Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Simulation Results for Common and Dedicated Pilots**
Date Submitted	**2008-05-05**
Source(s)	Jung Woon Lee, Zhigang Rong, Tao Wu, Young Hoon Kwon, Yang Tang, Yunsong Yang, Jianmin Lu Huawei E-mail: zrong@huawei.com
Re:	Call for Contributions on Project 802.16m System Description Document (SDD). Target topic: “Pilot Structures as relevant to downlink MIMO”.
Abstract	This contribution provides the simulation results for various common and dedicated pilot schemes supporting downlink MIMO transmissions.
Purpose	For discussion and approval by TGm
Notice	*This document does not represent the agreed views of the IEEE 802.16 Working Group or any of its subgroups*. It represents only the views of the participants listed in the “Source(s)” field above. It is offered as a basis for discussion. It is not binding on the contributor(s), who reserve(s) the right to add, amend or withdraw material contained herein.
Release	The contributor grants a free, irrevocable license to the IEEE to incorporate material contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE’s name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE’s sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.16.
Patent Policy	The contributor is familiar with the IEEE-SA Patent Policy and Procedures: <http://standards.ieee.org/guides/bylaws/sect6-7.html#6> and <http://standards.ieee.org/guides/opman/sect6.html#6.3>. Further information is located at <http://standards.ieee.org/board/pat/pat-material.html> and <http://standards.ieee.org/board/pat>.

Objectives

- This contribution provides the performance comparison of various common pilot and dedicated pilot schemes for downlink MIMO transmission.
- The simulation results show that common pilot plus the on-demand dedicated pilot [1,2] is an efficient MIMO pilot structure for various MIMO configurations and channel scenarios.

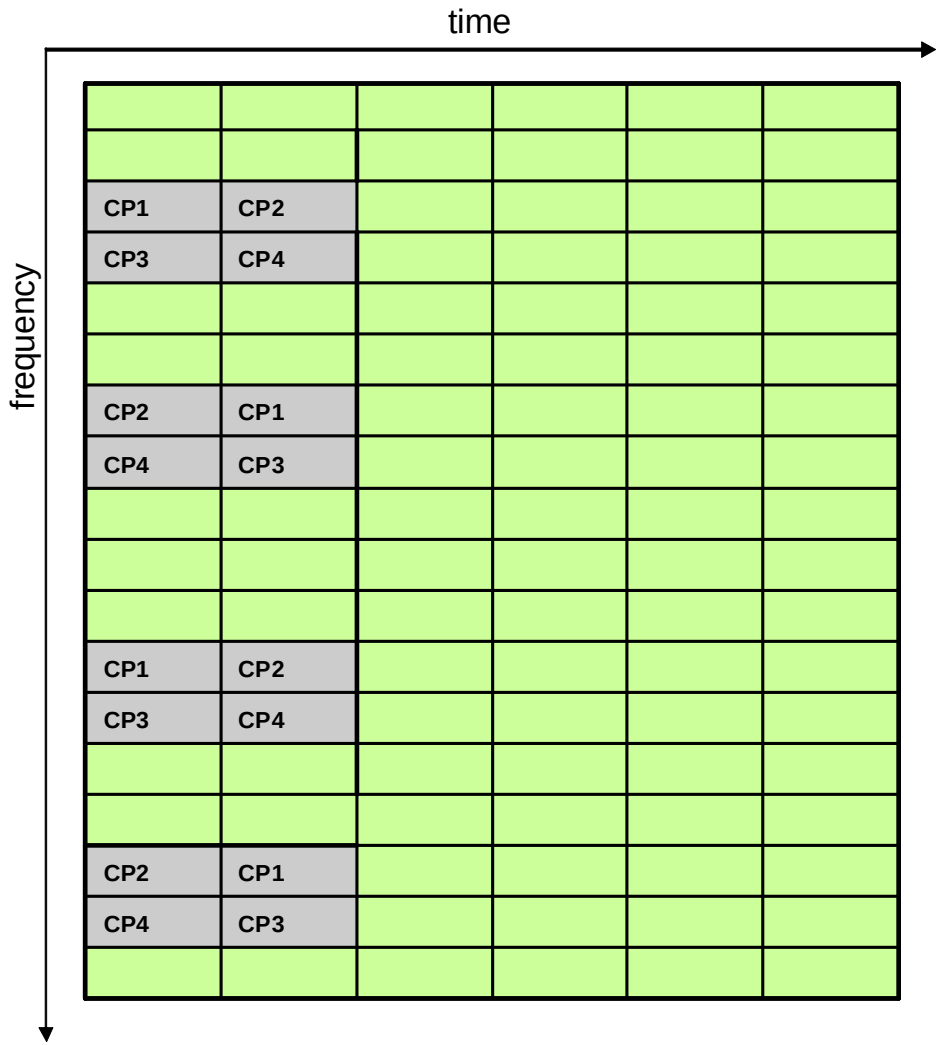
[1] C80216m-08_214r1, Zhigang Rong, et al, “16m Downlink Common Pilot Structure for TDM Control Structure”, March 10, 2008, IEEE 802.16m contribution

[2] C80216m-08_215r1, Young Hoon Kwon, et al, “16m Downlink Dedicated Pilot Structure for TDM Control Structure”, March 10, 2008, IEEE 802.16m contribution

Proposed Common Pilot Pattern

Grey: Common pilot

Green: Available for data and control. Dedicated pilot can be sent over the last four OFDM symbols based on needs.



Simulation Parameters and Assumptions

- Carrier frequency: 2 GHz
- System BW: 5 MHz
- Ped. B with 3km/h and Veh. A with 120km/h
- Antenna Configuration: 2x2, 4x2, 4x4
- Tile size = 18 subcarriers * 6 symbols
- Common pilot is boosted by 3dB
- Dedicated pilot pattern is summarized in C80216m-08_253
- Total power per tile is set to same among all schemes and power of data tone is set to 1
  - Pilot overhead per tile and pilot boost

	Intel (B)	Motorola, LG	MediaTek, Samsung (BD)
2 streams	12 (3.0dB)	12 (3.0dB)	12 (3.0dB)
4 streams	16 (4.8dB)	20 (3.8dB)	24 (3.0dB)

Channel Estimation

- Dedicated pilot
  - –2D-MMSE CE
  - –3.7 μsec delay spread with equal power and Doppler frequency corresponding to mobile speed
- Common pilot
  - –2 stage MMSE CE
  - –MMSE-based CE on frequency domain with filter length 4 (common pilots of next tile are used too)
  - –MMSE-based CE on time domain with 4 OFDM symbol (2 in previous + 2 in current)
  - –3.7 μsec delay spread with equal power and Doppler frequency corresponding to mobile speed

Spectral Efficiency Calculation [1]

- Spectral efficiency can be calculated as

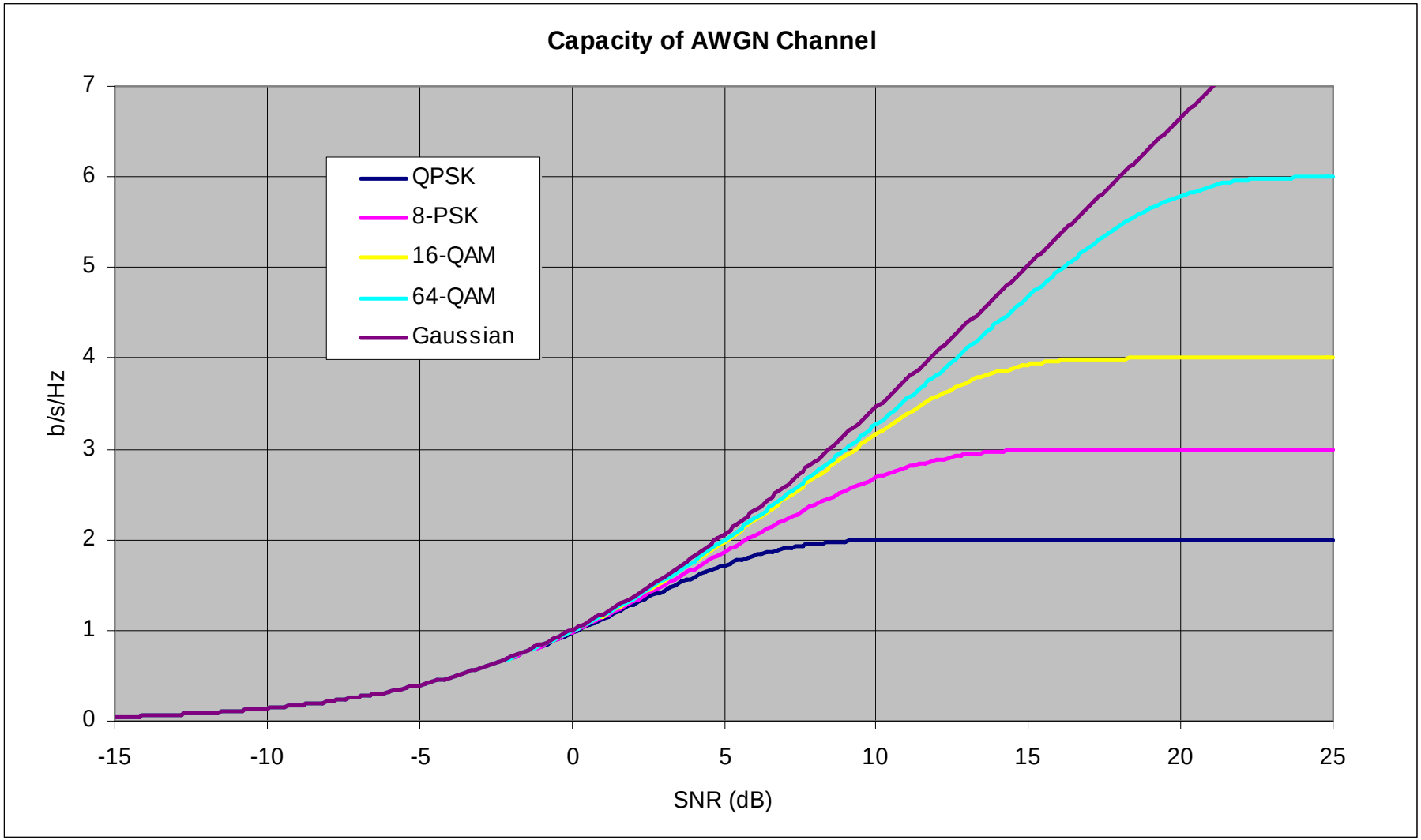
$$SE = \left(1 - \frac{N_P}{N_t} N_s\right) \frac{1}{N_t} \sum_{t=1}^{N_t} \sum_{s=1}^{N_s} Capacity_{ModOrd}(SNR_{decoder}(t,s))$$

  - N_p: number of pilot per stream;
  - N_t: number of tones per tile;
  - N_s: number of streams
  - SNR <= 3 dB: Capacity curve for QPSK
  - 3 dB < SNR <= 9 dB: Capacity curve for 16QAM
  - SNR > 9 dB: Capacity curve for 64QAM
- Equivalent SNR at the decoder output with MMSE estimator is

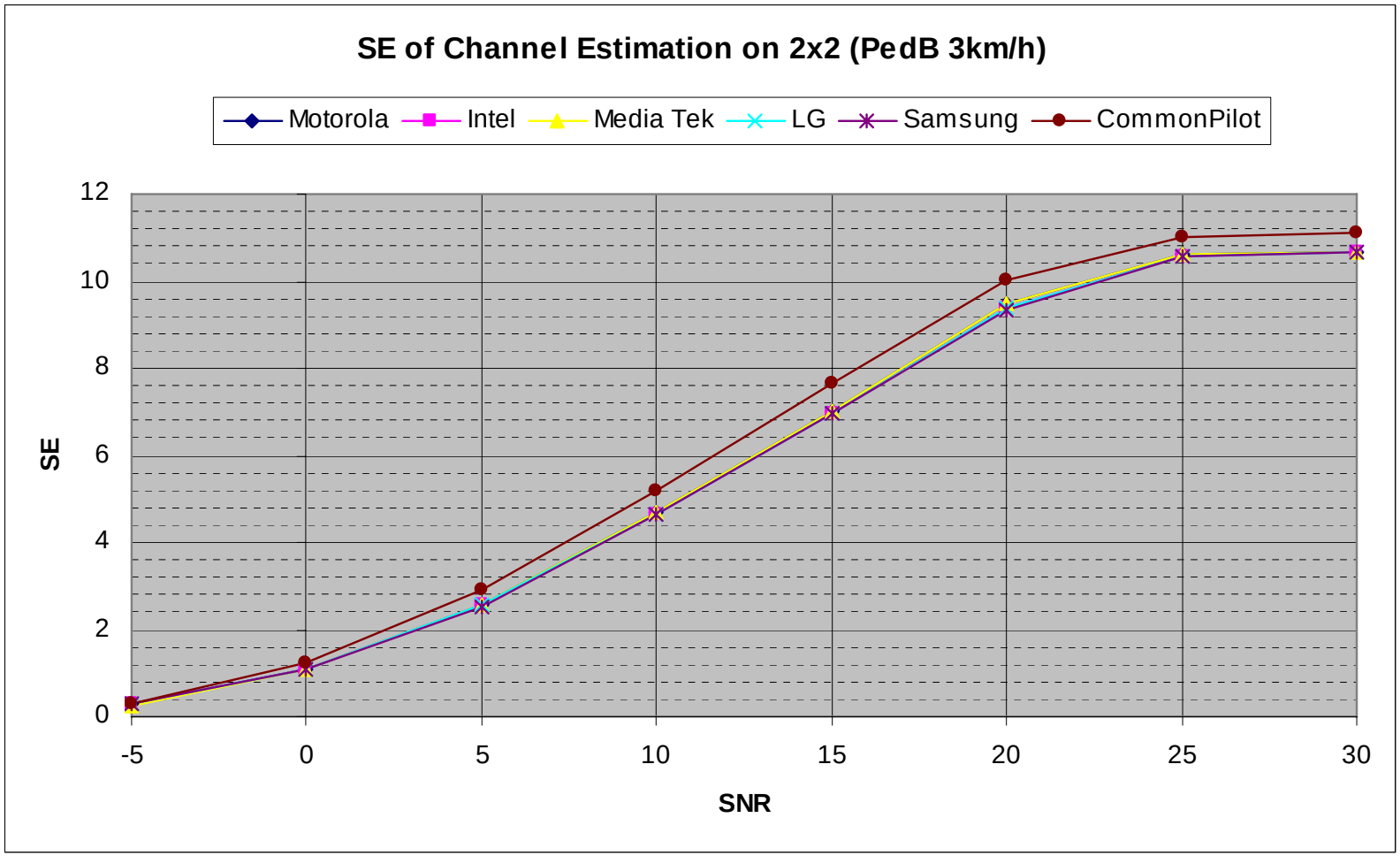
$$SNR_{decoder} = \frac{|h|^2}{\sigma_{eff}^2} = \frac{E_d \cdot E[|h|^2] - \sigma_e^2}{\sigma^2 + N_T \sigma_e^2} = \frac{1 - \frac{\sigma_e^2}{E_d \cdot E[|h|^2]}}{\frac{\sigma^2}{E_d \cdot E[|h|^2]} + N_T \frac{\sigma_e^2}{E_d \cdot E[|h|^2]}} = \frac{1 - SNR_{H,MMSE}^{-1}}{SNR^{-1} + N_T SNR_{H,MMSE}^{-1}}$$

[1] S80216m-08_120r1, Yuval Lomnitz, et al, “Proposal for IEEE 802.16m Downlink Symbol Structure Concept”, March 12, 2008, IEEE 802.16m contribution

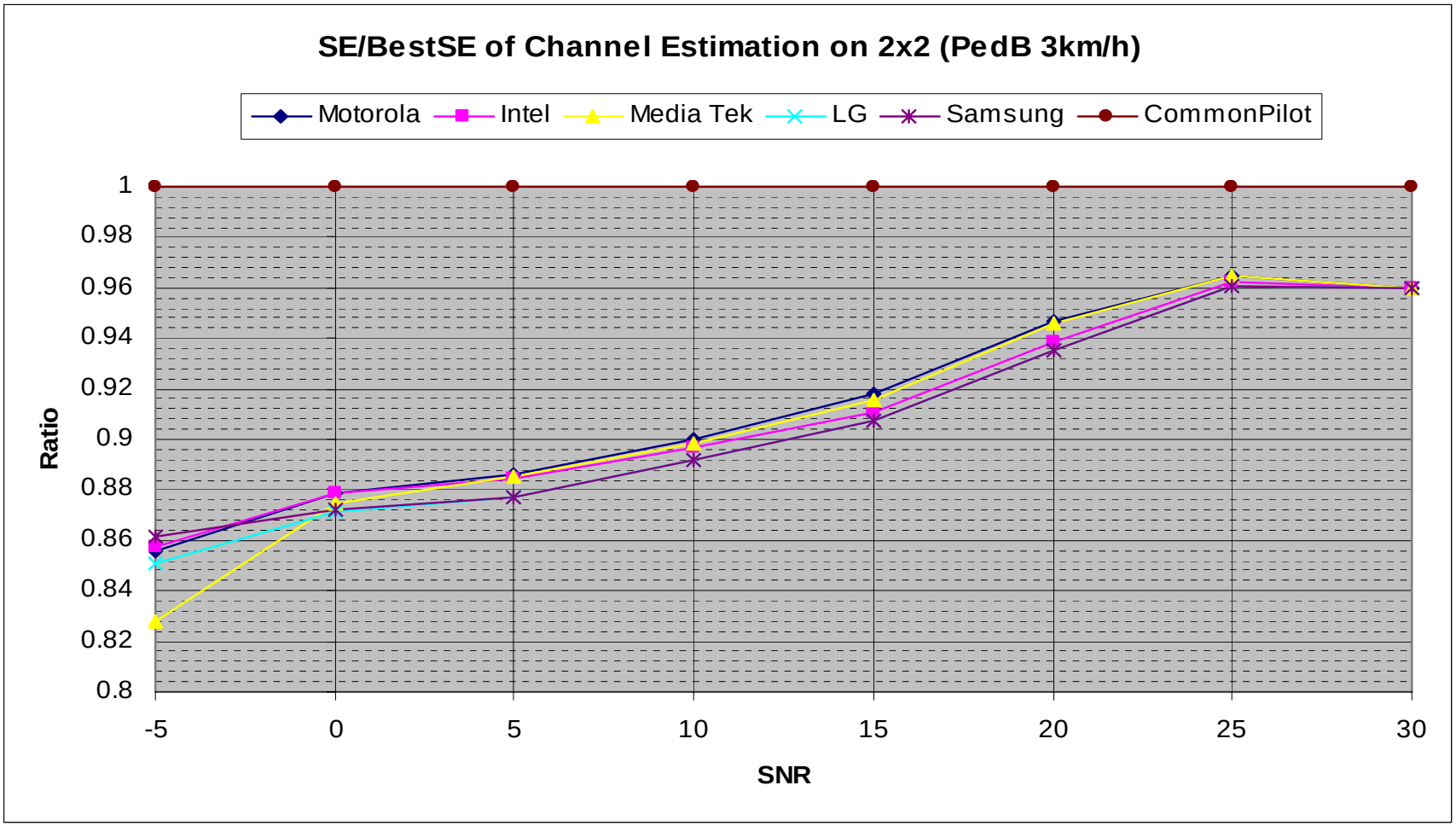
Capacity Curve for Different Modulation Schemes



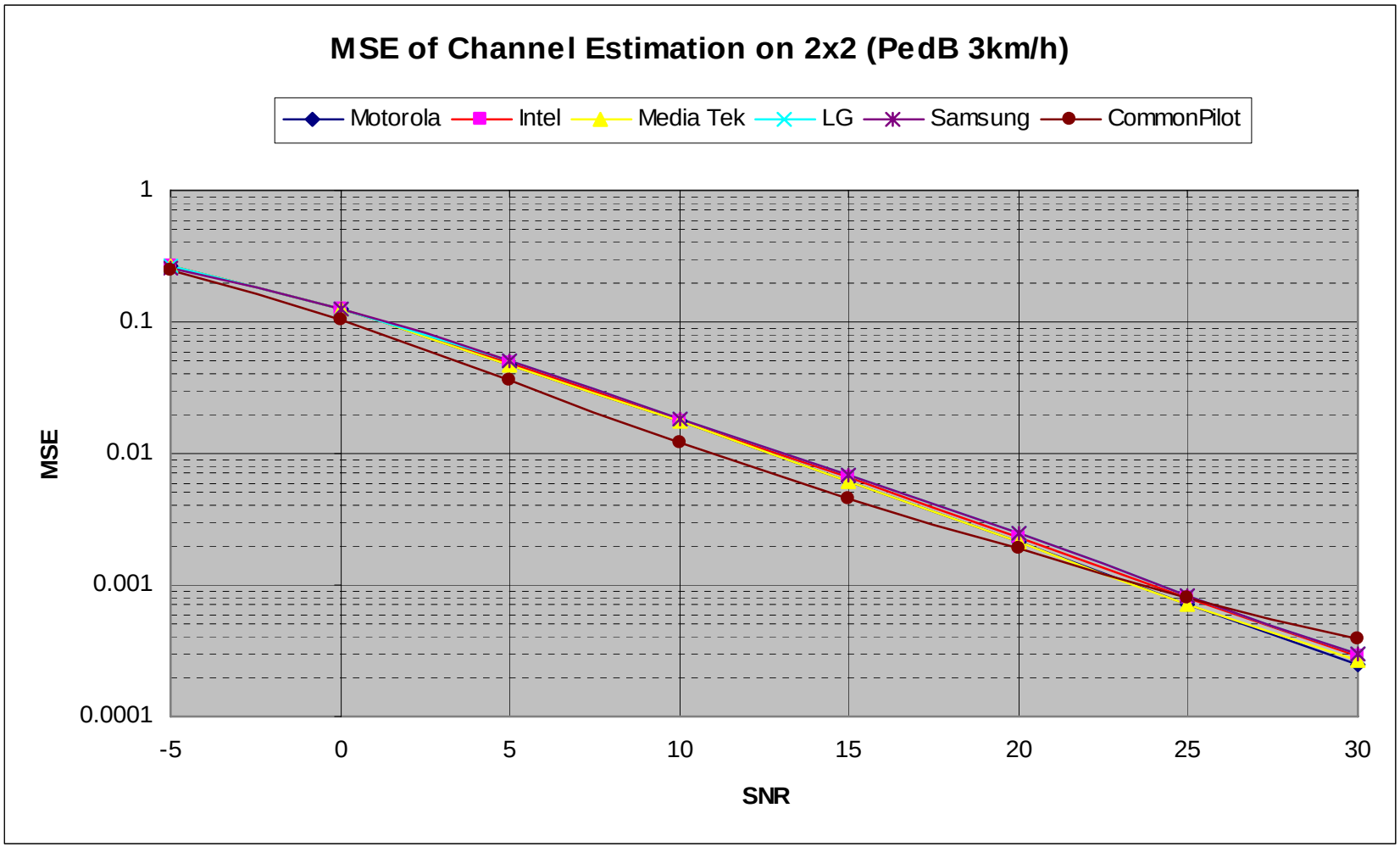
Simulation Results



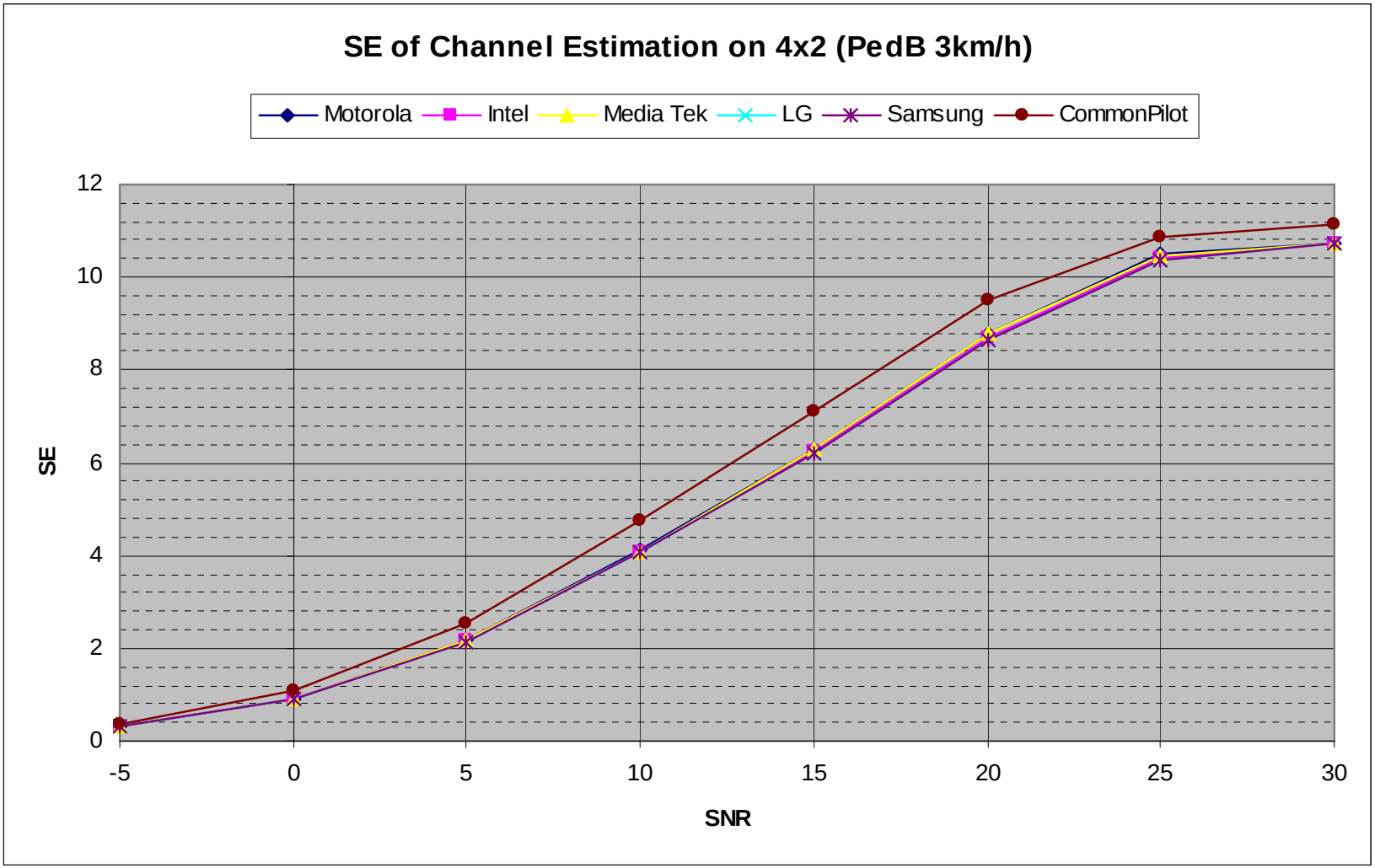
Simulation Results



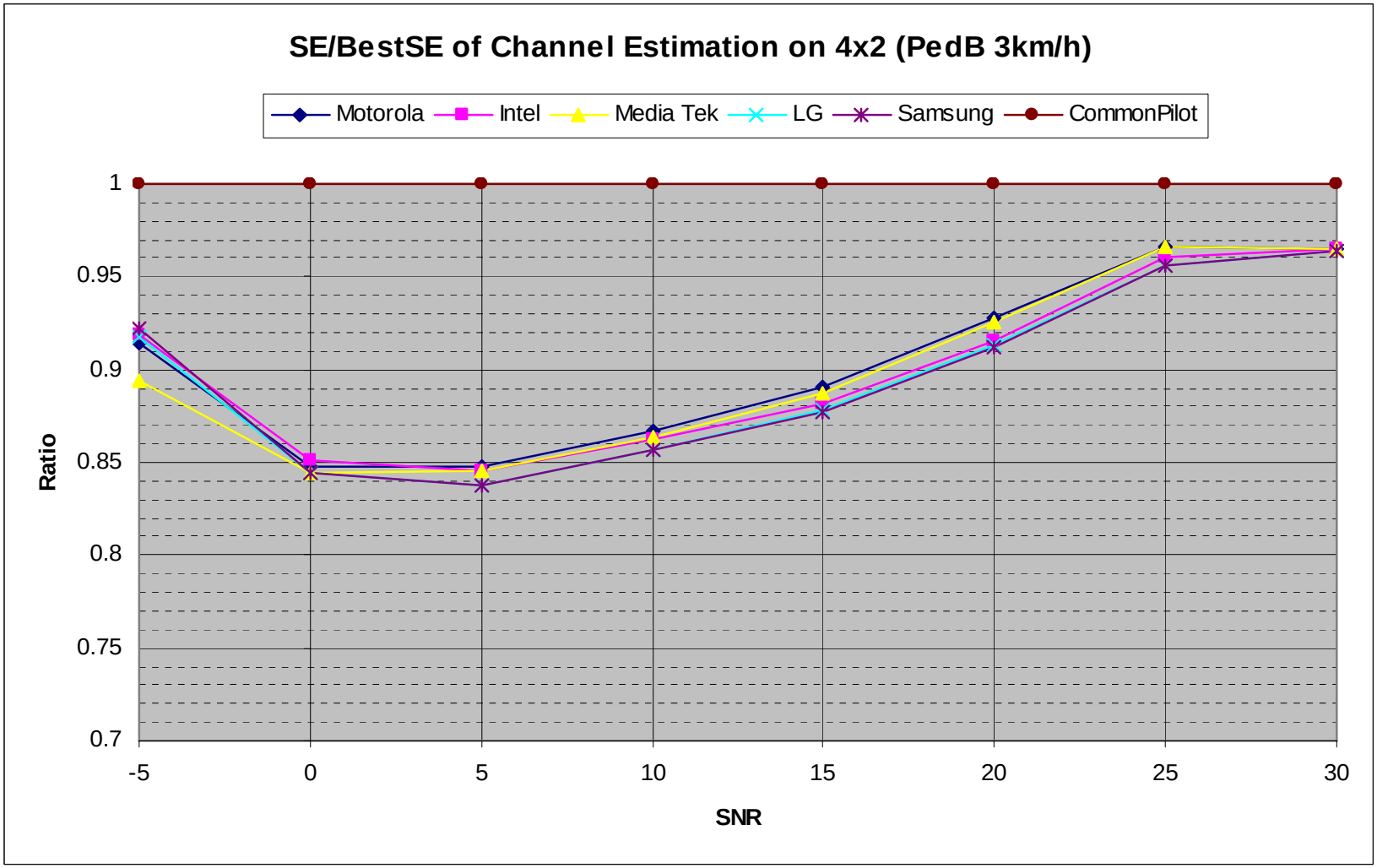
Simulation Results



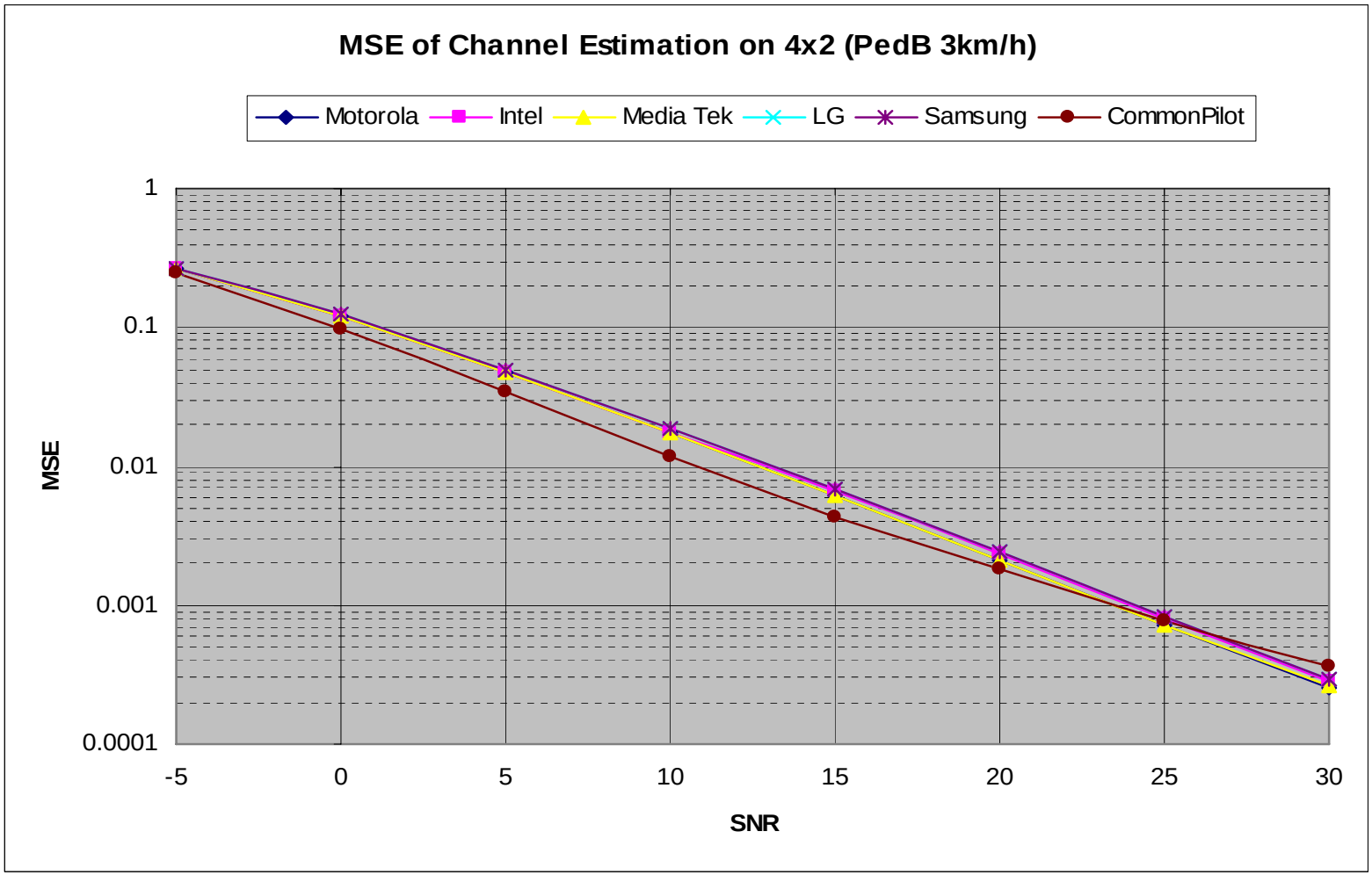
Simulation Results



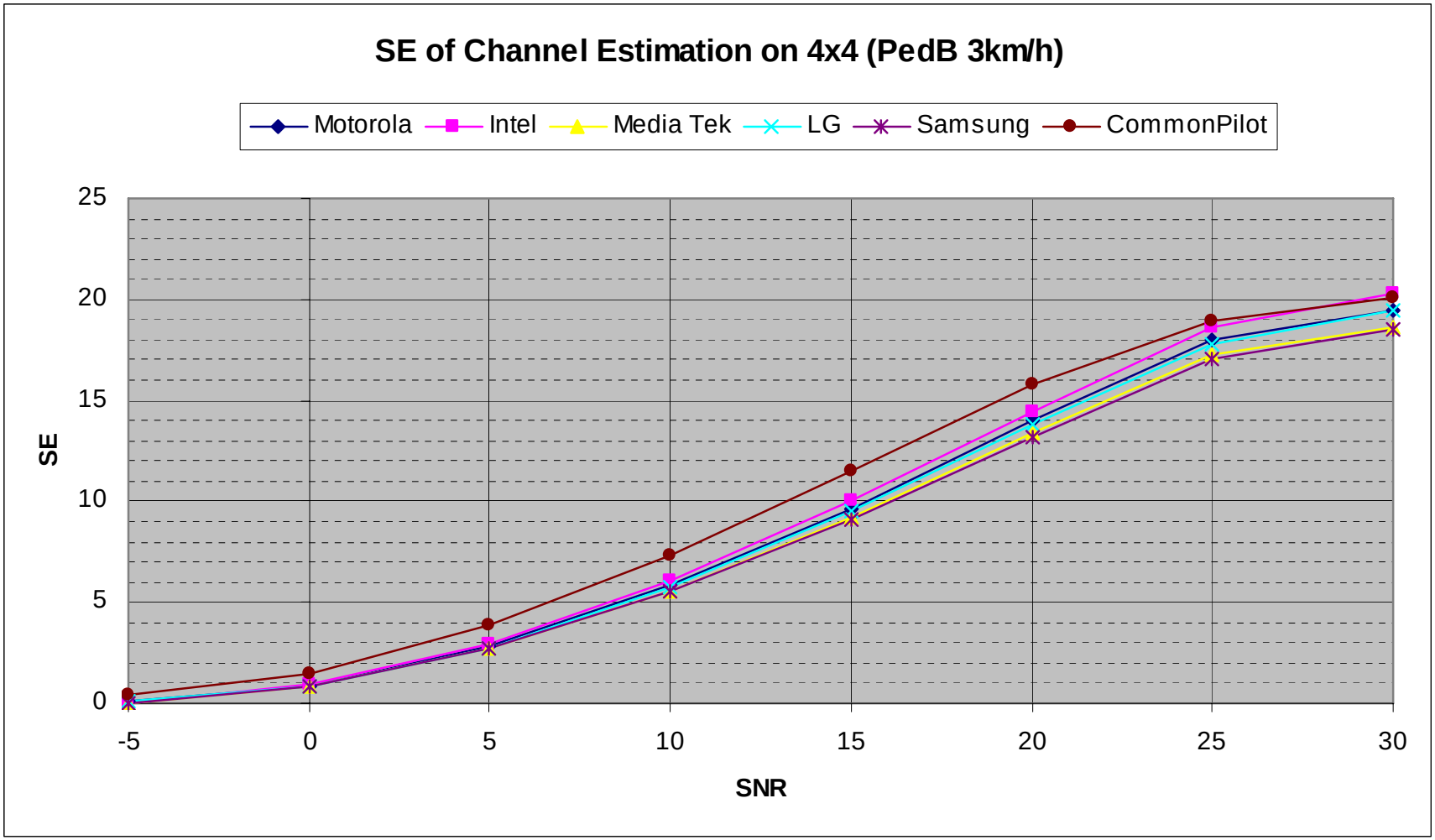
Simulation Results



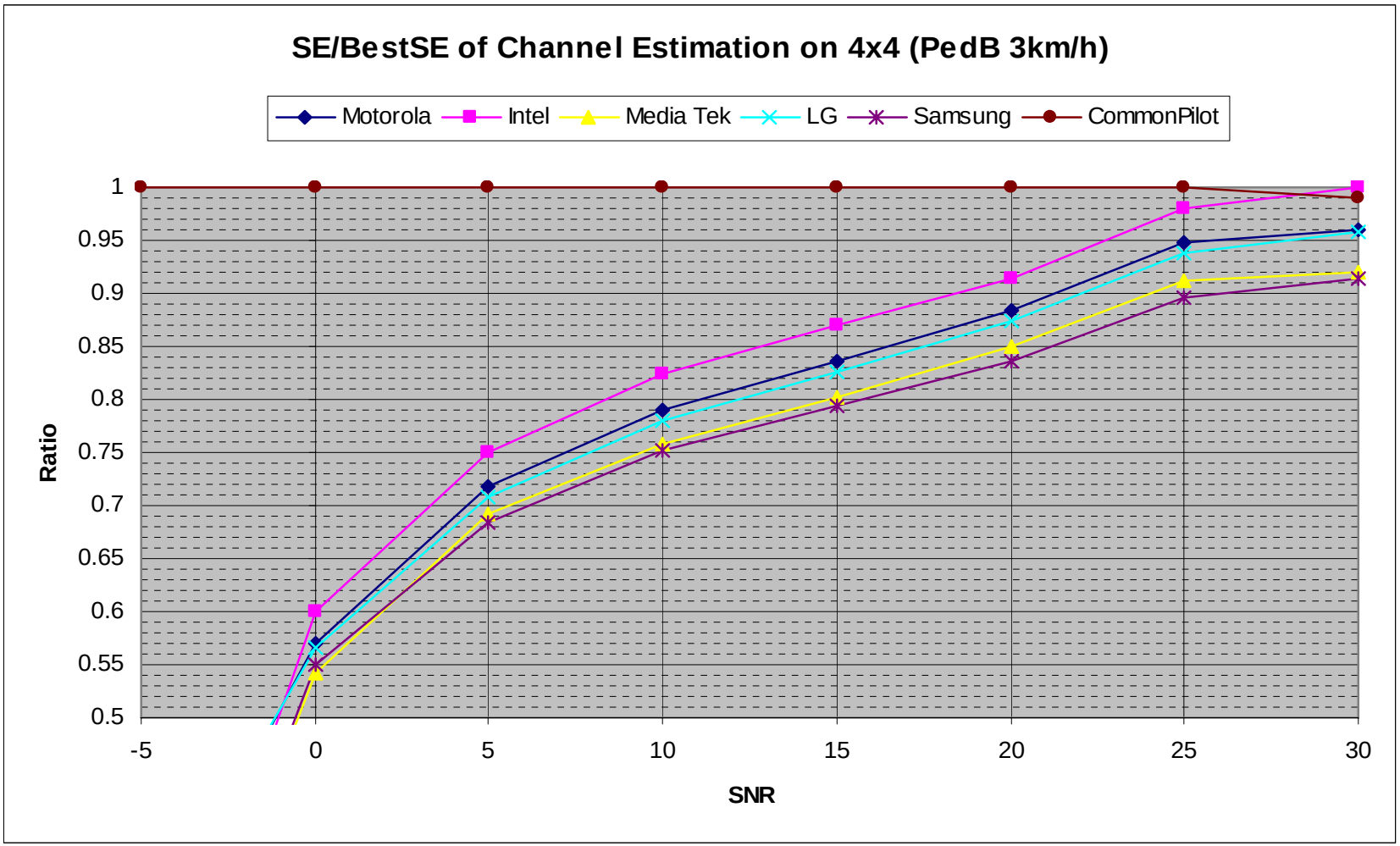
Simulation Results



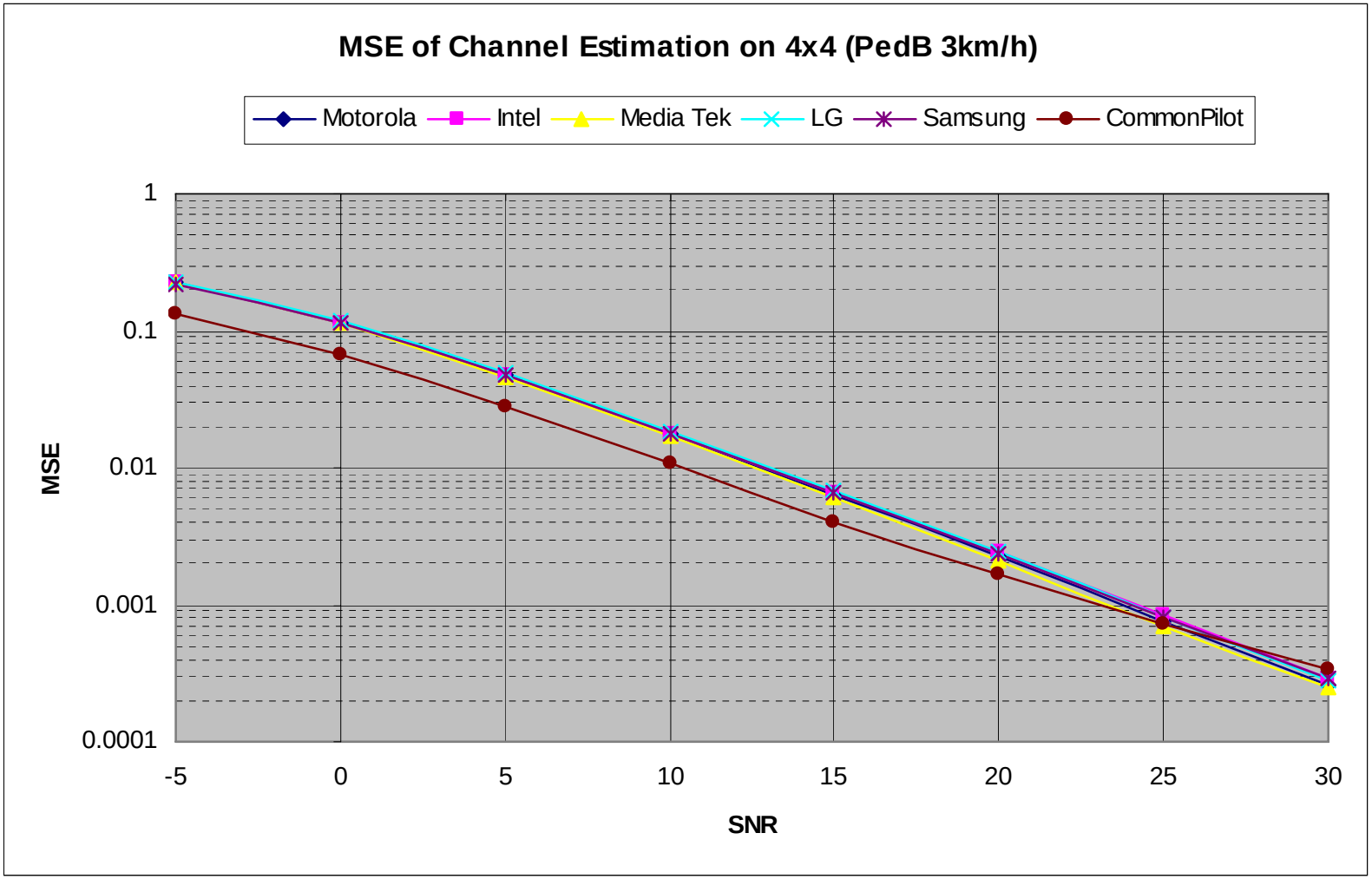
Simulation Results



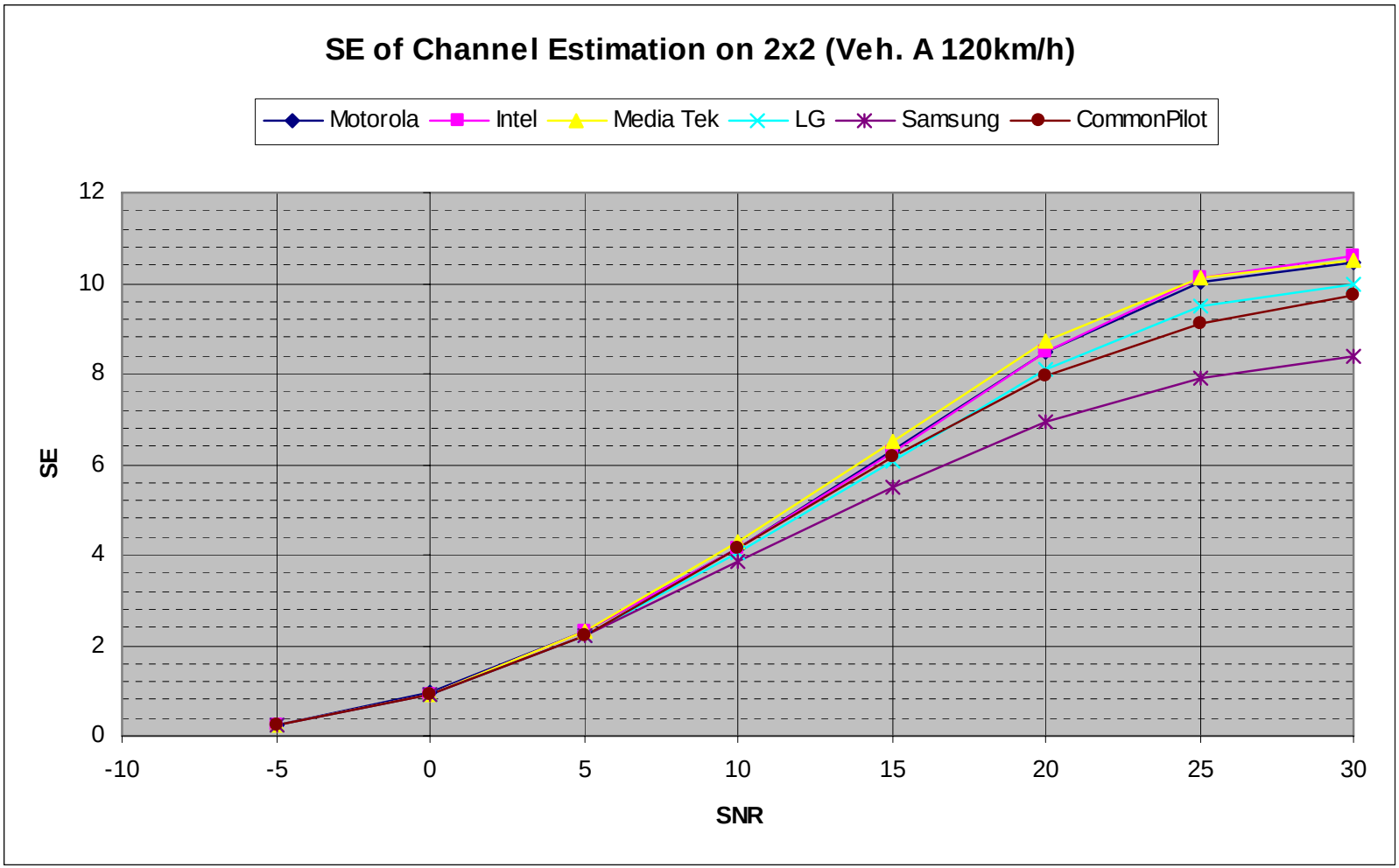
Simulation Results



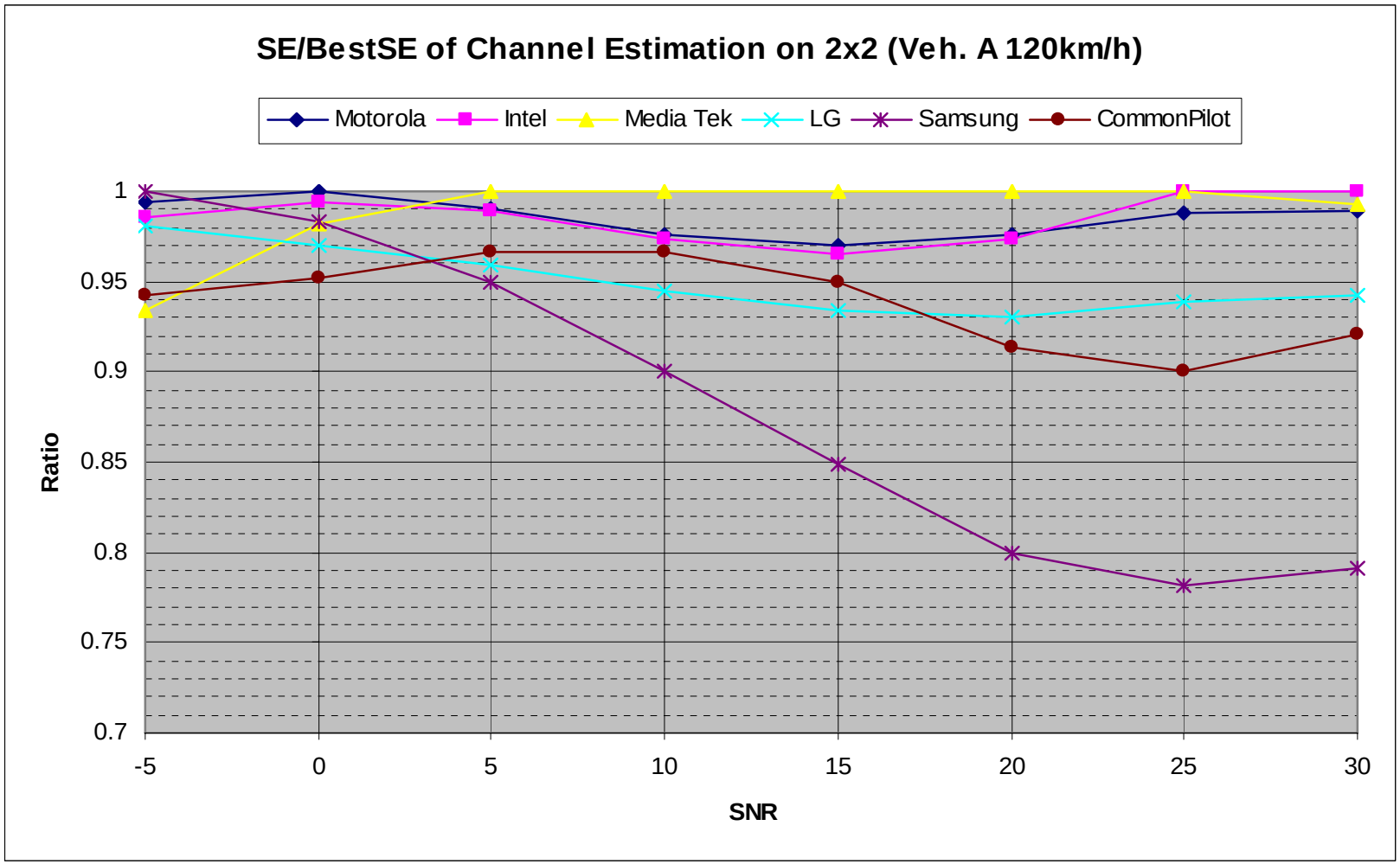
Simulation Results



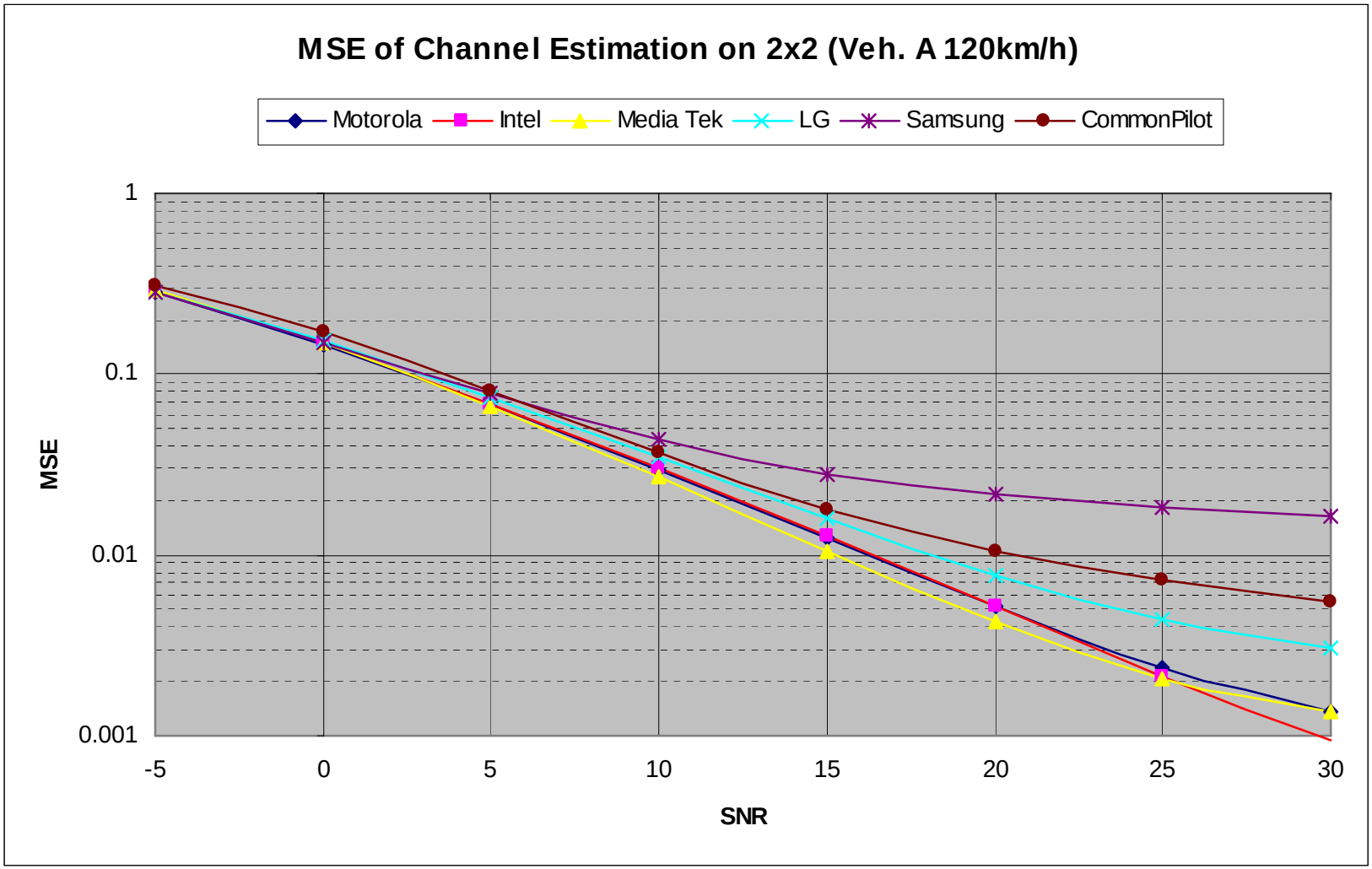
Simulation Results



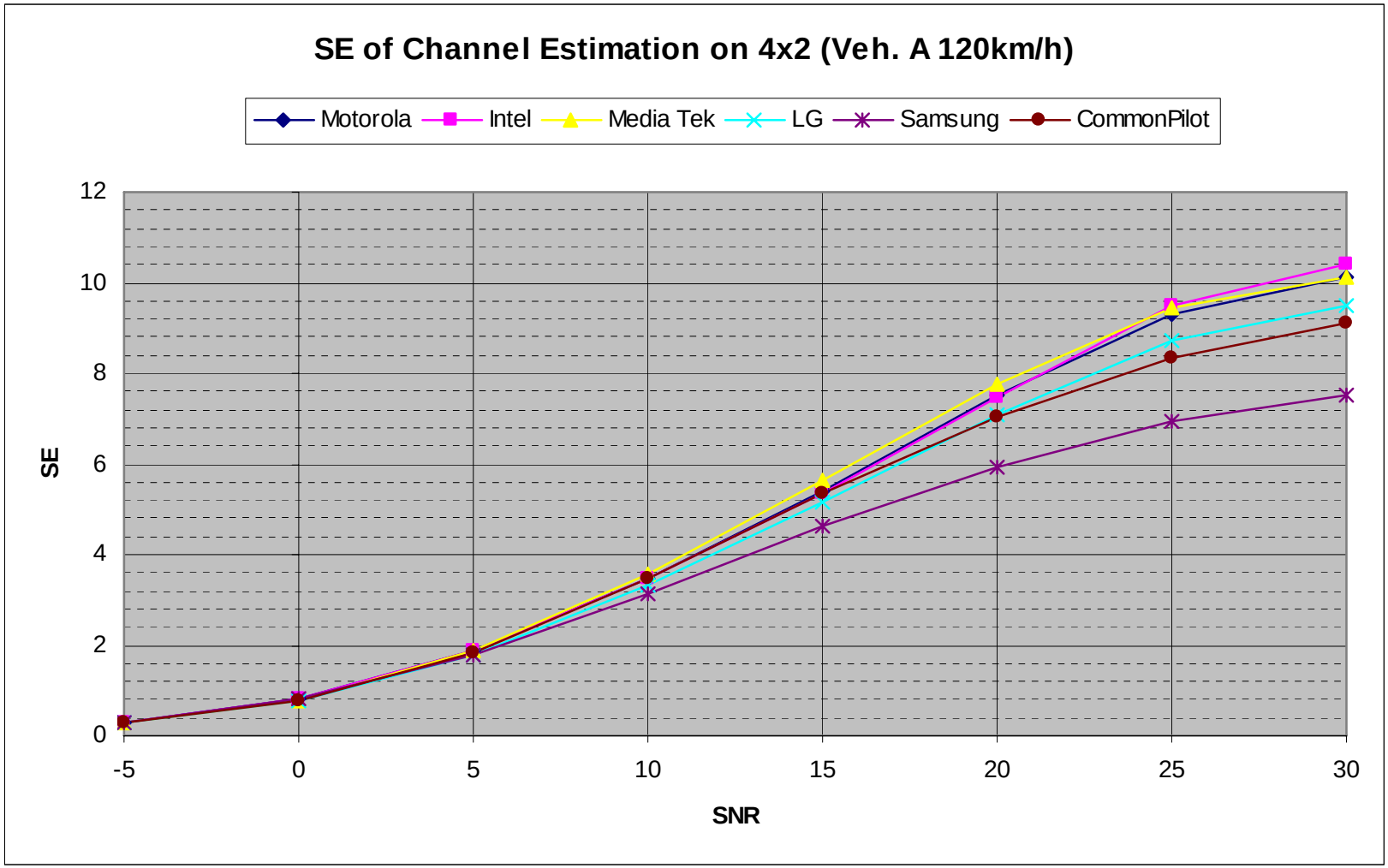
Simulation Results



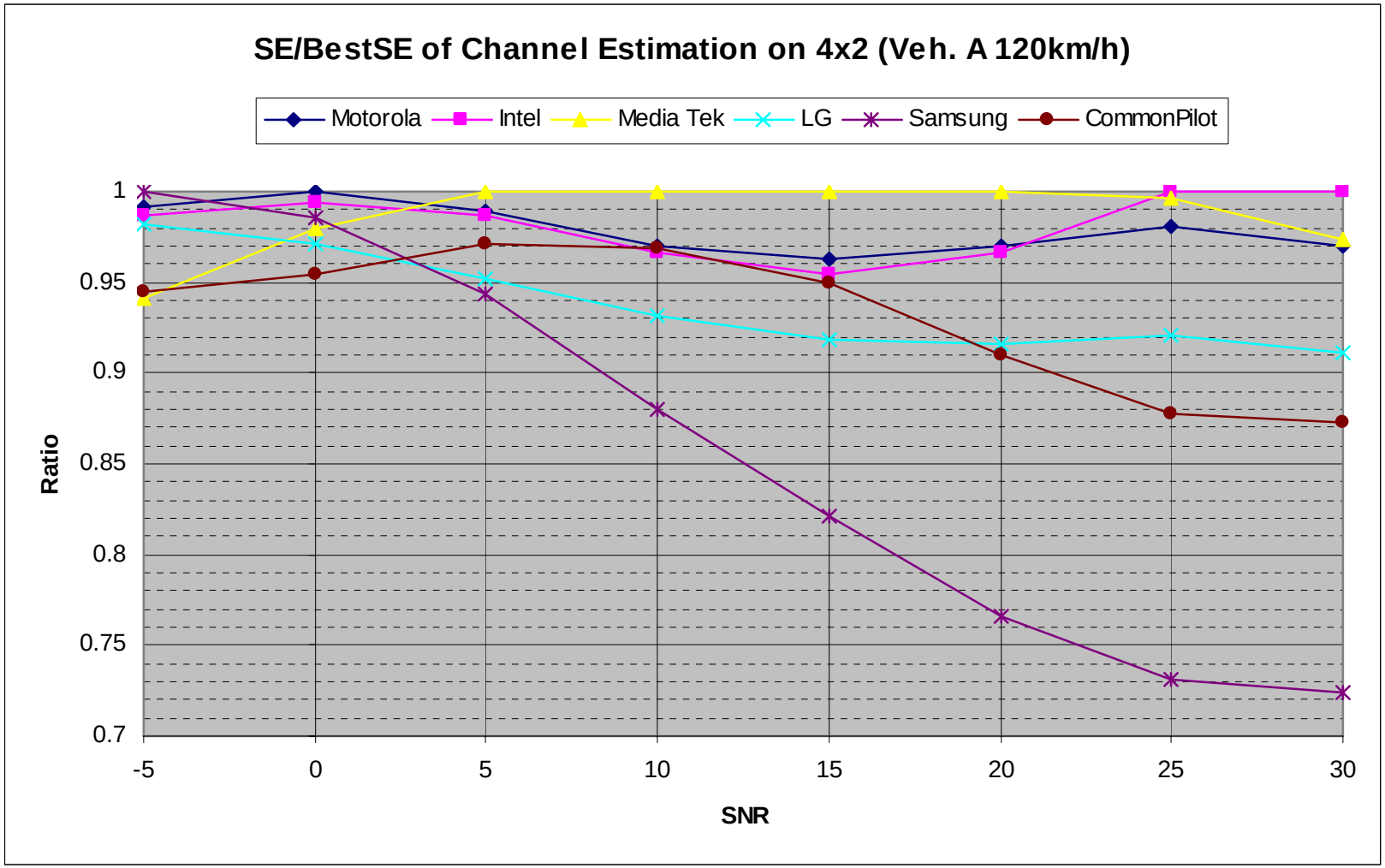
Simulation Results



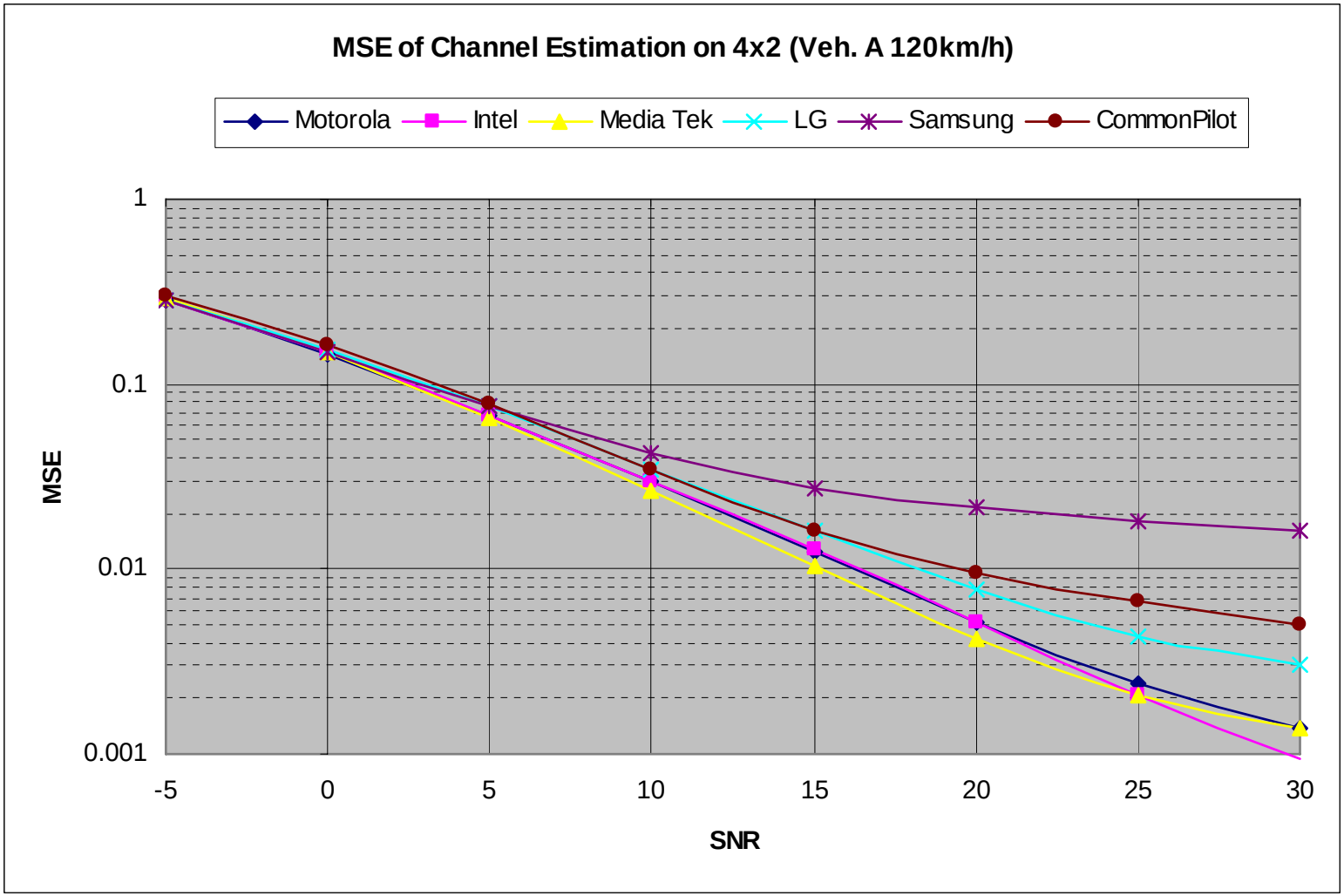
Simulation Results



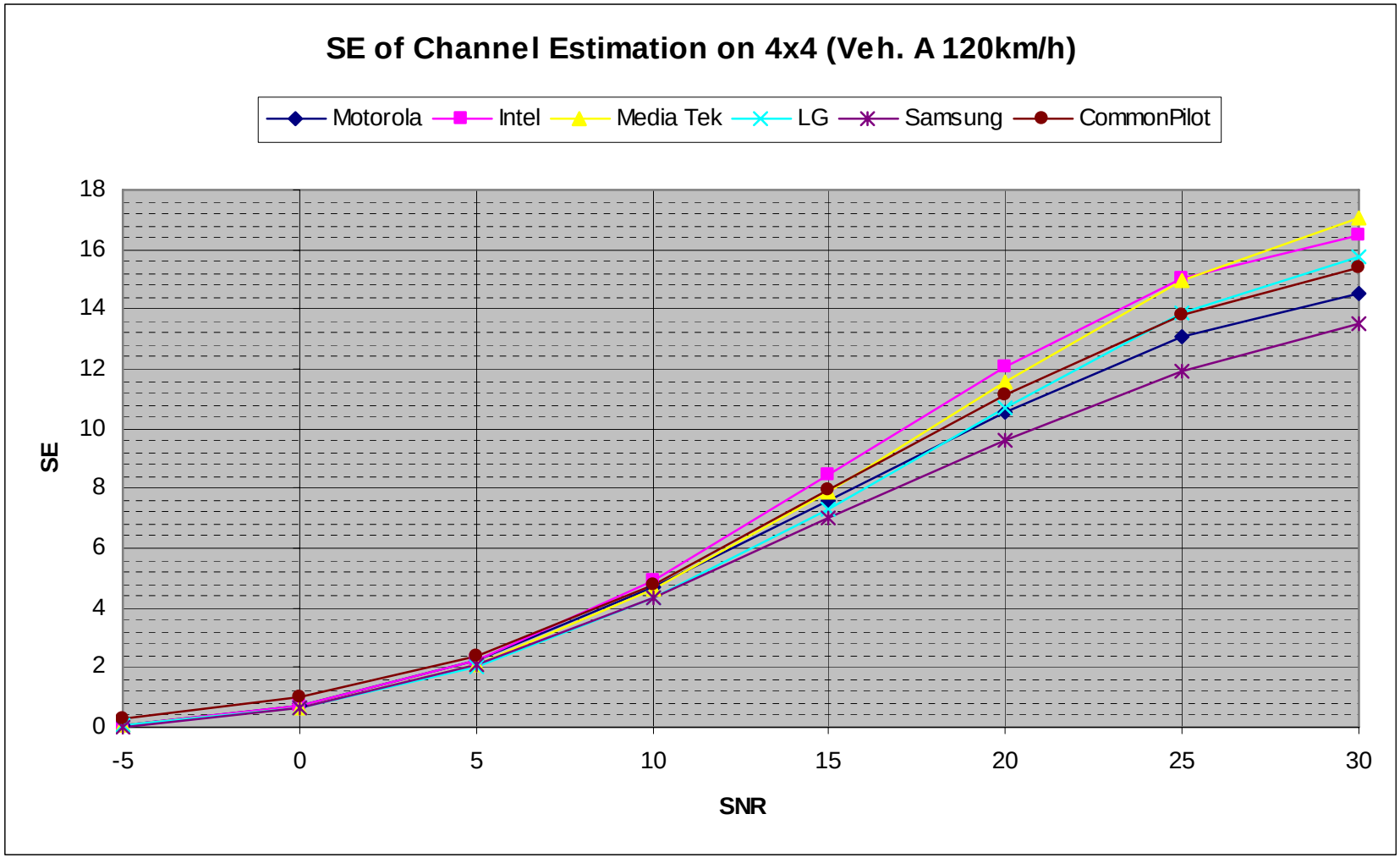
Simulation Results



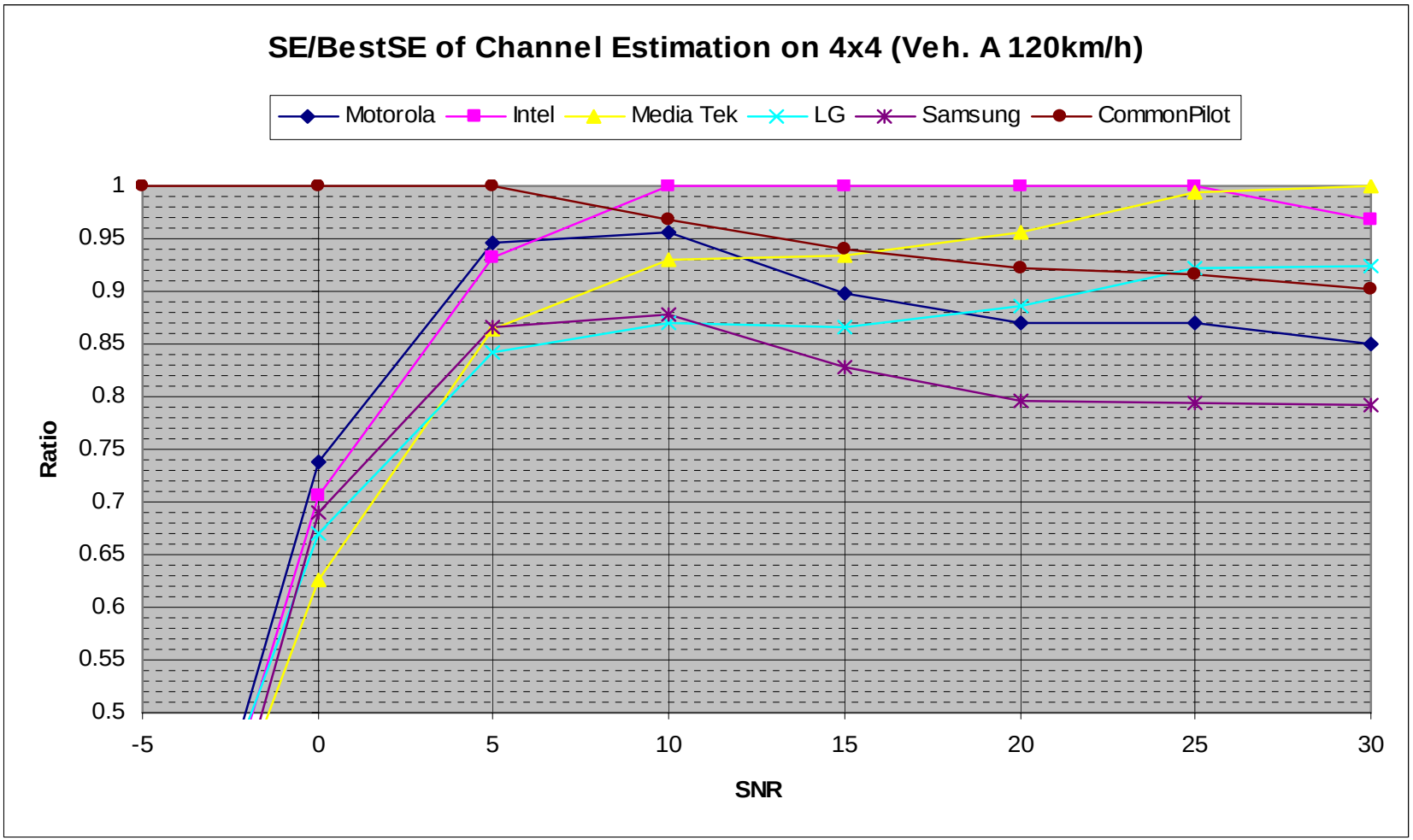
Simulation Results



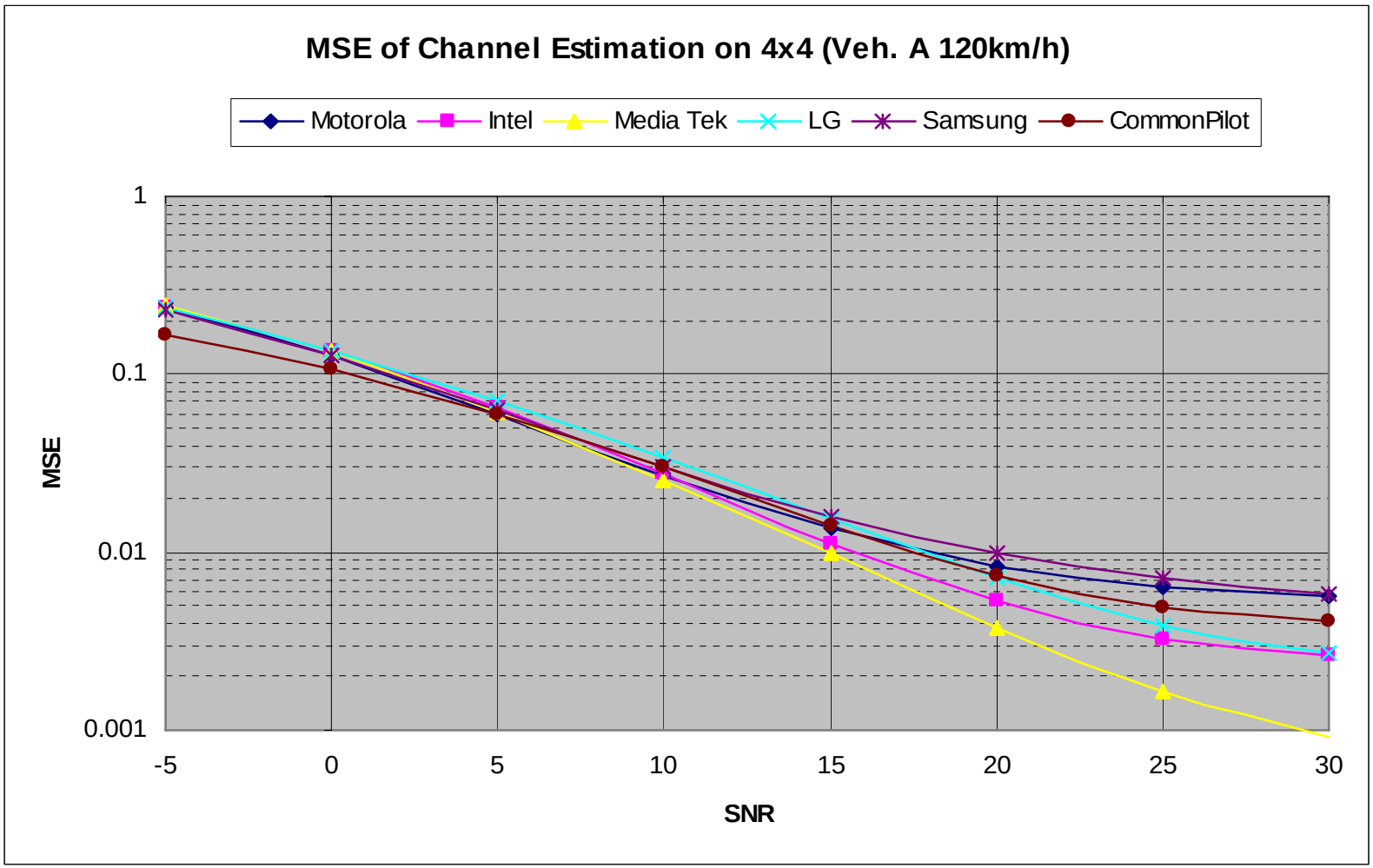
Simulation Results



Simulation Results



Simulation Results



Conclusions

- With low mobile speed, common pilot carried in the first two OFDM symbols outperforms the dedicated pilot pattern proposed
  - Low mobile speed is where MIMO schemes target at
  - Using only common pilot can satisfy average user's need
- With high mobile speed,
  - In low SNR range, common pilot has better or similar performance as dedicated pilot
  - In high SNR range, common pilot has some performance loss compared to some of the dedicated pilot pattern proposed
    - Probability to use MIMO in high mobile speed is low
    - If needed, additional dedicated pilot can be sent in the last 4 OFDM symbols to help improve the performance
- Our proposed "common pilot + on-demand dedicated pilot" [1,2] provides flexibility to serve a wide range of scenario without burdening average users with unnecessary MIMO pilot overhead
- Common pilot can also serve as reference signal for DL MIMO measurement
  - Save the overhead of reference signal such as mid-amble

[1] C80216m-08_214r1, Zhigang Rong, et al, "16m Downlink Common Pilot Structure for TDM Control Structure", March 10, 2008, IEEE 802.16m contribution

[2] C80216m-08_215r1, Young Hoon Kwon, et al, "16m Downlink Dedicated Pilot Structure for TDM Control Structure", March 10, 2008, IEEE 802.16m contribution