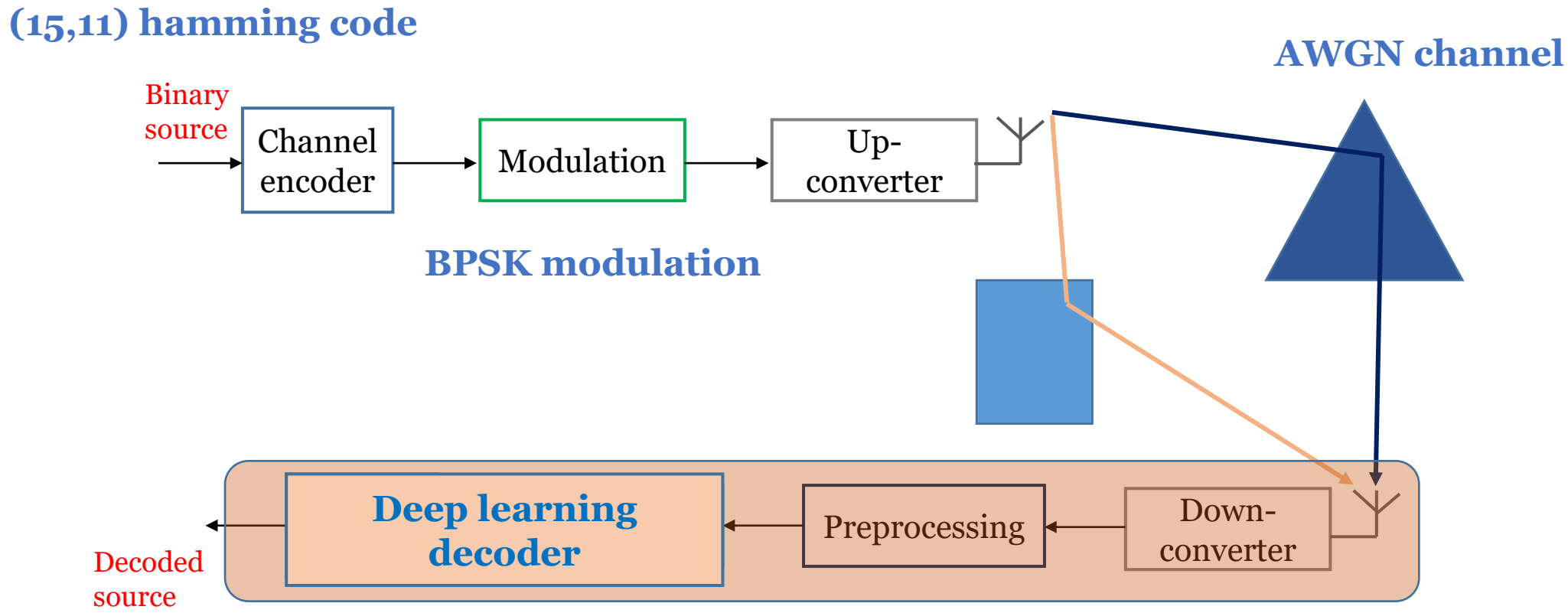
AI Lab for Wireless Communications

Week5 – Mini project

System model



Encoding part

- (15,11) Hamming code
- Relationship: $\boldsymbol{c = mG}$, $\boldsymbol{rH^T = 0}$,
- Parity check matrix

$$H = \begin{bmatrix} 1 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 1 & 1 & 0 & 1 & 1 & 0 & 0 & 1 & 0 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 1 & 0 \\ 1 & 1 & 1 & 1 & 0 & 1 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} = [P^T \quad I_4]$$

$$G = [I_{11} \quad P]$$

Modulation & AWGN channel

- When transmit, we map coded bits to baseband signal
- Binary phase shift keying (BPSK)

$$x_i = \sqrt{P}(2c_i - 1), \qquad \boldsymbol{x} = [x_1, \dots, x_n]$$

- Additive white Gaussian noise (AWGN) channel

$$y_i = x_i + w_i,\ \ w_i \sim N(0, \frac{N_0}{2}),\ \ \boldsymbol{y} = [y_1, \dots, y_n]$$

Noise in Communication System

- How to simulate the noisy channel?
  - ➢Set a target signal to noise ratio (SNR)
  - ➢Calculate the related signal power and noise power
  - ➢Generate the noise sequence and add it to the signal

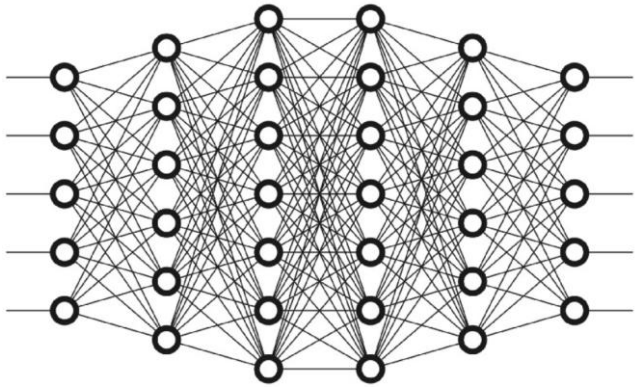
$$SNR = 10\log_{10}\frac{\sigma_s^2}{\sigma_w^2} \Rightarrow \sigma_s^2 = \sigma_w^2 \times 10^{-\frac{SNR}{10}}$$

σ_s^2: signal power (variance) σ_w^2: noise power (variance)

- For complex signal, the noise is also complex. The calculated variance has to be divided by two for the generation of real or imaginary signal/noise

Decoding part

- Formulate decoding problem as a classification problem
- Design your own model



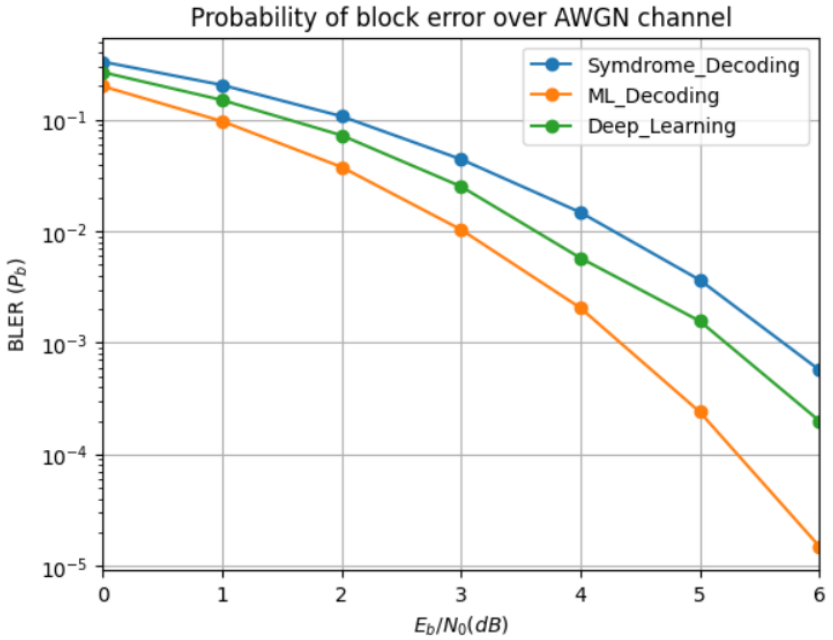
- Bonus – Directly decode by a DNN model
  - Input: received codeword
  - Output: recovered message

Lab for Today

- Implement the whole communication system
- Apply a DNN model for the decoder
- Demo
  - Part 1 (SNR=0~6) – Show the curve
  - Part 2 (SNR=6) – BLER competition

Top 1/3:	100
Top 2/3:	95
BLER $\leq 6 \times 10^{-4}$	90

  - Model requirement
    - Epoch ≥ 5
    - # of layers ≥ 3



Module 1 - Report Assignment

- Hand in a lab report including
  - ➢Description and final results of mini project
  - ➢Description and discussion of all decoding method in Module 1
  - ➢Simulation results (BLER of all decoding method) is necessary!
- **Deadline 3/31**