FullMAX Air Inetrface Parameters for Upper 700 MHz A Block v1.0

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This document describes the FullMAX Air Interface Parameters for operation in the Upper 700 MHz A Block.

The Upper 700 MHz A Block consists of two 1 MHz wide channels centered at 757.5 and 787.5 MHz. Operation in these channels is subject to the compliance with FCC Part 27.

Objectives:

1. Support fixed and mobile broadband services in a unified network. Applications include:
   - SCADA
   - AMI Backhaul
   - DA Applications
   - Mobile Workforce Management
   - Video surveillance

2. Support a Base Station (BS) service area of up to 40 miles
3. Non-line-of-sight
4. Support multi-sector and multi-cell deployments with a minimum of 3 orthogonal subchannels. A higher number of subchannels (e.g., 6 subchannels) is desired because it offers more reuse flexibility in case of interference.
5. Total throughput per sector up to 2 Mb/s
6. Latency requirements: one way latency of 10 ms for small packets

Considerations:

1. The services described above are all reverse asymmetrical, i.e., they require significantly more bandwidth in the uplink direction (from the remote station to the base station) than in the downlink direction (from the base station to the remote station). This implies the air interface should have flexibility in configuring the number of OFDMA symbols in the downlink subframe and in the uplink subframe (referred to as the DL: UL ratio) such that the capacity in the DownLink SubFrame (DLSF) is minimized and the capacity in the UpLink SubFarme (UL SF) is maximized.

2. As a consequence of the reverse asymmetrical traffic characteristics, Time Division Duplex (TDD) operation in both channels of the Upper 700 MHz A Block offers significant throughput advantages over Frequency Division Duplex (FDD).

3. Typical deployments may use 1 (omni), 2 or 3 sector towers. Depending on the type of deployment, it is desirable to support operation of a sector in any subset of downlink and uplink subchannels. For example, with 6

subchannels, if a re-use factor of 3 is sufficient for a specific deployment, it is desirable to support 2 downlink and 2 uplink subchannels in each sector.

4. A consumer market WiMAX system leverages the relatively large number of subchannels and the asymmetrical traffic characteristics (i.e., much higher throughput required in downlink than in uplink direction) to balance the CINR, i.e., the Base Station transmits at high power over the full channel while the Remote Stations transmit at a relatively low power over few sub-channels only. In the case of a relatively narrow channel, the number of subchannels used by the Base Station and by the Remote Stations is similar. A balanced system requires therefore the Remote Stations to be able to transmit at a similar power level as the Base Stations.

5. Support of 40 miles radius translates into a round trip delay of 430 µs. In order not to exceed the minimum necessary gaps overhead, the actual gaps should be configurable according to the longest distance in the system. The system should support however a maximal value of BS TTG = 430 µs plus the minimum required receive to transmit switching time.

6. The relatively narrow channel does not offer much benefit in frequency diversity. Continuous subcarriers per subchannel offer greater flexibility to reduce interference both in the transmit and receive directions.

7. Significant reduction in subcarrier spacing relative to the 10.94 KHz of the WiMAX standard is not recommended because it introduces Inter-Carrier Interference due to poor orthogonality. The main parameter effecting orthogonality performance is the accuracy of the oscillator. Orthogonality performance can be improved with a GPS synchronized oscillator at both the Base Station and Remote Stations. This consideration led to the adoption of the 128 FFT variant which was designed by WiMAX for 1.25 MHz wide channels.

8. The channel is relatively narrow and therefore a large number of pilots to measure the frequency response of the channel is not required. This consideration and the need to reduce overhead as much as possible, suggests that AMC permutation is better suited for this system than PUSC permutation in both the downlink and uplink directions. For example, a downlink PUSC system employs 4 pilots per sub-channels vs 2 pilots per sub-channel in AMC 2 X 3.

9. Efficient use of the Upper 700 MHz A Block requires alignment of all phases of communication into the same band, i.e., the downlink subframe, the uplink subframe, the preamble and the CDMA code should all employ the same set of subcarriers. One optional configuration of the FullMAX Air Interface is to disable preamble transmission at the Base Station and employ GPS at the remote Station to synchronize time (i.e., beginning of the TDD frame), and frequency.

10. Frame Duration: Some applications require very low latency and therefore a frame duration of 5 ms needs to be supported. On the other hand, delay tolerant applications may require high throughput which increases with the increase in frame duration due to the reduction in the per frame overhead and reduced fragmentation.

11. The use of multiple zones in downlink and uplink sub-frames offers the opportunity to create groups of Remote

Stations in the sector and optimize certain parameters for each of the groups. The downside however is the related inefficiency. It is recommended to maintain a single AMC zone in the downlink and in uplink directions.

12. Support of the FCC Part 27 emission mask requires attenuation at the edge of the channel exceeding 43 + 10 log (P) in dB where P is the transmit power in watts. For example, if the transmit power of the radio is 10 Watts, the attenuation at the edge of the channel should exceed 53 dB. The guard band required from the edge of the channel depends on the transmit power level required, the type of Power Amplifier used, the power back off and the performance of the Digital Pre-Distortion (DPD) mechanism. Price constraints may dictate the guard band size and therefore, it is recommended to use one of the following flexible solutions:
    - Allow for a configurable sampling clock which can be adjusted as needed to support the FCC Part 27 requirement
    - Use AMC 1 X 6 permutation (12 subchannels with 9 consecutive subcarriers per subchannel including one pilot) and remove subchannels on the edge to create the guard band needed

13. Maximization of throughput within 1 MHz wide channel is accomplished by:
    - Maximize FEC code in both the downlink and uplink.
    - Reduce per frame overhead by support of longer frame duration if the applications can sustain the latency.
    - Reduce 802.16 protocol overhead
    - Dynamic PHS

14. FEC code maximization:
    - Uplink CINR is maximized by maximizing the power transmitted by the Remote Stations. This is accomplished by reduction in the Base Station Receive gain subject to the Receive Power Density (RPD) constraints.

FullMAX Air Interface Parameters for Upper 700 MHz A Block

1. The following table the reduced DL MAP overhead version used by FullMAX relative to standard WiMAX:

S.NO	Features	As per Standard in bits	Compression in bits proposed	After compression in bits	Remarks
DL-MAP					
1	DL-MAP MMM	8	8	0	MAP Management Message (MMM)
2	Frame Duration Code (Needs to be added to MS Configuration file)	8	8	0	A – priori known by MS
3	Frame Number	24	8	16	16 bit Frame number after reduction
4	DCD Count	8	8	0	DCD Removed. A-Priori known to the MS.
5	BSID	48	48	0	A-Priori known to MS
6	Number Of OFDMA DL symbols	8	8	0	Present in MS Configuration file.
DL-MAP IE- If DIUC = 15 CID Switch IE					
1	DIUC	4	4	0	Needed for zone switch. We are doing single zone.
2	Extended DIUC	4	4	0	Needed for zone switch. We are doing single zone.
3	Length	4	4	0	Needed for zone switch. We are doing single zone.
DL-MAP IE - If DIUC between 0 to 12					
1	DIUC	4	0	4	
2	N_CID (Number of CIDs)	8	8	0	Not used by MS
3	CIDs (array of CIDs)	16	16	0	Not used by MS
4	Symbol Offset (Number of slots)	8	0	8	This field is replaced by number of slots. Slots allocation is continuous. First in frequency and then time
5	Subchannel Offset	6	6	0	
6	Boosting	3	3	0	Not used
7	No of Symbols	7	7	0	
8	No of Sub-channels	6	6	0	

9	Repetition	2	**2**	**0**	This field is removed by adding new DIUC value for QPSK ½ with repetition 2

- Reduced DL MAP Length = 2 bytes (Common DL MAP parameters) from 14.5 bytes so reduction by 12.5 bytes
- Reduced DL-MAP_IE Length = 1.5 bytes from 7.5 bytes so reduction by 6 bytes (per FEC code)

Reduced Minimum DLMAP Length =

DL MAP Length + Length of DL-MAP_IE (carrying ULMAP message) + PDU Overhead (CRC+GMH)
= 2 (14.5) bytes +1.5 (7.5) bytes + 10 bytes

= 13.5 (32) bytes

For worst case where 7 different types of FEC burst information is carried in DL-MAP.

7 Burst = Minimum DLMAP Length + 7 DL-MAP_IE
= 13.5 (32) + 7 *1.5 (7*7.5) bytes

= 24 (84.5) bytes so savings of 60.5 bytes

= 4 slots @ QPSK1/2 so saving of 11 slots

1. The following table describes the reduced UL MAP overhead version used by FullMAX relative to standard WiMAX:

S.NO	**Features**	**As per Standard in bits**	**Compression in bits proposed**	**After compression in bits**	**Remarks**
1	ULMAP MMM	8	8	0	Not used
2	Reserved + FDD Partition flag	8	8	0	
3	UCD Count	8	8	0	
4	Allocation Start Time	32	32	0	
5	Number Of OFDMA symbols	8	8	0	A –Priori known
ULMAP IE (common to all burst type)					
1	CID	16	8	8	
2	UIUC	4	0	4	
If UIUC = 12 IR / PR IE					
1	OFDMA Symbol Offset	8	8	0	By defining a unique unused UIUC for IR and PR and ensuring in UL scheduler that IR and PR both do not get scheduled in the same frame. There is no necessity to send geometry information. From UIUC, Remote Station MAC can derive the default geometry
2	Sub-channel Offset	7	7	0	
3	No of Symbols	7	7	0	
4	No of Sub-channels	7	7	0	
5	Ranging Method	2	2	0	
6	Ranging Indicator	1	1	0	
If UIUC = 13 PAPR IE					
1	OFDMA symbol offset	8	4	4	PAPR normally gets scheduled as first burst. If IR/PR is present, than it will be second burst. So we need to know only start symbols number. There is no necessity to send entire geometry information. From UIUC, Remote Station MAC can derive the default geometry
2	Sub-channel offset	7	7	0	
3	No. OFDMA symbols	7	7	0	
4	No. sub-channels/SZ Shift Value	7	7	0	
5	PAPR Reduction/Safety Zone	1	1	0	
6	Sounding Zone	1	1	0	
7	*Reserved*	1	1	0	

If UIUC = 1 to 8 DATA BURST IE					
1	Duration	10	**2**	**8**	The number of UL symbols per frame is restricted to 192 with the fullband allocation
2	Repetition coding indication	2	**2**	**0**	Removed by adding new UIUC value for QPSK ½ with repetition 2
If UIUC = 14 CDMA-ALLOC-IE					
1	Duration	6	**2**	**4**	9 slots are allocated for RNG-REQ message
2	UIUC	4	0	**0**	A-Priori known to the Remote Station.
3	Repetition Coding Indication	2	**2**	**0**	Is removed by adding new UIUC value for QPSK ½ with repetition 2
4	Frame Number Index	4	0	4	
5	Ranging Code	8	**4**	**4**	Restrict ranging code to 16 from 255.
6	Ranging Symbol	8	**8**	**0**	This is known at Remote Station
7	Ranging sub channel	7	**7**	**0**	This is known at Remote Station.
8	BW request mandatory	1	**1**	**0**	Not needed
If UIUC = 15 Extended UIUC for power control (We have changed UIUC =9)					
1	Extended UIUC	4	**4**	**0**	Employ an addition UIUC = 9 for power control.
2	Length	4	**4**	**0**	
3	Power Control	8	0	8	
4	Power Measurement Frame	8	**8**	**0**	

ULMAP size with 4 connected Remote Stations + Ranging allocation + CDMA alloc IE

For 1 IR/PR UL-MAP_IE + 4 data UL-MAP_IE + 1 CDMA-Alloc-IE =

Minimum ULMAP Length + 1 IR/PR UL-MAP_IE + 4 data UL-MAP_IE + 1 CDMA-Alloc-IE + PDU Overhead
= 0 byte (32 bytes) + 1.5 bytes (6.5 bytes) + 4* 2.5 bytes (4*4 bytes) + 3.5 bytes (7.5 bytes) + 10 bytes

= 25 bytes (72 bytes) so 47 bytes saving i.e. @ QPSK ½, 8 slots savings

- For common part 8 bytes saved compared to standard
- For data 1.5 bytes saved compared to standard
- For CDMA-Alloc IE 4 bytes saved compared to standard
- For IR/PR 5 bytes saved compared to standard
- For Power Control 3 bytes saved compared to standard
- For PAPR 4.5 bytes saved compared to standard

2. FullMAX Air Interface Parameters for Upper 700 MHz A Block

Nominal Channel Bandwidth	1 MHz Channel
Sampling frequency (MHz)	1.12 MHz
FFT size	128
Subcarrier spacing (kHz)	8.75 KHz
Subcarrier Allocation Scheme in downlink and in uplink	AMC 2 x 3 and AMC 1 x 6
Subchannels in downlink and in uplink	6 and 12
Actual Bandwidth (centered on nominal channel) for full channel	945 KHz
Actual Bandwidth (centered on nominal channel) for single subchannel with AMC 2 x 3	157.5 KHz (*)
Actual Bandwidth (centered on nominal channel) for single subchannel with AMC 1 x 6	78.75 KHz (*)
Preamble	Preamble Off or preamble transmitted within the actual bandwidth (**)
Frame Size (ms)	5, 10, 20, 25
Number of samples per frame	5600, 11,200, 22,400, 28,000
Number of symbols per frame	Up to 38 for 5 ms frame Up to 77 for 10 ms frame Up to 155 for 20 ms frame Up to 194 for 25 ms frame (***)
Number of samples per symbol	144
Symbol duration (µs)	128.57
Useful symbol duration (µs)	114.26
Slot definition in downlink and in uplink	AMC 2 x 3: 1 SC x 3 symbols AMC 1 x 6: 1 SC x 6 symbols
Duplexing Mode	TDD
Base Station TTG/Remote Station RTG duration	Configurable up to 482 samples (430 µs).
Base Station RTG	Configurable (e.g., 150 samples)

(*) The bandwidth for N consecutive subchannel is N * 157.5 KHz, N = 1…,6 for AMC 2x3 and N * 78.5 KHz for AMC 1X6.

(**) Preamble Off requires GPS synchronization at both Base Station and Remote Station.

(***) The actual number of symbols per frame depends on the gap duration which is configured to accommodate the distance.