Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**	
Title	**Sample Factor requirements of OFDM PHY for MMDS licensed spectrum**	
Date Submitted	**2004-01-14**	
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Re:	P802.16-REVd/D2-2003 and working group re-circulation Ballot #13a Announcement	
Abstract	The contribution identifies a problem and proposes a solution in the OFDM PHY sampling factor value with respect to meeting the mask for the MMDS licensed spectrum contained in P802.16-REVd/D2-2003	
Purpose	Error correction	
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IEEE 802.16-Revd OFDM PHY Sampling Factor Requirement for MMDS Subscriber Station

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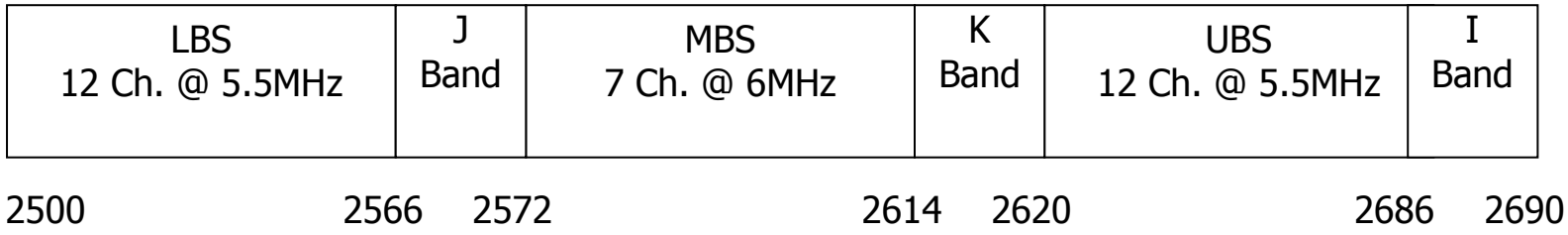
FCC Notice of Proposed Rulemaking (FCC 03-56) MMDS Band Plan



Proposed MMDS Band Plan

I band: 32 Ch. @ 125 kHz/Ch.
J band: 4 Ch. @ 1.5 MHz/Ch.
K Band: 4 Ch. @ 1.5 MHz/Ch.
LBS, and UBS bands: Low-power operation
MBS band: High-power operation
J and K Bands: Transition bands or Guard bands
I band: Narrow band auxiliary channels

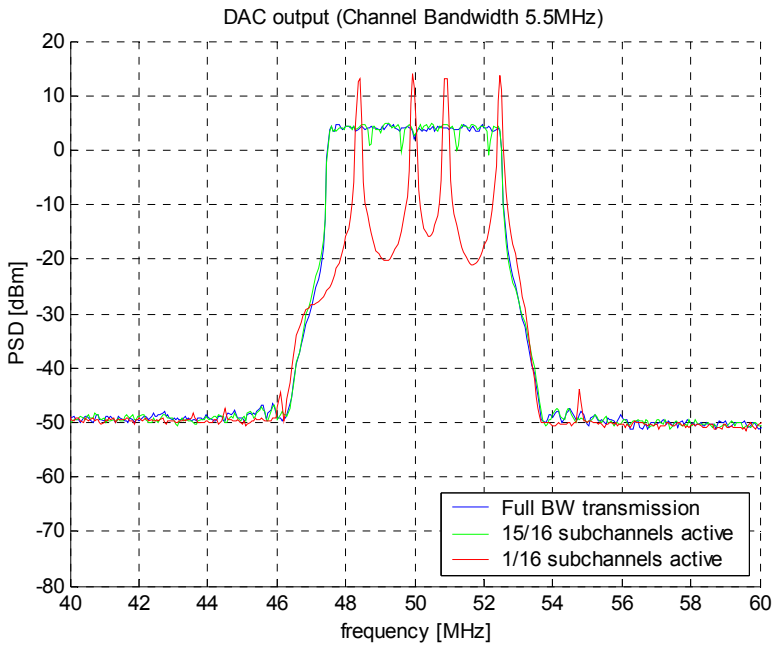
SUBSCRIBER STATION MASK PROPOSAL

- Assumptions:
  - Mask based on FCC Notice of Proposed Rulemaking, FCC 03-56, for the MMDS band
  - Mask for a channel bandwidth at the upper edge of Lower Band Segment, LBS, or lower edge of Upper Band Segment, UBS, of licensed MMDS band
  - Proposed MMDS mask units are absolute (dBm)
  - Default FFT sampling factor: 7/6
  - Default CP length: 256/32=8 samples
  - Total Output Power, TOP, is 24dBm
  - Transmit Effective number of bits, ENOB, is 9
  - Typical Noise from RFIC is included
  - No pre-distortion for PAR reduction
  - Results are presented at IF frequency of 50MHz
  - Rapp's model for Power Amplifier

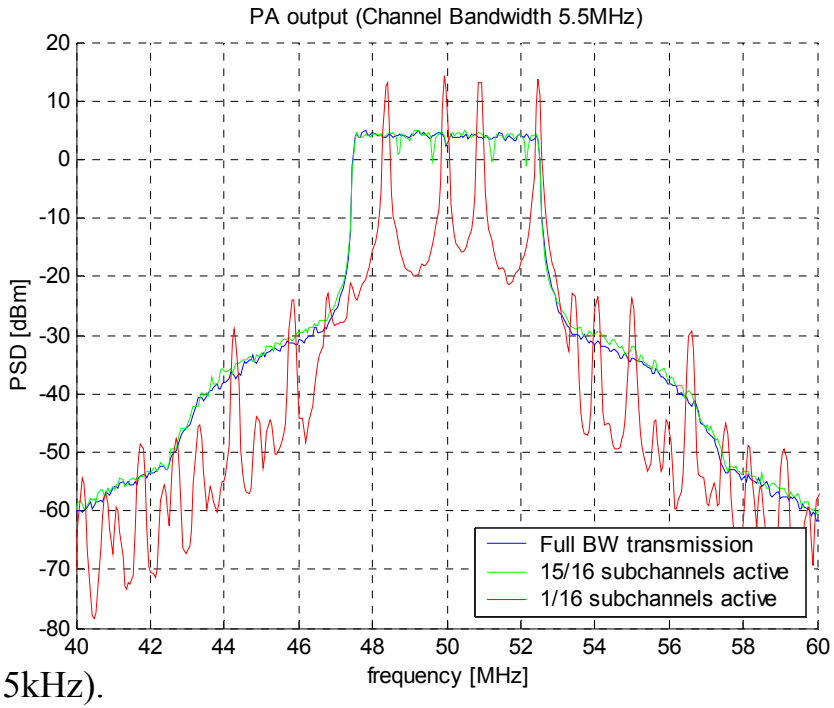
$$v_{OUT} = v_{IN} \Big/ \left(1 + \left(|v_{IN}| / v_{SAT}\right)^{2P}\right)^{1/(2P)}, P = 2$$

Channel Bandwidth 5.5 MHz – no change in integration BW

- DAC output



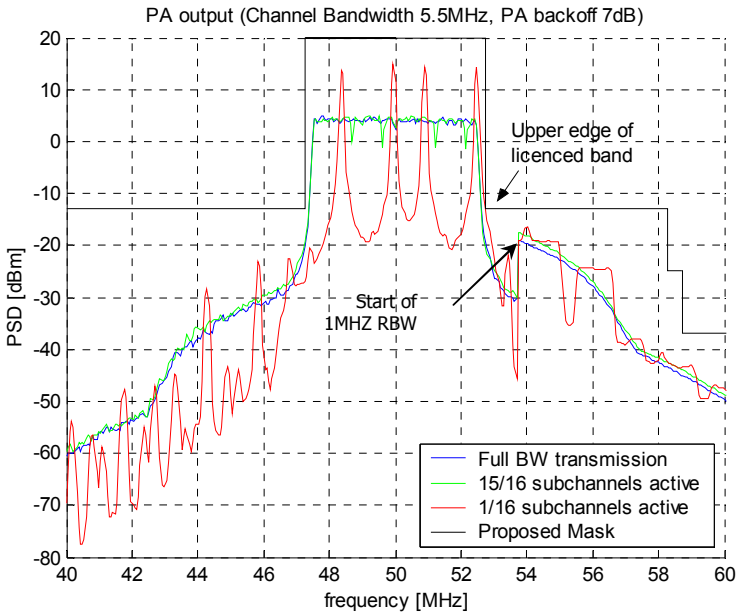
PA output



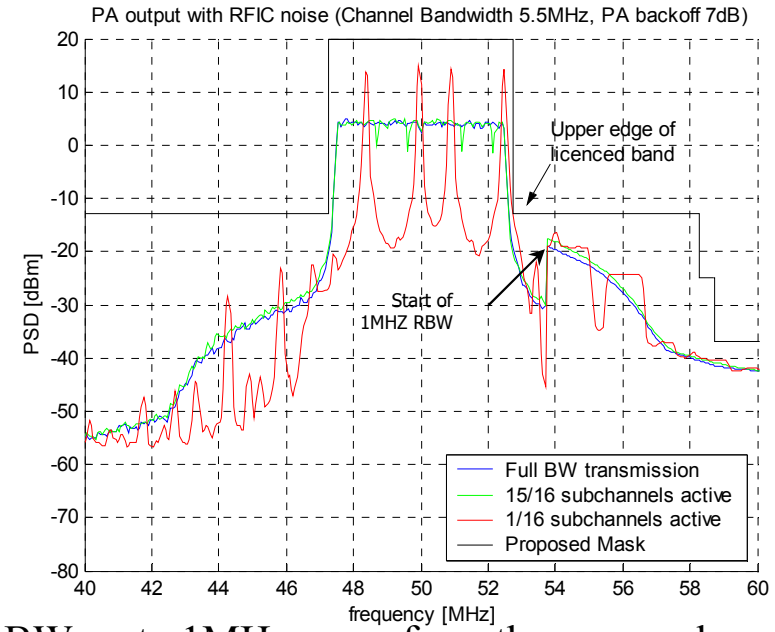
- Resolution bandwidth is 1% of channel bandwidth (55kHz).
- Total output power is held constant for any number of active subchannels - thus for n/16 subchannelization, active sub-channels are boosted by 16/n factor
  - Due to resolution of coarse integration bandwidth (~2x tone spacing), peaks of 1/16 subchannelization do not appear boosted by 10log10(16)=12dB
- Third order IM products of active subcarriers, cause prominent in-band and out-of-band peaks at discrete frequencies at the PA output for 1/16 subchannelization
- Small out-of-band peak at DAC output for 1/16 subchannelization is simulator related – but, its effect is negligible

Channel Bandwidth 5.5 MHz vs MASK

- PA output

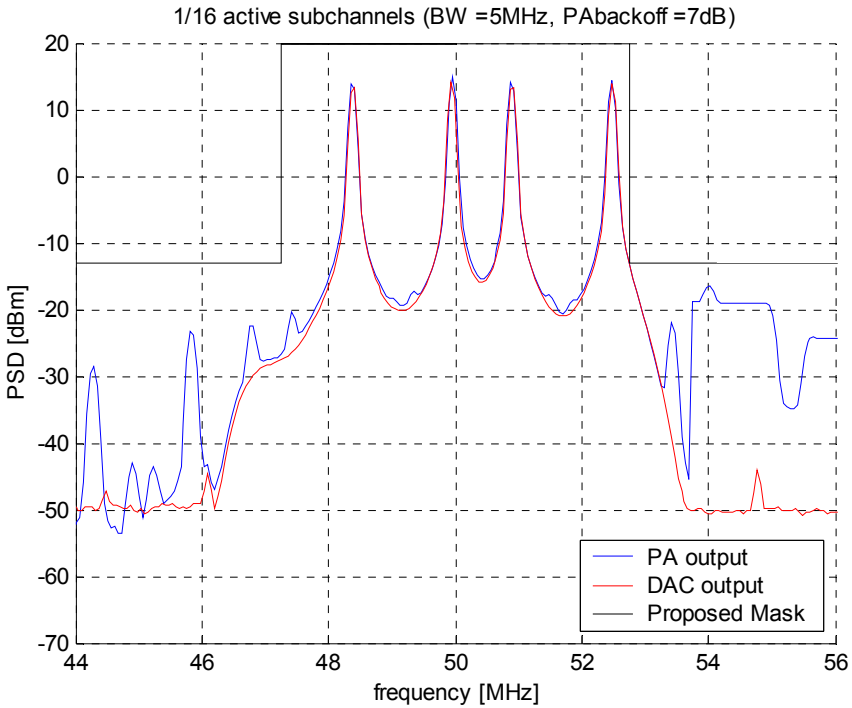


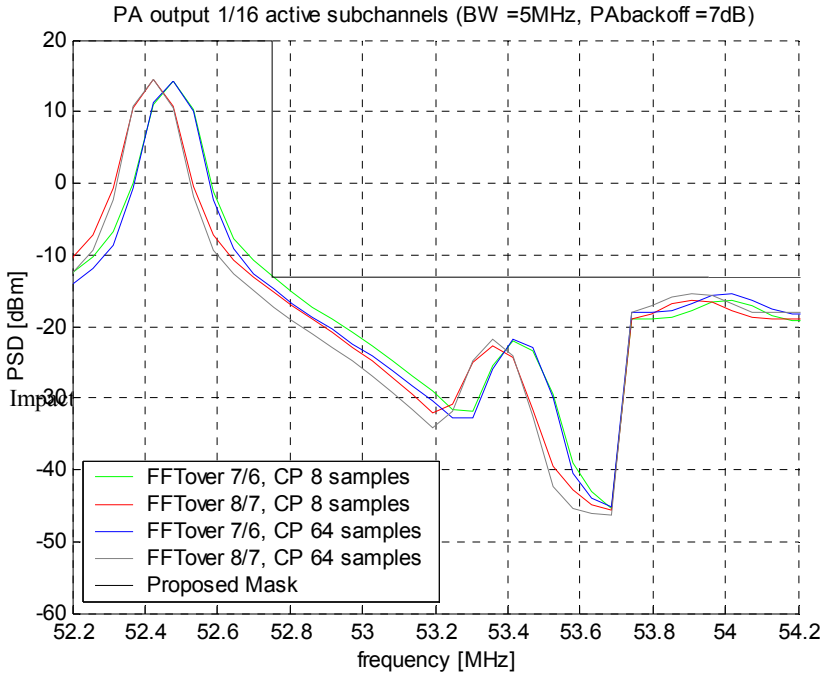
PA output with RFIC noise included



- Resolution bandwidth, RBW, is 1% of channel BW up to 1MHz away from the upper edge of used spectrum block, 1MHz otherwise
- Roll-off shape of sub-channelized transmission is preserved, but pulled up due to increase in individual sub-channel power
- In 1/16 sub-channelized mode no margin between edge of licensed band and transmit spectrum is available
- Meeting the mask in subchannelized mode limits TOP

Channel Bandwidth 5.5 MHz vs. sampling factor and CP length





- Transmit spectrum is limited by roll-off rather than PA spectral re-growth
- Reducing *sampling factor* from 7/6 to 8/7, brings in margin of ~50KHz, or equivalently, allows for increase in maximum TOP by ~2dB (8 tap window) or ~2.5dB (64tap window)
- Increasing *CP length* from minimum 8 to maximum 64 samples, brings in ~40KHz additional margin, or equivalently additional 1.5dB (FFTover 7/6) or 2dB (FFTover 8/7) in maximum TOP
- However, higher efficiency is preserved by changing FFT sampling factor, rather than increasing CP length. Changing sampling factor from 7/6 to 8/7 is a 2% decrease in occupied bandwidth.