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RP-172635

Motivation paper for SI on NR waveform beyond 52.6GHz

Qualcomm

Outline

- Background
- Technical justification
- Applicable scenarios
- Waveform candidates
- Preliminary comparisons
- Proposal

Background

- Originally, NR SI considered operation at frequencies of up to 100GHz
  - Channel model defined up to 100 GHz (ref. TR 38.900)
- NR Rel-15 WI is defining operation up to 52.6GHz
  - CP-OFDM for DL/UL and DFT-S-OFDM for UL
  - Max channel BW: 100MHz (freq-range 1), 400MHz (freq-range 2)
    - Subcarrier spacing: 15, 30, 60kHz for freq-range 1; 60, 120kHz for freq-range 2 (in addition to 240kHz for SSB)
    - Max assumed FFT size: 4K points
- Vast amount of spectrum available at 57-71GHz range
  - Global spectrum for IEEE 802.11ad operation in 57-64GHz range [TR 38.805 for 60GHz band]
  - ITS spectrum in Europe in 63-64GHz range
  - FCC newly identified spectrum for wireless communications in the 64-71GHz range
- NR-unlicensed SI calls out for operation at unlicensed bands above 52.6GHz to the extent that waveform design principles remain unchanged with respect to below 52.6GHz bands
- **Goal**: want NR to be applicable for operation at these bands

Technical justification

- Operation at frequencies above 52.6GHz share some unique characteristics:
  - Extremely harsh propagation loss
  - Low PA efficiency
  - High phase noise
  - PSD limitations when applicable, e.g., 13dBm/MHz and 40dBm EIRP in 60GHz band
- In addition, operation in 60GHz band (ref. 38.805) may require definition of channel bandwidths beyond 400MHz (e.g., around 2GHz) for, e.g., coex with IEEE 802.11ad systems
- All of the above calls out for the need to study NR waveform for operation at frequencies above 52.6GHz

Applicable scenarios

- Operation at frequencies above 52.6GHz should be relevant for a variety of use cases:
  - WAN operation, private networks, vehicular communications (C-V2X), and others

- The waveform studies themselves should be agnostic to the type of spectrum, i.e., licensed, unlicensed or shared

- Studies should consider the following aspects:
  - From transmitter perspective: PAPR, power consumption
  - From receiver perspective: implementation complexity, performance
  - Generally: applicability to channel bandwidths beyond 400MHz

Waveform candidates

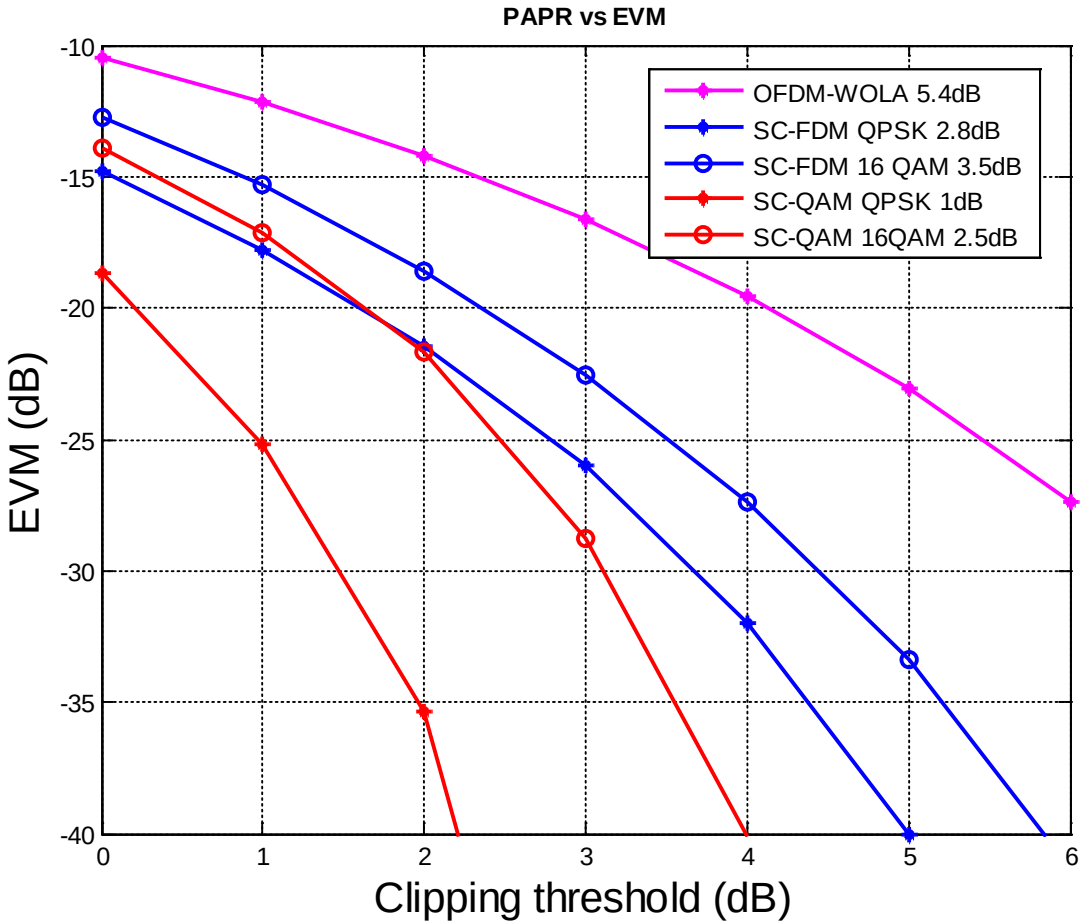
- CP-OFDM – regular NR DL waveform but with larger subcarrier spacing, e.g., 960KHz
  - High PAPR, complexity relatively high complexity at both transmitter/receiver (due to FFT)

- Single carrier waveform family: DFT-s-FDM and single-carrier (SC) QAM
  - Better PAPR compared to OFDM
  - DFT-s-FDM: NR UL waveform scaled to 960KHz subcarrier spacing
    - Easy user multiplexing but with the cost of DFT spreading at transmitter
  - SC-QAM
    - Lowest PAPR, lower complexity at transmitter (no FFT) and receiver (if TDE used)
    - Not as flexible in multiplexing users in frequency
    - Bandwidth growth due to pulse shaping filter

- Note that SID does not explicitly call out specific waveform candidates
  - Shown here for background purposes only and to put in context some preliminary comparisons

Preliminary comparisons

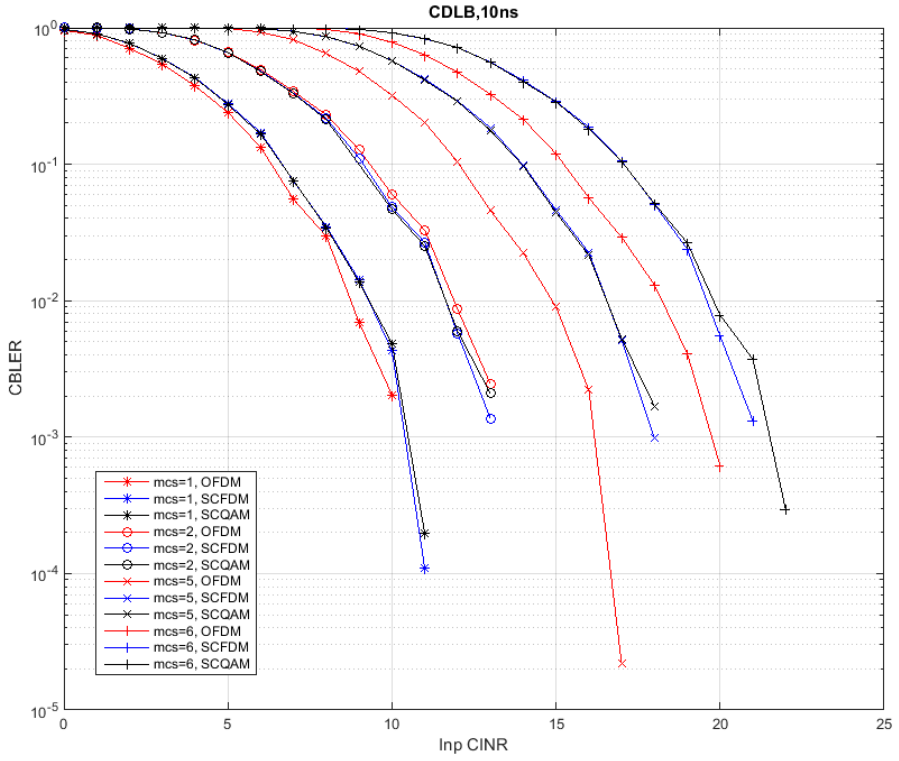
EVM vs. clipped waveform



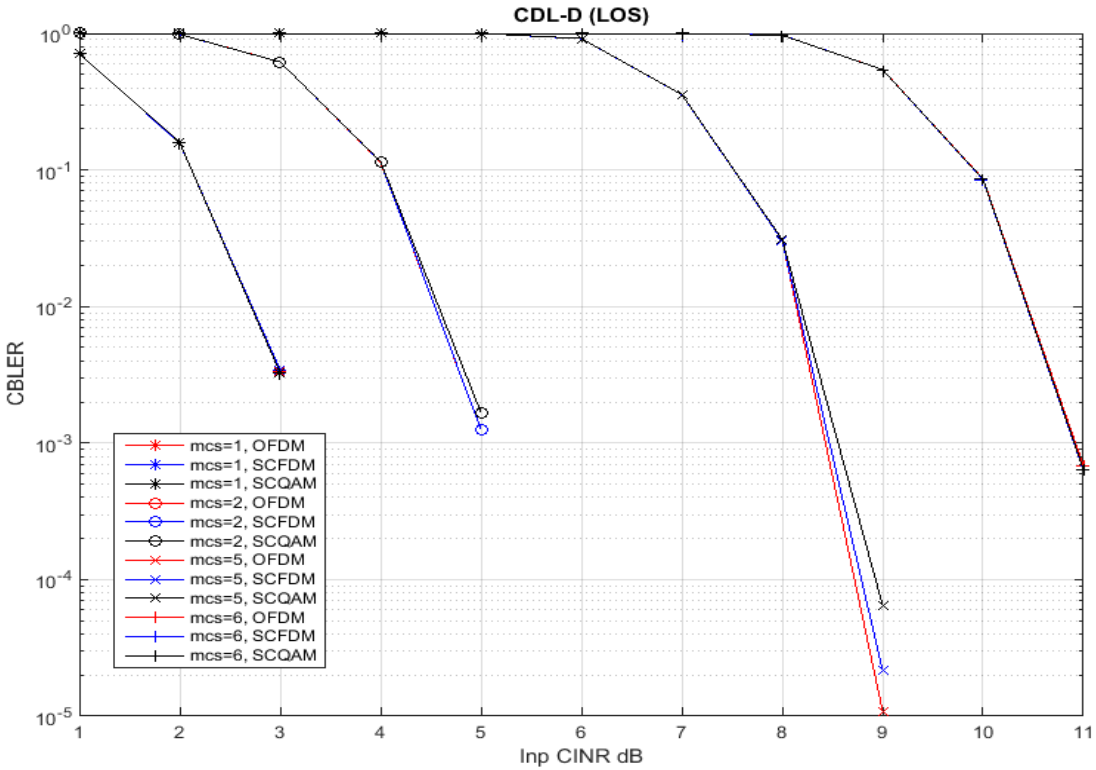
- Single carrier waveform helpful for providing better coverage, critical in coverage limited mmW use case
  - SC-QAM w/ QPSK has 4.4dB PAPR gain over OFDM
    - SC-QAM w/ 16QAM still has 2.9dB PAPR gain
  - SC-FDM w/ QPSK has 2.6dB PAPR gain over OFDM
    - SC-FDM w/ 16QAM still has 1.9dB PAPR gain
- Between SC-QAM and SC-FDM, SC-QAM has even better PAPR gain and worth considering
  - 1.8dB w/ QPSK
  - 2dB w/ 16QAM

Preliminary comparisons

Link level comparisons



- For NLOS channel, the PAPR benefit of SC-QAM far outweighs the performance gain of OFDM



- For LOS channel , SC-QAM achieves similar performance as OFDM

Proposal

- With the objective to further increase the footprint for applicability of 3GPP 5G NR systems, 3GPP needs to define a waveform suitable for operation at frequencies above 52.6GHz
- Open SI in June ‘18 for the duration of 2 Quarters and with the following objectives:
  - Waveform design for operation beyond 52.6GHz -- RAN1
    - This design should take into consideration the following aspects:
      - From transmitter perspective: PAPR, power consumption
      - From receiver perspective: implementation complexity, performance
      - Generally: applicability to channel bandwidths beyond 400MHz

    Note: the waveform design should be agnostic to the type of spectrum (i.e., licensed, unlicensed, or shared) or the applicable use case as the driving aspects for the waveform design are meant to apply fundamentally to any communication system operating at that frequency range.
  - Channelization suitable for target bands, e.g., 57-64GHz (60GHz band), 64-71GHz (FCC) -- RAN4

- Proposed TU allocation as shown in spreadsheet attached to the SID in RP-172633 (RAN1: 10TUs, RAN4: 3.5 TUs) over the duration of 2 Quarters: Q3 and Q4 ’18.

Thank you

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