National Yang-Ming Chiao-Tung University

Principle of Communication Engineering (I): Term Project

Professor: Po-Ning Chen
Teaching Assistants: Ting-Yu Wu & Ming-Hsiang Hung

I. Project Notes

1. The project is due at **midnight** on **May 20, 2021**.
2. **Duplication** from others will receive **zero points** in this term project.
3. For any questions about this project, you are welcome to contact TAs before the due date. Note that if you wish to send your questions to TAs through emails, please send your questions to both TAs.

II. System Model

1. In this project, the system model in Slide 4-2 (Part 4) is assumed.
2. A message $m(t)$ will be modulated and upcoverted to generate
$$s(t) = \mathrm{Re}\{\tilde{s}(t)e^{j2\pi f_c t}\},$$
where $\tilde{s}(t)$ is the baseband modulated waveform of $m(t)$. The channel is mildly noisy with carrier-to-noise ratio $\rho = 10$ dB, and hence the channel output $x(t)$, received by your demodulator, will be $x(t) = s(t) + w(t)$, where $w(t)$ is a Gaussian random process. Instead of giving students the continuous waveform of $x(t)$, students will receive a sampled version of it, i.e.,
$$x[n] = x(nT),$$
where $n = 0, 1, 2, \ldots, N-1$, and T is the sampling period.

3. (new) Two counterparts of $s(t)$ for the same message $m(t)$ will be given. The first counterpart $s(t) = \mathrm{Re}\{\tilde{s}(t)e^{j2\pi f_c t}\}$ has no phase distortion, while the second one $s_{\mathrm{pd}}(t) = \mathrm{Re}\{\tilde{s}(t)e^{j(2\pi f_c t+\phi)}\}$ has a phase distortion ϕ due to unsynchronization between TX carrier and RX carrier. To distinguish them, the sampled version $x_{\mathrm{pd}}[n]$ corresponding to the phase-distorted $s_{\mathrm{pd}}(t)$ will be named

   1_pd.txt (respectively, 2_pd.txt, 3_pd.txt, 4_pd.txt, 5_pd.txt)

   if that corresponding to the phase-distortionless $s(t)$ is named

   1.txt (respectively, 2.txt, 3.txt, 4.txt, 5.txt

   ϕ will be randomly picked between -5 degrees to 5 degree. You shall comment how a mild phase distortion impacts the recovery of the original data in your report.

4. Students shall downconvert and demodulate $x[n]$ (and $x_{\mathrm{pd}}[n]$) and submit the estimate of message signal, $\hat{m}[n]$.

5. What shall be submitted includes the following items. Note that there shall be eight individual files.

   (a) Five demodulation results shall be given one by one in the file named as

   "student ID"+"_results.txt"

   (b) Demodulator codes/programs with proper comments must also be uploaded, where files should be named as

   "dec"+"student ID"+"_1.m"
   "dec"+"student ID"+"_2.m"
   "dec"+"student ID"+"_3.m"
   "dec"+"student ID"+"_4.m"
   "dec"+"student ID"+"_5.m"

   (c) A written report, remarking on the demodulator program and the demodulation results (i.e., $\hat{m}[n]$), should be submitted as well. The demodulation outputs should be plotted in the report. It is suggested that the report is within 10 pages, including the five plots. The files should be named as

   "student ID"+".docx" and "student ID"+".pdf"

   (d) To be more specific, examples based on student ID number "0610XXX" are provided. Note that you should replace this ID with your own.

   "0610XXX_results.txt"
   "dec0610XXX_1.m"
   "dec0610XXX_2.m"
   "dec0610XXX_3.m"

"dec0610XXX_4.m"
"dec0610XXX_5.m"
"0610XXX.docx"
"0610XXX.pdf"

(e) You should pack all the files described above into a zip file named as

"student ID"+".zip"

III. Baseband Signals and Carrier Frequency

Below we describe how the message signal $m(t)$ is generated.

1. A decimal number such as $(758)_{10}$ can be binary-represented as

$$(0010\ 1111\ 0110)_2.$$

2. In a binary sequence that consists of 32 bits, each "0" will be sent as $-\sin(2\pi t)$ with $t \in [0,1)$, and each "1" will be sent as $\sin(2\pi t)$ with $t \in [0,1)$. This implies that the duration of a bit is 1 second. The sampling period is $\frac{1}{1000}$ seconds. Thus there will be $32,000$ samples in a file.

3. From the above description, the frequency of the message signal $m(t)$ is $f_{\mathrm{m}} = 1$ Hz.

4. The carrier frequency is $f_{\mathrm{c}} = 100$ Hz.

Here are some notes for your interest.

1. MATLAB has the functions for "covering DEC to BIN" and also for "converting BIN to DEC."

2. If you wish to generate a $\sin(2\pi t)$ signal wave of duration "1 second" and sample it with sampling period $\frac{1}{1000}$ seconds, the MATLAB command is:

```
t = 0:0.001:1-0.001;   % create an array [0, 0.001, 0.002, ..., 0.999]
A = sin(2*pi*t);       % evaluate sin(2πt) for each t
```

IV. Samples of $m(t)$

Message signal $m(t)$ is formed by a sequence of 0-waveforms and 1-waveforms, which are respectively depicted in Figures 1 and 2. For example, $m(t)$ corresponding to bits [0110] will be the curve shown in Figure 3.

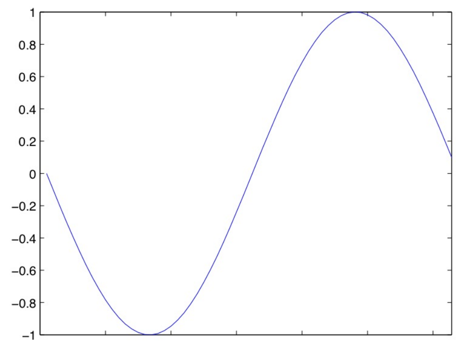

Figure 1: The 0-waveform

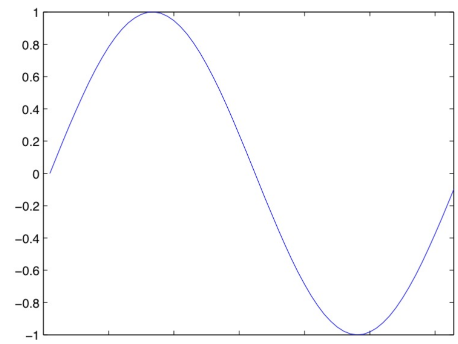

Figure 2: The 1-waveform

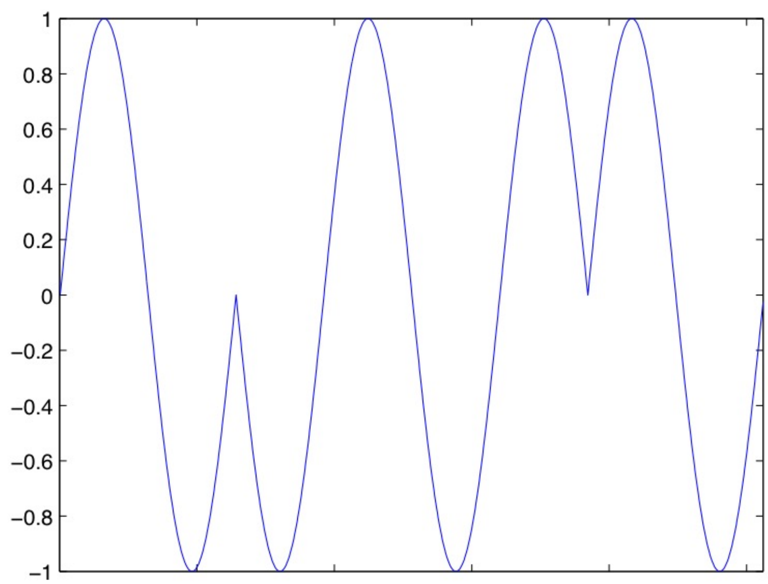

Figure 3: The exemplified $m(t)$ corresponding to bits [1001].

V. MODULATOR AND UPCONVERTER

Four modulations will be possibly used in this project.

i) DSB-C

ii) DSB-SC

iii) SSB

iv) FM

In other words, TAs will modulate the message $m(t)$ by one of these four modulation schemes selected in a random manner to generate $s(t)$.

VI. Demodulator and Downconverter

This is the part you are required to implement in this project. As you have already known the possible form of $m(t)$, you shall realize, perhaps in a try-and-error manner, which of the four modulation schemes is used for each data file. As long as you argue your results reasonably in your report, you shall get the full mark.

VII. File Upload and Download

1. You shall download your data files from

   http://140.113.236.139/CMProject/

   with ID: CM2022 and password: cm2022.

   > *Hint:* In MATLAB, you can read in a "*xxxx*.txt" file by using the below command:
   >
   > A = textread('hello.txt');

2. You shall upload your project outputs to e3.

3. The file name of your zip file should be "Student ID.zip". For example, you shall name your file as "0610XXX.zip". If you wish to renew the file that you have already uploaded, just re-upload it with a proper version number such as

   "0610XXX-v2.zip", "0610XXX-v3.zip", ..., etc.

4. The project report is due at **midnight** on **May 20, 2021**.

VIII. Project Grade

1. (50%) Each student will receive five $x(t)$ files. Recovering one of them correctly will earn you 10% of the grade for the software term project.

2. (50%) The report will gain each student another 50% of the grade. It should include:

   (a) Name and Student ID.

(b) A table that lists the File Name, the Modulation Type and the Decimal Numbers your demodulator obtained.

File Name	Modulation	Decimal
1.txt	DSB-SC	758
2.txt	DSB-C	128
...	...	...

(c) A paragraph to describe how or in which manner you design your demodulators.

(d) For each of the messages recovered, which demodulator (i.e., which modulation type) you are using and why?

(e) What is the main difficulty you encountered in this project?

(f) Your demodulator program/code with comments/explanations (either inside the written report or on the program body) will also be considered a part of the report grade.