Coursework Exercise for the MSc Course B31SI: Principles of Mobile Communications

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Introduction

1. Aim

After you have finished all the Lab exercises for the course B31SI Principles of Mobile Communications, you should have been familiar with the use of Matlab. Also, you should have already known how to simulate a Rayleigh fading channel and the bit error rate (BER) performance of an uncoded QPSK system with an AWGN channel.

The aim of this coursework exercise is for you to demonstrate how to simulate the BER performance of an uncoded QPSK mobile communication system over a Rayleigh fading channel by using Matlab. The simulation result will be compared with the theoretical one.

2. General Information

1) You must submit a formal report containing i) the Matlab programs together with ii) the plotted figure(s) and iii) complete analytical discussions of the results. Please use the attached blue cover as a template for the cover page and fill in ALL applicable details.

   This should be submitted in Canvas as a pdf file within the deadline as announced in Canvas.

2) The Matlab m-files should also be uploaded at the same time to verify your results.

3) This coursework exercise will contribute to 25% of the total mark.

4) Your report as well as the Matlab program(s) will be marked against the following criteria:

	Criteria		Max Marks
Part 1	**Resulting figure in coursework report**	correctness, x & y axis labels, legend, title	2
	Programming	comments	2
		efficiency	2
		codes of generating source sequence	1
		codes of QPSK with Gray labelling	2
		codes of Rayleigh fading channel with AWGN	2
		codes of ML demodulation	2
Part 2	Programming	Will be judged against all applicable criteria listed above	8
	Critical analysis (comments) in report		4
	Total		25

Figure 1: Marking criteria.

Coursework Exercise

PART 1

1. Fig. 1 shows a transmission system composed of a QPSK modulator, followed by a slow Rayleigh fading channel and a QPSK demodulator.

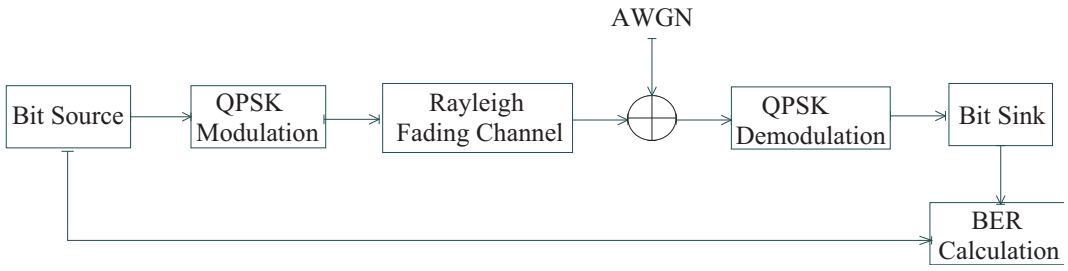


Fig. 1: A QPSK transmission system over a Rayleigh fading channel.

The QPSK signal constellation uses a Gray coding. The sum-of-sinusoids Rayleigh fading channel simulator is employed to generate the complex fading channel coefficients, which can be expressed by

$$\tilde{g}(t) = \tilde{g}_1(t) + j\tilde{g}_2(t)\,,$$

where

$$\tilde{g}_i(t) = \sum_{n=1}^{N_i} c_{i,n}\cos(2\pi f_{i,n}t + \theta_{i,n})\;, \quad i = 1, 2\;.$$

The gains $c_{i,n}$ and discrete Doppler frequencies $f_{i,n}$ are given by

$$\begin{aligned} c_{i,n} &= \sqrt{\frac{2b}{N_i}}\;, \\ f_{i,n} &= f_m \sin\left[\frac{\pi}{2N_i}(n - \frac{1}{2})\right]\;, \end{aligned}$$

respectively, while the phases $\theta_{i,n}$ are simply the realizations of a random generator uniformly distributed over $(0, 2\pi]$. The related quantities are chosen as follows: $f_m = 91\,\text{Hz}$, $b = 1/2$, $N_1 = 9$, and $N_2 = 10$.

The maximum likelihood (ML) receiver is used to detect the received signals. This means that the receiver has the knowledge of the complex fading channel coefficients. Simulate the whole transmission system by using 500000 transmission bits with the transmission rate of $R_b = 541.6$ kbits/s and the channel sampling frequency $f_s = 270.8\,\text{kHz}$.

Plot the BER for SNR $= 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20$ dB. The SNR is defined here as the ratio of the bit energy to noise power, i.e., SNR $= E_b/N_0$. Remember to save the obtained simulation results by using the Matlab function *save*. The data can be retrieved by using the function *load*.

2. For QPSK with Gray encoding over a slow Rayleigh fading channel, the theoretical BER is expressed by

$$p_b = \frac{1}{2}\left[1 - \sqrt{\frac{\overline{\gamma}_b}{1+\overline{\gamma}_b}}\right],$$

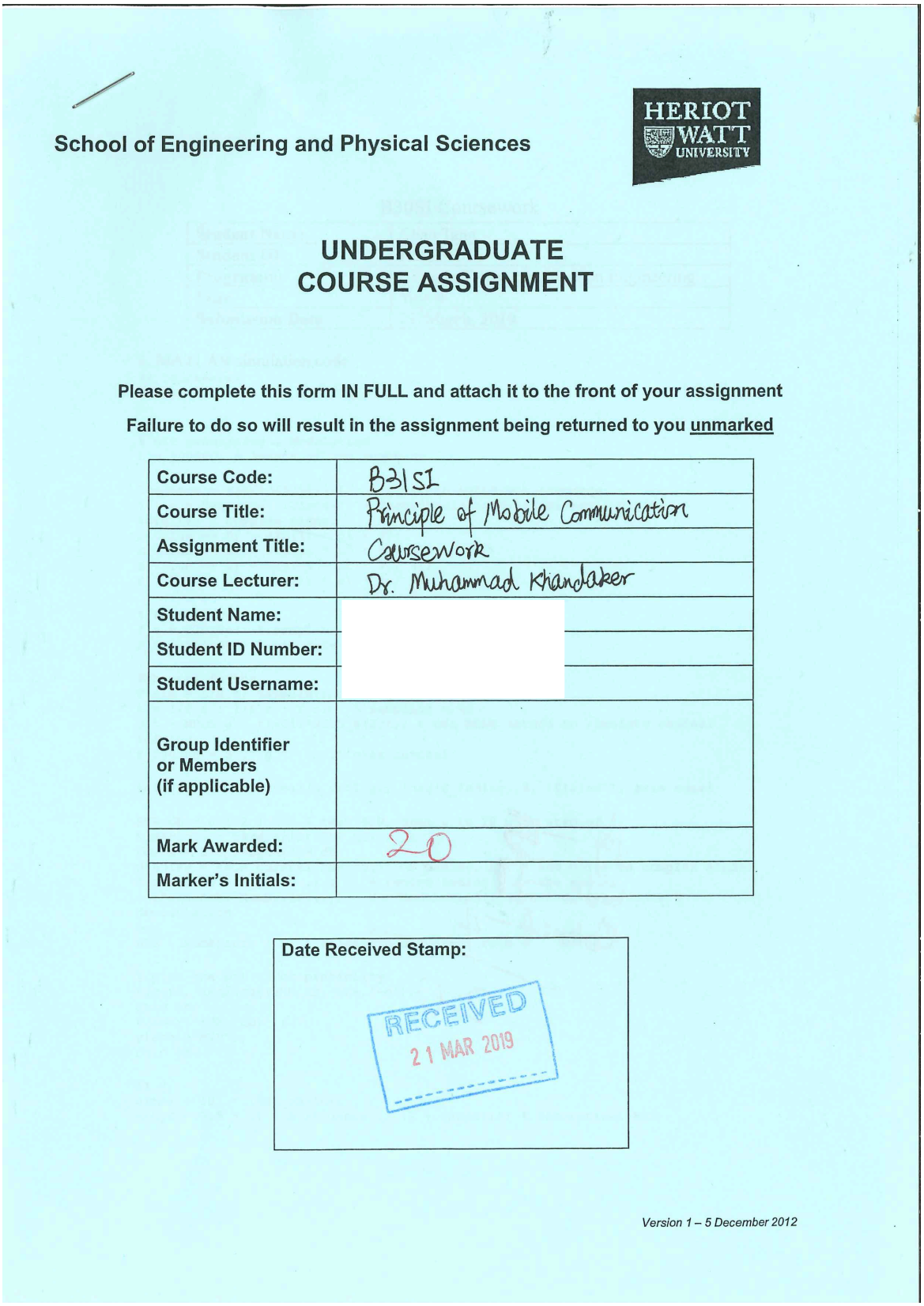
where $\overline{\gamma}_b = 2bE_b/N_0$ denotes the average received SNR. For $b = 1/2$, compute p_b and plot it for SNR $= 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20$ dB. Compare the theoretical result with the above simulated BER and plot them in the same figure.

PART 2

3. We now consider a repetitive coding scheme (consider repetitions $L = 2$ and $L = 3$) for the question in Q2 over a Rayleigh fading channel, where the channel h is a different random channel for each transmitted QPSK symbol. Repeat the BER plot for this scheme using a matched filtering receiver. Compare the high SNR approximation of the theoretical error probability with the simulated BER results in the same figure. We assume the channel knowledge is perfectly known at the receiver end.

   In this case, the high SNR approximation of the theoretical probability of error for time diversity channels is given by

$$\begin{aligned} p_e &\approx P\left(\|h\|^2 < \frac{1}{\text{SNR}}\right) \\ &\approx \frac{1}{L!}\frac{1}{\text{SNR}^L} \end{aligned} \tag{1.1}$$



School of Engineering and Physical Sciences

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UNDERGRADUATE COURSE ASSIGNMENT

Please complete this form IN FULL and attach it to the front of your assignment

Failure to do so will result in the assignment being returned to you unmarked

Course Code:	B31SI
Course Title:	Principle of Mobile Communication
Assignment Title:	Coursework
Course Lecturer:	Dr. Muhammad Khandaker
Student Name:	
Student ID Number:	
Student Username:	
Group Identifier or Members (if applicable)	
Mark Awarded:	20
Marker's Initials:	

Date Received Stamp:

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21 MAR 2019

Version 1 – 5 December 2012

Figure 1.2: Sample cover.