

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

IEEE 802.16 Presentation Submission Template (Rev. 9)

Document Number:

IEEE C802.16m-09/1501r1

Date Submitted:

2009-07-06

Source:

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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.

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Ranging Channel Structure for 16m Only Mode

❑ In current AWD [802.16m-09/0010r2]

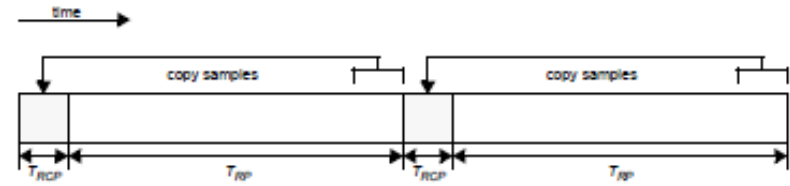
- 4 structures with 5 formats
- Need to check the performance of Format 4 and its usage
 - ✓ Can use freq. domain detector?
 - ✓ High-complexity & phase discontinuity?

Table 721—Ranging channel formats and parameters

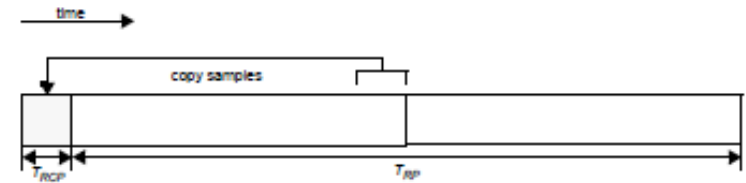
Format No.	Ranging Channel Structure	T_{RCP}	T_{RP}	Δf_{RP}
0	Structure 1	$T_g + k \times T_b^{(a)}$	$2 \times T_b$	$\Delta f/2$
1	Structure 3			
2	Structure 2	$m \times T_g + n \times T_b^{(b)}$	$2 \times 2 \times T_b^{(c)}$	$\Delta f/8$
3	Structure 3	$7 \times T_g + T_b$	$8 \times T_b$	
4	Structure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

👉 Remove the Structure 4 & Format 4

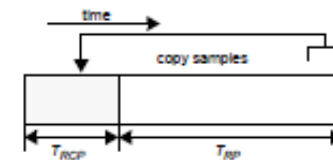
Syntax	Size (bits)	Notes
Ranging channel formats	2	0b00 : Ranging channel format 0 0b01 : Ranging channel format 1 0b10 : Ranging channel format 2 0b11 : Ranging channel format 3



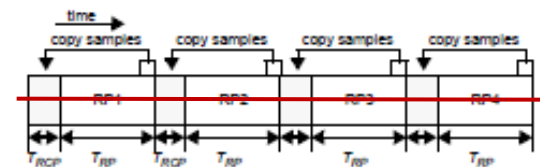
(a) Structure 1



(b) Structure 2



(c) Structure 3



(d) Structure 4

Figure 500—Ranging channel structures in the time domain

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

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

❑ Computer generated/other codes

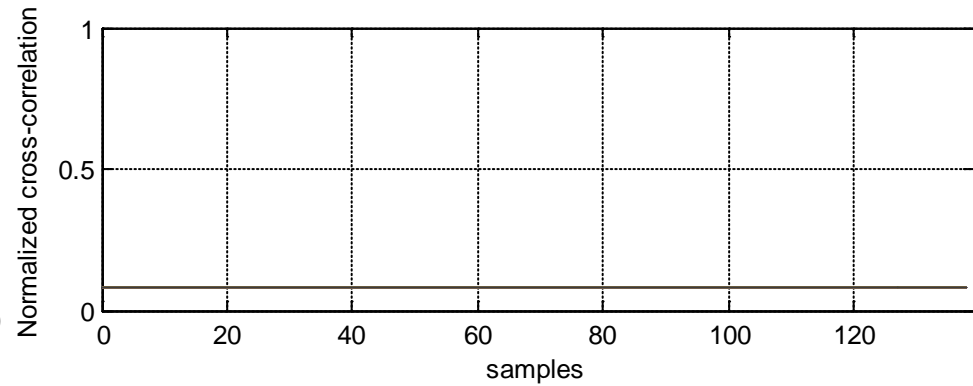
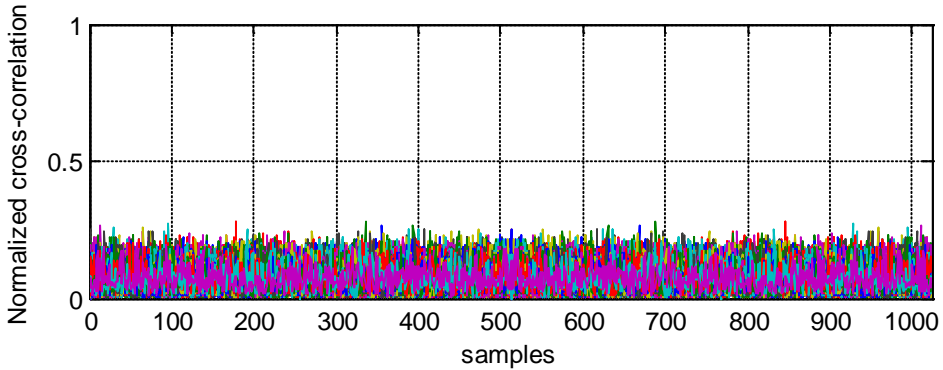
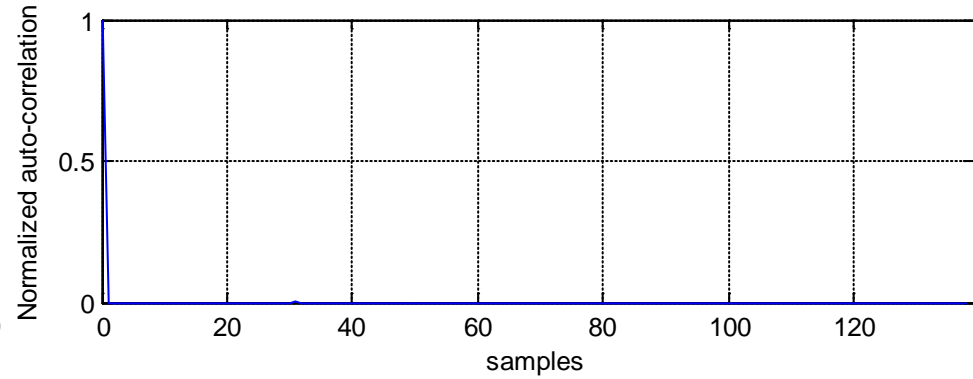
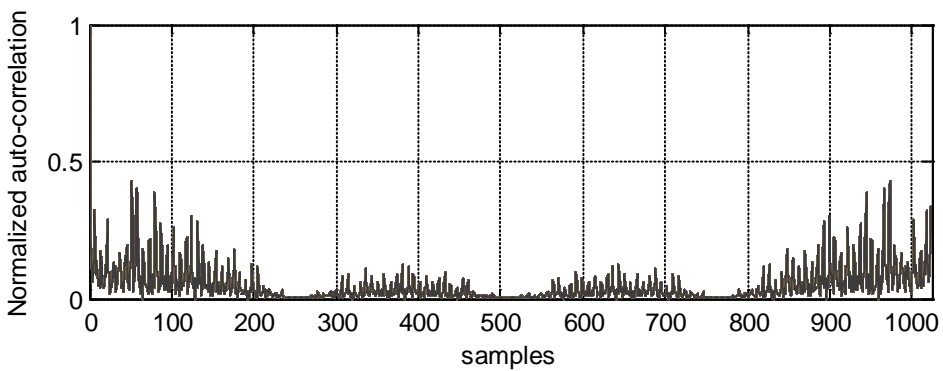
- Is it possible to find a ranging code comparable to ZC codes?

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 UE Ctrl section)
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Root index : 7 bits
Cyclic shift unit[Ncs] : 4 bits

👉 **ZC codes with cyclic shifts**

Correlation Properties

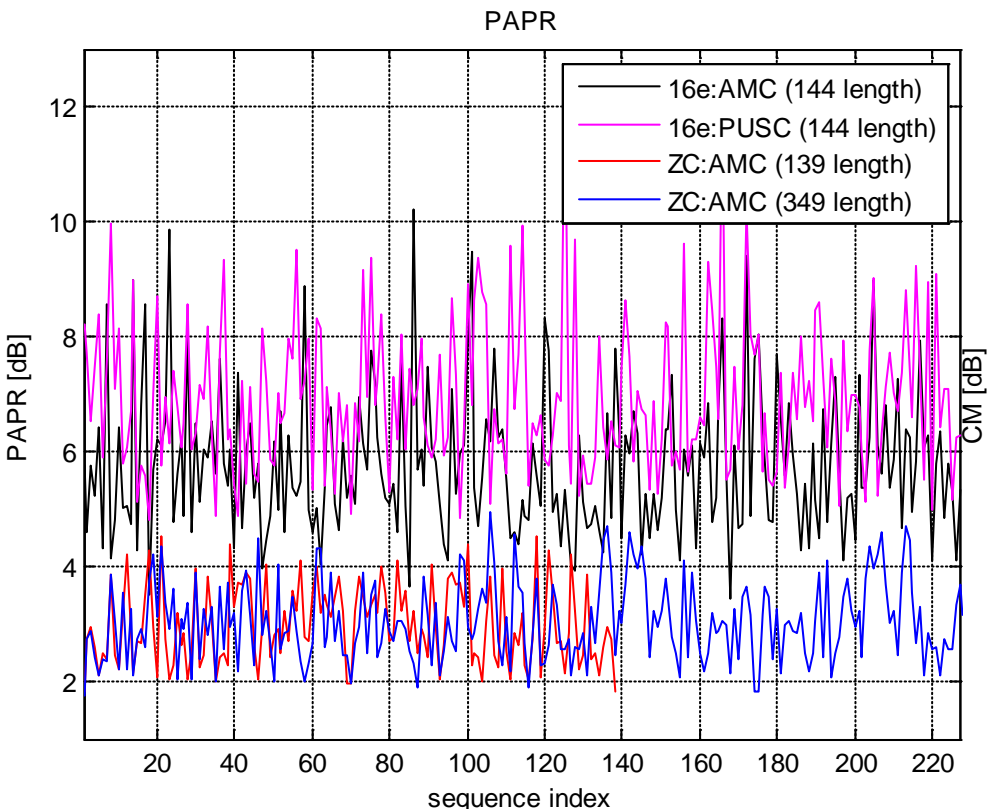


(a) Legacy codes (144)

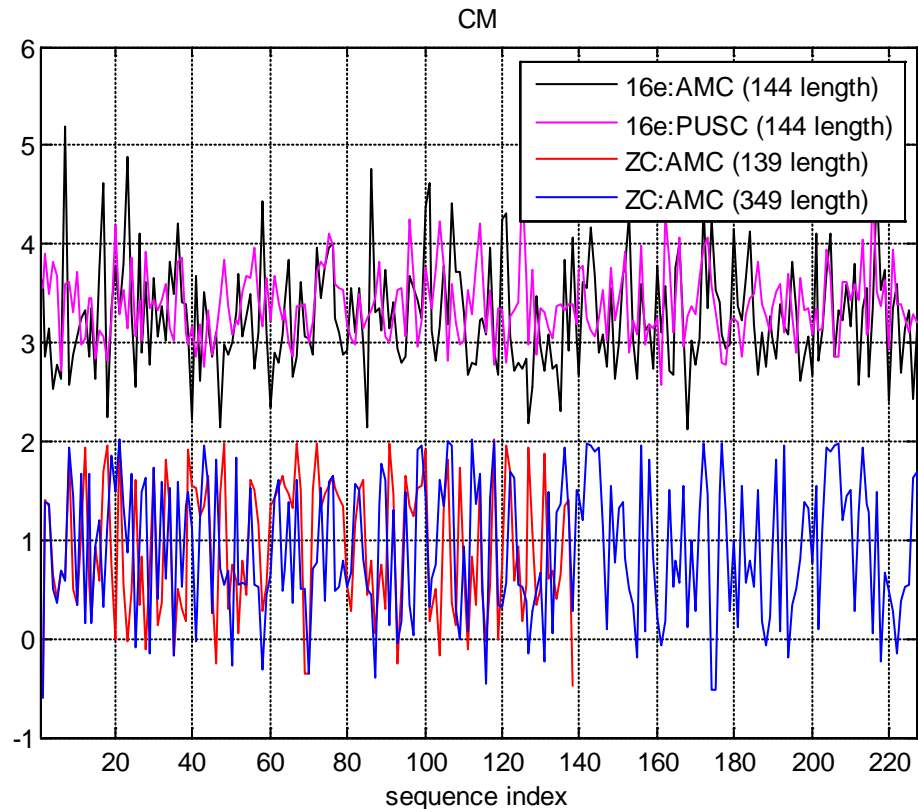
(b) ZC codes (139)

< Auto- and cross-correlation >

PAPR/CM Properties



(a) PAPR



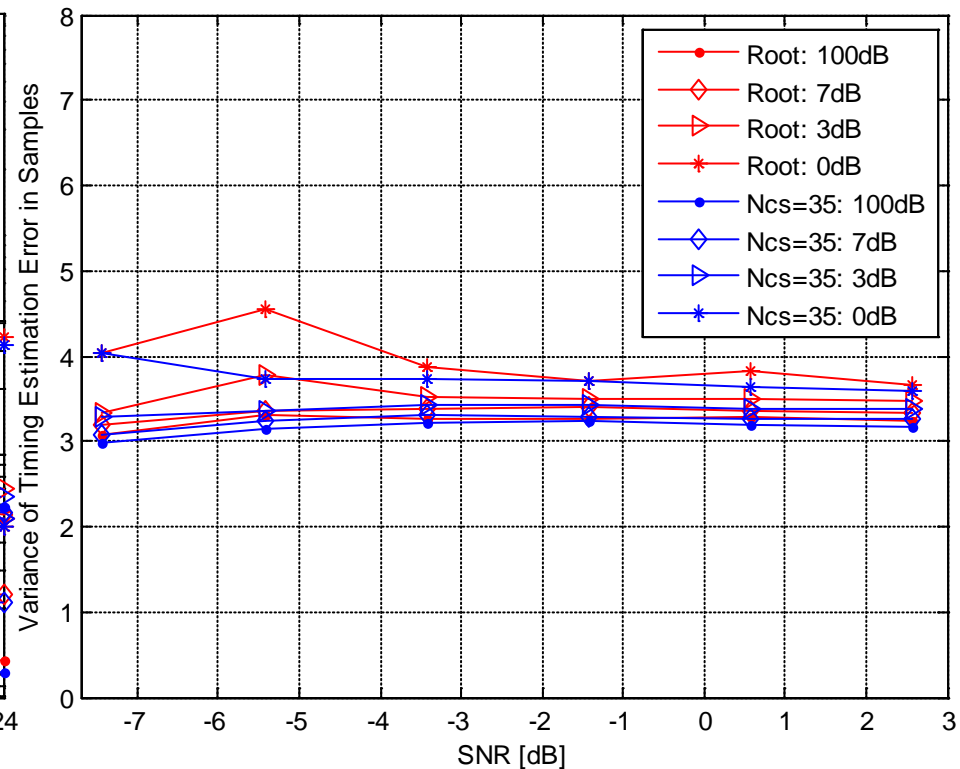
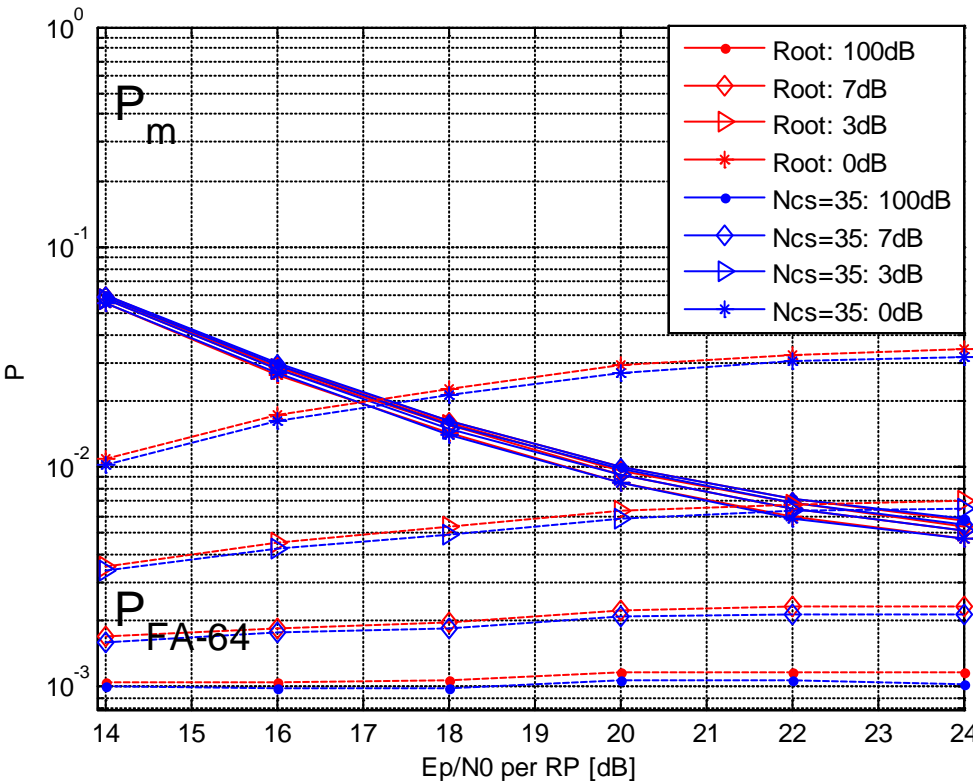
(b) CM

< PAPR and CM Properties >

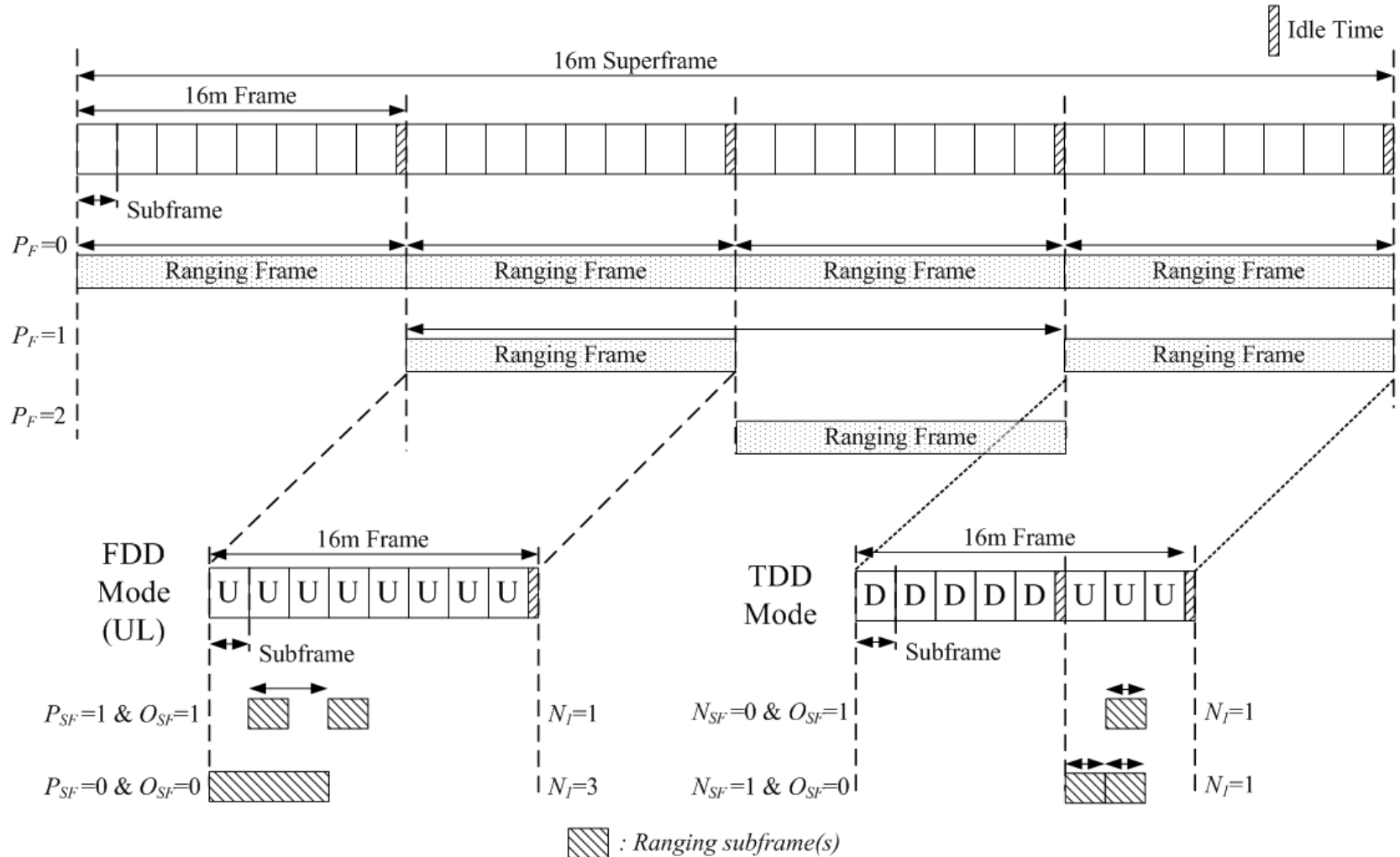
Performance w or w/o Cyclic Shift

□ 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, $\lfloor N_{SF} / (P_{SF} + 1) \rfloor \cdot k + O_{SF}$, $k = 0, 1, \dots, P_{SF}$

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, $N_{SF} - N_{UL} + O_{SF} + k$, $k = 0, 1, \dots, P_{SF}$

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 Subframe offset : 2 bits Subband offset : 2 bits
Initial ranging channel information (initial ranging region location)	TDD	(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
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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 (Δf)	10.9375 kHz
	OFDMA Symbol Duration without Cyclic Prefix ($T_b = 1 / \Delta f$)	91.43 μ s
	Cyclic Prefix Length (fraction of T_b)	1/8
	OFDMA Symbol Duration with Cyclic Prefix (T_s)	102.86 μ s for CP=1/8
	Residual Frequency Offset	Random < 218.75 Hz (< 2% of Δf)
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 %

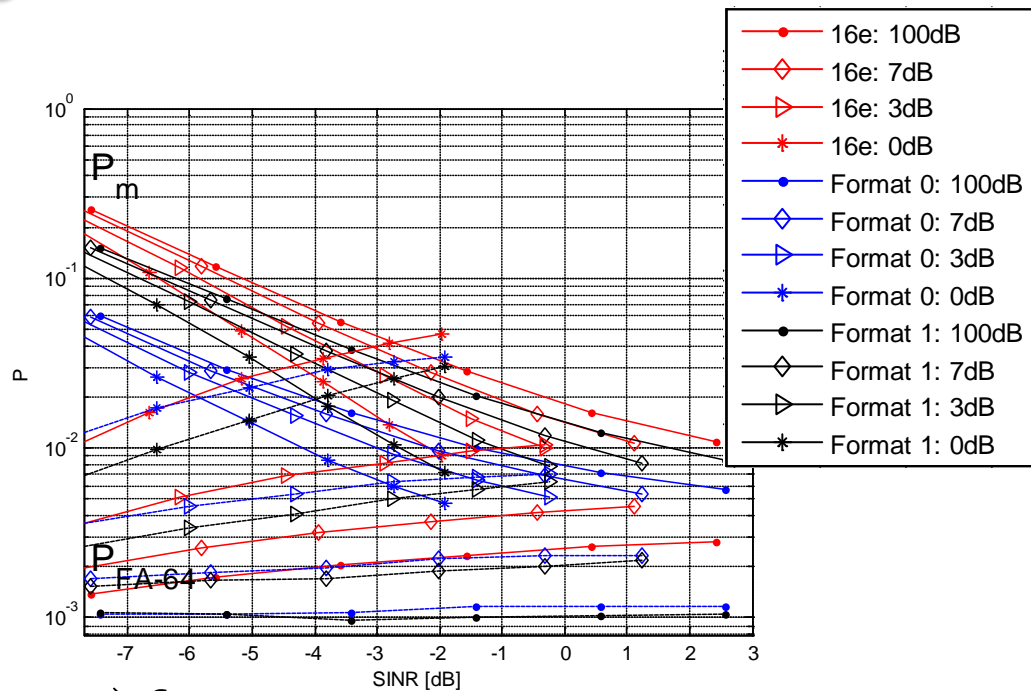
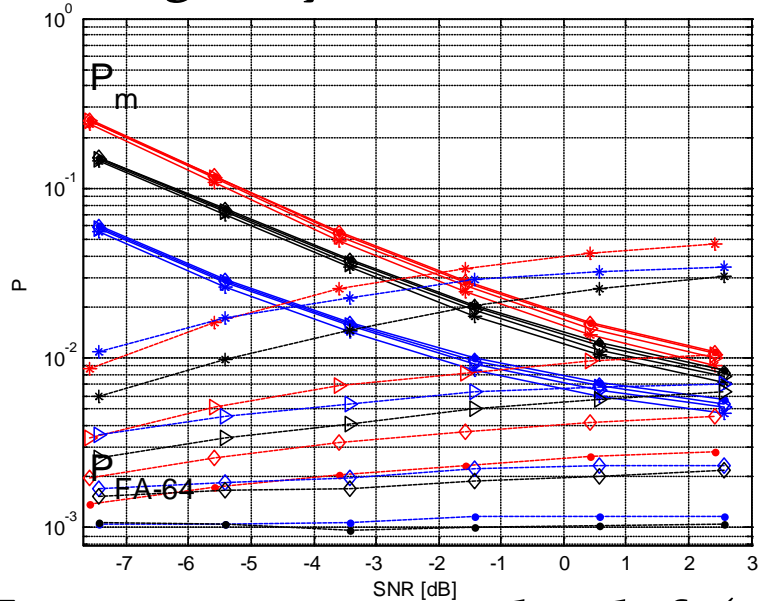
Definitions

- ❑ **False Alarm Probability (P_{FA})** \Rightarrow 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.

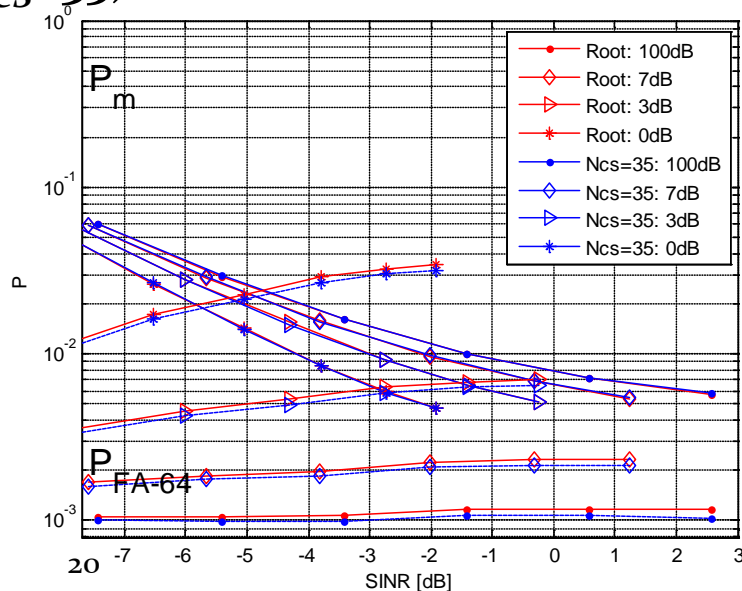
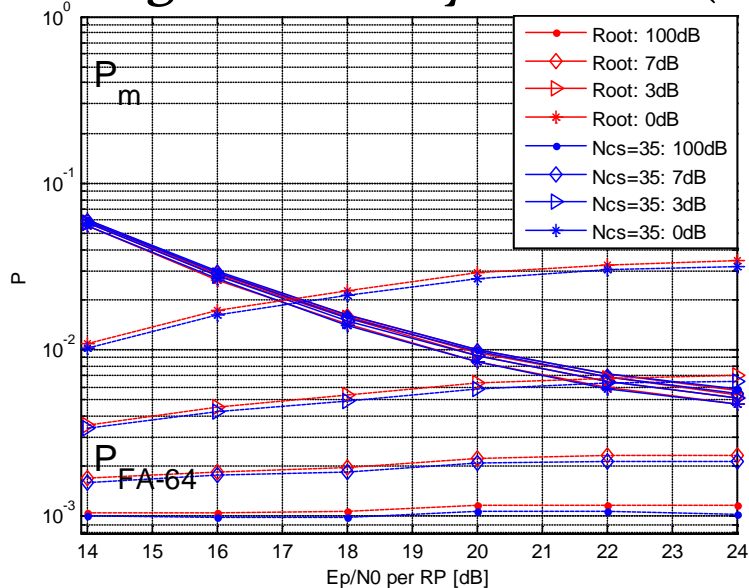
- ❑ **Miss-Detection Probability (P_m)** \Rightarrow target $P_m = 1\%$
 - (No. of total miss-detection events) / (total no. of transmitted codes)
 - Miss-detection event : The code is not detected which is transmitted code.

P_m & P_{FA-64} : 2 AMSs case

Using Only Root Indexes

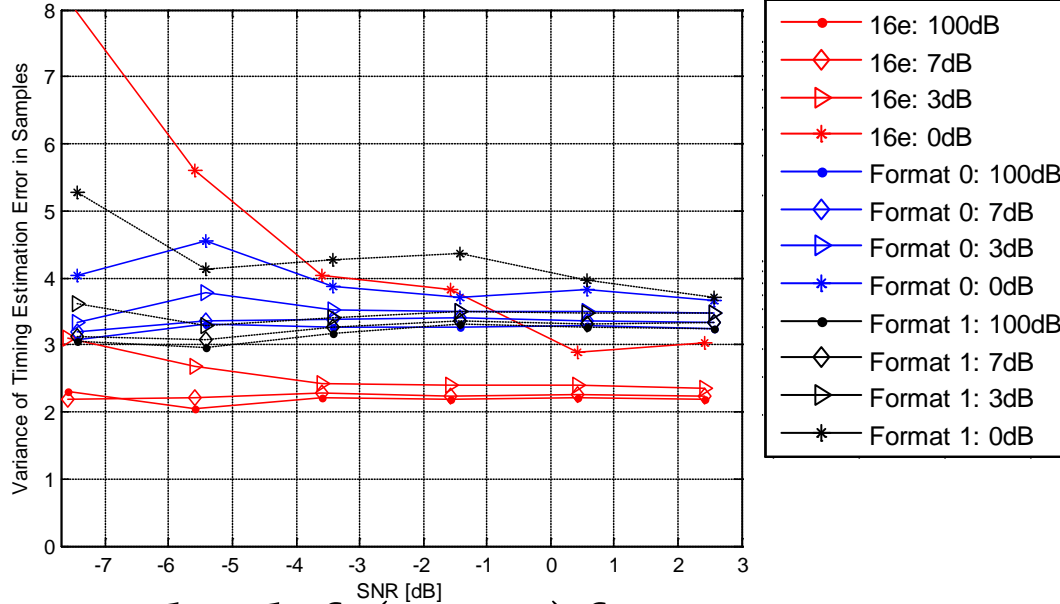


Using w or w/o Cyclic Shift ($N_{CS}=35$) for Format 0



Timing Performance : 2 AMSs case

Using Only Root Indexes



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

