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Abstract: [SC-PHY MCS Updates of the baseline document is shown.]

Purpose: [To be considered in TG3C baseline document.]

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SC-PHY MCS Updates of the baseline document

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Summary

- The number of Single Carrier (SC) Modulation and Coding Schemes (MCSs) is reduced from 40 in total to 10+2 based on many comments received: the number of MCSs is too high and a down-selection is necessary

Why the number of MCS has to be reduced

- The proposers have received many comments after Atlanta meeting: the number of MCSs is too high
- The proposers took the comments seriously and have reduced the number of MCS

Reasons for smaller number of MCS

- Minimalist implementation preference of silicon implementers
 - 1) To keep the architecture simple.
 - 2) To reduce pre-tape-out design verification time.
 - 3) To reduce the probability that chips must be re-spun to correct DV failures.
 - 4) To reduce silicon bring-up time.
 - 5) To reduce software driver complexity and development time.

- Elimination of similar BER/PER performance MCSs for reducing difficulties in implementation selection

- Reduction of market confusion

MCS confirmed in Atlanta meeting

- 40 MCSs
 - CR (Common rate: 50.6 Mbps)
 - MLR(Mandatory low rate: 1518.4 Mbps)
 - 17 LR (Low rate: up to 2 Gbps) including CR and MLR
 - 4 MR (Medium rate: from 2Gbps to 3 Gbps)
 - 15 HR (High rate: over 3Gbps)
 - 4 SC OOK
- 8 different modulation schemes
 - $\pi/2$ BPSK, $\pi/2$ QPSK, Dual Rail Bipolar(DRB), $\pi/2$ star 8QAM, $\pi/2$ - NSQAM, $\pi/2$ 8PSK, $\pi/2$ 16QAM, OOK
- 7 different coding schemes
 - 2 RS: (255,239), (63,55)
 - 2 LDPC family: [(576,288), (576,432), (576,504)]; [(1440,1344)]
 - 2 CC: family Rates:1/2 and 3/4 (K=5), Rate:2/3 (K=4)
 - 1 TCM family: Rates:2/3 and 3/4

Rationale for MCS selection

- Need logical reasons -

- Necessity of its data rate
- Relative performance compared with other MCSs in the same/similar data rate range
- Relative complexity and power consumption compared with other MCSs in the same/similar data rate range
- Additional performance improvement versus complexity of more complicated MCS introduction

Regrouping by application

- The Modulation and Coding schemes (MCSs) are regrouped
 - Class 1: 50Mbps~1.5Gbps (Some mandatory)
 - Class 2: 1.6Gbps~3Gbps (All optional)
 - Class 3: 3Gbps~6Gbps (All optional)
 - Class 4: SC OOK and DRB (child piconet only)
- FECs reduced to two types: RS and LDPC

Selected MCS by class

- Class 1 (3 MCSs)

- $\pi/2$ -BPSK with:

- RS(255,239): **50.6/379.6/759.2/1518.4** Mbps*
 - LDPC(576,288): 810.0 Mbps
 - LDPC(576,432): 607.5/1215.0 Mbps**

- Class 2 (4 MCSs)

- $\pi/2$ -QPSK with:

- RS(255,239): 3036.7 Mbps
 - LDPC(576,288): 1620.0 Mbps
 - LDPC(576,504): 2835.0 Mbps
 - LDPC(1440,1344): 3024.0 Mbps

* Spreading factors (SFs) are 32/4/2/1

** Spreading factors (SFs) are 2/1

Selected MCS by class

- Class 3 (3 MCSs)
 - $\pi/2$ -Star 8QAM with RS(255,239): 4555.1 Mbps
 - $\pi/2$ -16QAM with LDPC(576,432): 4860.0 Mbps
 - $\pi/2$ -16QAM with RS(255,239): 6073.4 Mbps

- Class 4 (2 MCSs)
 - OOK with RS(255,239): 759.2/1518.4** Mbps
 - DRB with RS(255,239): 3036.7 Mbps

** Spreading factors (SFs) are 2/1

Conclusions

- 40 MCSs has been reduced to 10+2 through “HARD WORK”
- The new set of MCS should meet market requirements
- This may contribute to speed up the standardization process: less number of comments expected

Appendix 1

MCS table confirmed in Atlanta

SC mode (CR, MLR, MR)

| MCS Class | MCS Identifier | Data Rate (Mbps) | Symbol /Chip Rate (Mcps) | Modulation Scheme | Spreading factor | FEC Type | FEC Rate | Pilot Word Length (Symbols /chips) | Burst Length (Symbols /chips) |
|-----------|----------------|------------------|--------------------------|----------------------|------------------|---------------------------|----------|------------------------------------|-------------------------------|
| CR | CR (LR1) | 50.2 | 1728 | $\pi/2$ -BPSK/(G)MSK | 32 | RS(255,239) | 0.937 | 0 | 256 |
| MLR | MLR(LR13) | 1506.6 | 1728 | $\pi/2$ -BPSK/(G)MSK | 1 | RS(255,239) | 0.937 | 16 | 256 |
| LR | LR1 (CR) | 50.2 | 1728 | $\pi/2$ -BPSK/(G)MSK | 32 | RS(255,239) | 0.937 | 0 | 256 |
| | LR2 | 188.3 | 1728 | $\pi/2$ -BPSK/(G)MSK | 8 | RS(255,239) | 0.937 | 16 | 256 |
| | LR3 | 376.6 | 1728 | $\pi/2$ -BPSK/(G)MSK | 4 | RS(255,239) | 0.937 | 16 | 256 |
| | LR4 | 401.9 | 1728 | $\pi/2$ -BPSK/(G)MSK | 2 | LDPC(576,288) | 0.500 | 16 | 256 |
| | LR5 | 401.9 | 1728 | $\pi/2$ -BPSK/(G)MSK | 2 | CC(R=1/2,K=5) | 0.500 | 16 | 256 |
| | LR6 | 602.8 | 1728 | $\pi/2$ -BPSK/(G)MSK | 2 | LDPC(576,432) | 0.750 | 16 | 256 |
| | LR7 | 703.3 | 1728 | $\pi/2$ -BPSK/(G)MSK | 2 | LDPC(576,504) | 0.875 | 16 | 256 |
| | LR8 | 753.3 | 1728 | $\pi/2$ -BPSK/(G)MSK | 2 | RS(255,239) | 0.937 | 16 | 256 |
| | LR9 | 803.7 | 1728 | $\pi/2$ -BPSK/(G)MSK | 1 | LDPC(576,288) | 0.500 | 16 | 256 |
| | LR10 | 1071.6 | 1728 | $\pi/2$ -BPSK/(G)MSK | 1 | CC(R=2/3,K=5) | 0.667 | 16 | 256 |
| | LR11 | 1205.6 | 1728 | $\pi/2$ -BPSK/(G)MSK | 1 | LDPC(576,432) | 0.750 | 16 | 256 |
| | LR12 | 1406.5 | 1728 | $\pi/2$ -BPSK/(G)MSK | 1 | LDPC(576,504) | 0.875 | 16 | 256 |
| | LR13 (MLR) | 1506.6 | 1728 | $\pi/2$ -BPSK/(G)MSK | 1 | RS(255,239) | 0.937 | 16 | 256 |
| | LR14 | 1506.6 | 1728 | Dual Rail Bipolar | 2 | RS(255,239) | 0.937 | 16 | 256 |
| | LR15 | 1607.4 | 1728 | $\pi/2$ -QPSK | 1 | LDPC(576,288) | 0.500 | 16 | 256 |
| | LR16 | 376.6 | 864 | $\pi/2$ -BPSK/(G)MSK | 2 | RS(255,239) | 0.937 | 16 | 256 |
| | LR17 | 1506.6 | 864 | $\pi/2$ -QPSK | 1 | RS(255,239) | 0.937 | 16 | 256 |
| MR | MR1 | 2143.3 | 1728 | $\pi/2$ -QPSK | 1 | CC(R=2/3,K=5) | 0.667 | 16 | 256 |
| | MR2 | 2411.2 | 1728 | $\pi/2$ -QPSK | 1 | LDPC(576,432) | 0.750 | 16 | 256 |
| | MR3 | 2806.6 | 1728 | $\pi/2$ -star 8QAM | 1 | CC(R=2/3,K=4) & RS(63,55) | 0.582 | 16 | 256 |
| | MR4 | 2813.0 | 1728 | $\pi/2$ -QPSK | 1 | LDPC(576,504) | 0.875 | 16 | 256 |

SC mode (HR,SC-OOK)

| MCS Class | MCS Identifier | Data Rate (Mbps) | Symbol /Chip Rate (Mcps) | Modulation Scheme | Spreading factor | FEC Type | FEC Rate | Pilot Word Length (Symbols /chips) | Burst Length (Symbols /chips) |
|------------|----------------|------------------|--------------------------|--------------------|------------------|-----------------|----------|------------------------------------|-------------------------------|
| HR | HR1 | 3000.6 | 1728 | $\pi/2$ -QPSK | 1 | LDPC(1440,1344) | 0.933 | 16 | 256 |
| | HR2 | 3013.2 | 1728 | $\pi/2$ -QPSK | 1 | RS(255,239) | 0.937 | 16 | 256 |
| | HR3 | 3013.2 | 1728 | Dual Rail Bipolar | 1 | RS(255,239) | 0.937 | 16 | 256 |
| | HR4 | 3214.9 | 1728 | $\pi/2$ -NS8QAM | 1 | TCM(R=1/2,K=5) | 0.667 | 16 | 256 |
| | HR5 | 3214.9 | 1728 | Dual Rail Bipolar | 1 | Uncoded | 1.000 | 16 | 256 |
| | HR6 | 3616.7 | 1728 | $\pi/2$ -8PSK | 1 | LDPC(576,432) | 0.750 | 16 | 256 |
| | HR7 | 4210.0 | 1728 | $\pi/2$ -star 8QAM | 1 | RS(63,55) | 0.873 | 16 | 256 |
| | HR8 | 4219.5 | 1728 | $\pi/2$ -8PSK | 1 | LDPC(576,504) | 0.875 | 16 | 256 |
| | HR9 | 4500.8 | 1728 | $\pi/2$ -8PSK | 1 | LDPC(1440,1344) | 0.933 | 16 | 256 |
| | HR10 | 4519.7 | 1728 | $\pi/2$ -8PSK | 1 | RS(255,239) | 0.937 | 16 | 256 |
| | HR11 | 4519.7 | 1728 | $\pi/2$ -NS8QAM | 1 | RS(255,239) | 0.937 | 16 | 256 |
| | HR12 | 4822.3 | 1728 | $\pi/2$ -16QAM | 1 | TCM(R=2/3,K=5) | 0.750 | 16 | 256 |
| | HR13 | 4822.3 | 1728 | $\pi/2$ -16QAM | 1 | LDPC(576,432) | 0.750 | 16 | 256 |
| | HR14 | 5626.0 | 1728 | $\pi/2$ -16QAM | 1 | LDPC(576,504) | 0.875 | 16 | 256 |
| | HR15 | 6026.3 | 1728 | $\pi/2$ -16QAM | 1 | RS(255,239) | 0.937 | 16 | 256 |
| SC- OOK | SCOOK1 | 50.2 | 1728 | OOK | 32 | RS(255,239) | 0.937 | 0 | 256 |
| | SCOOK2 | 376.6 | 1728 | OOK | 4 | RS(255,239) | 0.937 | 16 | 256 |
| | SCOOK3 | 753.3 | 1728 | OOK | 2 | RS(255,239) | 0.937 | 16 | 256 |
| | SCOOK4 | 1506.6 | 1728 | OOK | 1 | RS(255,239) | 0.937 | 16 | 256 |

Appendix 2

Updated MCS table

Class 1 and 2

| MCS Class | MCS Identifier | PHY-SAP rate Mbs | Modulation Scheme | Spreading factor | FEC Type | FEC Rate |
|-----------|----------------|---|----------------------|------------------|-----------------|----------|
| Class 1 | LR1 | 50.6(CR)/379.6/ 759.2/ 1518.4 (MLR) | $\pi/2$ -BPSK/(G)MSK | 32/4/2/1 | RS(255,239) | 0.937 |
| | LR2 | 607.5/1215.0 | $\pi/2$ -BPSK/(G)MSK | 2/1 | LDPC(576,432) | 0.750 |
| | LR3 | 810.0 | $\pi/2$ -BPSK/(G)MSK | 1 | LDPC(576,288) | 0.500 |
| Class 2 | MR1 | 1620.0 | $\pi/2$ -QPSK | 1 | LDPC(576,288) | 0.500 |
| | MR2 | 2835.0 | $\pi/2$ -QPSK | 1 | LDPC(576,504) | 0.875 |
| | MR3 | 3024.0 | $\pi/2$ -QPSK | 1 | LDPC(1440,1344) | 0.933 |
| | MR4 | 3036.7 | $\pi/2$ -QPSK | 1 | RS(255,239) | 0.937 |

Class 3 and 4

| MCS Class | MCS Identifier | PHY-SAP rate Mbs | Modulation Scheme | Spreading factor | FEC Type | FEC Rate |
|-----------|----------------|------------------|--------------------|------------------|---------------|----------|
| Class 3 | HR1 | 4555.1 | $\pi/2$ -Star 8QAM | 1 | RS(255,239) | 0.873 |
| | HR2 | 4860.0 | $\pi/2$ -16QAM | 1 | LDPC(576,432) | 0.750 |
| | HR3 | 6073.4 | $\pi/2$ -16QAM | 1 | RS(255,239) | 0.937 |
| Class 4 | OOK1 | 1518.4/759.2 | OOK | 2/1 | RS(255,239) | 0.937 |
| | DRB1 | 3036.7 | Dual Rail Bipolar | 1 | RS(255,239) | 0.937 |