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| Project | **IEEE 802.16 Broadband Wireless Access Working Group <**<http://ieee802.org/16>**>** | |
| Title | **Proposed Amendments to IEEE Std 802.16-2012 to Support <1.25 MHz Channels** | |
| Date Submitted | **2017-01-02** | |
| Source(s) | Doug Gray, EPRI | E-mail: dgray.tcs@gmail.com  \*<<http://standards.ieee.org/faqs/affiliationFAQ.html>> |
| Re: | IEEE 802.16s GRIDMAN Task Group Discussions | |
| Abstract | Draft of proposed amendments to IEEE Std 802.16-2012 as amended by 802.16n, p, and | |
| Purpose | This document is intended to facilitate the GRIDMAN Task Group discussions leading to a consensus on proposed amendments to IEEE Std 802.16 in support of channel BWs <1.25 MHz | |
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3. Definitions

For the purposes of this standard, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause

**Band AMC:** aka ‘adjacent subcarrier permutation’ is a permutation scheme in which the entire channel is split into non-overlapping groups of nine contiguous physical subcarriers each group comprising one pilot subcarrier and eight data subcarriers.

**8.1.3 Duplexing techniques and PHY Type parameter encodings**

Both FDD and TDD are supported. The duplexing method shall be reflected in the PHY Type parameter (11.4.1) as shown in Table 8-2. For channel bandwidths less than 1.25 MHz only TDD shall be supported.

**8.1.4.4.7 DL modulation**

To maximize utilization of the airlink, the PHY uses a multilevel modulation scheme. The modulation constellation can be selected per subscriber based on the quality of the RF channel. If link conditions permit, then a more complex modulation scheme can be utilized to maximize airlink throughput while still allowing reliable data transfer. If the airlink degrades over time, possibly due to environmental factors, the system can revert to the less complex constellations to allow more reliable data transfer.

In the DL, the BS shall support QPSK and 16-QAM modulation and, optionally, 64-QAM for channel BWs ≥1.25 MHz and shall support QPSK, 16-QAM, and 64QAM for channel BWs <1.25 MHz

**8.1.5.3.7 UL modulation**

The modulation used on the UL channel shall be variable and set by the BS. QPSK shall be supported, while 16-QAM and 64-QAM are optional for channel BWs ≥1.25 MHz and QPSK, 16-QAM, and 64QAM shall be supported for channel BWs <1.25 MHz, with the mappings of bits to symbols identical to those described in 8.1.4.4.7.

**8.4.2.3 Primitive parameters**

The following four primitive parameters characterize the OFDMA symbol:

—*BW:* The nominal channel bandwidth.

—*N*used: Number of used subcarriers (which includes the DC subcarrier).

—*n*: Sampling factor. This parameter, in conjunction with *BW* and *N*used determines the subcarrier spacing and the useful symbol time. This value is set as follows: for channel bandwidths that are a multiple of 1.75 MHz, then *n* = 8/7; else, for channel bandwidths that are a multiple of any of 1.25, 1.5, 2, or 2.75 MHz, then *n* = 28/25; then 28/25 for channel BWs 0.55, 0.60, 0.65, 0.70, 0.75, 0.80, 0.85, 0.90, 0.95, 1.00, 1.05, 1.10, 1.15, 1.20 MHz, then 55/25 for channel BWs 0.35, 0.40, 0.45, 0.50 MHz, then 82/25 for channel BWs 0.20, 0.25, 0.30 MHz then 109/25 for channel BWs 0.10, 0.15 MHz else, for channel bandwidths >1.25 MHz not otherwise specified, then *n* = 8/7.

—*G*: This is the ratio of CP time to “useful” time. The following values shall be supported: 1/32, 1/16, 1/8, and 1/4.

**8.4.5.4.1 UIUC allocation**

*TBD*

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**8.4.6.1.1 Preamble**

The first symbol of the DL transmission is the preamble. For each FFT size, three different preamble carrier-sets are defined, differing in the allocation of subcarriers. Those subcarriers are modulated using a boosted BPSK modulation with a specific pseudo-noise (PN) code.

*Need redefined UL and DL preambles for Channel Groups 1, 2, and 3 channel groups in Clause 12.9*

*From Menashe – Full Spectrum contribution* *16-16-0039-03*

Preamble set #1 employs 54 bit preamble sequences which can be mapped into any of the sectors, i.e.:

* Each preamble index can be used in each sector independent of IDcell and Segment ID
* The 54 bit sequence is mapped into 54 consecutive subcarriers employed in the respective sector.

Preamble sequences suggested in Table 8-252 of the IEEE 802.16-2012 standard, are considered. (or Table 302 in amended std)

There are 114 possible sequence, we choose those candidates which satisfy a PAPR constraint of less than 4 dB, while ensuring the auto and cross correlation gains of these sequences are better than 3 dB.

The following 34 sequences meet both the constraints.

**5, 8, 11, 12, 16, 20, 22, 28, 31, 32, 33, 41, 43, 47, 50, 52, 57, 58, 59, 63, 72, 76, 77, 78, 85, 88, 90, 91, 94, 96, 100, 101, 102, 103.**

A length 54 sequence is created by appending 9 zeros each on either side of the length-36 sequence.

Preamble set #2 employs length-27 preamble sequences that can be mapped onto any of the sectors, i.e.:

* Each preamble index can be used in each sector independent of IDcell and Segment ID
* The 27 bit sequence is mapped into 27 consecutive subcarriers employed in the respective sector.

Preamble sequences suggested in Table 8-252 (or Table 302) of the IEEE 802.16-2012 are considered. There are 114 possible candidates, each of length-36. The first 27-bits from each of these sequences are considered to form length-27 preamble sequences. We shall refer to this as truncated sequences.

Among the possible 114 truncated sequence, we choose those candidates which satisfy a PAPR constraint of less than 4 dB, while ensuring the auto and cross correlation gains of these sequences are better than 3 dB.

The following 12 sequences meet both the constraints: **17, 21, 25, 35, 38, 39, 45, 73, 87, 88, 89, and 97.**

CDMA Code set #1

CDMA Code set #1 consists of 96 bit sequences generated by truncating the original 144 bit code sequences. The 96 bit code sequences are spread across 2 symbols (54x2) for periodic ranging and repeated over 4 symbols (54x2, 54x2) for initial ranging. A length 54 sequence is created by splitting length-96 into 2 parts and each part length-48 is appended with 6 zeros to make length-54 for each symbol. This is described in figure 1.

CDMA Code set #2

CDMA Code set #2 consists of 96 bit sequences generated by truncating the original 144 bit code sequences bits. The 96 bit code sequences are spread across 4 symbols (27x4) for periodic ranging and repeated over 8 symbols (27x4, 27x4) for initial ranging. A length 27 sequence is created by splitting length-96 into 4 parts and each part length-24 is appended with 3 zeros to make length-27 for each symbol. This is described in figure 2.

**8.4.6.3 Optional adjacent subcarrier permutations for AMC**

A BS may change from the distributed subcarrier permutation, described in 8.4.6.1 and 8.4.6.2, to the adjacent subcarrier permutation when changing from non-AAS to AAS-enabled traffic to support AAS adjacent subcarrier user traffic in the cell. Alternatively, the adjacent subcarrier permutation can be used to take advantage of the structure of the adjacent subcarrier permutation in parts of the DL subframe that are indicated accordingly by the DL-MAP and UL subframe that are indicated accordingly by the UL-MAP. After this change, the BS shall only transmit/receive traffic using the adjacent subcarrier permutation during the allocated period. The BS shall always return to the distributed subcarrier permutation at the beginning of a new DL subframe for channel bandwidth ≥1.25 MHz but not for channel bandwidth <1.25 MHz. Note that an AAS-enabled SS, which does not provision the same permutation (PUSC/FUSC or adjacent) for AAS traffic selected by the BS for this purpose, is not capable of using its AAS capabilities with this BS.

**8.4.14.1.1 Receiver sensitivity**

**Table 8-87-Receiver SNR assumption (BER = 10-6)**

|  |  |  |
| --- | --- | --- |
| **Modulation** | **Coding Rate** | **Receiver SNR (dB)** |
| QPSK | 1/2 | 5 |
| 3/4 | 8 |
| 16QAM | 1/2 | 10.5 |
| 3/4 | 14 |
| 64QAM | 1/2 | 16 |
| 2/3 | 18 |
| 3/4 | 20 |
| 5/6 | 22 |

12.9 WirelessMAN OFDMA TDD Sub-1.25 MHz Channel BW

This subclause defines system requirements for systems operating with channel bandwidths less than 1.25 MHz.

To maintain sufficient subcarrier spacing in support of moderate mobility requirements and intercarrier interference requirements, Channel Groups 1, 2, and 3 shall use only a subset of the available subchannels. Groups 1 and 2 shall use Band AMC 1x6 permutation (1 subcarrier x 6 symbols). Group 3 and Group 4 shall use Band AMC and either 2x3 or 1x6 permutation.

**Table 12-41a—Profile definitions 0.10 MHz to 0.15 MHz BW Channel Group 1**

| **Identifier** | **Channel Group 1 Description** |
| --- | --- |
|  | DL and UL Preamble confined to 27 subcarriers |
| OFDMA\_xxx | WirelessMAN-OFDMA 0.10 MHz channel basic PHY TDD profile, AMC 1x6 |
|  | WirelessMAN-OFDMA 0.15 MHz channel basic PHY TDD profile, AMC 1x6 |

**Table 12-41b—Profile definitions 0.20 MHz to 0.30 MHz BW Channel Group 2**

| **Identifier** | **Channel Group 2 Description** |
| --- | --- |
|  | DL and UL Preamble confined to 36 subcarriers |
| OFDMA\_xxx | WirelessMAN-OFDMA 0.20 MHz channel basic PHY TDD profile, AMC 1x6 |
|  | WirelessMAN-OFDMA 0.25 MHz channel basic PHY TDD profile, AMC 1x6 |
|  | WirelessMAN-OFDMA 0.30 MHz channel basic PHY TDD profile, AMC 1x6 |

**Table 12-41c—Profile definitions 0.35 MHz to 0.50 MHz BW Channel Group 3**

| **Identifier** | **Channel Group 3 Description** |
| --- | --- |
|  | DL and UL Preamble confined to 54 subcarriers |
| OFDMA\_xxx | WirelessMAN-OFDMA 0.35 MHz channel basic PHY TDD profile, AMC 1x6 or 2x3 |
|  | WirelessMAN-OFDMA 0.40 MHz channel basic PHY TDD profile, AMC 1x6 or 2x3 |
|  | WirelessMAN-OFDMA 0.45 MHz channel basic PHY TDD profile, AMC 1x6 or 2x3 |
|  | WirelessMAN-OFDMA 0.50 MHz channel basic PHY TDD profile, AMC 1x6 or 2x3 |

**Table 12-41d—Profile definitions 0.55 MHz to 1.20 MHz BW Channel Group 4**

| **Identifier** | **Channel Group 4 Description** |
| --- | --- |
|  |  |
| OFDMA\_xxx | WirelessMAN-OFDMA 0.55 MHz channel basic PHY TDD profile, AMC 1x6 or 2x3 |
|  | WirelessMAN-OFDMA 0.60 MHz channel basic PHY TDD profile, AMC 1x6 or 2x3 |
|  | WirelessMAN-OFDMA 0.65 MHz channel basic PHY TDD profile, AMC 1x6 or 2x3 |
|  | WirelessMAN-OFDMA 0.70 MHz channel basic PHY TDD profile, AMC 1x6 or 2x3 |
|  | WirelessMAN-OFDMA 0.75 MHz channel basic PHY TDD profile, AMC 1x6 or 2x3 |
|  | WirelessMAN-OFDMA 0.80 MHz channel basic PHY TDD profile, AMC 1x6 or 2x3 |
|  | WirelessMAN-OFDMA 0.85 MHz channel basic PHY TDD profile, AMC 1x6 or 2x3 |
|  | WirelessMAN-OFDMA 0.90 MHz channel basic PHY TDD profile, AMC 1x6 or 2x3 |
|  | WirelessMAN-OFDMA 0.95 MHz channel basic PHY TDD profile, AMC 1x6 or 2x3 |
|  | WirelessMAN-OFDMA 1.00 MHz channel basic PHY TDD profile, AMC 1x6 or 2x3 |
|  | WirelessMAN-OFDMA 1.05 MHz channel basic PHY TDD profile, AMC 1x6 or 2x3 |
|  | WirelessMAN-OFDMA 1.10 MHz channel basic PHY TDD profile, AMC 1x6 or 2x3 |
|  | WirelessMAN-OFDMA 1.15 MHz channel basic PHY TDD profile, AMC 1x6 or 2x3 |
|  | WirelessMAN-OFDMA 1.20 MHz channel basic PHY TDD profile, AMC 1x6 or 2x3 |

**Table 12-42—Channel Groups 1, 2, and 3 details**

|  |  |  |  |
| --- | --- | --- | --- |
| **Channel Group** | **Description** | **Subcarrier Spacing** | **Used subchannels/ Total subchannels** |
| 1 | 0.10 MHz Channel | 3.406 kHz | 1/4 (25%) |
| 0.15 MHz Channel | 5.109 kHz |
| 2 | 0.20 MHz Channel | 5.125 kHz | 1/3 (33.3%) |
| 0.25 MHz Channel | 6.406 kHz |
| 0.30 MHz Channel | 7.688 kHz |
| 3 | 0.35 MHz Channel | 6.016 kHz | 1/2 (50%) |
| 0.40 MHz Channel | 6.875 kHz |
| 0.45 MHz Channel | 7.734 kHz |
| 0.50 MHz Channel | 8.594 kHz |

12.9.1 WirelessMAN-OFDMA Power class profiles

**Table 12-43—Power classes**

|  |  |
| --- | --- |
| **Class Identifier** | **Tx power dBm** |
| Class 1 | 17 ≤ PTx,max < 20 |
| Class 2 | 20 ≤ PTx,max < 23 |
| Class 3 | 23 ≤ PTx,max < 30 |
| Class 4 | 30 ≤ PTx,max |

**Table 12-44a—Minimum performance requirements for group 1 profiles**

|  |  |
| --- | --- |
| **Capability** | **Minimum performance** |
| Channel bandwidth | 0.100 MHz reference |
| Operation mode | Licensed bands |
| BER performance threshold, BER = 10-6 (using all available subchannels)  QPSK-1/2  QPSK-3/4  16-QAM-1/2  16-QAM-3/4  64-QAM-2/3  64-QAM-3/4  64-QAM-5/6 (if supported)  For other channel BWs in this group add 10Log(ChannelBW in MHz/0.100)  Add to sensitivity if using less than allowed number of subchannels 10Log(Used subchannels/Allowed subchannels) | ≤-106.3 dBm  ≤-104.3 dBm  ≤-101.8 dBm  ≤ -98.3 dBm  ≤ -96.3 dBm  ≤ -94.3 dBm |
| Reference frequency tolerance  BS  SS-to-BS synchronization tolerance | ≤ ± 2 x 10-6  ≤ tbd Hz |
| Frame duration code set | tbd |
| Spectrum mask | Local regulation |

**Table 12-44b—Minimum performance requirements for group 2 profiles**

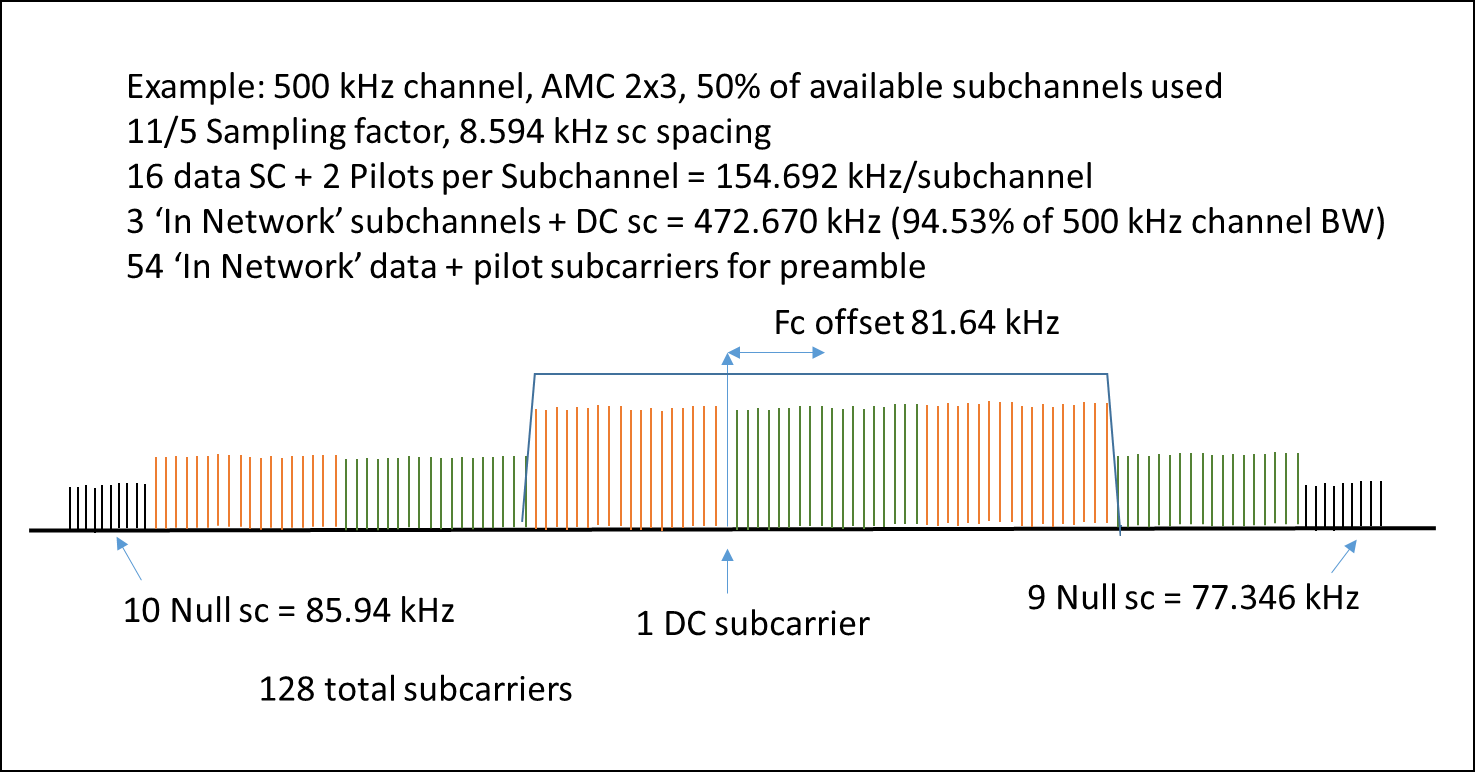
|  |  |
| --- | --- |
| **Capability** | **Minimum performance** |
| Channel bandwidth | 0.200 MHz reference |
| Operation mode | Licensed bands |
| BER performance threshold, BER = 10-6 (using all available subchannels)  QPSK-1/2  QPSK-3/4  16-QAM-1/2  16-QAM-3/4  64-QAM-2/3  64-QAM-3/4  64-QAM-5/6 (if supported)  For other channel BWs in this group add 10Log(ChannelBW in MHz/0.200)  Add to sensitivity if using less than allowed number of subchannels 10Log(Used subchannels/Allowed subchannels) | ≤-103.3 dBm  ≤-101.3 dBm  ≤ -98.8 dBm  ≤ -95.3 dBm  ≤ -93.3 dBm  ≤ -91.3 dBm |
| Reference frequency tolerance  BS  SS-to-BS synchronization tolerance | ≤ ± 2 x 10-6  ≤ tbd Hz |
| Frame duration code set | tbd |
| Spectrum mask | Local regulation |

**Table 12-44c—Minimum performance requirements for group 3 profiles**

|  |  |
| --- | --- |
| **Capability** | **Minimum performance** |
| Channel bandwidth | 0.350 MHz reference |
| Operation mode | Licensed bands |
| BER performance threshold, BER = 10-6 (using all available subchannels)  QPSK-1/2  QPSK-3/4  16-QAM-1/2  16-QAM-3/4  64-QAM-2/3  64-QAM-3/4  64-QAM-5/6 (if supported)  For other channel BWs in this group add 10Log(ChannelBW in MHz/0.350)  Add to sensitivity if using less than allowed number of subchannels 10Log(Used subchannels/Allowed subchannels) | ≤-100.8 dBm  ≤ -98.8 dBm  ≤ -96.3 dBm  ≤ -92.8 dBm  ≤ -90.8 dBm  ≤ -88.8 dBm |
| Reference frequency tolerance  BS  SS-to-BS synchronization tolerance | ≤ ± 2 x 10-6  ≤ tbd Hz |
| Frame duration code set | tbd |
| Spectrum mask | Local regulation |

**Table 12-44c—Minimum performance requirements for group 4 profiles**

|  |  |
| --- | --- |
| **Capability** | **Minimum performance** |
| Channel bandwidth | 0.550 MHz ref |
| Operation mode | Licensed bands |
| BER performance threshold, BER = 10-6 (using all available subchannels)  QPSK-1/2  QPSK-3/4  16-QAM-1/2  16-QAM-3/4  64-QAM-2/3  64-QAM-3/4  64-QAM-5/6 (if supported)  For other channel BWs in this group add 10Log(ChannelBW in MHz/0.550)  Add to sensitivity if using less than allowed number of subchannels 10Log(Used subchannels/Allowed subchannels) | ≤ -98.8 dBm  ≤ -96.8 dBm  ≤ -94.3 dBm  ≤ -90.8 dBm  ≤ -88.8 dBm  ≤ -86.8 dBm |
| Reference frequency tolerance  BS  SS-to-BS synchronization tolerance | ≤ ± 2 x 10-6  ≤ tbd Hz |
| Frame duration code set | tbd |
| Spectrum mask | Local regulation |

**Additional Material for Discussion Purposes**

| **Channel Plan for sub 1.25 MHz Channels** | | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Nominal Channel BW** | **Sampling Factor** | **Sampling Clock Frequency** | | **Subcarrier Spacing** | **Permutation (AMC2X3 - 3, AMC1X6 - 6)** | **Total # of**  **Sub channels** | **% of sub channels used in Network** | **Occupied BW1 (includes DC subcarrier)** | **% Nominal Channel BW1** | **# Data+Pilot Sub carriers** | **Samples per 5 ms Frame** | **Rss2 (QPSK-1/2)** |
| **Group 1** | | | **Slot definition in DL and UL: AMC 1x6, 1 SC in 6 symbols** | | | | | | | | | |
| 0.100 MHz | 4 9/25 | 0.436 MHz | | 3.406 kHz | 6 | 12 | 25.0% | 0.095 MHz | 95.38% | 27 | 2180 | -106.3 dBm |
| 0.150 MHz | 4 9/25 | 0.654 MHz | | 5.109 kHz | 6 | 12 | 25.0% | 0.143 MHz | 95.38% | 27 | 3270 | -104.6 dBm |
| **0.100 MHz Alternative** | | | | | | | | | | | | |
| 0.100 MHz | 6 11/25 | 0.644 MHz | | 5.031 kHz | 6 | 12 | 16.7% | 0.096 MHz | 95.59% | 18 | 3220 | -106.4 dBm |
| **Group 2** | | | **Slot definition in DL and UL: AMC 1x6, 1 SC in 6 symbols** | | | | | | | | | |
| 0.200 MHz | 3 7/25 | 0.656 MHz | | 5.125 kHz | 6 | 12 | 33.3% | 0.190 MHz | 94.81% | 36 | 3280 | -103.3 dBm |
| 0.250 MHz | 3 7/25 | 0.820 MHz | | 6.406 kHz | 6 | 12 | 33.3% | 0.237 MHz | 94.81% | 36 | 4100 | -102.3 dBm |
| 0.300 MHz | 3 7/25 | 0.984 MHz | | 7.688 kHz | 6 | 12 | 33.3% | 0.284 MHz | 94.81% | 36 | 4920 | -101.5 dBm |
| **Group 3** | | | **Slot definition in DL and UL: AMC 1x6, 1 SC in 6 symbols, or AMC 2x3, 1 SC in 3 symbols** | | | | | | | | | |
| 0.350 MHz | 2 1/5 | 0.770 MHz | | 6.016 kHz | 6 | 12 | 50.0% | 0.331 MHz | 94.53% | 54 | 3850 | -100.8 dBm |
| 0.400 MHz | 2 1/5 | 0.880 MHz | | 6.875 kHz | 6 | 12 | 50.0% | 0.378 MHz | 94.53% | 54 | 4400 | -100.3 dBm |
| 0.450 MHz | 2 1/5 | 0.990 MHz | | 7.734 kHz | 6 | 12 | 50.0% | 0.425 MHz | 94.53% | 54 | 4950 | -99.8 dBm |
| 0.500 MHz | 2 1/5 | 1.100 MHz | | 8.594 kHz | 6 | 12 | 50.0% | 0.473 MHz | 94.53% | 54 | 5500 | -99.3 dBm |
| **Group 4** | | | **Slot definition in DL and UL: AMC 1x6, 1 SC in 6 symbols, or AMC 2x3, 1 SC in 3 symbols** | | | | | | | | | |
| 0.550 MHz | 1 3/25 | 0.616 MHz | | 4.813 kHz | 3 | 6 | 100% | 0.525 MHz | 95.38% | 108 | 3080 | -98.8 dBm |
| 0.600 MHz | 1 3/25 | 0.672 MHz | | 5.250 kHz | 3 | 6 | 100% | 0.572 MHz | 95.38% | 108 | 3360 | -98.4 dBm |
| 0.650 MHz | 1 3/25 | 0.728 MHz | | 5.688 kHz | 3 | 6 | 100% | 0.620 MHz | 95.38% | 108 | 3640 | -98.1 dBm |
| 0.700 MHz | 1 3/25 | 0.784 MHz | | 6.125 kHz | 3 | 6 | 100% | 0.668 MHz | 95.38% | 108 | 3920 | -97.8 dBm |
| 0.750 MHz | 1 3/25 | 0.840 MHz | | 6.563 kHz | 3 | 6 | 100% | 0.715 MHz | 95.38% | 108 | 4200 | -97.5 dBm |
| 0.800 MHz | 1 3/25 | 0.896 MHz | | 7.000 kHz | 3 | 6 | 100% | 0.763 MHz | 95.38% | 108 | 4480 | -97.2 dBm |
| 0.850 MHz | 1 3/25 | 0.952 MHz | | 7.438 kHz | 3 | 6 | 100% | 0.811 MHz | 95.38% | 108 | 4760 | -96.9 dBm |
| 0.900 MHz | 1 3/25 | 1.008 MHz | | 7.875 kHz | 3 | 6 | 100% | 0.858 MHz | 95.38% | 108 | 5040 | -96.7 dBm |
| 0.950 MHz | 1 3/25 | 1.064 MHz | | 8.313 kHz | 3 | 6 | 100% | 0.906 MHz | 95.38% | 108 | 5320 | -96.4 dBm |
| 1.000 MHz | 1 3/25 | 1.120 MHz | | 8.750 kHz | 3 | 6 | 100% | 0.954 MHz | 95.38% | 108 | 5600 | -96.2 dBm |
| 1.050 MHz | 1 3/25 | 1.176 MHz | | 9.188 kHz | 3 | 6 | 100% | 1.001 MHz | 95.38% | 108 | 5880 | -96.0 dBm |
| 1.100 MHz | 1 3/25 | 1.232 MHz | | 9.625 kHz | 3 | 6 | 100% | 1.049 MHz | 95.38% | 108 | 6160 | -95.8 dBm |
| 1.150 MHz | 1 3/25 | 1.288 MHz | | 10.063 kHz | 3 | 6 | 100% | 1.097 MHz | 95.38% | 108 | 6440 | -95.6 dBm |
| 1.200 MHz | 1 3/25 | 1.344 MHz | | 10.500 kHz | 3 | 6 | 100% | 1.145 MHz | 95.38% | 108 | 6720 | -95.4 dBm |

1. Must comply with spectral mask for OOBE (FCC part 27) – need to validate
2. Defined as: -174dBm/Hz + NF + Implementation Loss + SNR + 10Log(occupied BW in Hz), where NF= 8dB, ImpLoss = 5dB, and SNR for BER<10-6 = 5dB (per 8.4.14.1.1)