandwidth same as Resolution Bandwidth
- Note: take into account that the requirement limits the power in a bandwidth of 1 MHz.
- *If the measurement is carried out with a bandwidth of 100 kHz (for frequencies below 1 GHz), the limit shall be reduced with 10 dB.*
- For example 2.5 uW in 1 MHz = -26 dBm limit, becomes –36 dBm for 100 kHz bandwidth.
- Y-Axis Scale 10 dB/Div
- Input Level: choose input level within the linear range of the SA mixer (so that no additional spurious are generated by the mixer)
- Sweep Time: Minimum amount of time to ensure measurement accuracy. However, in the case of burst waves, time exceeds duration of 1 burst.
- Data Points Over 400 points
- Sweep Mode: Single sweep
- Detection Mode Sample (BIN-Width << RBW, so that all spurious emissions are captured) [BIN-width is the frequency difference between 2 adjacent display points on the display)

3 Status of Testing Equipment
Set to testing frequency and testing spread codes and modulate using standard encoding test Signals. Choose a frequency / channel according to the specified range (Low, Middle, High). In the case of the frequency hopping system or combined systems of direct spread and frequency hopping, it is necessary to conduct the measurements on the 3 representative upper, middle and lower frequencies (L, M or H) in hopping mode, so that the hopping mechanism uses the same frequency. (It will be on off switching for these frequencies)

Note: If the spurious limit is specified with the EIRP value, the effective (maximum) antenna gain shall be taken into account.

4 Operating Procedure for Measurements
(1) Configure the settings of the spectrum analyzer to 2(1) and search for spurious frequencies by sweeping. Do not conduct the measurements in 2(2) if the amplitude value of the acquired spurious frequencies meets the standard value (in the case of 2[1]
Note, the standard value is –3 dB below the limit and set the acquired amplitude value as the measured value.
(2) If the acquired spurious amplitude value exceeds the standard value, narrow the sweep bandwidth, in the order of 100 MHz, 10 MHz, and 1 MHz, to increase the frequency accuracy of the spectrum analyzer and accurately find the spurious frequency. Configure the spectrum analyzer to the settings in 2(2), find the average of the spurious amplitude values (in the case of burst waves, the average values are within the respective burst and set this as the measured value.
Averaging can be done by summing up the power (display must give the linear power in uW)

according to 2(2) and dividing by the amount of points (e.g. 400 points). Correction on the equivalent noise bandwidth shall be necessary (if not realized automatically)

The average P can be found by the following formula:

$$P = 10 \times \log \left[B_s \times \frac{(1/n) \times \sum_{i=1}^{n} \left(10^{\frac{P(i)}{10}} \right)}{NBW} \right]$$

where:
P = total power in the channel bandwidth
BS = channel bandwidth
NBW = equivalent noise bandwidth of the spectrum analyzer
n = number of sample points within the channel bandwidth
P(i) = power reading on spectrum analyzer at trace element *i*.

5 Recording Methods of Test Results
Take the spurious power acquired in 4 and list the frequency of the individual large emissions in uW units for every frequency classification of the acceptable values.

6 Other Conditions
(1) In the case of the frequency hopping system or combined systems of direct spread and frequency hopping, it is necessary to conduct special measurements of 3 representative upper, middle and lower frequencies, limited to those that hop, as the emitted spurious frequencies change.

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23 Test: Retention time, (only for hopping systems)

Reference: Article 2, Item (19), WW, UV: 49.20 1) j Notice 88, Appendix 43

Requirement: Applicable for hopping systems with direct modulation (not in combination with DSSS or OFDM). The requirements for the retention time are:

1. Observe the frequency retention time during the *observation time* *T* (in seconds) equal to :
T = spreading rate x 0.4 s.
2. Select a discrete frequency for monitoring (L. M, and H)
3. *Sum-up* the different lengths of the bursts for the selected frequency during the observation time. By definition the sum is equal to the retention time.
4. Repeat the measurement for each different mode (e.g. DH1, DH3, DH5 for Bluetooth) and for both the maximum amount of hopping channels and the minimum (e.g. when Adaptive Frequency Hopping, AFH is available)

The Retention time shall be less than *0.4 seconds* in any situation. In addition, for category UV equipment (Model-aircraft) the limit for a single transmission burst is *0.05 seconds*.

Result: List Retention time, depending upon frequency, mode, modulation, possible supply voltage, AFH)

Test-exec.: *Depending upon the hopping mechanism and technology. For Bluetooth it is possible to select a specific mode, so that the equipment is always transmitting the same type of bursts (while hopping). Possible modes are DH1, DH3, and DH5. The spectrum analyzer can be used to measure the duration of a single frequency burst if setting the frequency span to 0 Hz and the centre frequency to the selected frequency (L.M, H). Choose a sweep time between 2 and 4 ms*

The second step is to measure the amount of (equal mode & frequency) bursts within the observation time. Therefore the sweep time should be set in a realistic relation to the prescribed observation time. (e.g. between 5 and 10 seconds). Extrapolate the amount of bursts to the defined observation time and define it N.

Multiply N with the duration of the frequency burst to find the retention time.

Repeat the measurement for the different frequencies (L, M and H) and the different modes. The highest value of the retention time shall be recorded for reporting.

For Bluetooth it is possible to use a simple formula for the retention time:

***Retention time** =*
[spreading rate/amount of channels] x duty-cycle x 0.4 seconds

This formula can be used only for 1 specific mode (with a constant duty-cycle). The actual retention time can be found by a "weighted" average of the different retention times, based upon the relative appearing of each mode.

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24 Test: Carrier sensing

Reference: Article 49.20 3) Notice 88, Appendix 43, 44, 45, 46

Requirement: The requirement is compulsory for DSSS & OFDM equipment with frequencies from 5.150 MHz up to 5.725 MHz. (i.e. XW and YW) and for equipment with 40 MHz channel spacing in the 2.4 GHz band (WW). In addition, transmitters used exclusively for radio control of model aircraft outdoors (Category UV and VV) shall have carrier sensing *if they don't use frequency hopping*. If more antenna's are used for receiving, the sensing test is applied separately for the receiving antenna with the lowest gain.

For equipment using frequency hopping, carrier sensing is not necessary. Before starting to operate, equipment shall be capable to detect carrier frequencies already in use, to avoid interference. This capability is required for master devices and for those slaves capable to operate in the ad-hoc mode (= direct communication between 2 slaves).

The equipment shall be capable to detect any regular carrier frequency with a field strength of *100 mV/meter* or less. Testing shall be done for the carrier frequencies within the specified range of use (L,M and H)

Result: Table of sensing capabilities for L,M and H operational channels

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Test-execution:

1. Determine the antenna voltage based upon the max. antenna gain.

Consider 100 mV / meter for E as the starting point.

The corresponding antenna power for the receiver can be found by

Antenna power Pcs (in dBm) = 22.79 + max. antenna Gain - 20 x Log f (f in MHz)

This antenna power will be available when the antenna is receiving 100 mV/m
(rf power vector towards antenna, max. Gain direction)

With an effective Gain of 1 (= 0 dBi) the result is - 44,81 dBm at 2.4 GHz
Select a worst-case (minimal) gain value for the receiving sensitivity. (but it should be a realistic value, since it is within the direction of communication).
A gain value of 0 dBi is standardized. (ITU recommendation)