# Considerations on the Ranging Channels (AWD-15.3.9.1.4/15.3.9.2.4)

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Venue:

Re: IEEE 80216m-09/0028r1, “Call for Comments and Contributions on Project 802.16m Amendment Content”
AWD-15.3.9.1.4/15.3.9.2.4

Purpose: To be discussed and adopted by TGm for the IEEE 802.16m AWD.

# Contents

- Ranging Channel Structure for 16m Only Mode
- Ranging Channel Structure for Legacy Support Mode
- Ranging Preamble Code
- Ranging Channel Allocations/Configurations
- Periodic Ranging Channel Structure

# Ranging Channel Structure for 16m Only Mode

- **In current AWD [802.16m-09/0010r2]**
  - 4 structures with 5 formats
  - Need to check the performance of Format 4 and its usage
    - ✓ Can use freq. domain detector?
    - ✓ High-complexity & phase discontinuity?

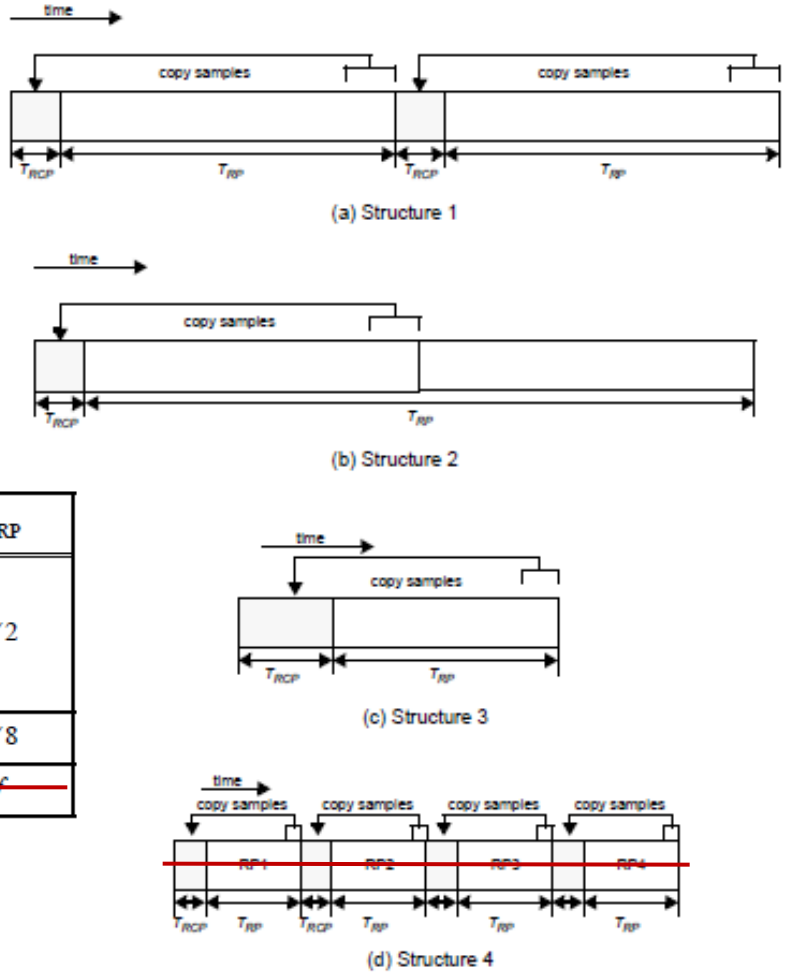



Figure 500—Ranging channel structures in the time domain

**Table 721—Ranging channel formats and parameters**

| Format No. | Ranging Channel Structure | $T_{RCP}$ | $T_{RP}$ | $\Delta f_{RP}$ |
|---|---|---|---|---|
| 0 | Structure 1 | $T_g + k \times T_b$ (a) | $2 \times T_b$ | $\Delta f/2$ |
| 1 | Structure 3 | | | |
| 2 | Structure 2 | $m \times T_g + n \times T_b$ (b) | $2 \times 2 \times T_b$ (c) | |
| 3 | Structure 3 | $7 \times T_g + T_b$ | $8 \times T_b$ | $\Delta f/8$ |
| ~~4~~ | ~~Structure 4~~ | ~~$T_g$~~ | ~~$T_b$~~ | ~~$\Delta f$~~ |

☞ **Remove the Structure 4 & Format 4**

| Syntax | Size (bits) | Notes |
|---|---|---|
| Ranging channel formats | 2 | 0b00 : Ranging channel format 0<br>0b01 : Ranging channel format 1<br>0b10 : Ranging channel format 2<br>0b11 : Ranging channel format 3 |

※ See Appendix for the simulation results.

# Ranging Channel Structure for Legacy Support Mode

## ❑ Reuse of legacy ranging structure without new structure

| | Option 1 | Option 2 | Option 3 |
|---|---|---|---|
| Ranging Structure | Legacy 2-symbol | Legacy 2-symbol | Legacy 4-symbol |
| Bandwidth / Zone | 6 subchannels in L-Zone | 6 DRUs in M-Zone | 3, 4, or 5 DRUs in M-Zone |
| Overhead | 144 subcarriers × 3 symbols (w or w/o overlapping with 16e) | 144 subcarriers × 6 symbols (Multi-RCH allocation?) | (72~120) subcarriers × 6 symbols |
| RNG-RSP / Procedure | L-Zone? (Need to study the feasibility) | M-Zone (16m-based) | M-Zone (16m-based) |
| Signaling for Resource Allocation | Complicated | Easy | Easy |
| How to distinguish b/w Legacy and 16m MSs ranging signals | Additional function is necessary, e.g., 16e code partition | Implicit (MZone) | Implicit (MZone) |
| Performance | Need to verify, e.g., impact on the legacy/16m performance | Better than 16e | Need to verify the 16m performance |

☞ **Slightly prefer Option 1 or 3**

✓ **It is preferable 1) to maintain the same procedure in 16m only and 2) to reuse the 16e structure, 3) not to make new additional structure & functions, 4) to reduce the ranging overhead, 5) to support comparable or better performance than 16e, etc.**

# Ranging Resource Allocations for Legacy Support Mode

- **For Option 1: IR+HO+Periodic in LZone**
  - 1st and 2nd OFDMA symbols : initial/handover ranging ch.
  - 3rd OFDMA symbol : periodic ranging ch.
    - ✓ Can it be allocated by unit of 3 symbols?
    - ✓ Can it restrict legacy ranging allocation?
- **For Option 2: IR+HO+Periodic in the same Lzone subframe**
  - Case 1 : two initial/handover ranging ch. & two periodic ranging ch.
    - ✓ '1st and 2nd' & '4th and 5th (or 3rd and 4th)' OFDMA symbols : each initial/handover ranging ch.
    - ✓ '3rd'(or 5th) and '6th' OFDMA symbols : each periodic ranging ch. (if it is 1-symbol structure)
  - Case 2 : one initial & one handover ranging ch. & two periodic ranging ch.
    - ✓ '1st and 2nd' OFDMA symbols : a initial ranging ch.
    - ✓ '4th and 5th (or 3rd and 4th)' OFDMA symbols : a handover ranging ch.
    - ✓ '3rd'(or 5th) and '6th' OFDMA symbols : each periodic ranging ch.
- **For Option 3: IR+HO+Periodic in the same Lzone subframe**
  - Case 1 : one initial/handover ch. & one periodic ranging ch.
    - ✓ '1st ~4th' OFDMA symbols : a initial/handover ranging ch.
    - ✓ '5th ~6th' OFDMA symbols : a periodic ranging ch.
  - Case 2 : one initial/handover/periodic ranging ch.
    - ✓ '1st ~4th' OFDMA symbols : a initial ranging ch.

# Ranging Code Allocations for Legacy Support Mode

## ❑ Reuse of legacy ranging codes

- Option 1 : Use of remaining legacy ranging codes with the same seed
  - ✓ How to indicate the ranging code configurations in Lzone?
  - ✓ # of legacy codes enough to accommodate 16m MSs (code partitioning)?
  - ✓ Other possible impacts?
- Option 2 : Use of the same 16e ranging codes in MZone
- Option 3 : Use of the new ranging codes in MZone

# Ranging Preamble Code

- **Zadoff-Chu codes**
  - Properties
    - ✓ Sharp auto-correlation properties
    - ✓ Low cross-correlation properties
    - ✓ Low PAPR/CM properties
    - ✓ Constant amplitude
  - Increased # of codes in the small cells
    - ✓ E.g., 1529 (=11*139) in 0.5 km cell radius
    - ✓ E.g., 1251 (=9*139) in 1.0 km cell radius
  - Small no. of codes in the large cells
    - ✓ E.g., 139 in 12~18 km cell radius
- **Computer generated/other codes**
  - Is it possible to find a ranging code comparable to ZC codes?

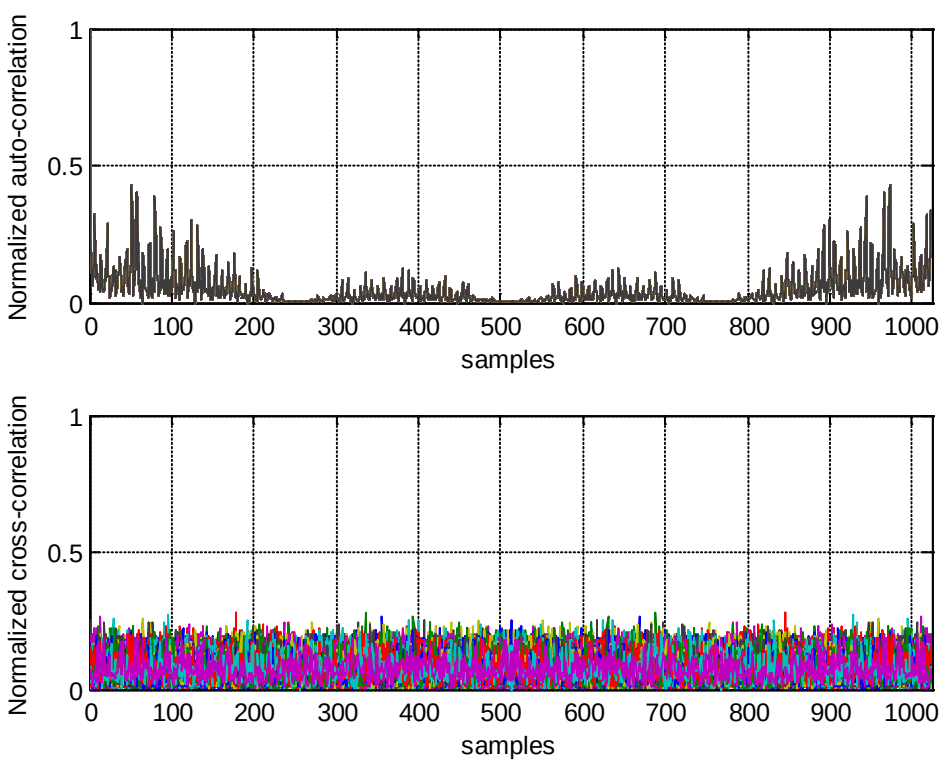
$$x_p(k) = \exp\left(-j \cdot \pi \frac{r\,k(k+1) + 2 \cdot k \cdot s \cdot N_{CS}}{N_{RP}}\right), \quad k = 0,1,\ldots,N_{RP}-1$$

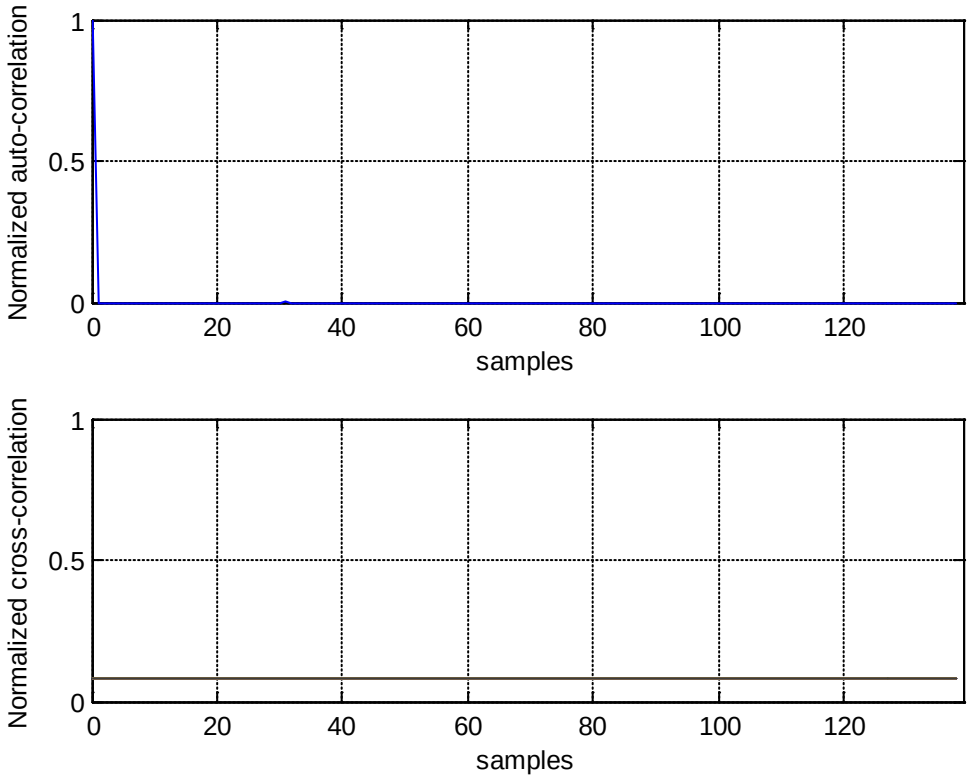
| | | |
|---|---|---|
| RNG codes information | 12 | ~~Parameters for determining the root sequences and their cyclic shifts in the preamble set for the cell (Up to 12 bits, Need the decision from UL Ctrl section)~~ |

**Root index : 7 bits**
**Cyclic shift unit[Ncs] : 4 bits**

☞ **ZC codes with cyclic shifts**

# Correlation Properties

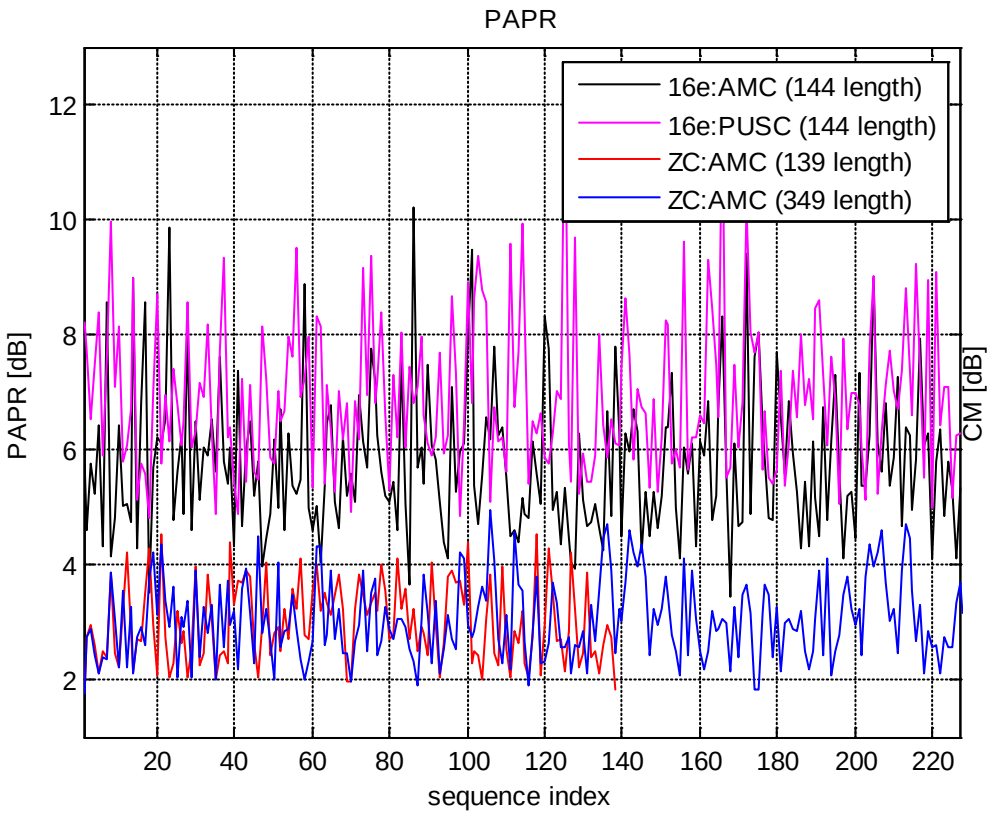


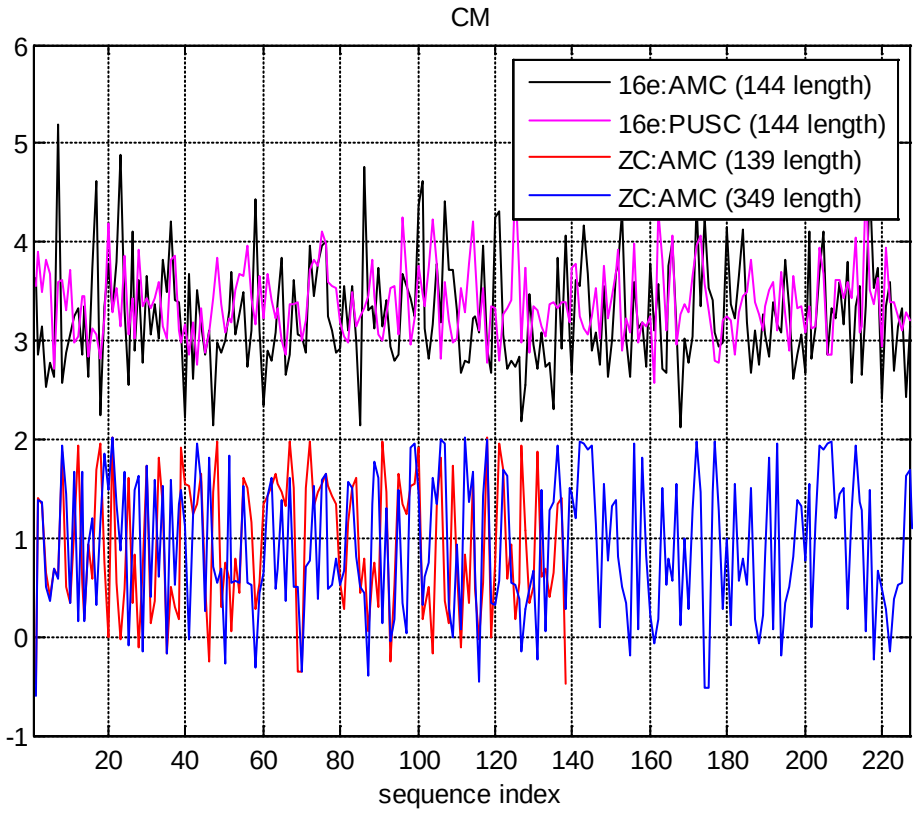




**(a) Legacy codes (144)** **(b) ZC codes (139)**

**< Auto- and cross-correlation >**

# PAPR/CM Properties



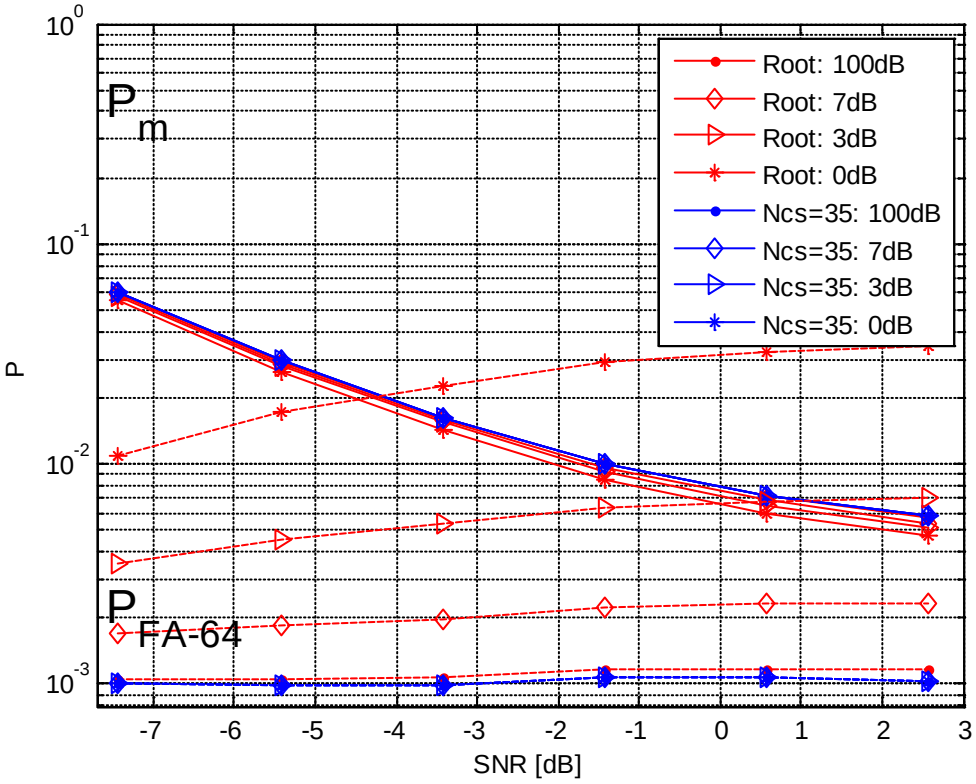

**(a) PAPR** **(b) CM**

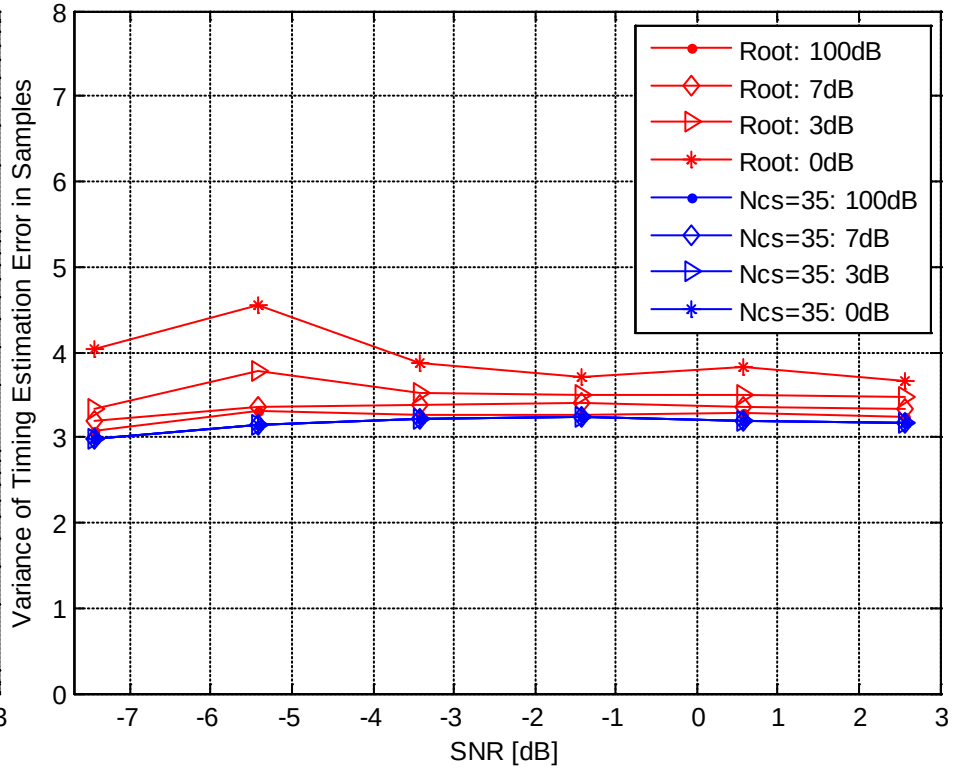
**< PAPR and CM Properties >**

# Performance w or w/o Cyclic Shift

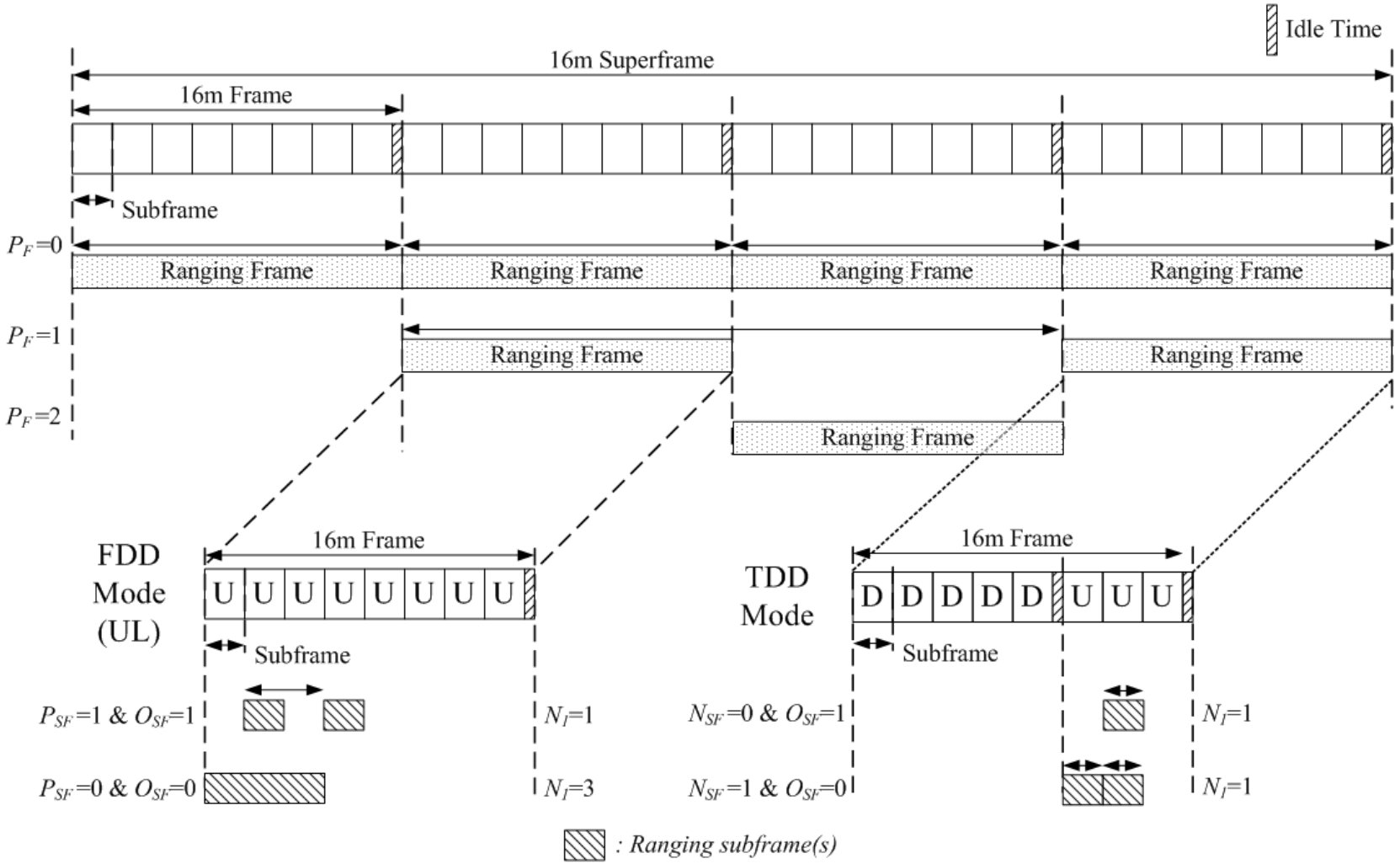
## ❑ Increased Ranging Performance

- The cross-correlation is zero among different cyclic shifted codes with same root index
- With reduced cross-correlation, the performance is improved



# [Example] Ranging Configurations for 802.16m




- **The ranging channels are allocated in the frame level, depending on the value of "$P_F$," e.g., in every frames ($P_F$=0), every odd frames ($P_F$=1) or only one frame ($P_F$=2).**
- **In the ranging allocated frame, ($P_{SF}$+1) ranging channels can be allocated.**
- **For the increased time-domain opportunities, $O_{SF}$ denotes a subframe-level offset.**

# [Example] Ranging Configurations for 802.16m

- **Frame-level position: $P_F$**
  - Indication of the position of frame allocated the ranging channel in a superframe
- **Subframe-level position : $P_{SF}$**
  - Indication of the position and the number of subframes allocated ranging channels within the frame
  - Support of multiple allocation in a frame
- **Subframe (Time) Offset : $O_{SF}$**
  - Indication of the offset in the units of subframes for ranging channel allocation
  - To support flexible allocation with increased reuse factor in the time domain
- **Subband (Frequency) Offset : $O_{SB}$**
  - Indication of the offset in the units of subbands for ranging channel allocation
  - To support flexible allocation with increased reuse factor in the frequency domain

# Ranging Configurations for 802.16m

- ❑ Support of the allocation of 1~8 ranging channels within a superframe
- ❑ 2-bit signaling for $P_F$ and $P_{SF}$

- The ranging channels are allocated from the $P_F^{th}$ frame in every frames ($P_F$=0) or every odd frames ($P_F$=1) or only one frame ($P_F$=2) where frame index is 0, 1, 2, and 3 in a superframe.
- In the ranging allocated frame, ($P_{SF}$+1) ranging channels are allocated.
- The ranging subframe index within a allocated frame is calculated as follow:

✓ For FDD, $\left\lfloor N_{SF} / \left(P_{SF}+1\right) \right\rfloor \cdot k + O_{SF}$ , $k = 0,1,\ldots,P_{SF}$

where $O_{SF}$ is the subframe offset and $N_{SF}$ is the minimum number of subframes among frames. The number of subframes per frame is defined in the subclause *15.3.3.1. Basic Frame Structure*.

✓ For TDD, $N_{SF} - N_{UL} + O_{SF} + k$ , $k = 0,1,\ldots,P_{SF}$

where $N_{UL}$ is the number of UL subframe in the TDD. For examples, it is defined by 2, 3, 4, or 5 for 6:2, 5:3, 4:4, or 3:5 DL:UL ratio, respectively.

| Configurations | $P_F$ | $P_{SF}$ | $N_{RA}$ |
|---|---|---|---|
| 0 | 0 | 0 | 4 |
| 1 | 0 | 1 | 8 |
| 2 | 1 | 0 | 2 |
| 3 | 2 | 0 | 1 |

where $N_{RA}$ is the number of ranging channel per superframe

# 802.16m Ranging Configurations

## ❑ Ranging Configurations in the Legacy System

- Time/Freq. position : 15 bits (* 4 frames)
  - ✓ OFDMA symbol offset : **8 bits/** Subchannel offset : **7 bits**
- Multiple allocation : 14 bits (* 4 frames)
  - ✓ No. OFDMA symbols : **7 bits**/No. subchannels : **7 bits**
- **Total Max 116 bits per 20ms**

## ❑ Ranging Configurations for 802.16m

- Pre-defined & Configurable time position with $P_F$ , $P_{SF}$ , and $O_{SF}$
  - ✓ To support flexible allocation in time domain, fully-configured timing position is not needed.
  - ✓ To support different ranging load with small and simple signaling efforts
  - ✓ **4-bit signaling can be enough: Configuration (2 bits) and subframe offset (2bit)**
- Frequency position with subband offset $O_{SB}$
  - ✓ To support flexible allocation in frequency domain, fully-configured subband allocation is not needed due to the restriction of available no. of subbands.
  - ✓ **Maximum 5 bits** (max. 24 subbands): **2-bit signaling can be enough.**
- **Total 6-bit ranging channel information**

| | | |
|---|---|---|
| | 6 | **Ranging configurations : 2 bits**<br>**Subframe offset : 2 bits**<br>**Subband offset : 2 bits** |
| Initial ranging channel information (initial ranging region location) | ~~TBD~~ | ~~(Need the decision from UL Ctrl section)~~ |

# Periodic Ranging Channel Structure

- **Periodic Ranging in 16e**
  - UL Time/Freq. synchronization update
  - Power control update, etc
- **16m Periodic Ranging or Reuse of Other Channels?**
  - Sounding channels
    - ✓ Can be used UL time/freq. synchronization update
    - ✓ Can be used power control update
  - Also, several existing signal (e.g. reference signal) can be used for these purposes
  - Its usages is small
    - ✓ How about same structure/region with initial ranging channel?

☞ **Periodic ranging uses the same initial ranging structure/region with different ranging code sets.**

| | | |
|---|---|---|
| ~~Periodic ranging channel information (periodic ranging region location)~~ | ~~TBD~~ | ~~Need the decision from UL Ctrl section~~ |

# Conclusions

- **Proposed AWD Text**
  - Adopt the proposed AWD text in C802.16m-09/1502 or its latest version.
    - ✓ Text Proposal #1 ~ #5

# Appendix

# Simulation Parameters

| | Parameters | Assumptions |
|---|---|---|
| System | Carrier Frequency $(f_c)$ | 2.5 GHz |
| | Total Bandwidth $(BW)$ | 5 MHz |
| | Number of Points in FFT $(N_{FFT})$ | 512 |
| | Sampling Frequency $(F_s)$ | 5.6 MHz |
| | Subcarrier Spacing $(\Delta f)$ | 10.9375 kHz |
| | OFDMA Symbol Duration without Cyclic Prefix $(T_b = 1/\Delta f)$ | 91.43 μs |
| | Cyclic Prefix Length (faction of $T_b$) | 1/8 |
| | OFDMA Symbol Duration with Cyclic Prefix $(T_s)$ | 102.86 μs for CP=1/8 |
| | Residual Frequency Offset | Random<br>< 218.75 Hz (< 2% of $\Delta f$) |
| Channel | Multi-antenna Transmission Format | 1 Tx |
| | Receiver Structure | 2 Rx |
| | Fading Channel Model | Modified Pedestrian B 3km/h |
| Ranging | Ranging Resource | 1 subband (72 data subcarriers) |
| | Ranging Subcarrier Spacing | $\Delta f$ / 2 (5.46875 kHz) |
| | Ranging Detector | Energy detector |
| | Number of Ranging Codes per Channel | 64 |
| | Number of Ranging Channel per Sector | 1 |
| | Codes Set per Sector | Random within all codes |
| | Code Selection per AMS | Random within code set of sector |
| | Round Trip Delay | Random within 5km RTD |
| | Target Miss-Detection Probability | 1 % |
| | Target Overall False Alarm Probability | 0.1 % |

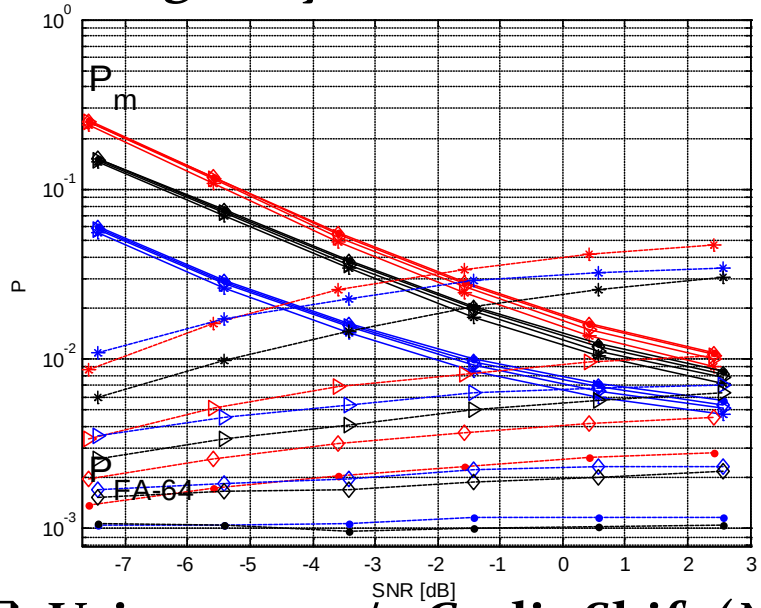
# Definitions

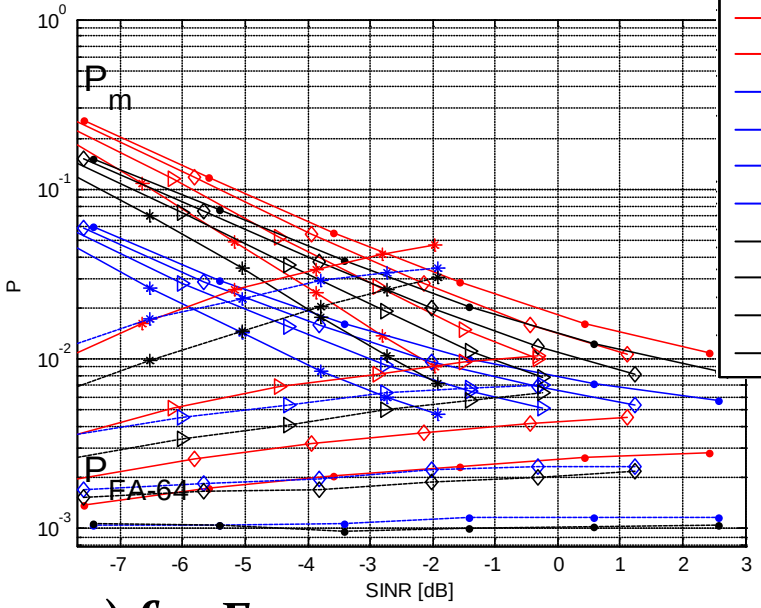
- **False Alarm Probability ($P_{FA}$) ☞ target $P_{FA}$ = 0.1%**
  - (Total no. of false alarm events) / (Total no. of candidate codes(=64) - total no. of transmitted codes)
  - False alarm event : A code is detected which is not one of transmitted codes.

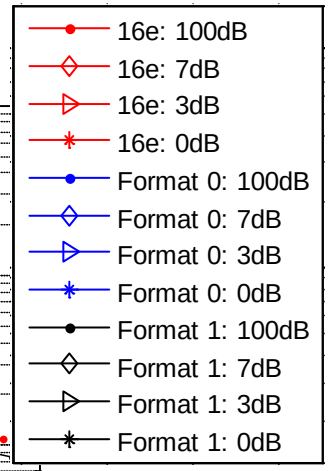
- **Miss-Detection Probability ($P_m$) ☞ target $P_m$ = 1%**
  - (No. of total miss-detection events) / (total no. of transmitted codes)
  - Miss-detection event : The code is not detected which is transmitted code.

# $P_m$ & $P_{FA\text{-}64}$ : 2 AMSs case

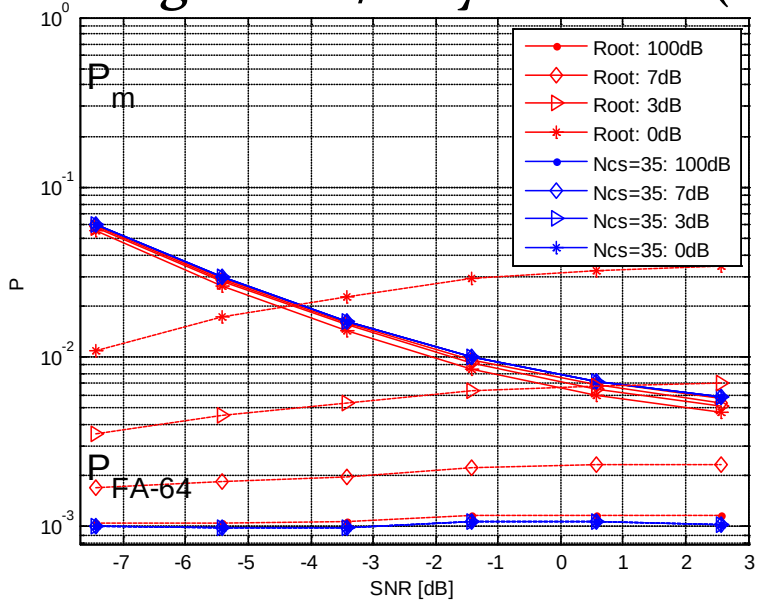
- Using Only Root Indexes

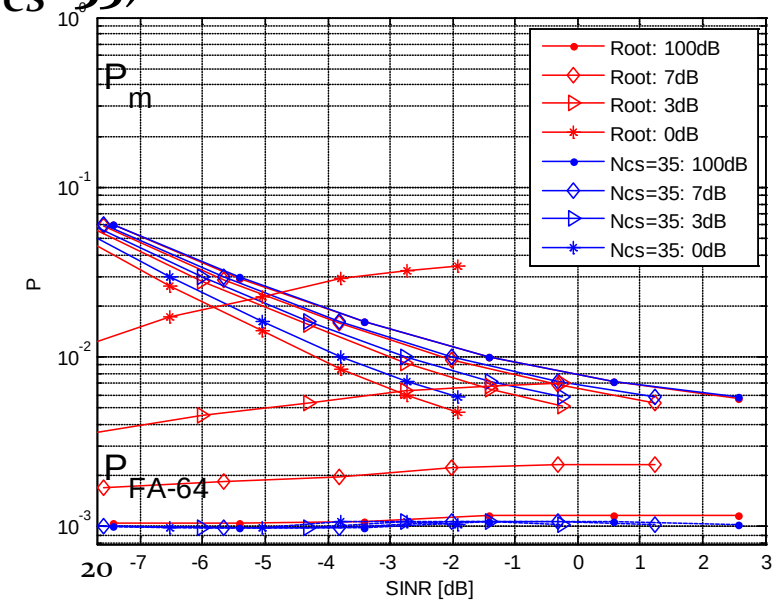


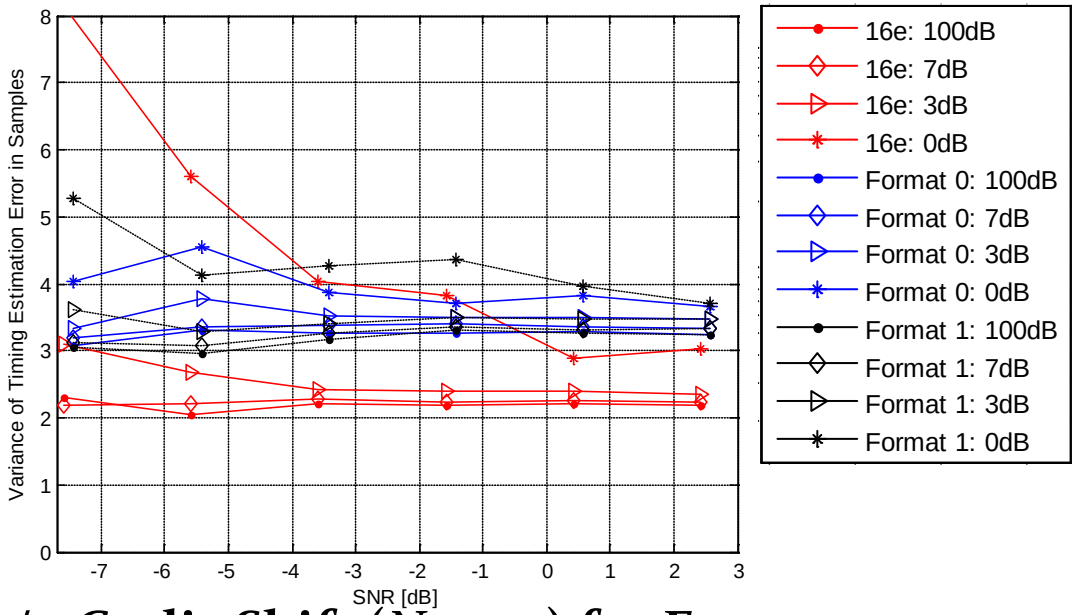

- Using w or w/o Cyclic Shift ($N_{CS}$=35) for Format 0



# Timing Performance : 2 AMSs case

- Using Only Root Indexes




- Using w or w/o Cyclic Shift ($N_{CS}$=35) for Format 0