M1 課題レポート 第1回目

りゅう　ゆしん†

† 東京工業大学　〒152-8550　東京都目黒区大岡山 2-12-1
E-mail: †liuyuchen@radio.ict.e.titech.ac.jp

Technical Report for M1 Labwork 1-st

Yuchen LIU†

† Tokyo Institute of Technology, 2-12-1, O-okayama, Meguro-ku, Tokyo, 152-8550 Japan
E-mail: †liuyuchen@radio.ict.e.titech.ac.jp

Abstract In this first C workshop, we will use C langaugae to simulate the workflow of a QPSK modulation and dection system over AWGN channel. In the begin, this report will introduce the overall design of the communicion system. Then the background knowlege is introduced. Final part is the simulation desgin come with simulation result compared to theoretical value.

1. Introduction

QPSK is kind of digital phase shifting modulation method, which conveys data by changing the phase of a constant amplitude high freuqency carrier. Compared with BPSK, which can only use two phases, QPSK can utilize four phases, and one symbol is able to convey 2 bits of information. QPSK is widly deployed in system like wireless LANS, RFID, Bluetooth, etc. To map the bit to QPSK symbol, we aslo adopt gray code which is an ordering of the binary numeral system that two successive values differ in only one bit. Gray code is an effective strategy to improve total system performance.Corresponding bit mapping is in Table 1.

The channel we choose to conduct the simulation is AWGN, which is the simplest model to mimic the effect of many random process that occurs in nature due to thermal phenomenon. The expression formula is as followed:

$$R(t) = S(t) + N \tag{1}$$

$R(t)$ is received signal and $S(t)$ is transmitted signal, W is AWGN. The characteristic of AWGN is a normal ditribution in time domain, Guassian ditribution in amplitude and is able to directly add in original signal [1].

In the receiver side, we use MLE as our estimation method to determine received symbol in constellation diagram [2]. MLE is a method to estimate parameters of a

Table 1 MAPPING TABLE OF PHASE

bitA bitB	$\Delta\theta_i$
0 0	$\frac{\pi}{4}$
1 0	$\frac{3\pi}{4}$
1 1	$\frac{5\pi}{4}$
1 0	$\frac{7\pi}{4}$

Table 2 ACRONYMS AND FULL MEANING

Acronyms	**Full Form**
MLE	Maximum Likelihood Estimator
QPSK	Quadrature Phase Shift Keying
SNR	Signal Noise Ratio
CNR	Channel Noise Ratio
BPSK	Binary Phase Shift Keying
AWGN	Additive White Gaussian Noise
BW	Band Width

probablity distribution by maximizing a likelihood function. The genral form of MLE is shown:

$$\hat{\theta} = \underset{\theta \in (\frac{\pi}{4}, \frac{3\pi}{4}, \frac{5\pi}{4}, \frac{7\pi}{4})}{\arg\max} \|R(t) - \theta_i\| \tag{2}$$

In our caese, the likelihood function is the distance between received signal and constellation diagram.

2. Simulation and Result

In our simulation, first we use C standard liabray rand() function to generate information bits, and then convert serial bit to 2 parallel bit and map the bit to QPSK sym-

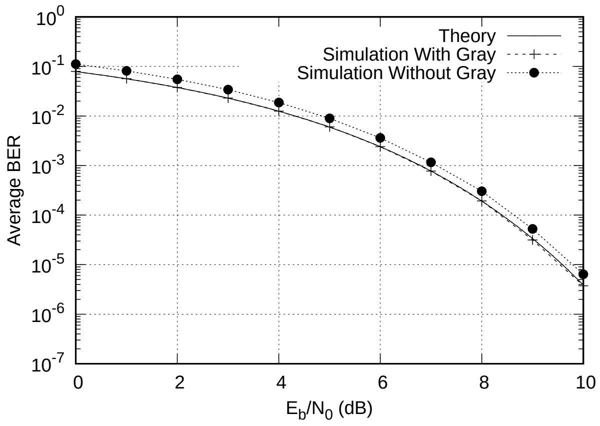

Fig. 1 QPSK BER IN DIFFERENT SNR

bol. To generate noise to simulate channel, we adopt Box-Muller method, the formula is shown:

$$n_k = \sqrt{-\sigma_n^2 \ln(u_1)} e^{j2\pi u_2} \tag{3}$$

In this equation, u_1 and u_2 are uniform distribution ranging from 0 to 1, which can be generated by C rand() function. The σ_n^2 is noise power which is:

$$\sigma_n^2 = 10^{-\frac{CNR}{10}} \tag{4}$$

CNR in our cases is SNR add 3 dB, because according to [3], modulation rotation gain of QPSK is 3 dB. Finally, we use the MEL mentioned earlier to estimation received signal and calculate BER.

In order to verify the validity of the Gray code, we run simulation on SNR from 0 to 11 dB in using gray code and without gray code two cases. The simulation parameter is shown in Table 3 and simulation result is in Figure 1. The BER of QPSK modulation over AWGN is shown as follow:

$$\frac{1}{2}\mathrm{erfc}(\sqrt{\exp(\mathrm{SNR} \cdot \frac{\ln 10}{10})})) \tag{5}$$

3. Conclusion

From Figure 2 we can see that the simulation result is very close to the theoretical value. And the BER curve withou gray code is obviously higher than deployed, this shows that Gray Code can effectively improve system performance.

Table 3 SIMULATION CONDITIONS

ITEMS	CONDITIONS
Moduation Method	QPSK
Transmission Bits	128
Channel	AWGN
Detection	MLE
Number of Trials	10^6

REFERENCE

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[3] U. Rizvi, G. Janssen, and J. Weber, “Ber analysis of bpsk and qpsk constellations in the presence of adc quantization noise,” 11 2008, pp. 1 – 5.