IEEE P802.15
Wireless Personal Area Networks

Project	IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)		
Title	**Proposed Resolution for MR-FSK Channel Parameters for the License-Exempt 902 - 928 MHz ISM Band**		
Date Submitted	[30 June, 2010]		
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Re:			
Abstract			
Purpose	Methods of defining the ACP or modulation bandwidth requirements of Clause 6 Table 1a		
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Background

Currently both FSK and GFSK modulation is permitted for the MR-FSK PHY in the North American 902-928 MHz License-exempt ISM band with a spectral limiting method defined in terms of adjacent channel attenuation or adjacent channel power level of -20 dB to introduce a degree of spectral efficiency.

Table 1a of P802.15.4g/D1 defines the mandatory data rate parameters for this frequency band as tabulated below:

Parameter	Specification	Units
Data rate	50	kb/s
Modulation	2-FSK / GFSK (BT = 0.5)	-
Modulation Index	1.0	-
Channel Spacing	200	kHz

From a regulatory point of view, operation within the 902 – 928 MHz band in the United States or Canada, as defined above, requires compliance with Title 47 CFR 15.249 or 5.247 ("FCC Part 15.247" and "FCC Part 15.249") within the United States and RSS-210 within Canada.[1]

As the channel spacing has been defined at 200 kHz and for most practical applications the required ERP will exceed 50 mV/m measured at a distance of 3 m, operation within this frequency band will require compliance with either FCC 15.247(a)(1) or RSS-210 Annex 8.1(c).

The purpose of this document is to define a methodology for the measurement of adjacent channel attenuation, from which a suitable attenuation level may be defined.

So as to ensure no untoward bias to any silicon vendors, a Rhode and Schwarz SMIQ VSG has been used to generate PN15 modulated waveform examples.

The adjacent channel attenuation has been measured for each proposed test method under two conditions:

The VSG is set to a peak unmodulated carrier output of +14 dBm (chosen since this represents typical output power limits obtainable from current generation ISM transceiver silicon and approximates to 25 mW ERP permissible in Europe for FHSS operation in the 863 – 870 MHz band).

The VSG is set to a peak unmodulated carrier output of 0dBm and used to power a 1 W commercial available integrated power amplifier IC to replicate +30 dBm permissible for FHSS systems within North America.

[1] It is noted that similar regulatory requirements apply in North, Central and South America

Methods of Measuring Adjacent Channel Attenuation

1. FCC Publication DA 00-705

The FCC defines the recommended method of measurement of the 20 dB bandwidth in publication DA 00-705. Although the test method is used to determine whether the bandwidth is greater or less than 250 kHz and hence defining both the maximum permissible output power and minimum number of hopping channels that must be implemented, this method could be easily adopted as to the determination of adjacent channel attenuation.

The advantage of this method is that it is consistent with existing regulations.

To summarize the procedure, the spectrum analyzer is set to a span of approximately 2 to 3 times the 20 dB bandwidth. Resolution bandwidth is set to $\geq$ 1% of the 20 dB bandwidth and video bandwidth to $\geq$ of the resolution bandwidth. A peak detector is used in conjunction with the max. hold function.

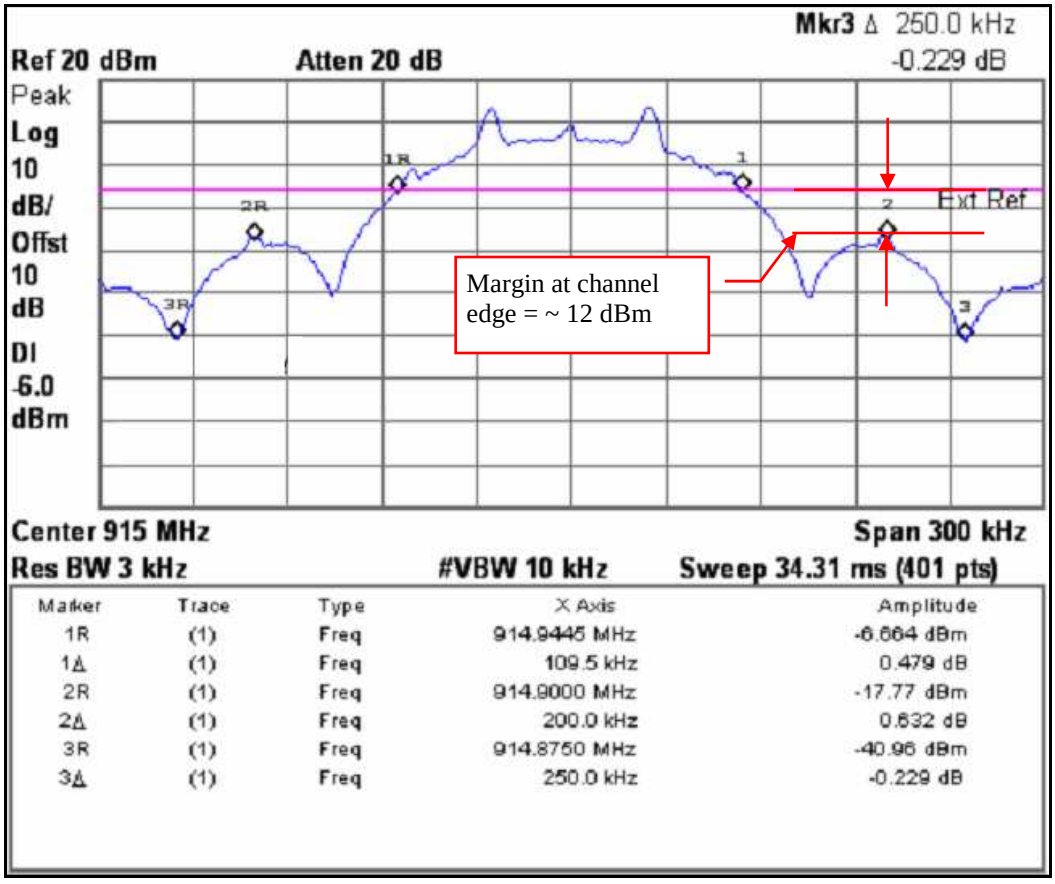

Figure 1: Measurement of Adjacent Channel Attenuation to FCC DA 00-705 at +14 dBm Output Power

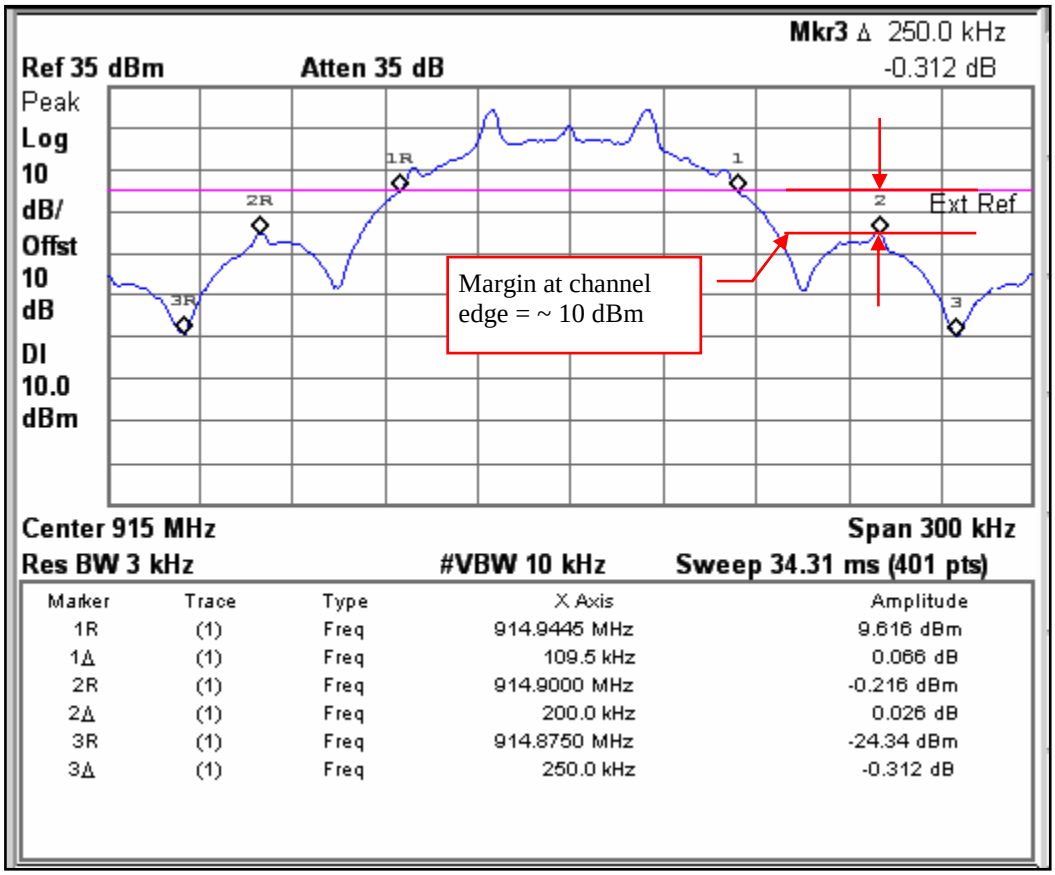

Figure 2: Measurement of Adjacent Channel Attenuation to FCC DA 00-705 at +30 dBm Output Power

Figure 1 and Figure 2 illustrates that for FSK modulation, the adjacent channel attenuation for both condition at ±100 kHz from the channel center frequency exceeds the 20 dB adjacent channel attenuation figure by a margin of typically 10 dB.

Note that the addition of an external PA reduces the margin by ~ 2 dB compared to the +14 dBm power setting due to the NF associated with the PA and attenuation setting of the spectrum analyzer.

2. ETSI Test Method

For systems implementing FHSS, ETSI EN 300 220-1 v2.3.1 defines adjacent channel attenuation (or power) in terms of modulation bandwidth limits. Whilst ETSI refers to absolute limits, the procedure could be considered as a method of determining the adjacent channel attenuation.

To summarize the procedure, the emissions at the sub-band edge (or adjacent channel) frequency are measured with a 1 kHz resolution bandwidth and 3 kHz video bandwidth. As outlined above, the test limit is -30 dBm, however a limit of 30 dB has been arbitrarily chosen (the display line is set to 30 dB below peak signal amplitude). A peak detector is used in conjunction with the max. hold function.

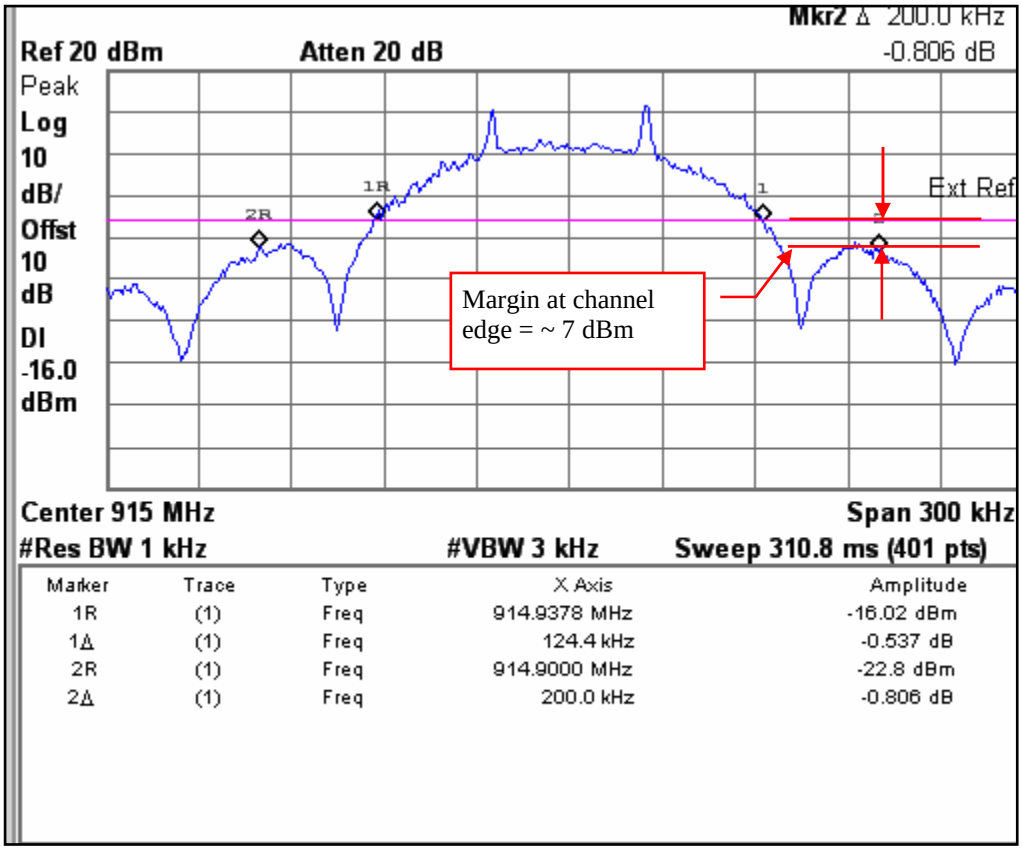

Figure 3: Measurement of Modulation Bandwidth to ETSI EN 300 220-1 at +14 dBm Output Power

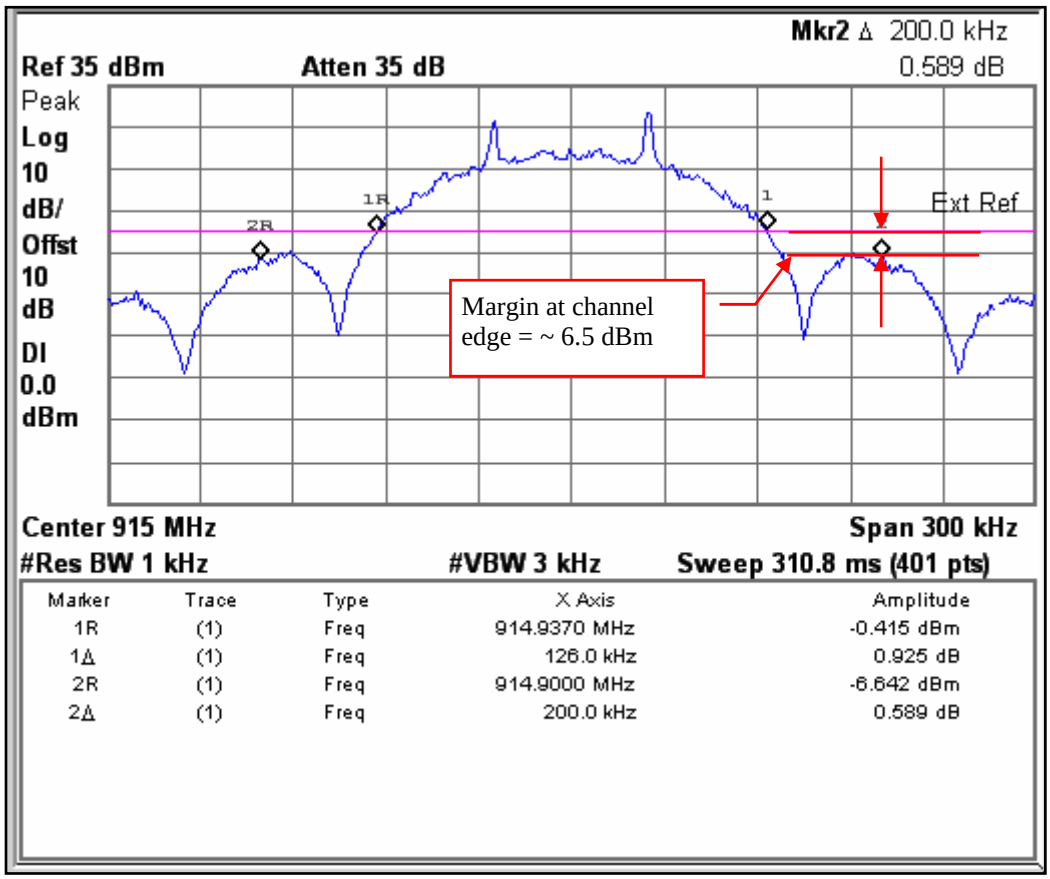

Figure 4: Measurement of Modulation Bandwidth to ETSI EN 300 220-1 at +30 dBm Output Power

Figure 3 and Figure 4 illustrates that for FSK modulation, the adjacent channel attenuation for both condition at ±100 kHz from the channel center frequency exceeds arbitrary 30 dB adjacent channel attenuation figure by a margin of typically 7 dB.

Note that the addition of an external PA reduces the margin by ~ 0.5 dB compared to the +14 dBm power setting due to the NF associated with the PA and attenuation setting of the spectrum analyzer.

3. Interpretation of Comment Resolutions #360 - #364

Comment resolutions #360 - #364 defines a method of measurement of adjacent channel attenuation similar to that defined by the FCC for licensed band operation:

Any emission must be attenuated below the power (P) of the highest emission contained within the authorized bandwidth as follows: On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in KHz) of more than 100 kHz: 20dB. The measurement bandwidth shall be 3x the channel bandwidth, i.e. 600 kHz for the 200 kHz channel.

Comment resolution #300 defines the measurement bandwidth as 10 kHz.

For the purposes of this document, resolution and video bandwidths are set to 10 kHz. A peak detector is used in conjunction with the max. hold function.

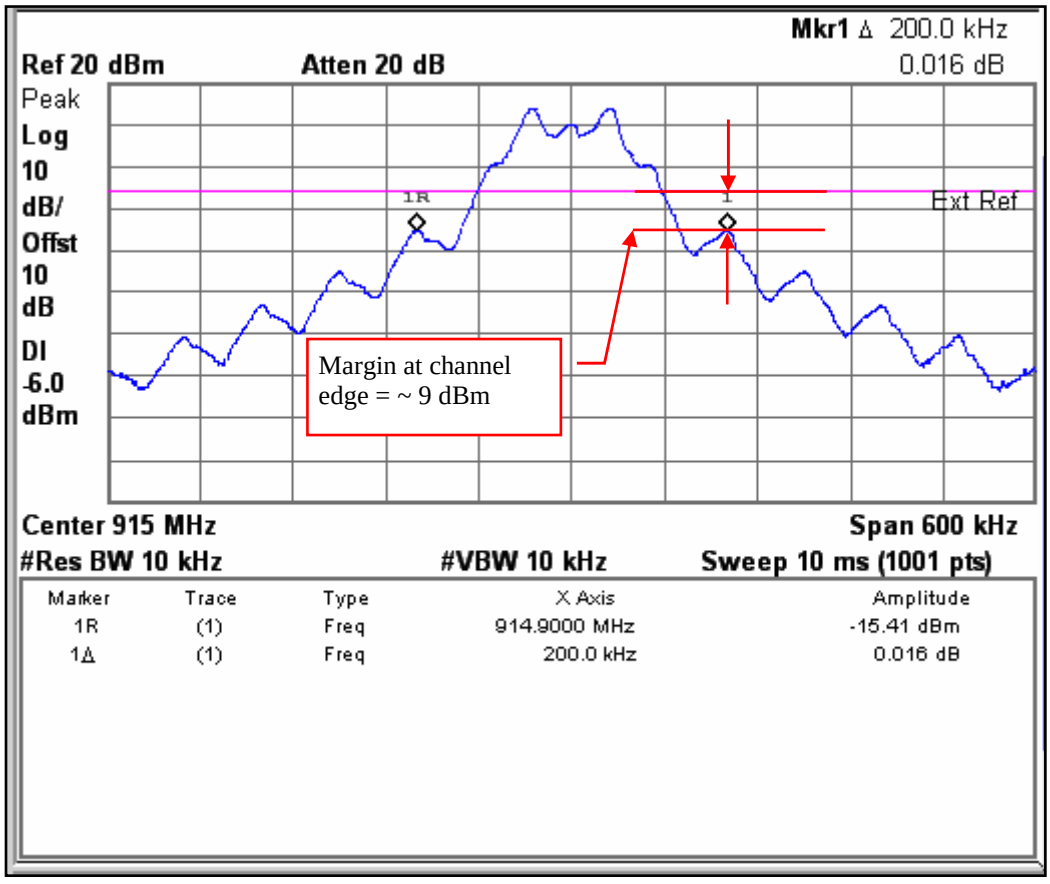

Figure 5: Interpretation of Comment Resolutions #360 - #364 at +14 dBm Output Power

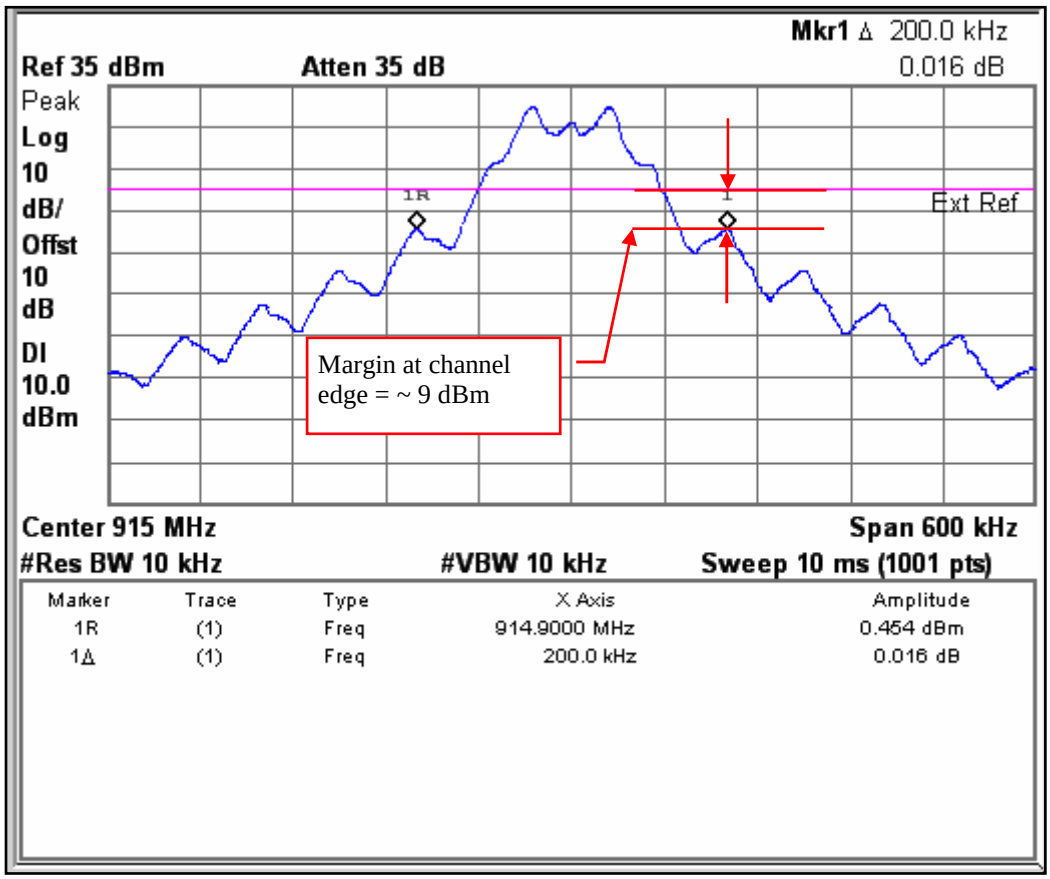

Figure 6: Interpretation of Comment Resolutions #360 - #364 at +30 dBm Output Power

The display line indicated by is the -20 dB attenuation limit describe above. At the channel edges the 20 dB limit can be met by 2-FSK modulation with approximately 9 dB margin.

Conclusions

This document provides for an example of the adjacent channel attenuation figures that might be obtained should one of the three methods outlined above be adopted and hopefully highlights that it is important to not only define the test limits but also the test methodology.

As stated, a vector signal generator has been used to generate the test signals. This yields a significantly cleaner spectrum that can be expected from low-power ISM transceiver architectures. The phase noise of the VSG at 100 kHz offset is typically -120 dBc/Hz, compared with anywhere between -90 dBc/Hz and -105 dBc/Hz obtainable with current generation ISM band transceivers.

Replacing the R&S VSG with ISM band transceivers from major vendors, degrades the transmitter adjacent channel attenuation at the channel edge by a between 5 and 10 dB,

depending upon the test methodology and conditions adopted. Thus what is described in this document as (for example) a 10 dB margin can be reduced to between 4 dB and 0 dB!

Since the draft standard currently defines transmitter adjacent channel attenuation purely in terms of the North American 902-928 MHz ISM band, this document recommends both the method outlined in FCC publication DA 00-705 since this is consistent with the description of both FCC 15.247 and RS-210.

Part 15.247(a)(1) states:

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater…

P802.15.4g/D1 defines 200 kHz channel spacing. Hence, the 20 dB BW, as measured in accordance with DA 00-705, will apply at ±100 kHz from the channel center frequency.

Thus this document recommends the limits consistent with those outlined in Part 15.247(a)(1).