Simulation Results for Several of the Proposed Pilot Format Designs in IEEE 802.16m

Document Number:

IEEE C802.16m-08/253

Date Submitted:

2008-03-19

Source:

Fred Vook, Tim Thomas, Mark Cudak E-mail: fred.vook@motorola.com

Motorola

*<http://standards.ieee.org/faqs/affiliationFAQ.html>

Venue:

TGm Call for contributions on 802.16m System Description Document, IEEE 802.16m-08/005.

Topic: "Pilot structures as relevant to downlink MIMO" and "Downlink Physical Resource Allocation Unit"

Abstract:

Simulation results for various different pilot format designs in IEEE 802.16m

Purpose:

Informational – Provide assistance for selection between proposals

Introduction

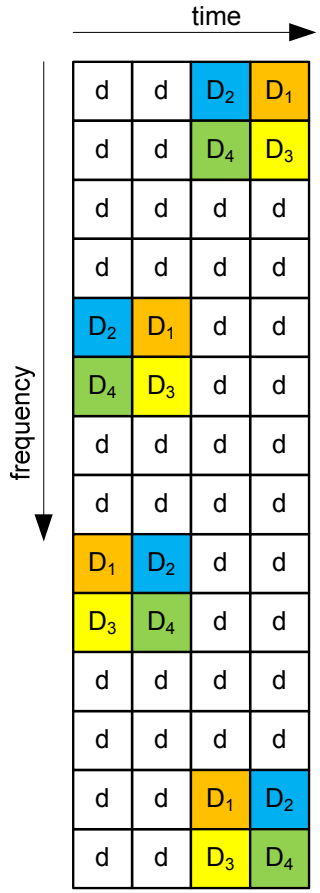
- Purpose
  - Summarize and compare several of the proposed MIMO pilot formats
  - Provide basis for further harmonization and additional design considerations
- Scope
  - Examine formats proposed for use with dedicated pilots
  - Examine formats that support up to 4 transmission streams
  - Did not examine formats for use with broadcast pilot
  - Did not examine formats that included control information
- Basis for comparison:
  - Link-level hull curve
    - Shows the throughput taking into account both FER and pilot overhead
  - Channel Estimation Mean Square Error (MSE)
    - 2-D MMSE channel estimator

Pilot Formats Considered in this Study

Author Affiliation	**Contribution**
ETRI	C802.16m-08/194
Intel	C802.16m-08/121r1
LG Electronics	C802.16m-08/153
MediaTek	C802.16m-08/139r2
Motorola	C802.16m-08/123
Nokia Siemens	C802.16m-08/160
Nortel	C802.16m-08/172r1
Samsung	C802.16m-08/188r2

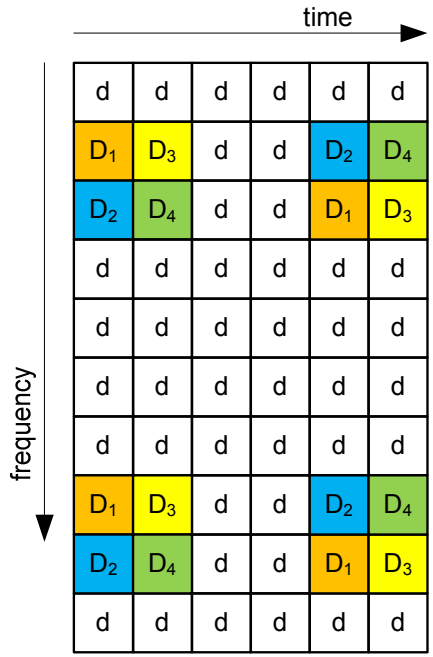
802.16e Downlink PUSC (PUSC-like)

- 14x4
- Overhead:
  - 7.14% per stream
- Rate matching assumed (i.e., data is not punctured when transmitting streams 3 and/or 4)



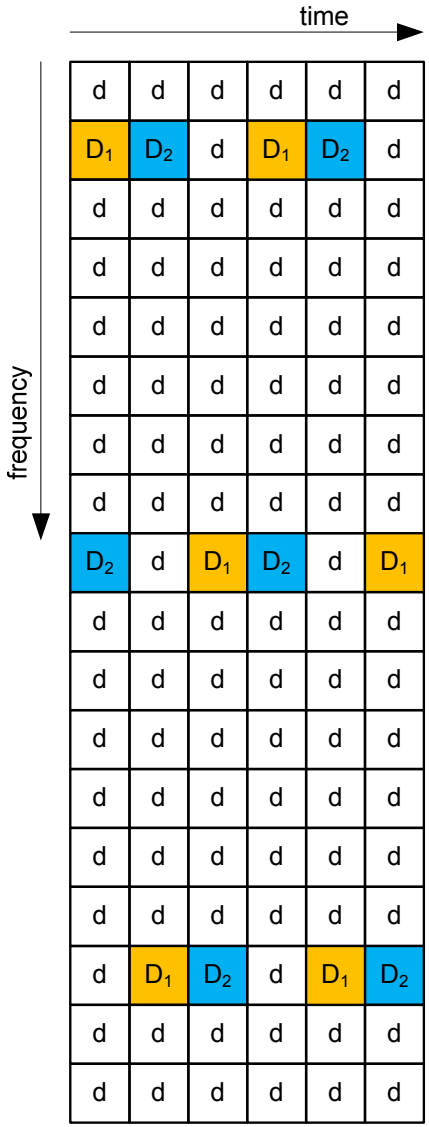
ETRI's Pilot Format

- From 08/194
- 10x6
- Overhead:
  - 6.67% per stream

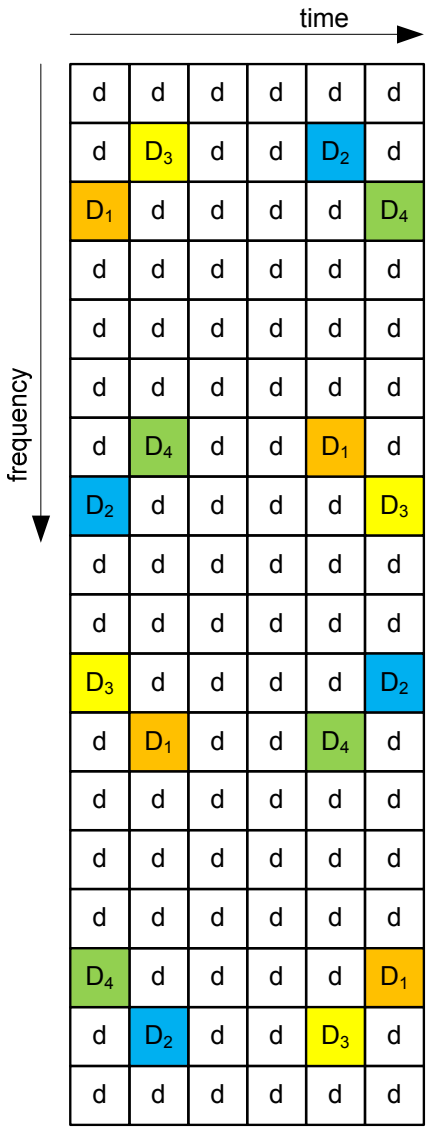


Intel's Pilot Formats

- From 08/121r1
- 18x6 (or 12x6)
- Overhead:
  - 3.7% per stream for B
  - 5.56% per stream for A
- Format A is for 1 and 2 streams
- Format B is for 3 and 4 streams



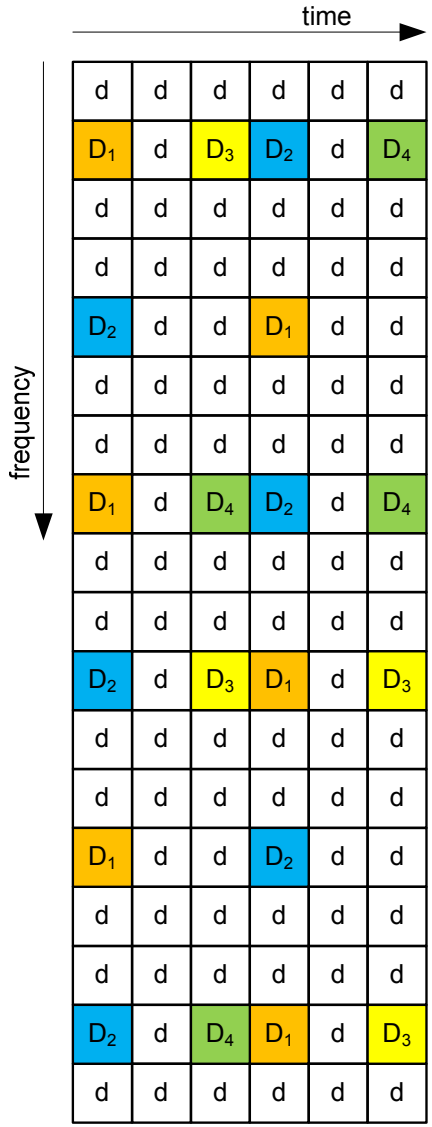
Format A



Format B

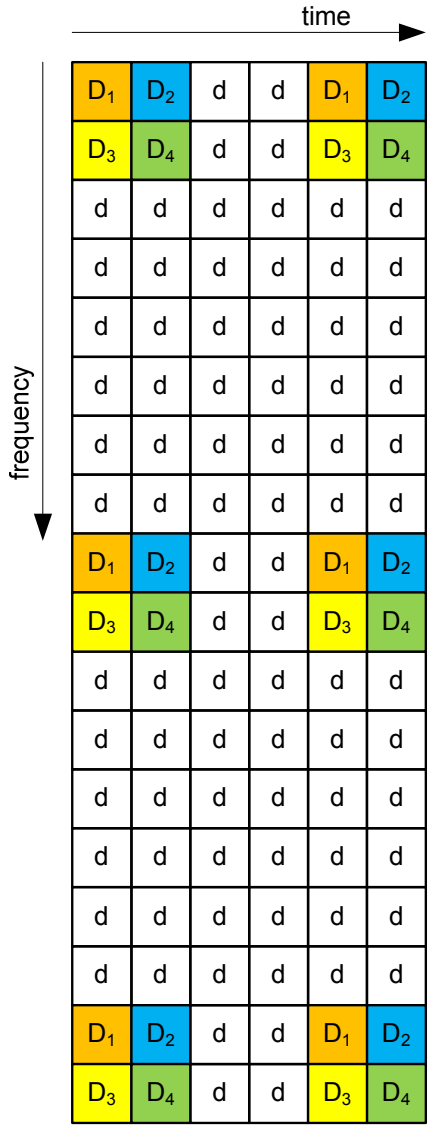
LG Electronic's Pilot Format (type B)

- From 08/153
- 18x6
- Overhead:
  - 5.56% for one stream
  - 11.11% for two streams
  - 14.81% for three streams
  - 18.52% for four streams



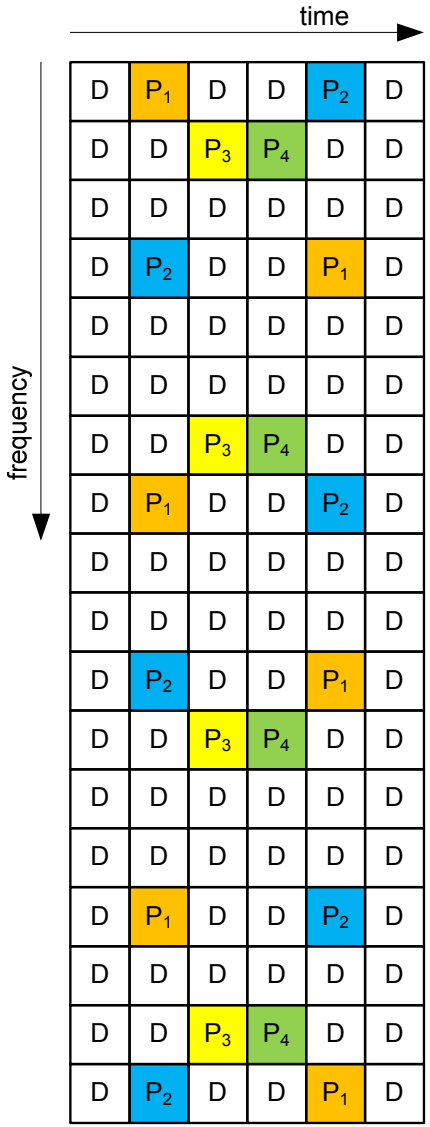
MediaTek's Pilot Format

- From 08/139r2
- 18x6
- Overhead:
  - 5.56% per stream



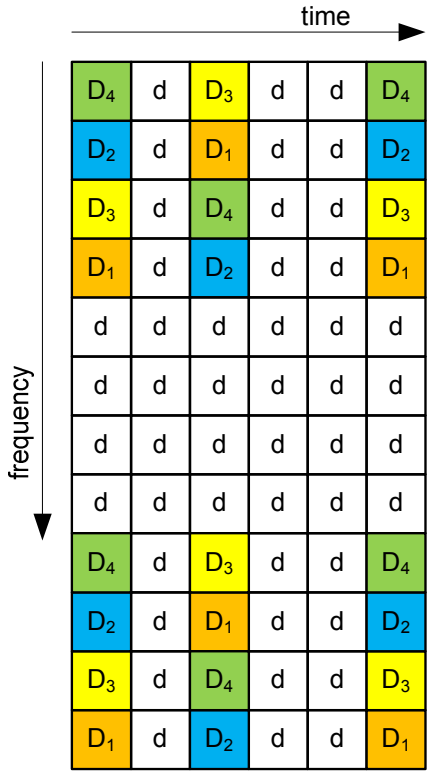
Motorola's Pilot Format

- From 08/123
- 18x6
- Overhead:
  - 5.56% for 1 stream
  - 11.11% for two streams
  - 14.81% for three streams
  - 18.52% for four streams



Nortel's Pilot Format

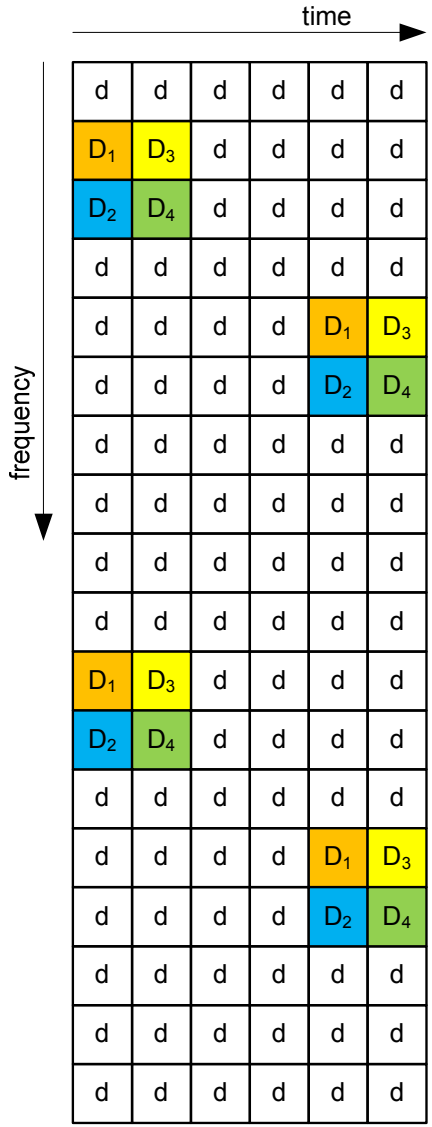
- From 08/172r1
- 12x6
- Overhead:
  - 8.3% per stream if single resource tile allocation
  - 6.3% for two resource tiles in frequency
  - 5.6% for three resource tiles in frequency
  - 4.2% for N resource tiles in frequency (N large)



Note: Only single resource tile format shown. When concatenated in frequency the format will have lower overhead.

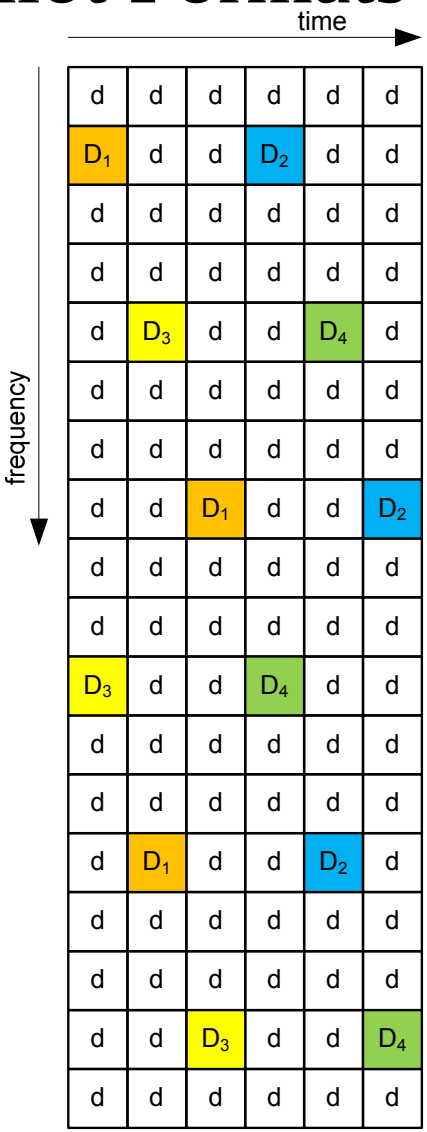
Nokia Siemen's Pilot Format

- From 08/160
- 18x6
- Technically 08/160 is a MU-MIMO pilot format, but was run for SU-MIMO in these simulations
- Overhead:
  - 3.7% per stream

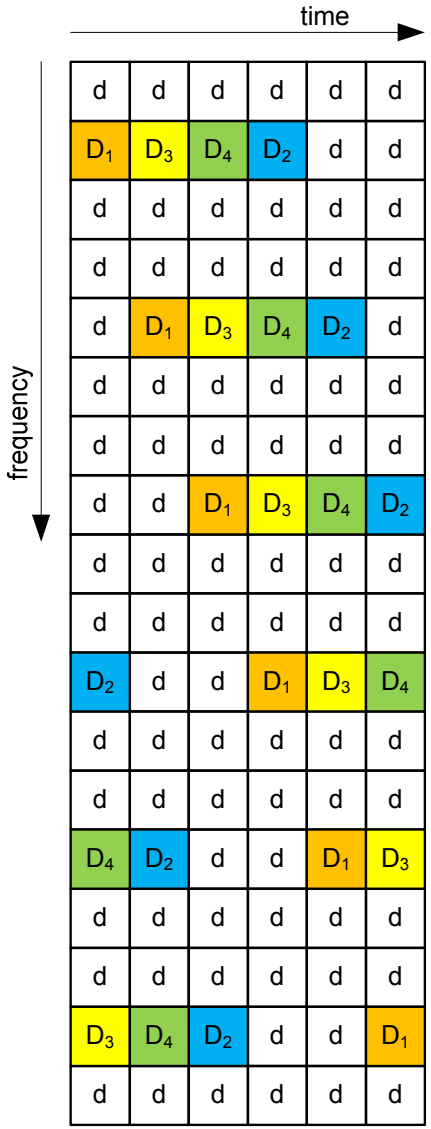


Samsung's Pilot Formats

- From 08/188r2
- 18x6
- Overhead:
  - 2.78% per stream for C
  - 5.56% per stream for B&D
- Format B is for 2 streams and is Format D with D_3 and D_4 replaced with data (rate matching is assumed)



Format C



Formats B&D

Downlink Performance Comparisons

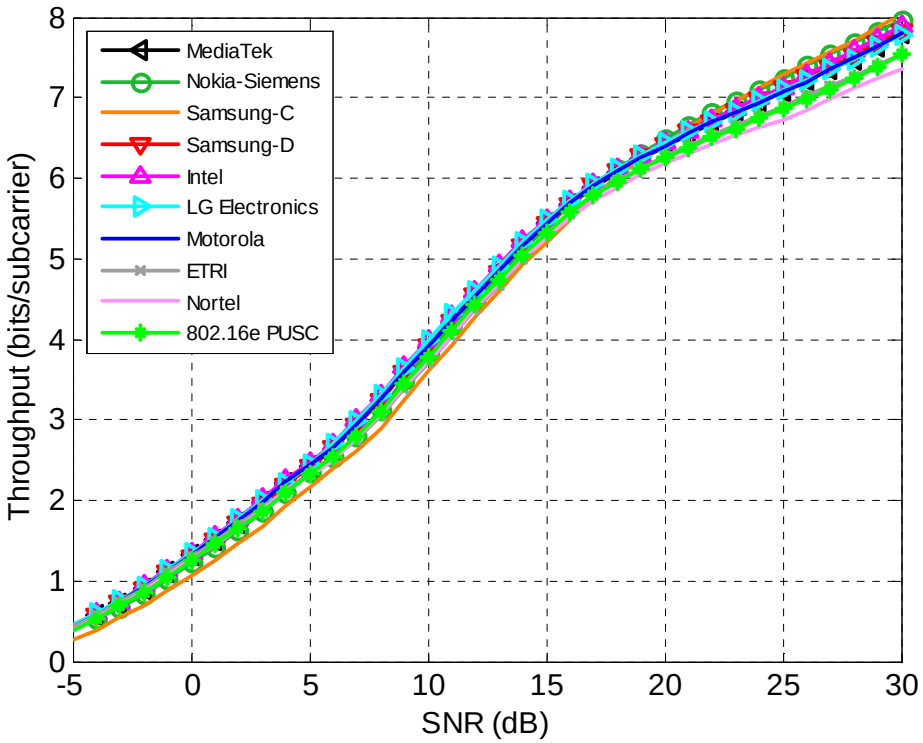
- BS: 4 or 8 Tx antennas *
  - l/2 lambda spacing, vertical polarization, 3 degree angular spread
- MS: 2 or 4 Rx antennas *
  - independent fading
- Doppler/Delay Spread Model *
  - 3 kph-modified PedB channel,
  - 120 kph-modified VehA channel
- Single 18x6 resource tile data allocation (except ETRI which is 10x6)
  - Dedicated pilots
  - 2 dB boosting of pilot power
- 2-D MMSE channel estimation
  - Per-tile channel estimation
  - 3.2 usec window for mPedB
  - 3.2 usec window for mVehA if SNR≤10 dB
  - 4.3 usec window for mVehA if SNR>10 dB
  - Doppler window is flat profile with Doppler frequency matched to mobile speed
- SU-MIMO downlink transmission
  - Number of streams adapted to current channel conditions
  - All streams have same TX power
  - Modulation and coding rate can be different on each stream
- UL Sounding (TDD):
  - UL sounding from all MS antennas simulated with channel estimation
  - Sounding matched to resource tile, 18dB DL-UL total power difference, power concentration on UL Sounding
  - 3 symbol delay from sounding to beginning of DL transmission
- Rx weights: successive cancellation
- Pilot overhead is accounted for in the throughput results

* Follows Case 2 of Evaluation Methodology Document

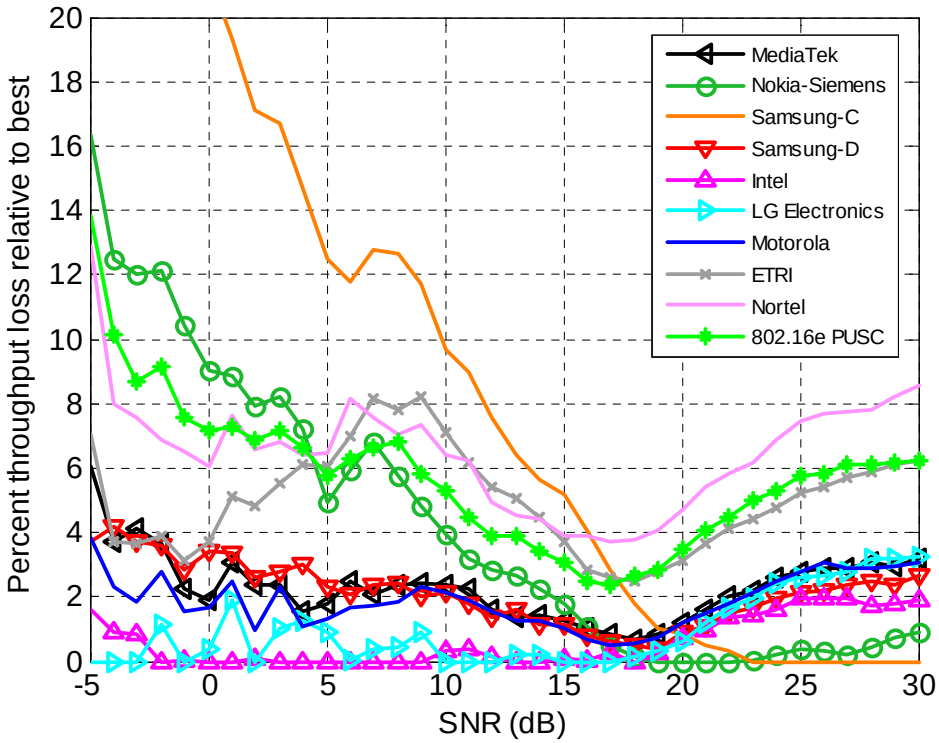
Results with 3 kph, mPedB

Performance Comparisons for 4 Tx, 2 Rx, 3 kph, mPedB

Throughput



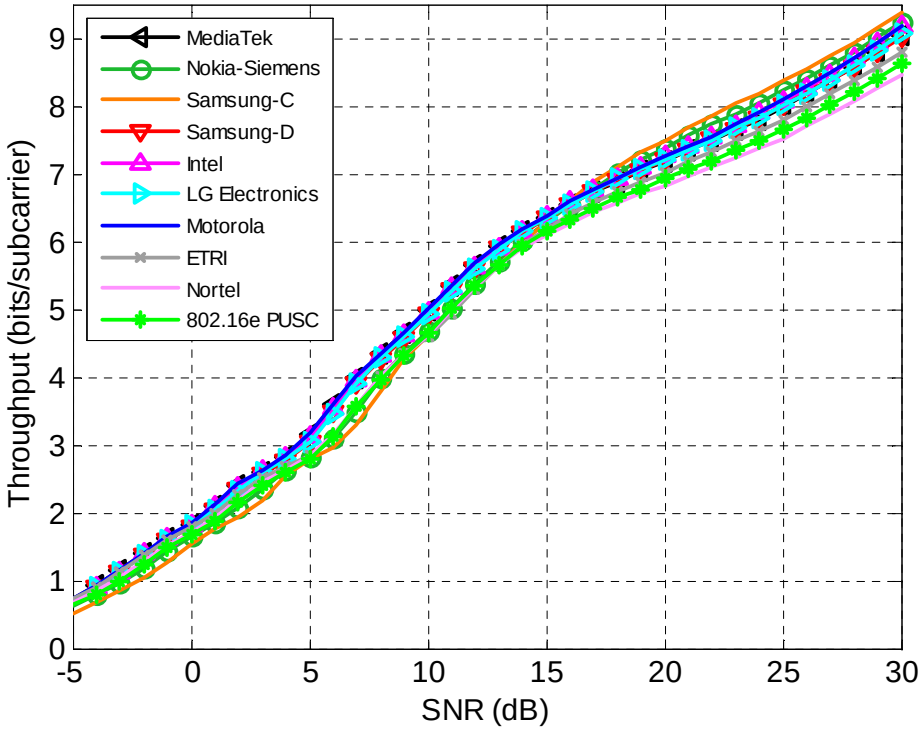
Throughput Loss over Best



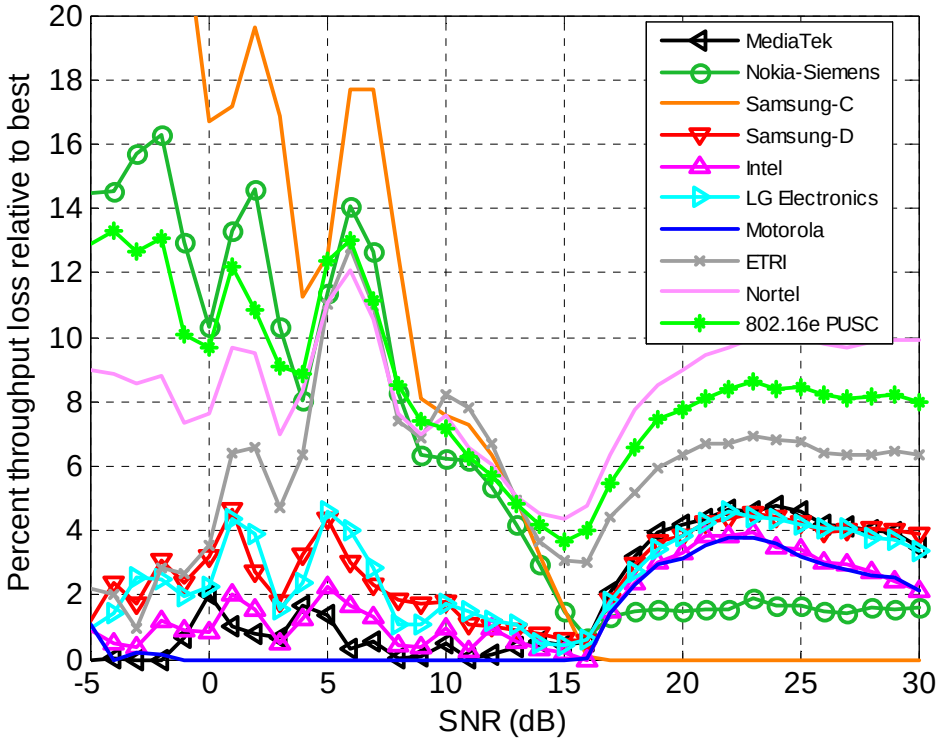
- Observations:
  - Intel/LG best at SNRs<17 dB
  - Nokia-Siemens/Samsung C best at SNRs>18

Performance Comparisons for 4 Tx, 4 Rx, 3 kph, mPedB

Throughput



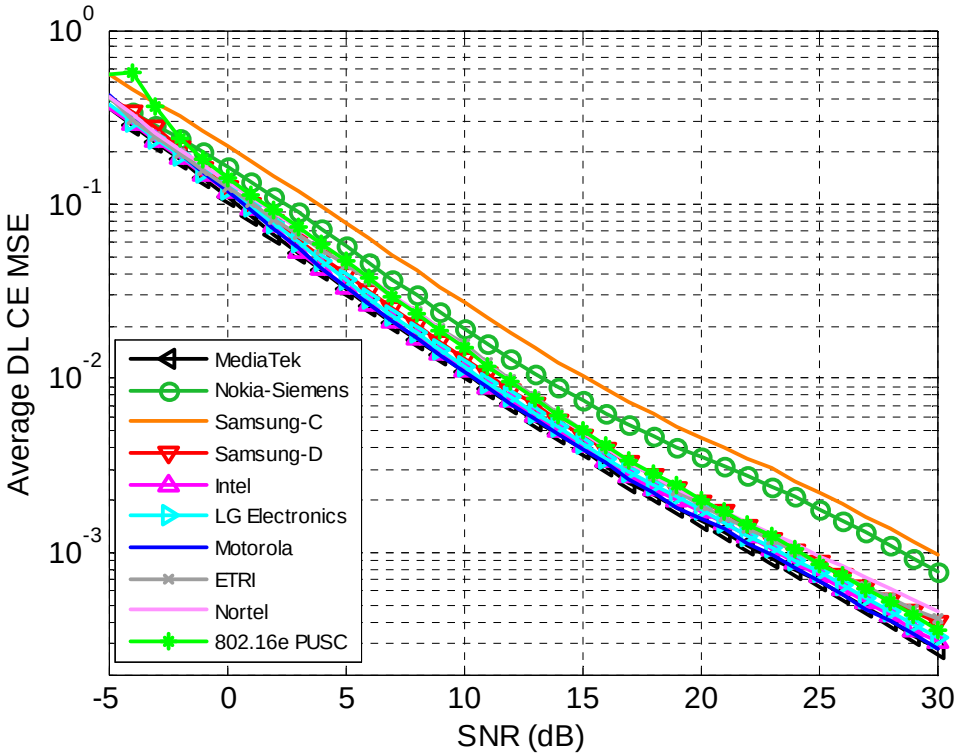
Throughput Loss over Best



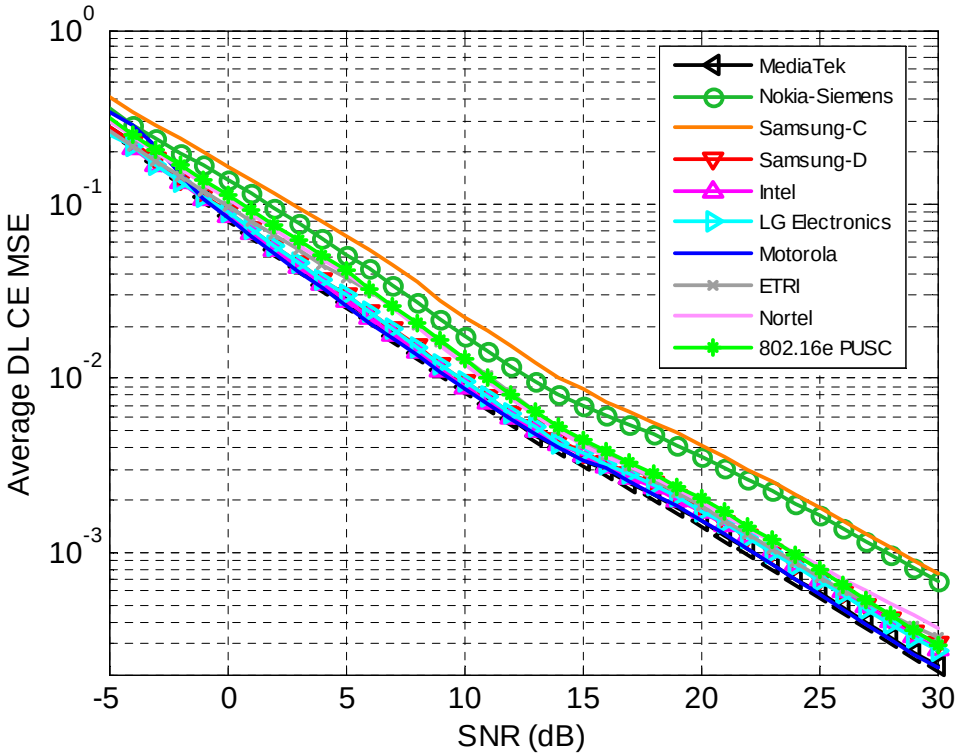
- Observations:
  - Motorola best at SNRs<16 dB
  - MediaTek and Intel close to Motorola at SNRs<18 dB
  - Samsung C best at SNRs>16 dB

Channel Estimation MSE Results for 4 Tx, 3 kph, mPedB

4 Tx, 2 Rx



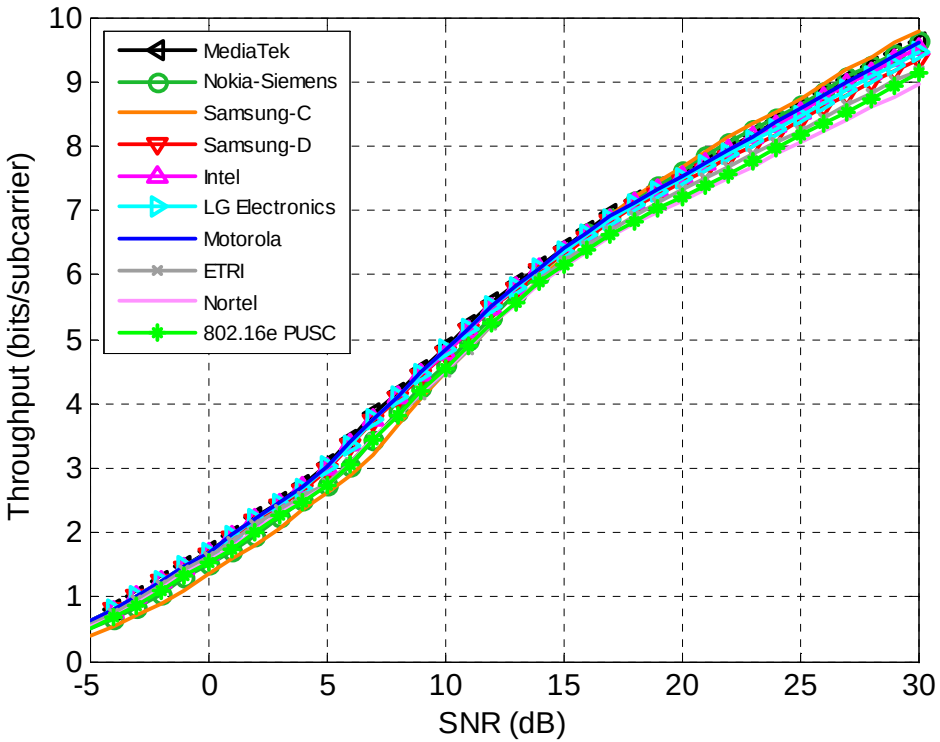
4 Tx, 4 Rx



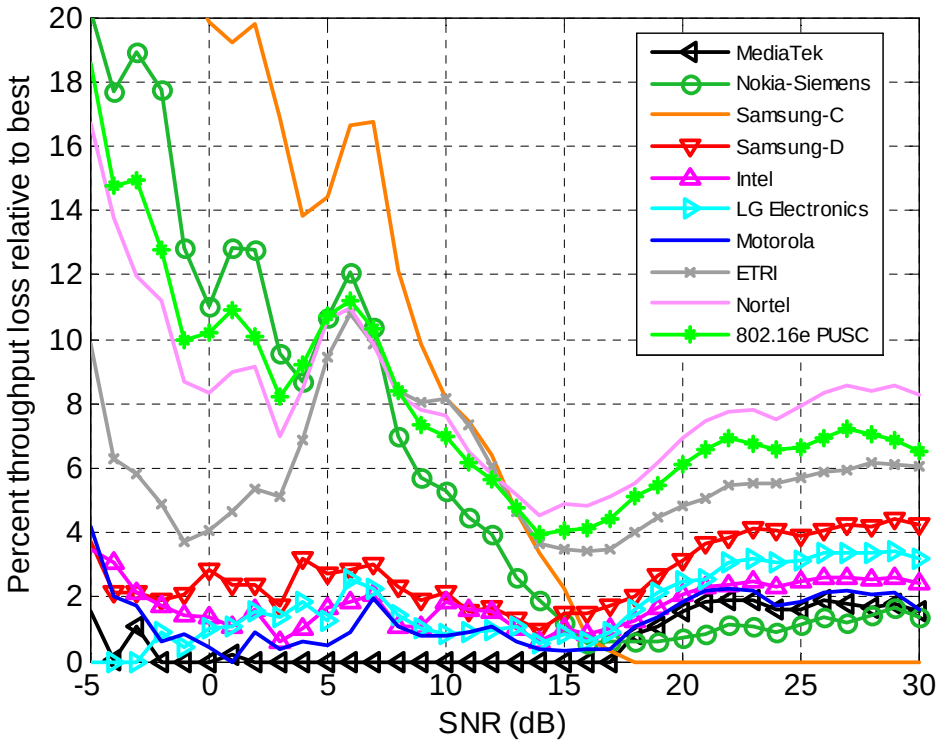
- Observations:
  - All but Nokia-Siemens and Samsung-C have similar performance
  - MediaTek/Motorola has slightly better performance than rest

Performance Comparisons for 8 Tx, 2 Rx, 3 kph, mPedB

Throughput



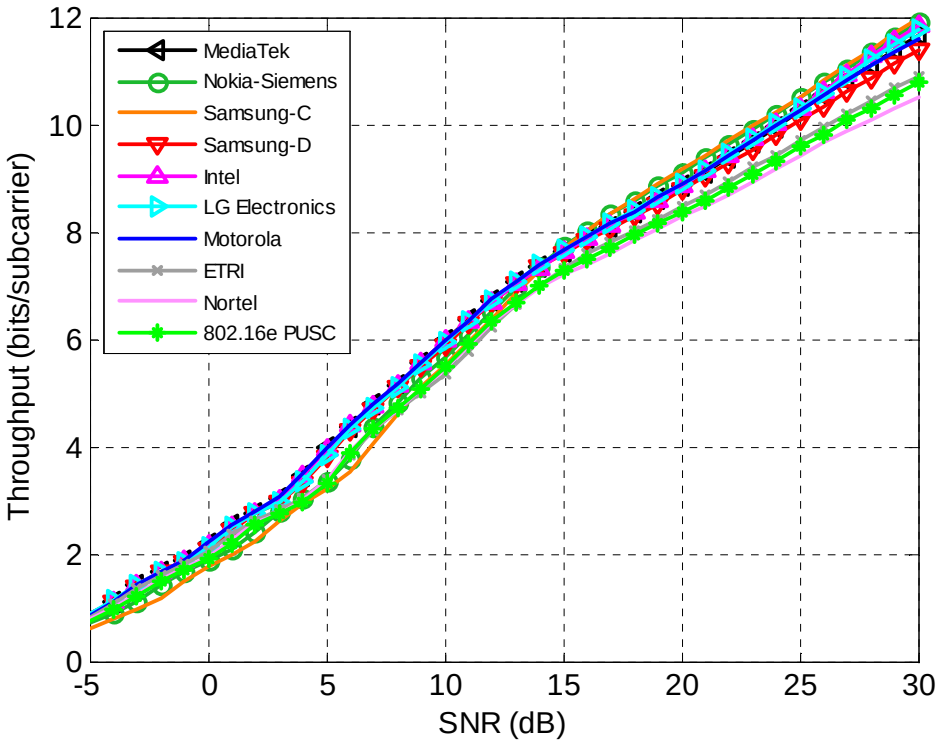
Throughput Loss over Best



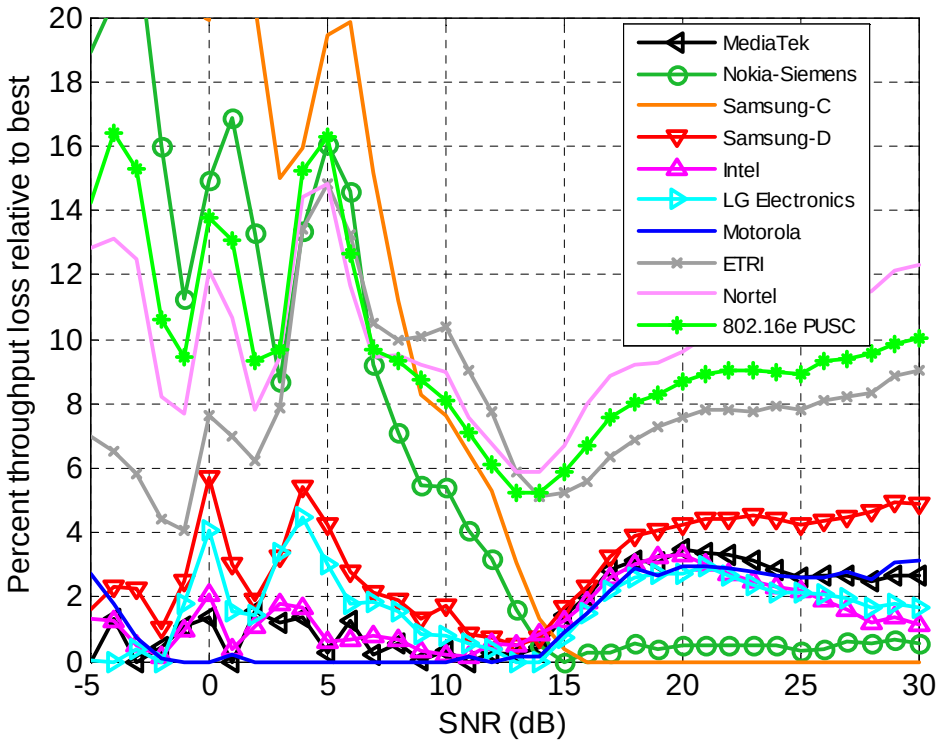
- Observations:
  - MediaTek best at SNRs<18 dB
  - Intel, LG, Motorola, Samsung-D close to MediaTek at SNRs<18 dB
  - Samsung C best at SNRs>18 dB

Performance Comparisons for 8 Tx, 4 Rx, 3 kph, mPedB

Throughput



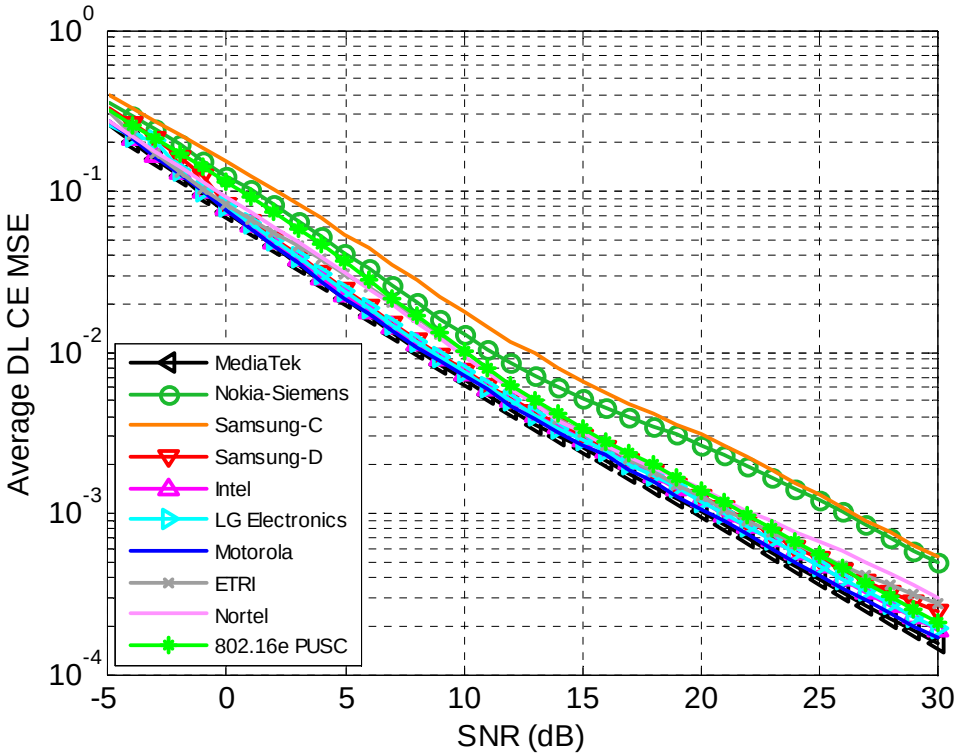
Throughput Loss over Best



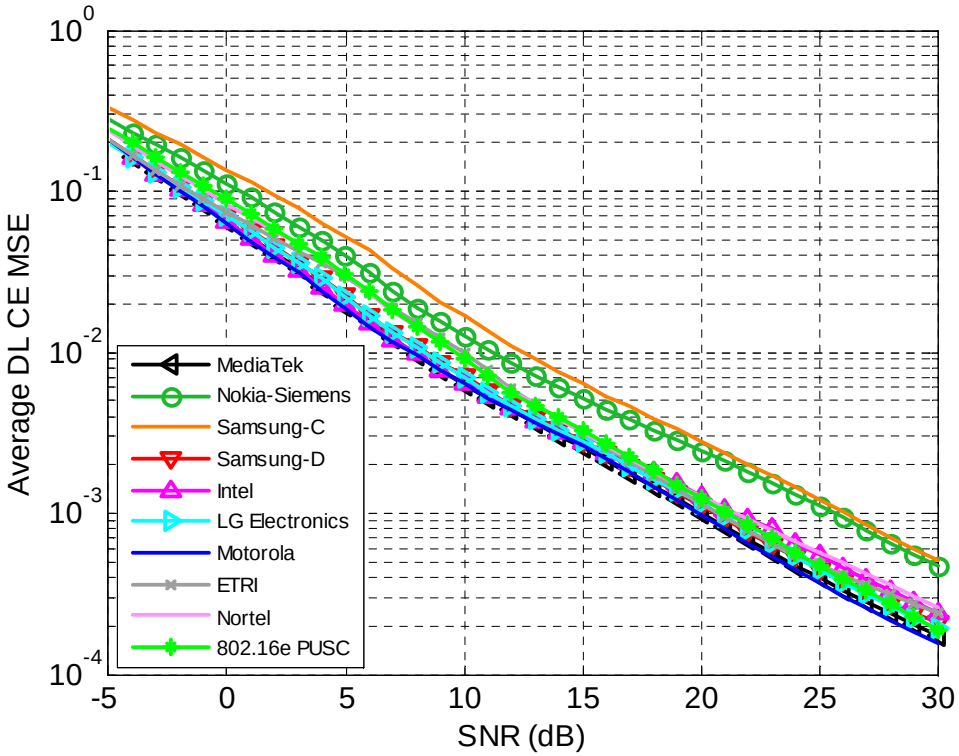
- Observations:
  - Motorola best at SNRs<13 dB
  - MediaTek and Intel's formats close to Motorola's performance at SNRs<13 dB
  - Samsung-C best at SNRs>14 dB (Nokia-Siemens close second)

Channel Estimation MSE Results for 8 Tx, 3 kph, mPedB

8 Tx, 2 Rx



8 Tx, 4 Rx

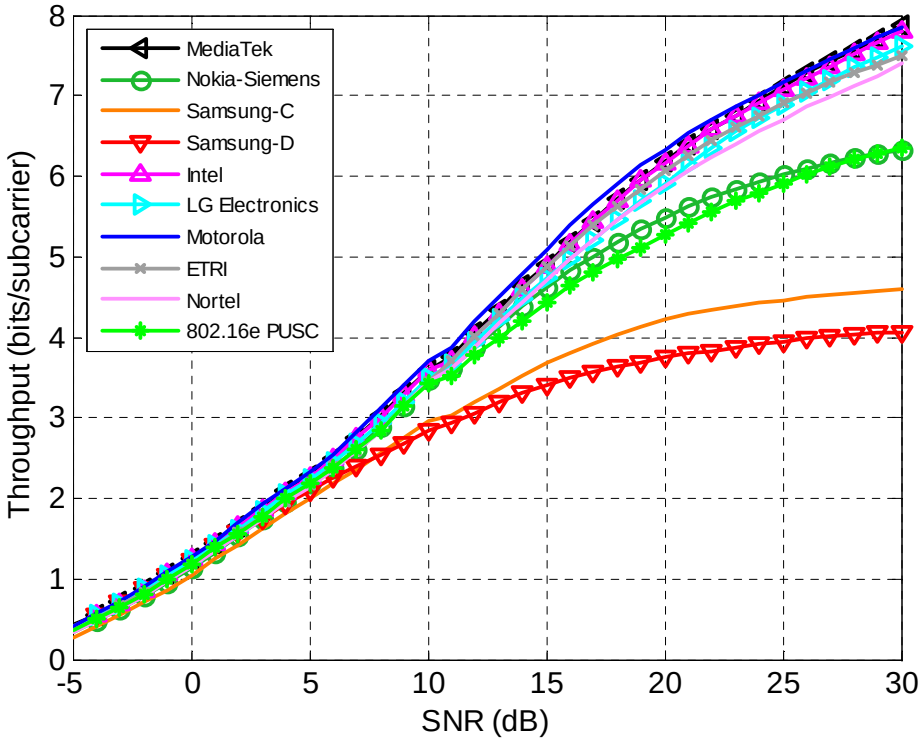


- Observations:
  - All but Nokia-Siemens and Samsung-C have similar performance
  - MediaTek/Motorola has slightly better performance than rest

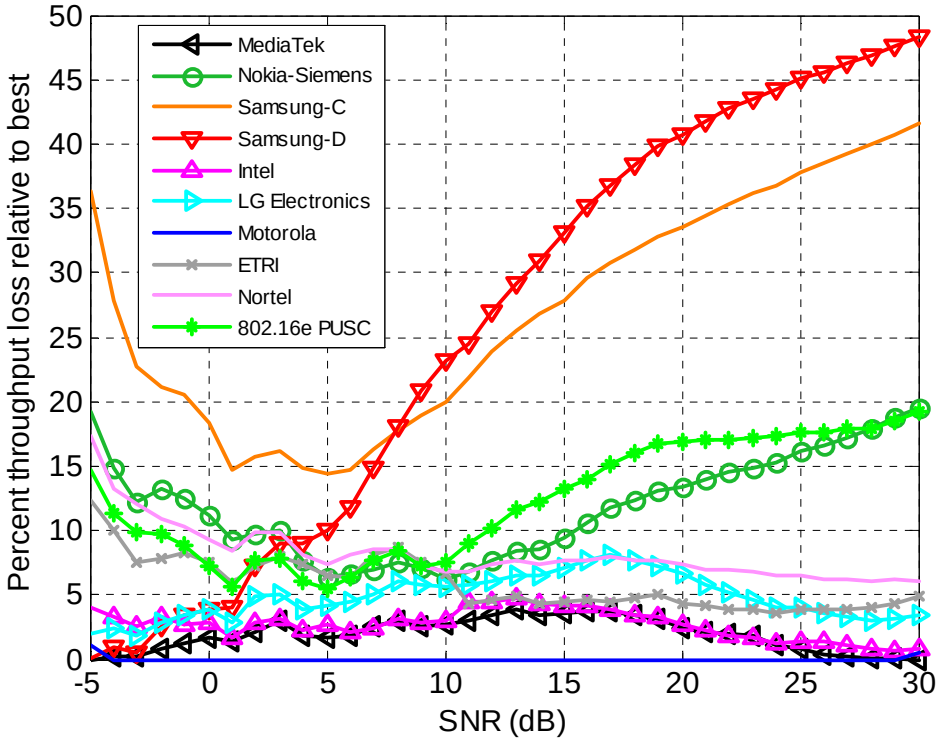
Results with 120 kph, mVehA

Performance Comparisons for 4 Tx, 2 Rx, 120 kph, mVehA

Throughput



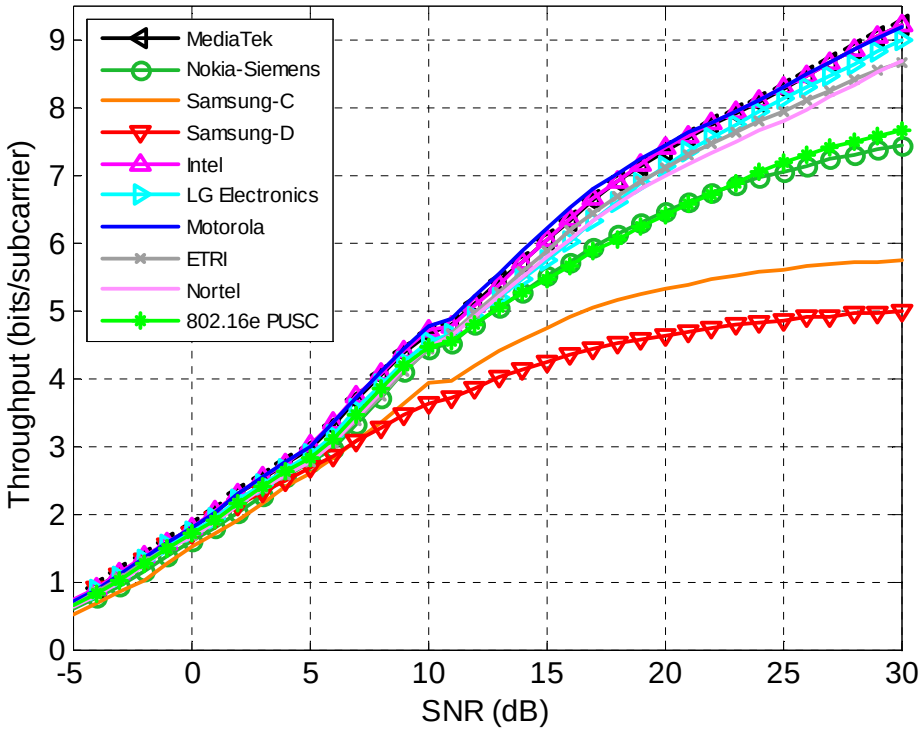
Throughput Loss over Best



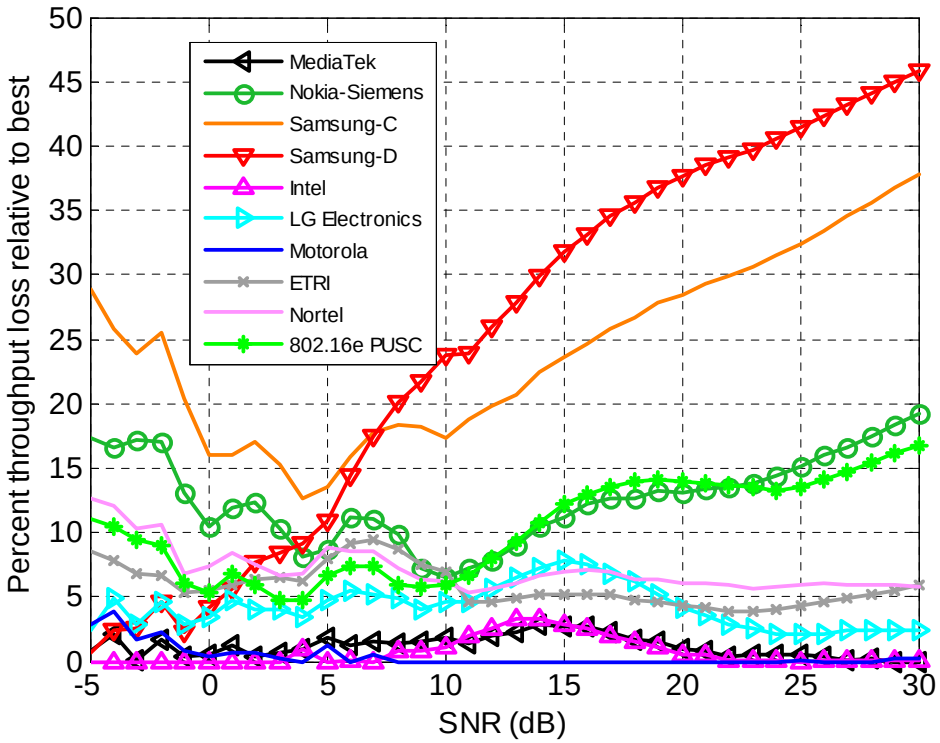
- Observations:
  - Motorola best at all SNRs
  - MediaTek and Intel fairly close to Motorola
  - Samsung C&D, PUSC, Nokia-Siemens do not perform well in velocity

Performance Comparisons for 4 Tx, 4 Rx, 120 kph, mVehA

Throughput



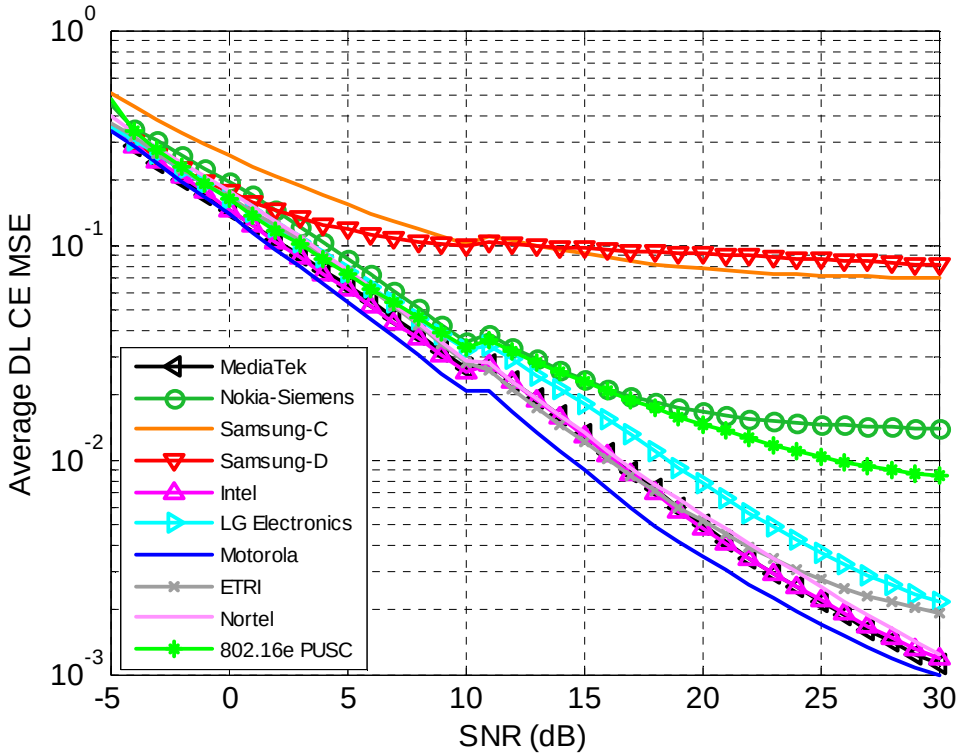
Throughput Loss over Best



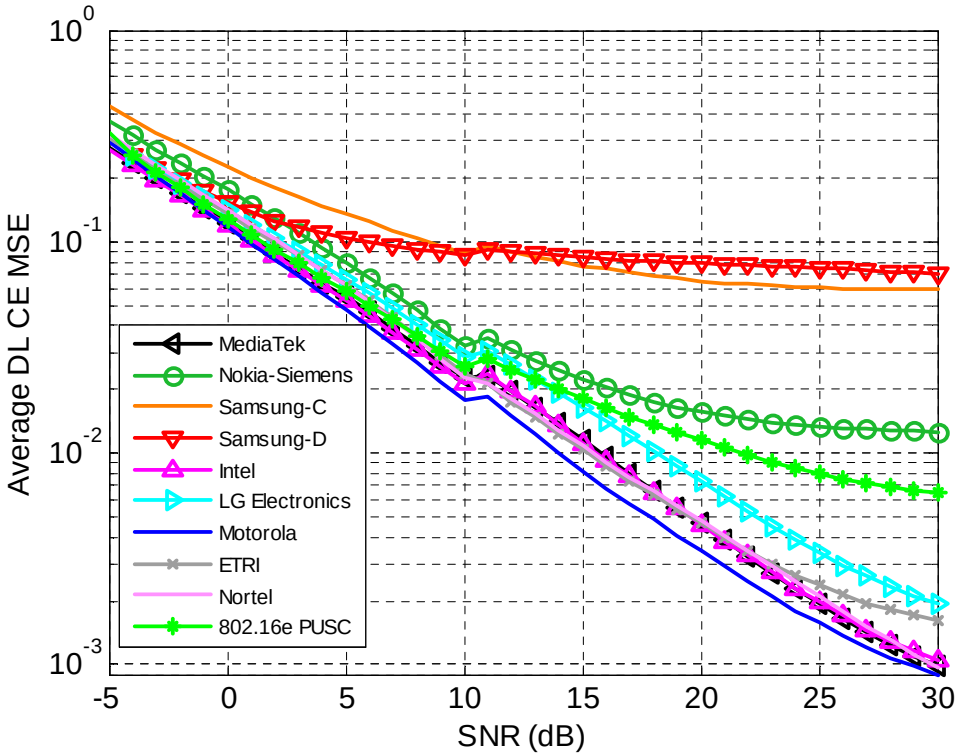
- Observations:
  - Motorola best at all SNRs
  - MediaTek and Intel fairly close to Motorola
  - Samsung C&D, PUSC, Nokia-Siemens do not perform well in velocity

Channel Estimation MSE Results for 4 Tx, 120 kph, mVehA

4 Tx, 2 Rx



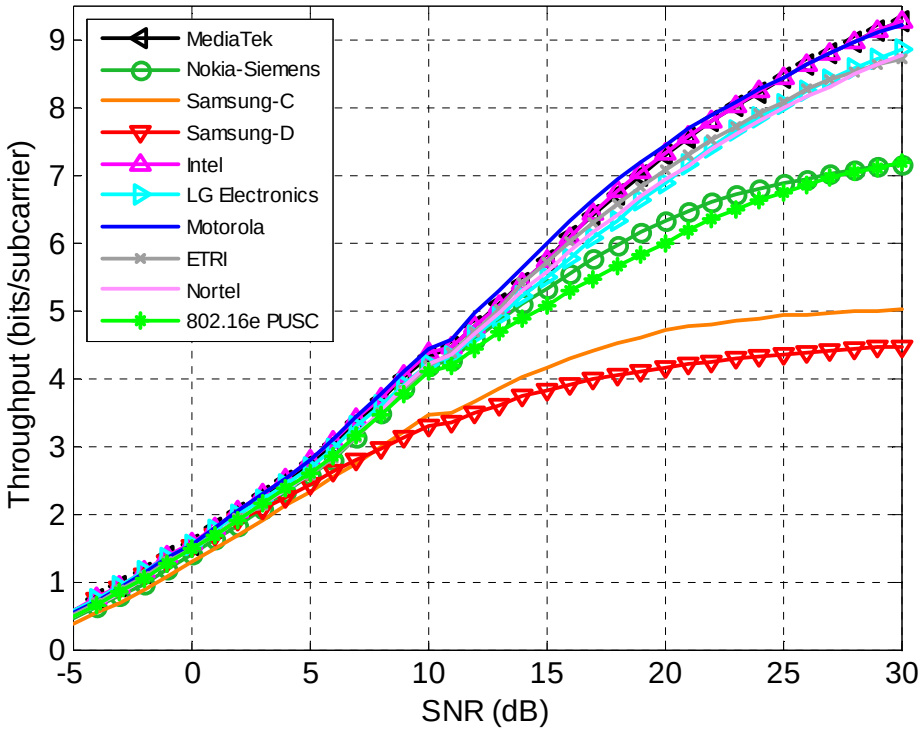
4 Tx, 4 Rx



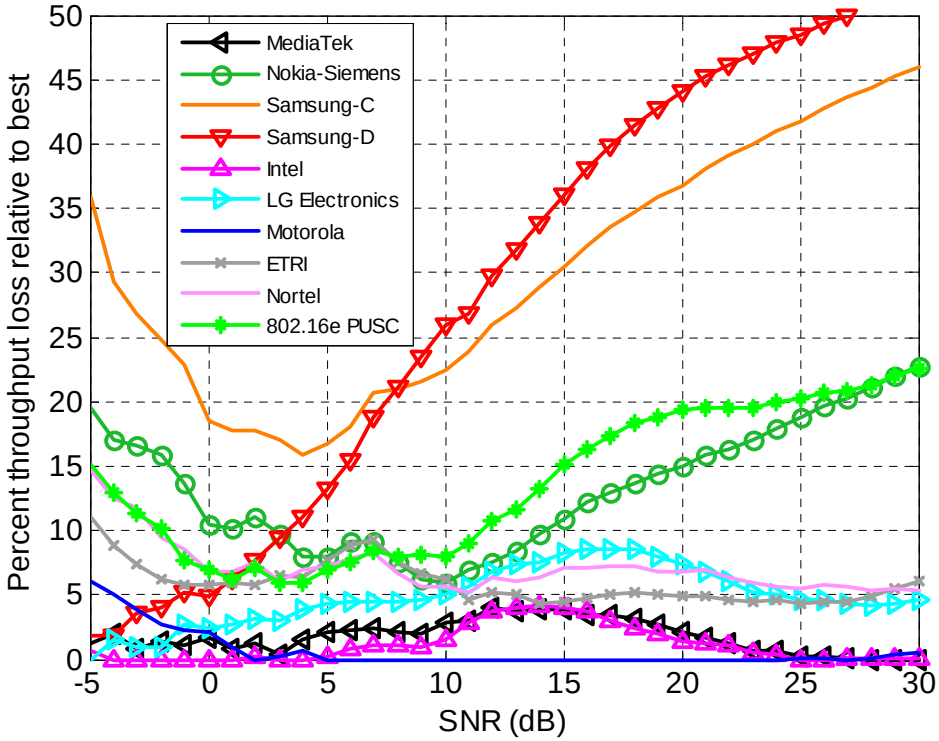
- Observations:
  - Motorola has best CE MSE performance
  - Bump in CE MSE around 10 dB due to switching delay spread window for MMSE CE

Performance Comparisons for 8 Tx, 2 Rx, 120 kph, mVehA

Throughput



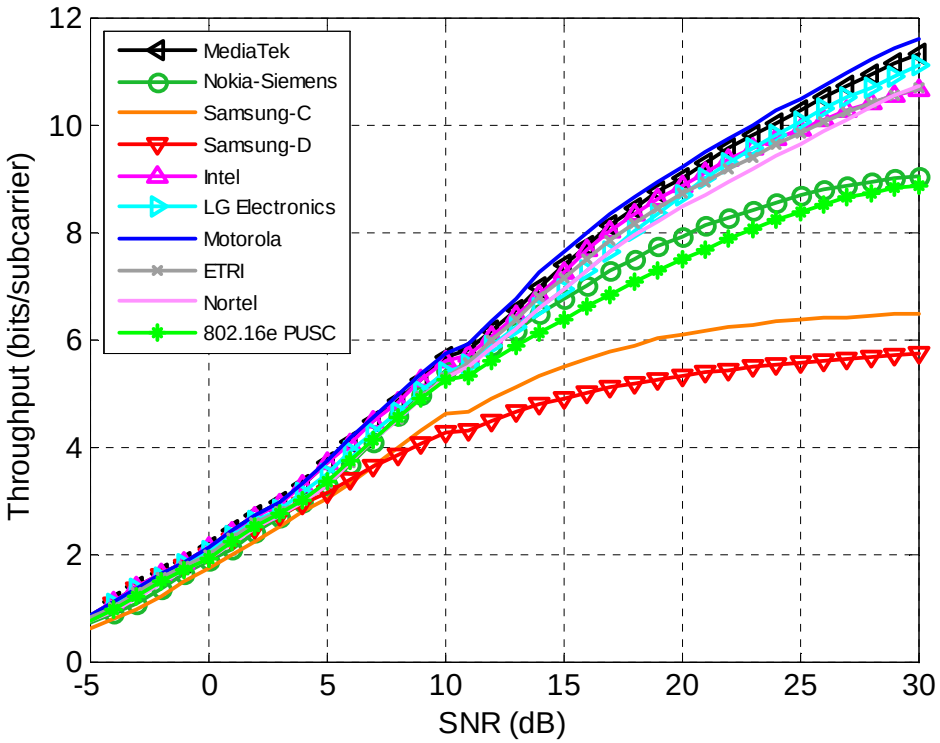
Throughput Loss over Best



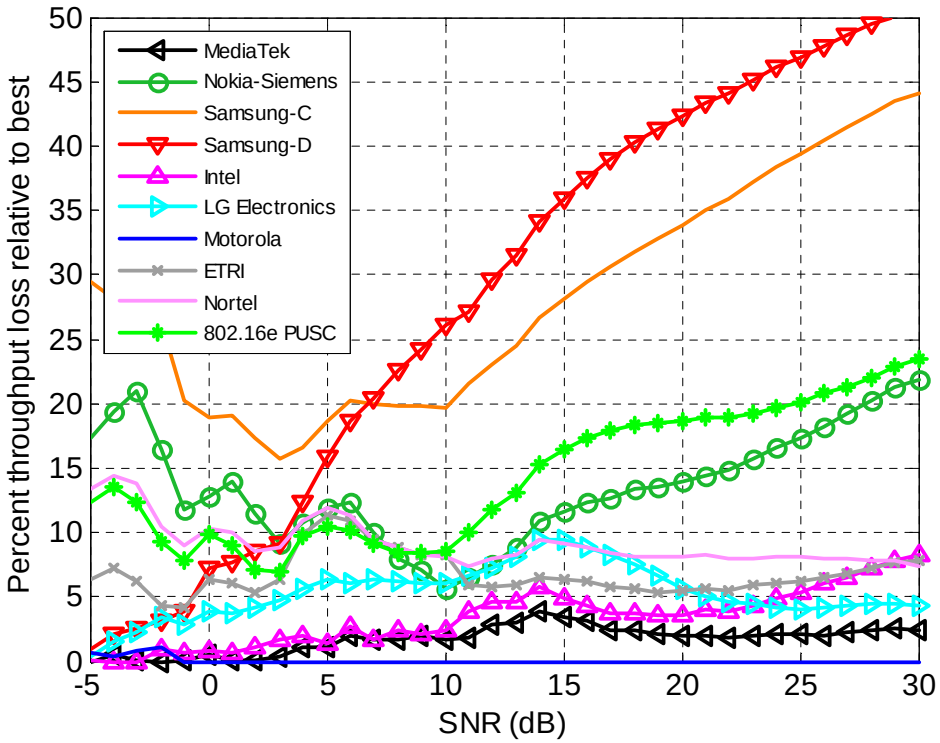
- Observations:
  - Motorola best at all SNRs
  - MediaTek and Intel fairly close to Motorola
  - Samsung C&D, PUSC, Nokia-Siemens do not perform well in velocity

Performance Comparisons for 8 Tx, 4 Rx, 120 kph, mVehA

Throughput



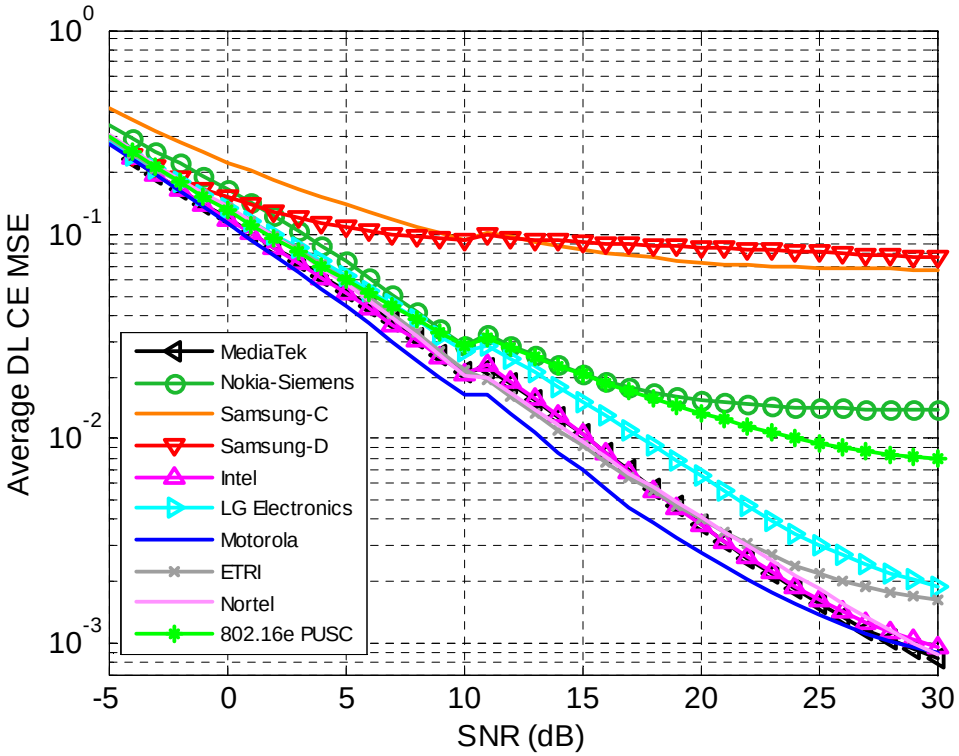
Throughput Loss over Best



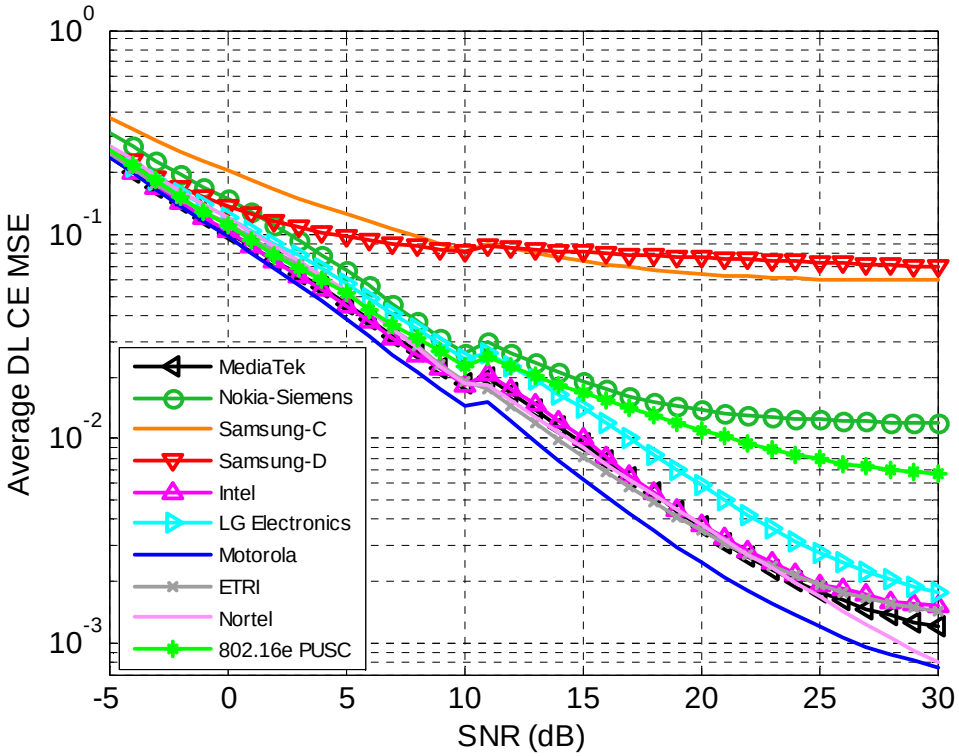
- Observations:
  - Motorola best at all SNRs
  - MediaTek fairly close to Motorola (Intel close at SNR<11 dB)
  - Samsung C&D, PUSC, Nokia-Siemens do not perform well in velocity

Channel Estimation MSE Results for 8 Tx, 120 kph, mVehA

8 Tx, 2 Rx



8 Tx, 4 Rx



- Observations:
  - Motorola has best CE MSE performance
  - Bump in CE MSE around 10 dB due to switching delay spread window for MMSE CE

Summary of Results

- Motorola's format is most robust to all cases (Intel's and MediaTek's formats a close second)
- Motorola's format best at 120 kph (mVehA)
- Results for Nortel were based on single resource tile which has a very high overhead (multiple resource tile formats will improve Nortel's results)
- Samsung's and Nokia-Siemen's formats have poor performance in velocity (as well as 802.16e PUSC)

Considerations for improving all designs:

- Are these pilot formats robust to high delay spreads?
- Does one format support pilot power boosting better than the others?
- Can performance be improved at low speeds by dropping pilot density at very high SNRs (>20 dB)?
- Implementation issues to consider:
  - Motorola's formats do not require the mobile to change the one- and two-stream channel estimator when changing from one and two streams to three and four streams (Intel's does require a change)
  - MS channel estimation is simplified with fewer tile types