Chapter 2

System Model

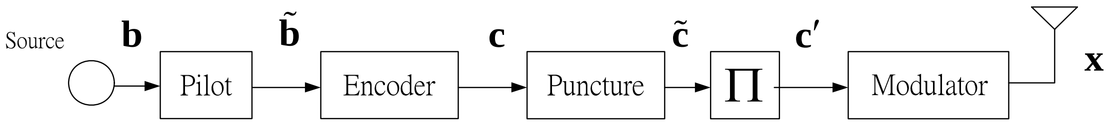

Fig.2-1: Transmitter

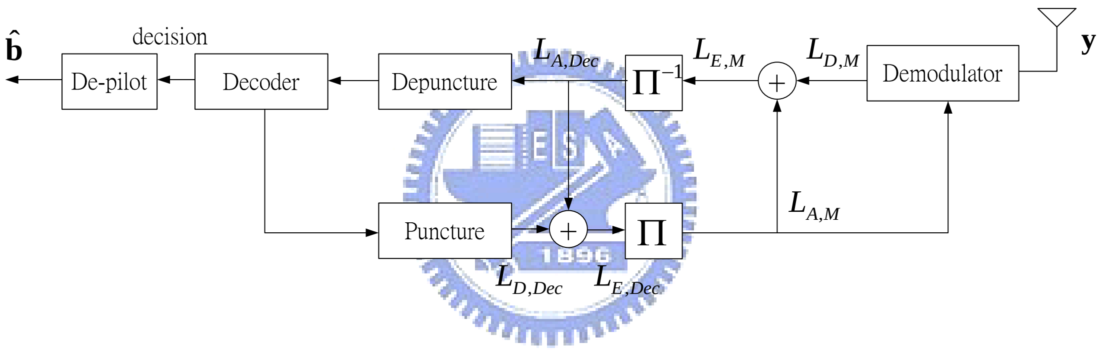

Fig. 2-2: Receiver

Notations in Fig.2-1 and Fig.2-2:

$\mathbf{b}$: the information bit sequence

$\tilde{\mathbf{b}}$: the bit sequence after inserting pilot bits

$\mathbf{c}$: the coded bit sequence

$\tilde{\mathbf{c}}$: the bit sequence after puncturing

$\mathbf{c}'$: the interleaved bit sequence of $\tilde{\mathbf{c}}$

$\mathbf{x}$: the transmitted symbol vector

$\mathbf{y}$: the received channel output symbol vector

$L_{D,M}$: the a posteriori log likelihood ratio of $\mathbf{c}'$ at the output of the demodulator

$L_{A,M}$: the a priori log likelihood ratio of $\mathbf{c}'$ going into the demodulator

$L_{E,M}$: the extrinsic log likelihood ratio of $\mathbf{c}'$ at the output of the demodulator

$L_{D,Dec}$: the a posteriori log likelihood ratio of $\tilde{\mathbf{c}}$ going into the puncturer

$L_{A,Dec}$: the a priori log likelihood ratio of $\tilde{\mathbf{c}}$ at the output of the puncturer

$L_{E,Dec}$: the extrinsic log likelihood ratio of $\tilde{\mathbf{c}}$ at the output of the puncturer

We consider a bit-interleaved coded modulation with iterative decoding (BICM-ID) system . In the transmitter, we add pilot bits into to information bits before entering the encoder. After encoding, puncturing scheme is applied. The details about pilot-insertion and puncturing are discussed in the following chapters.

The i*th* channel output y_i under AWGN channel is given by

$$y_i = x_i + n_i \quad , \quad i = 0,1,...,N_s - 1 \tag{2.1}$$

Where n_i is Gaussian distributed with zero mean and variance $\sigma_n^2 = N_0/2$ and N_s is the number of the transmitted symbols. In this chapter, we will introduce the basic knowledge of a BICM-ID system.

2.1 Encoder

The encoder we use here is a convolutional encoder, but it can be another encoder such as a Turbo code encoder or a low-density-parity-check (LDPC) encoder. We use a code rate 1/2 convolutional code of memory 6, and the industry-standard generator polynomials are $(g_0, g_1) = (133_8, 171_8)$, as shown in Fig.2-3.

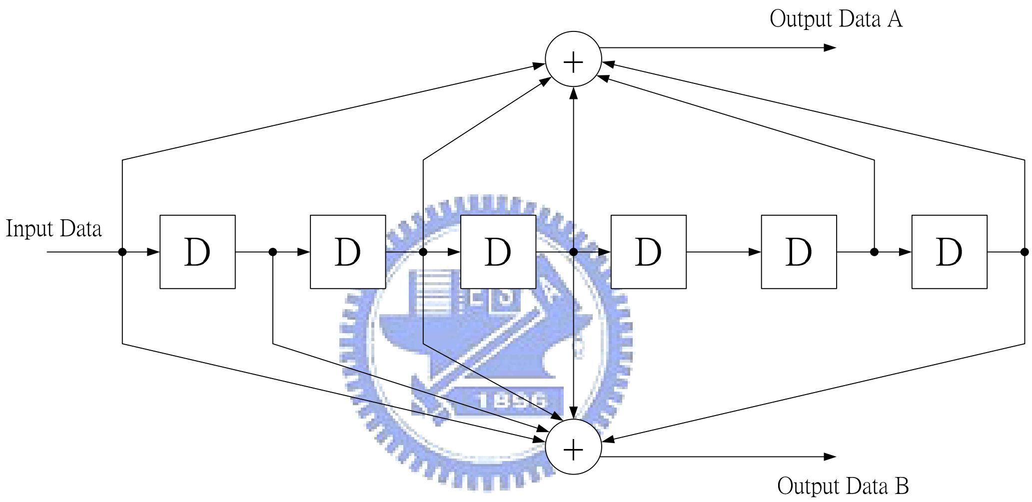

Fig. 2-3: The convolutional encoder (K=7, R=1/2)

2.2 Bit interleaving

In order to avoid burst errors, the interleaving technique is utilized . In the BICM system , coded and punctured bits are interleaved through a bit-level interleaver before mapping to symbols. There are many different designs on the interleavers. In this thesis, we choose the S-random interleaver [12], [13].

An S-random interleaver guarantees that the two bits within a distance S_1 at the interleaver input can not be mapped to a distance less than S_2 apart at the interleaver output. Usually $S_1=S_2=S_{sq}$ is chosen. Considering the two inputs i and j , such that

$$0 < |i - j| < S_{sq} \tag{2.2}$$

then the design guarantees that

$$|\Pi(i) - \Pi(j)| > S_{sq} \tag{2.3}$$

Equations (2.2) and (2.3) are basic criterions of the S-random interleaver. There are other modifications of the S-random interleaver that may bound the sum of the length of the error events at the input and at the output of the interleaver [14]. In this thesis, if the size of one frame is large enough, we let S_{sq} be larger than 5 times of the constraint length of the outer code.

2.3 Signal mapping

The interleaved bits should be modulated by BPSK, QPSK, 16QAM and 64QAM with the well known labeling methods, such as Gray, Anti-Gray and Natural. In the chapter 6, we will design other bit-mappings suited for the outer codes that we choose to achieve higher performance.

In this thesis, we focus on the constellations of 16QAM and 64QAM with Gray [15], Anti-Gray and Natural labeling , as shown in the Fig.2-4 to Fig.2-8.

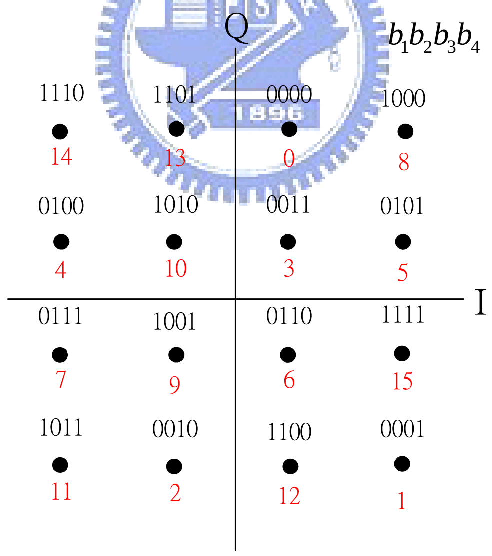

Fig. 2-4: 16QAM, Anti-Gray labeling

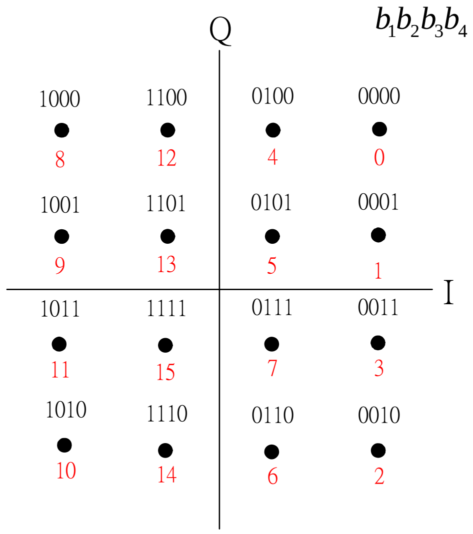

Fig. 2-5: 16QAM, Gray labeling

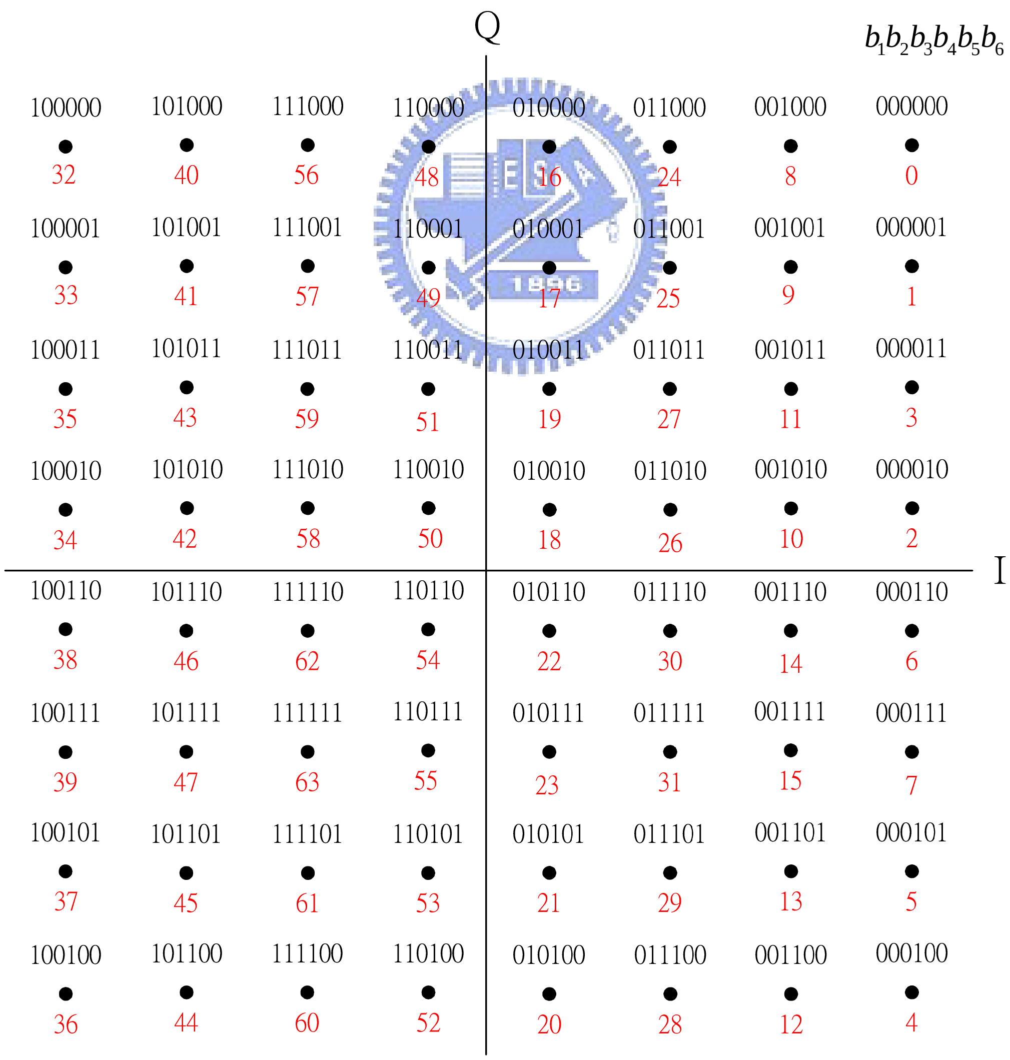

Fig. 2-6: 64QAM, Gray labeling

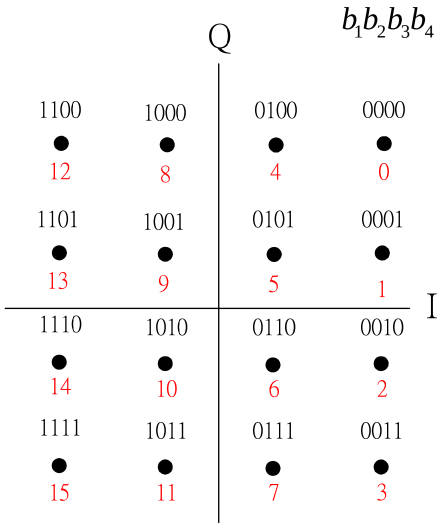

Fig. 2-7: 16QAM, Natural labeling

Fig. 2-8: 64QAM, Natural labeling