SNR 추정오류가 있는 환경에서 GNSS를 위한 LDPC 부호와 극 부호의 성능 분석

2021 IPNT Conference

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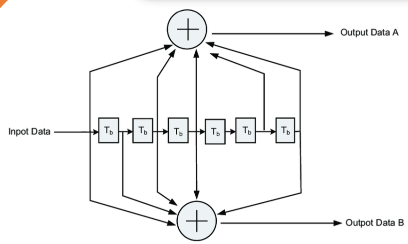
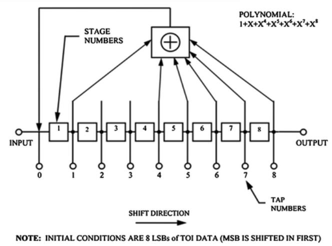
Error correction codes

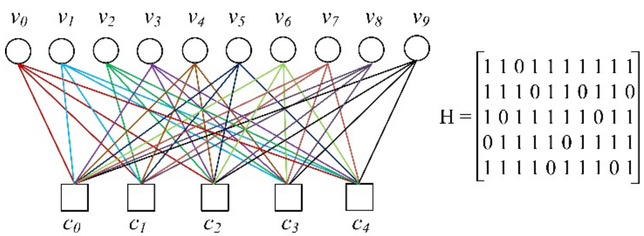
GNSS Error Correction Code



Convolutional
(GPS, QZSS, Galileo)

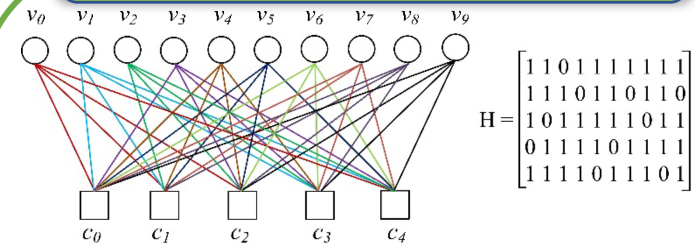


BCH, RS
(GPS L1C, Beidou B1C)

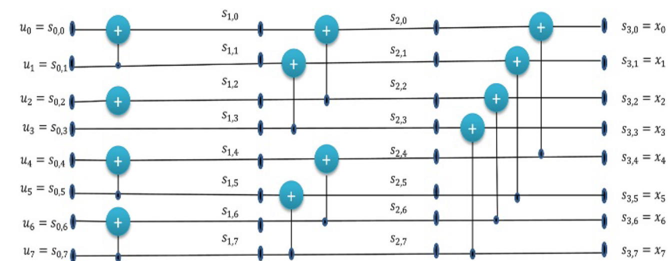


LDPC
(GPS L1C, Beidou)

5G NR Error Correction Code



LDPC
(Data channel)



Polar
(Control Channel)

Low complexity

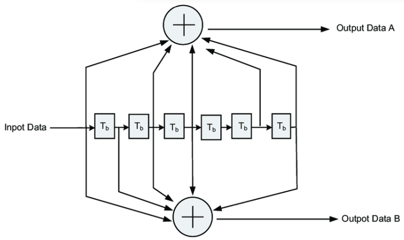
Bad FER performance

High complexity

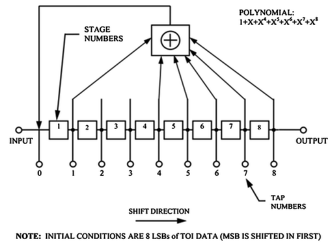
Good FER performance

Error correction codes

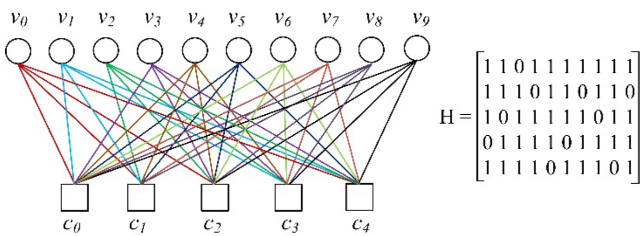
GNSS Error Correction Code



Convolutional
(GPS, QZSS, Galileo)

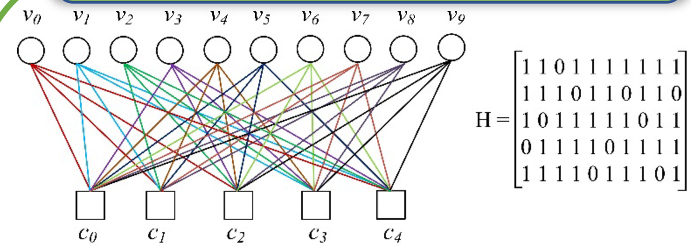


BCH, RS
(GPS L1C, Beidou B1C)

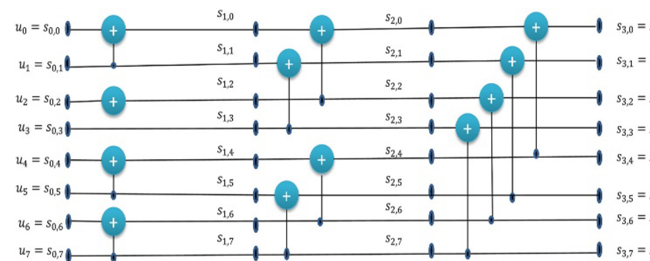


LDPC
(GPS L1C, Beidou)

5G NR Error Correction Code



LDPC
(Data channel)



Polar
(Control Channel)

Low com… …**omplexity**

Bad F… …**ER performance**

Jamming GNSS Channel

Wouldn't we need High complexity, Good FER performance codes such as polar codes ?

LDPC Codes

R. G. Gallager

D. J. C. Mackey

- Low density parity check (LDPC) codes
- 1962년 R. Gallager가 제안, 1990년 D. MacKay에 의해 재발견
- 부호어 길이가 충분히 큰 경우, <u>반복 복호</u>를 통해 채널 용량(샤논의 한계)에 근접한 성능을 보임
- 패리티 검사 행렬 내 저밀도 (low density) 의 1로 구성
- 활용 분야
  - 무선 통신 (ex. ETSI DVB-S2, IEEE 802.11n(wifi), 5G NR data channel, **GPS L1C, BEIDOU B1C, B2a**)

Polar Codes

E. Arikan

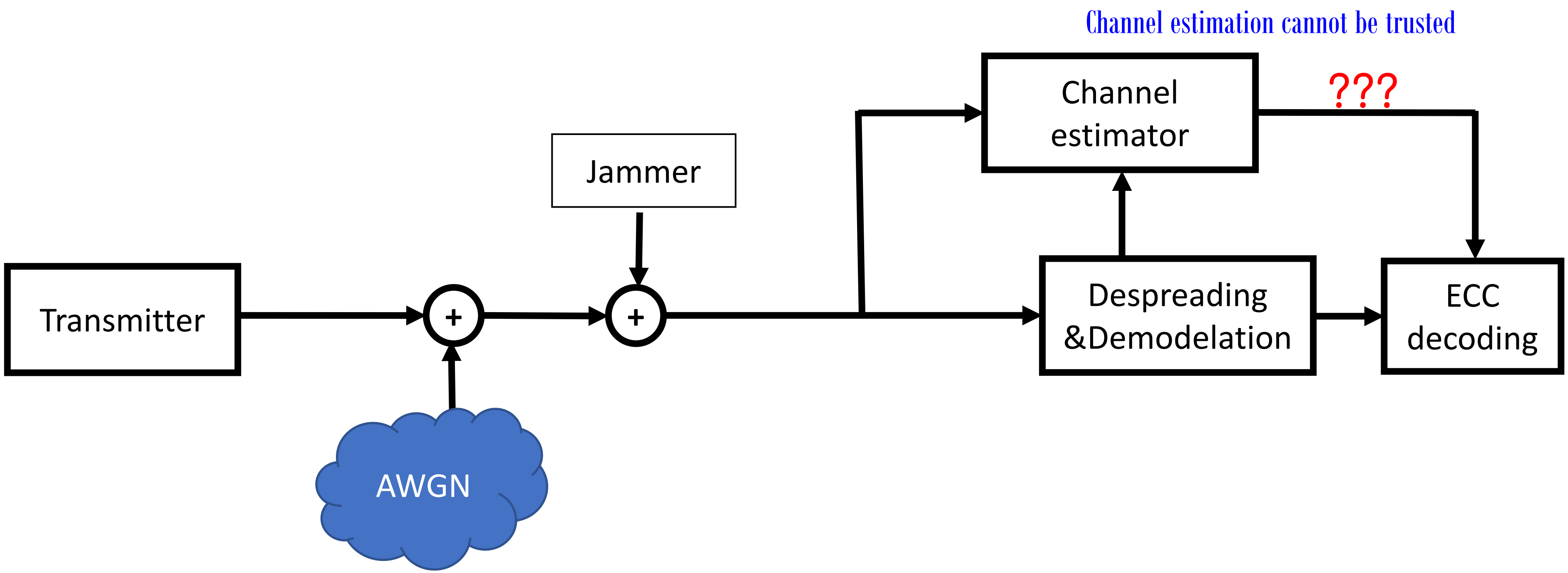
- 2009년 E.Arikan이 제안한 이진 부호
    - 샤넌 채널용량을 달성하는 최초의 부호
- 채널용량의 양극화를 이용한 코드로써 Polar code라고 명함
- Soft decision decoding(SC decoding, SCL deciding, CA-SCL decoding)을 사용하여 우수한 성능을 가짐
- 활용 분야
    - 무선 통신 (ex. 5G NR control 채널)

How about for GNSS?

Channel codes

부호 계열	사용되는 부호 계열	신호 종류
BCH 부호	[52,9] extended BCH	GPS L1C
	[51,8] BCH	Beidou B1C
RS 부호	$[246,214]_{2^8}$ RS	QZSS L6S
Convolution 부호	[600 300] convolutional(171, 133)	GPS L2C/L5 QZSS L1S Galileo
LDPC 부호	[1200,600] LDPC	GPS L1C
	[584,274] LDPC	
	LDPC **(code length: 1000~30000)**	5G NR data channel
Polar 부호	Polar **(code length: <1000)**	5G NR control channel

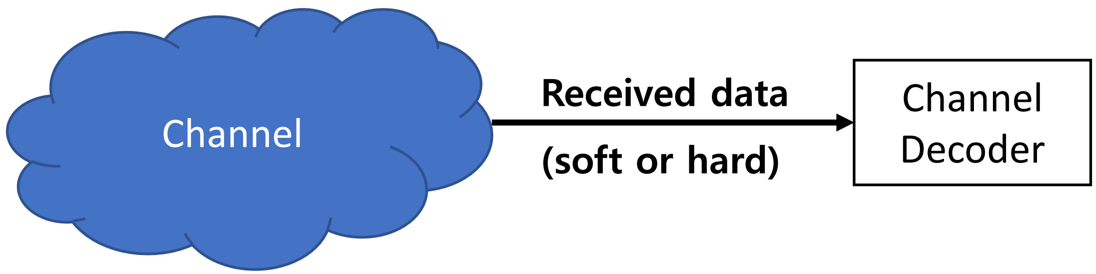
GNSS jamming channel



FER performance **with mismatched channel information (SNR)** is one of the FoM for GNSS channel codes

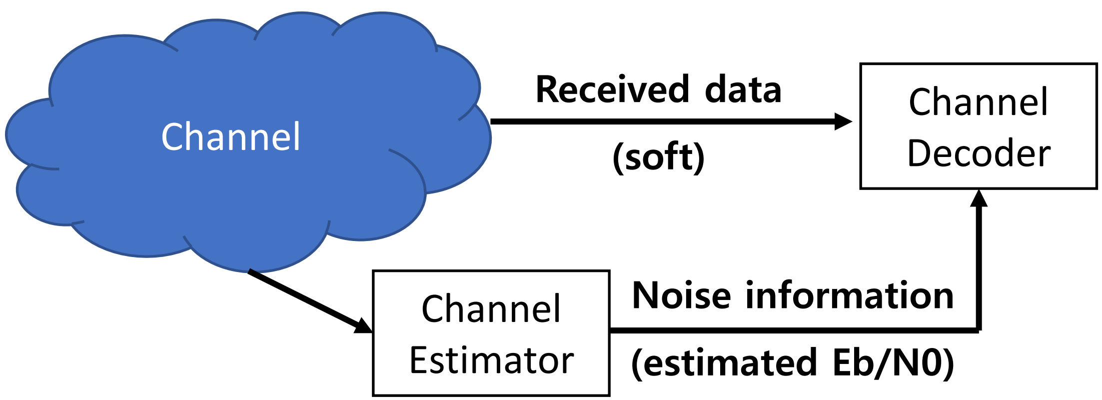
Channel estimation for channel decoding

- **Do not need channel estimation for channel decoding: BCH**(ML soft decision decoding), **RS**((Hard decision)BM decoding), **Convolutional(**Soft decision Viterbi decoding in AWGN)

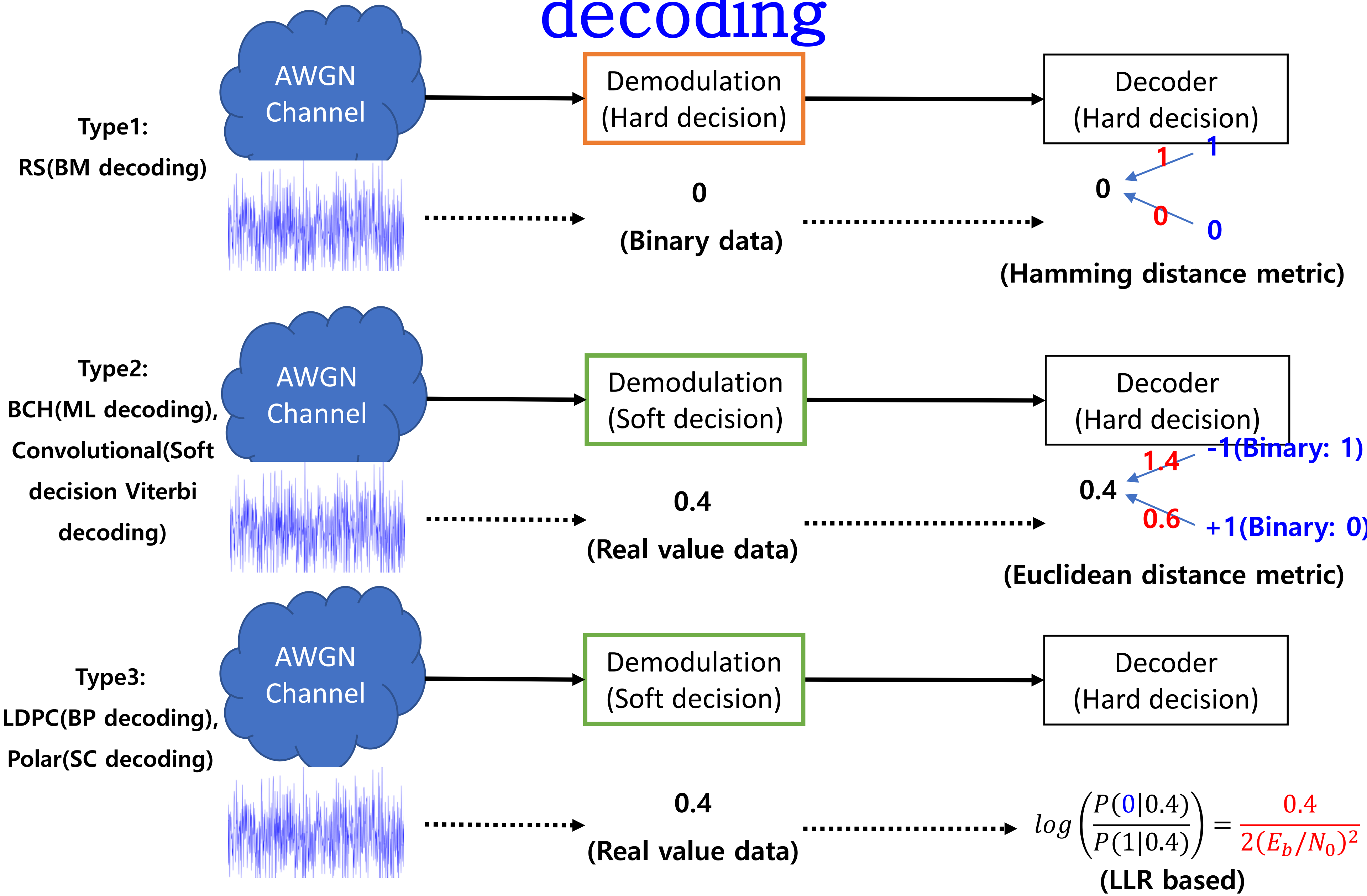


- **Need channel estimation for channel decoding:**

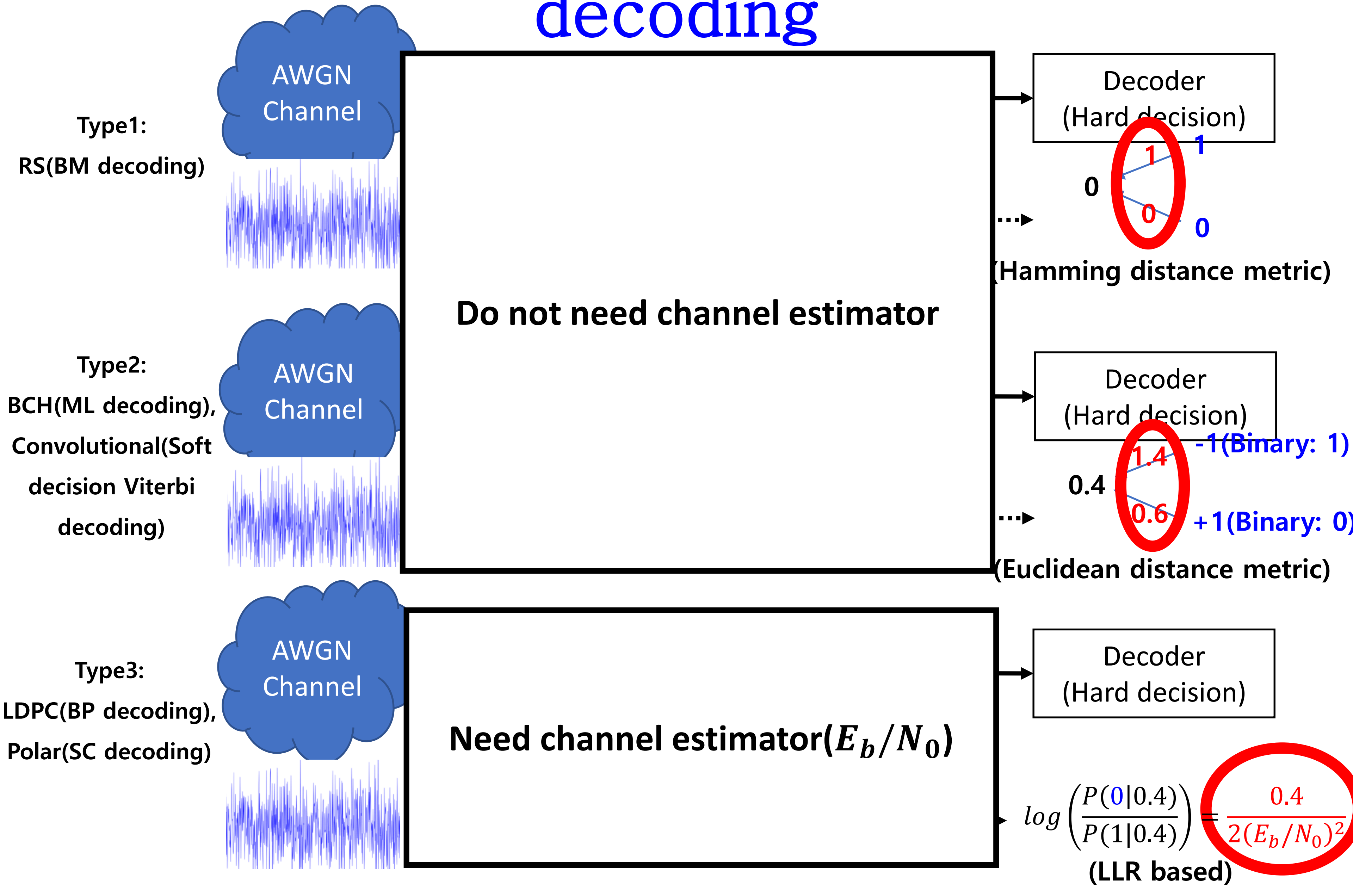
  LDPC((Soft decision) BP decoding)**, Polar**((Soft decision) CRC aided SCL decoding)



Channel estimation for channel decoding

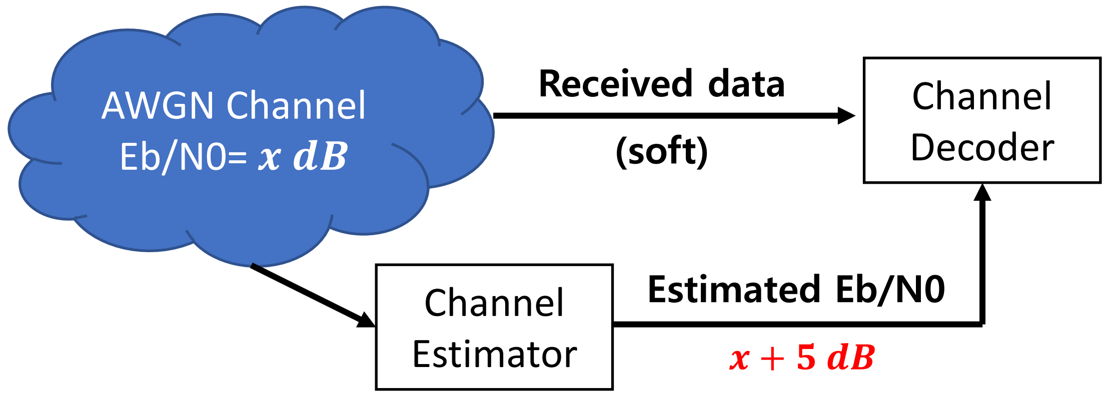


Channel estimation for channel decoding

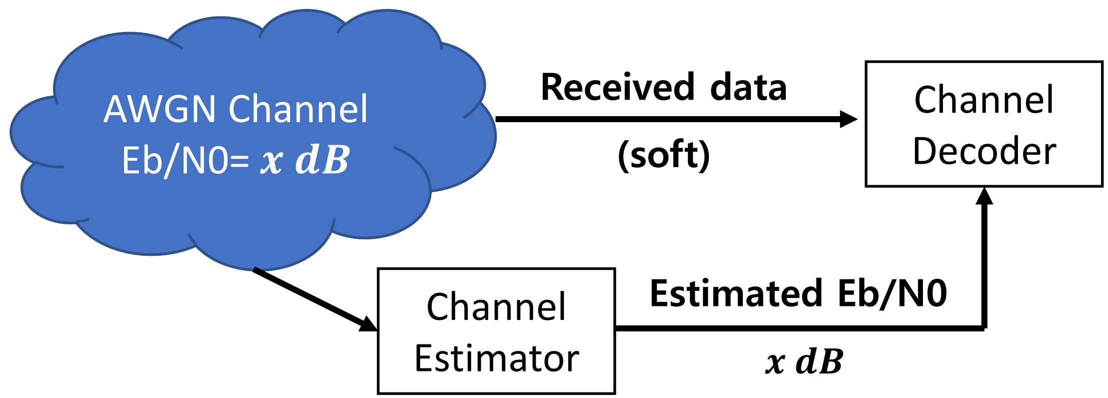


Simulation setting

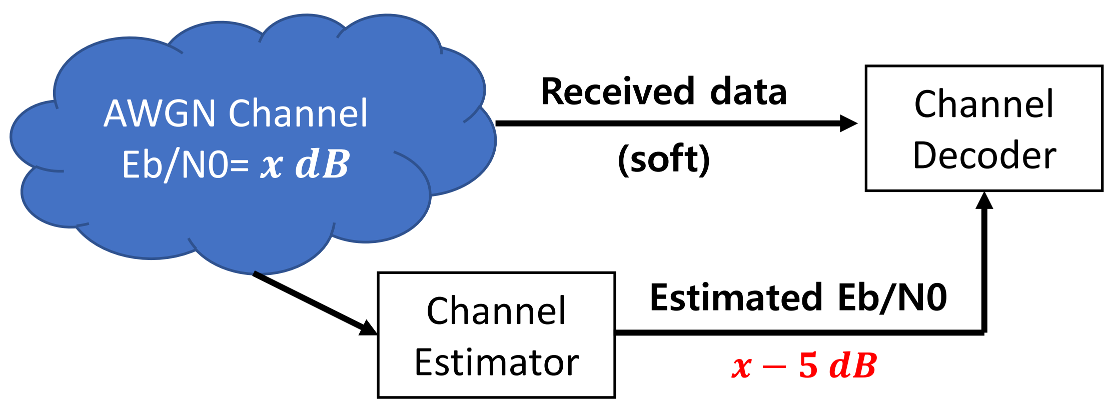
Mismatched channel estimation ($+5dB$)



Correct channel estimation

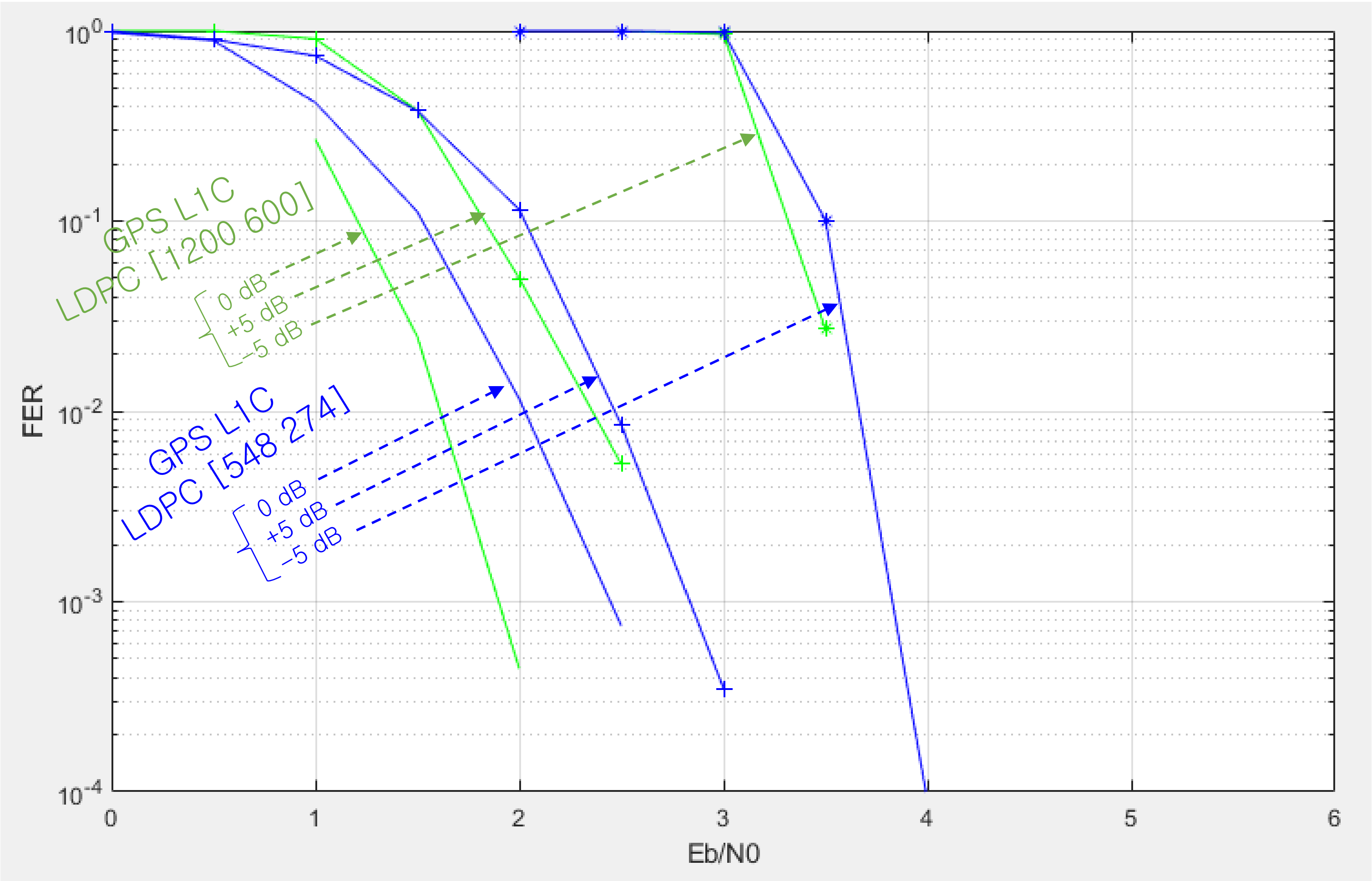


Mismatched channel estimation ($-5dB$)



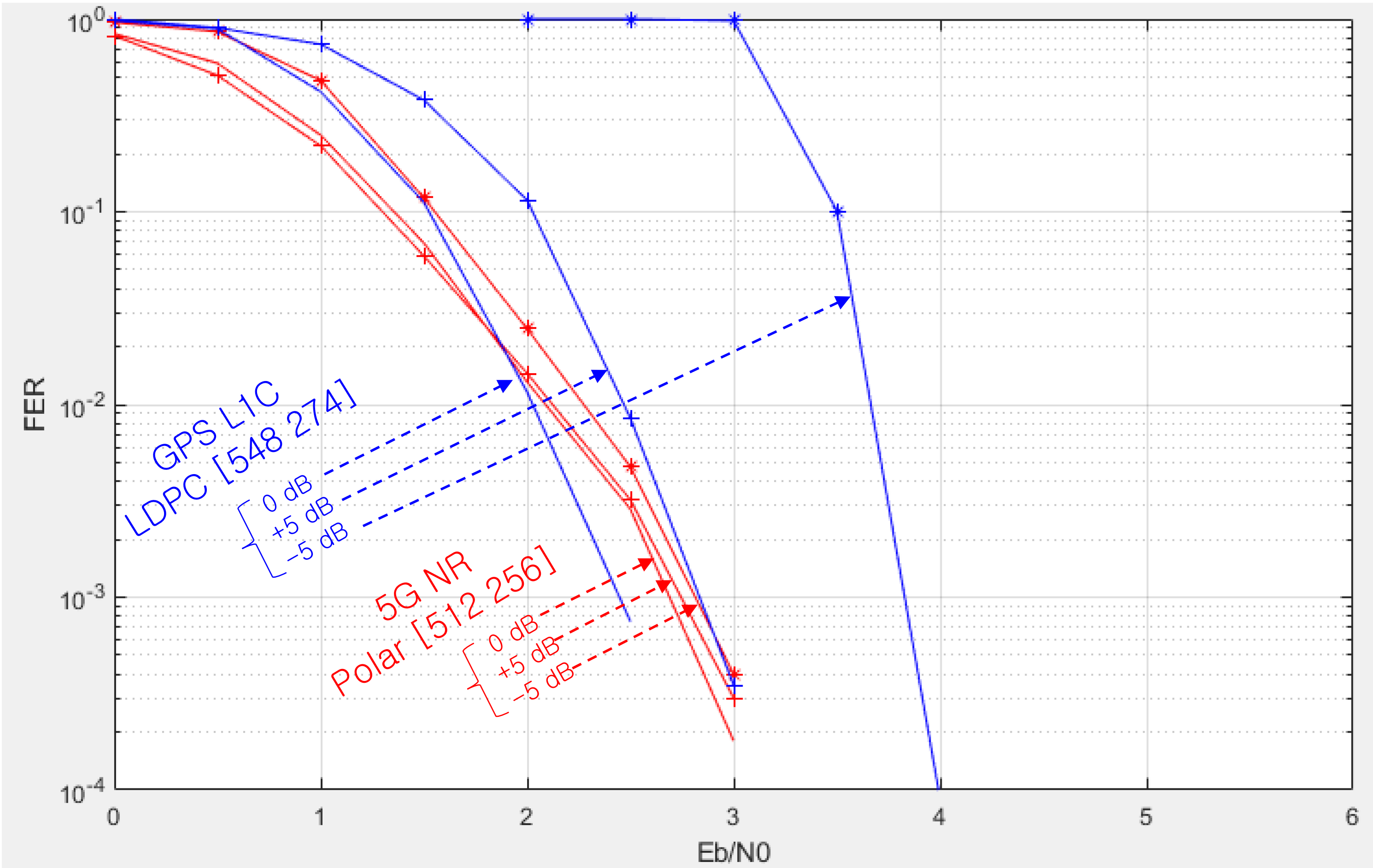
LDPC FER in mismatched SNR

✓ LDPC 부호는 mismatched SNR에 매우 취약함



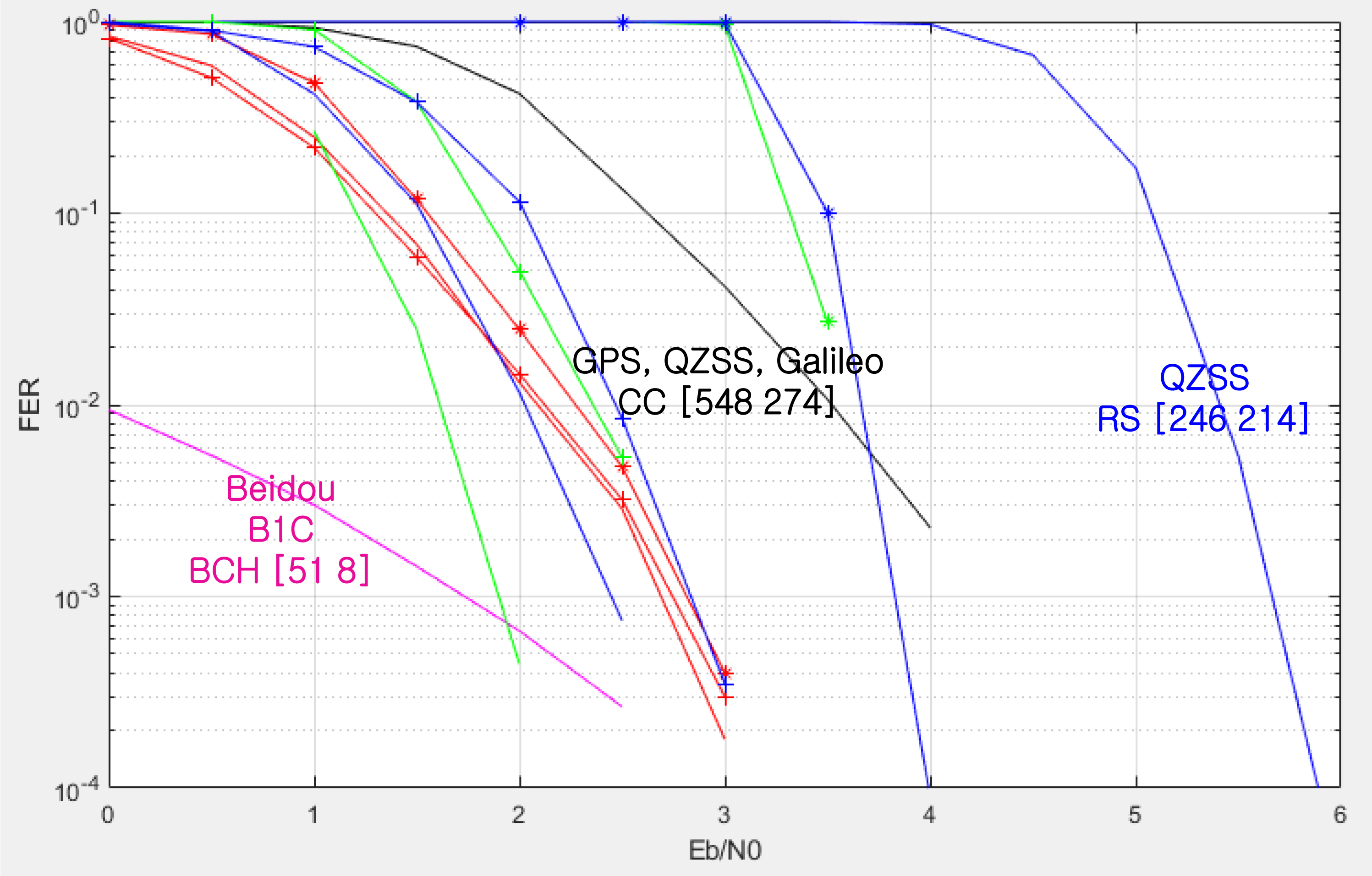
Polar FER in mismatched SNR

✓ Polar 부호는 mismatched SNR에 매우 강인함



Compare with other GNSS codes

- ✓ 추가적으로 AWGN 채널에서 CC, BCH, RS 부호의 FER 성능 측정
- ✓ Mismatched SNR에서의 LDPC 및 polar 부호는 CC보다 성능이 좋음



Conculusion

SNR 추정오류가 있는 환경에서 극 부호와 LDPC 부호의 FER을 분석

- ✓ Mismatched SNR에서의 성능 열화는 LDPC에서 많이 발생하고 극 부호에서는 거의 발생하지 않음
- ✓ 비슷한 파라미터의 컨볼루셔날 부호와 비교하였을 때 추정오류가 존재하는 상황에서도 LDPC와 Polar의 성능이 좋음
- ✓ 추후 GNSS의 더 다양한 재밍 채널상황에서 극부호의 FER 특성을 분석하여 효용성 제시

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