

Mid-semester Examination

22/09/2017

Time: 90 minutes

1. *You are not allowed access to any notes, labsheets, or older GNU Radio files during the exam.*
2. *Access to the internet, except for downloading the two data files required for the exam, is strictly prohibited.*
3. *Save important snapshots and your GNU Radio source files in a folder (the folder name being your roll number); you have to provide this folder to your TA.*
4. *You may assume that the bandwidth of audio clips used is ≤ 15 kHz.*

1. **[12 marks]** We have modulated two audio clips $m_1(t)$ and $m_2(t)$ together using a combination of AM and FM. Your task is to perform a joint demodulation to extract m_1 and m_2 .

The modulation has been performed as follows. The message $m_1(t)$ is encoded into the amplitude of the carrier, and the message $m_2(t)$ is encoded into the phase of the carrier, resulting in the (transmitted) passband signal

$$s_P(t) = A(1 + k_1 m_1(t)) \cos \left(2\pi f_c t + 2\pi f_\Delta \int_0^t m_2(s) ds \right).$$

Here, the carrier frequency $f_c = 500$ kHz, modulation index k_1 is set such that $k_1|m_1(t)| < 1$, $|m_2(t)| < 1$, and $f_\Delta = 25$ kHz. You are provided with a data file containing $s_P(t)$, sampled at 1.92 MHz. This file can be downloaded from:

<https://www.ee.iitb.ac.in/~jayakrishnan.nair/ee340/data1.bin>

Your task is to extract the two audio clips.

Useful information: You can use the “File Source” block to read the data file into GNU Radio. Remember to set the output type to float, and to configure the block to repeat the data in a loop so that you have a continuous data stream to work with.

- (a) Once you are able to extract and play the two music clips, show this to your TA.
 - (b) Save a screenshot of your flowgraph, as well your .grc file into the submission folder.
2. **[8 marks]** The goal of this problem is to demodulate an FM signal with uncertainty in the carrier frequency as well as a parameter of the pre-emphasis filter.

The message signal consists of an audio clip, plus two tones of equal amplitude, having frequencies 20 kHz and 45 kHz. This message is sampled at 1.92 MHz, passed through the pre-emphasis filter $1 - \alpha z^{-1}$, before being frequency modulated at carrier frequency f_c . The value of α is unknown and f_c is known to be in the range 490–500 kHz. The received signal, corrupted by

additive noise, is available to you here:

<https://www.ee.iitb.ac.in/~jayakrishnan.nair/ee340/data2.bin>

The sampling rate in the above data file equals 1.92 MHz. Your task is to extract the audio clip. Follow these steps:

- (a) Estimate the value of α . Report this value, as well as your methodology, to your TA. (*Hint: The two tones added to the audio message should help.*)
- (b) Extract the audio clip, show this to your TA.
- (c) Save a screenshot of your flowgraph, as well your .grc file into the submission folder.