**IEEE P802.15**

**Wireless Personal Area Networks**

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| Project | IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs) |
| Title | SNUST ISC/LR-PD PHY Modes Description for Draft D0 Text Input |
| Date Submitted | 18 May 2016 |
| Source | Jaesang Cha 1, Vinayagam Mariappan 2[Seoul National University of Science & Technology [SNUST], Korea] | Voice: [ ]Fax: [ ]E-mail: [chajs@seoultech.ac.kr]1,  [vinayagam\_m@hotmail.com]2 |
| Re: |  |
| Abstract | A short description of SNUST ISC/LR-PD PHY Modes description to follow on the Draft D0 Documentation. |
| Purpose | To describe PHY ISC/LR-PD Mode Support on SNUST Proposals |
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**PHY Layer Operating Modes**

**PHY A Modes**

The following table gives the detailed description for SNUST PHY A Mode descriptions.

Table 1.1: SNUST PHY A Mode: OffsetVPWM

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| **PHY Operating Modes** |
| **Modulation** | **RLL Code** | **Optical Clock Rate** | **FEC** | **Data Rate**  |
| **Outer Code (RS)** | **Inner Code (CC)** |
| OffsetVPWM | None | 25Hz | None | None | 18 bps  |
|  |  |  |  |  |  |

**PHY C Modes**

The following table gives the detailed description for SNUST PHY C Mode descriptions.

Table 3.1: SNUST PHY C Mode 1: Sequential Scalable 2D Code

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| **PHY Operating Modes** |
| **Modulation** | **RLL Code** | **Optical Clock Rate** | **FEC** | **Data Rate (Kbps)** |
| 1x1Sequential Scalable 2D Code | None | 2DCodeDecodingRate | RS(64,32)/ RS(160,128)/None | 23 Kbps |
| 2x2Sequential Scalable 2D Code | None | 2DCodeDecodingRate | RS(64,32)/ RS(160,128)/None | 92 Kbps |
| 4x4Sequential Scalable 2D Code | None | 2DCodeDecodingRate | RS(64,32)/ RS(160,128)/None | 368 Kbps |
| 1x1SS Sequential Scalable 2D Code | None | 2DCodeDecodingRate | None | 12 Kbps |
| 2x2SS Sequential Scalable 2D Code | None | 2DCodeDecodingRate | None | 46 Kbps |
| 4x4SS Sequential Scalable 2D Code | None | 2DCodeDecodingRate | None | 184 Kbps |

Table 3.1.1: FEC Rate

|  |  |  |
| --- | --- | --- |
| **No** | **RS Method Used** | **FECRate** |
| 1 | None | 1 |
| 2 | RS(64,32) | 32/64 |
| 3 | RS(160,128) | 128/160 |

**Data Rate:**

The Data Rate calculated using following Mathematical representation,

DataRate = NoOfCodeSequence\* (2DCodeDataCapacity \* OpticalClockrate \* FECRate) / CodeLength)

Where, “CodeLength” is 1 for without SS Coded schemes and respective code length for with SS Coded Schemes

Note this case study designed with 2D Code decoding Rate is 1 for QR. The maximum data capacity for 2D Codes is 2953 bytes.

The Data Rate for 2x2 Sequential Scalable 2D Code without SS Coded Code (CodeLength is 1),

FECRate = 1 (Refer Table 3.2.1)

DataRate = 4\* (2953 \* 8)\* 1 \* 1) / 1) = 94494 Approximated to 92 Kbps

Table 3.2: SNUST PHY C Mode 2: VTASC Code

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| --- |
| **PHY Operating Modes** |
| **Modulation****(TxAxSxC)** | **RLL Code** | **Optical Clock Rate** | **FEC** | **Data Rate (Kbps)** |
| 2 Color VTASC Code1(T = 2,A=2/4/8,S=2/4,C=2) | None | 30Hz | RS(64,32)/ RS(160,128)/ None | 390 Kbps |
| 4 Color VTASC Code1(T = 2,A=2/4/8,S=2/4, C=4) | None | 30Hz | RS(64,32)/ RS(160,128)/ None | 450 Kbps |
| 8 Color VTASC Code1(T = 2,A=2/4/8,S=2/4,C=8) | None | 30Hz | RS(64,32)/ RS(160,128)/ None | 506 Kbps |
| 16 Color VTASC Code2(T = 2,A=2/4/8,S=2/4,C=16) | None | 30Hz | RS(64,32)/ RS(160,128)/ None | 1054 Kbps |
| 2 Color SS VTASC Code1(T = 2,A=2/4/8,S=2/4,C=2) | None | 30Hz | None | 195 Kbps |
| 4 Color SS VTASC Code1(T = 2,A=2/4/8,S=2/4,C=4) | None | 30Hz | None | 225 Kbps |
| 8 Color SS VTASC Code1(T = 2,A=2/4/8,S=2/4,C=8) | None | 30Hz | None | 253 Kbps |
| 16 Color SS VTASC Code2(T = 2,A=2/4/8,S=2/4,C=16) | None | 30Hz | None | 527 Kbps |

 Note: [32x32 Block Size] 1 and [24x24 Block Size] 2

Table 3.2.1: FEC Rate

|  |  |  |
| --- | --- | --- |
| **No** | **RS Method Used** | **FECRate** |
| 1 | None | 1 |
| 2 | RS(64,32) | 32/64 |
| 3 | RS(160,128) | 128/160 |

Table 3.2.2: Symbol Bit Mapping

|  |  |  |
| --- | --- | --- |
| **VTASC Block Model****(TxAxSxC)** | **No of Block Types (T\*A\*S\*C)** | **BitsPerSymbol** |
| T = 2, A = 2,S = 2,C = 2 | 16 = 24 | 4 |
| T = 2, A = 4,S = 2, C = 2 | 32 = 25 | 5 |
| T = 2, A = 4,S = 4, C = 2 | 64 = 26 | 6 |
| T = 2, A = 8,S = 4, C = 2 | 128 = 27 | 7 |
| T = 2, A = 2,S = 4, C = 4 | 64 = 26 | 6 |
| T = 2, A = 4,S = 4, C = 4 | 128 = 27 | 7 |
| T = 2, A = 8,S = 4, C = 4 | 256 = 28 | 8 |
| T = 2, A = 4,S = 2, C = 8  | 128 = 27 | 7 |
| T = 2, A = 4,S = 4, C = 8 | 256 = 28 | 8 |
| T = 2, A = 8,S = 2, C = 8 | 256 = 28 | 8 |
| T = 2, A = 8,S = 4, C = 8 | 512 = 29 | 9 |
| T = 2, A = 8,S = 4, C = 16 | 1024 = 210 | 10 |

 Where,

“C” represents Number of Colors

“A” represents Number of Block Size Amplitude

“S” represents Number of shapes

“T” represents Level of transparency

**NoofBlocks:**

The No of blocks in Display screen varies with Size of the coded block generated in the Transmission end.

VTASC uses single size coded or Multi size coded Blocks. In the single size coded block scheme use only one size blocks for the data symbol mapping but in the multi coded block uses the different size blocks. The ratio of block size variation is 1:2:4:8 in order of Power of 2.

The Mathematical form is,

NoofBlocks = (M1+M2+M3+M3)

For Single Size Code Scheme,

 NoofBlocks = M1 / M2 / M3 / M3

 = (DisplayWidth/BlockWidthSize)\* (DisplayHeight/BlockWidthSize)

For Multi Size Code Scheme,

NoofBlocks = M1 + M2 + M3 + M3

= ((DisplayWidth / Block1WidthSize) \* (DisplayHeight / Block1HeightSize) \* Block1Interval) + ((DisplayWidth / Block2WidthSize) \* (DisplayHeight / Block2HeightSize) \* Block2Interval) + ((DisplayWidth / Block3WidthSize) \* (DisplayHeight / Block3HeightSize) \* Block3Interval) + + ((DisplayWidth / Block4WidthSize) \* (DisplayHeight / Block4HeightSize) \* Block2Interval)

**Data Rate:**

The Data Rate calculated using following Mathematical representation,

DataRate = (NoofBlocks \* BitsPerSymbol \* OpticalClockrate \* FECRate) / CodeLength)

Where, “CodeLength” is 1 for without SS Coded schemes and respective code length for with SS Coded Schemes

Note this case study designed with Full HD Display (1920x1080) with minimum block size of 32x32 pixels and this data rate calculation vary from Display Screen Size.

NoofBlocks = (1920/32)\* (1080/32) = 60 x 32 (Approximated to even multiplication for coding efficiency)

The Data Rate for 2 Color VTASC Code with 8 size scalability & 4 shapes & 2 transparency Level without SS Coded Code (CodeLength is 1),

BitsPerSymbol = 7 (Refer Table 3.2.2)

OpticalClockrate = 30

FECRate = 1 (Refer Table 3.2.1)

DataRate = ((1920/32)\* (1080/32) \* 7 \* 30 \* 1) / 1) = 403200 Approximated to 390 Kbps

The Data Rate for 2 Color VTASC Code with 8 size scalability with SS Coded Code (Minimum CodeLength is 2),

BitsPerSymbol = 4 (Refer Table 3.1.2)

OpticalClockrate = 30

FECRate = 1 (Refer Table 3.1.1)

DataRate = ((1920/32)\* (1080/32) \* 4 \* 30 \* 1) / 2) = 201600 Approximated to 195 Kbps

Table 3.3: SNUST PHY C Mode 3: Invisible Data Embedding Code

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| --- |
| **PHY Operating Modes** |
| **Modulation** | **RLL Code** | **Optical Clock Rate** | **FEC** | **Data Rate (Kbps)** |
| M-PSK | None | 30Hz | RS(64,32)/ RS(160,128)/None | 16 Kbps |
| M-FSK | None | 30Hz | RS(64,32)/ RS(160,128)/None | 16 Kbps |
| HYBRID-PSK/FSK | None | 30Hz | RS(64,32)/ RS(160,128)/None | 32 Kbps |
| 2D-CODE | None | 30Hz | RS(64,32)/ RS(160,128)/None | 128 Kbps |
| Sequential Scalable 2D Code | None | 30Hz | RS(64,32)/ RS(160,128)/None | 256 Kbps  |
| SS-M-PSK | None | 30Hz | None | 8 Kbps |
| SS-M-FSK | None | 30Hz | None | 8 Kbps |
| SS-HYBRID-PSK/FSK | None | 30Hz | None | 16 Kbps |
| SS- 2D-CODE | None | 30Hz | None | 64 Kbps |
| SS -Sequential Scalable 2D Code | None | 30Hz | None | 128 Kbps  |

Table 3.3.1: FEC Rate

|  |  |  |
| --- | --- | --- |
| **No** | **RS Method Used** | **FECRate** |
| 1 | None | 1 |
| 2 | RS(64,32) | 32/64 |
| 3 | RS(160,128) | 128/160 |