

# Performance Evaluation for IEEE 802.16m Downlink Pilot Structure

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

Re: [IEEE 802.16m-08/024](#) Call for Comments on Project 802.16m System Description Document (SDD) on the topic of DL pilot.

Purpose: Adopt the proposal into the IEEE 802.16m System Description Document

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

# Scope

- Evaluation pilot structures, and their variations, as proposed by different proponents
- Make recommendation on pilot structures to be adopted in SDD

# Summary of Pilot structures proposed

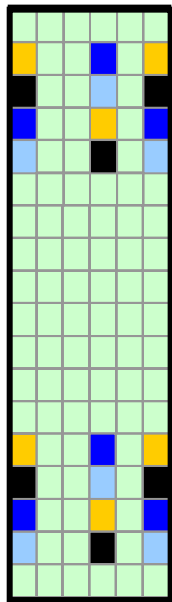
	Common and dedicated pilot	Source
Alcatel-Lucent	Unified	433r1
Intel	Unified	Phy-017
LGE	Unified	Phy-025r2
MediaTek	Dedicated only	Phy-011
Motorola	Non-unified	Phy-010
Nortel	Unified	Phy-019 variation for 18x6 PRU
Samsung	Unified	Phy-029





# Pilot structures Proposed by Nortel (1/2)

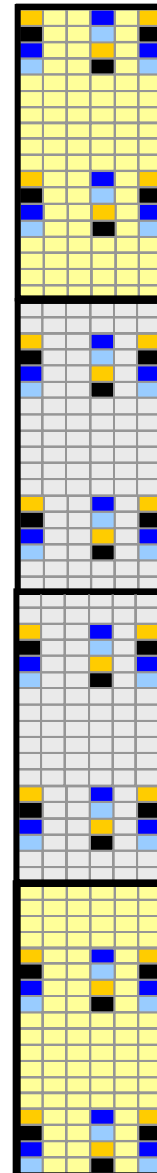
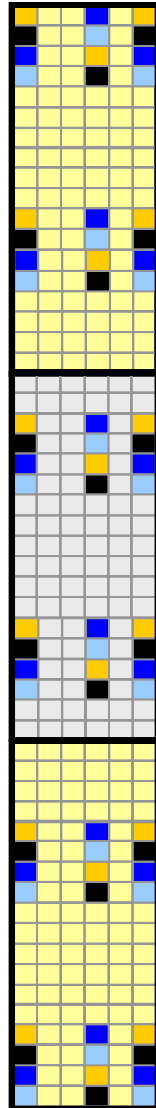
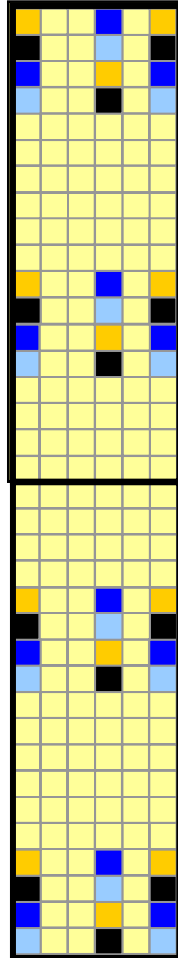
- Nortel proposed unified pilot structure design in March meeting (C80216m-08\_172r1). The highlights of the design is described as following
  - Staggered pilot pattern
  - Boundary pilot design at resource boundary for avoiding extrapolation in both time and frequency direction
  - Adaptive pilot density and allocation for optimal performance and overhead.
- Following these design principles, pilot structure can be derived for single PRU (18x6) and multiple PRUs.

# Pilot structures Proposed by Nortel (2/2)

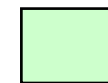
*For single and multiple PRUs*



-  Pilot for tx 1
-  Pilot for tx 2
-  Pilot for tx 3
-  Pilot for tx 4



1. Pilot arrangement is adapted to resource allocation, or number of contiguous PRUs. Pilot locations can be derived from number of PRUs allocated.
2. Pilots are allocated at the resource boundaries
3. Pilot distribution in frequency direction should be as uniform as possible
4. Pilot for each Tx antenna is staggered



Pilot pattern 1 for single PRU case

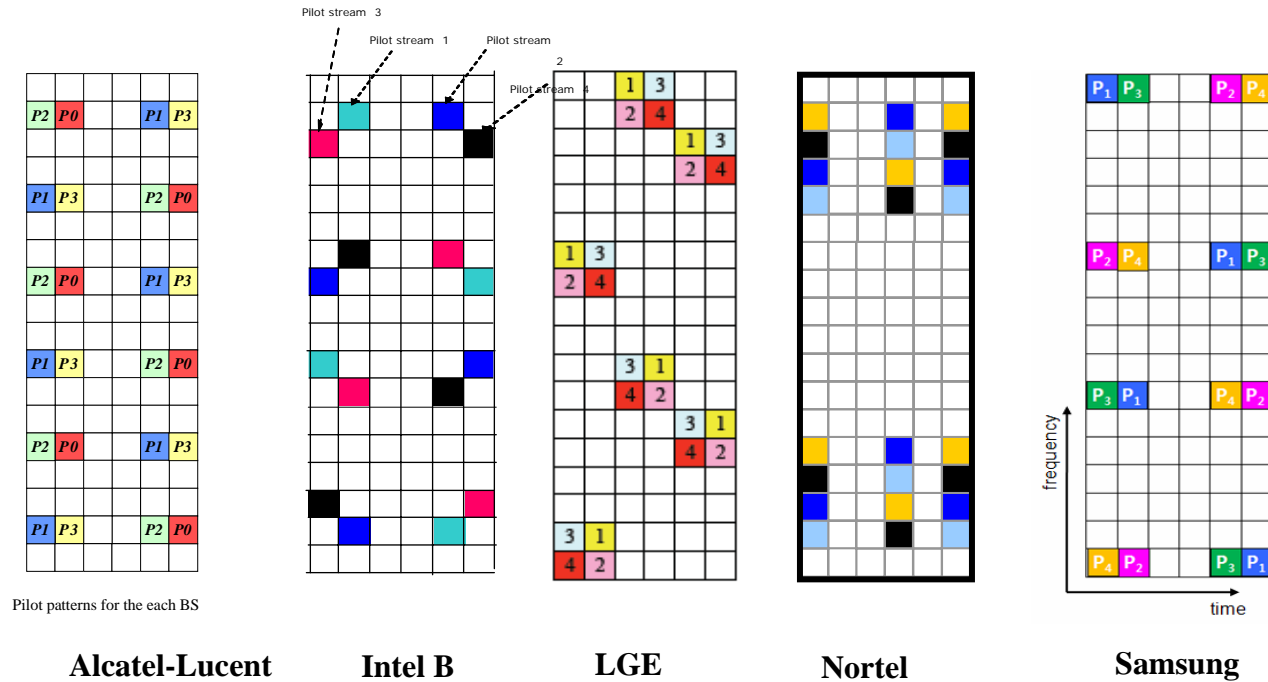


Pilot pattern 2 for boundary PRU



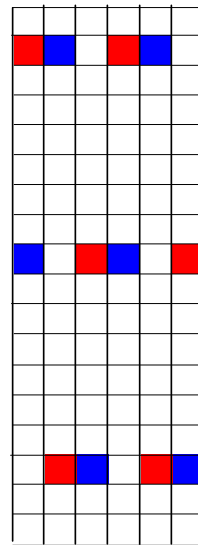
Pilot pattern 3 for intermediate PRU

# Unified pilot structure for 4 Tx and Single PRU

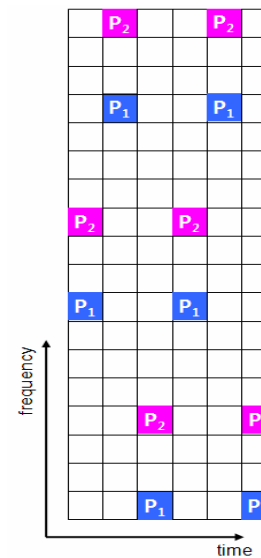


Pilot structure for less number of Tx antennas can be derived from these pilot structures, except Samsung's and Intel's

# Unified Pilot structure for 2 Tx and Single PRU *which are not derived from pilot structure for 4 Tx*



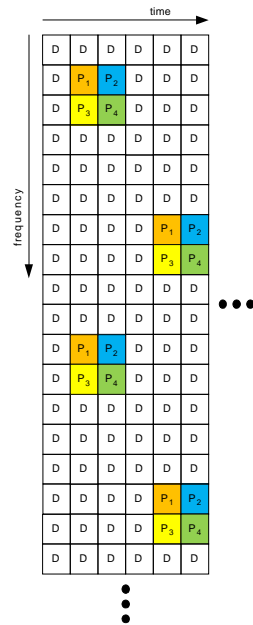
Intel A



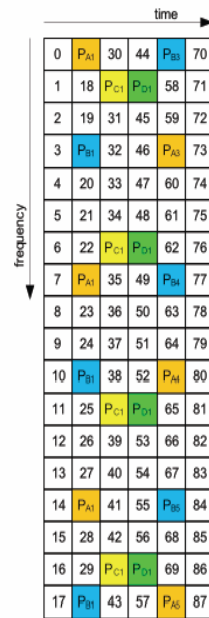
Samsung A

**Intel has three variations of the pattern for different cells**

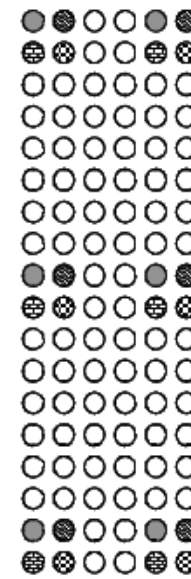
# Non-Unified Pilot Structures



**Motorola  
Common**



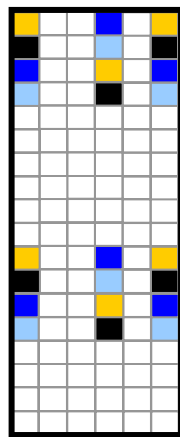
**Motorola  
Dedicated**



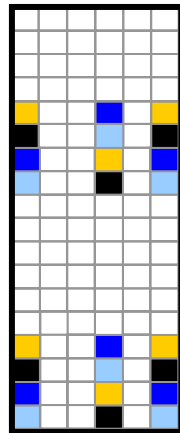
**MediaTek  
Dedicated**



# Common pilots for 4 Tx and multiple PRUs



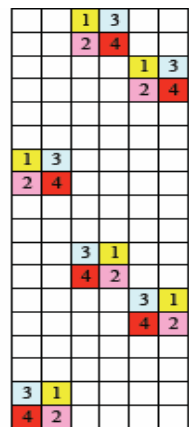
⋮



Nortel



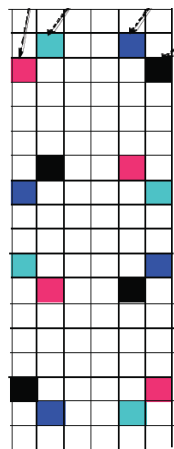
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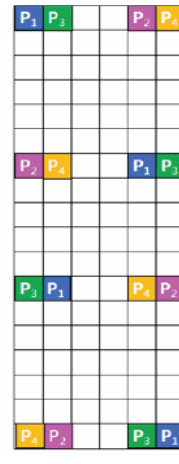
LGE



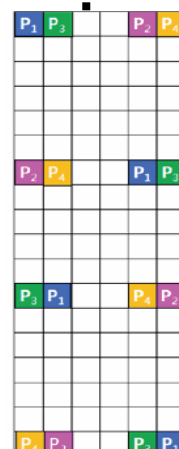
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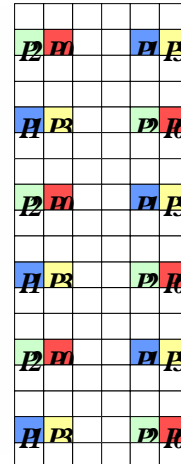
Intel B



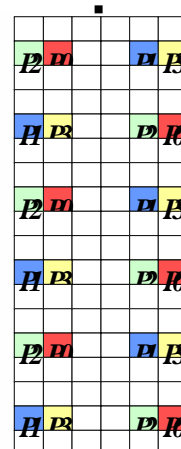
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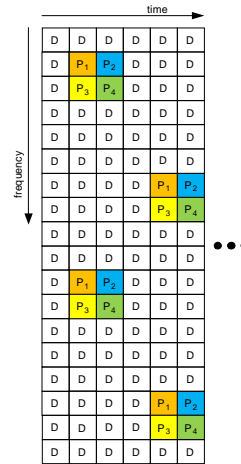
Samsung B



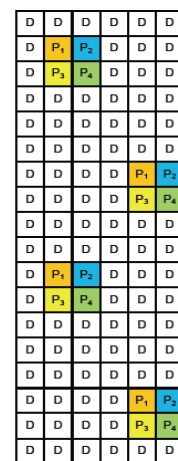
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Alcatel-Lucent

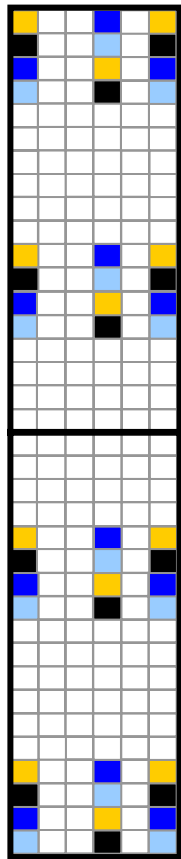


⋮



Motorola

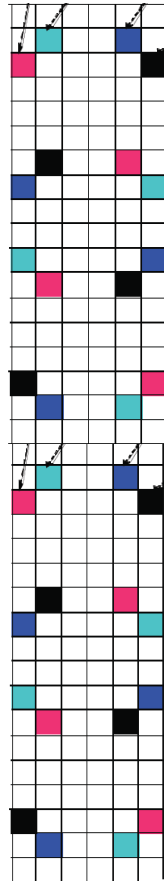
# Dedicated pilot for 4 Tx and 2 PRUs



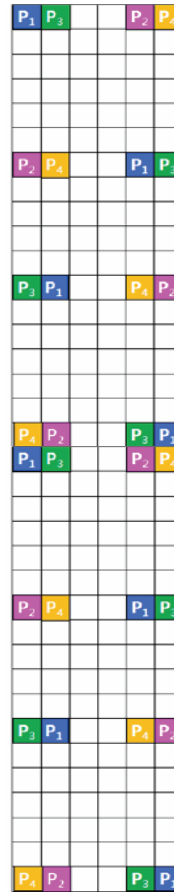
Nortel



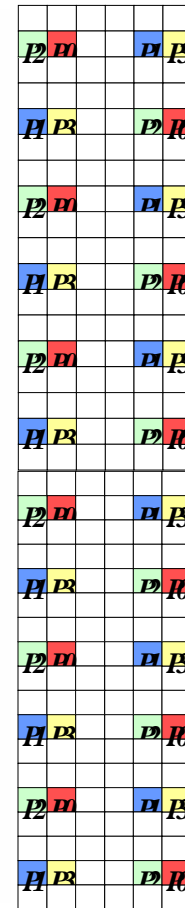
LGE



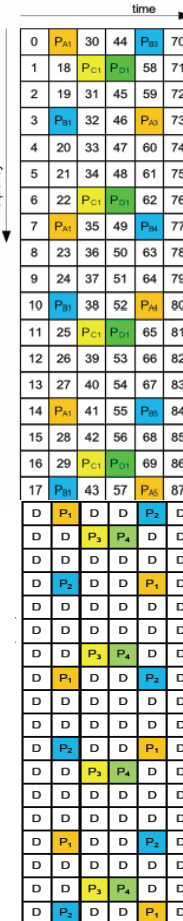
Intel B



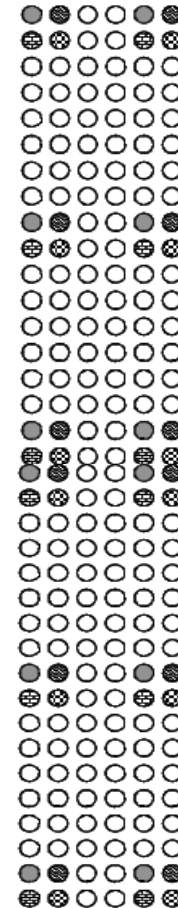
Samsung B



Alcate-Lucentl Motorola



MrdiaTek



## **Evaluation assumption: General**

- Adopt the simulation parameters and performance metrics for evaluation pilot patterns as agreed in IEEE C802.16m-08/518
  - VA 240km/h is added to make transition point more clear for some speed sensitive pilot structures
- Pilot structure designs for regular 18x6 PRU are evaluated
  - Pilot structures and their variations are proposed by RG members
- Simulation parameters: 10MHz, 2.5GHz, 1024-FFT with 864 useful subcarriers.

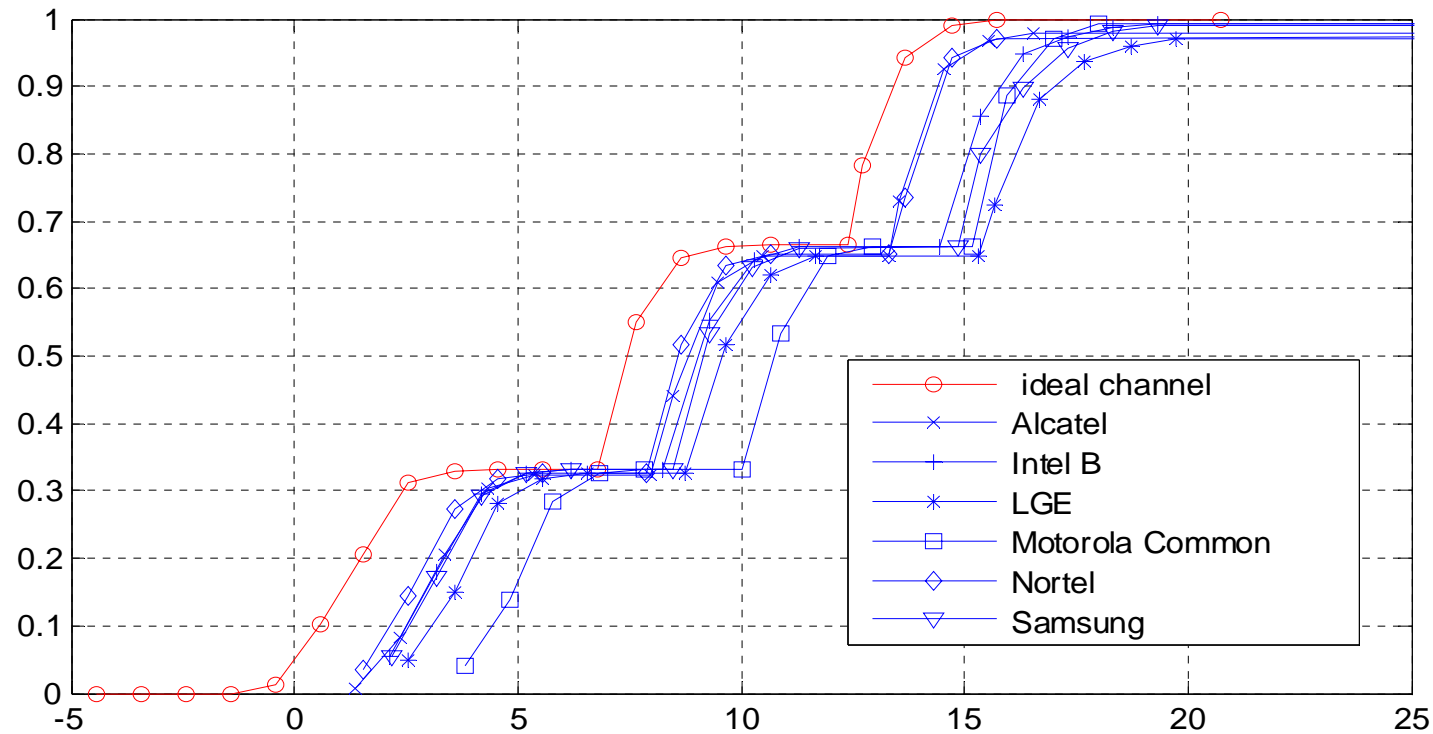
# Evaluation assumption: Channel Estimation

- 1-D channel estimation is used for evaluation purpose
  - It is a practical and simple channel estimation method
  - Prior knowledge of channel statistics is not needed
  - Channel estimation method is an implementation issue. Pilot structure should be robust enough to get optimal channel estimation quality for different methods and should not rely on extra channel information and highly complicated estimation methods
- For common pilot, channel estimation is over all PRUs in a sub-frame. Data packet is distributed over all PRUs.
  - MIMO scheme: 1 stream, 4x2 SFTD
- Pilot power boosting level: pilot power are boosted by borrowing power from vacant pilot tones for other Tx in the same symbol.
  - Data tone power is not affected
  - Total OFDM symbol power is not affected
  - This is for reason of simple and fare comparison. Optimal pilot boosting level is FFS

# Pilot structure evaluation for common pilot

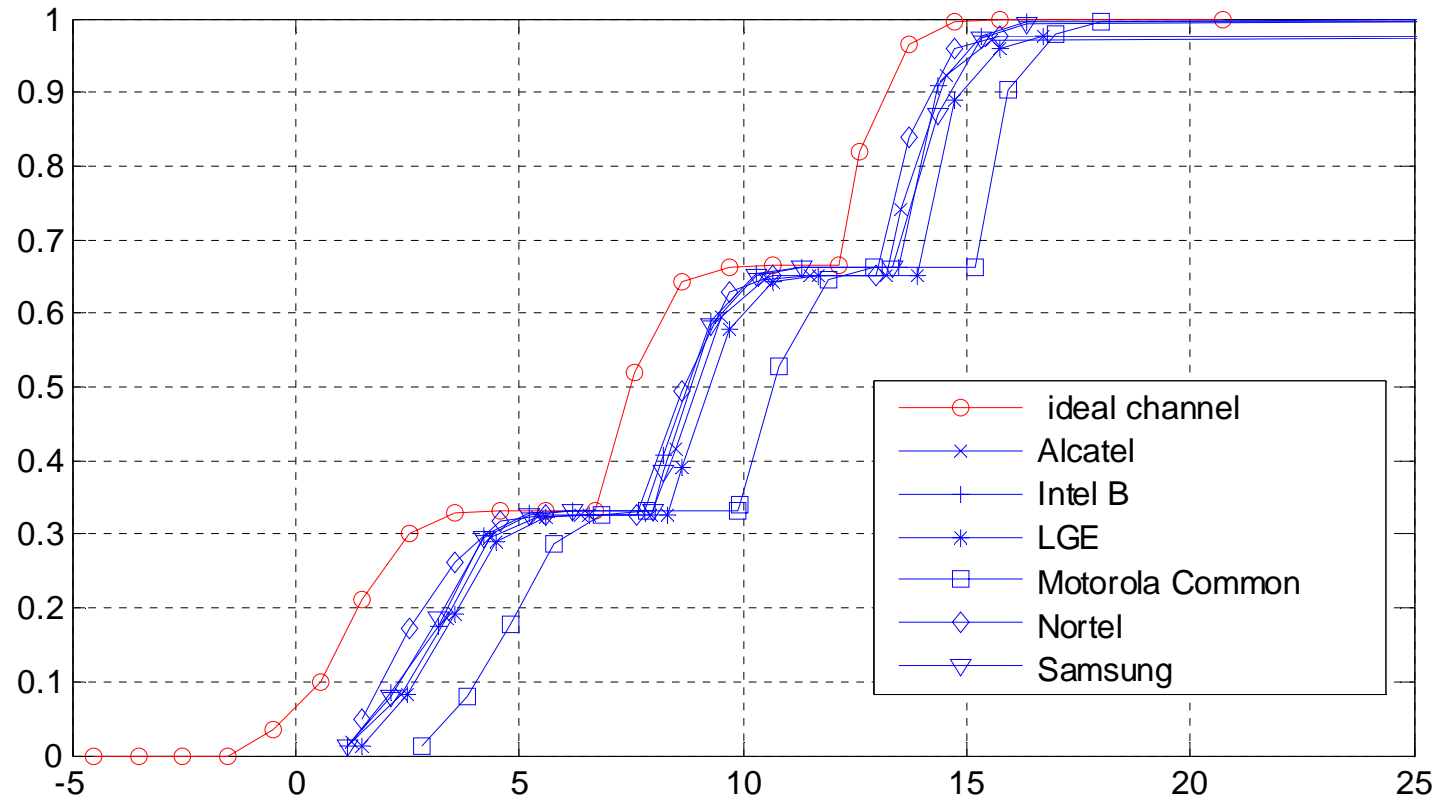
- Evaluation conditions:
  - Tone based distributed data subcarriers. Data block size is 2 PRUs
  - Common pilots are allocated over full bandwidth. 48 PRUs for 10MHz system.
  - Channel interpolation in frequency is second order 1-D
  - No cross sub-frame interpolation. Time direction interpolation is linear 1-D
    - Interpolation across sub-frames can not be guaranteed, since symbol structure permutation may change from sub-frame to sub-frame, according to the current 16m DL PHY definition

# Common pilot: PB 3km/h



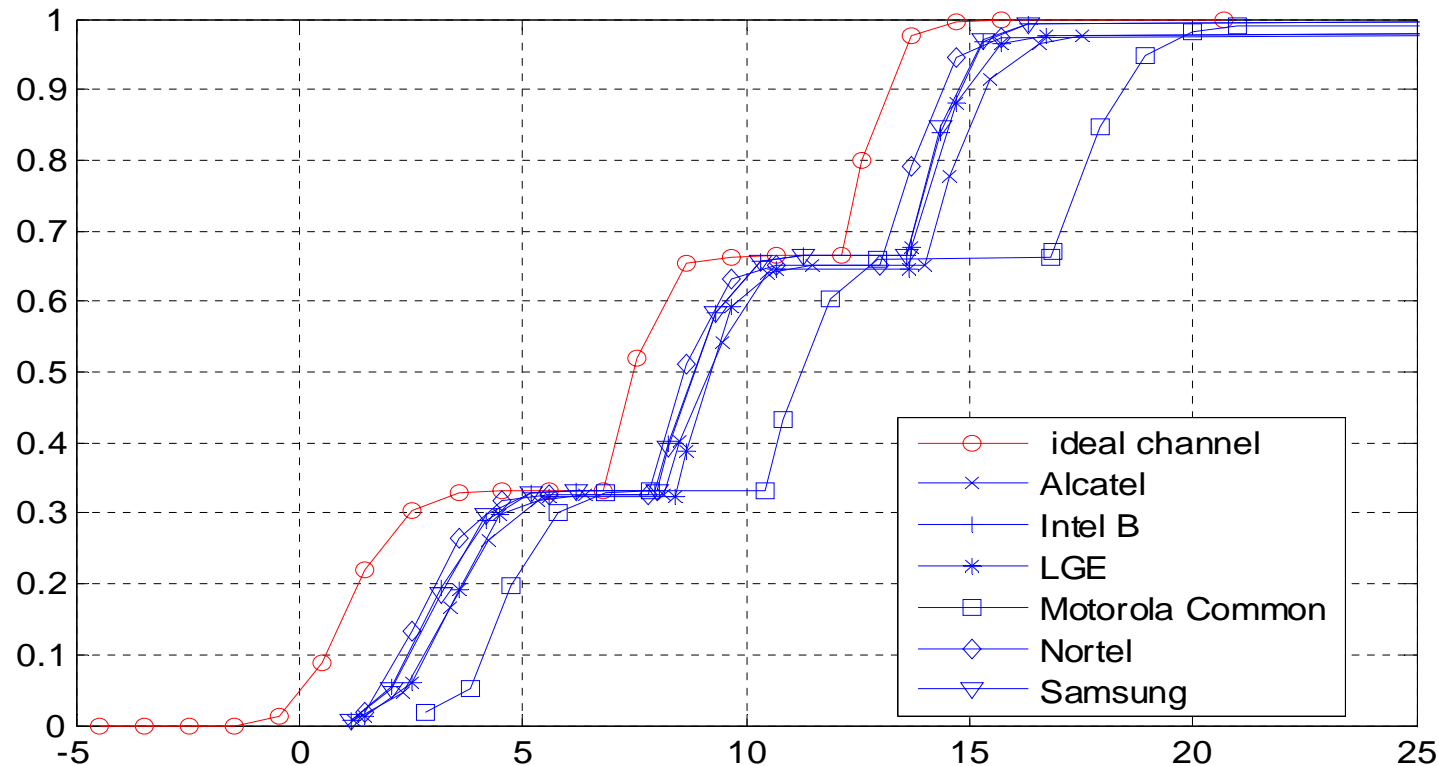
- **Nortel's and Alcatel-Lucent's are the best options at low speed**
- **Motorola's underperforms at low SNR, even at low speed**
- **LGE's, Intel's and Samsung's are close to each other.**

# Common pilot: VA 120km/h



- At VA 120, Nortel's outperform others by small margin
- Alcatel-Lucent's, LGE's, Intel's and Sumsung's are closed to each other
- Motorola's shows degradation caused by extrapolation in time

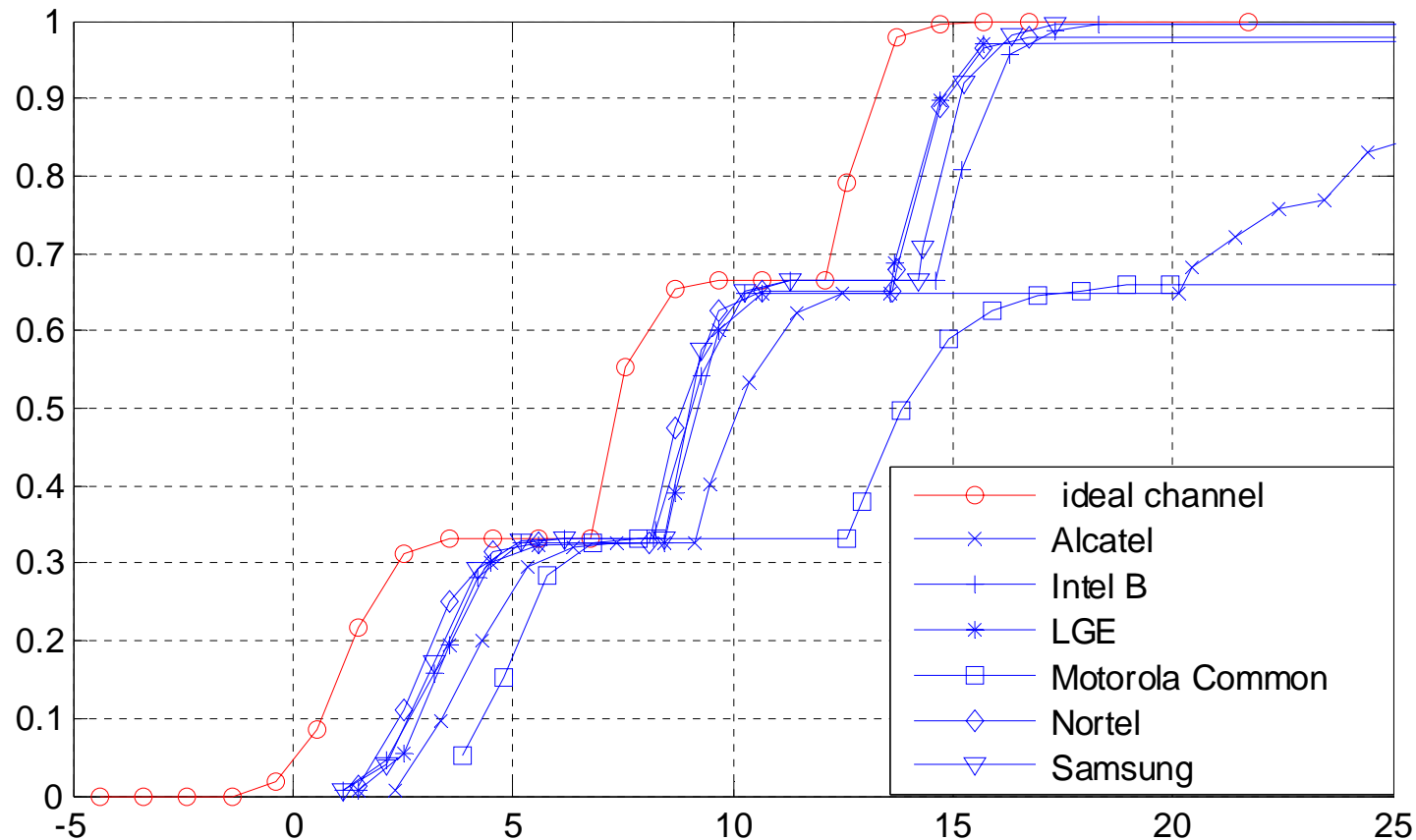
# Common pilot: VA 240km/h



- At VA 240, Nortel's outperform others by bigger margin than VA 120 case
- Alcatel-Lucent's shows degradation caused by extrapolation in time
- LGE's, Intel's and Sumsung's are closed to each other
- Motorola's has larger degradation caused by extrapolation in time

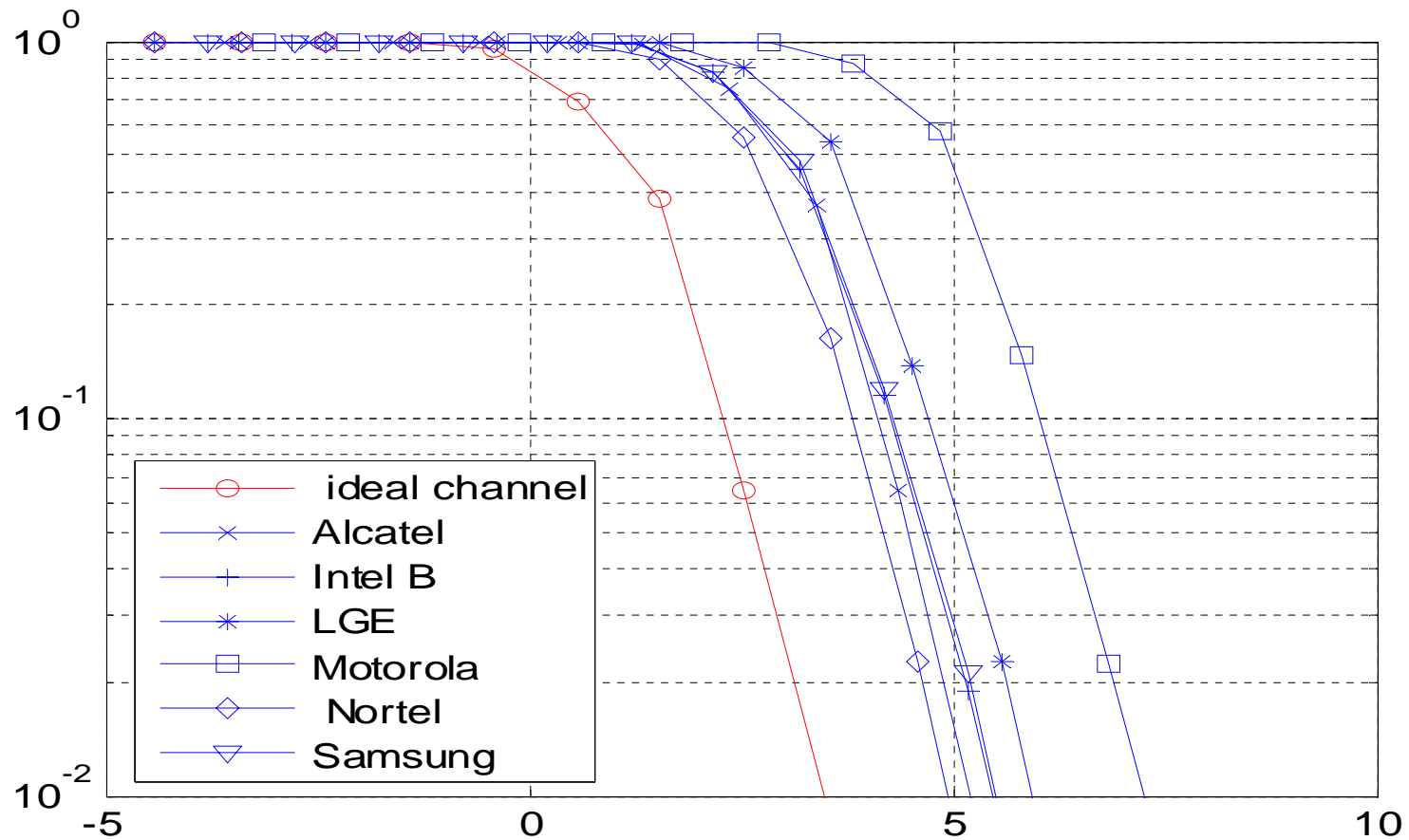


# Common pilot: VA 350km/h

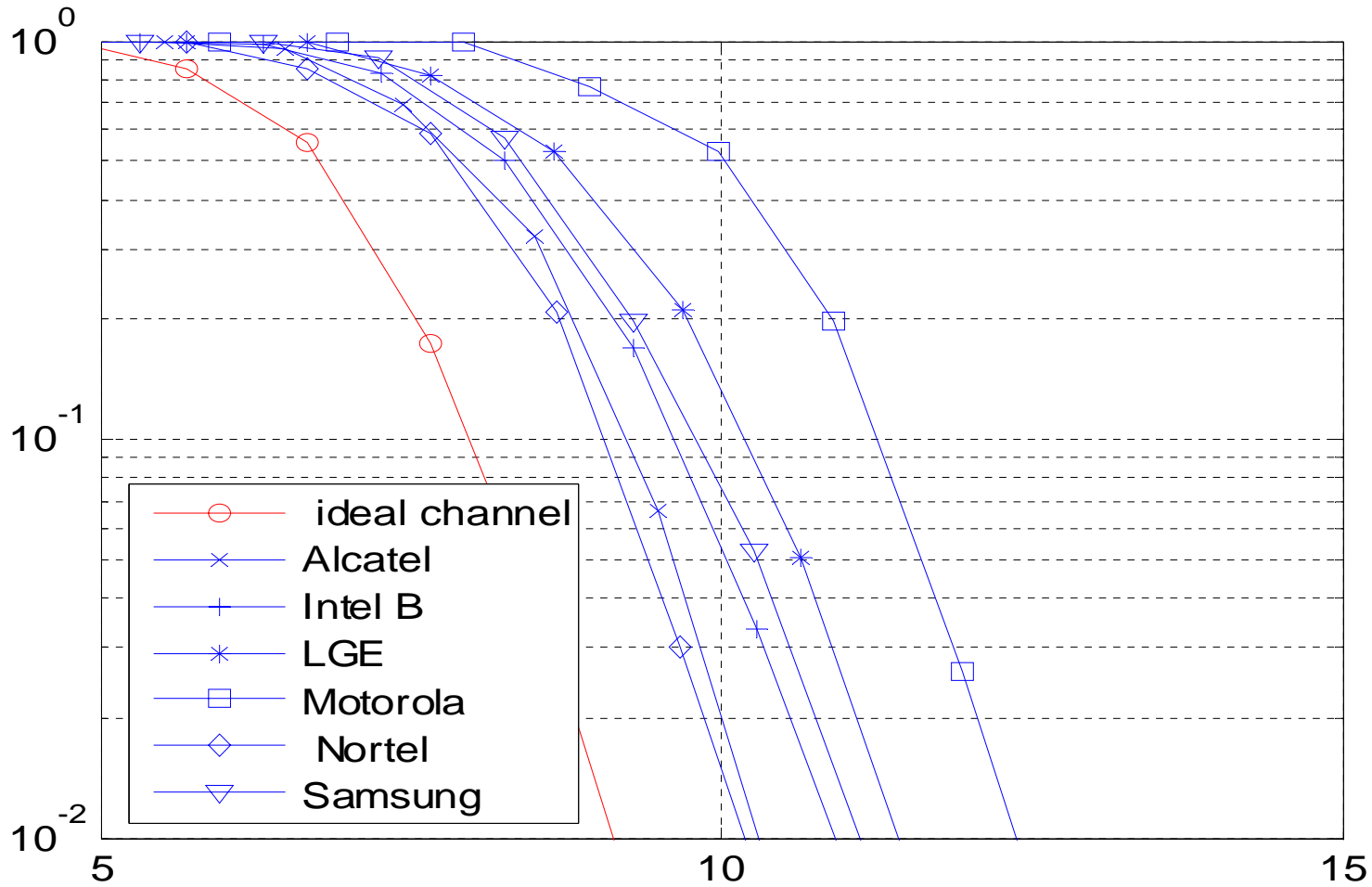


- At VA 350, Nortel's and LGE's outperform others. LGE's has pilots located at every OFDM symbol, which compensate its large frequency spacing at high speed.
- Alcatel-Lucent's and Motorola's shows very large degradation caused by extrapolation in time
- Intel's and Samsung's are closed to each other

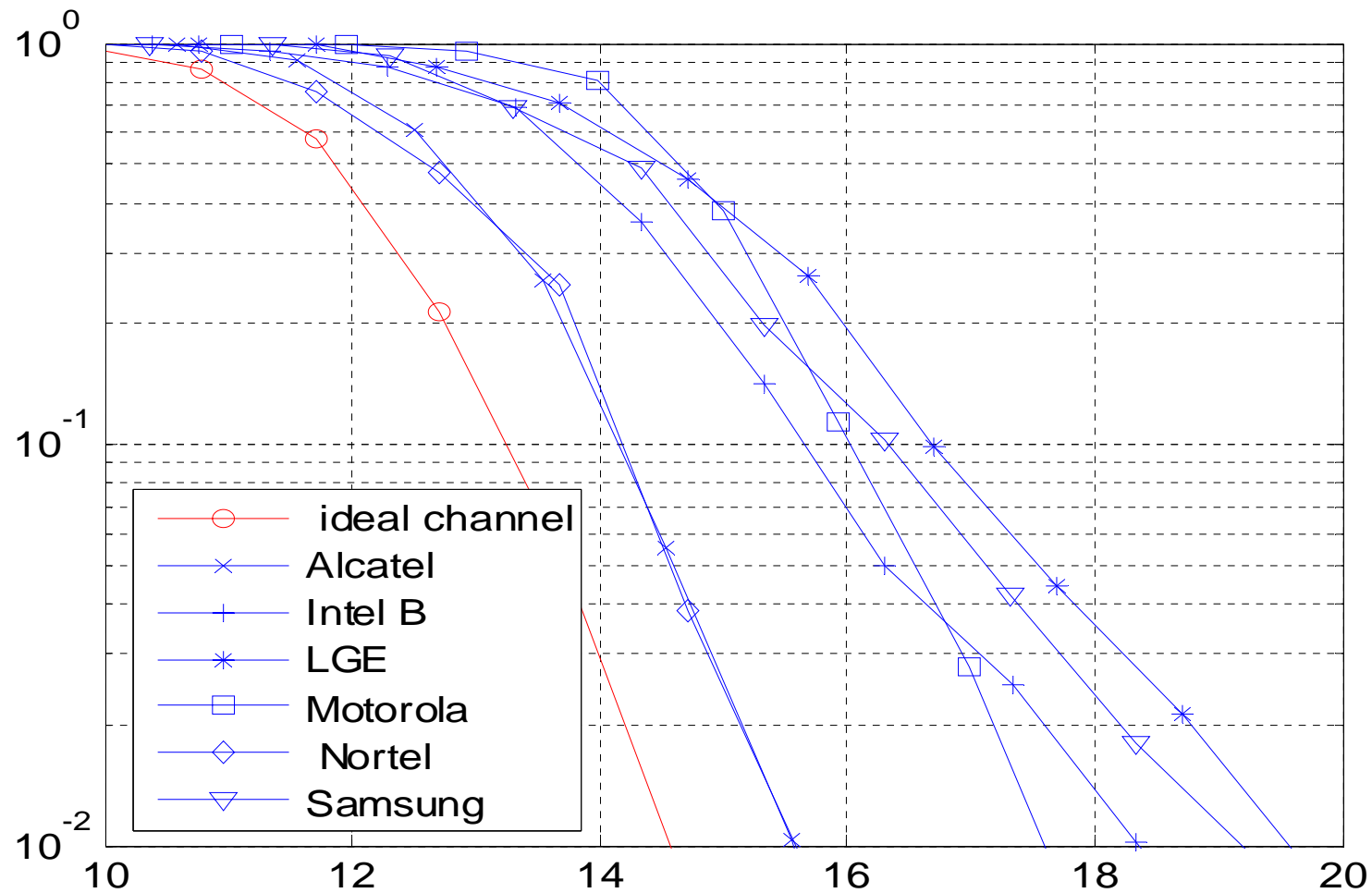
# Common pilot: PB 3km/h QPSK



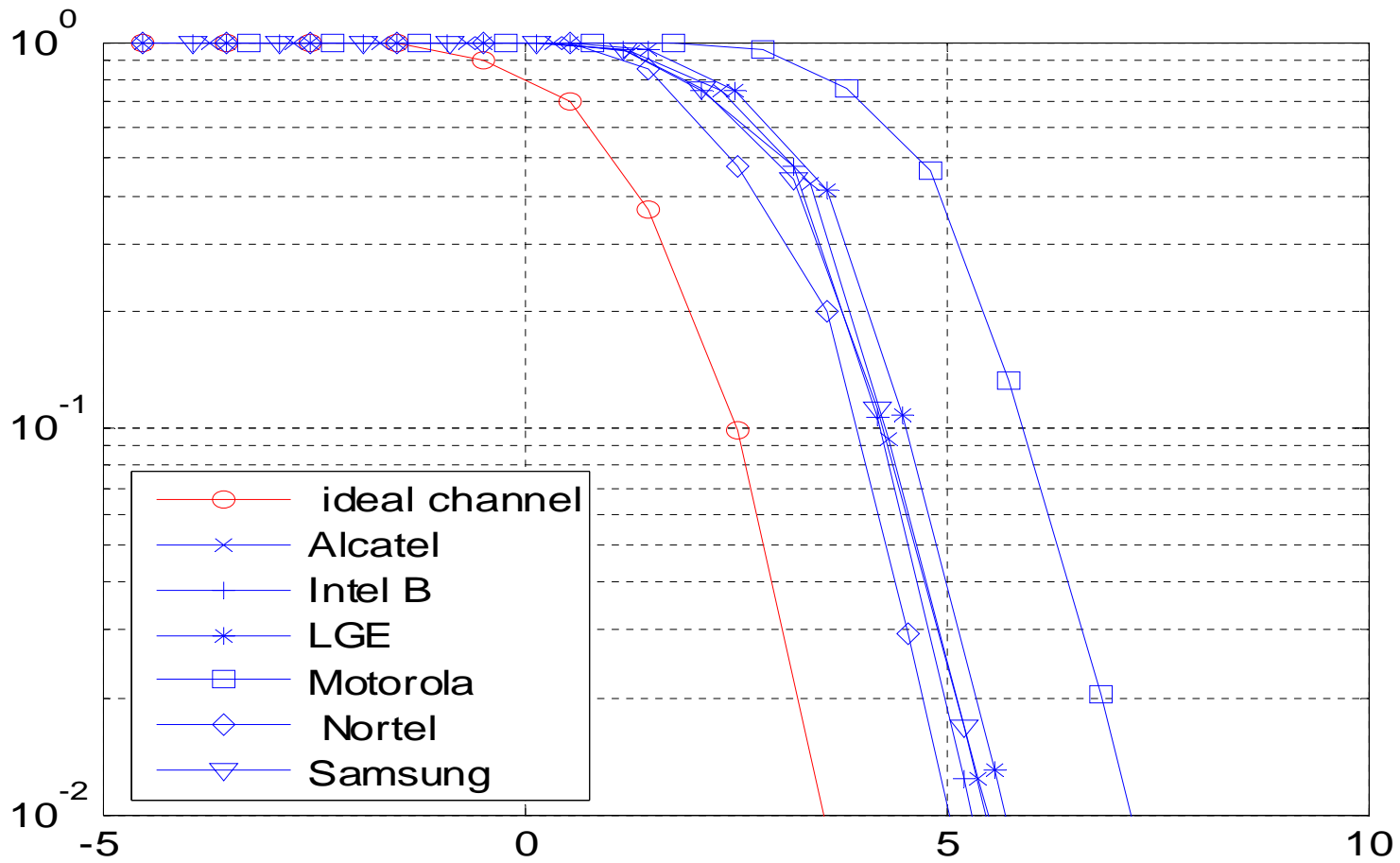
# Common pilot: PB 3km/h QAM-16



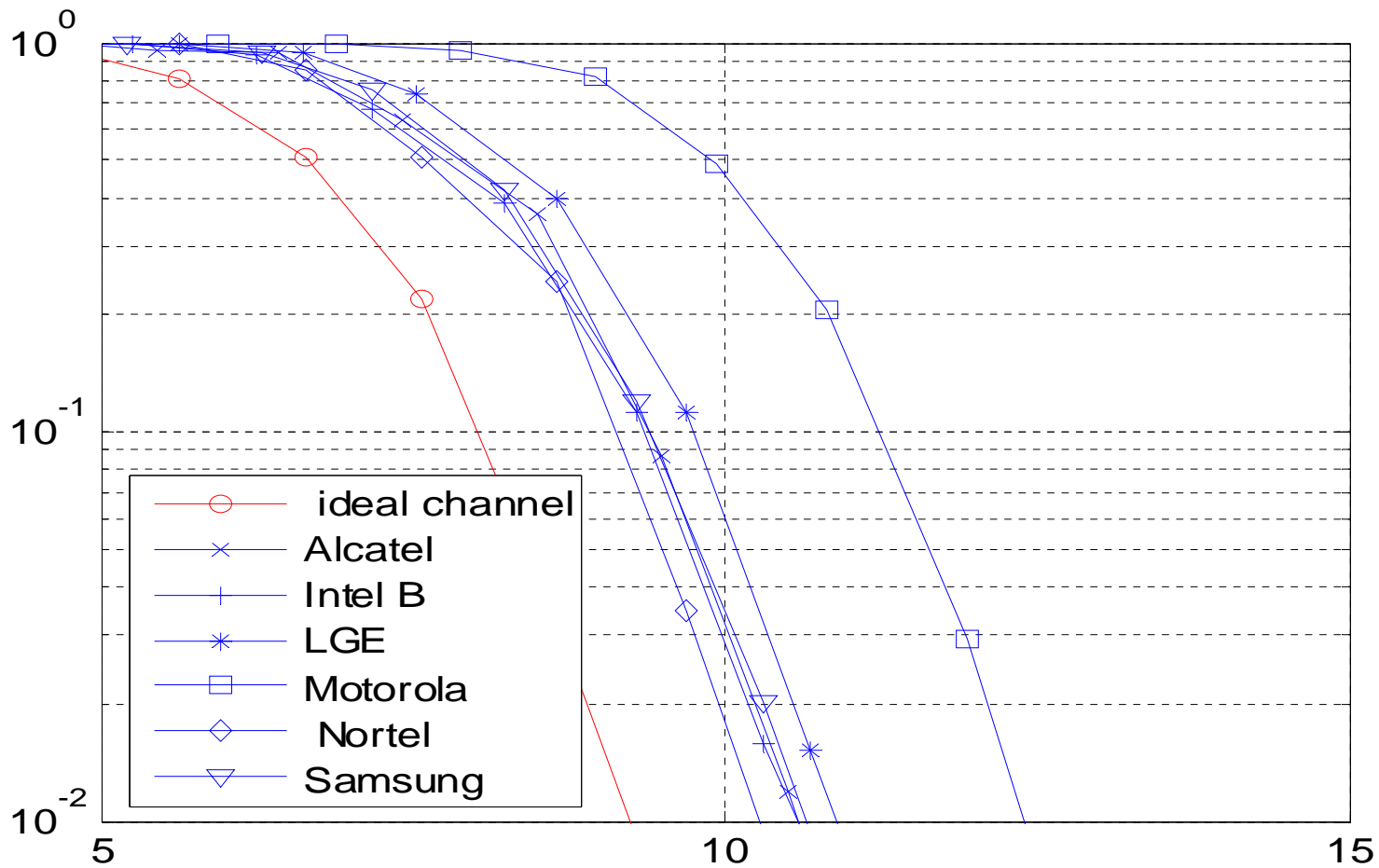
# Common pilot: PB 3km/h QAM-64



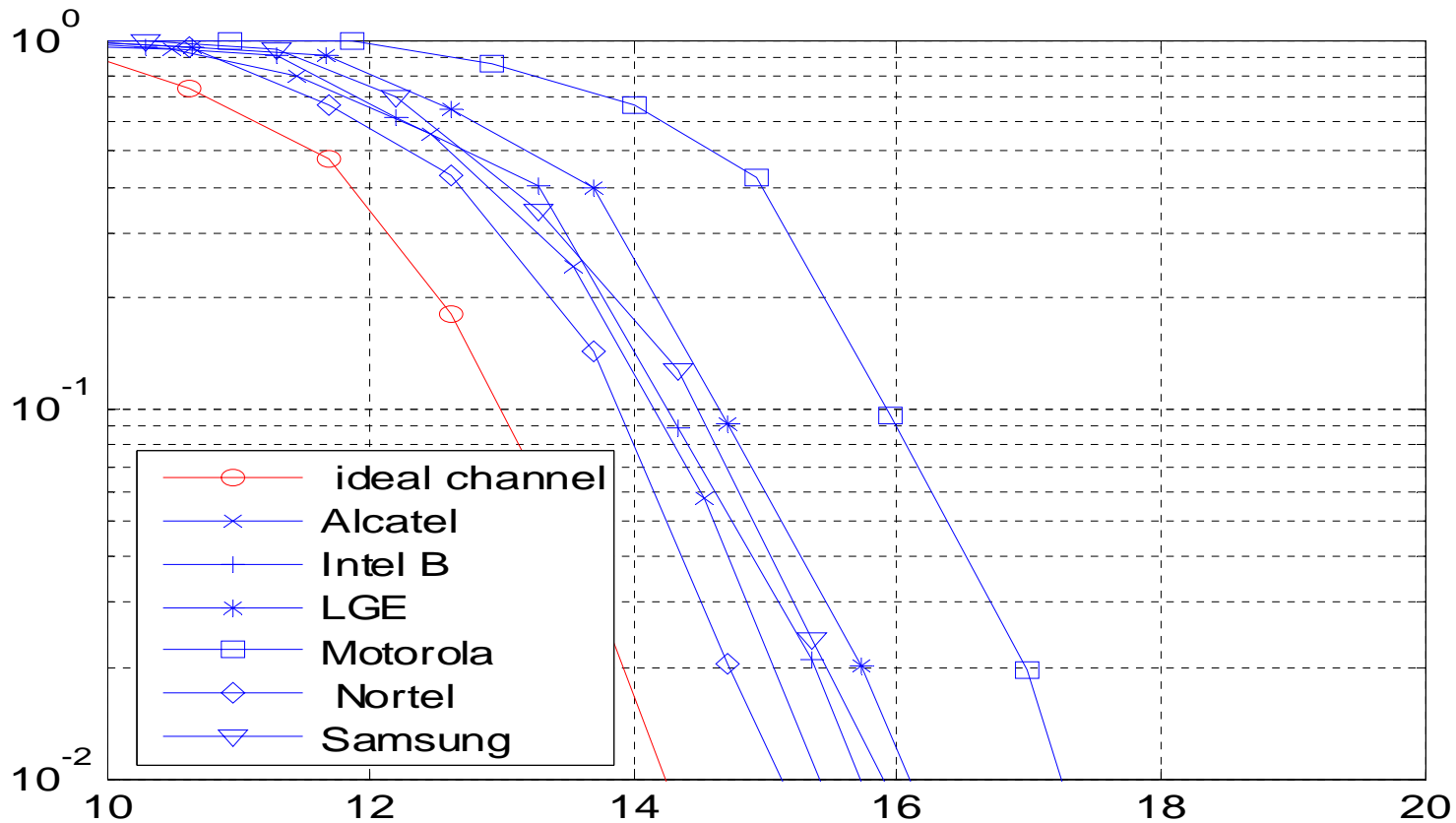
# Common pilot: VA 120km/h QPSK



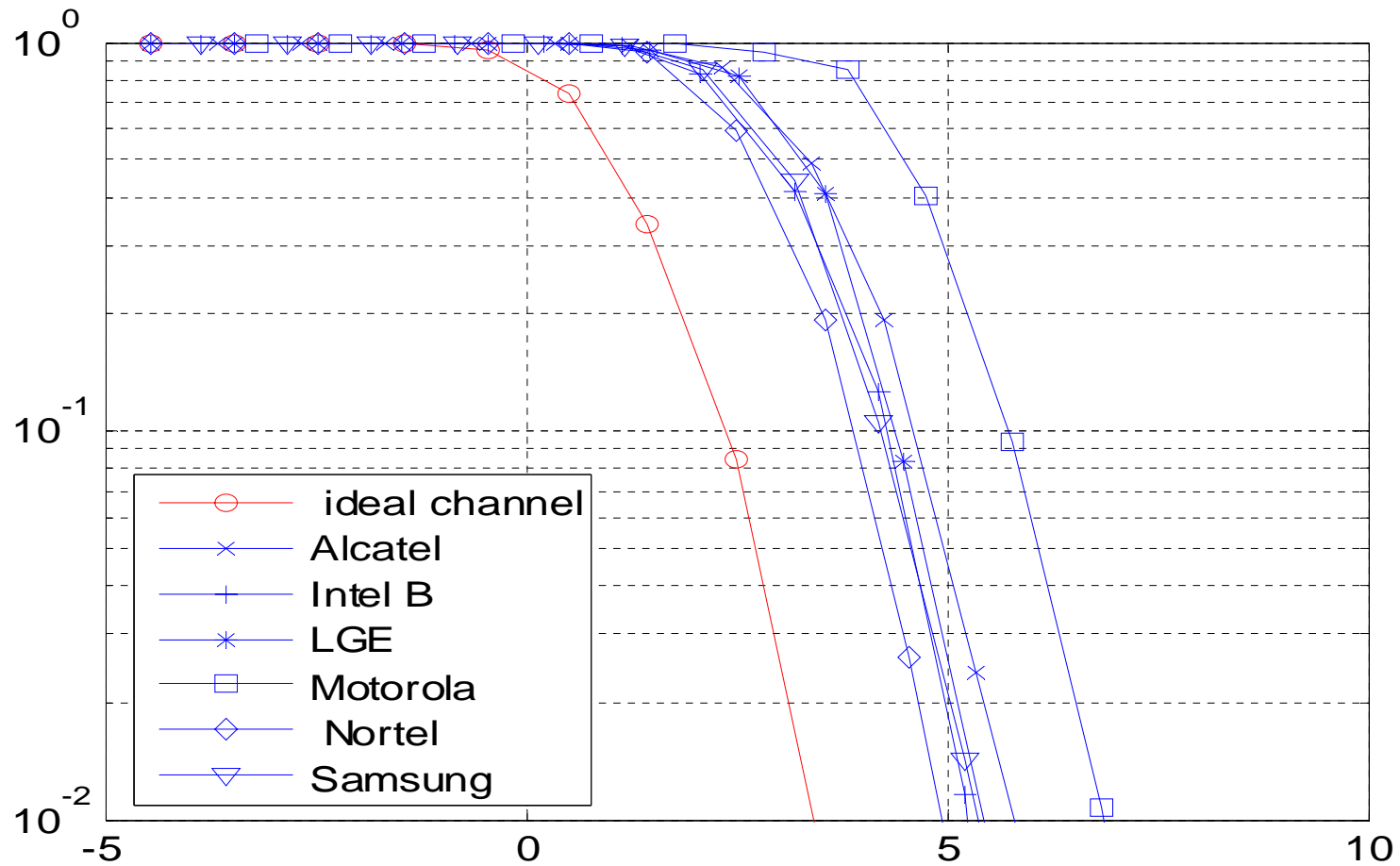
# Common pilot: VA 120km/h QAM-16



# Common pilot: VA 120km/h QAM-64

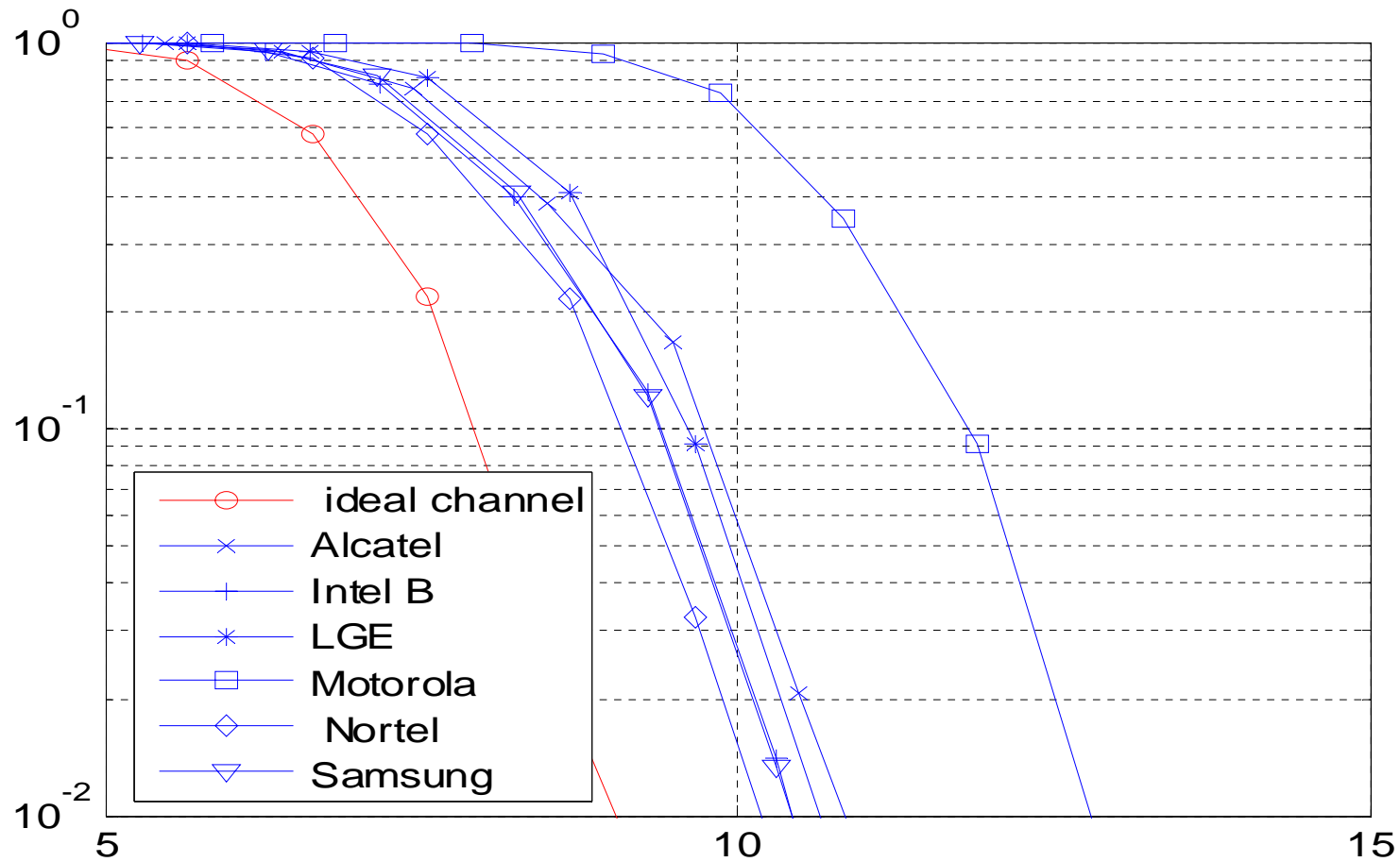


# Common pilot: VA 240km/h QPSK

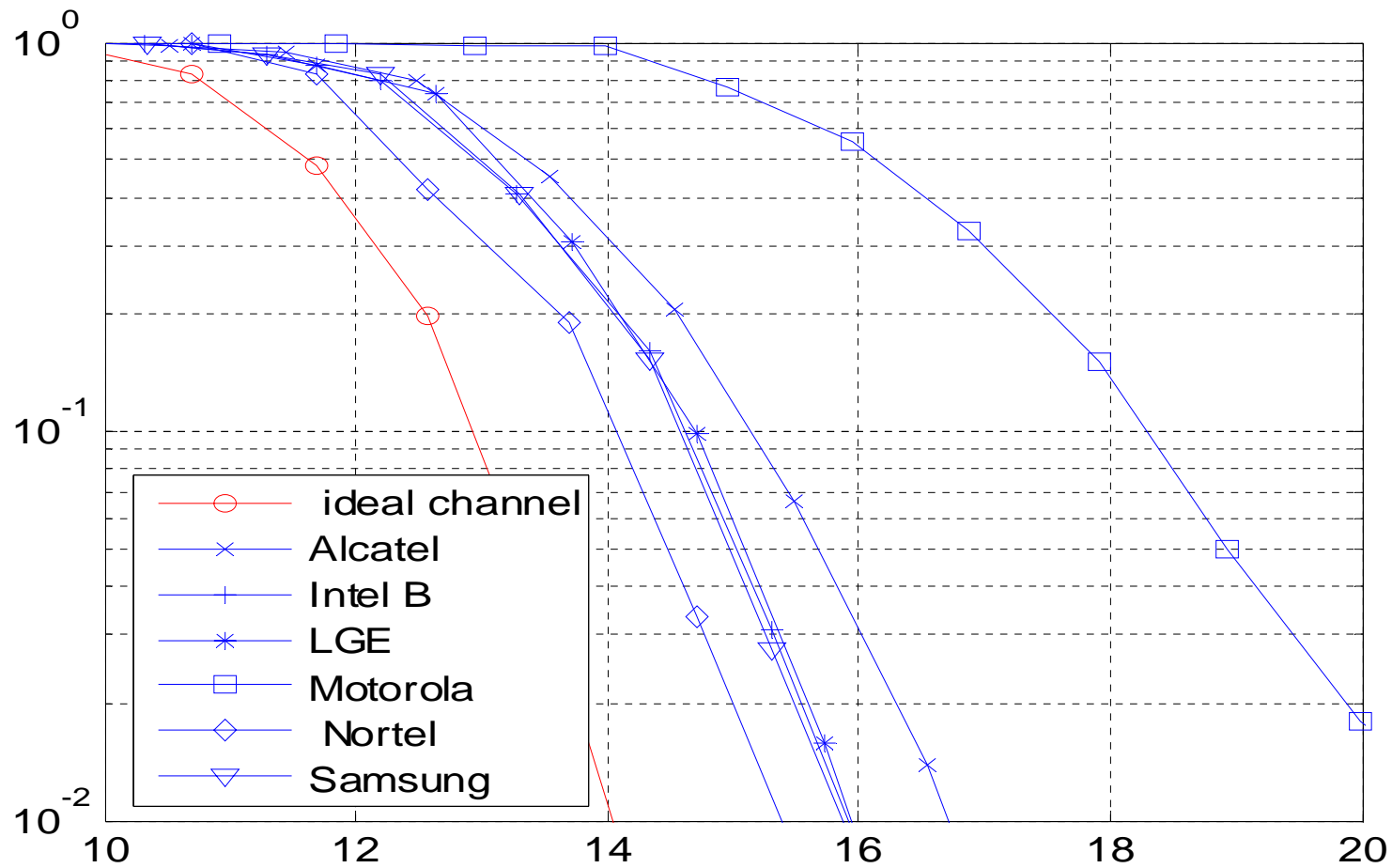




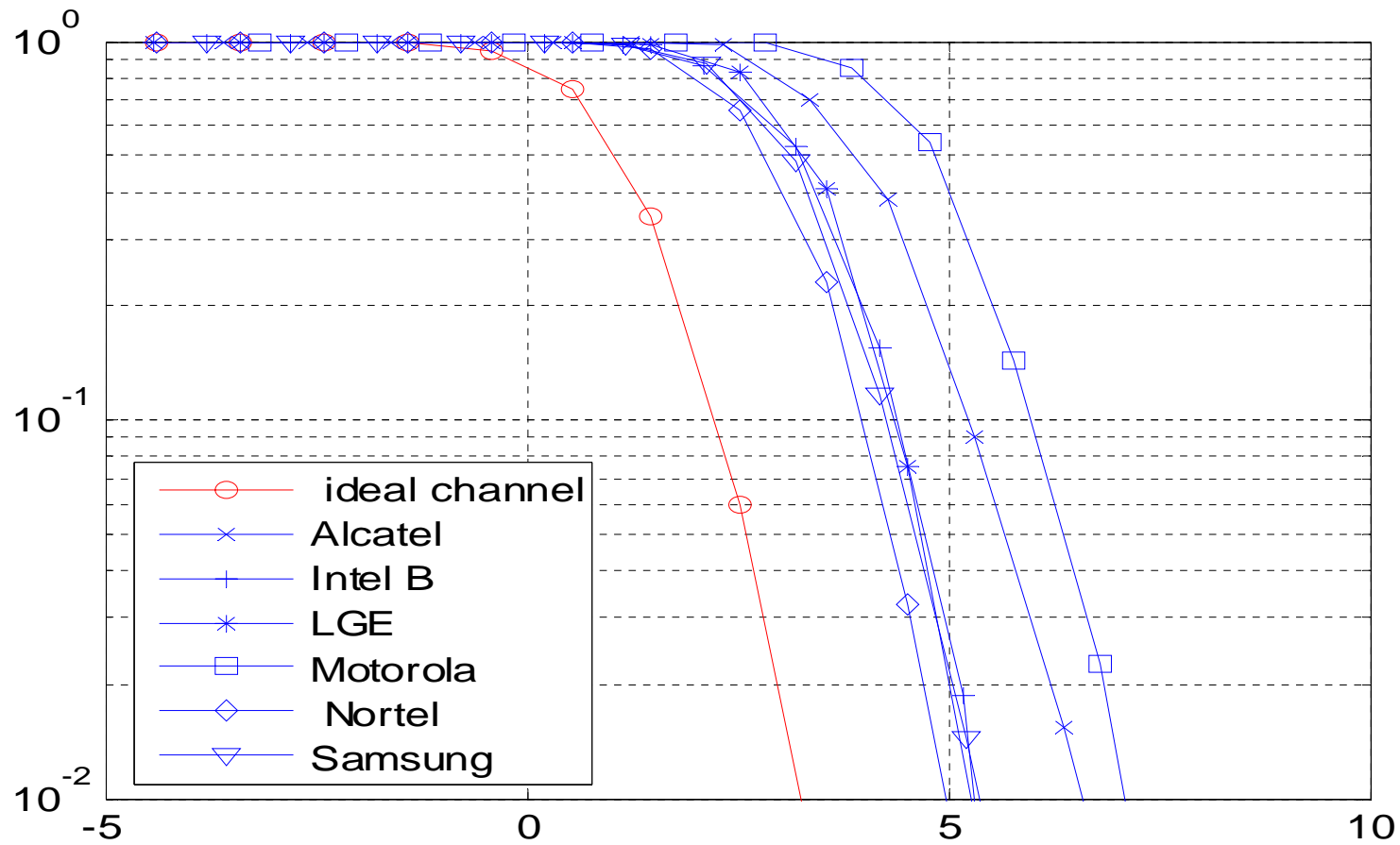
# Common pilot: VA 240km/h QAM-16



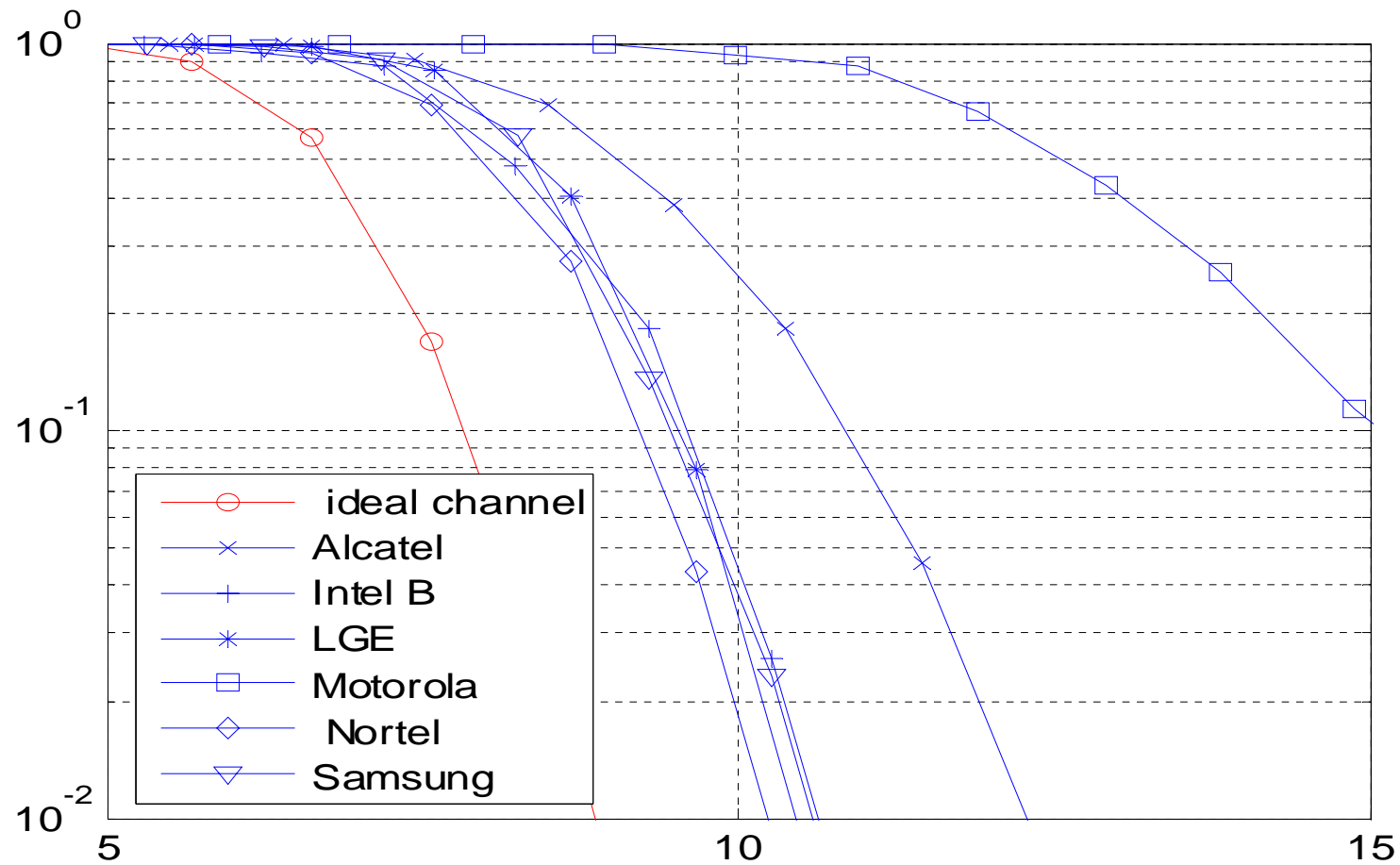
# Common pilot: VA 240km/h QAM-64



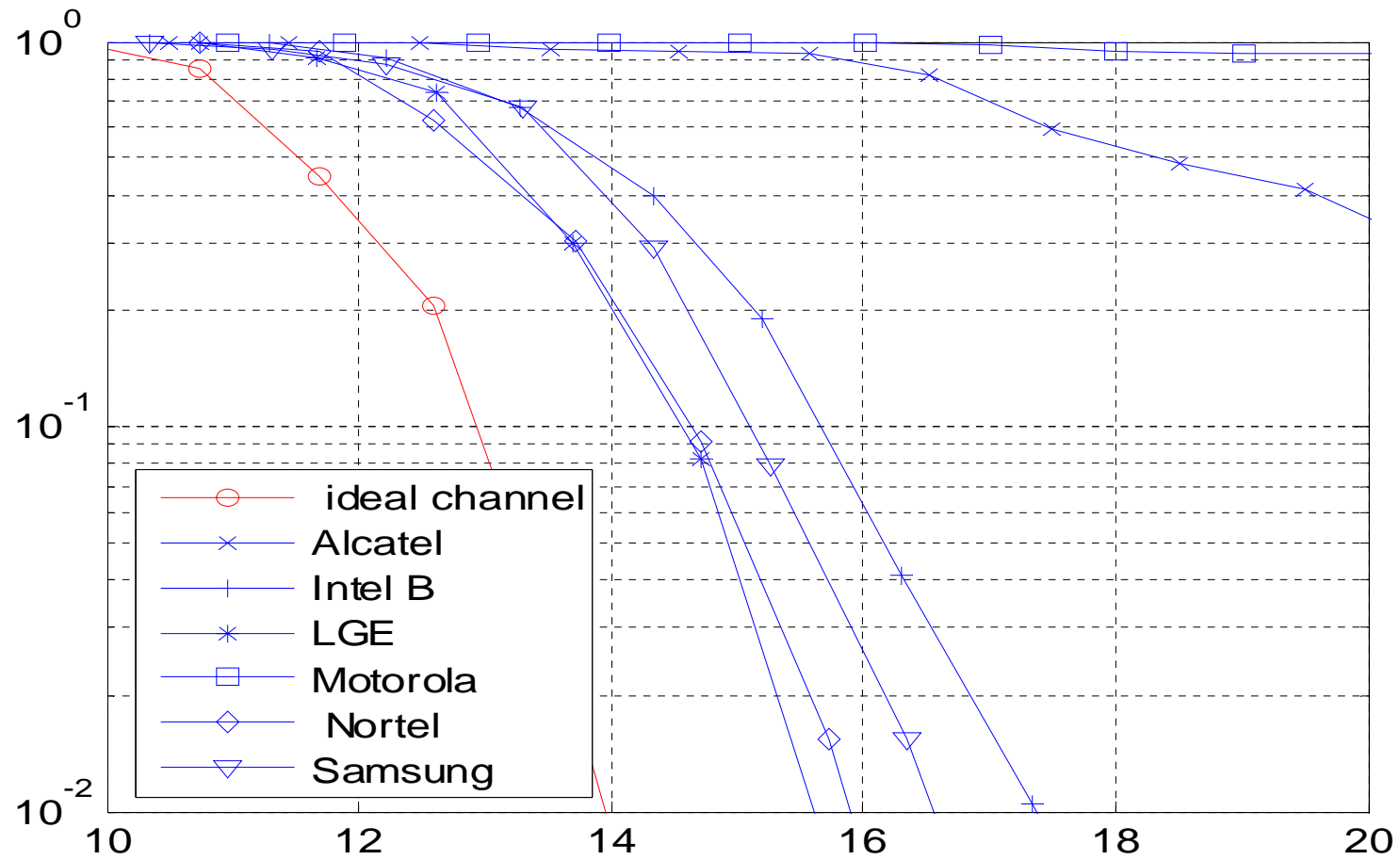
# Common pilot: VA 350km/h QPSK



# Common pilot: VA 350km/h QAM-16



# Common pilot: VA 350km/h QAM-64

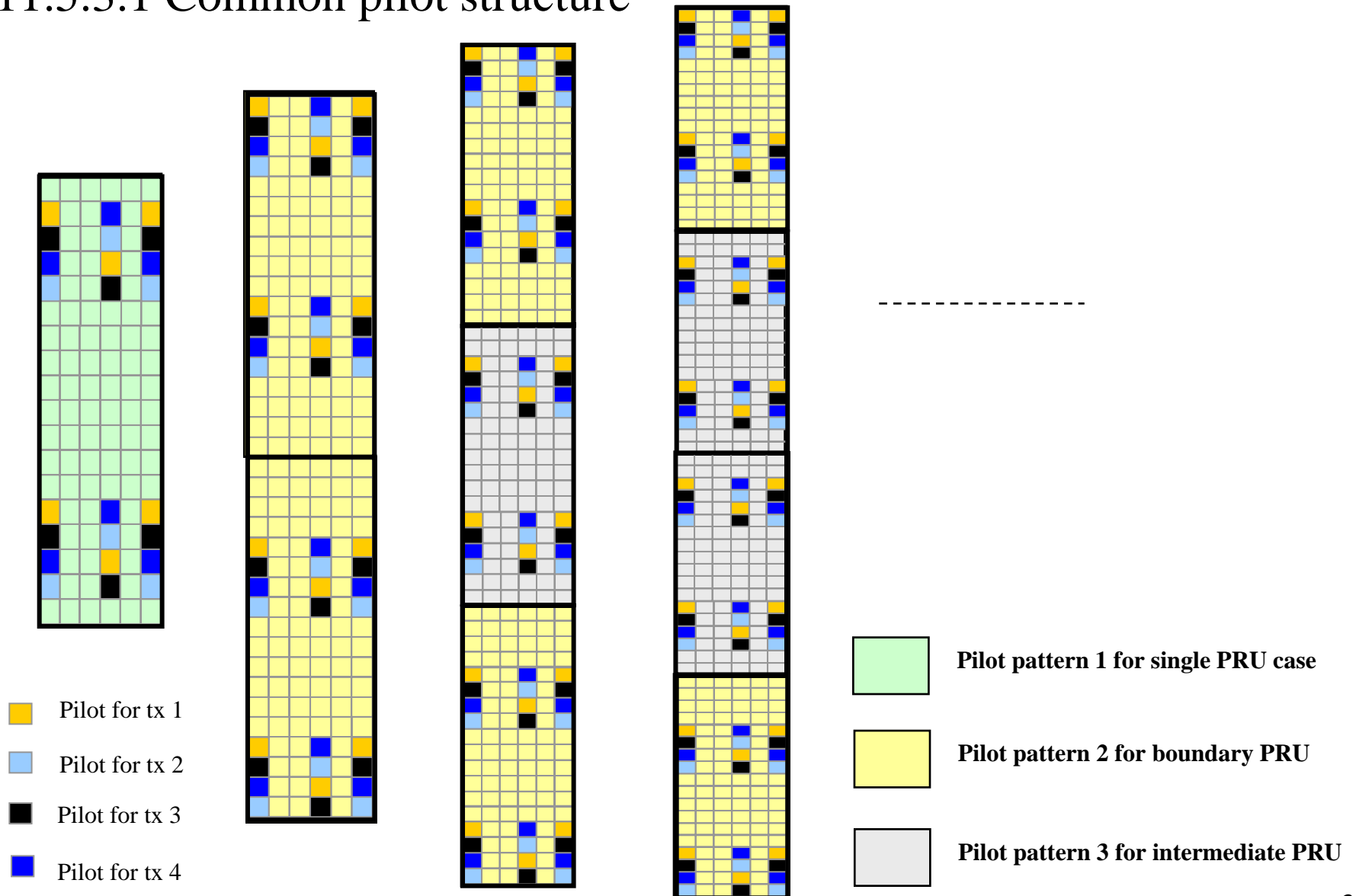


## Recommendation

- Recommended pilot structure
  - At high speed up to 350km/h, Nortel's and LGE's pilot structures are the best
  - At low speed, Nortel's and Alcatel-Lucent's pilot structures are the best
  - Overall, Nortel pilot structure provides the best performance

# Proposed SDD Text (1/2)

## 11.5.3.1 Common pilot structure



# Proposed SDD Text (2/2)

## 11.5.3.2 Dedicated pilot structure

