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Re:	**Ad Hoc Committee on Licensed-Exempt Coexistence -** Meeting 31 to Meeting 32
Abstract	
Purpose	Start of work, to be completed
Notice	
Release	
Patent Policy and Procedures	

Interference scenarios in 2.4GHz ISM and 5.8GHz UNII bands

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1. Introduction

The scope of this work is to define the scenarios in which interference between cells can cause disruption in service. The target frequency is 5.8GHz LE band, according to UNII rules. Will be taken into account un-coordinated deployment cases, to address access providers and private networks.

2. Parameters and interference calculation

2.1. System parameters

The following parameters are proposed, resulting as an average of product characteristics in 5.8GHz:
BST:

Tx power is chosen for compliance with max. e.i.r.p. allowance, for every antenna gain and regulatory domain:

- 2.4GHz: Pt = SS: 25dBm; BS: Ptd = 25dBm; Pto = 28dBm, where Ptd is used with directional antennae and Pto is used with omni antennae.
- 5.8GHz: Pto = 27dBm; Ptd = 20dBm;

Antenna gain: omni: AGo = 10dBi; directional: AGd = 17dBi;
Cable loss: CL =1dB;

SS:

Tx power: Pts = 20dBm;
Antenna gain: omni: AGo = 10dBi; directional: AGda = 17dBi; AGdb = 23dBi (for UNII SS only)
Cable loss: 1dB.

Antenna isolation for co-located outdoor antennae:

AI = -75dB for directional – to- directional, 2m between sectors
AI = -30dB for omni-to-directional or omni-to-omni (simplification).

Signal BW for evaluation: 10MHz.

The Receive Sensitivity Level (RSL), Adjacent Channel Interference (ACI) resistance, Signal-to-Noise Ratio - SNR, at minimum rate, as defined in 802.16REVd/D3 (see Annex 1) as minimum requirement, are summarized below:

Table 1 – RSL, ACI, SNR

	RSL (dBm) / Modulation	ACI (dB) / Modulation	SNR (dB) / Modulation	Blocking Rx level (dBm)
SCa	-83.2 / QPSK	-9 / QPSK	9.8 / QPSK	-40 (BS) and –20 (SS)
OFDM	**-82.6 / QPSK 1/2**	-11 / 16QAM 3/4	9.4 / QPSK 1/2	-30

			18.2 / 16QAM3/4	
OFDMA	**-82.6 / QPSK 1/2**	-11 / 16QAM 3/4	9.4 / QPSK 1/2	-30
			18.2 / 16QAM 3/4	

It is proposed to use the following values, for QPSK ½, reflecting an average system implementation:

RSL: –174 +10*log BW + NF+SNR+impl_loss = -174 +70+6+9+2 = -87dBm and SNR: 9dB
Blocking Level: BL= -40dBm.

2.2. Adjacent channel interference

ACI: shall be calculated for QPSK ½, taking into account that for a given degradation the power in adjacent channel is un-changed (what is affected is actually the noise level). So, when the SNR decrease, the RSL decrease and ACI is proportionally increased:

$ACI = ACI_{16QAM3/4} + (SNR_{16QAM3/4} – SNR_{QPSK1/2}) = 11 + (18.2-9.4) = 20dB$, for the first adjacent channel;

$ACI_{2nd} = ACI_{2nd16QAM3/4} + (SNR_{16QAM3/4} – SNR_{QPSK1/2}) = 30 + (18.2-9.4) = 39dB$, for the second adjacent channel.

Translation of interference into the victim channel

For 3dB RSL degradation, the power in the adjacent channel should be:

$P_{adj\_3dB} = RSL + ACI_{3dB}$

This power creates, in the desired channel, a noise level equal with the existing noise.
To translate the power in the adjacent channel, into interference in the desired channel, we should use the translation factor given by the relation:

$$TF = RSL + ACI_{3dB} – (RSL-SNR-impl\_loss) = SNR+impl\_loss+ACI$$

$$TF1 = 9+2+20= 31dB, \text{ for the first adjacent channel}$$

$$TF2 = 9+2+39 = 50dB, \text{ for the second adjacent channel}$$

RSL degradation due to adjacent channel interference

RSL, in watts, is given by:

$$RSL\ (watts) = 10^{RSL/10} = 10^{N/10} * 10^{NF/10} * 10^{(SNR)/10} * 10^{Impl\_loss/10}$$

For a power in adjacent channel equal with:

$$P_{adj\_3dB} = 10^{RSL/10} * 10^{ACI/10},$$

the power in the desired channel will be, in watts:

$$P = 10^{(RSL-SNR-impl\_loss)/10}$$

For a power higher than P_{adj_3dB} , with k dB:

$$P_{adj} = P_{adj\_3dB} + k = RSL+ACI+k,$$

$$k = P_{adj} – (RSL+ACI) \qquad (1)$$

the power in the desired channel will be, in watts:

$$10^{P1/10} = 10^{(RSL-SNR-impl\_loss)/10} * 10^{k/10}$$

The degraded RSL, D_RSL, will be in watts, after adding the noise:

$$10^{D\_RSL/10} = 10^{(RSL-SNR-impl\_loss)/10} \ (1 + 10^{k / 10})*^{10(SNR+impl\_loss)/10}$$

$$10^{D\_RSL/10} = 10*\log (10^{RSL/10} * (1 + 10^{k/10})$$

The degraded RSL, D_RSL, will be in dBm:

$$D\_RSL = RSL + 10*\log (1 + 10^{k/10})$$

The relative RSL degradation is:

$$DeltaRSL_{ACI}\ (dB) = 10*\log (1 + 10^{k/10}),$$

$$\mathbf{DeltaRSL_{ACI}\ (dB) = 10*\log (1 + 10^{(Padj – RSL –ACI)/10})} \qquad (2)$$

2.3. Co-channel interference

The degraded RSL in watts, in the co-channel case is:

$$10^{D\_RSL/10} = (10^{(RSL-SNR-impl\_loss)/10} + 10^{I/10}) * 10^{(SNR+impl\_loss)/10}$$

$$10^{D\_RSL/10} = 10^{RSL/10} + 10^{(I+SNR+impl\_loss)/10}$$

$$10^{D\_RSL/10} = 10^{RSL/10}(1 + 10^{(I+SNR+impl\_loss-RSL)/10})$$

The degraded RSL, in dBm, is:

$$D\_RSL = RSL + 10*\log((1 + 10^{((I-RSL)+(SNR+impl\_loss))/10})$$

The relative RSL degradation, for co-channel interference case, is:

$$\mathbf{DeltaRSL_{CCI} = 10*\log(1 + 10^{((I-RSL)+(SNR+impl\_loss))/10})} \qquad (3)$$

3. Interference cases

3.1. Base Station to Base Station

Scenario 1: Access Points operating with NON-synchronized Tx/Rx.

The Tx interval can overlap the Rx intervals, making the receive periods not operational, as shown below:

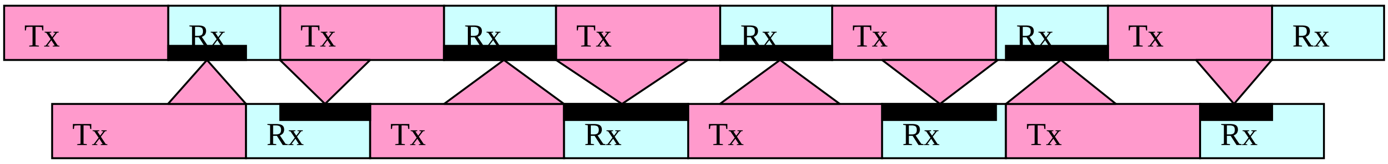

Figure 1 – Interference will mess the reception periods

Scenario 2: Synchronization: same MAC Frames and Tx/Rx interval duration

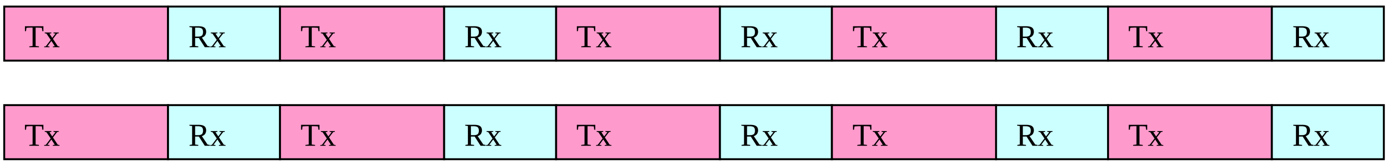

Figure 2 – Synchronized MAC Frames and Tx/Rx intervals

In this case, the problem disappears.

In continuation will be calculated the degradation in case of co-location and the minimum Base Station separation.

3.1.1. Co-located BS – 5.8GHz

In this case, will be 2 systems: one transmitting and one receiving. If the Tx and Rx intervals are not synchronized, the victim receiver will be interfered by the transmitter.

The interference level will be, in the best case, first adjacent channel (using directional antennae):

$$I1 = Ptb – AI = 20dBm – 75dB – = -55dBm.$$

The RSL degradation will be, applying (2):

$$DeltaRSL_{ACI}\,(dB) = 10*\log(1 + 10^{(Padj – RSL – ACI)/10}) = 10*\log(1 + 10^{(-55+87 – 20)/10} = 12.2dB$$

If one guard channel will be used:

$$DeltaRSL_{ACI2nd}\,(dB) = 10*\log(1 + 10^{(Padj - RSL - ACI2nd)/10}) = 10*\log(1 + 10^{(-55+87-39)/10} < 3dB$$

Conclusion: for co-located base stations, with directional antenna, there are 2 ways to resolve the interference problem:

- 1 guard channel
- synchronization of Tx/Rx intervals.

If one of the Base Stations will have an omni antenna, , for Pto = 27dBm, the interference level in the first adjacent channel will be 27- 30 = -3dBm.
The RSL degradation will be, applying (2):

$$DeltaRSL_{ACI}\,(dB) = 10*\log(1 + 10^{(Padj - RSL - ACI)/10}) = 10*\log(1 + 10^{(-3+87-20)/10} = 64dB$$

$$DeltaRSL_{ACI2nd}\,(dB) = 10*\log(1 + 10^{(Padj - RSL - ACI2nd)/10}) = 10*\log(1 + 10^{(-3+87-39)/10}) = 45dB$$

Conclusion: Base stations, with at least one omni antenna, cannot be co-located.

3.1.2. Co-located BS – 2.4GHz

Same conclusions as before apply for 2.4GHz co-located Base Stations.

3.1.3. Base Station minimum separation

3.1.3.1. Adjacent channel

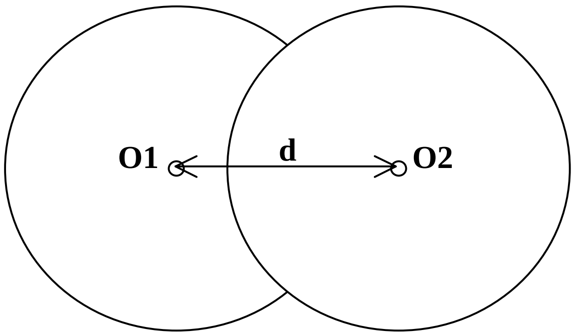

Figure 3 – BS to BS Interference

Problem: In the case of NOT synchronized transmissions, the Base Station located in O1, will create interference to the Base Station located in O2, for the duration of common Tx-Rx periods.
The worst case interference level should be calculated for **Line-of-Sight (LOS)** propagation, sector BS antennae.
The interfering signal at O2 is:

$$I2 = Ptb1+AGb1-CL1+ AGb2-CLs2 - Path\_loss= 20dBm + 17dBi - 1dB + 17dBi - 1dB - Path\_loss$$

$$I2 = 52dBm - Path\_loss$$

The RSL degradation is given by (2):

$$DeltaRSL_{ACI}\ (dB) = 10*\log\ (1 + 10^{(Ptb1+AGb1-CL1+ AGb2-CLs2\ -\ Path\_loss\ -\ RSL)\ -ACI)/10}$$

$$DeltaRSL_{ACI2nd}\ (dB) = 10*\log\ (1 + 10^{(Ptb1+AGb1-CL1+ AGb2-CLs2\ -\ Path\_loss\ -\ RSL)\ -ACI2nd)/10})$$

The following tables show the RSL degradation, function of BS separation, for 5.8GHz and 2.4GHz:

Table 2 – RSL degradation in case of BS-BS interference, first adjacent channel, 5.8GHz

RSL degradation (dB) at BS1, BS2 at x meters	Directional to directional	Directional to omni	Omni to omni	Omni to directional
50	37.35	30.36	30.36	37.35
100	31.33	24.35	24.35	31.33
250	23.39	16.47	16.47	23.39
500	17.43	10.74	10.74	17.43
1000	11.64	5.70	5.70	11.64
1500	8.48	3.43	3.43	8.48
2500	5.02			5.02
3500	3.24			3.24

It can be observed that the interference level depends on the gain of the receive antenna.

Table 3 – RSL degradation in case of BS-BS interference, second adjacent channel, 5.8GHz

RSL degradation (dB) at BS1, BS2 at x meters	Directional to directional	Directional to omni	Omni to omni	Omni to directional
50	18.42	11.66	11.66	18.42
100	12.58	6.45	6.45	12.58
180	7.98	3.12	3.12	7.98
300	4.62			4.62
350	3.80			3.80
400	3.16			3.16

Table 4 – RSL degradation in case of BS-BS interference, first adjacent channel, 2.4GHz

RSL degradation (dB) at BS1, BS2 at x meters	Directional to directional	Directional to omni	Omni to omni	Omni to directional
50	45.02	38.02	39.02	45.02
100	39.00	32.00	33.00	39.00

250	31.04	24.05	25.05	31.04
500	25.03	18.08	19.07	25.03
1000	19.05	12.26	13.21	19.05
1800	14.06	7.70	8.54	14.06
2750	10.60	4.90	5.61	10.60
3500	8.74	3.60	4.19	8.74
4500	6.92		2.98	6.92
6000	5.06			5.06
8000	3.50			3.50

The difference between the 2 midle columns is explained by different powers transmitted by BS and SS.

Table 5 RSL degradation in case of BS-BS interference, second adjacent channel, 2.4GHz

RSL degradation (dB) at BS1, BS2 at x meters	Directional to directional	Directional to omni	Omni to omni	Omni to directional
50	26.03	19.07	20.06	26.03
100	20.04	13.21	14.17	20.04
200	14.15	7.77	8.62	14.15
300	10.83	5.07	5.78	10.83
350	9.62	4.19	4.84	9.62
450	7.73	2.98	3.50	7.73
700	4.83			4.83
1000	3.01			3.01

Conclusions:

1. First adjacent channel cannot be used; a guard interval is necessary;
2. With a guard channel, the interference radius will be reduced;
3. A co-existence protocol is needed to avoid the remaining interference.

3.1.4. Co-channel

The RSL degradation is given by rel. (3):

$$DeltaRSL_{CCI} = 10*\log(1 + 10^{((I-RSL)+(SNR+impl\_loss))/10})$$

The following tables show the RSL degradation, with co-channel interference, function of separation distance.

Table 6 RSL degradation in case of BS-BS interference, co-channel, 5.8GHz

RSL degradation (dB) at BS1, BS2 at x meters	Directional to directional	Directional to omni	Omni to omni	Omni to directional
50	68.35	61.35	61.35	68.35
100	62.33	55.33	55.33	62.33
250	54.37	47.37	47.37	54.37
500	48.35	41.35	41.35	48.35
1000	42.33	35.33	35.33	42.33
2000	36.31	29.32	29.32	36.31
4000	30.29	23.31	23.31	30.29
7500	24.84	17.90	17.90	24.84
10 000	22.36	15.46	15.46	22.36
20 000	16.41	9.79	9.79	16.41
40 000	10.68	4.96	4.96	10.68
80 000	5.65			5.65

Table 7 RSL degradation in case of BS-BS interference, co-channel, 2.4GHz

RSL degradation (dB) at BS1, BS2 at x meters	Directional to directional	Directional to omni	Omni to omni	Omni to directional
50	76.02	69.02	70.02	77.02
100	70.00	63.00	64.00	71.00
250	62.04	55.04	56.04	63.04
500	56.02	49.02	50.02	57.02
1000	50.00	43.00	44.00	51.00
2000	43.98	36.98	37.98	44.98
4000	37.96	30.96	31.96	38.96
7500	32.50	25.51	26.50	33.50
10000	30.00	23.02	24.01	31.00
20000	23.99	17.06	18.04	24.99
40000	18.02	11.29	12.22	19.01
80000	12.20	6.14	6.92	13.15

Conclusion:

Not-correlated deployment cannot reuse the same frequency in LOS. In NLOS, the reuse distance depends of signal attenuation.
Not-correlated deployment might reuse the same frequency if a co-existence protocol will be defined.

3.2. Subscriber Station to Base Station

3.2.1. Interference level calculation

The assumed scenario is that a foreign SS, belonging to another system, will transmit during the time when the victim BS is in receive state. The victim Base Station will be affected by interference. This situation is relevant also for synchronized MAC Frames or even for FDD deployment, in Licensed bands.
Figure 4 represents the considered scenario.

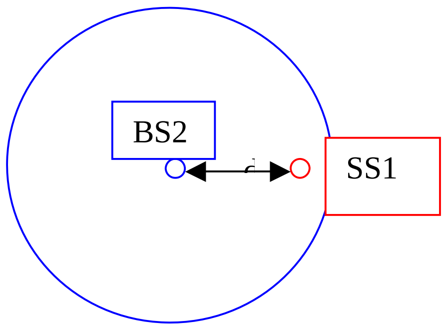

Figure 4 Foreign Subscriber to Base Station Interference

The relative RSL degradation is given by relation 2.

We can have 4 cases, depending the antenna type. We assume the worst case, LOS propagation and same line antenna mounting, looking one to the other.

In the following tables is given the interference level, translated to the victim channel, according to rel. RSL degradation, as function of distance and antenna gains.
The color code for radio blocking is violet.

Table 8 Blocking and RSL degradation, victim Base Station and foreign SU, adj. channel, 5.8GHz

RSL degradation (dB) and interference level at BS1, BS2 at x meters	BS Omni, SS Omni		BS Directional SS Directional		BS Directional, SS Omni		BS Omni, SS Directional	
	Level (dBm)	Delta_ RSL	Level (dBm)	Delta_ RSL	Level (dBm)	Delta_ RSL	Level (dBm)	Delta_ RSL
50	-36.65	30.36	-29.65	37.35	-29.65	30.36	-36.65	37.35
100	-42.67	24.35	-35.67	31.33	-35.67	24.35	-42.67	31.33
250		16.47	-43.63	23.39	-43.63	16.47		23.39
500		10.74		17.43		10.74		17.43
1000		5.70		11.64		5.70		11.64
1500		3.43		8.48		3.43		8.48
2500				5.02				5.02
3500				3.24				3.24

Table 9 Blocking and RSL degradation, victim Base Station and foreign SU, second adj. channel, 5.8GHz

RSL degradation (dB) and interference level at BS1, BS2 at x meters	BS Omni, SS Omni		BS Directional SS Directional		BS Directional, SS Omni		BS Omni, SS Directional	
	Level (dBm)	Delta_ RSL	Level (dBm)	Delta_ RSL	Level (dBm)	Delta_ RSL	Level (dBm)	Delta_ RSL
50	-36.65	11.66	-29.65	18.42	-29.65	11.66	-36.65	18.42
100	-42.67	6.45	-35.67	12.58	-35.67	6.45	-42.67	12.58
180		3.12	-40.77	7.98	-40.77	3.12		7.98
300				4.62				
350				3.80				
400				3.16				

Table 10 Blocking and RSL degradation, victim Base Station and foreign SU, adj. channel, 2.4GHz

RSL degradation (dB) and interference level at BS1, BS2 at x meters	BS Omni, SS Omni		BS Directional SS Directional		BS Directional, SS Omni		BS Omni, SS Directional	
	Level (dBm)	Delta_ RSL	Level (dBm)	Delta_ RSL	Level (dBm)	Delta_ RSL	Level (dBm)	Delta_ RSL
50	-28.98	38.02	-21.98	45.02	-28.98	31.02	-28.98	45.02
100	-35.00	32.00	-28.00	39.00	-35.00	25.01	-35.00	39.00
250	-42.96	24.05	-35.96	31.04	-42.96	17.12	-42.96	31.04
500		18.08	-41.98	25.03		11.35		25.03
1000		12.26		19.05		6.19		19.05
1800		7.70		14.06		2.96		14.06
2750		4.90		10.60				10.60
3500		3.60		8.74				8.74
4500				6.92				6.92
6000				5.06				5.06
8000				3.50				3.50

Table 11 Blocking and RSL degradation, victim Base Station and foreign SU, second adj. channel, 2.4GHz

RSL degradation (dB) and interference level at BS1, BS2 at x meters	BS Omni, SS Omni		BS Directional SS Directional		BS Directional, SS Omni		BS Omni, SS Directional	
	Level (dBm)	Delta_ RSL	Level (dBm)	Delta_ RSL	Level (dBm)	Delta_ RSL	Level (dBm)	Delta_ RSL
50	-28.98	19.07	-21.98	26.03	-28.98	12.28	-28.98	26.03
100	-35.00	13.21	-28.00	20.04	-35.00	6.97	-35.00	20.04
200	-41.02	7.77	-34.02	14.15	-41.02	3.00	-41.02	14.15
300		5.07	-37.55	10.83				10.83
350		4.19	-38.89	9.62				9.62
450		2.98	-41.07	7.73				7.73
700				4.83				4.83
1000				3.01				3.01

The tables above show very high interference level, such that out-door operation is impossible without sharing the radio resource.

Even if the foreign SS will operate 2 channels aside, the radio blocking still remains.

Conclusions:

- a guard channel is necessary;
    - a co-existence protocol is necessary to share the radio resource.

3.3. Base Station to Subscriber Station

3.3.1. Interference level calculation

Same scenario (Figure 4) as before applies. As the SS and BS transmit powers were assumed equal, in 5.8GHz, the results in the 4 tables above will be quite similar with results obtained for this case.

3.4. Subscriber Station to Subscriber Station

The same principles, as before, apply for interference calculation.

3.4.1. Proposed solutions in 802.16 community

See next Table.

Table 12 – Proposed solutions to resolve BS-BS Interference

No.	Commenter	Comment	Replay Commenter	Replay Comment	Group resolution
1	Zion Hadad	Probably we will have tables of BW reference clocks, GI sizes, which will bring the PHy's to synchronize in time. I think that we have to add that to 802.16c			
2	Phil Barber	I think more robust mechanics for supporting indirect BS synchronization through SS detection and reporting of 'hidden node' conflicts might be a better mechanism in LE use.	Marianna	How will talk different PHYs?	
3	Marianna G.	Use PHY sync of MAC Frames and Tx/Rx: Co-ordination possible: Frame start PHY Sync marker and MIB for Frame duration, Tx and Rx intervals. Co-ordination not possible (private use): PHY only mechanism. Systems may use GPS or follow the Sync Markers of already deployed systems	Duncan McClure	Agree that PHY synchronization is the best solution, if it is technology independent.	
	Barry Lewis	Dynamic Channel Selection, using Interference Detection Threshold			
	Barry Lewis	Operator co-ordination			
	Marianna G.	Cognitive radio			

ANNEX 1

Radio Characteristics

The data is taken from 802.16REVd/D3.

WirelessMAN Single Carrier (Sca)

8.2.3.9 Receiver sensitivity

Receiver sensitivity shall be better than the values listed below (computed at 10 -3 uncoded BER, and a total of 7 dB in receiver noise figure and 3 dB implementation loss). BW is specified in MHz.

QPSK: -93.2 +10*log(BW)
16-QAM: -86.2 +10*log(BW)
64-QAM: -80 +10*log(BW)

SN*Rreq* assumptions (for uncoded signals at 10 -3 BER) are the following:
QPSK: 9.8 dB
16-QAM: 16.8 dB
64-QAM: 23.0 dB.

8.2.3.10 Receiver maximum input signal

A BS shall be capable of receiving a maximum on-channel operational signal of –40 dBm and should tolerate a maximum input signal of 0 dBm without damage to circuitry. An SS shall be capable of receiving a maximum on-channel operational signal of –20 dBm and should tolerate a maximum input signal of 0 dBm without damage to circuitry.

8.2.3.11 Receiver adjacent channel interference

A system shall achieve the minimum adjacent and alternate adjacent channel interference performance as shown in Table 185. All measurements shall be performed uncoded.

Table 185—Minimum adjacent and alt. adjacent channel interference performance

	At BER 10^{-3}, for 3 dB degradation	**At BER 10^{-3}, for 1 dB degradation**
1st adjacent channel interference C/I	BPSK: –12 QPSK: –9 16-QAM: –2 64-QAM: +5 256-QAM: +12	BPSK: –8 QPSK: –5 16-QAM: +2 64-QAM: +9 256-QAM: +16
2nd adjacent channel interference C/I	BPSK: –37 QPSK: –34 16-QAM: –27 64-QAM: –20 256-QAM: –13	BPSK: –33 QPSK: –30 16-QAM: –22 64-QAM: –16 256-QAM: –9

WirelessMAN OFDM

8.3.10.1 Receiver sensitivity

The BER measured after FEC shall be less than 10^{-6} at the power levels given by Equation (90) for standard message and test conditions. If the implemented bandwidth is not listed, then the values for the nearest smaller listed bandwidth shall apply. The minimum input levels are measured as follows:

— At the antenna connector or· through a calibrated radiated test environment,

— Using the defined standardized message packet formats, and

— Using an AWGN channel.

The receiver minimum input level sensitivity *(R_{SS}*) shall be (assuming 5 dB implementation margin and 7dB Noise Figure):

$$R_{SS} = -102 + SNR_{Rx} + 10 \cdot \log\left(F_S \cdot \frac{N_{used}}{N_{FFT}} \cdot \frac{N_{subchannels}}{16}\right)$$

where:

SNR_{Rx} the receiver SNR as per Table 224 in dB

F_S sampling frequency in MHz as defined in 8.3.2.2

$N_{sub\text{-}channels}$ the number of allocated sub-channels (default 16 if no sub-channelization is used).

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Table 224—Receiver SNR assumptions

Modulation	Coding rate	Receiver SNR (dB)
QPSK	1/2	9.4
	3/4	11.2
16-QAM	1/2	16.4
	3/4	18.2

8.3.10.2 Receiver adjacent and alternate channel rejection

The receiver adjacent and alternate channel rejection shall be met over the required dynamic range of the receiver, from 3dB above the reference sensitivity level specified in 8.3.10.1 to the maximum input signal level as specified in 8.3.10.3.

Table 225—Adjacent and nonadjacent channel rejection

Modulation/coding	Adjacent Channel Interference C/I (dB)	Nonadjacent channel rejection (dB)
16-QAM-3/4	-11	-30
64-QAM-3/4	-4	-23

8.3.10.3 Receiver maximum input signal
The receiver shall be capable of receiving a maximum on-channel signal of –30 dBm, and shall tolerate a maximum signal of 0 dBm without damage.

WirelessMAN OFDMA

8.4.13.1 Receiver sensitivity
The BER shall be less than 10^{-6} at the power levels shown in Table 264 for standard message and test conditions.
If the implemented bandwidth is not listed, then the values for the nearest smaller listed bandwidth shall apply. The minimum input levels are measured as follows:
— At the antenna connector or· through a calibrated radiated test environment,
— Using the defined standardized message packet formats, and
Using an AWGN channel.
Table 264 (as well as Table 263) are derived assuming 5 dB implementation loss, a Noise Figure of 7 dB and receiver SNR and E_b/N_0 values as listed in Table 265.
Table 265—Receiver SNR and E_b/N_0 assumptions

Modulation	E_b/N_0 (dB)	Coding rate	Receiver SNR (dB)
QPSK	10.5	1/2	9.4
		3/4	11.2
16-QAM	14.5	1/2	16.4
		3/4	18.2
64-QAM	19.0	2/3	22.7
		3/4	24.4

8.4.13.2 Receiver adjacent and alternate channel rejection
The adjacent channel rejection and alternate channel rejection shall be measured by setting the desired signal's
strength 3 dB above the rate dependent receiver sensitivity (see Table 264) and raising the power level of the interfering signal until the specified error rate is obtained. The power difference between the interfering
signal and the desired channel is the corresponding adjacent channel rejection. The interfering signal in the adjacent channel shall be a conforming OFDMA signal, not synchronized with the signal in the channel under test. For nonadjacent channel testing the test method is identical except the interfering channel shall be any channel other than the adjacent channel or the co-channel.
For the PHY to be compliant, the minimum rejection shall exceed the following:
Table 266—Adjacent and nonadjacent channel rejection

Modulation/coding	Adjacent channel rejection (dB)	Nonadjacent channel rejection (dB)
16-QAM-3/4	11	30
64-QAM-2/3	4	23

8.4.13.3 Receiver maximum input signal
The receiver shall be capable of receiving a maximum on-channel signal of –30 dBm, and shall tolerate a maximum signal of 0 dBm without damage.