

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

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*<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

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Further information is located at <http://standards.ieee.org/board/pat/pat-material.html>> and <http://standards.ieee.org/board/pat>>.

Introduction

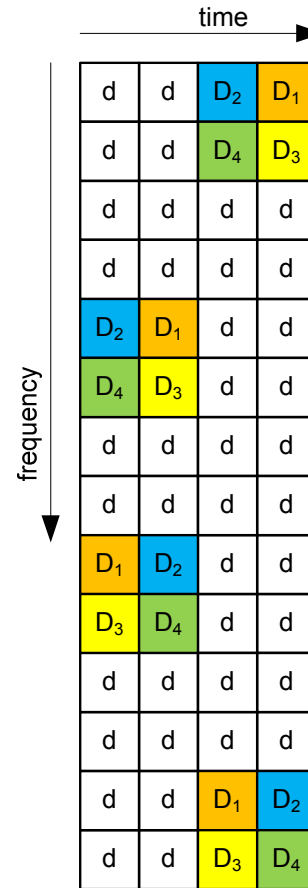
- Purpose
 - Summarize and compare several of the proposed MIMO pilot formats
 - Provide basis for further harmonization and additional design considerations
- Scope
 - Examine formats proposed for use with dedicated pilots
 - Examine formats that support up to 4 transmission streams
 - Did not examine 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
Nortel	C802.16m-08/172r1
Samsung	C802.16m-08/188r2

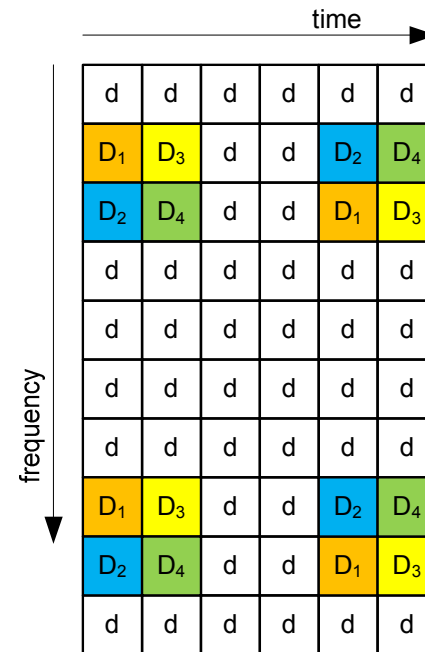
802.16e Downlink PUSC (PUSC-like)

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



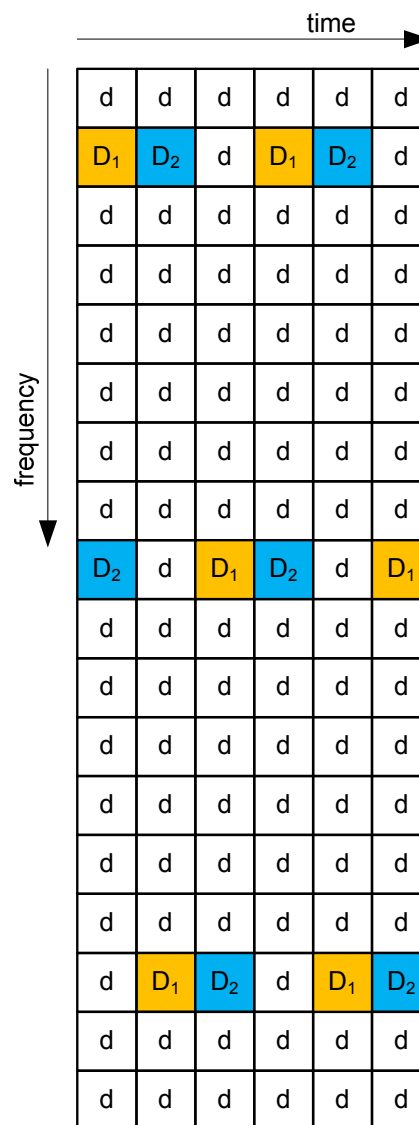
ETRI's Pilot Format

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

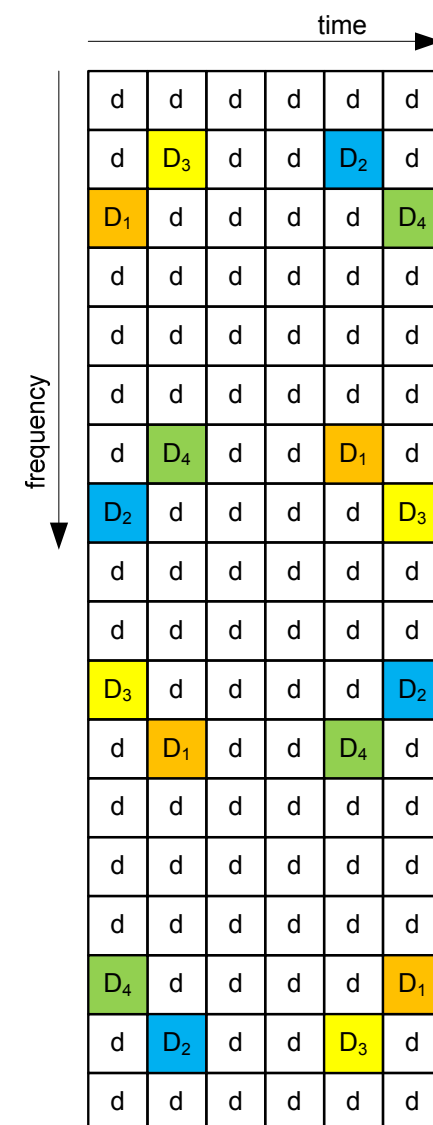


Intel's Pilot Formats

- 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



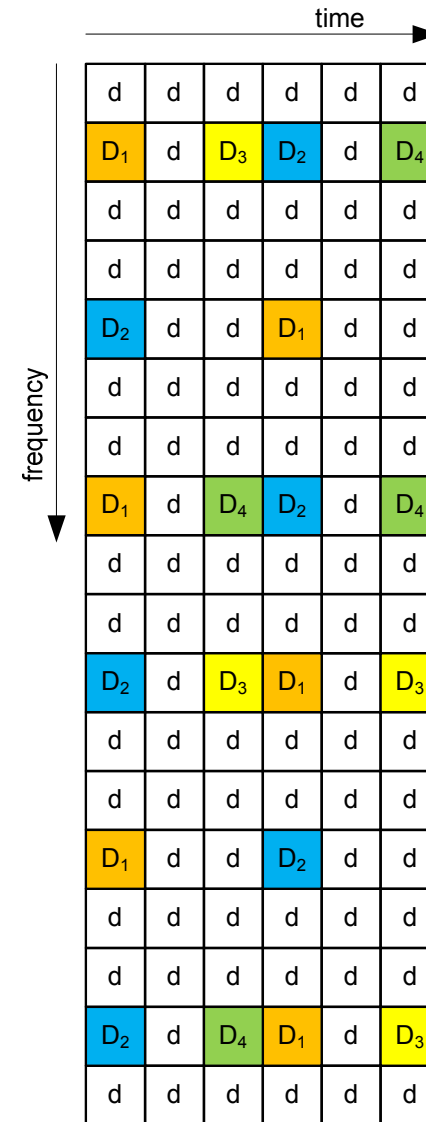
Format A



Format B

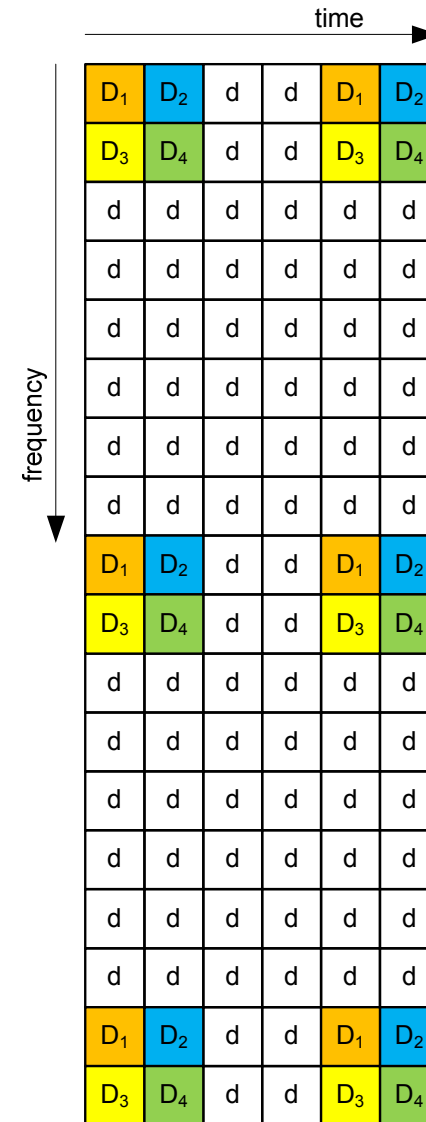
LG Electronic's Pilot Format (type B)

- 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



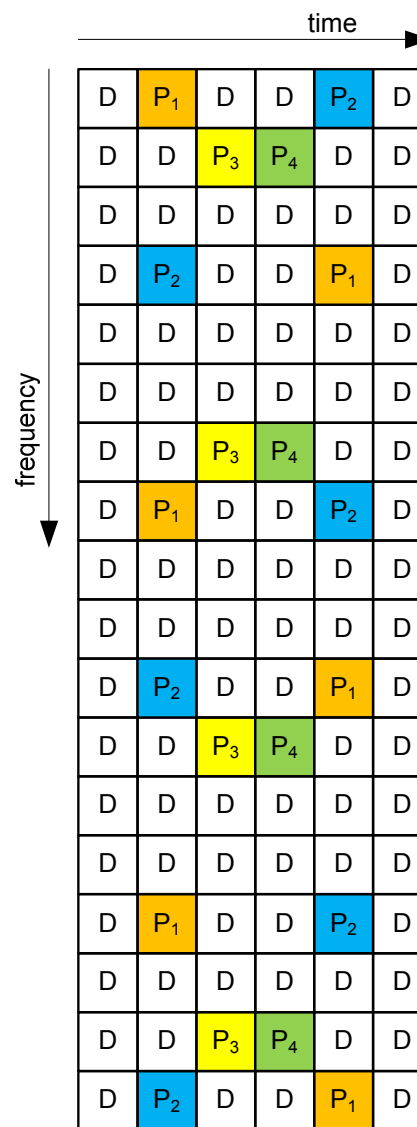
MediaTek's Pilot Format

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



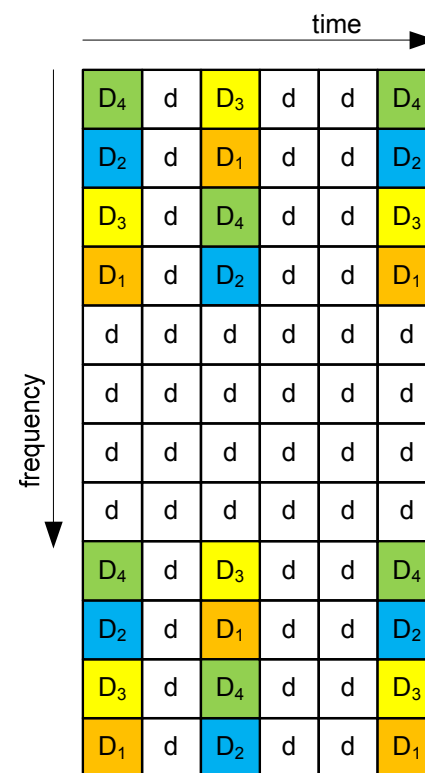
Motorola's Pilot Format

- 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

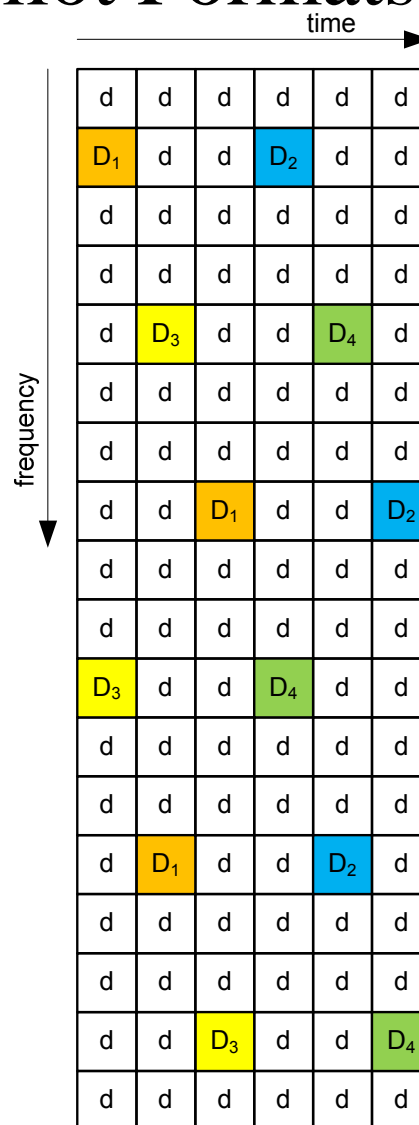
- From 08/172r1
- 12x6
- Overhead:
 - 8.3% per stream if single resource tile allocation
 - 6.3% for two resource tiles in frequency
 - 5.6% for three resource tiles in frequency
 - 4.2% for N resource tiles in frequency (N large)



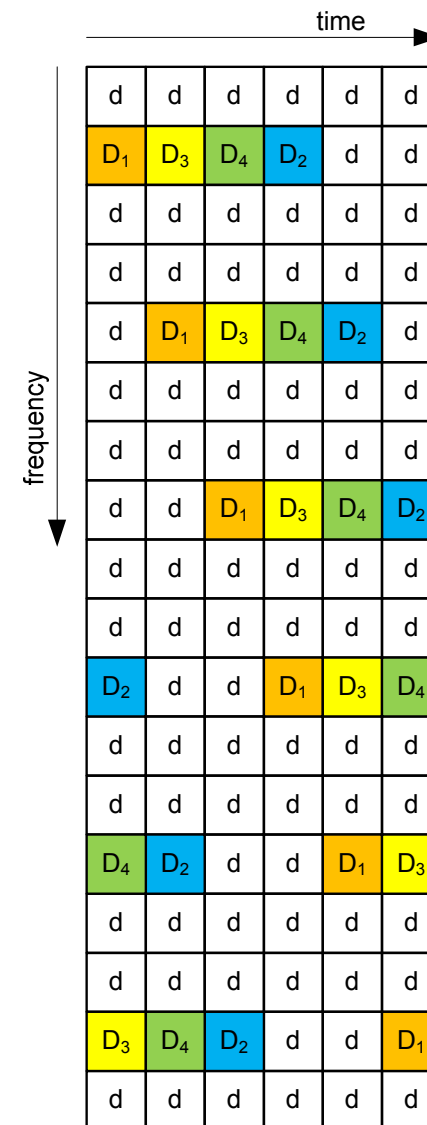
Note: Only single resource tile format shown. When concatenated in frequency the format will have lower overhead.

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

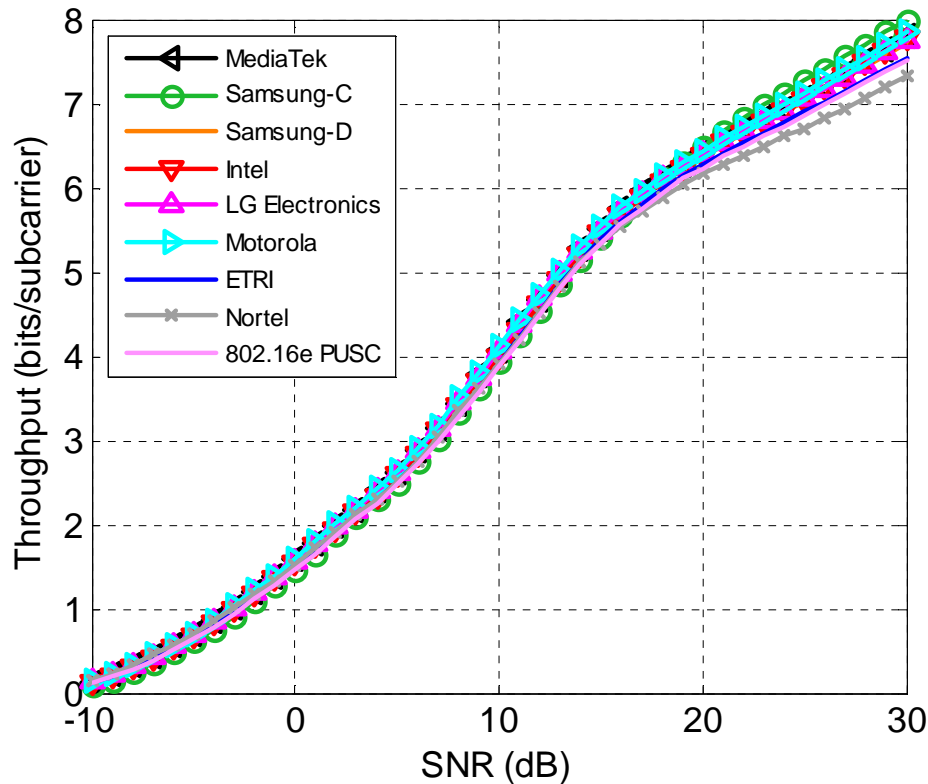
Downlink Performance Comparisons

- BS: 4 or 8 Tx antennas *
 - 1/2 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 $SNR \leq 10$ 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

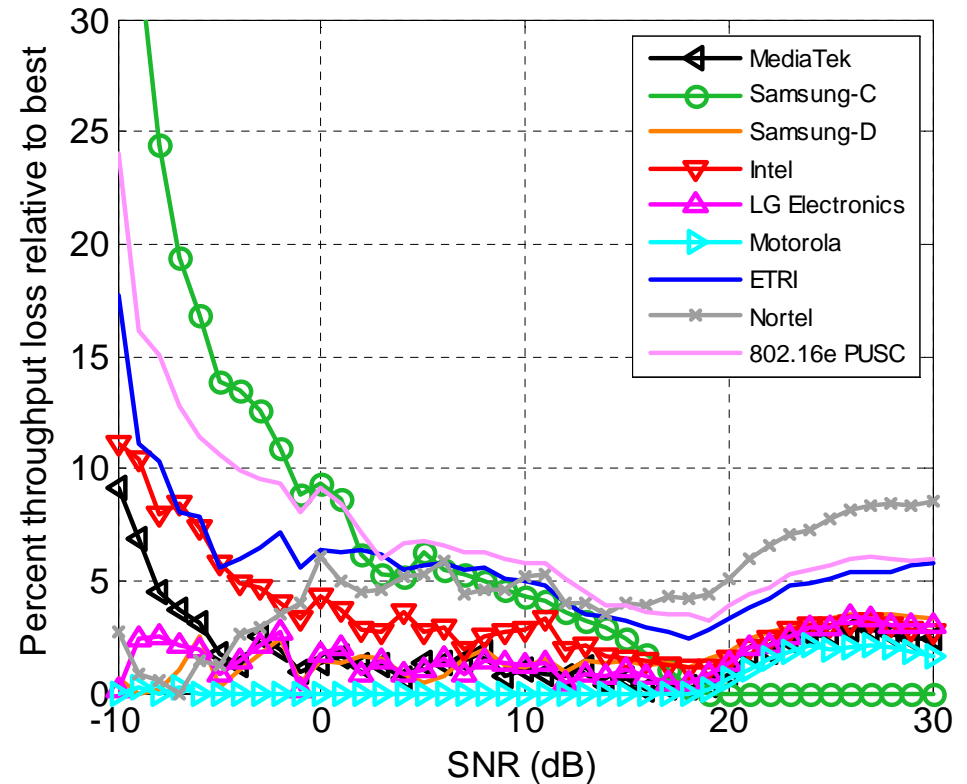
Results with 3 kph, mPedB

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

Throughput



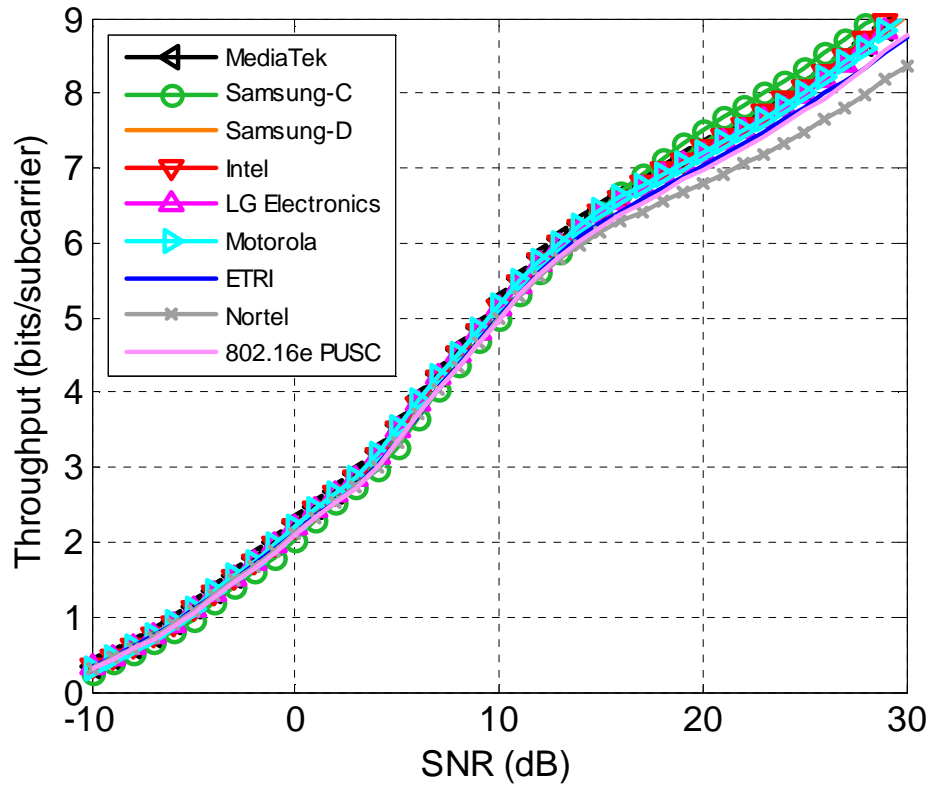
Throughput Loss over Best



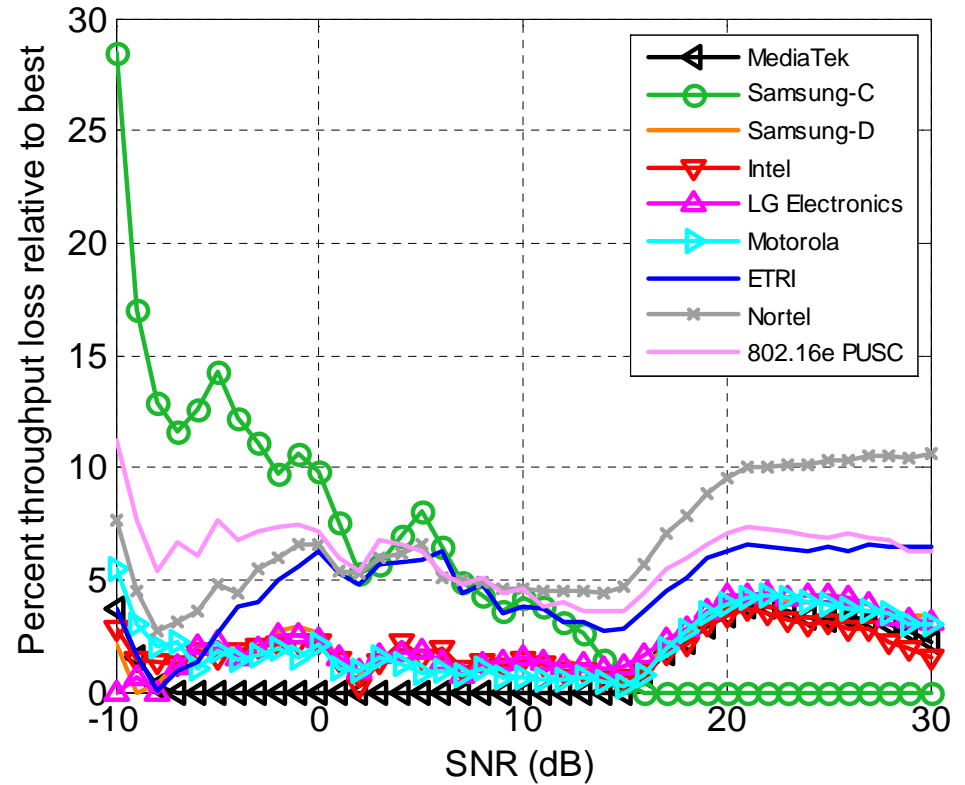
- Observations:
 - Motorola best at SNRs < 19 dB
 - LG, MediaTek, and Samsung-D close to Motorola's performance
 - Samsung C best at SNRs > 18

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

Throughput



Throughput Loss over Best

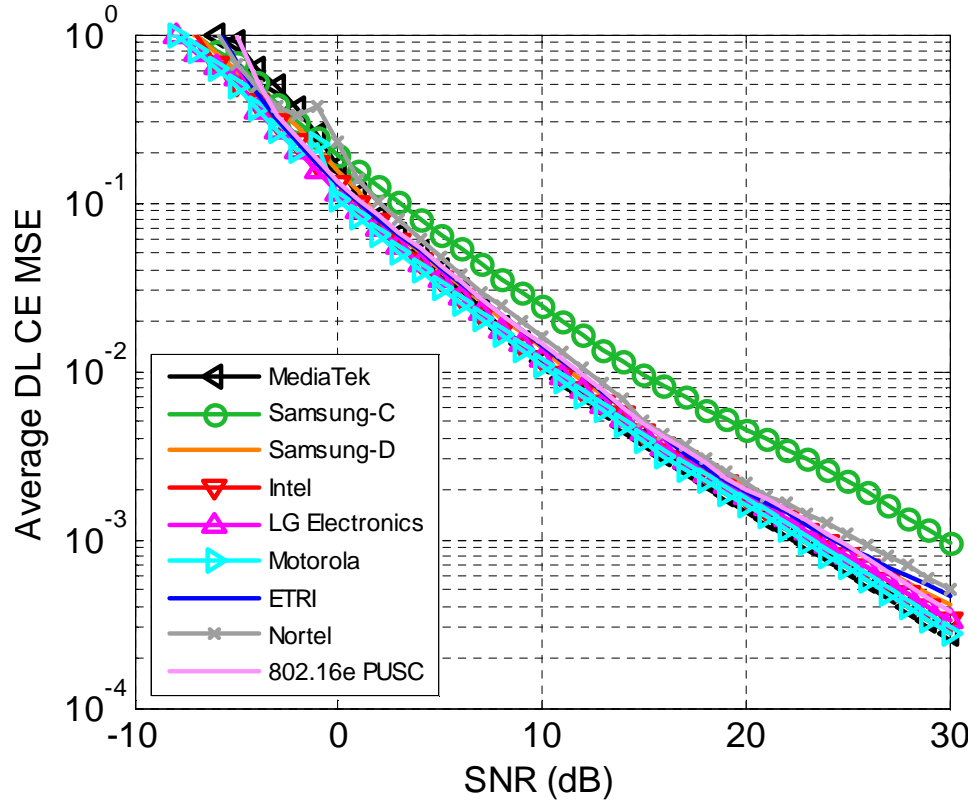


- Observations:

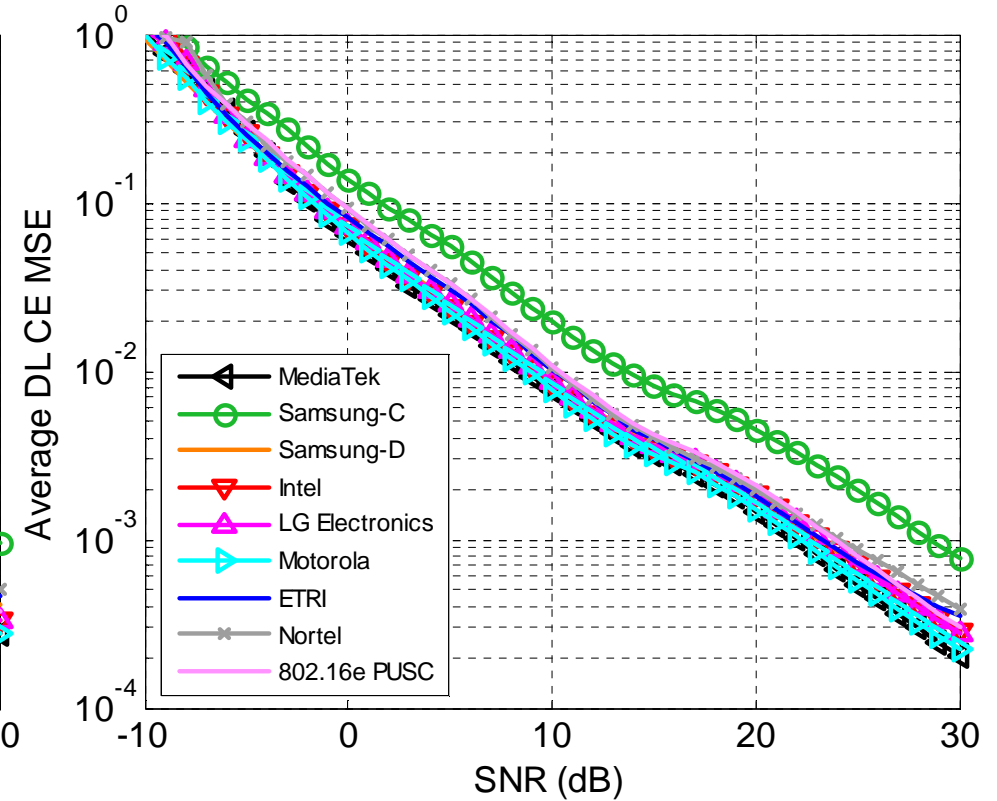
- MediaTek best at SNRs < 16 dB
- Intel, LG, Motorola, Samsung-D close to MediaTek at SNRs < 18 dB
- Samsung C best at SNRs > 16 dB

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

4 Tx, 2 Rx



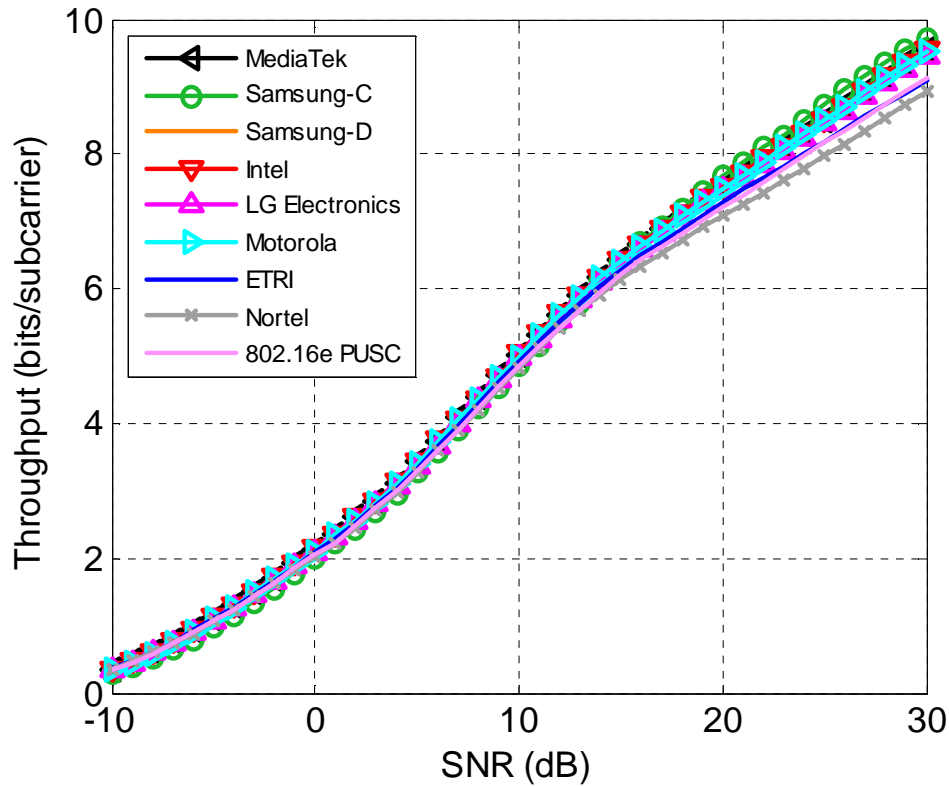
4 Tx, 4 Rx



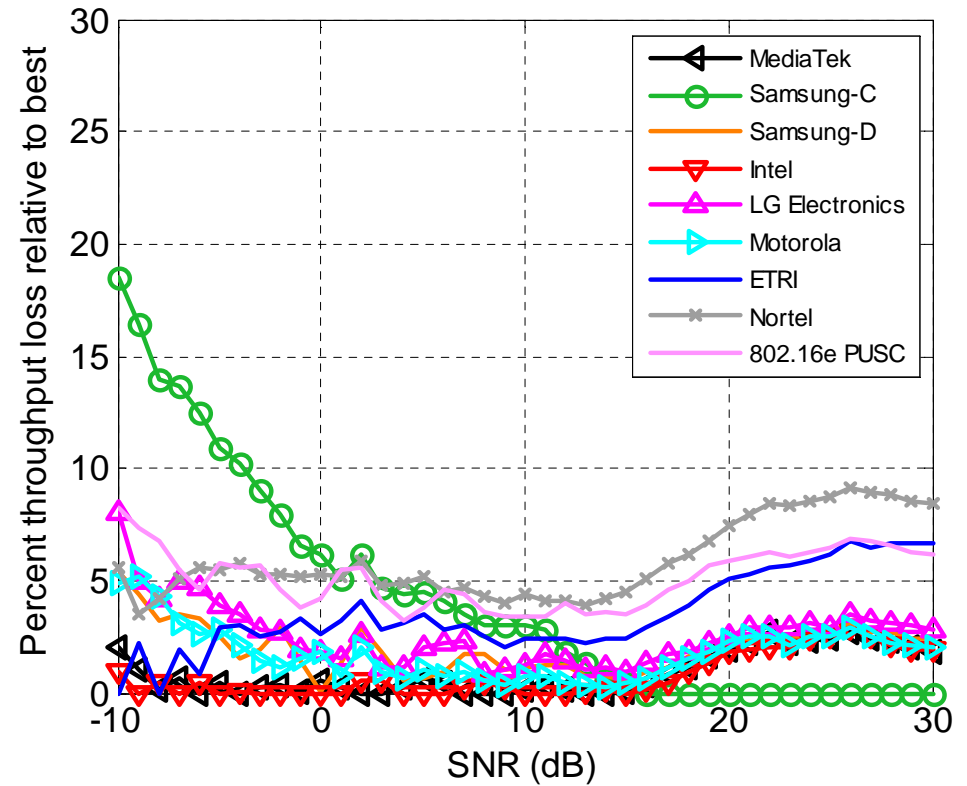
- Observations:
 - All but Samsung-C have similar performance
 - MediaTek has slightly better performance than rest

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

Throughput



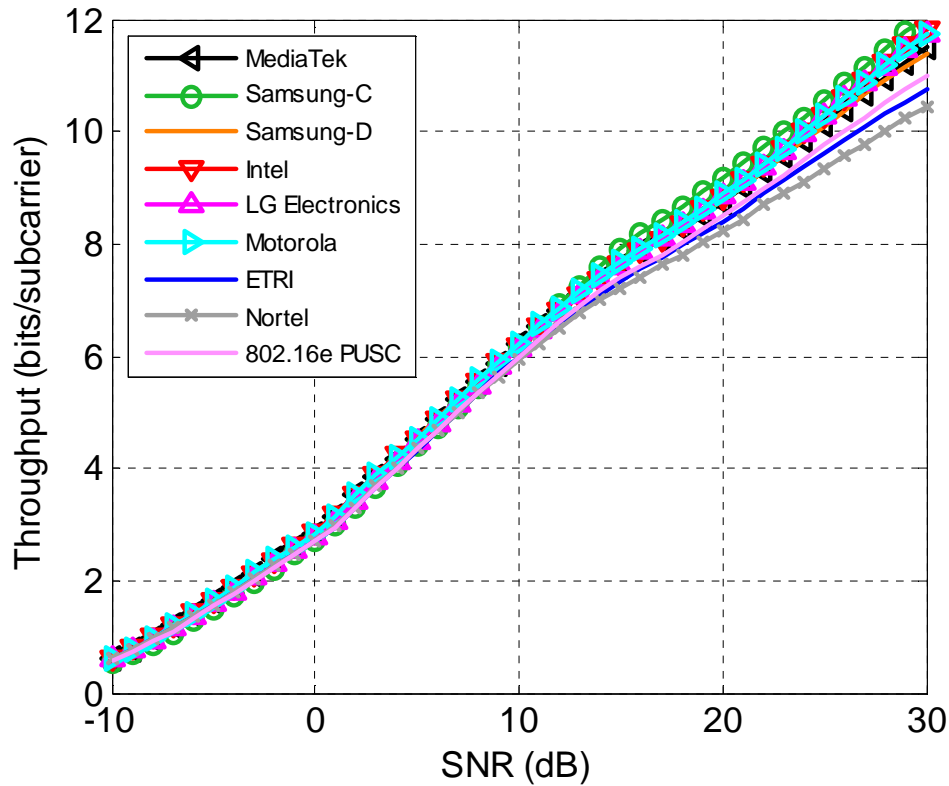
Throughput Loss over Best



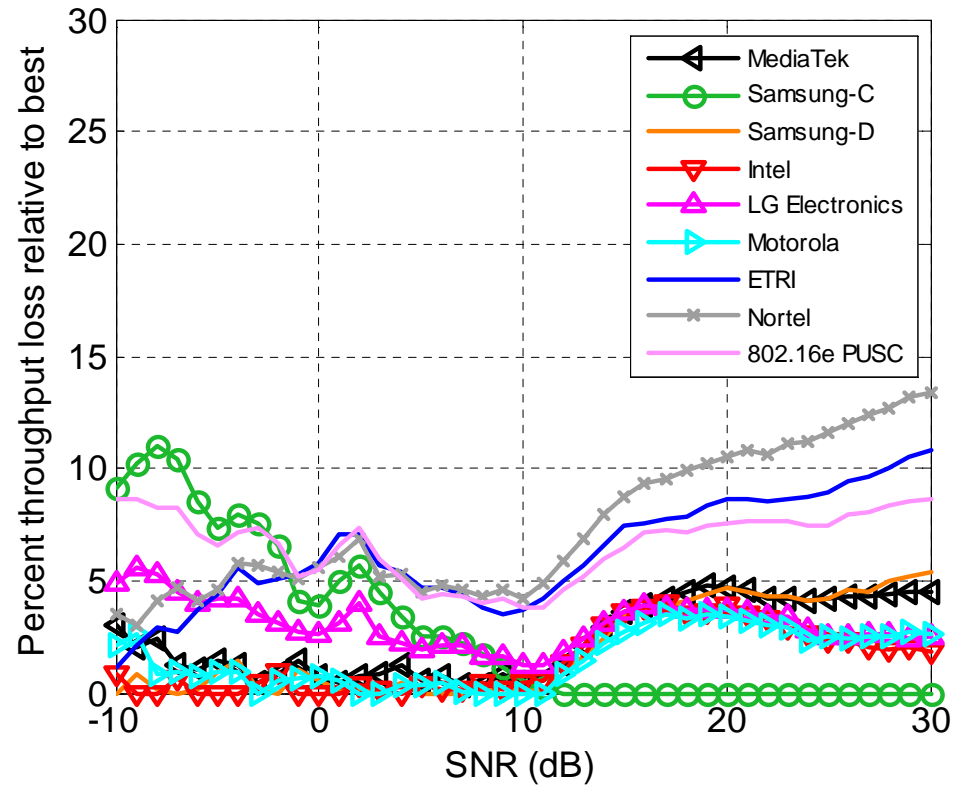
- Observations:
 - Intel and MediaTek best at SNRs < 16 dB
 - LG, Motorola, Samsung-D close to Intel and MediaTek at SNRs < 16 dB
 - Samsung C best at SNRs > 16 dB

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

Throughput



Throughput Loss over Best

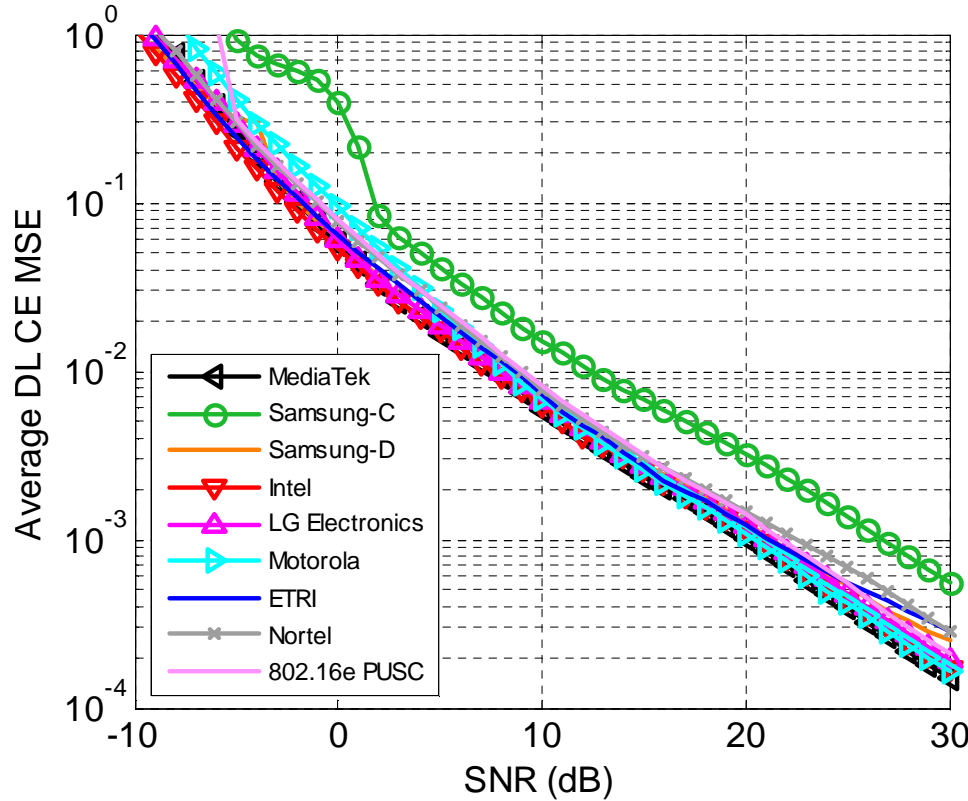


- Observations:

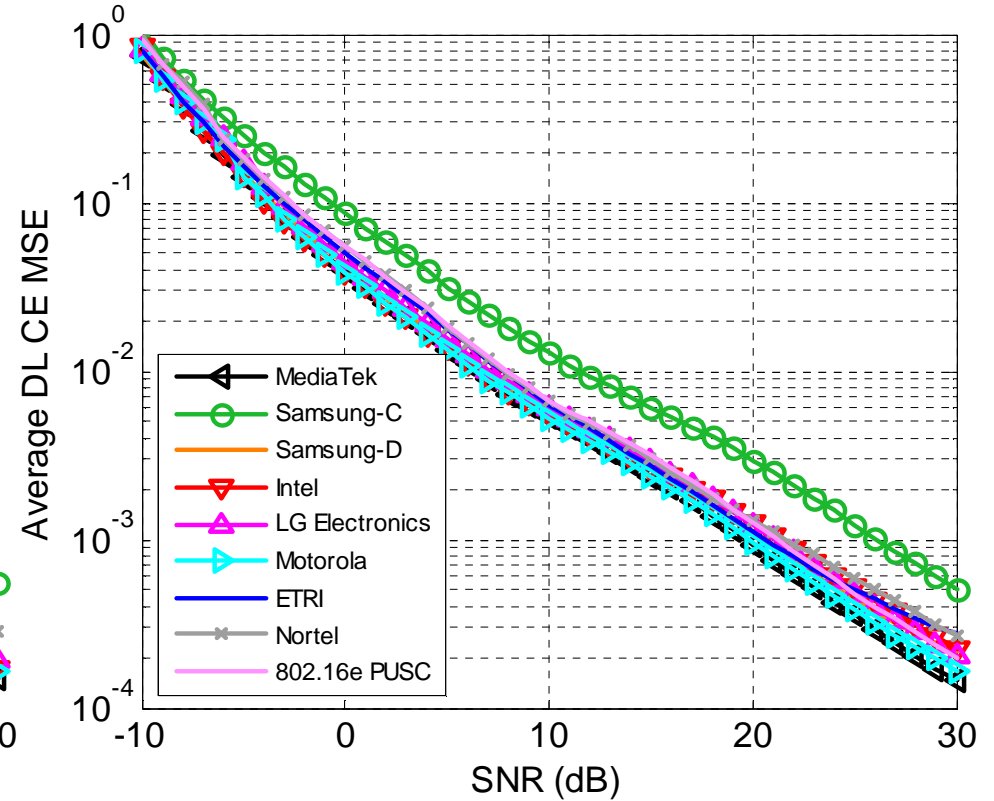
- Intel, Samsung-D, MediaTek, and Motorola best at SNRs < 12 dB
- Samsung-C best at SNRs > 11 dB

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

8 Tx, 2 Rx



8 Tx, 4 Rx

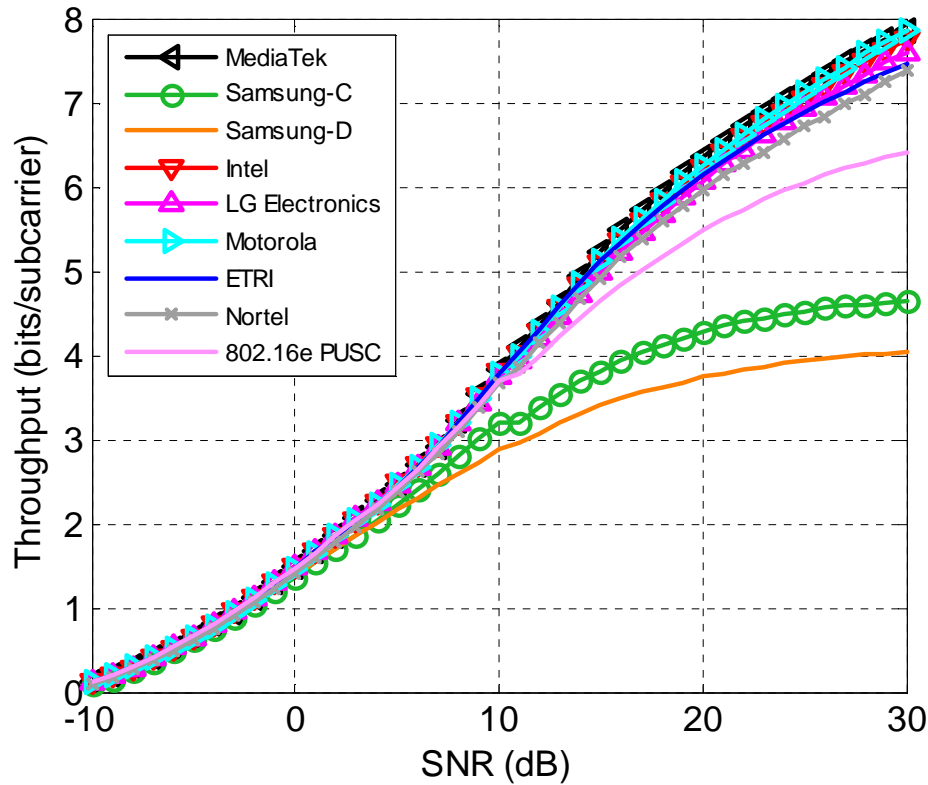


- Observations:
 - All but Samsung-C have similar performance
 - MediaTek has slightly better performance than rest

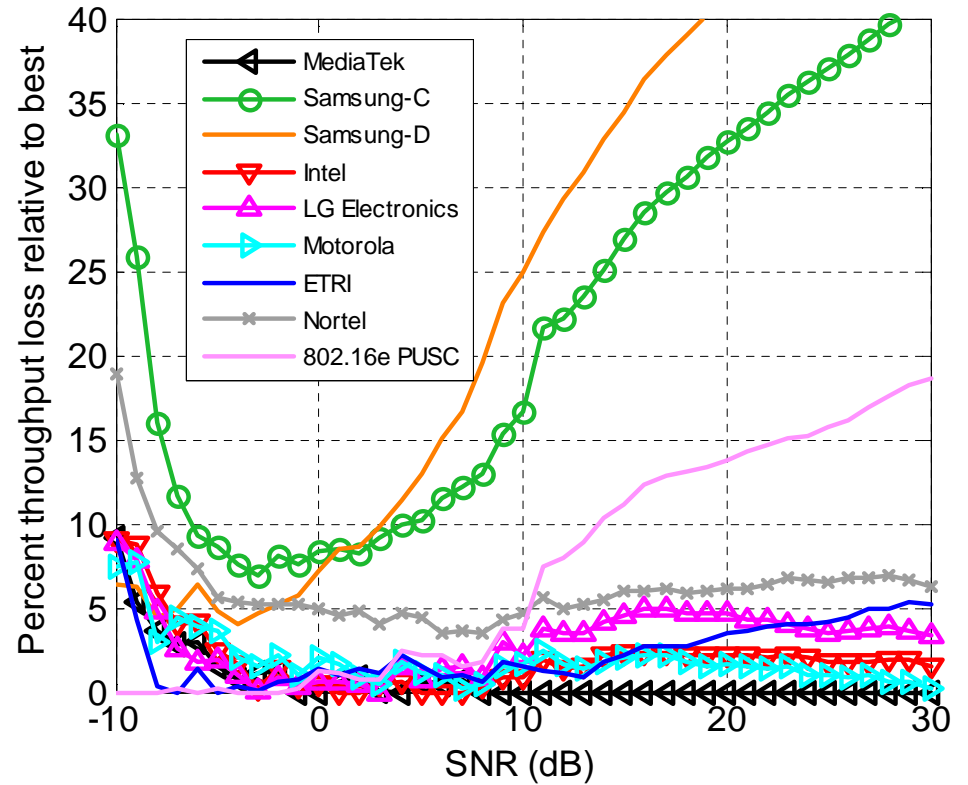
Results with 120 kph, mVehA

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

Throughput



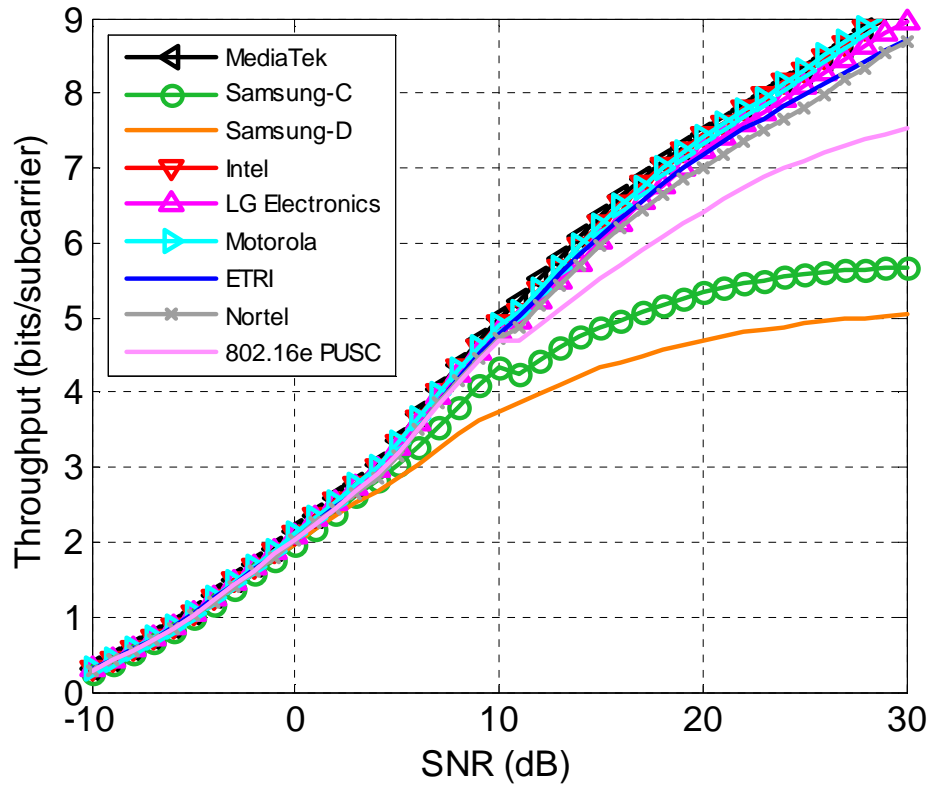
Throughput Loss over Best



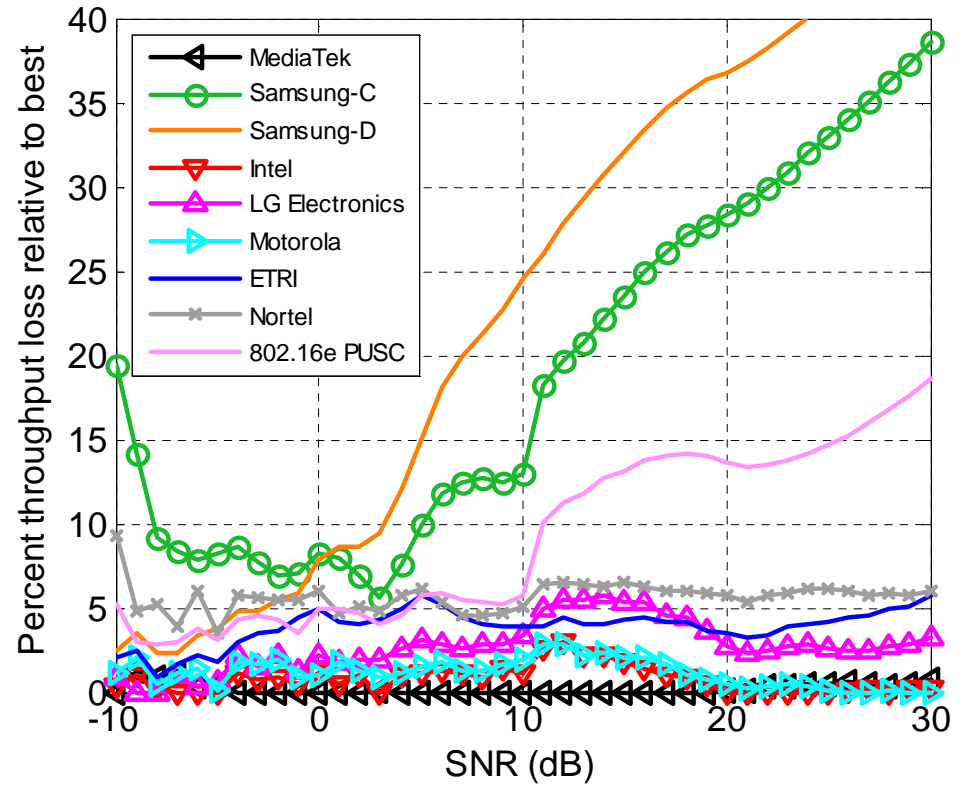
- Observations:
 - MediaTek best at most SNRs
 - Intel and Motorola fairly close to MediaTek
 - Samsung C&D, PUSC do not perform well in velocity

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

Throughput



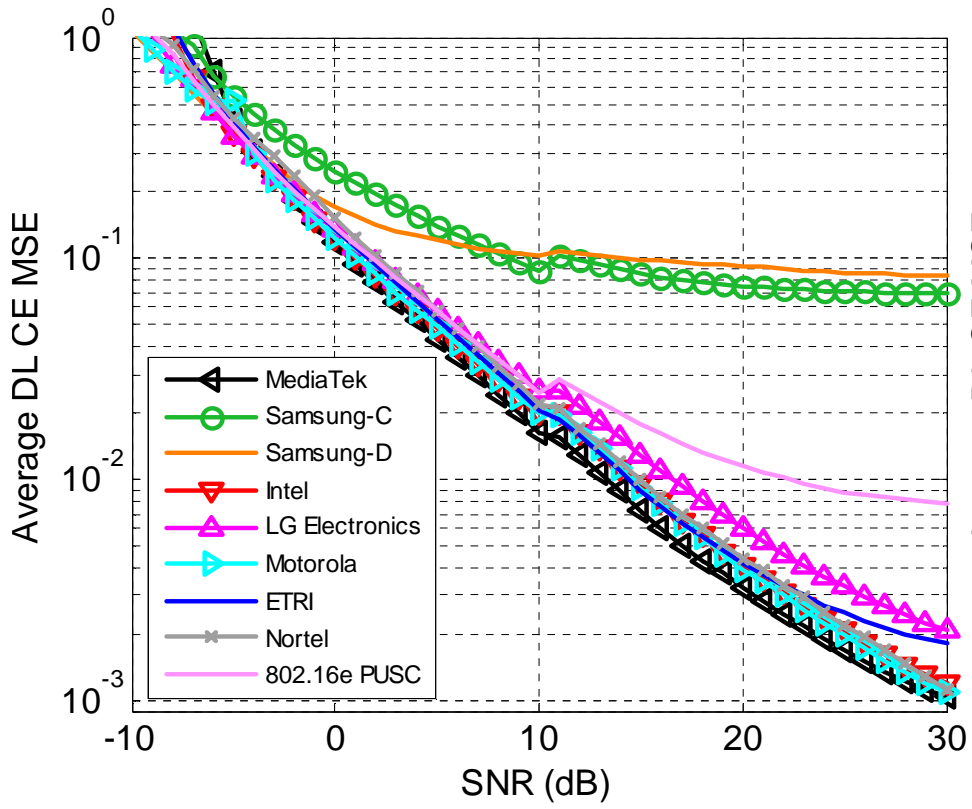
Throughput Loss over Best



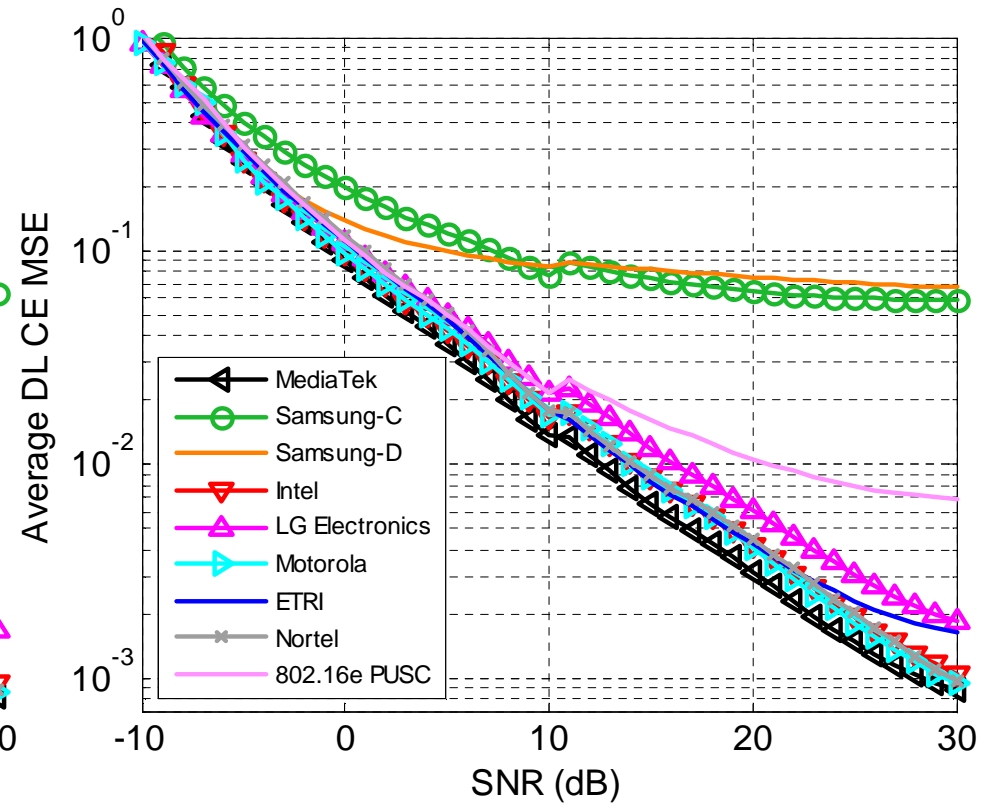
- Observations:
 - MediaTek best at most SNRs
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 - Samsung C&D, PUSC do not perform well in velocity

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

4 Tx, 2 Rx



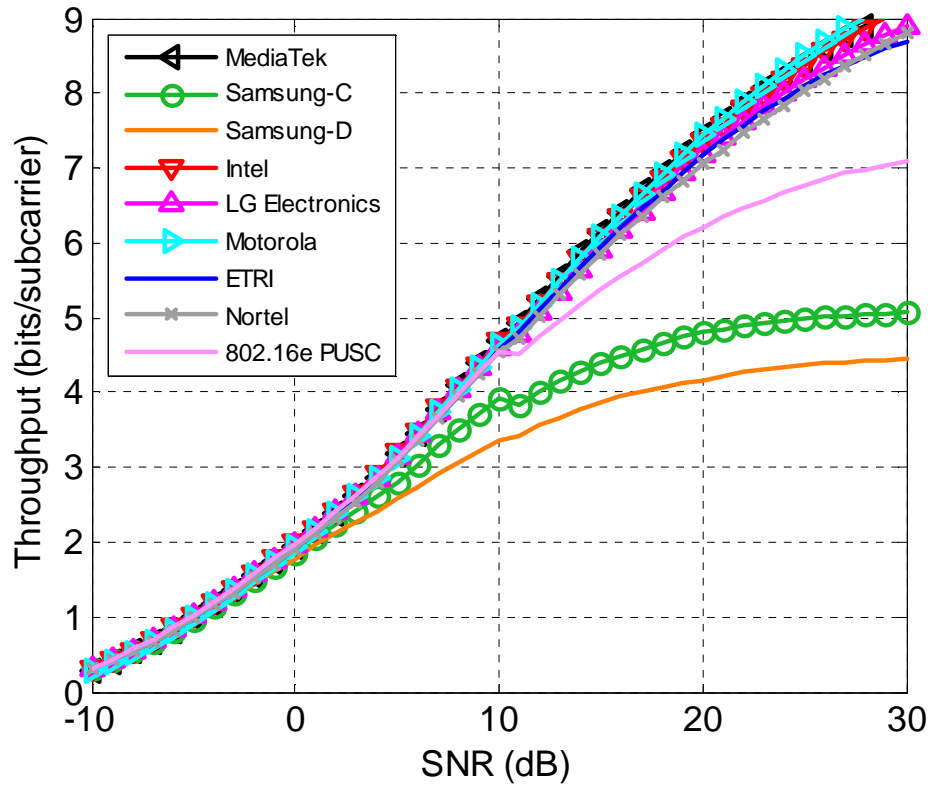
4 Tx, 4 Rx



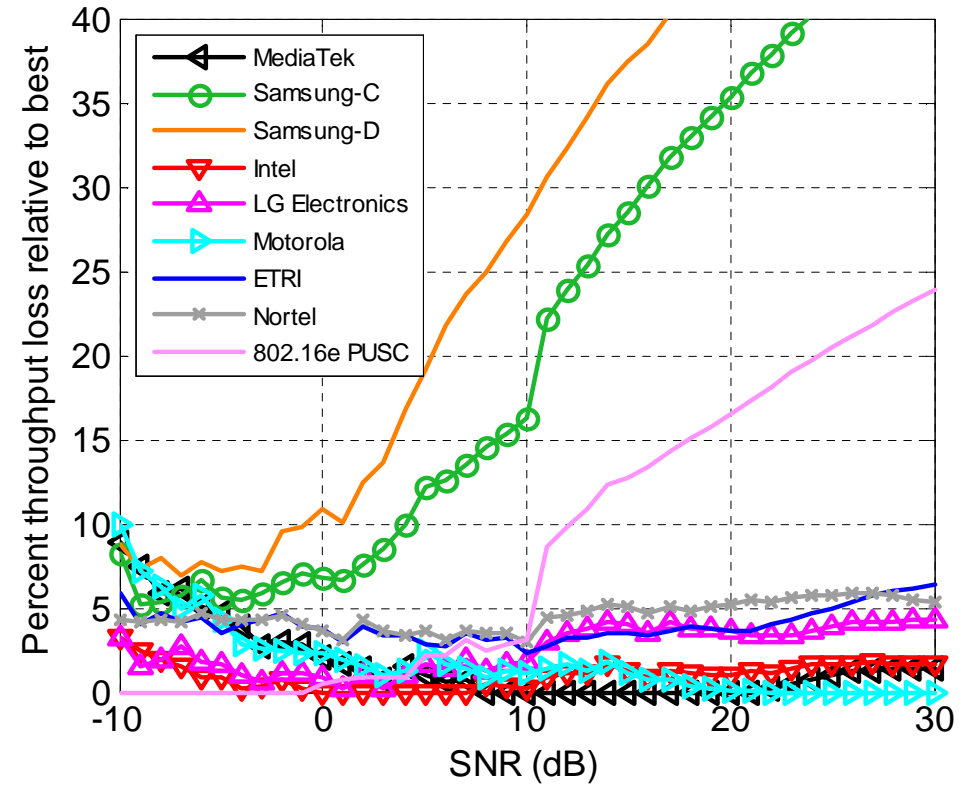
- Observations:
 - MediaTek has best CE MSE performance
 - Bump in CE MSE around 10 dB due to switching delay spread window for MMSE CE

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

Throughput



Throughput Loss over Best

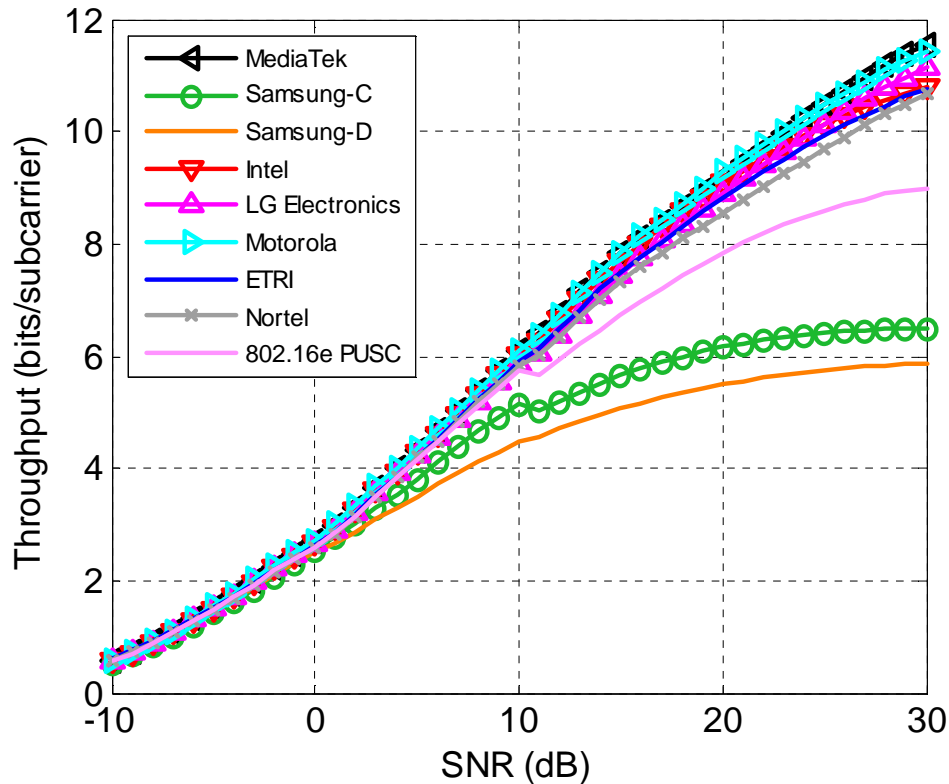


- Observations:

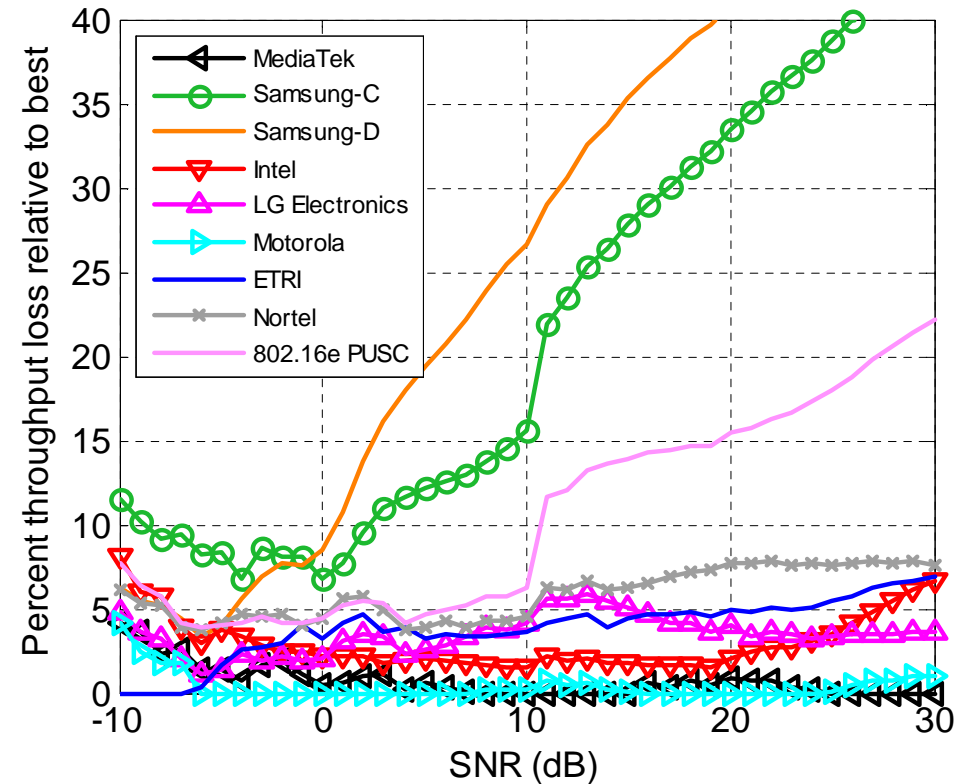
- Intel and Lg best at SNRs < 8 dB, MediaTek best at SNRs between 8 dB and 21 dB, Motorola best at SNRs > 21 dB
- Samsung C&D, PUSC do not perform well in velocity

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

Throughput



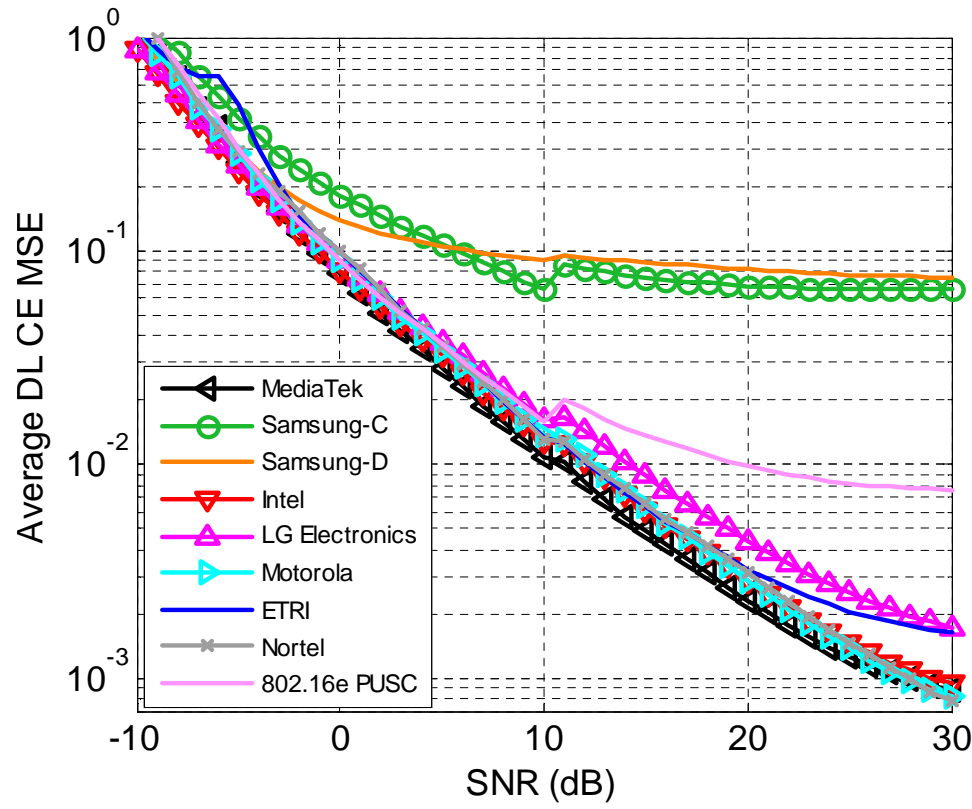
Throughput Loss over Best



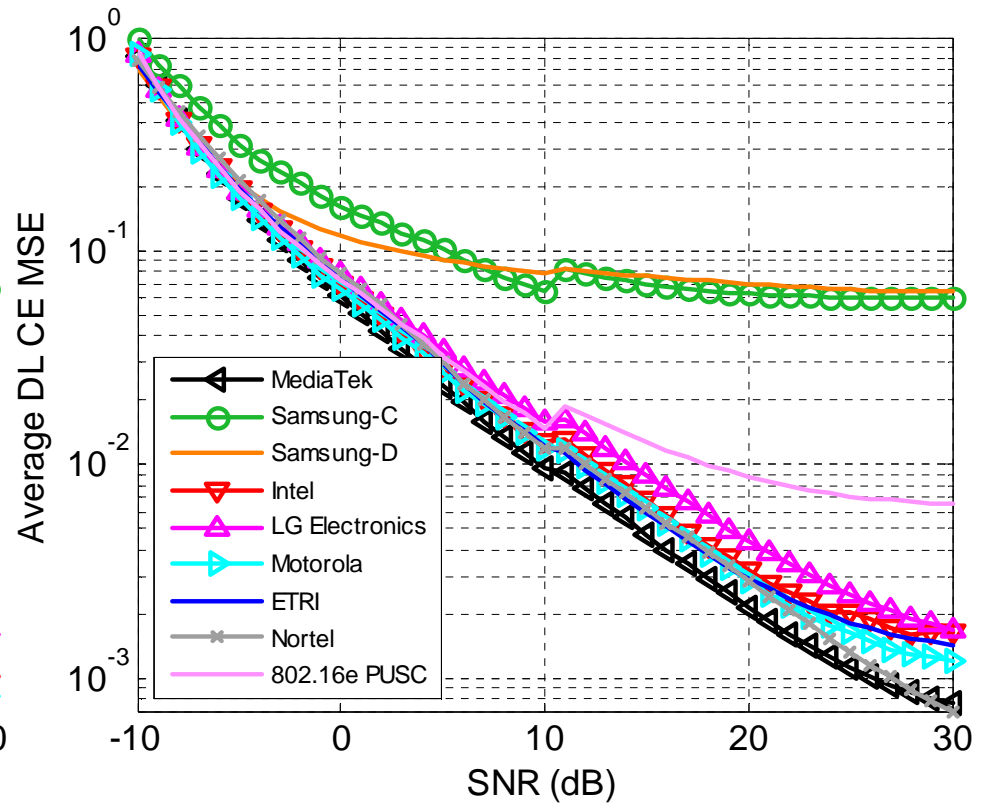
- Observations:
 - MediaTek or Motorola best at SNRs > -7 dB (ETRI best at SNRs < -6 dB)
 - Intel's performance fairly close to MediaTek/Motorola at SNRs < 23 dB
 - Samsung C&D, PUSC do not perform well in velocity

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

8 Tx, 2 Rx



8 Tx, 4 Rx

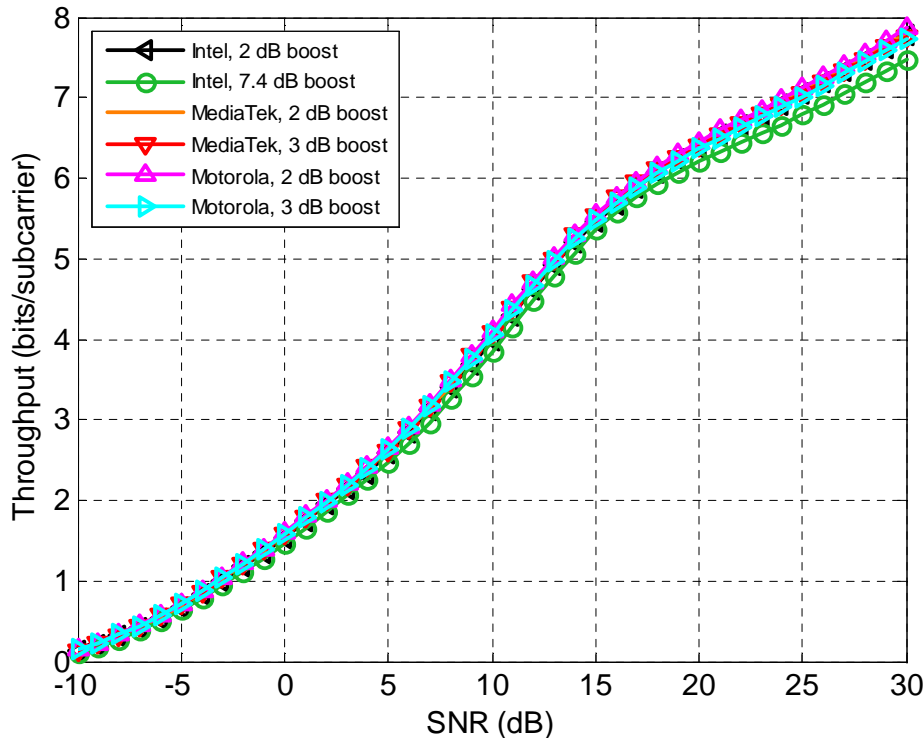


- Observations:
 - MediaTek has best CE MSE performance
 - Bump in CE MSE around 10 dB due to switching delay spread window for MMSE CE

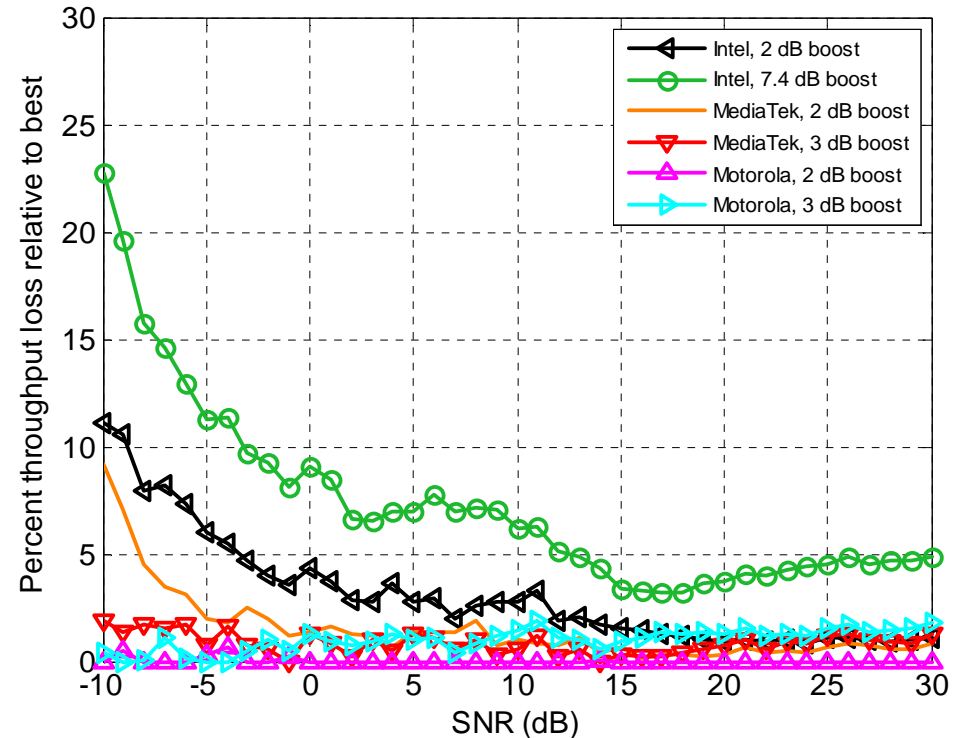
Results with 3 kph, mPedB Different Pilot Power Boosting

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

Throughput



Throughput Loss over Best



- Observations:

- Boosting by 7.4 dB hurts Intel's performance because too much power is stolen from the data
- 2 dB power boosting better for Motorola and MediaTek than 3 dB

Summary of Results

- Intel's, MediaTek's, and Motorola's formats are all fairly robust to the cases simulated
- MediaTek's format best at 120 kph (mVehA) in terms of channel estimation MSE
- 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 PUSC formats have poor performance in velocity
- Pilot boosting beyond 2 dB provides no improvement in throughput

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?
- What is the performance when two or more resource tiles are available in frequency?
- 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