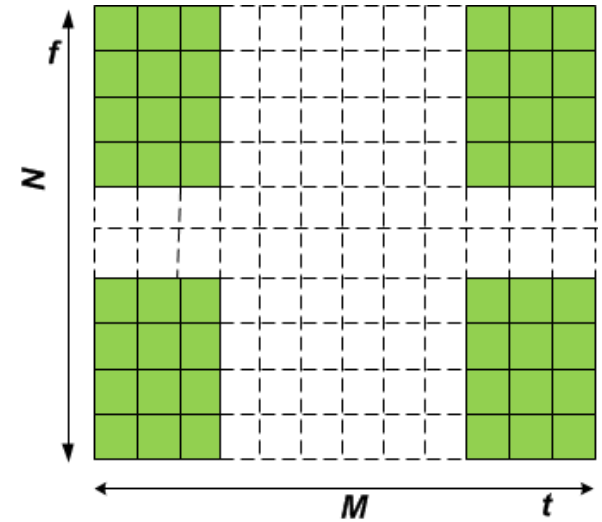


Resource Blocks for EPoC Considerations

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Broadcom

RB Size – Current Status in 802.3bn

- Size in number of symbols (M)
 - Configurable and TBD
- Size in number of subcarriers (N)
 - Three options are specified: 1,4,8
 - Configurable
- Pilot spacing
 - Configurable 1,2,4,8
- This presentation proposes values for the number of symbols and pilot patterns



- Data is written horizontally (subcarrier by subcarrier) and read vertically (symbol by symbol)
- Time interleaving of codewords

Number of OFDMA Symbols in a RB

- Considerations
 - To increase number of symbols
 - Performance with burst noise
 - Improves with longer interleaver
 - Pilots overhead
 - Pilots are transmitted on two symbols in the RB
 - Increasing the number of symbols reduces latency
 - To decrease number of symbols
 - Latency
 - Granularity overhead
 - Granularity overhead is a function of both number of symbols and number of subcarriers
 - For a specific number of subcarriers more symbols means higher overhead

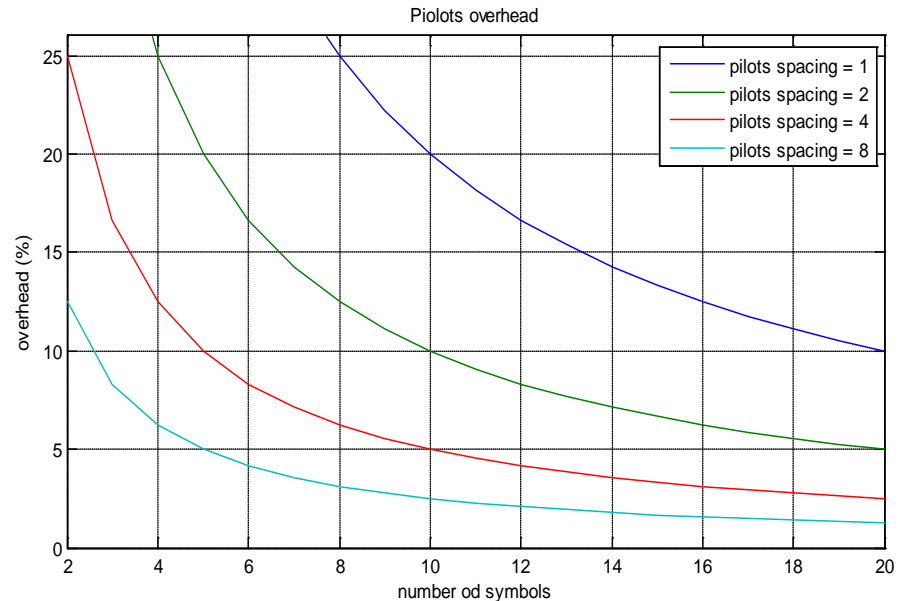
Performance with Burst Noise

- Table shows burst noise durations and levels to be considered
 - Assumed to represent worst case conditions in the upstream
- With simulated burst noise an Interleaver depth of 16 with 20uSec symbols and 11 with 40 uSec is required
- Corresponding Interleaver latency (CP size = 2.0 uSec) is 374 uSec and 462 uSec for 20u and 40u symbols

Burst noise	Duration (uSec)	SNR (dB)	Interleaver Depth (20uS symbols)	Interleaver Depth (40uS symbols)
Upstream	10	10	16	11
	1	0	16	8

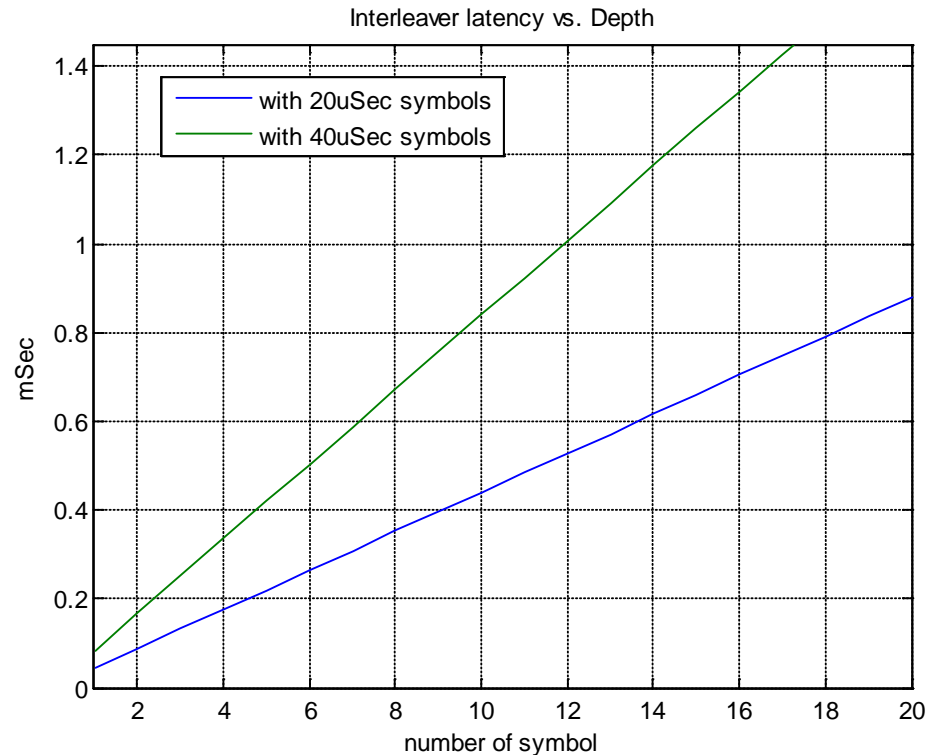
Overhead due to Pilots

- Assume pilots every 1,2,4 or 8 subcarriers with 20 uSec symbols
- Two pilots in a subcarrier with pilots to protect against burst noise
- Overhead vs. number of symbols equals $2/L$
 - L is the multiplication of the pilot spacing with the number of symbols
- With a pilots spacing of 8 subcarriers
 - Overhead with 8 symbols is 3.1%
 - Overhead with 12 symbols is 2%
 - Overhead with 16 symbols is 1.5%
 - Below 8 symbols overhead becomes significant, in particular with the more dense pilot patterns



Additional Latency due to Interleaver Depth

- Assume additional latency due to Interleaving is twice the Interleaver depth
- With 20 uSec symbols additional latency is:
 - ~ 350 uSec with 8 symbols
 - ~ 530 uSec with 12 symbols
 - ~ 750 uSec with 16 symbols

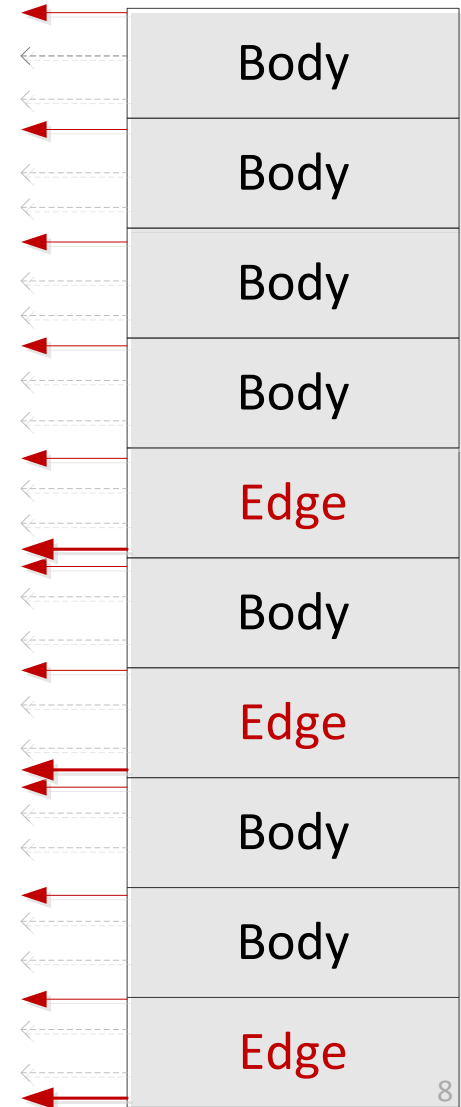


Proposal for Number of Symbols in a Resource Block

- Allow three configurable options for the number of symbols (M) in a Resource Block
- Allow operators to trade-off between latency/overhead and performance with burst noise propose
- M values with 20 uSec symbols
 - M= 8 for low latency, burst noise support is weak
 - M=16 to protect against high level/long burst noise
 - M=12 lower latency, burst noise support is mild
 - Protect well against lower level burst noise
- All RBs in an OFDMA channel must have the same number of symbols

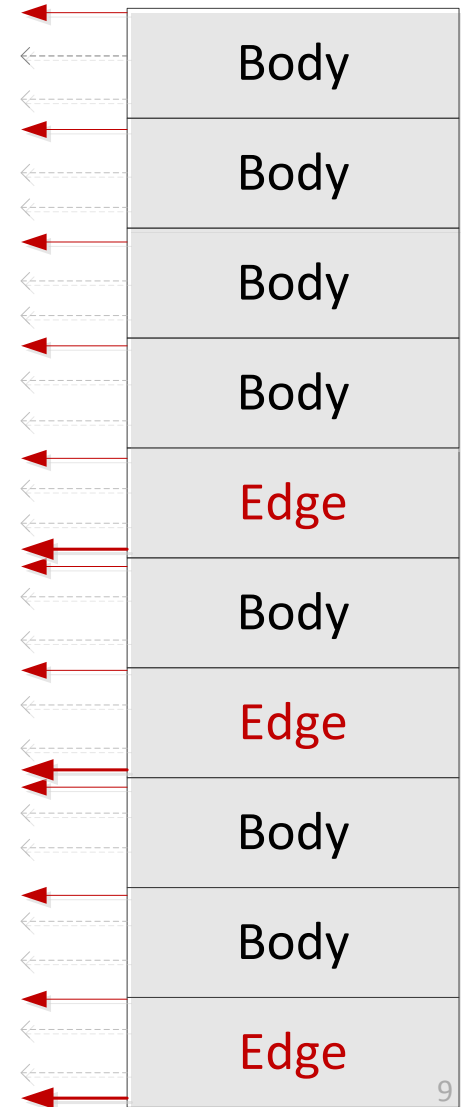
Pilot Patterns (1)

- Pilot patterns are defined for the different RB sizes
- Pilot spacing (per current decision)
 - Pilot every 1,2,4 or 8 subcarriers
 - Less patterns is possible with cost in overhead or in robustness to frequency response variations
- Use edge and body pilot patterns
 - To avoid extrapolation every burst starts with a pilot and ends with a pilot
 - Every RB after exclusion starts with a pilot
- Two pilots used on every subcarrier with pilots to protect against burst noise that hit a symbol with pilots

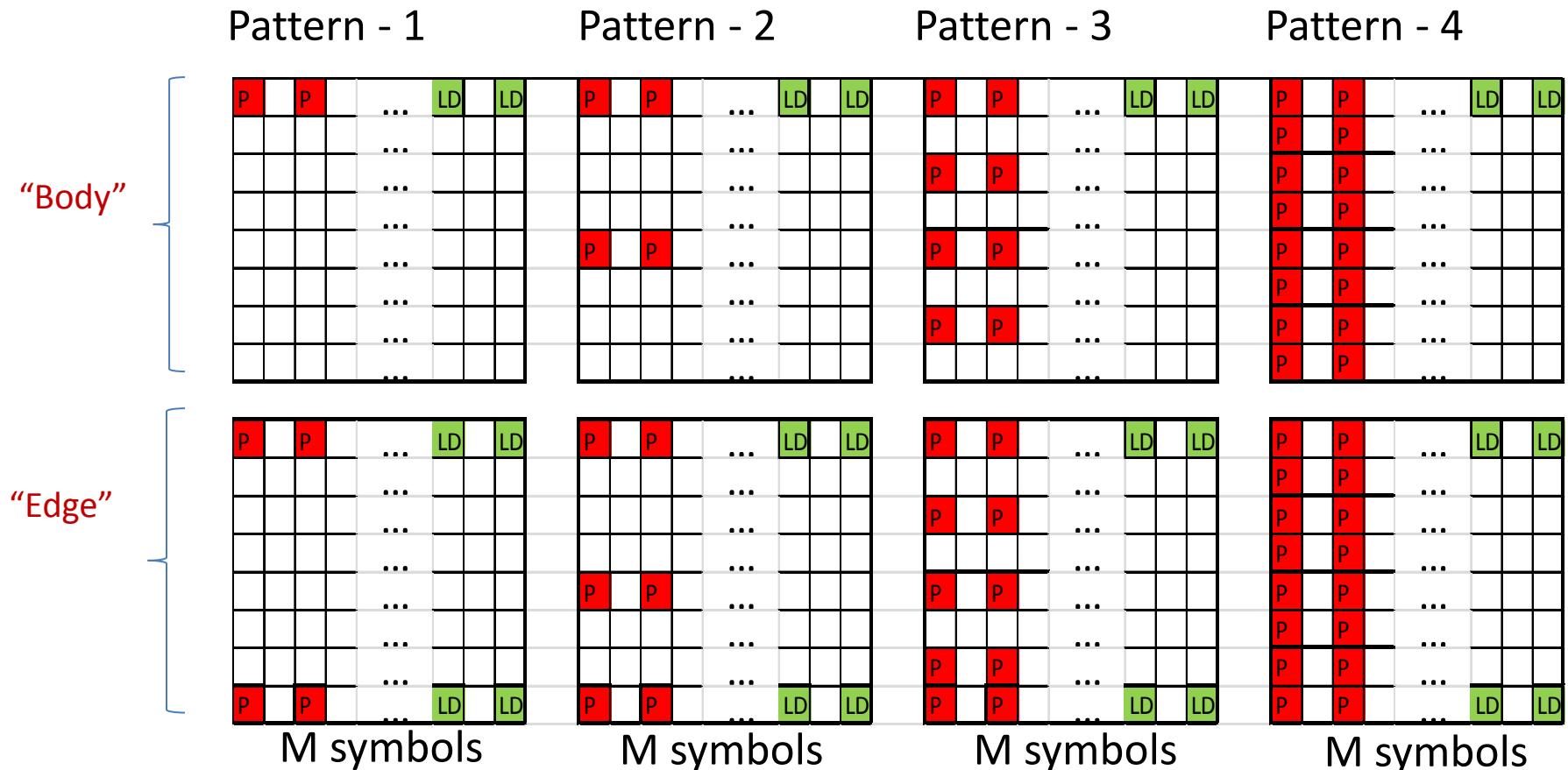


Pilot Patterns (2)

- Two pilots used on every subcarrier with pilots to protect against burst noise that hit a symbol with pilots
- Low density pilots are data REs with a lower order modulation
 - Can be used to improve initial frequency and phase correction



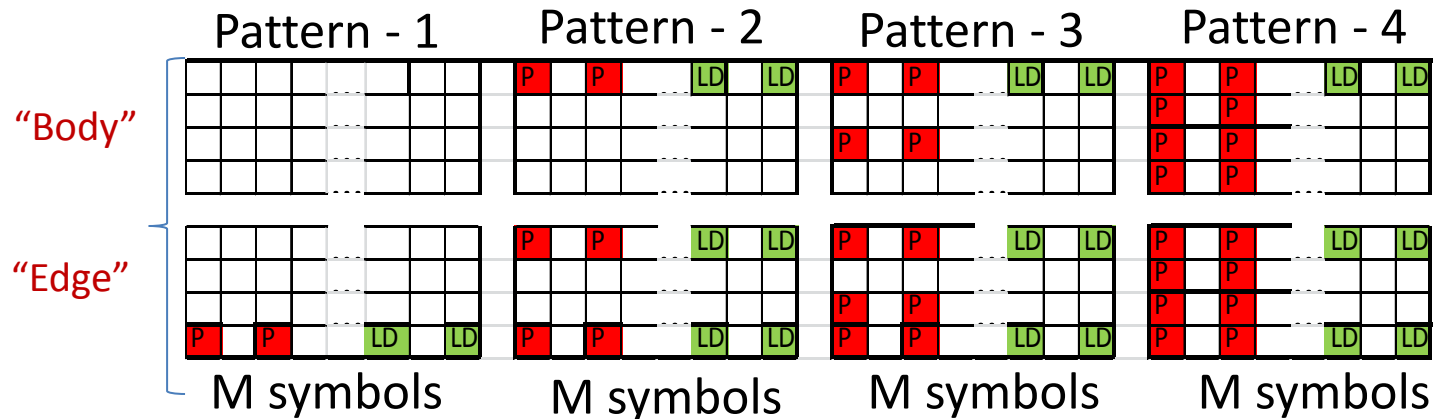
Pilot Patterns for 8-subcarrier RBs



- M can equal 8,12 or 16
- P – Pilots LD – Low Density pilots , blank RE for data

Pilot Patterns for 4-subcarrier RBs

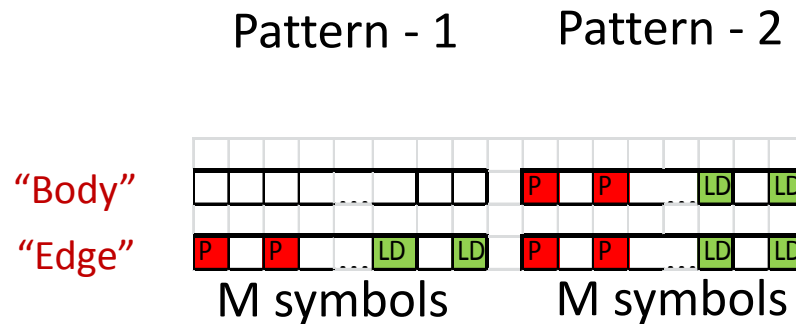
- Four pilot patterns are available



- M can equal 8,12 or 16
- P – Pilots LD – Low Density pilots , blank RE for data

Pilot Patterns for a single subcarrier RBs

- Two pilot patterns are available



- M can equal 8,12 or 16
- P – Pilots LD – Low Density pilots , blank RE for data

Proposed Motion (1)

Move to:

Specify three options for the number of symbols in a Resource Block: 8, 12 and 16

Moved:

Seconded:

Proposed Motion (2)

Move to:

Specify edge and body pilot patterns as described in slides 10-12 for EPoC FDD Upstream

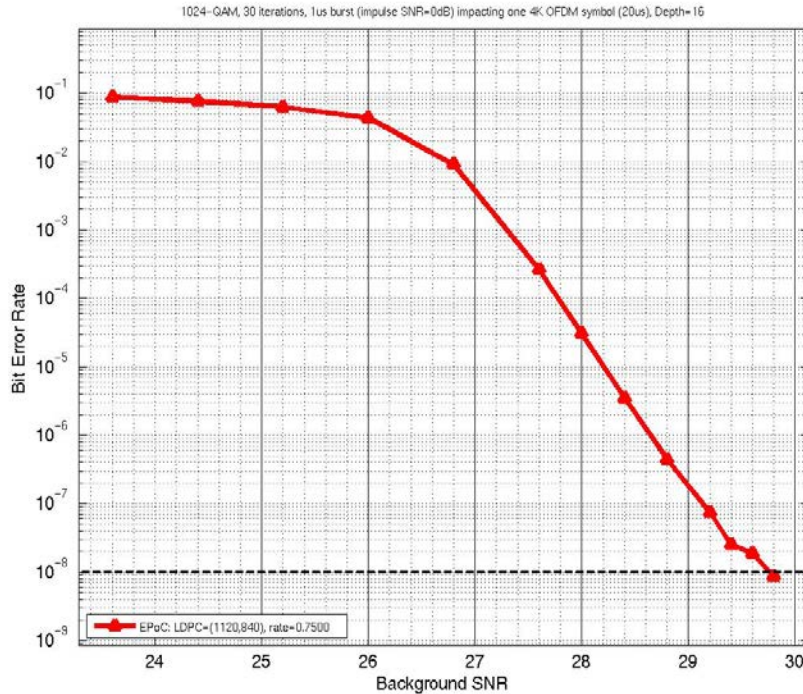
Moved:

Seconded:

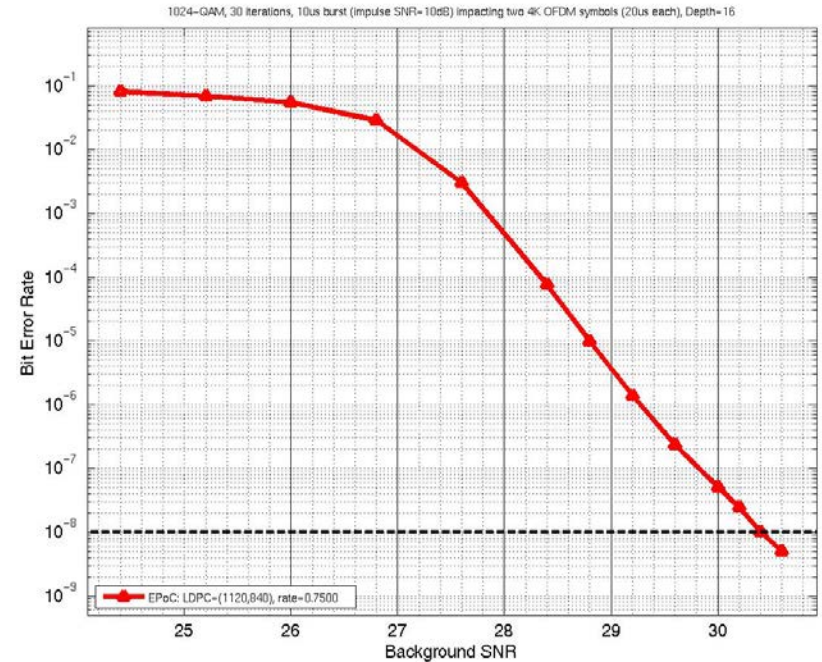
(this section all new slides)

PERFORMANCE ANALYSIS

PER Performance with an Interleaver Depth of 16 Symbols – 4KQAM (Short Code)

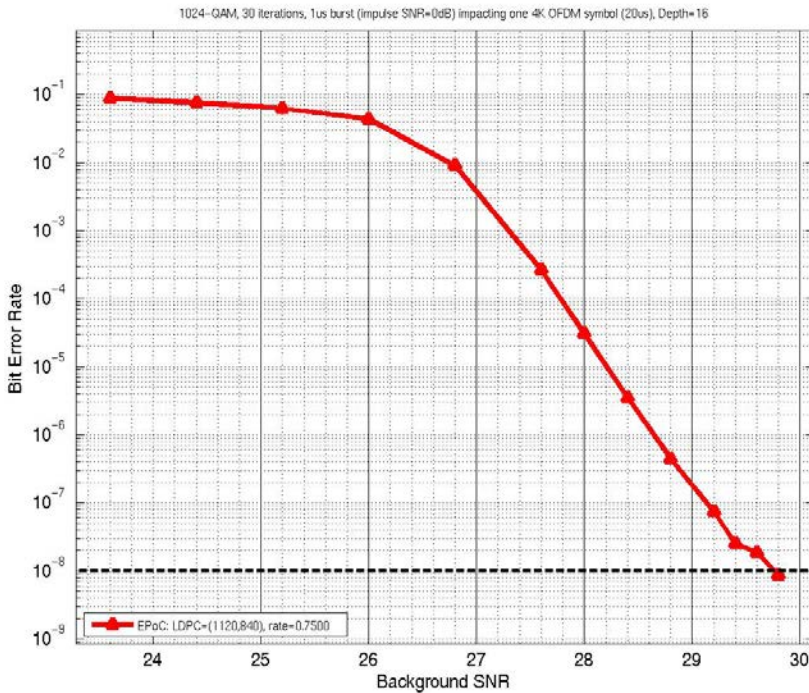


1 uSec / 0 dB

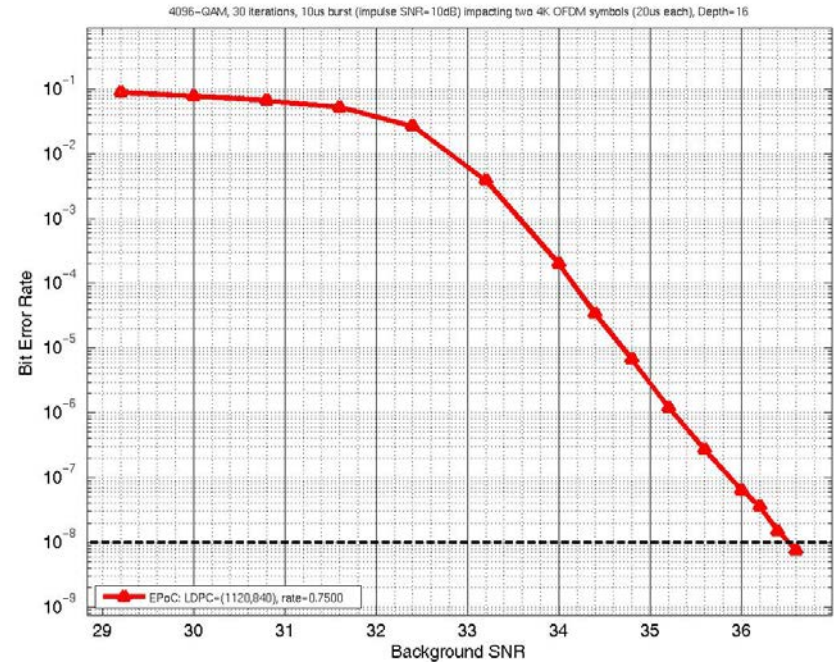


10 uSec / 10 dB

PER Performance with an Interleaver Depth of 16 Symbols – 4KQAM (Short Code)

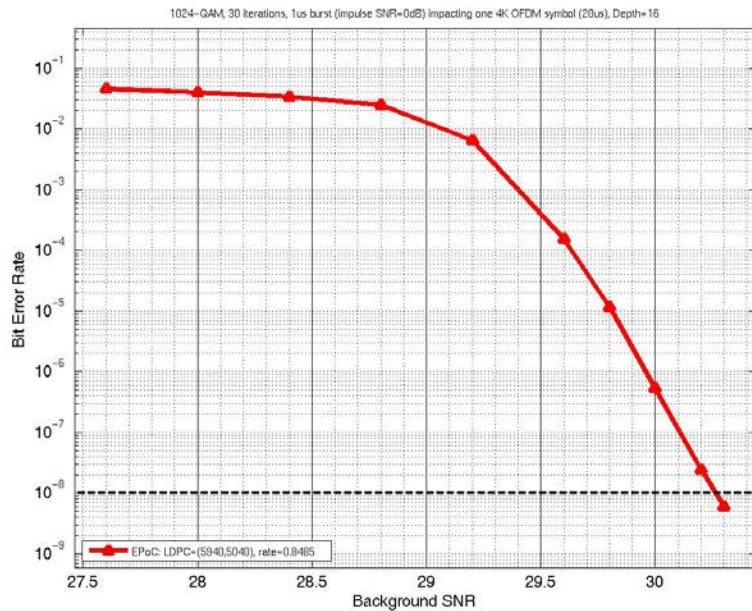


1 uSec / 0 dB

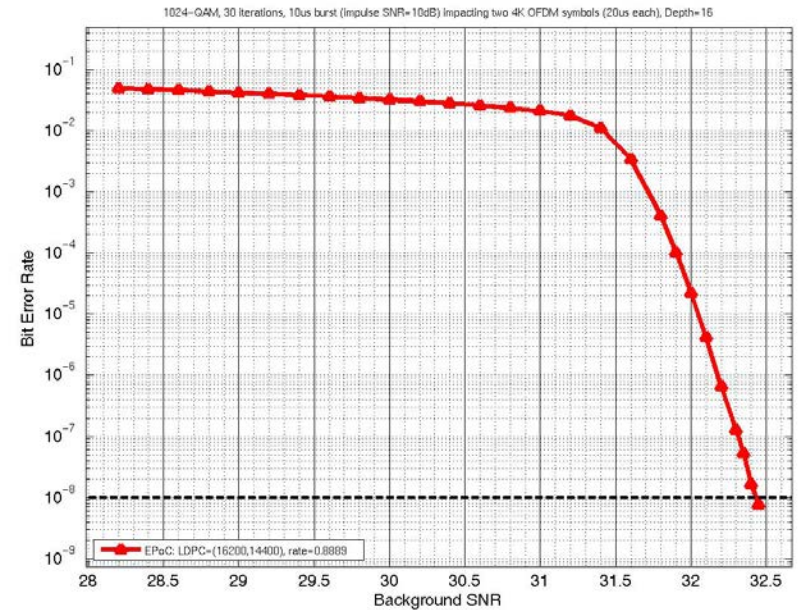


10 uSec / 10 dB

PER Performance with an Interleaver Depth of 16 Symbols – 4KQAM (Med. Code

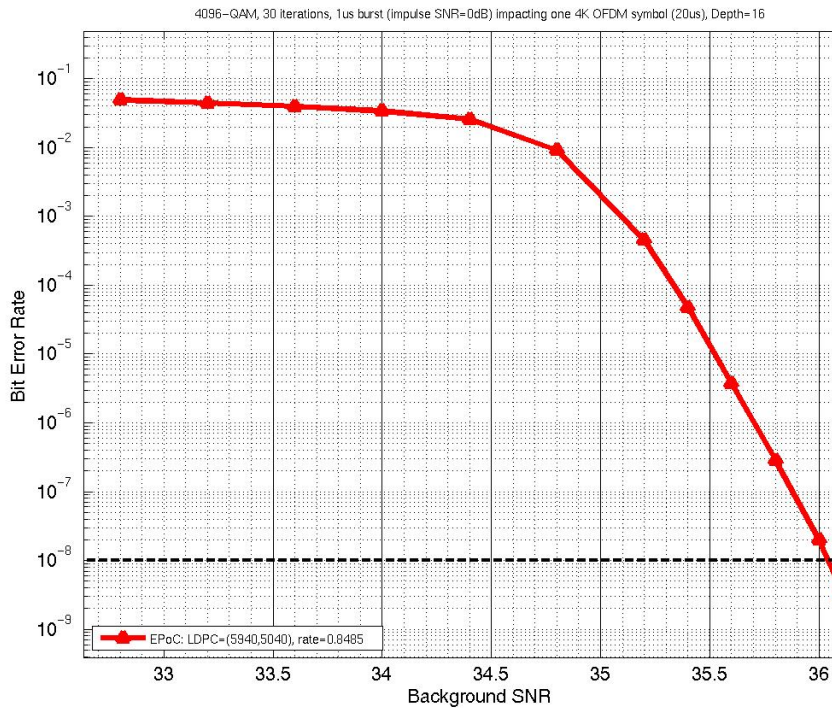


1 uSec / 0 dB

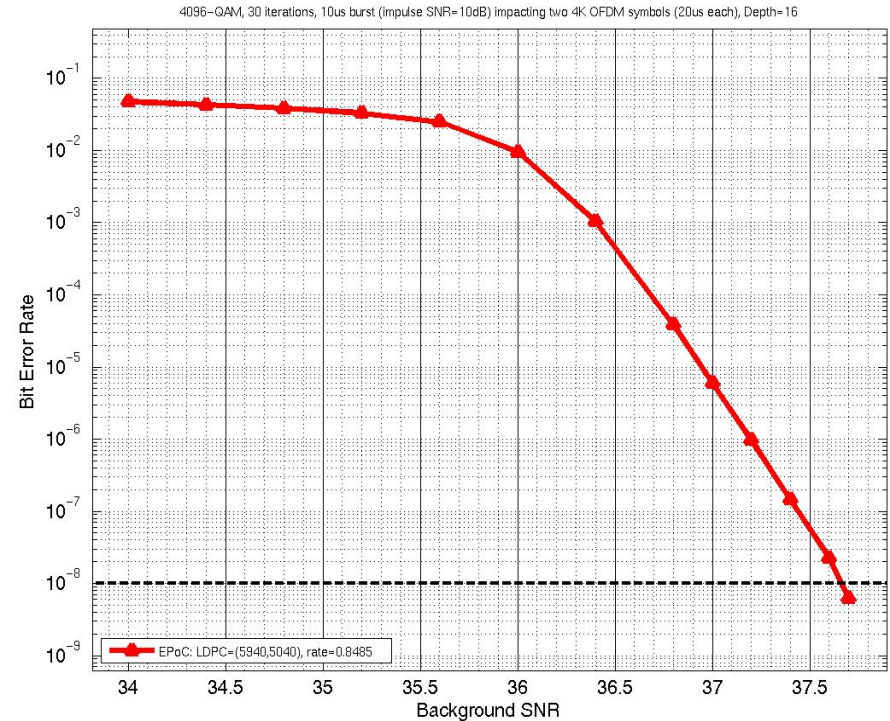


10 uSec / 10 dB

PER Performance with an Interleaver Depth of 16 Symbols – 4KQAM (Med. Code



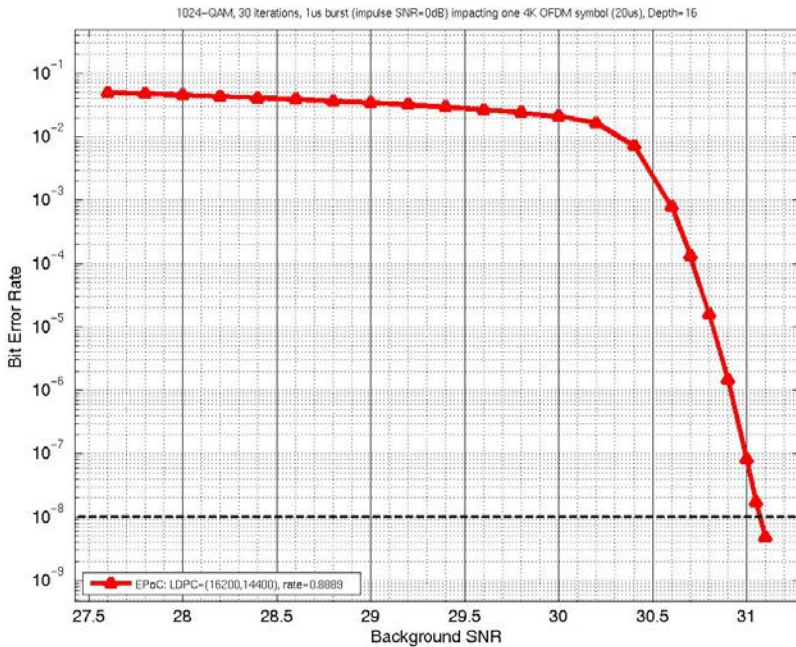
1 uSec / 0 dB



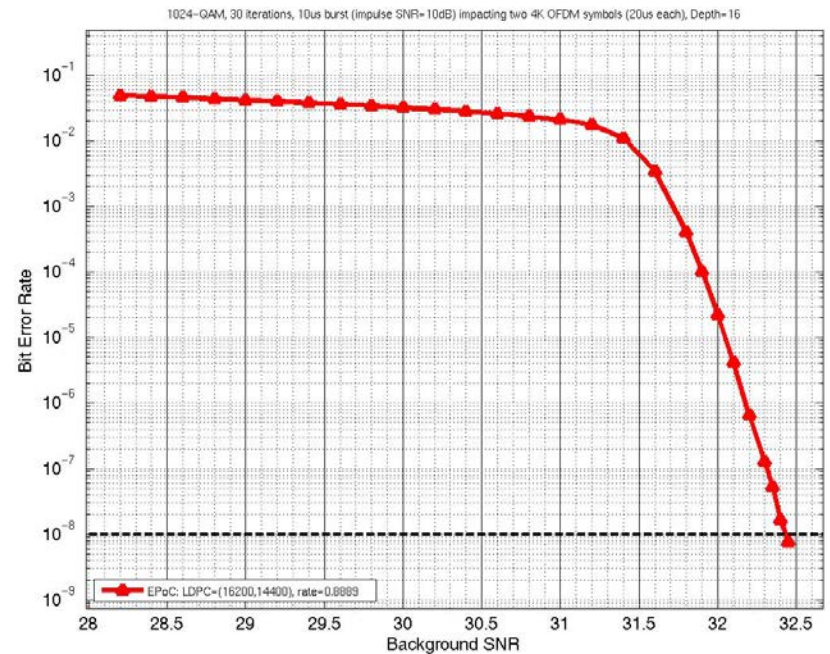
10 uSec / 10 dB

PER Performance with an Interleaver

Depth of 16 Symbols – 1KQAM (Long Code

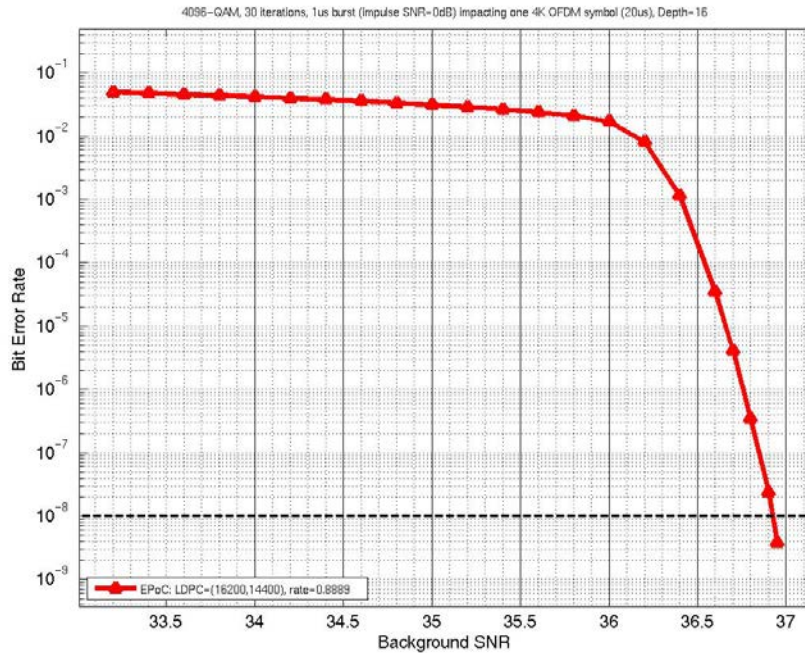


1 uSec / 0 dB

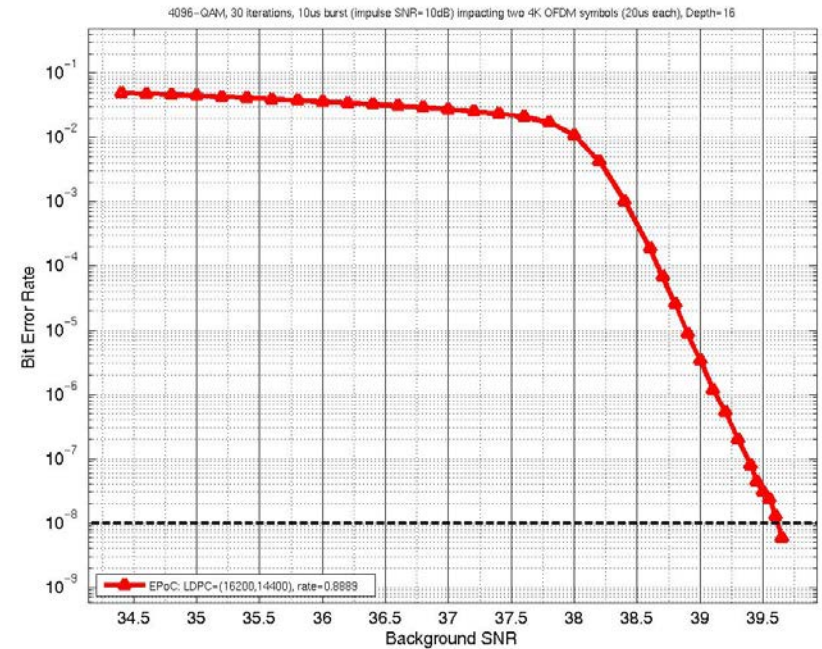


10 uSec / 10 dB

PER Performance with an Interleaver Depth of 16 Symbols – 4KQAM (Long Code)



1 uSec / 0 dB

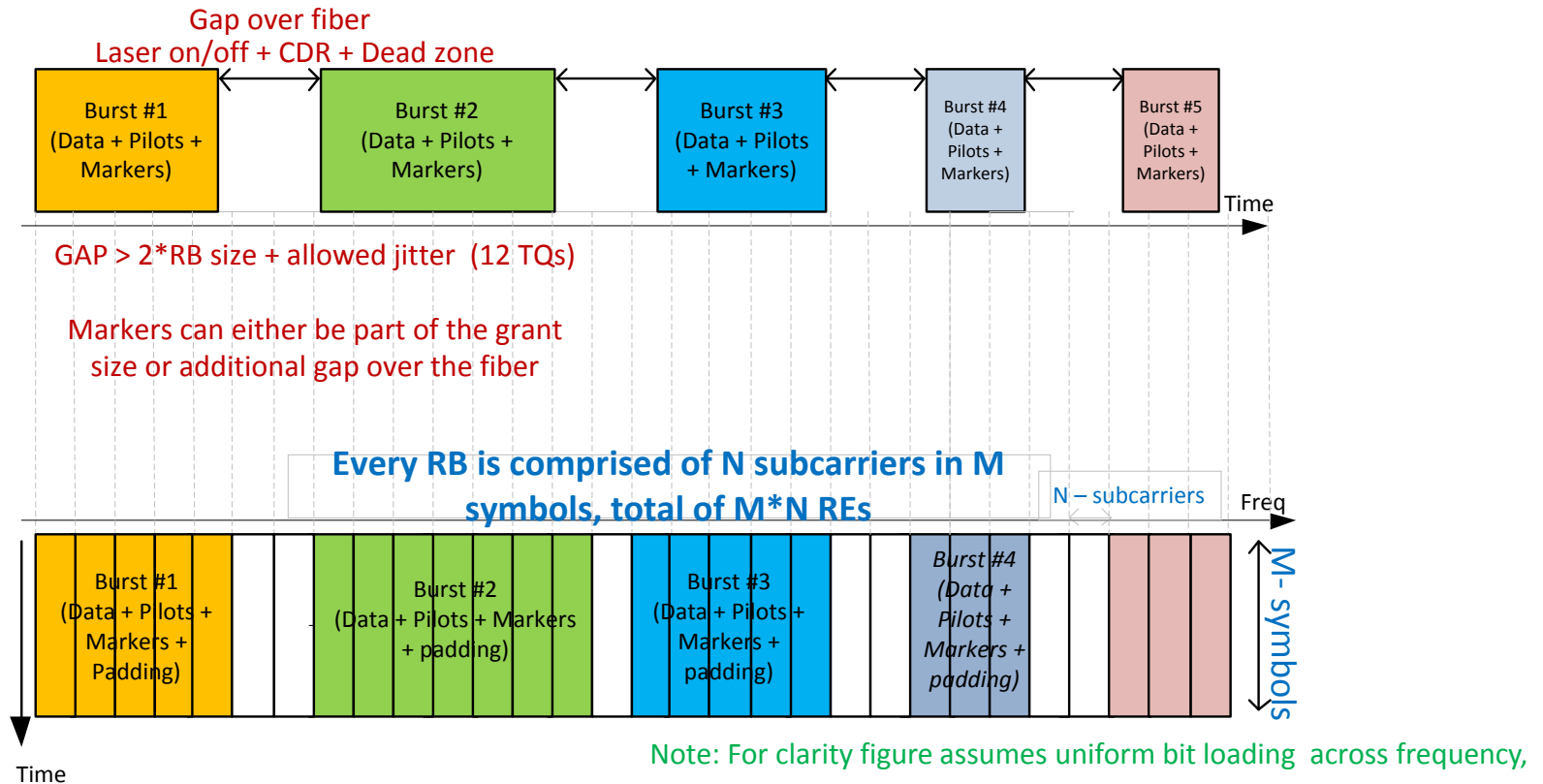


10 uSec / 10 dB

Grants to RB Mapping (1)

- Assumptions
 - Data transmission starts and ends at the boundary of a Resource Block
 - Padding bits (“IDLE” are added if required to align to the RB)
 - Markers are mixed with the data (16 REs for each start and end markers)

Grants to RB Mapping (2)



- Gaps on fiber Gaps on fiber set by the CLT
 - CLT allocates gap for Laser on/off, CDR+AGC, “dead zone”,
 - Gap sizes are configurable in the CLT
 - OFDMA TX uses idle padding in the RB to align transmission to RB
 - Markers can either be considered as a fixed overhead added to every grant or as gaps over fiber

Grants to RB Mapping (3)

- Minimum required gap over fiber
 - Avoid two transmitters using same RB
 - Two RBs plus the 12 TQs time for EPON jitter
 - Two Markers are additional overhead
- Assume: 20 uSec symbols and CP size of 2.5 uSec

BW (MHz)	RB size (M)	RB size (N)	OFDMA symbol size (uSec)	num of subcarriers in OFDMA frame	Subcarrier equivalent time duration (nSec)	Number of TQs in RB	Minimal Gap size (in TQs)
192	16	8	22.5	3840	93.75	46.88	106
192	16	4	22.5	3840	93.75	23.44	59
192	16	1	22.5	3840	93.75	5.86	24
96	16	8	22.5	1920	187.50	93.75	200
96	16	4	22.5	1920	187.50	46.88	106
96	16	1	22.5	1920	187.50	11.72	36
24	16	8	22.5	480	750.00	375.00	762
24	16	4	22.5	480	750.00	187.50	387
24	16	1	22.5	480	750.00	46.88	106

- Red are gaps larger than 90 TQs

- Convert TQs to RBs
 - Conversion ratio depends on available bandwidth
 - One OFDMA frame duration is the symbols size times M
 - Equivalent subcarrier duration equals OFDMA duration divided by the number of subcarriers in the OFDMA frame
 - Calculate RB time as the multiplication of the number of subcarriers in a RB by the subcarrier time duration
- Minimum required gap over fiber
 - to avoid two transmitters using same RB
 - Two RBs plus maximal allowed jitter (12 TQs)