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| Re: | IEEE 802.16e D4 Draft, C80216e-04_261 |
| Abstract | To enhance the preamble for the fast cell search and initial access. |
| Purpose | To incorporate the changes here proposed into the 802.16e D5 draft. |
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# Ranging postamble for OFDMA

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## 1 Introduction

In line with the contribution C80216e-04/261, we propose to introduce global SYNC symbol and group ID symbol. Global SYNC symbol uses one common PN sequence for all BSs and networks. Group SYNC symbol can be generated from total 8 common PN sequences for all BSs and networks. Both symbols possess a time repetition structure. The global SYNC symbol simplifies the frequency and coarse frame timing synchronization for MSS in multi-sector multi-cell deployment. This is especially important during the initial cell search after MSS powered on. The group SYNC symbol can be used for fine timing synchronization and the group identification of the legacy preamble, which can shorten the search time and reduce MSS processing power for the legacy preamble search. Global SYNC symbol facilitates the support of simple and fast cell search for neighboring cell with delay spread up to _ symbol time. Based on the signal measurements of global SYNC symbol, group SYNC symbol can be used to identify the group IDs of the neighboring cells as HO candidates. The presence of group SYNC symbol can be used to greatly reduce the number of legacy preamble PN sequences used for neighboring cell search.

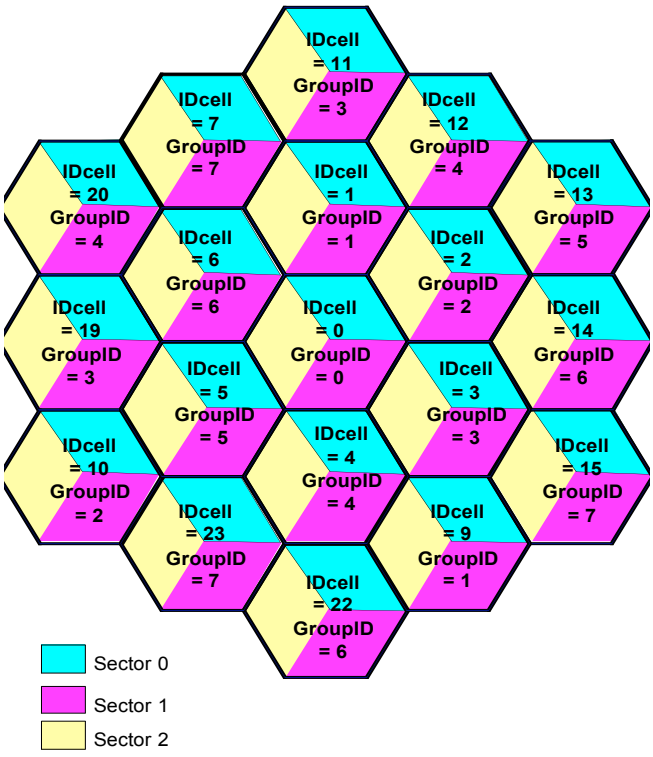


**Figure 1. 3-sector cell deployment**

**Table 1. Mapping group SYNC ID to IDcell**

| Group SYNC ID | IDcell | Preamble PN Sequence # | | |
|---|---|---|---|---|
| | | Segment 0 | Segment 1 | Segment 2 |
| **0** | 0, 8,16,24 | 0, 8,16,24, 96 | 32,40,48,56,112 | 64,72,80,88, 104 |
| **1** | 1,9,17,25 | 1,9,17,25, 105 | 33,41,49,57,97 | 65,73,81,89,113 |
| **2** | 2,10,18,26 | 2,10,18,26, | 34,42,50,58,106 | 66,74,82,90,98 |
| **3** | 3,11,19,27 | 3,11,19,27,99 | 35,43,51,59 | 67,75,83,91,107 |
| **4** | 4,12,20,28 | 4,12,20,28,108 | 36,44,52,60,100 | 68,76,84,92 |
| **5** | 5,13,21,29 | 5,13,21,29 | 37,45,53,61,109 | 69,77,85,93, 101 |
| **6** | 6,14,22,30 | 6,14,22,30,102 | 38,46,54,62 | 70,78,86,94,110 |
| **7** | 7,15,23,31 | 7,15,23,31,111 | 39,47,55,63,103 | 71,79,87,95 |

## 2 Proposed Solution

The proposed design approach is to re-use the preamble structure (legacy preamble) defined in IEEE802.16-2004 to provide basic preamble functionality and to achieve backward compatibility. Based on the "common SYNC" symbol proposed in C80216e-04_261, global SYNC symbol and group SYNC symbol are introduced as "common SYNC" symbols in the DL subframe. The "common SYNC" possesses the following properties:

1. The ranging postamble is allocated at the last symbol of DL subframe, as a postamble.
2. Ranging postamble can be a combination of global SYNC symbol and group SYNC symbol
3. The global SYNC symbol structure is a 4-time repetition in time domain and only every other even sub-carriers are used in frequency domain, as shown in Figure 2. The global SYNC symbol is generated from one PN sequence which is common to all base stations and networks.
4. The group SYNC symbol structure is a 2-time repetition in time domain and only even sub-carriers are used in frequency domain, used for group SYNC symbol, as shown in Figure 3. A group SYNC symbol can be generated from a set of 8 sequences, each sequence represents the lower 3 LSB of IDcell number.
5. Both global SYNC and group SYNC symbols have low PAPR values
6. Ranging postamble is transmitted on a fixed time interval to be able to have similar overhead for all frame sizes, as shown in Table 2. The time interval value is configurable by networks.
7. There are three options for global SYNC symbol and group SYNC symbol to be transmitted. 7c is the preferred option.
    a. Only group SYNC symbol is transmitted as postamble at the last symbol of DL subframe in even DL subframe numbers
    b. Global SYNC symbol is transmitted in even frame numbers, and group SYNC symbol is transmitted in the next odd frame, as shown in Figure 4. Both symbols are transmitted as postamble at the last symbol of DL subframe.
    c. Global SYNC symbol followed by group SYNC symbol are transmitted in even frame numbers, as shown in Figure 5. Both symbols are transmitted as postambles in the same DL subframe.

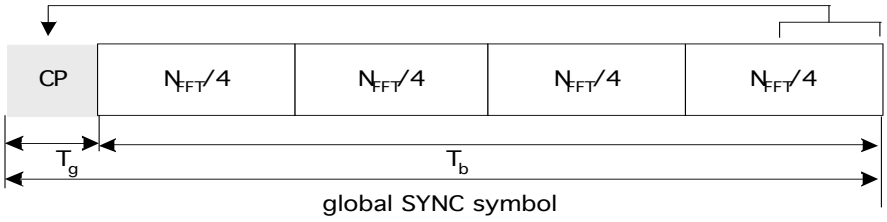


**Figure 2. Global SYNC symbol**

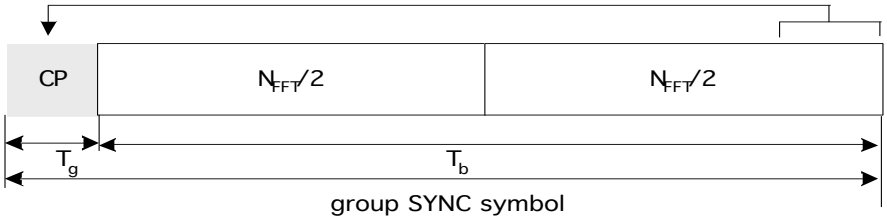


**Figure 3. Group SYNC symbol**

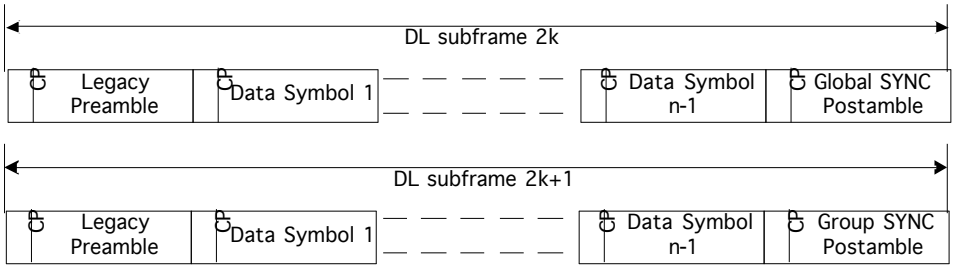


**Figure 4. DL subframe structure with global or group SYNC postamble**

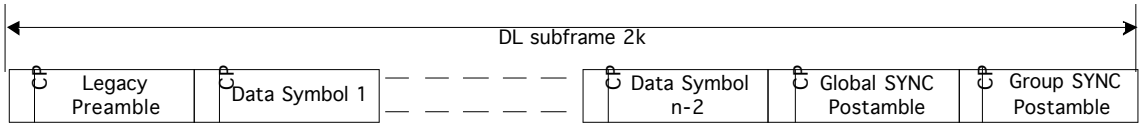


**Figure 5. DL subframe structure with both global and group SYNC postambles**

The location of ranging postamble is fixed to be the last symbol of DL subframe. The presence of ranging postamble is periodic on a fixed time interval base. The longest period for ranging postamble transmission is TBD (say 120ms). It is up to the service provider to choose a proper ranging postamble time interval in the network deployment.

The presence cycle of the ranging postamble $N_{POSTAMBLE\_PERIOD}$ can be determined by the frame duration and ranging postamble periodicity in real time, as shown in Table 2. In addition, such a ranging postamble can be assigned in very frame. The overhead vs. common SYNC time interval is listed in Table 3.

**Table 2. $N_{POSTAMBLE\_PERIOD}$ Time Interval vs. Frame Length**

| Frame Duration | Common SYNC Time Interval /$N_{POSTAMBLE\_PERIOD}$ | | | | | | |
|---|---|---|---|---|---|---|---|
| **2.0 ms** | 4ms /2 | 8ms /4 | 8ms /4 | 20ms /10 | 40ms /20 | 60ms /30 | 120ms /60 |
| **2.5 ms** | - | 5ms /2 | 10ms /4 | 20ms /8 | 40ms /16 | 60ms /24 | 120ms /48 |
| **4.0 ms** | - | 8ms /2 | 8ms /2 | 16ms /4 | 40ms /10 | 56ms /14 | 120ms /30 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **5.0 ms** | - | - | 10ms /2 | 20ms /4 | 40ms /8 | 60ms /12 | 12ms /24 |
| **8.0 ms** | - | - | - | 16ms /2 | 32ms /4 | 48ms /6 | 112ms /14 |
| **10.0 ms** | - | - | - | 20ms /2 | 40ms /4 | 60ms /6 | 120ms /12 |
| **12.5 ms** | - | - | - | - | 25ms /2 | 50ms /4 | 100ms /8 |
| **20.0 ms** | - | - | - | - | 40ms /2 | 40ms /2 | 120ms /6 |

**Table 3. DL subframe overhead vs. ranging postamble time**

| Frame Duration | 4ms | 8ms | 10ms | 20ms | 40ms | 60ms | 120ms |
|---|---|---|---|---|---|---|---|
| DL Subframe Overhead with Single SYNC Symbol | <5% | <2.5% | <2% | <1% | <0.5% | <0.3% | <0.15% |
| DL Subframe Overhead with Dual SYNC Symbols | <10% | <5% | <4% | <2% | <1% | <0.6% | <0.3% |

# 3 Proposed Text

Example text changes with 7a option are provided below.

*[Add section **8.4.6.1.2**[2]]*

----------Start text ----------

### 8.4.6.1.2 Ranging postamble (Optional)

Ranging postamble is composed of a global SYNC symbol followed by a group SYNC symbol. Global SYNC symbol is defined to be the same for all BSs and networks globally, generated by one common PN sequence in each scalable OFDMA mode. Group SYNC symbol is a choice of one out of the eight symbols generated from eight PN sequences predefined for all BSs and networks. For a fixed even number of OFDMA frames period, $N_{POSTAMBLE\_PERIOD}$, the last two symbols of downlink subframes are replaced by the ranging postamble, as exemplified in Figure LLL. Ranging postamble shall be transmitted by BSs in the 2048, 1024, 512, and 128 OFDMA modes.

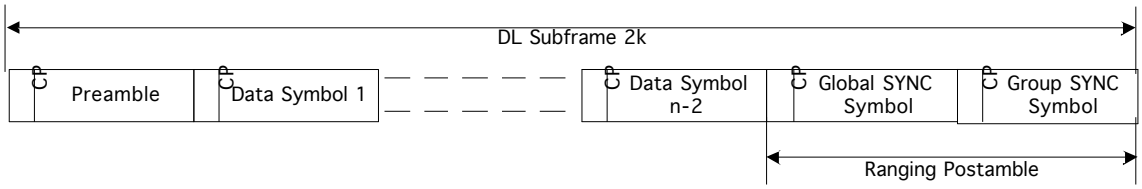


**Figure LLL. DL subframe structure with both global and group SYNC postambles**

Both global and group SYNC symbols possess a time repetition structure. The global SYNC symbol uses only the $N_{used}$ subcarriers with indices of a multiple of 4. As a result, the time domain waveform of the global symbol consists of 4 repetitions of $N_{FFT}/4$-sample fragment waveform, preceded by a CP. The group SYNC symbol utilizes only the even $N_{used}$ subcarriers, the time domain structure consists of 2 repetitions of a $N_{FFT}/2$-sample fragment waveform, also preceded by a CP. Both global and group SYNC symbol time domain structures are depicted in Figure AAA and Figure BBB respectively. The global and group SYNC symbols are generated by PN sequences from frequency domain as shown in Figure CCC and Figure DDD respectively.

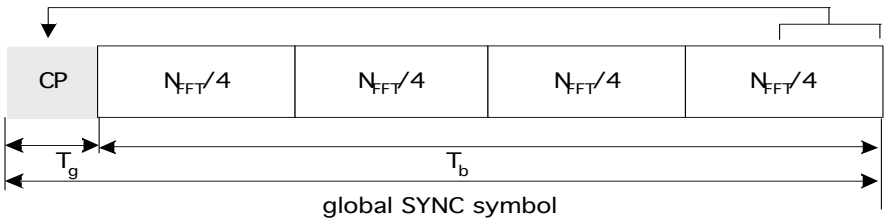


**Figure AAA. Global SYNC Symbol with repetition of 4 $N_{FFT}/4$ waveforms**

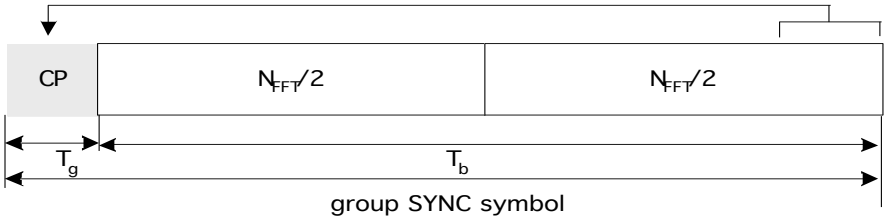


**Figure BBB. Group SYNC Symbol with repetition of 2 $N_{FFT}/2$ waveforms**

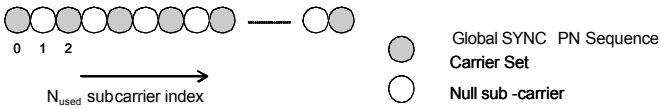


**Figure CCC. Global SYNC symbol PN sequence allocation**

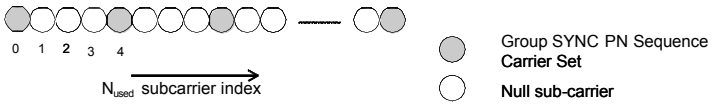


**Figure DDD. Group SYNC symbol PN sequence allocation**

The mapping of the global and group PN sequences to the $N_{used}$ subcarriers is defined by using the following simple formulas:

$$\text{Global\_SYNC\_Carrier\_Set} = 4j \qquad \textit{(aaa)}$$

$$\text{Group\_SYNC\_Carrier\_Set} = 2k \qquad \textit{(bbb)}$$

where:

*j* is the number of the running index 0, 1,2,…, floor($N_{used}/4$ -1)

*k* is the number of the running index 0, 1,2,…, floor($N_{used}/2$ -1)

DC subcarrier shall be zeroed before symbol transmission.

The PN sequences used to generate ranging postamble are presented in hex format; “0” bit for transmitting “1” in the subcarrier, and “1” bit for transmitting “-1” in the subcarrier. The global SYNC PN sequences for all scalable OFDMA modes are provided in Table EEE. The group SYNC PN sequences for 2048, 1024, 512, and 128 OFDMA modes are listed separately in Table FFF, Table GGG, Table HHH, Table III.

Table EEE. Global SYNC symbol PN sequences

| OFDMA mode | Global SYNC symbol PN sequences | PAPR (dB) |
|---|---|---|
| **2048** | 0x3CA35B49A867FED9714909C7009FB5B4977DB29F9544B65BA141BB4A5DBC0421CD406C310C39ABAA9FAD50205ED179B074E13C47AA6 | 5.82 |
| **1024** | 0x86169957D6CEB969EE3C4BCCAA0211526DA4E462AE40093E498355 | 5.07 |
| **512** | 0xEA819B39BD3E266AE1CC458BEBE | 4.11 |
| **128** | 0x4CD3AAC | 2.73 |

Table FFF. Group SYNC symbol PN sequences for 2048-OFDMA mode

| Group ID | 2048 OFDMA Group SYNC symbol PN sequences | PAPR (dB) |
|---|---|---|
| **0** | 0x2D7F22905CA89706A1C1AF33A469092813FE7D4177E8C153ECEDF834FA9AFBFE93029535BC61EE9C985EA3EDB8F08E7921DC1EA9B0F701B6AA0C8E5033C9F0D7FCE8CFFBE0DE91DCAEBFFA111BD1CBCF65D9F5D0386517BB39ED3B26AD61F6272E16981363C65E012B441 | 5.95 |
| **1** | 0x19C021863177EE4E915A3ADC240FA5B252BBD8EC8AE9B3AC098E303A78D19A7B2ECB26B8A499708B05D8BF96BC12FEF588C0C147BF2E190421618B654F09487F2DE5B40512D06A8A127E44728E98992A3A84BEF9A525D735D7EB18307F8A849C4544D103C6B9A66F2F30B | 6.00 |
| **2** | 0x41B0D6E6792F47020F1F8B878F1E5BD1964B6F81FD66584B2D58888553B7BA41E9AC243DB7AE47552F13641A7648A9FACC9218E2F410EFCF4747858BEABAEE93FFFBB803EF7CA2DCA4C751A83D62181597BC9130B729C8938708057F144C75B1C1788E040717E84AD2E0F | 5.95 |
| **3** | 0xBF74090707623D2B31ACAC571815898ABB27A1B7635EB848075AAEBC9D42DE884BEDF6F110AE80A0427FB414D501765F8C052A7DA413050A4CCA84CA227CBFB0F6E6F903FCE23864F31F63FDAD5BB8D67D596F5A918BC41E1AFEE036882B2A77FFE9269790BDFEE27FEE4 | 5.95 |
| **4** | 0xB174B38A87E6B640356A93C6C6A47782DAE4EDEF18B342D64E3628AD81BF153A8225F5B10792439B1B5E8D8780A4008039EFE80A6D3F620C81593FE564BAA1521EF8B12817E9D001E087F113AB8EBA9F9508CC1135199EA73369DE36B6A3160DF5CB4496F1C665658D451 | 6.15 |
| **5** | 0xB15A7E7D9CD51F5D536C7CDFE1F4651E338C630437B69A8CBC788AD21E668910E2E56CA9EB49FC739C22F09BAD8BB1D8BC8E634DCE709E593AA8B58F4006382DFF4EAFD0EE2ECA1C4BF53A7C8FAD07685285F9298EA210C5203C830B73DEC88EA0FA2111296D6F0C8C6A3 | 6.32 |
| **6** | 0x62D044BFF3C454A5B0A0724C4C796EAB4CB99C51EAC0B20EB9A606E62C5B8E0FD2AB7D82AE323DE40D0AA1F3FB289458D987E4BD0EABEAE8735DED6FE846E178288812779CDBF9EBC69497D71DBF89EE04751632352C29DDED0A837E0CBA4737D93446FDEEEB487993BB1 | 6.33 |
| **7** | 0x78FD513A5BE7A7BB64E6F63517B0532D840D12CBA98DF03AD32DC3F0FB1731D6417AB33F472BF45A60A9965E0E29630CDE28A80906E40187F51255502CE5F0569422F658863EDD957B7A8961C139CADD3EEA27C63C442FC8B216AA4F7EF46DEA53645D0AACF6C8658E6A8 | 6.34 |

Table GGG. Group SYNC symbol PN sequences for 1024-OFDMA mode

| Group ID | 1024 OFDMA<br>Group SYNC symbol PN sequences | PAPR (dB) |
|---|---|---|
| 0 | 0xDDA9978E3EA49F489313C4FCDCDABE16AC061B8AC6F085C88EE8867D86A2AB8D5FD6B50B2026CE461C12E0281E81084CB397D8511F4 | 5.43 |
| 1 | 0x827A2DDF3C6B8D19CE66CF5909E716C47B4035CAF872490622B23547C3C021AF8AA642AF8A700E10B4B5F36F42B24C74099A01790DF | 5.35 |
| 2 | 0xD6E74BD6F13F9FC809429082A9B1B7E2A1127C0A782123E4A3771FC3A5ACF2FFA854443DC69A9298C46BC645704F909E5EC14226D27 | 5.46 |
| 3 | 0x6DF7F2CB22C1A43D1A05E4379471FC534723A9540BC315533E081CC7B80A8864B9F99F524FD339E8672DC9534E056B92CEFA950D2F9 | 5.45 |
| 4 | 0xEC3CAE1B05F02E594C4EE633051B1D5982D7232985ABFB191A7E8878023AF2CFB40D317E165477DB5B940514DE09592D1F62554EFE5 | 5.50 |
| 5 | 0x7F22603ECB9135E532B0643AD7C714A60ED8AF861F303B568E7BD8BA2D8BD5C64256B4CDFEF412882809FC6F416BBA703A17F860D0A | 5.50 |
| 6 | 0x3D4399D1881F8DBA1671CC9C86122B150DA42BFDB903A781F4E47C6E2D7FDE4B300437295C46AC2EAF02D1813CBD36AD34532919836 | 5.62 |
| 7 | 0x8C537D4BEAF9C007D431010F019E121651E59AC3BABA3D6AA4785E44C3828326A4A84E4FFA61C13E78C6FE7D9908ACC4B44EAFF2748 | 5.60 |

Table HHH. Group SYNC symbol PN sequences for 512-OFDMA mode

| Group ID | 512 OFDMA<br>Group SYNC symbol PN sequences | PAPR (dB) |
|---|---|---|
| 0 | 0x49283FA8D65C99B2058622E62007A51D8B7860652F827E643F6AF6 | 4.8 |
| 1 | 0xA008C7DC5A71164AA87EA4093F0BFC48F0EAE052619F28A718D9B4 | 4.77 |
| 2 | 0xB5A5A376E7499E113A505CBE9E28F5A7228A90E4582A8E742B0037 | 4.85 |
| 3 | 0xAA26D242170E620C3EA12B6E79B40253B3DDFA3911357E4C27C743 | 4.84 |
| 4 | 0x96EE6503B7E42A9C76D235D61B9E855945D9148602462D8E80342D | 4.54 |
| 5 | 0xD61953D9422ED77CCCF35CD141909FA4ED4B6F33B1C223EBB33744 | 4.85 |
| 6 | 0xAED0FC2E1B07F9B61F4B3ECFF476FF1171992BB67345F1ABD88630 | 4.91 |
| 7 | 0xB39DD381538BFB0372F7C2CE75FF9101E36EDB172FBE5B73CDE292 | 4.96 |

**Table III. Group SYNC symbol PN sequences for 128-OFDMA mode**

| Group ID | 128 OFDMA<br>Group SYNC symbol PN sequences | PAPR (dB) |
|---|---|---|
| 0 | 0x06F96F9D0D6767 | 3.52 |
| 1 | 0x40ABB30B3D34CF | 3.64 |
| 2 | 0x75EB164DD44FBC | 3.59 |
| 3 | 0x4D13844885326B | 3.42 |
| 4 | 0xED8AD506263922 | 3.36 |
| 5 | 0x646FF3FFB16CCC | 3.19 |
| 6 | 0x40ABB30B3D34CF | 3.64 |
| 7 | 0x3263728845CD62 | 3.30 |

**Table JJJ. Mapping group SYNC ID to IDcell**

| Group SYNC ID | IDcell | Preamble PN Sequence # | | |
|---|---|---|---|---|
| | | Segment 0 | Segment 1 | Segment 2 |
| 0 | 0, 8,16,24 | 0, 8,16,24, 96 | 32,40,48,56,112 | 64,72,80,88, 104 |
| 1 | 1,9,17,25 | 1,9,17,25, 105 | 33,41,49,57,97 | 65,73,81,89,113 |
| 2 | 2,10,18,26 | 2,10,18,26, | 34,42,50,58,106 | 66,74,82,90,98 |
| 3 | 3,11,19,27 | 3,11,19,27,99 | 35,43,51,59 | 67,75,83,91,107 |
| 4 | 4,12,20,28 | 4,12,20,28,108 | 36,44,52,60,100 | 68,76,84,92 |
| 5 | 5,13,21,29 | 5,13,21,29 | 37,45,53,61,109 | 69,77,85,93, 101 |
| 6 | 6,14,22,30 | 6,14,22,30,102 | 38,46,54,62 | 70,78,86,94,110 |
| 7 | 7,15,23,31 | 7,15,23,31,111 | 39,47,55,63,103 | 71,79,87,95 |

Starting from frame 0, the location of the global SYNC symbol can be determined by every $N_{SYNC}$ frames, as listed in Table CCC.

**Table KKK. $N_{POSTAMBLE\_PERIOD}$ Time Interval vs. Frame Length**

| Frame Duration | Common SYNC Time Interval /$N_{POSTAMBLE\_PERIOD}$ | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.0 ms | 4ms /2 | 8ms /4 | 8ms /4 | 20ms /10 | 40ms /20 | 60ms /30 | 120ms /60 |
| 2.5 ms | - | 5ms /2 | 10ms /4 | 20ms /8 | 40ms /16 | 60ms /24 | 120ms /48 |
| 4.0 ms | - | 8ms /2 | 8ms /2 | 16ms /4 | 40ms /10 | 56ms /14 | 120ms /30 |
| 5.0 ms | - | - | 10ms /2 | 20ms /4 | 40ms /8 | 60ms /12 | 12ms /24 |
| 8.0 ms | - | - | - | 16ms /2 | 32ms /4 | 48ms /6 | 112ms /14 |
| 10.0 ms | - | - | - | 20ms /2 | 40ms /4 | 60ms /6 | 120ms /12 |
| 12.5 ms | - | - | - | - | 25ms /2 | 50ms /4 | 100ms /8 |
| 20.0 ms | - | - | - | - | 40ms /2 | 40ms /2 | 120ms /6 |

----------End text ----------

# 4 References

[1] IEEE P802.16-REVd/D5-2004
[2] IEEE P802.16d/D3-2004
[3] C80216e-04_261