Hopping localized transmission to improve UL transmit power

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Venue:

Call for Contributions on Project 802.16m Uplink Multiple Access

Base Contribution:

None.

Purpose:

For discussion

Introduction

- This contribution proposes a way to improve UL link budget by improvement of the TX power
- The information is provided for discussion only, as preparation for UL symbol structure discussions expected in next IEEE session

Link budget issue in the uplink

- From 802.16m SRD, section 7.4, Cell coverage:
  - ***"the link budget of the limiting link (e.g. DL MAP, UL bearer) of IEEE 802.16m shall be improved by at least 3 dB compared to the WirelessMAN-OFDMA Reference System."***
- One of the factors affecting UL link budget is the transmit power
- Mobile TX power is limited due to the following factors:
  - High PAPR - large variation of the of OFDM signal envelope
  - Non-linear "practical" power amplifier
  - Constraints
    - Out of band emission is limited by spectral mask (varies by regulation)
    - Minimum EVM is needed (in-band noise limitation), dending on MCS
    - PA may have power consumption limitation (in addition to peak power limitation)
- 802.16e OFDMA uplink performance is limited with respect to the downlink (TX power 23 dBm vs. 46 dBm, while maximum sub-channelization gain ~12 dB)
- <u>Maximum</u> TX power (of lowest rate) is limited by spectral mask requirement (since EVM requirement loosens for low rates)

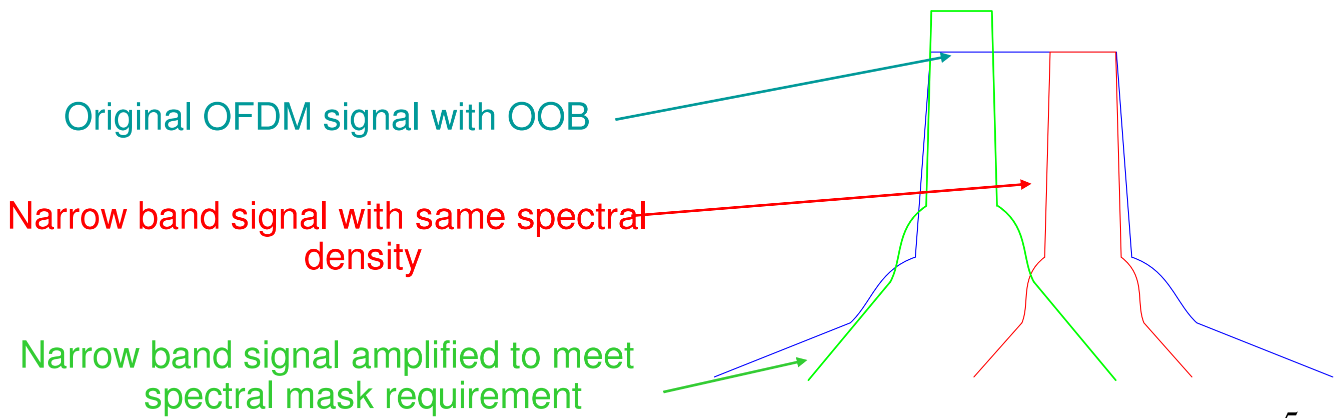
PAPR reduction methods

- PAPR reduction techniques improve peak power
- The actual performance gain from PAPR reduction methods like tone-reservation, tone-injection etc. is very small
- Reasons:
  - Improving the peak power doesn't have a 1:1 impact on the maximum TX power:
    - It has small effect on OOB and in-band distortion since most of them created by non-peak signal
    - EVM and OOB improvement relates in a ratio of approx 1:3 to TX power improvement (in dB)
    - For example ideally limiting the OFDM amplitude to 7dB has ~0.5dB gain in TX power (depending on model and mask)
  - These methods insert some overhead or loss in performance that balances some of the gain
- Clipping & filtering is an effective method to be applied in the transmitter and no standardization is needed for it, except correct definition of the EVM levels
- We propose to further improve the maximum TX power not by changing the signal amplitude distribution but by different use of the spectrum

=> "PAPR reduction" methods evaluation

Facing the spectral mask – localized-OFDMA

- Non-linear PA causes spectral expansion of the transmitted signal. Narrower signal's spectrum will cause narrower expansion.
- We suggest to allocate narrow localized chunk of subcarriers for power limited users
- This simple mechanism has very good performance, although it doesn't change the signal's PAPR.



Localized-OFDMA

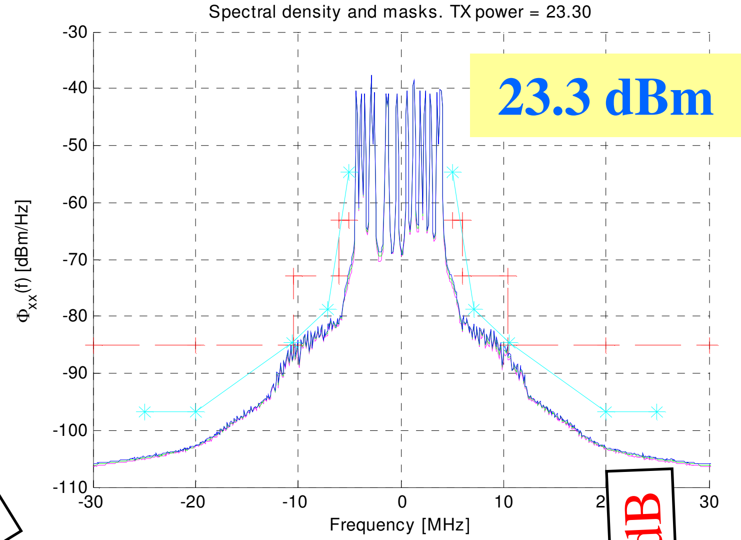
The following results show the gain obtained with actual OFDM signal and the following parameters:

PA model: RAPP-3

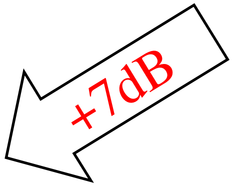
OFDM parameters: 10Mhz, FFT1024, wideband=PUSC 3 subchannels, narrowband = 72 subcarriers

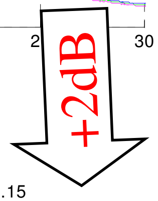
Mask: FCC & HUMAN

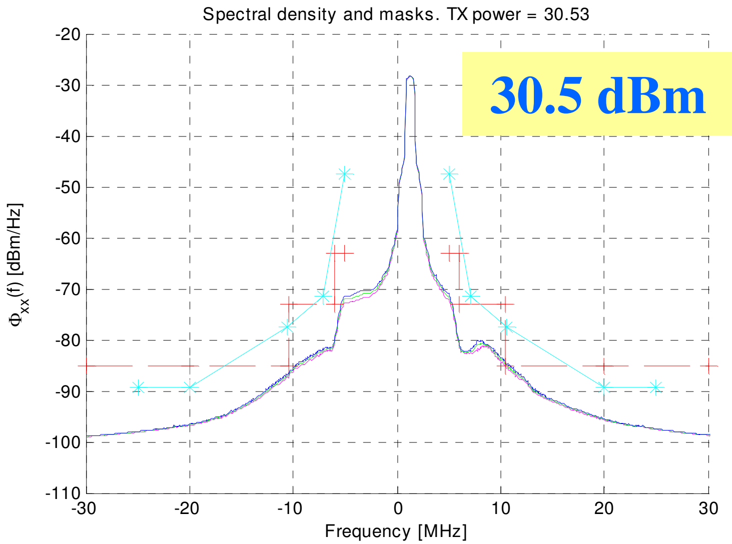
=> Spectral efficiency of localized OFDMA



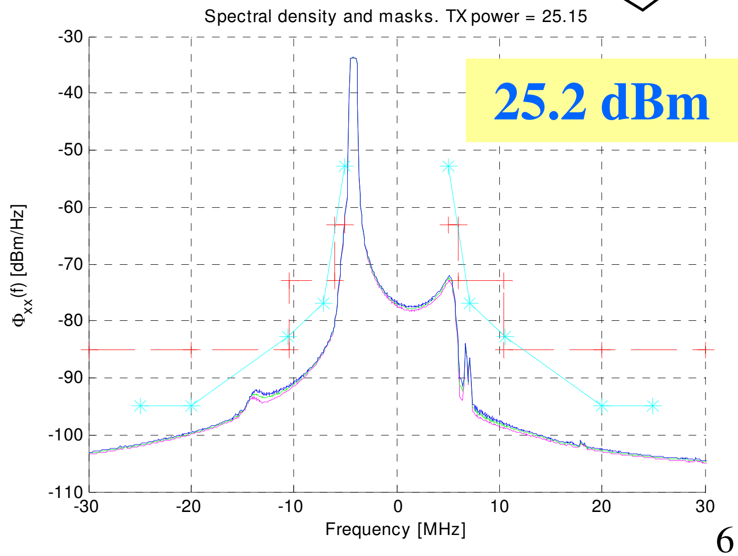
Wide-band OFDM signal







Narrow-band OFDM signal, band center



Narrow-band OFDM signal, band edge

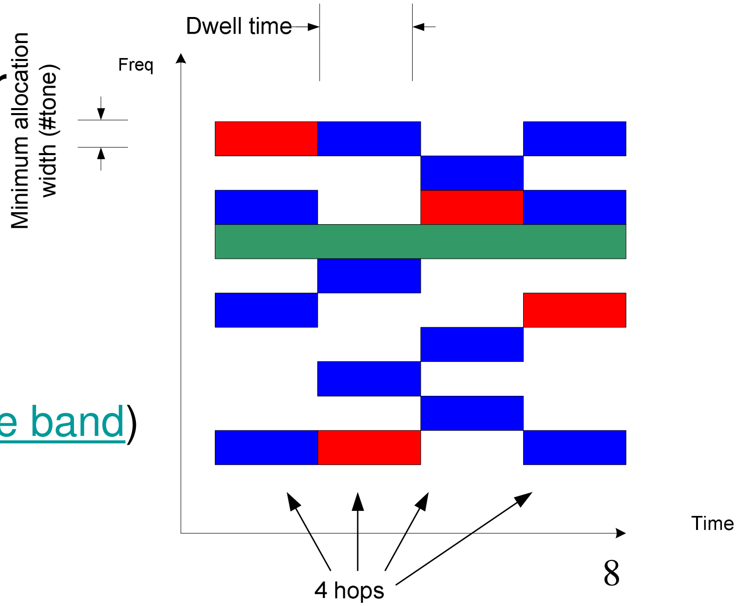
Adding frequency diversity by hopping

- For high mobility user the frequency diversity gain in MIMO 2x2 is ~6dB (PUSC versus AMC)
- In localized transmission we lose this diversity gain
- To combine the frequency diversity of UL-PUSC with power advantage of localized OFDMA, fast frequency hoping should be applied (e.g. hop duration of 2 symbols), therefore we propose **hopping localized** transmission
- On the other hand hopping localized requires continuous chunk of spectrum to be allocated to a single user which poses a limit on other users.
- Therefore we propose to limit this type of allocation to cell-edge (power and throughput limited) users

Hopping localized allocations

- We propose that a mix of three allocation types will be supported by the UL symbol structure:
  - Power limited diversity users: hoping localized (HL) allocation
  - Closed loop (low mobility) users: constant localized allocation ("AMC")
  - High throughput diversity users: distributed allocation (similar to UL-"PUSC")
- The power boosting in HL allocation can be a function of the location in the band (maximum power can be applied to ~80% of the band, lower power in the edges)

(See slide Localized gain as function of location in the band)



Dwell time tradeoffs

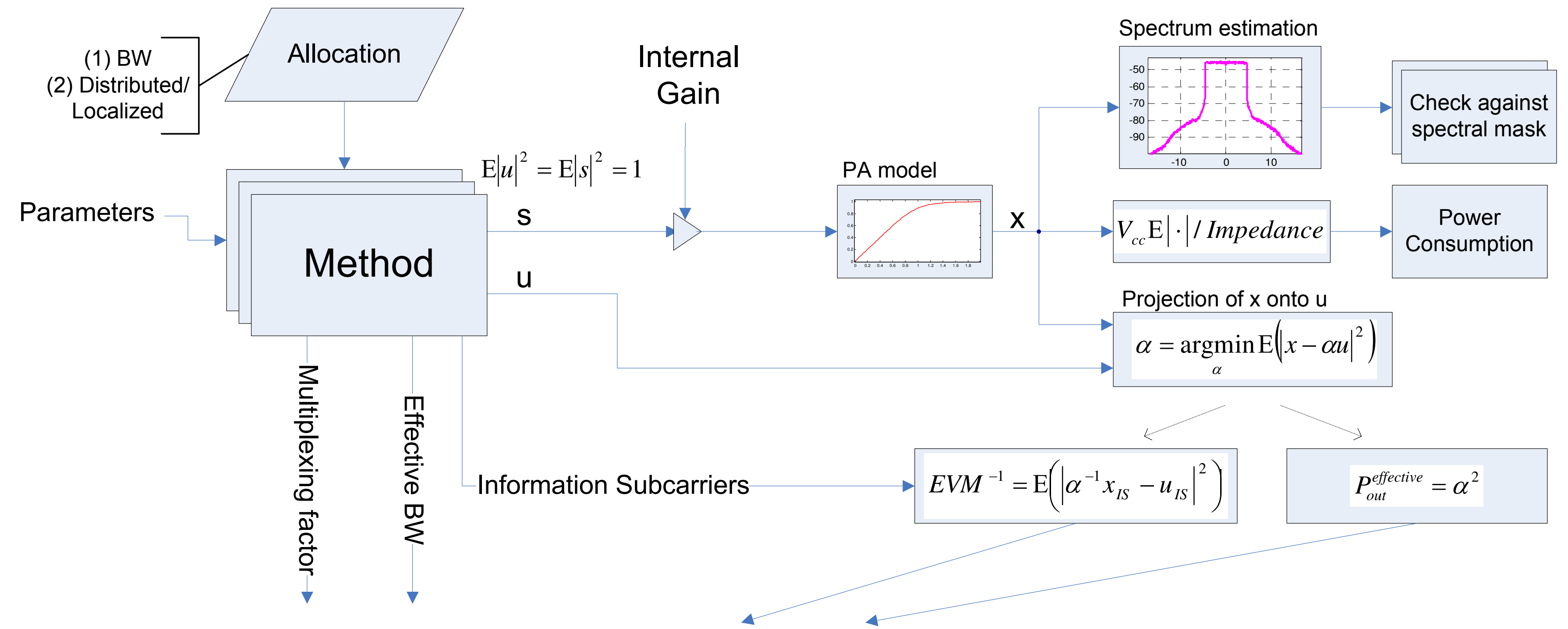
- The basic allocation unit is a time-frequency rectangle. It's size is affected by:
  - Large number of sub-carriers reduces the maximum sub-channelization gain, therefore span maximum time (e.g. 2 subframes) minimum frequency
  - Given the frequency width, the tradeoff on dwell time:
    - Small dwell time => more hops, more diversity
    - Large dwell time => higher pilot efficiency

- Recommended parameters:
  - A hop per 2 symbols yields an optimum point between pilot loss and diversity loss, assuming TTI=2 subframes
  - Having 6 hops within a frame yields reasonable frequency diversity (assuming interleaving over time).
  - Assuming UL transmission may span TTI=2 subframes, we assume 3 hops per subframe, i.e. hop every 2 symbols
  - This yields a tile of e.g. 9x2, 12x2 or 18x2 which has reasonable pilot efficiency

Backup

Methodology of transmission methods comparison

- Methodology
  - Generate sample signals
  - Compress them in PA model
  - Measure spectrum and EVM
  - Estimate performance and compare different methods:
    - Maximum TX power
    - EVM dependence on TX power
    - SE versus link margin



Performance approximation

$$FinalSNR = \frac{1}{\left(\frac{P_{out}^{effective} * loss}{N_0 * EffectiveBW * NF}\right)^{-1} + EVM^{-1}} * \mathrm{ImplementationLoss}$$

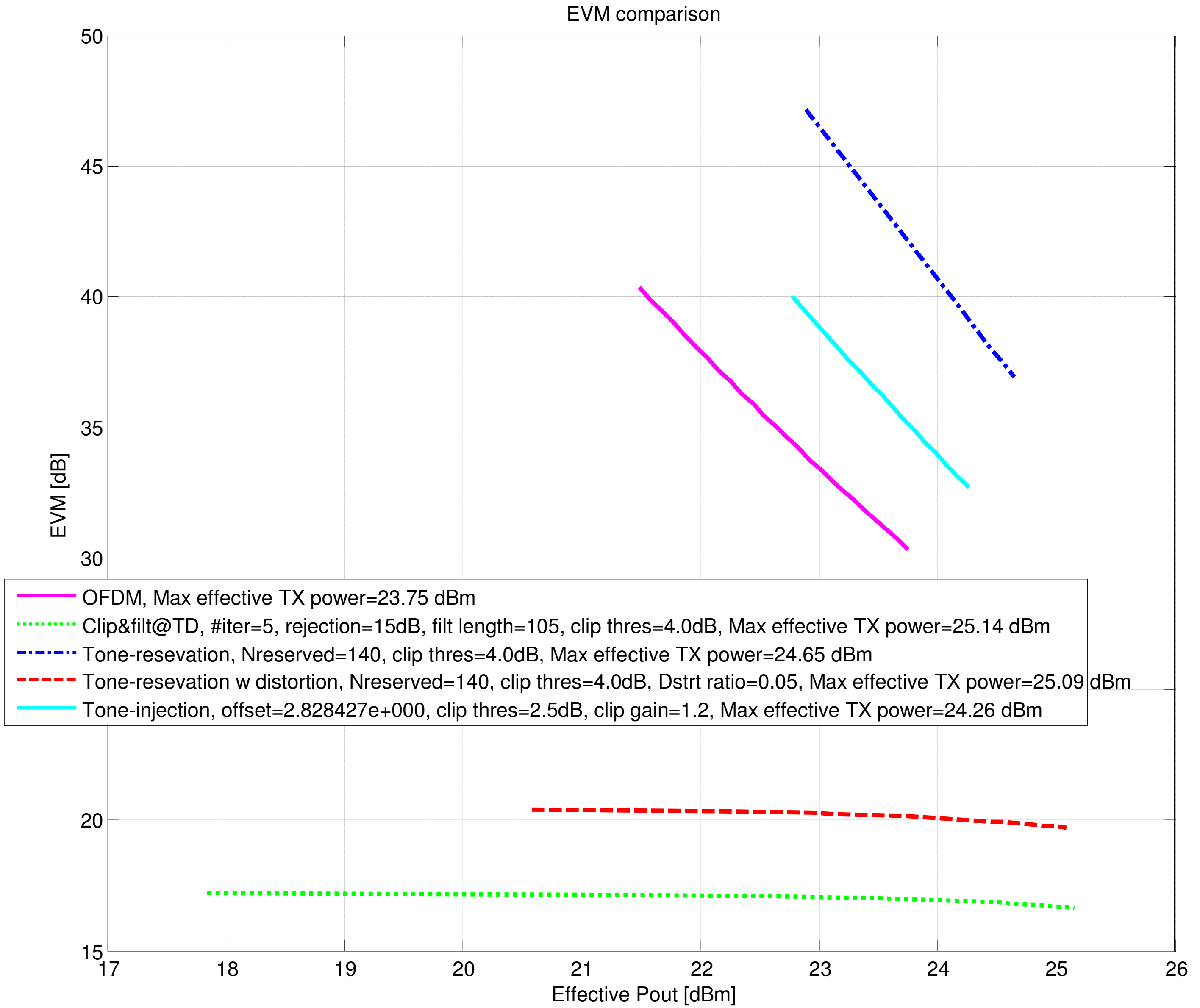
$$thput = \frac{EffectiveBW}{1 + CP} * \log_2(1 + FinalSNR)$$

$$SpectralEfficiency = MultiplexingFactor * thput / BW_{OFDM}$$

Fix allocation (approximately)
Loop over methods, and parameters
- Generate information signal (u)
- Generate TX signal (s)
- Loop over internal-gain
  - Calculate $P_{consumption}$, P_{out}, EVM
  - if spectral mask is violated
    - break
- end if, end loop
- Loop over "channel" loss
  - Maximize SpectralEfficiency over internal-gains

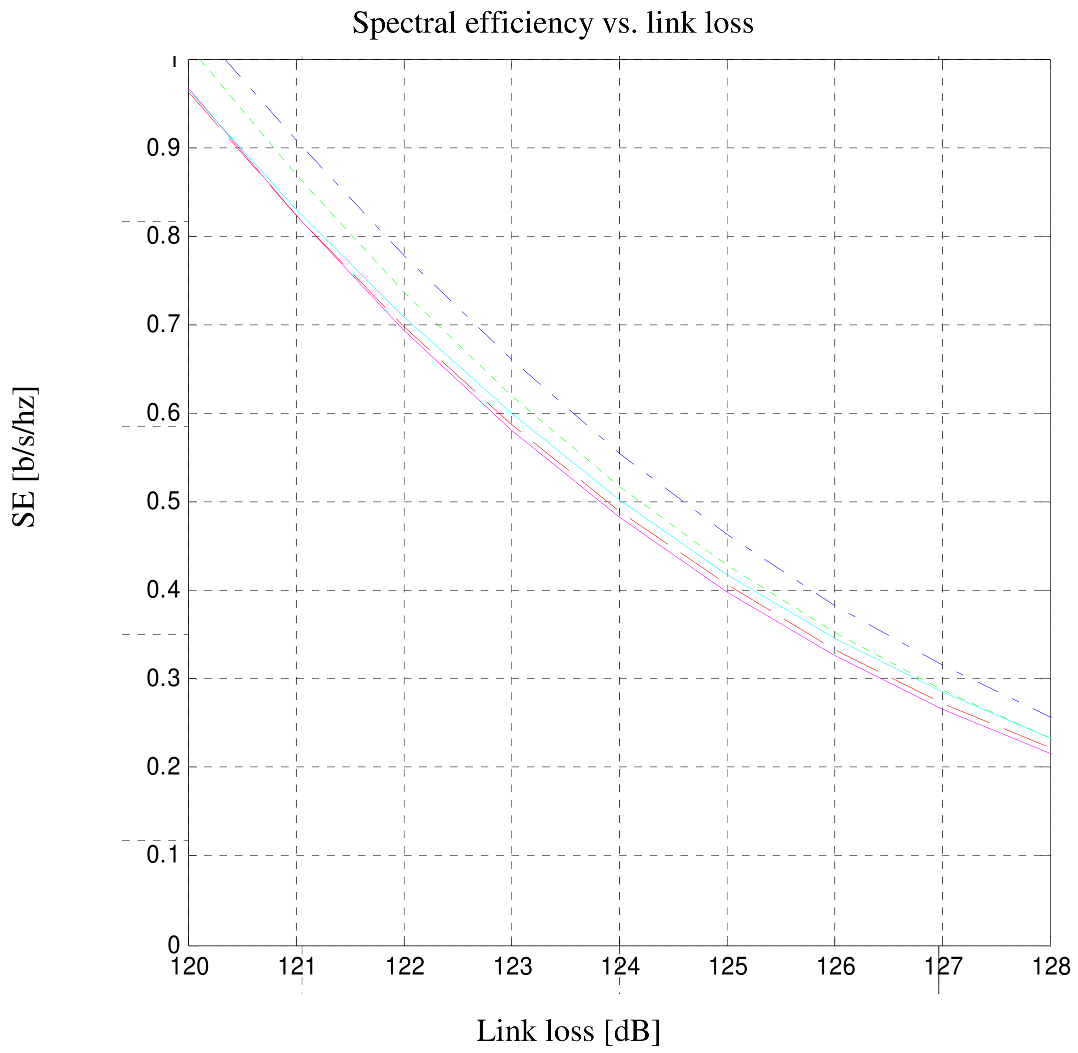
End loop, End loop
Plot SpectralEfficiency vs. loss

“PAPR reduction” methods evaluation

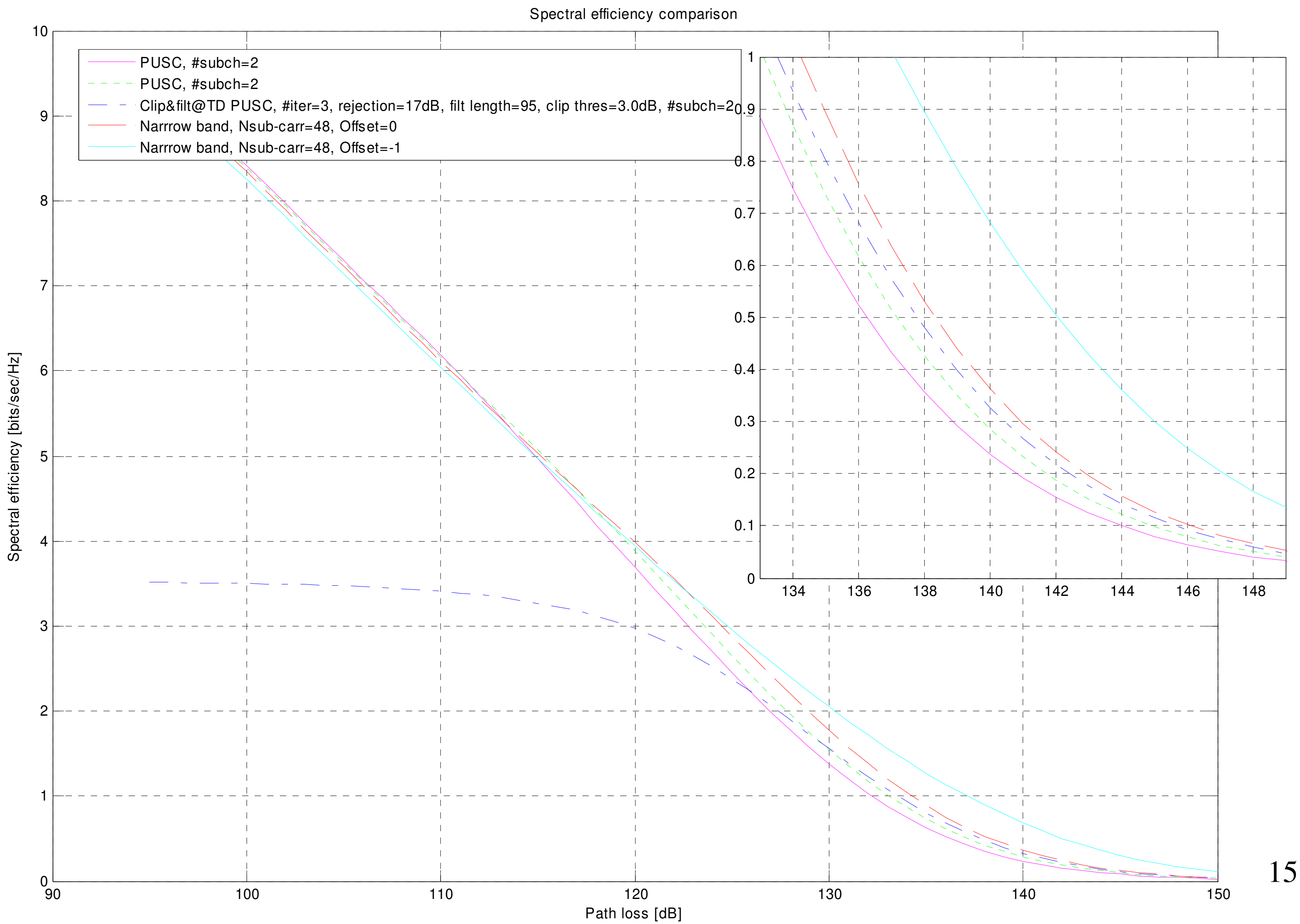


PA model: RAPP-2

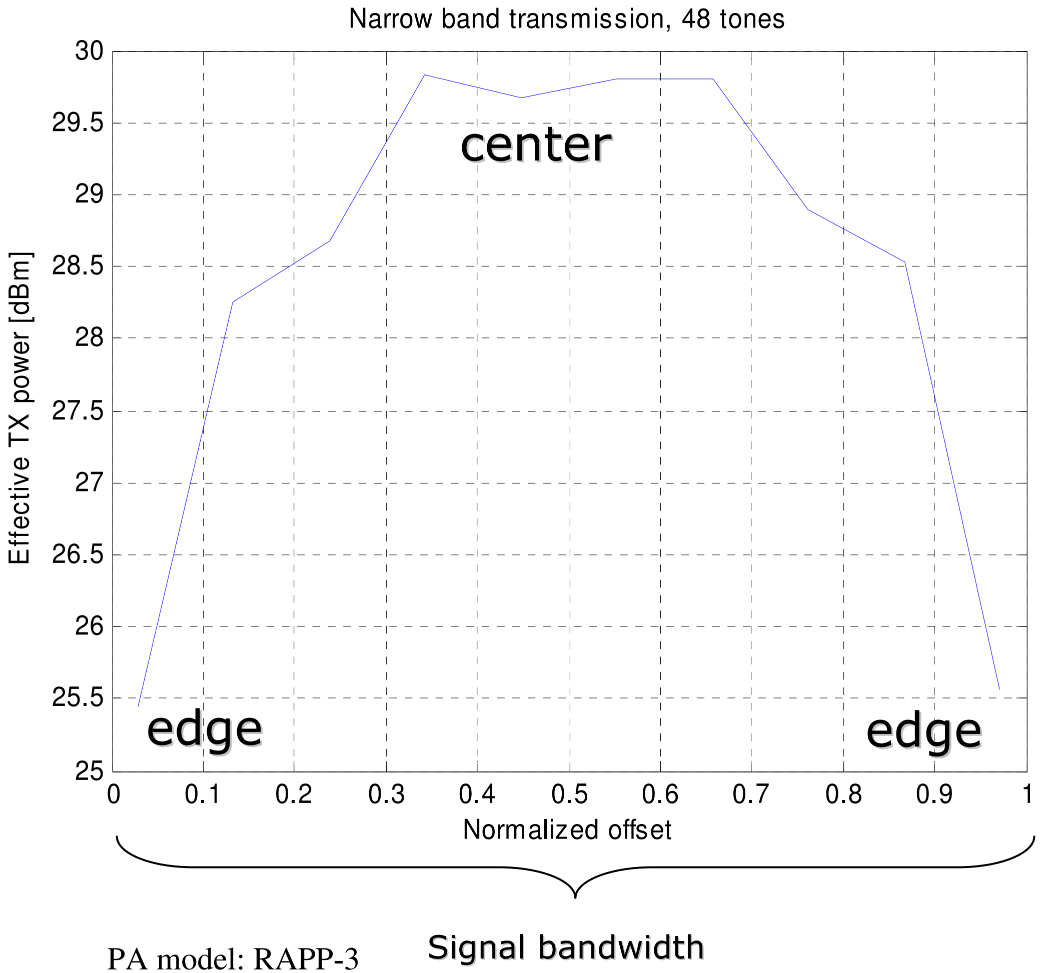
“PAPR reduction” methods evaluation

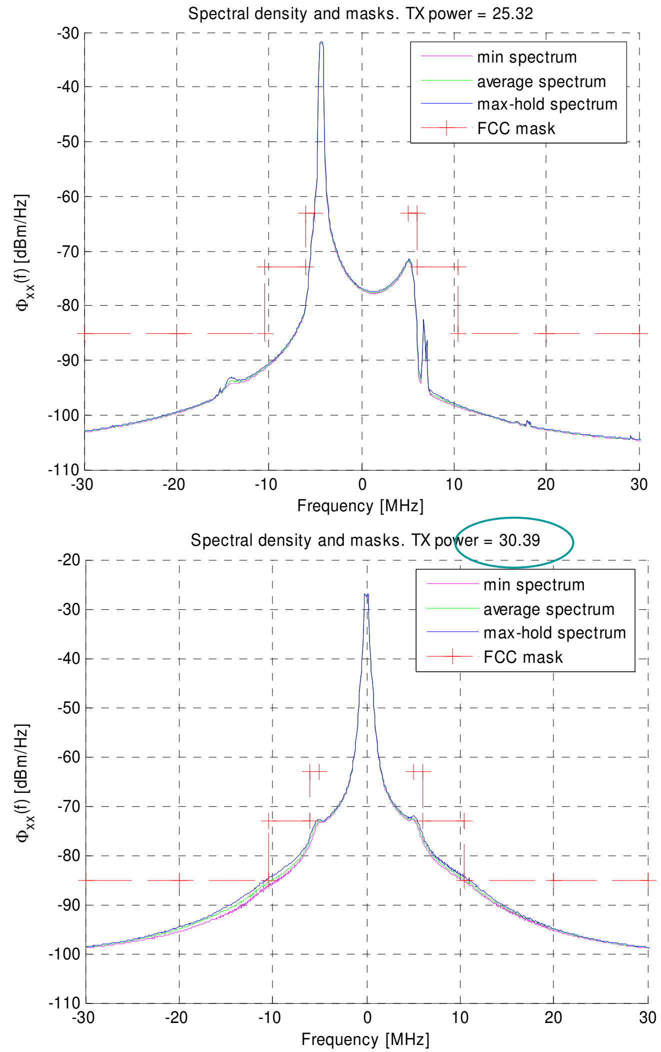


Spectral efficiency of localized OFDMA



Localized gain as function of location in the band





PA model: RAPP-3

Power limited PA

- Our results are with PA peak power limit (or fixed V_{cc}).
- Another option is to consider PA with a current limitation (modify V_{cc} to meet same power).
- In this case all differences in transmit powers are approximately halved (in dB)

1	Increase signal power while keeping constant Vcc, therefore reduce backoff	Slope = **2**
2	Scale signal power and Vcc together to keep constant backoff, that is keep constant proportion between signal and out-of-band emission. This can be associated with relative spectral mask.	Slope = **1**
3	Scale signal power while keeping the out of band emission power approximately constant.	Slope = **0.8**