Dynamic Range Increase for Working with high PAPR

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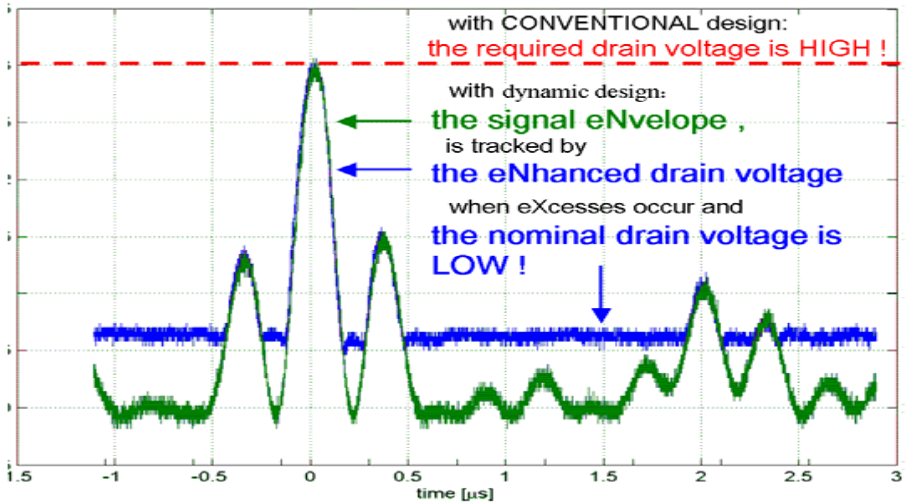
Purpose:
To show that the PAPR problem coupled with OFDMA can be reduced or accommodated by various techniques and to conclude that OFDMA is the preferred transmission technology for 802.16m.

The Problem: Transmitting Signals with High PAPR

- To ensure high linearity transmission of signals with high PAPR (Peak to Average Power Ratio), Power Amplifiers should cope with the problem of transmitting the peaks.
- The way RF Power Amplifiers are designed today is that for a given VCC the maximum RF power that can be transmitted with high linearity is aligned to the signal's peaks (Dotted Red Line) and the average power that is transmitted is then reduced (backed off) approximately by the signal's PAPR.
- Working with PA's in high back-off means that the average power transmitted is much lower than the peak power that the PA can transmit and therefore the PA efficiency is reduced dramatically.

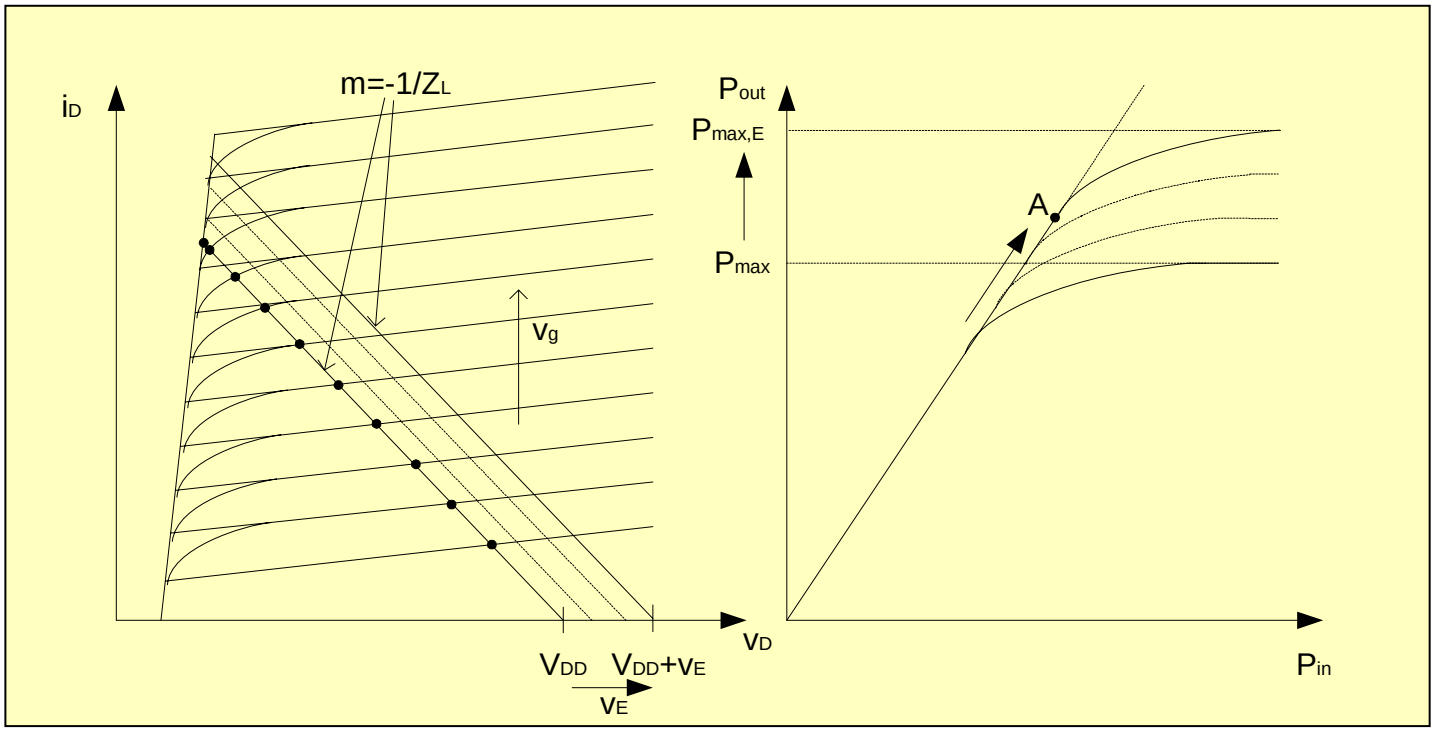


System solutions to overcome high PAPR

- ***Crest Factor Reduction***
  - Pros: Reduces signal's PAPR by 2-3 dB
  - Cons:
    - Additional IP/Chip
    - EVM performance degrades
    - Mask performance degrades

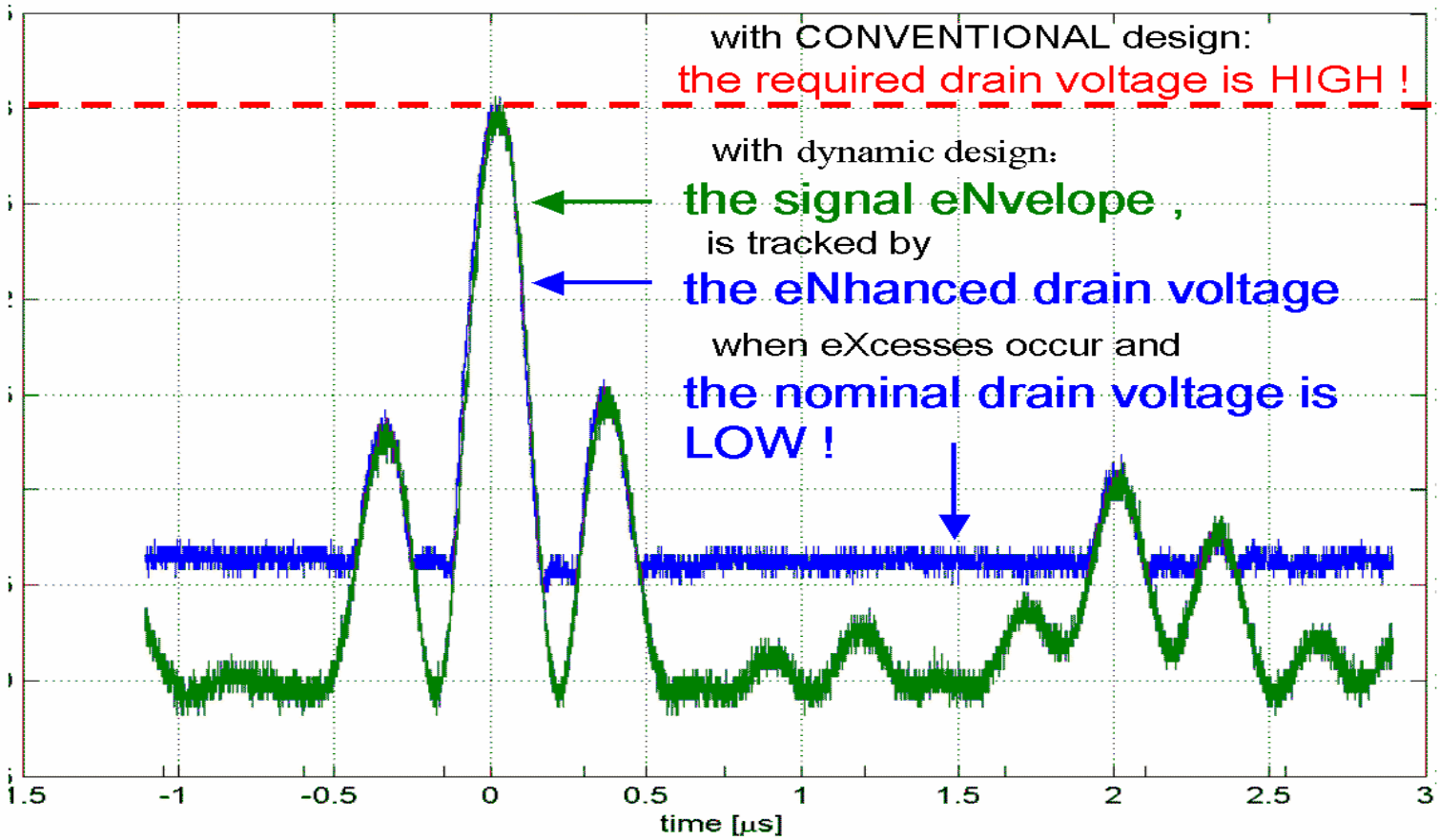
- ***SLM – Selective Mapping***
  - Pros: Reduces signal's PAPR by 2-3 dB
  - Cons:
    - System complexity.
    - Side information transmission is required (reduces BW).
    - Overall gain is not clear.

Increasing Power Amplifier's Dynamic Range to overcome high PAPR



Dynamic Range Increase: $$\rho = \frac{P_{\max,E}}{P_{\max}} = \left(\frac{V_{DD} + V_E}{V_{DD}} \right)^2$$

Increasing Power Amplifier's Dynamic Range to overcome high PAPR

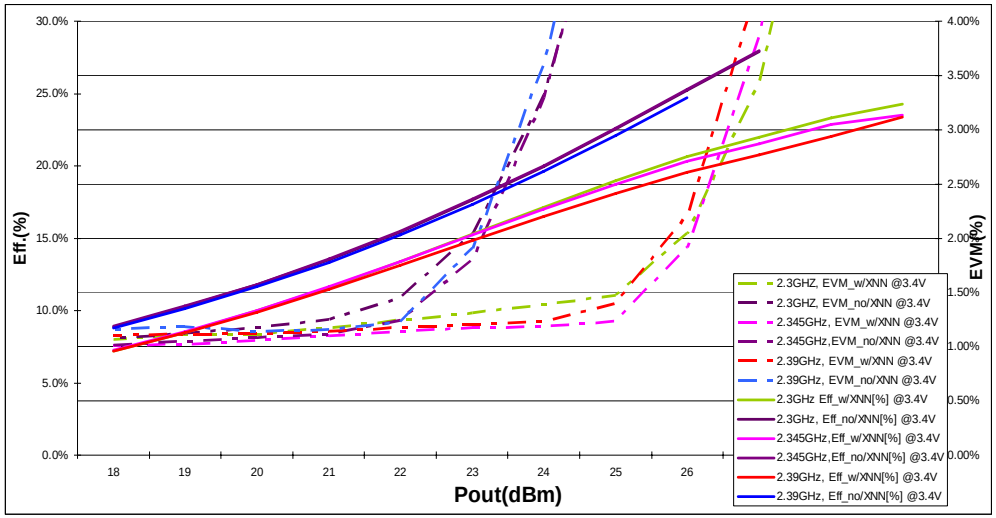


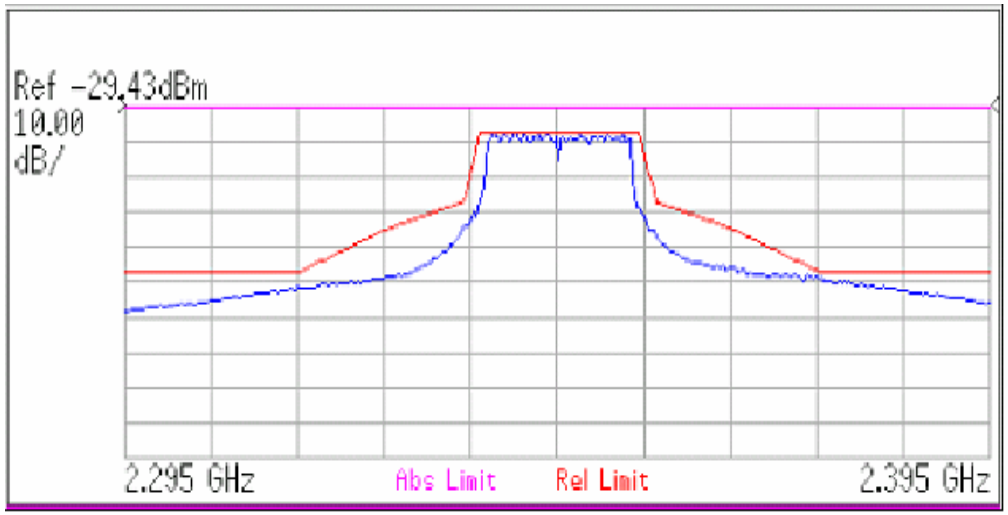
By partial envelope tracking we can change the VCC to the PA and raise It when the signal's peaks occur (Green line: signal envelope) to enable them to be transmitted linearly (Blue Line).

Dynamic Range Increase: Performance Enhancements

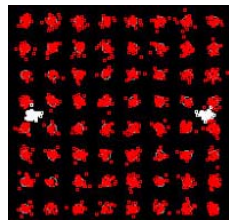
- Output Power Increase:
  - 20*Log (Vmax/Vnom)
- Efficiency Improvement:
  - Vmax/Vnom
- Same Linearity (EVM, Spectral Mask)

Dynamic Range Increase: Performance Results

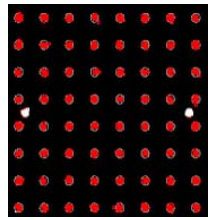




No Dynamic Range



With Dynamic Range



Most PA's tested provide more than 3dB Pout enhancement

Dynamic Range Increase: Implementation Complexity

- ***Two Blocks are needed:***
  - Envelope detector
    - HW (sensing the RF) or
    - SW
  - Voltage Booster
    - HW by 3 transistors and control
    - Capacitor of 1uF (for charge boosting)

- ***Full HW solution implemented in 0.18u cmos process in less than 2[mm^2]***

- Dynamic Range Increase: Benefits

  - ***Cops with signals with high PAPR***
  - ***Increased Linearity***
  - ***Higher Efficiency***
  - ***Prolong battery life***
  - ***Reduce PA current consumption***
  - ***Reduce heat dissipation***

Better Power Amplifier Utilization!

Conclusions

- The high PAPR introduced by OFDMA transmission may be reduced or accommodated by various techniques.
- One of the most promising techniques is Dynamic Range Increase, which may be implemented with low complexity at the transmitter.
- This leads to the understanding that OFDMA is the preferred transmission technology for the 802.16m UL, which drawbacks may be mitigated fairly easily.