100 LEVEL 1

Editor: this header only appears here to set number "100" and is not to be included.

100.2 Level two

Editor: this header only appears here to set number "2" and is not to be included.

Change Subclause 100.2.9 to the following. Remove all previous subclause headers under 100.2.9:

100.2.9 CNU transmitter requirements

100.2.9.1 Burst timing convention

The start time of an OFDMA transmission by a CNU is referenced to an OFDMA Superframe boundary that begins with a Probe region (5 or 6 OFDMA symbols) followed by 256 OFDMA symbols. The 256 OFDMA symbols are divided into 32 8-symbol Resource Blocks, or 16 16-symbol Resouce Blocks, as configured. See subclause x.x.x.x.

The upstream time reference is defined as the first sample of the first symbol of an OFDMA Superframe, pointed to by the dashed arrow of Figure 7-16. The parameter N_{FFT} refers to the length of the FFT duration of 4096, and the parameter N_{CP} is the length of the configurable cyclic prefix. The sample rate is 204.8 Msamples per second.

The upstream time reference for construction of each OFDMA symbol is defined as the first sample of each FFT duration of each OFDMA symbol, pointed to by the dotted arrow of Figure 7-16.

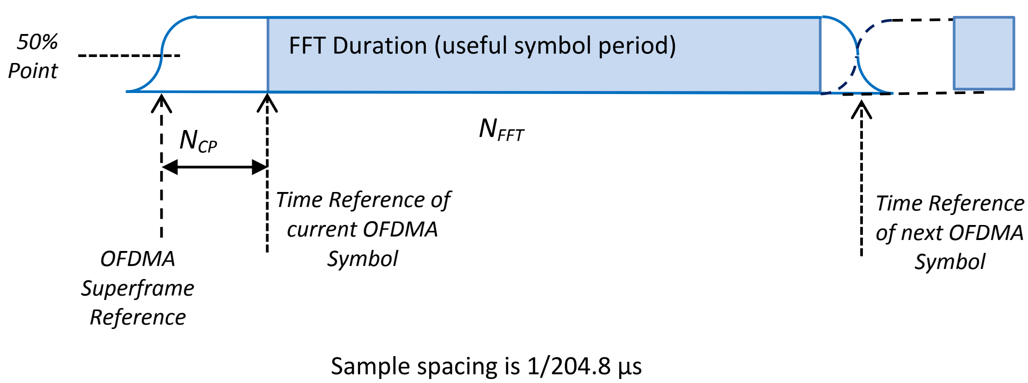

Figure 7-1 - Time references for OFDMA symbol and Superframe

100.2.9.2 Fidelity requirements

The channel power is defined as the average power when the channel is fully granted. The normalized channel power of an OFDMA channel is the average power of the OFDMA subcarriers in 1.6 MHz bandwidth with no exclusions. This normalized channel power of an OFDMA channel is denoted as $P_{1.6}$.

100.2.9.3 Transmit power requirements

The transmit power requirements are a function of the occupied bandwidth of the OFDMA channel.

The maximum value of the total power output of the CNU P_{max} is at least 65 dBmV.

For the upstream OFDMA channel:

$$N_{eq} = \text{ceil}(BW_{OFDMA} / 1.6)$$

BW_{OFDMA} (MHz) is the sum of the bandwidth of the modulated spectrum of the OFDMA channel.

Maximum equivalent channel power ($P_{1.6Max}$) is calculated as:

$$P_{1.6Max} = P_{max} \text{ dBmV} - 10\log_{10}(N_{eq}).$$

The CLT shall limit the commanded $P_{1.6Max}$ to no more than 53.2 dBmV+ (P_{max} - 65) if the bandwidth of the modulated spectrum is ≤ 24 MHz. This enforces a maximum power spectral density of P_{max} dBmV per 24 MHz.

The minimum equivalent channel power ($P_{1.6Min}$) for OFDMA channels is 17 dBmV.

During PHY Discovery ranging and before completion of Fine Ranging, a CNU shall initiate communications starting from lowest power. Note therefore that transmissions may use power per subcarrier which is as much as 9 dB lower than indicated by $P_{1.6Min}$ during PHY Discovery and Fine Ranging.

100.2.9.4 OFDMA transmit power calculations

In OFDMA mode the CNU determines its target transmit normalized channel power $P_{1.6t}$, as follows:

$P_{1.6r}$ = reported power level (dBmV) of CNU for the channel.

The CNU updates its reported power per channel in each channel by the following steps:

1. $P_{1.6r} = P_{1.6r} + \Delta P$ //Add power level adjustment to reported power level.
   The CLT SHOULD ensure the following:
2. $P_{1.6r} \leq P_{1.6Max}$ //Clip at max power limit
3. $P_{1.6r} \geq P_{1.6Min}$ //Clip at min power limit per channel.

The CNU then transmits each data subcarrier with target power:

$$P_{t\_sc\_i} = P_{1.6r} + \text{Pre-Eq}_i - 10 \log_{10}(32)$$

where Pre-Eq_i is the magnitude of the i^{th} subcarrier pre-equalizer coefficient (dB) and 32 is the number of subcarriers in 1.6 MHz.

That is, the reported power, normalized to 1.6 MHz, minus compensation for the pre-equalization for the subcarrier, less a factor taking into account the number of subcarriers in 1.6 MHz.

The modem transmit power, P_t, in a frame is the sum of the individual transmit powers P_{t,sc_i} of each subcarrier where the sum is performed using absolute power quantities [non-dB domain].

The transmitted power level varies dynamically as the number and type of allocated subcarriers varies.

100.2.9.5 OFDMA fidelity requirements

100.2.9.5.1 Spurious emissions

The noise and spurious power generated by the CNU shall now exceed the levels given in Table 7–6, Table 7–7, and Table 7–8. Up to five discrete spurs can be excluded from the emissions requirements listed in Table 7–6, Table 7–7 and Table 7–8 and have to be less than -42 dBc relative to a single subcarrier power level.

SpurFloor is related to the ratio of the number of subcarriers being modulated by a CNU is an OFDMA symbol to the maxiumum number of subcarriers available (3840) including guardbands. Let N_{S_Max} be the number of modulated subcarriers in an OFDMA symbol:

$$\text{SpurFloor} = \max\{ -57 + 10*\log_{10}(N_{S\_Max} / 3840), -60\} \text{ dBc}$$

Maximum number of simulatenous transmitters is defined as:

$$N_{T\_MAX} = \text{Floor}\{ 0.2 + 10\char`^((-44 - \text{SpurFloor})/10) \}$$

Under-grant Hold Bandwidth (number of subcarriers) is defined as:

$$\text{Under-grant Hold Bandwidth} = N_{S\_Max} / N_{T\_MAX}$$

NOTE: need to redefine in EPoC upstream terms or remove.

When a modem is transmitting with fewer subcarriers than the Under-grant Hold Bandwidth the spurious emissions requirement limit is the power value (in dBmV), corresponding to the specifications for the power level associated with a grant number of subcarriers equal to Under-grant Hold Bandwidth. In addition, when a modem is transmitting such that the total power of the modem, P_t, is less than 17 dBmV, but other requirements are met, then the modem spurious emissions requirements limit is the power value (in dBmV) computed with all conditions and relaxations factored in, plus an amount X dB where:

$$X \text{ dB} = 17 \text{ dBmV} - P_t$$

In Table 7–6, inband spurious emissions includes noise, carrier leakage, clock lines, synthesizer spurious products, and other undesired transmitter products. It does not include ISI. The measurement bandwidth for inband spurious for OFDM is equal to the Subcarrier Clock Frequency (50 kHz) and is not a synchronous measurement. The signal reference power for OFDMA inband spurious emissions is the total transmit power measured and adjusted (if applicable) as described in Section 7.4.13.5, and then apportioned to a single data subcarrier.

The measurement bandwidth is 160 kHz for the Between Bursts specs of Table 7–6, except where called out as 4 MHz or 250 kHz..

The signal reference power for Between Bursts transmissions is the reported power as in Section 7.4.13.3.

The Transmitting Burst specs apply during the transmission of Resource Blocks and for 20 µs before the first symbol of the OFDMA transmission and for 20 µs after the last symbol of an OFDMA transmission. The Between Bursts specs apply except during transmisson of Resource Blocks and for 20 µs before the first symbol of the OFDMA transmission and for 20 µs after the last symbol of an OFDMA transmission. The signal reference power for Transmitting Burst transmissions, other than inband, is the total transmit power measured and adjusted (if applicable) as described in this subsection.

For the purpose of spurious emissions definitions, a granted burst refers to a burst of resource blocks to be transmitted at the same time from the same CNU;.

For PHY Discover Ranging and before completion of Fine Ranging, spurious emissions requirements use Table 7–6, Table 7–7; and Table 7–8, with 100% Grant Spectrum equal to the bandwidth of the modulation spectrum of the transmission.

Spurious emissions requirements for transmission of N_{S_Max} / 10 or fewer subcarriers may be relaxed by 2 dB in an amount of spectrum equal to:

measurement BW * ceil(10% modulated spectrum / measurement BW)

anywhere in the whole upstream spectrum for emission requirements specified in Table 7–7 for Table 7–8.

A 2 dB relief applies in the measurement bandwidth. This relief does not apply to between bursts emission requirements.

Table 7–1 - Spurious emissions

[EPOC: this table is TBD for now, will be provided during comment round, Draft 1.2]

100.2.9.5.2Spurious emissions in the upstream frequency range

Table 7–7 lists the required spurious level in a measurement interval. The initial measurement interval at which to start measuring the spurious emissions (from the transmitted burst's modulation edge) is 400 kHz from the edge of the transmission's modulation spectrum. Measurements should start at the initial distance and be repeated at increasing distance from the carrier until the upstream band edge or spectrum adjacent to other modulated spectrum is reached.

For OFDMA transmissions with non-zero transmit windowing, the CNU shall meet the required performance measured within the 2.0 MHz adjacent to the modulated spectrum using slicer values from a CLT burst receiver or equivalent, synchronized to the downstream transmission provided to the CNU.

In the rest of the spectrum, the CNU shall meet the required performance measured with a bandpass filter (e.g., an unsynchronized measurement).

For OFDMA transmissions with zero transmit windowing, CNU shall meet the required performance using synchronized measurements across the complete upstream spectrum.

For legacy transmissions, the measurement is performed in the indicated bandwidth and distance from the transmitted legacy channel edge.

Spurious emissions allocation for far out spurious emissions =

Round{ SpurFloor + 10*$\log_{10}$(Measurement bandwidth/Under-grant hold Bandwidth),0.1}.

For transmission bursts with modulation spectrum less than the Under-grant Hold Bandwidth, the spurious power requirement is calculated as above, but increased by 10*$\log_{10}$ (Under-grant Hold Bandwidth/Grant Bandwidth).

Table 7–2 - Spurious emissions requirements in the upstream frequency range for grants of under-grant hold bandwidth and larger[1]

100% Grant Spectrum (MHz)	SpurFloor (dBc)	Under-grant Hold #Users	Under-grant Hold Bandwidth (MHz)	Measurement Bandwidth (MHz)[2]	Specification in the Interval (dBc)
Up to 64	-60.0	40	100% Grant Spectrum/40	1.6	Round{ SpurFloor + 10*$\log_{10}$(Measurement Bandwidth/Under-grant Hold Bandwidth),0.1}
[e.g., 22 MHz]			[0.55 MHz]		[-55.4]
[e.g., 46 MHz]			[1.15 MHz]		[-58.6]
Greater than 64, up to 96	-60.0	40	100% Grant Spectrum/40	3.2	Round{ SpurFloor + 10*$\log_{10}$(Measurement Bandwidth/Under-grant Hold Bandwidth),0.1
[e.g., 94 MHz]			[2.35 MHz]		[-58.7]
Greater than 96, up to 192	max{ -57 + 10*$\log_{10}$(100% Grant Spectrum/192 MHZ), -60}	Floor{ 0.2 + 10^((-44 - SpurFloor)/10) }	100% Grant Spectrum)/(Under-grant Hold Number of Users)	9.6	Round{ SpurFloor + 10*$\log_{10}$(Measurement Bandwidth/Under-grant Hold Bandwidth),0.1}
[e.g.,142 MHz]	[-58.3]	[27]	[5.3]		[-55.7]

100% Grant Spectrum (MHz)	SpurFloor (dBc)	Under-grant Hold #Users	Under-grant Hold Bandwidth (MHz)	Measurement Bandwidth (MHz)[2]	Specification in the Interval (dBc)
[e.g., 190 MHz]	[-57.0]	[20]	[9.5]		[-57.0]
Greater than 192 [e.g., 200 MHz]	max{ -57 + 10*$\log_{10}$(100% Grant Spectrum/192 MHZ), -60} [-56.8]	Floor{ 0.2 + 10^((-44 - SpurFloor)/10) } [19]	100% Grant Spectrum)/(Under-grant Hold Number of Users) [10.5]	12.8	Round{ SpurFloor + 10*$\log_{10}$ (Measurement Bandwidth/Under-grant Hold Bandwidth),0.1} [-55.9]

Note 1 Spurious Emissions Requirements in the Upstream Frequency Range Relative to the Per Channel Transmitted Burst Power Level for Each Channel for Grants of Under-grant Hold Bandwidth and Larger.

Note 2 The measurement bandwidth is a contiguous sliding measurement window.

The CNU shall control transmissions such that within the measurement bandwidth of Table 7–7, spurious emissions measured for individual subcarriers contain no more than +3 dB power larger than the required average power of the spurious emissions in the full measurement bandwidth. When non synchronous measurements are made, only 25 kHz measurement bandwidth is used.

100.2.9.5.3Adjacent channel spurious emissions

Table 7–8 lists the required adjacent channel spurious emission levels when there is a transmitted burst with bandwidth at the Under-grant Hold Bandwidth. The measurement is performed in an adjacent channel interval of 400 kHz adjacent to the transmitted burst modulation spectrum. For OFDMA transmissions, the measurement is performed starting on an adjacent subcarrier of the transmitted spectrum (both above and below), using the slicer values from a CLT burst receiver or equivalent synchronized to the downstream transmission provided to the CNU. For legacy transmissions, the measurement is performed in an adjacent channel interval of 400 kHz bandwidth adjacent to the transmitted legacy channel edge.

Firstly, it should be noted that the measurement bandwidth for Table 7–8 is less than the measurement bandwidths in Table 7–7. Thus comparing the two tables in terms of the specification "dBc" values requires appropriate scaling. Secondly, Table 7–8 provides specification "dBc" only for grants of a specific amount for each row, while Table 7–7 provides "dBc" specification for grants of all sizes from the Under-grant Hold Bandwidth to 100%.

For transmission bursts with the number of Modulated Subcarriers less than the Under-grant Hold Bandwidth, the spurious power requirement is calculated as above, but increased by 10*$\log_{10}$(Under-grant Hold Bandwidth/ Modulated Subcarriers).

For transmission bursts with modulation spectrum greater than the Under-grant Hold Bandwidth, the spurious power requirement in the adjacent 400 kHz is calculated by converting the requirement to absolute power "dBmV" for a grant of precisely Under-grant Hold Bandwidth from Table 7–8, and similarly computing the absolute power "dBmV" from Table 7–7 for a grant equal to:

Modulated Subcarriers - The Under-grant Hold Bandwidth.

Then the absolute power calculated from Table 7–7 is scaled back in exact proportion of 400 kHz compared to the measurement bandwidth in Table 7–7. Then the power from Table 7–8 is added to the scaled apportioned power from Table 7–7 to produce the requirement for the adjacent 400 kHz measurement with a larger grant than the Under-grant Hold Bandwidth. The requirement for adjacent spurious power in adjacent 400 kHz is:

P1(Modulated Subcarriers – Under-grant Hold Bandwidth) = absolute power derived from Table 7–7	(dBmV)
P2(Under-grant Hold Bandwidth) = absolute power derived from Table 7–8	(dBmV)
$P1_{scaled}$ = P1 * (0.4 MHz)/(Measurement Bandwidth (MHz) used in Table 7–7)	(dBmV)
$P_{spec\_limit} = P1_{scaled} + P2$	(dBmV)

The CNU shall control transmissions such that within the measurement bandwidth of Table 7–8, spurious emissions measured for individual subcarriers contain no more than +3 dB power larger than the required average power of the spurious emissions in the full measurement bandwidth (assuming a synchronous measurement).

Table 7–3 - Adjacent channel spurious emissions requirements relative to the per channel transmitted burst power level for each channel

100% Grant Spectrum (MHz)	SpurFloor (dBc)	Under-grant Hold #Users	Under-grant Hold Bandwidth (MHz)	Measurement Bandwidth (MHz)	Specification in Adjacent 400 kHz With Grant of Under-grant Hold Bandwidth (dBc)
Up to 64	-60.0	40	100% Grant Spectrum/40	0.4 MHz	Round{10*log$_{10}$(((10^(SpurFloor/10)) + (10^(-57/10))) x(0.4 MHz/Under-grant Hold Bandwidth)),0.1}
[e.g., 22 MHz]			[0.55 MHz]		[-56.6]
[Ex: 46 MHz]			[1.15 MHz]		[-59.8]
Greater than 64, up to 96	-60.0	40	100% Grant Spectrum/40	0.4 MHz	Round{10*log$_{10}$(((10^(SpurFloor/10)) + (10^(-57/10))) x(0.4 MHz/Under-grant Hold Bandwidth)),0.1}
[Ex 94 MHz]			[2.35 MHz]		[-62.9]
Greater than 96	max{ -57 + 10*log$_{10}$(100% Grant Spectrum/192 MHZ), -60} Round nearest 0.1 dB	Floor{ 0.2 + 10^((-44 - SpurFloor)/10) }	100% Grant Spectrum)/Under-grant Hold Number of Users	0.4 MHz	Round{10*log$_{10}$(((10^(SpurFloor/10)) + (10^(-57/10))) x(0.4 MHz/Under-grant Hold Bandwidth)),0.1}
[e.g., 142 MHz]	[-58.3]	[27]	[5.3]		[-65.8]
[e.g., 190 MHz]	[-57.0]	[20]	[9.5]		[-67.7]
[e.g., 200 MHz]	[-56.8]	[19]	[10.5]		[-68.1]

100.2.9.5.4Spurious emissions during burst on/off transients

The CNU shall control spurious emissions prior to and during ramp-up, during and following ramp-down, and before and after a burst.

The CNU's on/off spurious emissions, such as the change in voltage at the upstream transmitter output, due to enabling or disabling transmission, shall be no more than 50 mV.

The CNU's voltage step shall be dissipated no faster than 4 µs of constant slewing. This requirement applies when the CNU is transmitting at +55 dBmV or more

At backed-off transmit levels, the CNU's maximum change in voltage shall decrease by a factor of 2 for each 6 dB decrease of power level, from +55 dBmV down to a maximum change of 3.5 mV at 31 dBmV and below. This requirement does not apply to CNU power-on and power-off transients.

100.2.9.6 MER requirements

Transmit modulation error ratio (TxMER or just MER) measures the cluster variance caused by the CNU during upstream transmission due to transmitter imperfections. The terms "equalized MER" and "unequalized MER" refer to a measurement with linear distortions equalized or not equalized, respectively, by the test equipment receive equalizer. The requirements in this section refer only to unequalized MER, as described for each requirement. MER is measured on each modulated data subcarrier and non-boosted pilot (MER is computed based on the unboosted pilot power) in a minislot of a granted burst and averaged for all the subcarriers in each minislot. MER includes the effects of Inter-Carrier Interference (ICI), spurious emissions, phase noise, noise, distortion, and all other undesired transmitter degradations with an exception for a select number of discrete spurs impacting a select number of subcarriers. MER requirements are measured with a calibrated test instrument that synchronizes to the OFDMA signal, applies a receive equalizer in the test instrument that removes MER contributions from nominal channel imperfections related to the measurement equipment, and calculates the value. The equalizer in the test instrument is calculated, applied and frozen for the CNU testing. Receiver equalization of CNU linear distortion is not provided; hence this is considered to be a measurement of unequalized MER, even though the test equipment contains a fixed equalizer setting.

100.2.9.6.1Definitions

The transmitted RF waveform at the F connector of the CNU (after appropriate down conversion) is filtered, converted to baseband, sampled, and processed using standard OFDMA receiver methods, with the exception that receiver equalization is not provided. The processed values are used in the following formula. No external noise (AWGN) is added to the signal.

The carrier frequency offset, carrier amplitude, carrier phase offset, and timing will be adjusted during each burst to maximize MER as follows:

- One carrier amplitude adjustment common for all subcarriers and OFDM symbols in burst.
- One carrier frequency offset common for all subcarriers resulting in phase offset ramping across OFDM symbols in bursts.
- One timing adjustment resulting in phase ramp across subcarriers.
- One carrier phase offset common to all subcarriers per OFDM symbol in addition to the phase ramp.

MER per RB is computed as follows:

$$\mathrm{RB_{MER}(dB)} = 10 \cdot \log_{10}\left(\frac{E_{avg}}{\left(\frac{1}{M}\sum_{k=1}^{M}\left|e_{j,k}\right|^{2}\right)}\right)$$

MER per burst is computed as follows:

$$\mathrm{BURST_{MER}(dB)} = \frac{1}{N}\sum_{j=1}^{N}\left(RB_{MER}(dB)\right)$$

where:

E_{avg} is the average constellation energy for equally likely symbols,

M is the number of symbols averaged, either 8 or 16,

N is the number of Resource Blocks in a burst,

$e_{j,k}$ is the error vector from the *j*th subcarrier in the burst and *k*th received symbol to the ideal transmitted QAM symbol of the appropriate modulation order.

A sufficient number of OFDMA symbols shall be included in the time average so that the measurement uncertainty from the number of symbols is less than other limitations of the test equipment.

MER with a 100% grant is defined as the condition when all OFDMA subcarriers are granted to the CNU.

MER with a 5% grant is defined as the condition when less than or equal to 5% of the available OFDMA subcarriers have been granted to the CNU.

100.2.9.6.2Requirements

Unless otherwise stated, the CNU shall meet or exceed the following MER limits over the full transmit power range, all modulation orders, all grant configurations and over the full upstream frequency range.

The following flat channel measurements with no tilt (Table 7–9) are made after the pre-equalizer coefficients have been set to their optimum values. The receiver uses best effort synchronization to optimize the MER measurement.

Table 7–4 - Upstream MER requirements (with pre-equalization)

Parameter	Value
MER (100% grant)	Each burst MER ≥ 44 dB [1]
MER (5% grant)	Each burst MER ≥ 50 dB [1]
Pre-equalizer constraints	Coefficients set to their optimum values

Table Notes:

Note 1 Up to 5 subcarriers within the entire upstream bandwidth with discrete spurs may be excluded from the MER calculation if they fall within transmitted bursts. These 5 spurs are the same spurs that may be excluded for spurious emissions and not an additional or different set.

The following flat channel measurements (Table 7–10) are made with the pre-equalizer coefficients set to unity and no tilt and the receiver implementing best effort synchronization. For this measurement, the receiver may also apply partial equalization. The partial equalizer must not correct for the portion of the CNU's time-domain impulse response greater than 200 ns or frequency-domain amplitude response greater than +1 dB or less than -3dB from the average amplitude. An additional 1 dB attenuation in the amplitude response is allowed in the upper 10% of the specified passband frequency. It is not expected that the partial equalizer is implemented on the CLT receiver. A partial equalizer could be implemented offline via commercial receivers or simulation tools.

Table 7–5 - Upstream MER requirements (no pre-equalization)

Parameter	Value
MER (100% grant)	Each burst MER ≥ 40 dB [1]
MER (5% grant)	Each burst MER ≥ 40 dB [1]
Pre-equalizer constraints	Pre-equalization not used

Table Notes:

Note 1 Up to 5 subcarriers within the entire upstream bandwidth with discrete spurs may be excluded from the MER calculation if they fall within transmitted bursts. These 5 spurs are the same spurs that may be excluded for spurious emissions and not an additional or different set.

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100.2.9.7 CNU transmitter output requirements

The CNU shall output an RF Modulated signal with characteristics delineated in Table 7–11.

Table 7–6 - CNU transmitter output signal characteristics

Parameter	Value
Frequency	5 MHz to 234 MHz. Equipment may be adapted to all or part of this frequency band to suit regional requirements. See subclause 10.2.7.2.
Signal Type	OFDMA
Maximum OFDMA Channel Bandwidth	192 MHz
Minimum OFDMA Occupied Bandwidth	10 MHz
Subcarrier Channel Spacing	50 kHz
FFT Size	4096; 3800 Maximum active subcarriers
Sampling Rate	204.8 MHz
FFT Time Duration	20 µs
Modulation Type	BPSK, QPSK, 8-QAM, 16-QAM, 32-QAM, 64-QAM, 128-QAM, 256-QAM, 512-QAM, 1024-QAM, 2048-QAM, 4096-QAM. See Table 100-xx.
Bit Loading	Constant for a given subcarrier (Resource Block) in a SuperFrame and adjusted by Resource Element for pilot use. See subclause 101.x.x.x.

Parameter	Value
Pilot Tones	3 pilot patterns for 8 symbol Resource blocks and 3 pilot patterns for 16 symbol Resource Blocks. See subclause 101.4.4.7.
Cyclic Prefix Options	Samples μsec 256 1.25 384 1.875 512 2.5 640 3.125 768 3.75
Windowing Size Options	Samples μsec 0 0 64 0.3125 128 0.6250 192 0.9375 256 1.2500 Raised cosine absorbed by CP
Level	CNU shall be capable of transmitting a total average output power of 65 dBmV
Output Impedance	75 ohms
Output Return Loss	> 6 dB 5 to f_{max} MHz (42/65/85/117/234 MHz)
Connector	F connector per [ISO/IEC-61169-24] or [SCTE 02]

Insert new subclause 100.2.10:

100.2.10 CLT receiver requirements

100.2.10.1 CLT receiver input power requirements

The CLT Upstream Demodulator shall operate with an average input signal level, including ingress and noise to the upstream demodulator, up to 31 dBmV.

The CLT shall be settable according to Table 7–12 for intended received power normalized to 6.4 MHz of bandwidth.

The CLT Upstream demodulator shall operate within its defined performance specifications with received bursts within the ranges defined in Table 7–12 of the set power.

Table 7–7 - Upstream channel demodulator input power characteristics

Modulation	Minimum Set Point	Maximum Set Point[1]	Range
QPSK	-4 dBmV	10 dBmV	-9 / +3
8-QAM	-4 dBmV	10 dBmV	-9 / +3
16-QAM	-4 dBmV	10 dBmV	-9 / +3
32-QAM	-4 dBmV	10 dBmV	-9 / +3
64-QAM	-4 dBmV	10 dBmV	-9 / +3
128-QAM	0 dBmV	10 dBmV	-9 / +3
256-QAM	0 dBmV	10 dBmV	-9 / +3
512-QAM	0 dBmV	10 dBmV	-3 / +3
1024-QAM	0 dBmV	10 dBmV	-3 / +3
2048-QAM	7 dBmV	10 dBmV	-3 / +3
4096-QAM	10 dBmV	10 dBmV	-3 / +3

Table Notes:

Note 1 With respect to 6.4 MHz

100.2.10.2 CLT receiver error ratio performance in AWGN channel

The required level for CLT upstream post-FEC error ratio is defined for AWGN as less than or equal to 10^{-6} PER (packet error ratio) with 1500 byte Ethernet MAC packets. This section describes the conditions at which the CLT is required to meet this error ratio.

Implementation loss of the CLT receiver shall be such that the CLT achieves the required error ratio when operating at a CNR as shown in Table 7–13, under input load and channel conditions as follows:

- A single transmitter, pre-equalized and ranged
- A single OFDMA 192 MHz channel, using all 3800 subcarriers.
- Ranging with same CNR and input level to CLT as with data bursts, and with 5-symbol probes.
- Any valid transmit combination (frequency, , transmit window, cyclic prefix, OFDMA frame length, Resource Block size pilot patterns, etc.) as defined in this specification.
- Input power level per constellation is the minimum set point as defined in Table 7-12.
- OFDMA phase noise and frequency offset are at the max limits as defined for the CLT transmission specification.
- Ideal AWGN channel with no other artifacts (reflections, burst noise, tilt, etc.).
- Large bursts consisting of several 1500 byte MAC packets.
- CLT is allowed to construct Grants according to its own scheduler implementation.

Table 7–8 - CLT minimum CNR performance in AWGN channel

Constellation	CNR[1,2] (dB)	Set Point[3]	Offset
QPSK	11.0	-4 dBmV	0 dB
8-QAM	14.0	-4 dBmV	0 dB
16-QAM	17.0	-4 dBmV	0 dB
32-QAM	20.0	-4 dBmV	0 dB
64-QAM	23.0	-4 dBmV	0 dB
128-QAM	26.0	0 dBmV	0 dB
256-QAM	29.0	0 dBmV	0 dB
512-QAM	32.5	0 dBmV	0 dB
1024-QAM	35.5	0 dBmV	0 dB
2048-QAM	39.0	7 dBmV	0 dB
4096-QAM	43.0	10 dBmV	0 dB

Table Notes:

Note 1 CNR is defined here as the ratio of average signal power in occupied bandwidth to the average noise power in the occupied bandwidth given by the noise power spectral density integrated over the same occupied bandwidth.

Note 2 Channel CNR is adjusted to the required level by measuring the source inband noise including phase noise component and adding the required delta noise from an external AWGN generator.

Note 3 With respect to 6.4 MHz