Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [CSS over Multipath]
Date Submitted: [15 November 2007]
Source: [Kyung-Kuk Lee] Company [Orthotron Co., Ltd.]
Address [709 Kranz Techono, 5442-1 Sangdaewon-dong, Jungwon-gu, Sungnam-si, Kyungki-do, Korea 462-120]
Voice:[+82 31 777 8198], FAX: [], E-Mail:[kyunglee@orthotron.com]

Re: []

Abstract: []

Purpose: [Introduce CSS Technology for BAN Application]

NOTE: Update all red fields replacing with your information; they are required. This is a manual update in appropriate fields. All Blue fields are informational and are to be deleted. Black stays. After updating delete this box/paragraph.

Chirp-Spread-Spectrum over Multipath

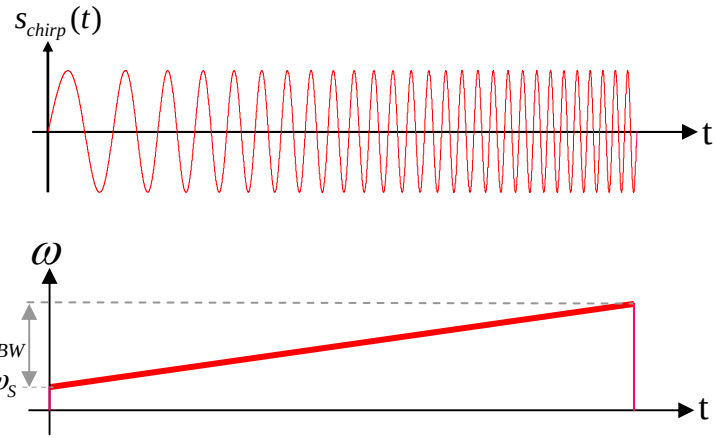
2007. 11. 15.

Kyung-Kuk Lee
kyunglee@orthotron.com

Chirp Signal

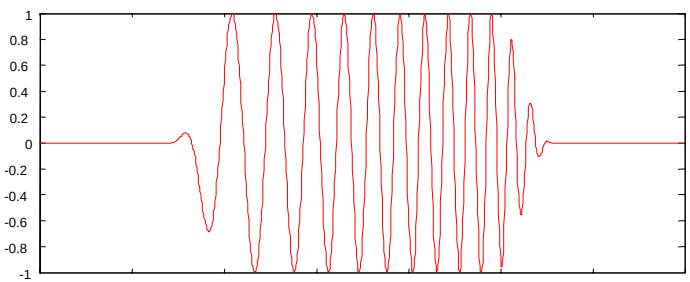
Linear Chirp: Rectangular Window

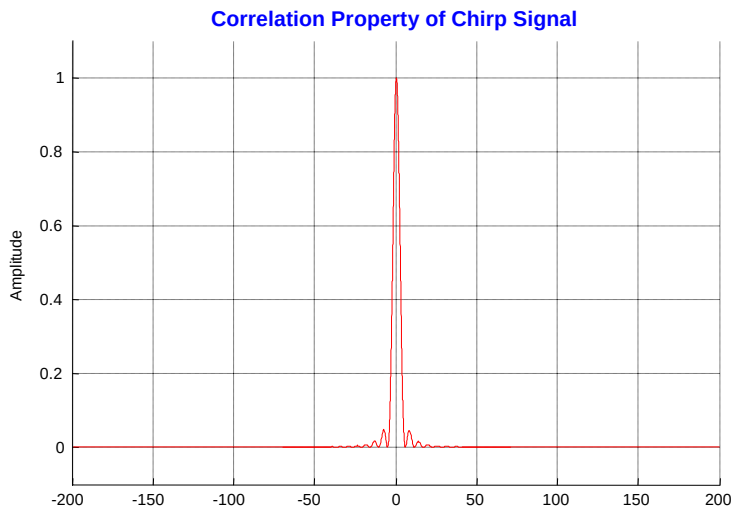
$$s_{chirp}(t) = \mathrm{Re}\left[\exp[\, j(\omega_s + \frac{\omega_{BW}}{2T_{chirp}} t)t + j\theta_0 \,] \times [u(t) - u(t - T_{chirp})] \right]$$



Linear Chirp: Raised-Cosine Window

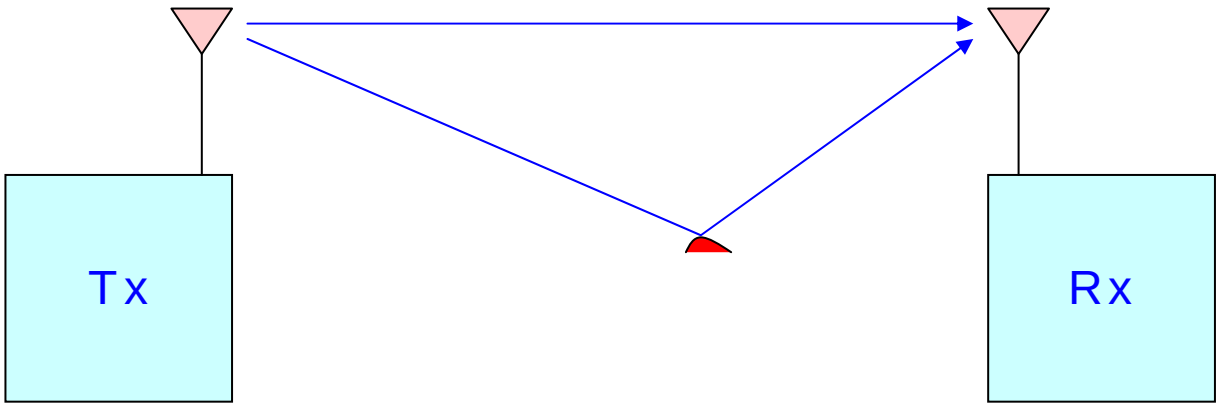
$$s_{chirp}(t) = \mathrm{Re}\left[\exp[\, j(\omega_s + \frac{\omega_{BW}}{2T_{chirp}} t)t + j\theta_0 \,] \times p_{RC}(t) \right]$$



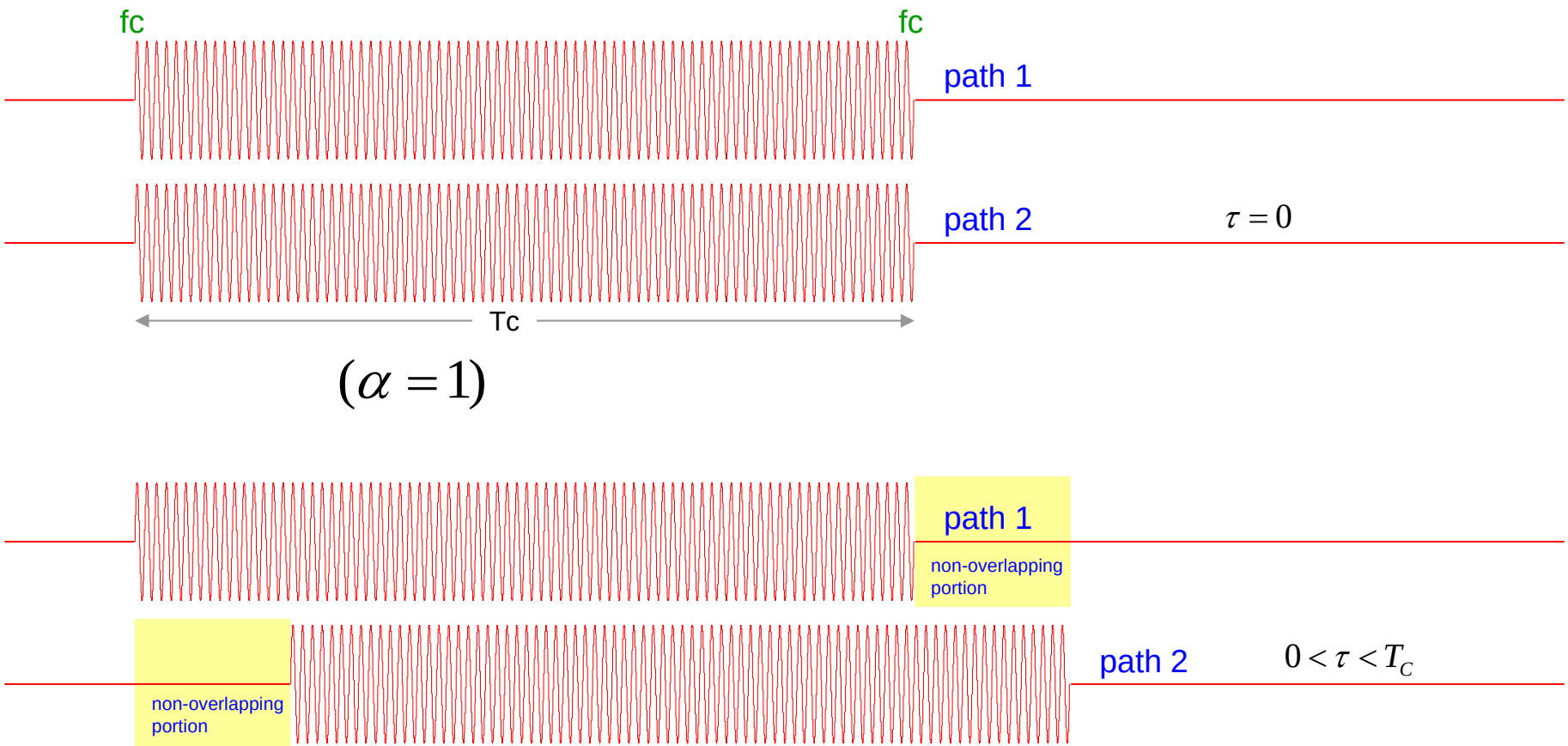


Two-path Model

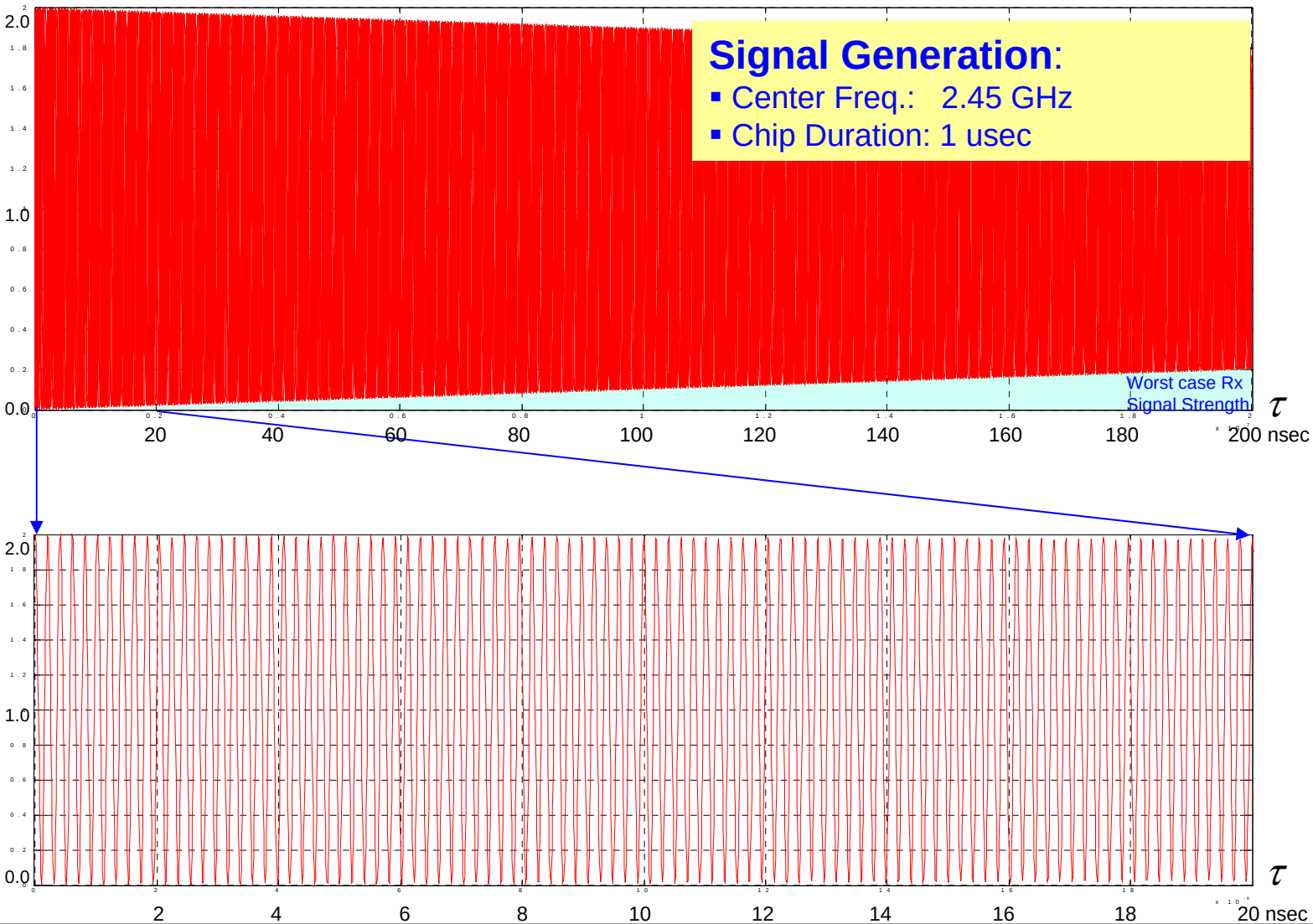
$$h(t) = \delta(t - T) + \alpha \cdot \delta(t - T - \tau)$$



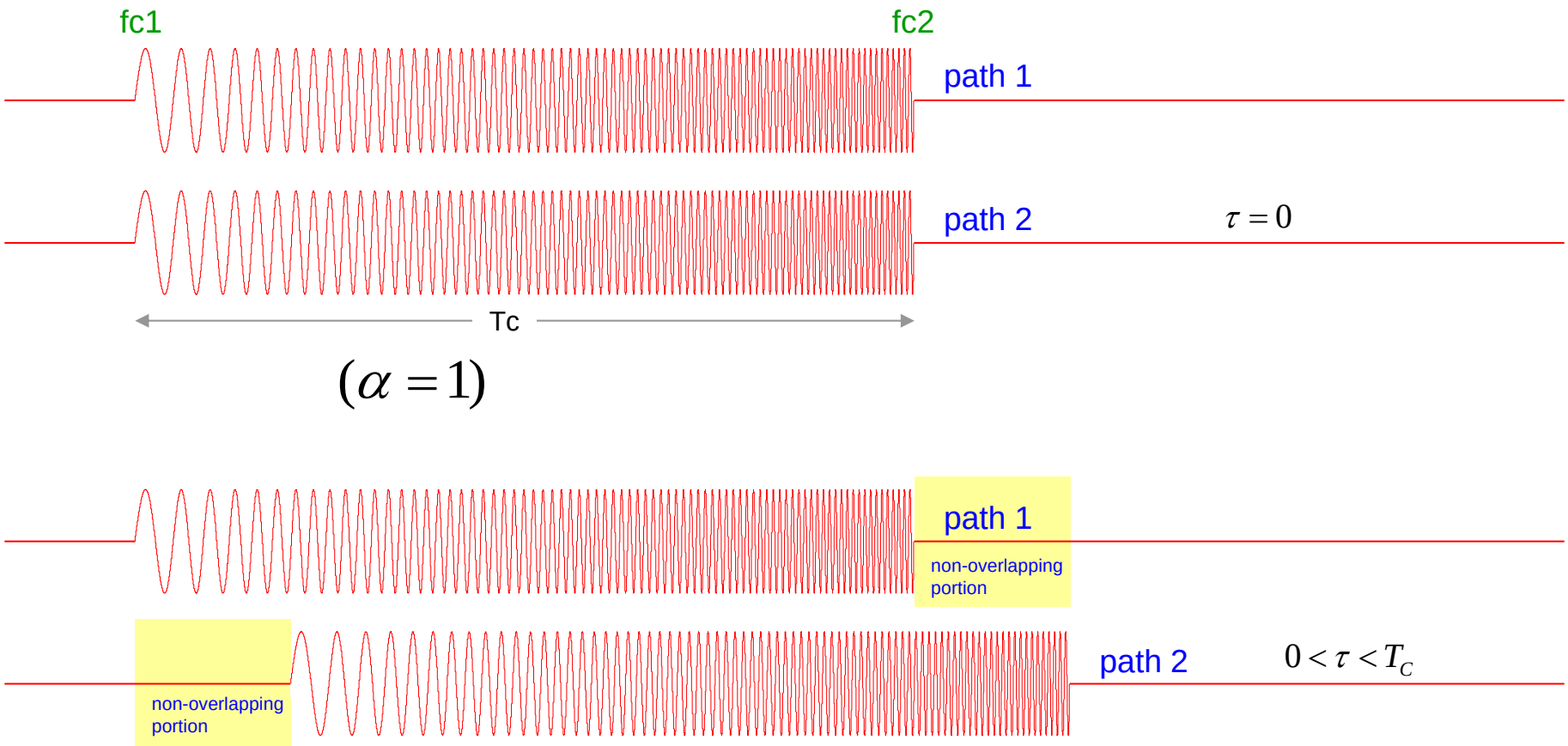
2-path Combining Property of Isolated DSSS



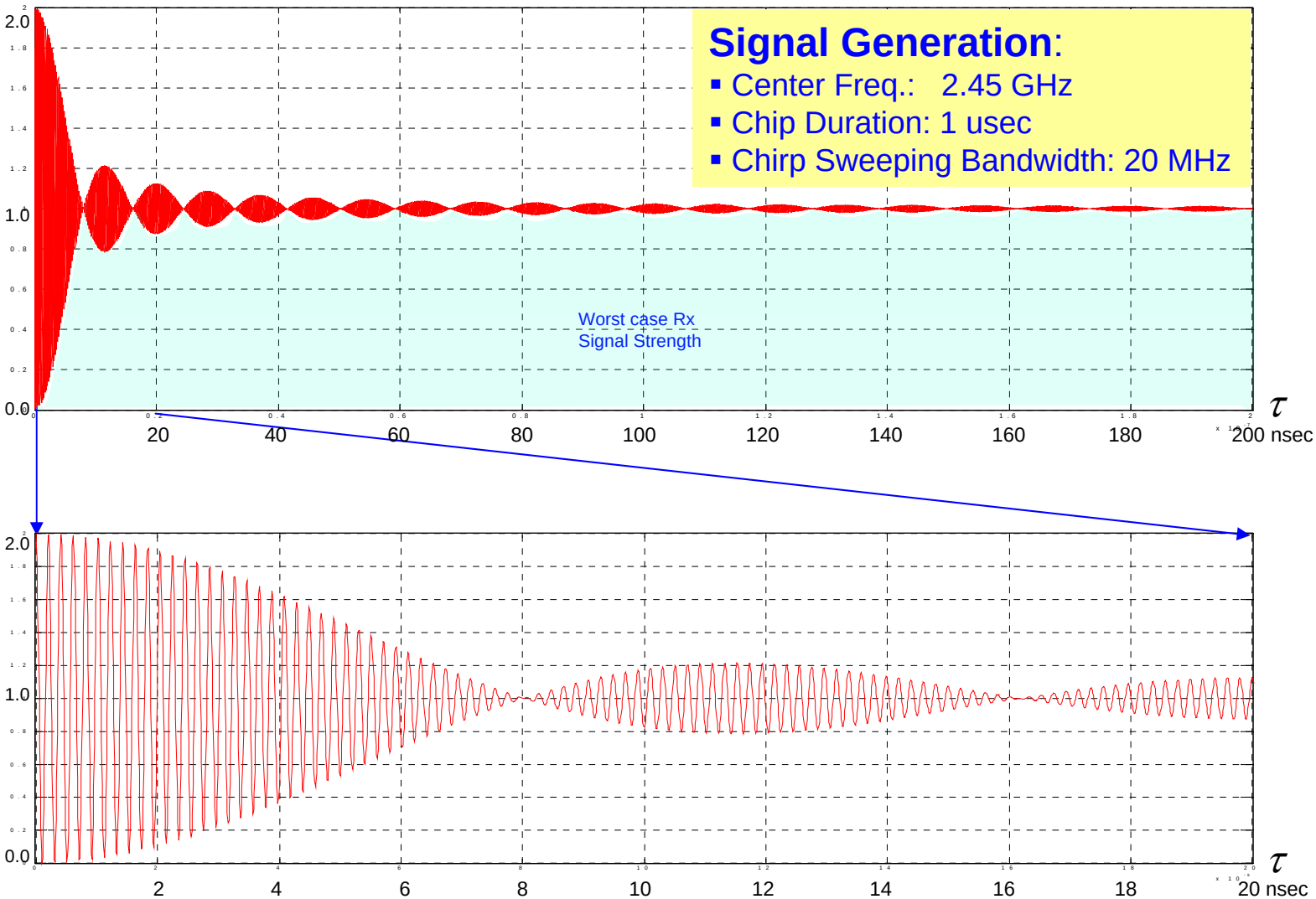
2-path Combining Property of Isolated DSSS



2-path Combining Property of Isolated CSS

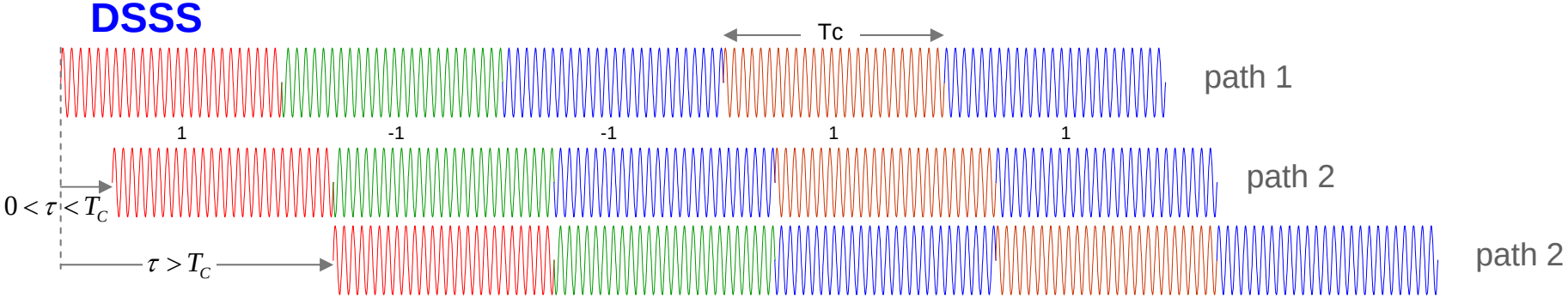


2-path Combining Property of Isolated CSS



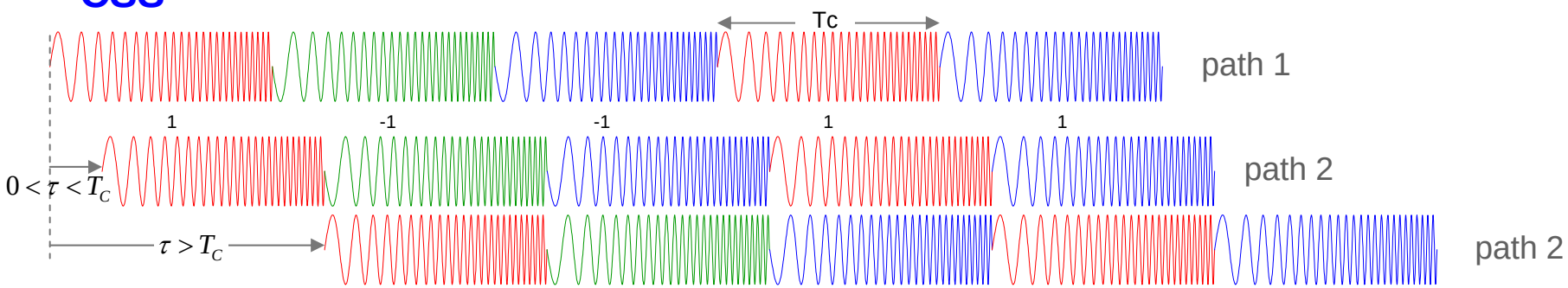
DSSS vs CSS

DSSS



- 0 < τ < Tchip: Not Resolvable
- τ > Tchip: Resolvable

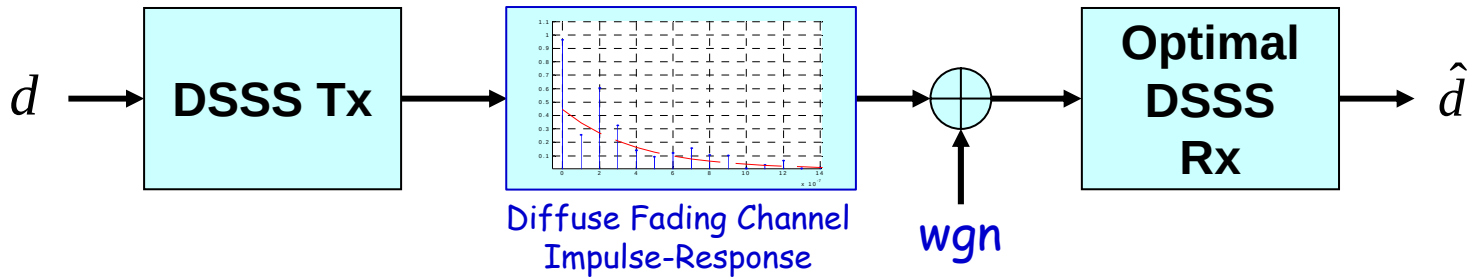
CSS



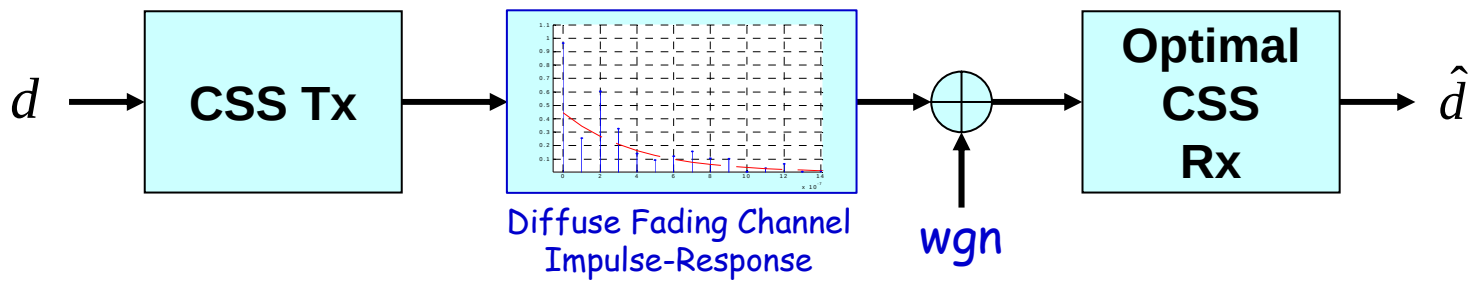
- 0 < τ < Tc: Resolvable
- τ > Tc: Resolvable

Performance over Exponential Diffused Channel

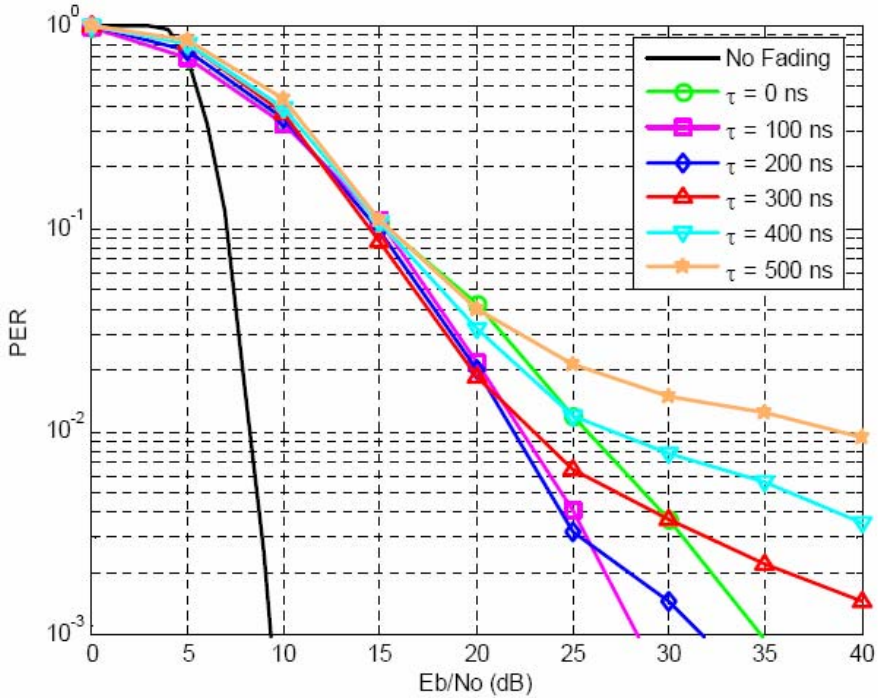
DSSS Transceiver



CSS Transceiver

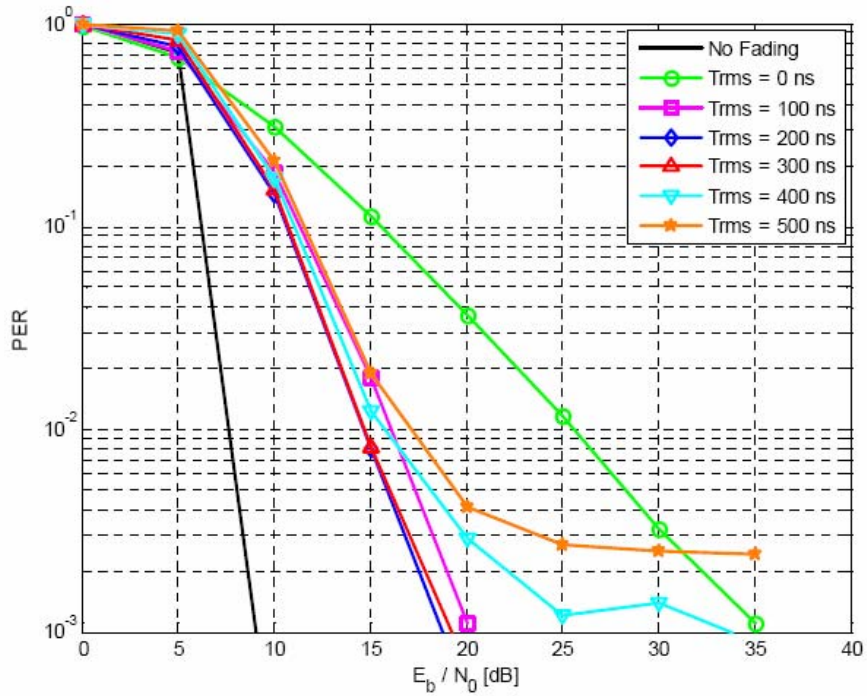


PER over Exponential Diffused Channel



IEEE 802.15.4 Performance (250Kbps)

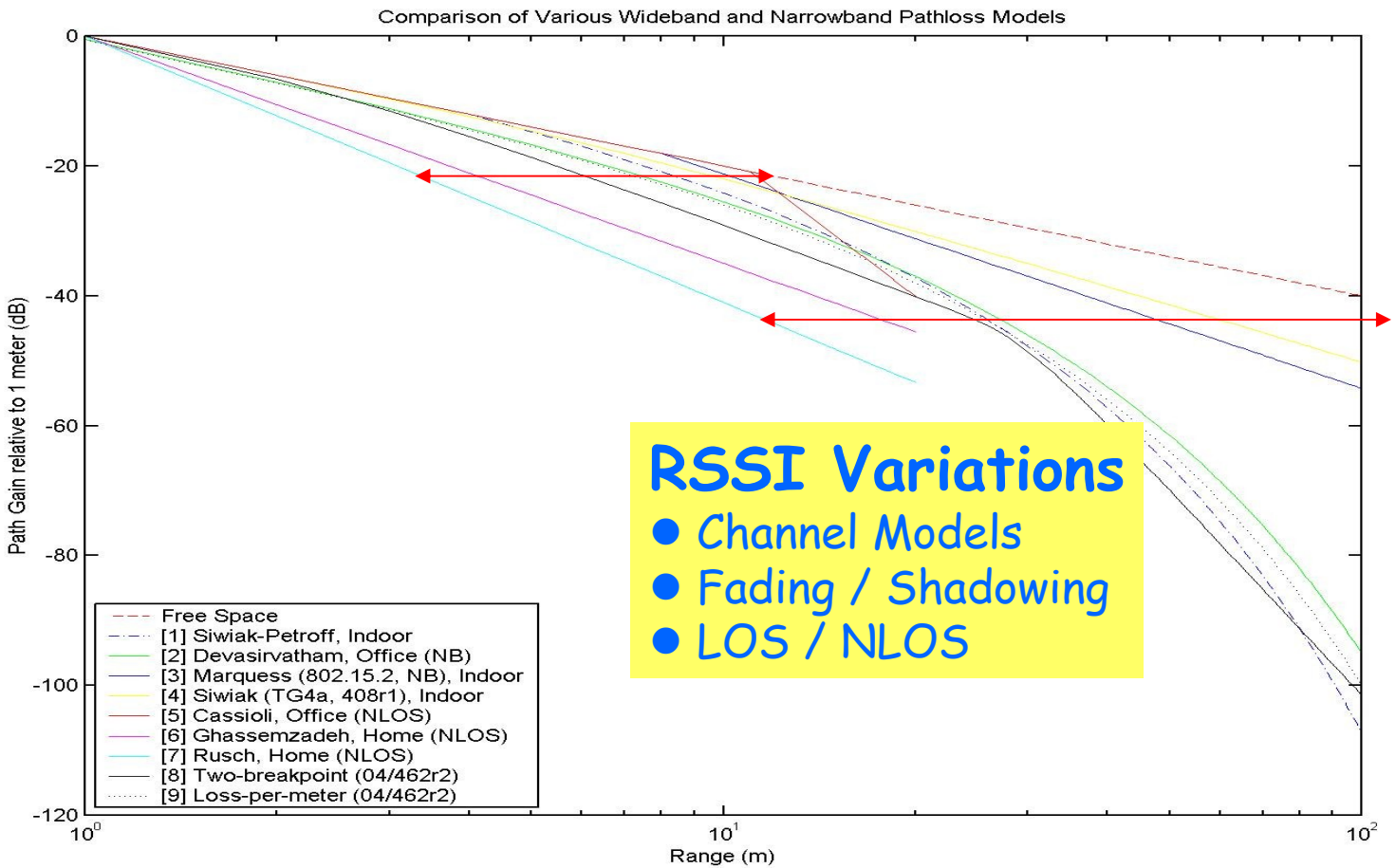
Reference: IEEE15-04-0337-00-004b



IEEE 802.15.4a Performance (1 Mbps)

Reference: IEEE 15-06-0116-01-004a

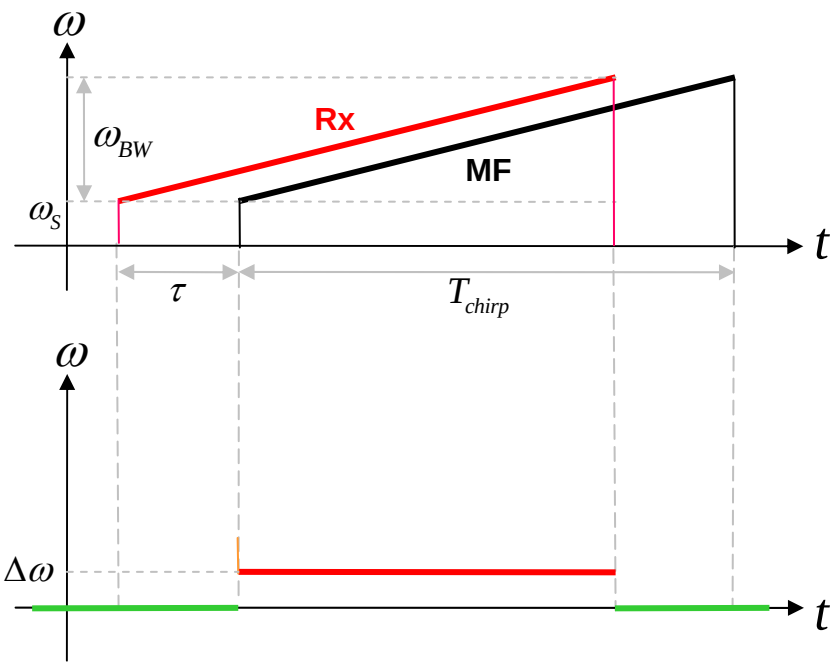
RSSI Ranging: Poor Accuracy



Ranging with CSS: ToA/TDoA

Property of Chirp-Signal

$$\tilde{s}_{chirp}(t) = \exp\left[j\left(\omega_s + \frac{\omega_{BW}}{2T_{chirp}} t \right) t \right] \times p(t)$$



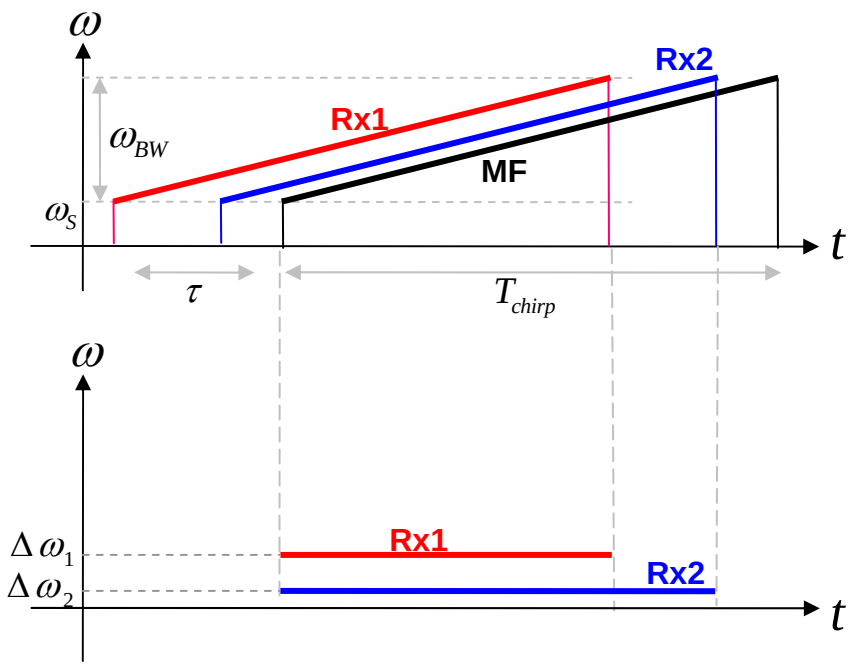
Freq-offset ($\Delta\omega$) caused by Time-offset (τ):

$$\Delta\omega = \frac{\omega_{BW}}{T_{chirp}} \times \tau \quad \text{(Single Frequency)}$$

MF: Matched Filter

Ranging with CSS: ToA/TDoA

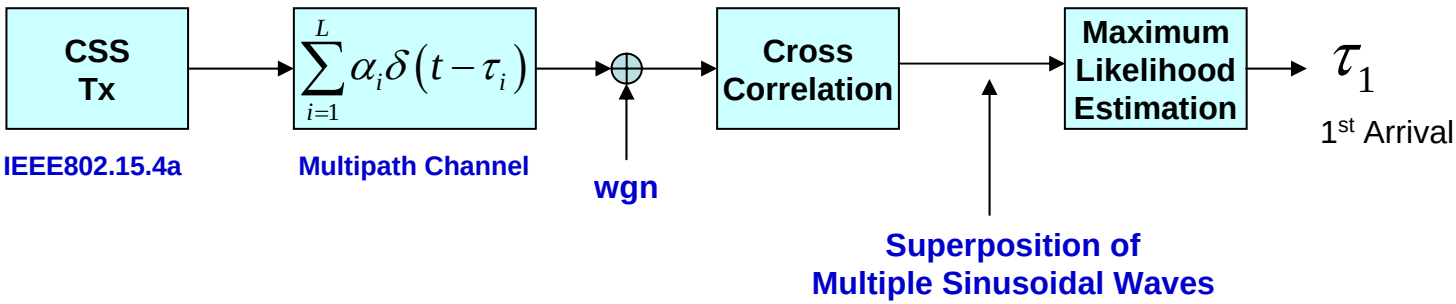
Property of Chirp-Signal



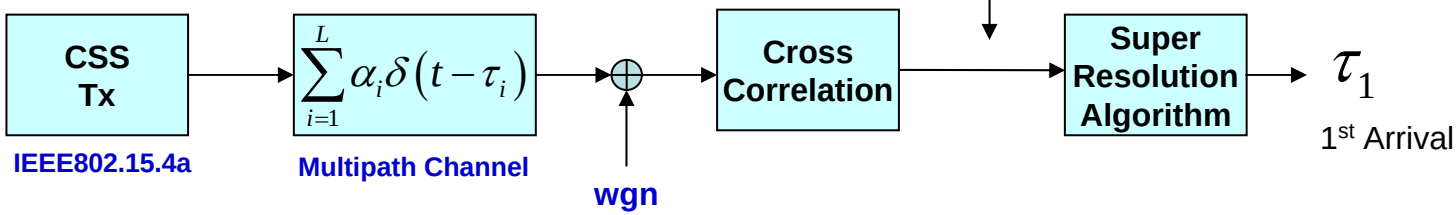
MF: Matched Filter

High Precision Ranging with CSS

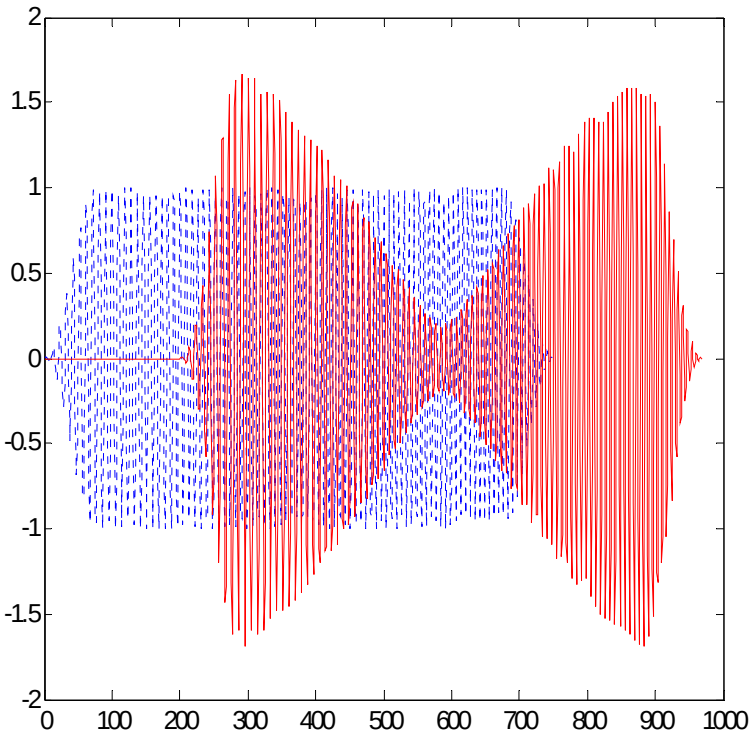
Maximum Likelihood Estimation

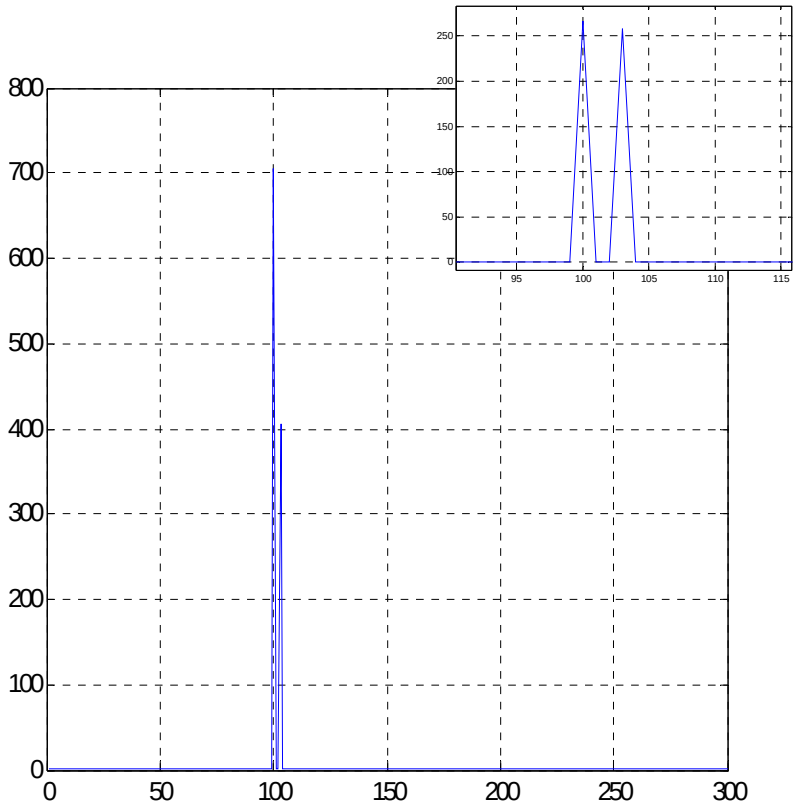


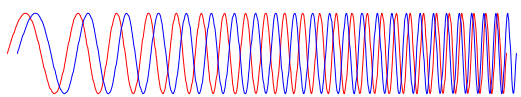
Subspace-based Method



High Precision Ranging with CSS







Conclusion

- CSS Signal is Robust over Harsh Multipath Environment
- CSS Signal has Very Good Indoor Multipath Resolvability
- Advantage for both Data Communication and Ranging
- Good Solution for Narrowband High-Precision Ranging
- Less Demand of Heavy FEC Coding for Reliability