Project	**IEEE 802.20 Working Group on Mobile Broadband Wireless Access** **<http://grouper.ieee.org/groups/802/20/>**	
Title	**Suggestion on a remedy for the missing transmitter and receiver requirements specification in 802.20 standard draft V 1.0**	
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Re:	IEEE 802.20 session #20, May 15-19, 2006	
Abstract	The issue on the lack of transmitter and receiver requirements specifications has been submitted in Comments No. 399 and 49. In response to Comment No. 399, the BRG comment admitted that these specifications are important requirements for the equipment, and proposed to include them in a separate document. The response to Comment No. 49 indicates that the BRC was not capable of addressing this issue. This contribution discusses the problem and suggests a remedy to one of the major open issues in 802.20 standards draft, which is the non-compliance with the systems requirements and incompleteness as an IEEE 802 standard.	
Purpose	For discussions	
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Introduction

Since the Jan 06 Interim meeting, a number of questions and issues on the MBTDD and MBFDD proposals have been identified by the meeting participants, as recorded in the minutes for Jan and March meetings. One of the major issues is the lack of transmitter and receiver specifications in the proposals and the current standards draft.

As discussed in Contribution C802.20-06/15r2 [1], the selected 802.20 proposals, i.e., the current version of the standards draft V1.0 [2] has not included transmitter and receiver specifications, which are part of system requirements for 802.20 [3]. This contribution has included examples from a few published 802 standards to show these requirements.

IEEE 802.20 Systems Requirements

Sections 4.2.5.2 and 4.2.5.3 of the SRD (Systems Requirements Document PD-06r1) [3] have stated that the transmitter and receiver specifications are required.

Technology Selection Process

Based on the definition in the technology selection document, IEEE 802.20-PD-10 [4], section 2.0, "A compliant proposal is a proposal that meets or exceeds all the system, simulation and evaluation requirements (all the "SHALL" entries in the SRD)".

Other IEEE 802 standards

With 802.20 as an exception, most other IEEE 802 standards specifications include the transmitter and receiver requirements as part of the main air interface specifications. These are important information for equipment vendors and service providers for the implementation of the technology. It is important to provide information on how the standard can comply with various regulatory requirements.

A few examples as quoted from published IEEE 802 standards are included in Appendix A and B for reference.

Proposed comment resolution by the ballot resolution committee (BRC) [5]

The issue on the lack of transmitter and receiver requirements specifications has been submitted in Comments No. 399 and 49. In response to Comment No. 399, the BRC comment admitted that the specifications are important requirements for the equipment, and proposed to include them in a separate document. Details of the comments and BRC resolution can be found in Appendix C.

However, without the transmitter and receiver requirements specifications included, the current version of the standard draft is not compliant with the 802.20 systems requirement.

The current version of 802.20 standard draft is obviously incomplete, as we can see that these requirements are included in other 802 standards. Besides the examples as shown in Appendix A & B, transmitter and receiver specifications are also part of the IEEE 802.15.3 standard for high rate wireless personal area networks [8].

Recommendation & Conclusion

The contributors would like to recommend the WG to start working on the specifications for transmitter and receiver requirements. After these requirements are completed, they can then be included into the standards draft for completeness, and compliance with the 802.20 TSP [4] and System Requirements documents [3].

For transmitter and receiver performance requirements, link-level simulations or analyses that include system impairments should be performed in order to determine the specifications.

Appendix A: Transmit and receiver specifications as quoted from IEEE 802.11g standard [5]

…19.4.3.9 PMD Transmit Specifications

For the OFDM mode, the PMD transmit specifications shall follow subclause 17.3.9 with the exception of the transmit power level (subclause 17.3.9.1), the transmit center frequency tolerance (subclause 17.3.9.4), and the symbol clock frequency tolerance (subclause 17.3.9.5). All applicable regulatory requirements such as FCC parts 15.247 and 15.249 shall apply. This may have an effect on the combination of maximum transmit power and spectral mask if the resulting signals violate restricted band emission limits such as found in FCC part 15.205.

19.4.3.9.2 Transmit Center Frequency Tolerance

The transmit center frequency tolerance shall be ±25 PPM maximum. The transmit center frequency and symbol clock frequency shall be derived from the same reference oscillator (locked oscillators).

19.4.3.9.3 Symbol Clock Frequency Tolerance

The symbol clock frequency tolerance shall be ±25 PPM maximum. The transmit center frequency and symbol clock frequency shall be derived from the same reference oscillator (locked oscillators).

19.4.3.9.4 Transmit spectral mask

The transmit spectral mask for the OFDM modes is found in subclause 17.3.9.2 and shown in figure 120 therein.

19.4.3.10 PMD Receiver Specifications

This subclause describes the receive specifications for the PMD sublayer. The receive specification for the OFDM modes shall follow subclause 17.3.10 with the exception of the receiver maximum input level (subclause 17.3.10.4). For the CCK modes, the *receiver specifications shall follow subclause 18.4.8 with the exception of the receiver maximum input level (subclause 18.4.8.2).*

19.4.3.10.1 Receiver Minimum Input Level Sensitivity

The packet error rate (PER) of the OFDM modes shall be less than 10% at a PSDU length of 1000 bytes for the input levels of Table 91 of subclause 17.3.10 of IEEE Std 801.11a, 1999. Input levels are specific for each data rate and are measured at the antenna connector. A noise figure (NF) of 10 dB and an implementation loss of 5 dB are assumed.

19.4.3.10.2 Adjacent channel rejection

The adjacent channel rejection shall be measured by setting the desired signal's strength 3 dB above the rate-dependent sensitivity specified in Table 91 of subclause 17.3.10 of IEEE Std 801.11a, 1999 and raising the power of the interfering signal until 10% PER is caused for a PSDU length of 1000 bytes. The power difference between the interfering and the desired channel is the corresponding adjacent channel rejection. The interfering signal in the adjacent channel shall be a conformant OFDM signal, unsynchronized with the signal in the channel under test. For a conformant OFDM PHY the corresponding rejection shall be no less than specified in Table 91.
Adjacent channels are at +/-25 MHz spacing. The alternate adjacent channel rejection of Table 91 shall not be required for the ERP.

19.4.3.10.3 Receive Maximum Input Level

The Packet Error Rate shall be less than 10% at a PSDU length of 1000 bytes for a maximum input level of –20 dBm measured at the antenna for any modulation signal or data rate (i.e., 1, 2, 5.5, 6, 9, 11, 12, 18, 22, 24, 33, 36, 48, 54 Mbps).

Appendix B: Transmit and receiver specifications as quoted from IEEE 802.16-2004 standard [7]

8.4.12 Transmitter requirements

8.4.12.1 Transmit power level control

The transmitter shall support monotonic power level control of 45 dB (30 dB for license-exempt bands) minimum with a minimum step size of 1 dB and a relative accuracy of ± 0.5 dB.

8.4.12.2 Transmitter spectral flatness

The average energy of the constellations in each of the n spectral lines shall deviate no more than indicated in Table 333. The absolute difference between adjacent subcarriers shall not exceed 0.1 dB excluding intentional boosting or suppression of subcarriers and PAPR reduction subchannels are not allocated.

Table 333—Spectral flatness

Spectral lines	Spectral flatness
Spectral lines from $-N_{used}/4$ to -1 and $+1$ to $N_{used}/4$	±2 dB from the measured energy averaged over all N_{used} active tones
Spectral lines from $-N_{used}/2$ to $-N_{used}/4$ and $+N_{used}/4$ to $N_{used}/2$	+2/–4 dB from the measured energy averaged over all N_{used} active tones

This data shall be taken from the channel estimation step.

8.4.12.3 Transmitter constellation error and test method

To ensure that the receiver SNR does not degrade more than 0.5 dB due to the transmitter SNR, the relative constellation RMS error, averaged over subcarriers, OFDMA frames, and packets, shall not exceed a burst profile dependent value according to Table 334.

Table 334—Allowed relative constellation error versus data rate

Burst type	Relative constellation error (dB)
QPSK-1/2	16.4
QPSK-3/4	18.2
16-QAM-1/2	23.4
16-QAM-3/4	25.2
64-QAM-2/3	29.7
64-QAM-3/4	31.4

All measurement errors taken together shall be 10 dB less than the required noise level, i.e., if a specification is TX S/N = 10 dB, the measurement S/N should be at least 20 dB. For all PHY modes, measurements shall be taken with all nonguard subcarriers active and no PAPR reduction subchannels used.

The sampled signal shall be processed in a manner similar to an actual receiver, according to the following steps, or an equivalent procedure [B29]:

a) Start of frame shall be detected.
b) Transition from short sequences to channel estimation sequences shall be detected, and fine timing (with one sample resolution) shall be established.
c) Coarse and fine frequency offsets shall be estimated.
d) The packet shall be de-rotated according to estimated frequency offset.
e) The complex channel response coefficients shall be estimated for each of the subcarriers.
f) For each of the data OFDMA symbols: transform the symbol into subcarrier received values, estimate the phase from the pilot subcarriers, de-rotate the subcarrier values according to estimated phase, and divide each subcarrier value with a complex estimated channel response coefficient.
g) For each data-carrying subcarrier, find the closest constellation point and compute the Euclidean distance from it.
h) Compute the RMS average of all errors in a packet. It is given by:

$$\mathrm{Error}_{RMS} = \frac{\sum_{i=1}^{N_f} \frac{\sum_{j=1}^{L_P}\left[\sum_{k=1}^{N_{FFT}}\left\{(I(i,j,k)-I_0(i,j,k))^2+(Q(i,j,k)-Q_0(i,j,k))^2\right\}\right]}{P_0 \cdot L_P \cdot N_{FFT}}}{N_f} \qquad (145)$$

where

L_p is the length of the packet;
N_f is the number of frames for the measurement;
$(I_0(i,j,k), Q_0(i,j,k))$ denotes the ideal symbol point of the i[th] frame, j[th] OFDMA symbol of the frame, k[t] subcarrier of the OFDMA symbol in the complex plane;
$(I(i,j,k), Q(i,j,k))$ denotes the observed point of the i[th] frame, j[th] OFDMA symbol of the frame,
k[th] is the subcarrier of the OFDMA symbol in the complex plane;
P_0 is the average power of the constellation.

8.4.13 Receiver requirements

8.4.13.1 Receiver sensitivity

The BER shall be less than 10^{-6} at the power levels shown in Table 335 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 335—Receiver minimum input level sensitivity (dBm)

Bandwidth (MHz)	QPSK		16-QAM		64-QAM	
	1/2	3/4	1/2	3/4	2/3	3/4
1.5	–91	–89	–84	–82	–78	–76
1.75	–90	–87	–83	–81	–77	–75
3	–88	–86	–81	–79	–75	–73
3.5	–87	–85	–80	–78	–74	–72
5	–86	–84	–79	–77	–72	–71
6	–85	–83	–78	–76	–72	–70
7	–84	–82	–77	–75	–71	–69
10	–83	–81	–76	–74	–69	–68
12	–82	–80	–75	–73	–69	–67
14	–81	–79	–74	–72	–68	–66
20	–80	–78	–73	–71	–66	–65

Table 335 (as well as Table 334) 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 336.

Table 336—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 335) 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 337—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 decoding a maximum on-channel signal of –30 dBm.

8.4.13.4 Receiver maximum tolerable signal

The receiver shall tolerate a maximum signal of 0 dBm without damage.

8.4.14 Frequency control requirements

8.4.14.1 Center frequency and symbol clock frequency tolerance

At the BS, the transmitted center frequency, receive center frequency and the symbol clock frequency shall be derived from the same reference oscillator. At the BS, the reference frequency accuracy shall be better than $\pm 2*10^{-6}$.

At the SS, both the transmitted center frequency and the symbol clock frequency shall be synchronized to the BS with a tolerance of maximum 2% of the subcarrier spacing.

For Mesh capable devices, all device frequencies shall be accurate to within $\pm 20*10^{-6}$ and achieve synchronization to its neighboring nodes with a tolerance of maximum 3% of the subcarrier spacing.

During the synchronization period, the SS shall acquire frequency synchronization within the specified tolerance before attempting any uplink transmission. During normal operation, the SS shall track the frequency changes and shall defer any transmission if synchronization is lost.

Appendix C: Proposed comment resolution for Letter Ballot 1 [5]

Comment No. 399: 'The draft standard do not address Radio Transmitter and Receiver Requirement subject of Sections 4.2.5.2 and 4.2.5.3 of 802.20 SRD which is a requirement for compliance and completeness as defined in 802.20 TSP.'

> **Recommended Change (by the original commenter): '**Add two new sections under Section 8 dedicated to Transmit and Receiver requirements. Include Min Rx sensitivity requirements, Min Tx EVM constellation error requirements, Tx spectral flatness, Rx adjacent and non adjacent requirements, Rx Max input requirements, Spurious emission, spectral masks, etc.'

Editor's comment/resolution: 'Declined: Radio Transmitter and Receiver requirements are equipment requirements and not air interface requirements. Hence, they will vary depending on the application of the 802.20 technology. These requirements, while important to equipment design, are not specified here; additional "minimum requirements" for anticipated scenarios are best addressed in a separate document.'

Comment No. 49: 'Transmitter and receiver specifications as required by the 802.20 systems requirements document are not available. Therefore the proposed technology in the standards draft v1.0 is non-compliant, based on the definition in the technology selection process (TSP) document IEEE 802.20-PD10.'

Recommended Change (by the original commenter): 'Withdrawn the current WG letter ballot, amend the original proposal with transmitter and receiver specifications, while allowing an open process for proposal submission from other WG members. Re-start the process of technology selection, comparison and merging.'

Editor's comment/resolution: 'This comment is out of the scope of the letter ballot. The comment is not addressable by the Ballot Comment Resolution Committee.'

References

[1] C802.20-06-15r2, 'Responses to Appendix C2: Questions and Answers for the proposals, as recorded in Jan 06 meeting minutes', Feb 24, 2006.

[2] IEEE P802.20/D1, 'Draft Standard for Mobile Broadband Wireless Access, January 2006.

[3] 802.20-PD-06r1, 'IEEE 802.20 System Requirements Document (V 1.0)', Aug 2004

[4] 802.20-PD-10, 'IEEE 802.20 Technology Selection Process (V 1.0), September 2005.

[5] '802.20 official ballot comment repository for Letter Ballot 1', April 28, 2006

[6] IEEE 802.11g/D2.5, 'Draft Supplement to IEEE Standards for Local and Metropolitan area networks, Part 11: Wireless LAN MAC and PHY specifications', January 2002.

[7] IEEE 802.16-2004, 'IEEE Standards for Local and metropolitan area networks, Part 16: Air Interface for Fixed Broadband Wireless Access Systems'

[8] IEEE 802.15.3-2003, 'IEEE standards for Local and metropolitan area networks – Part 15.3: Wireless MAC and PHY specifications for high rate wireless personal area networks'.