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SKEE 3732
FACULTY OF ELECTRICAL ENGINEERING,
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BASIC COMMUNICATION LABORATORY

FREQUENCY MODULATION (FM) PRE-LAB

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1.0 PRE-LAB EXPERIMENT PROCEDURE

- Install the windows-based GNU radio by referring to the link provided (use **version 3.7**)
  Link:
  https://drive.google.com/drive/u/1/folders/1N0SzktKDeLhIFOKOJ9C608CLeK9litxl
- Each group **must complete the Pre-Lab experiment and discussion before attending the laboratory session**. The completed answers (including flow graph, output signals, and short discussions) must be **printed**, brought **to the lab** and **shown to the supervisor for verification** at the beginning of the session.
- Students must **save** all flow graph files on a **portable storage device** (e.g., pendrive, external hard disk, or other suitable media) or **cloud storage** (google drive, one drive, etc.) to ensure they can be readily accessed and executed the flow graph during the lab session.

1.1 PRE-LAB EXPERIMENT: FREQUENCY MODULATION (FM)

1.1.1 FM MODULATOR/TRANSMITTER

(1) Start a new file in GNU Radio Companion (GRC). There will be two blocks in the workspace, i.e. **Options** block and **Variable** block. Open **Variable** block. Set the Sampling Rate in the Variable block to 200 kHz and variable name to samp_rate. In **Options** block, select WX GUI.

(2) Create a signal source block by selecting **Signal Source** block as the message modulating signal. Change the frequency to 2kHz. Change the output type from "Complex" to "Float".

(3) Connect the **Signal Source** block to a **Mutiply Const** block. Set value constant to 5. Then connect this block to two **Transcendental** blocks. Set Function Name to cos and sin for the first **Transcendental** block and second **Transcendental** block, respectively.

(4) Add another two **Signal Source** blocks which acts as a carrier signals. Change the frequency to 25 kHz. This will be the carrier frequencies. Set Waveform to Cosine with amplitude 1 for the first carrier **Signal Source** block, while Waveform to Sine with amplitude -1 for the second carrier **Signal Source** block.

(5) After that, connect the output of the first carrier **Signal Source** block and the first **Transcendental** block to a **Multiply** block.

(6) Then connect the output of the second carrier **Signal Source** block and the second **Transcendental** block to another **Multiply** block.

(7) Add both outputs from **Multiply** blocks by using **Add** block.

(8) Connect the output of **Add** block to **Throttle** block.

(9) Finally, connect the output of the **Throttle** block to the input of **WX GUI Scope Sink, WX GUI FFT Sink** and **File Sink.** Save the generated modulated signal using **File Sink** block. Choose the folder in which you want to save the file and name it as **FMsinuswave.dat.**

(10) Save and execute the flow graph. Now, observe and print screen the output signals both in time and frequency domain representations. Compare these output signals with input signals. Analyze and answer all the questions in discussion.

(11) Change the value of Multiply Const, modulating signal frequency, f_m and carrier signal frequency, f_c. Discuss what happen to the signals. Analyze and discuss in your pre-lab report.
(12) Now, replace the sinusoid message signal with music wave signal. Add **Wav File Source** block. Choose the folder in which you have saved the Music.wav file.
(13) Change the name of file to **FMmusicwave.dat** in **File Sink** block.
(14) Execute. Now, observe and print screen the output signals both in time and frequency domain representations. Discuss what happened to the signals. Compare with signals from Step (9).

1.1.2 FM DEMODULATION/RECEIVER

(1) Start new file and add **File Source** block. Choose the folder in which you have saved the filename **FMsinuswave.dat** from **Pre-Lab Experiment 1.1.1**.
(2) Add two **Signal Source** blocks. Set the first **Signal Source** block with Waveform to Cosine, Frequency to 25 kHz and amplitude to 1. Set the second **Signal Source** block with Waveform to Sine, Frequency to 25 kHz and amplitude to -1.
(3) Then, add two **Multiply** blocks and connect both **File Source** block and **Signal Source** block as inputs.
(4) Add two **Low Pass Filter** blocks. Connect each of the **Multiply** blocks output to the **Low Pass Filter** block. Set cutoff frequency to 25 kHz and the transition width to 100 Hz.
(5) After that connect both **Low Pass Filter** block outputs to **Float to Complex** block.
(6) Add **Throttle** block. Connect the input of the block to Float to Complex block and the output to **Delay** block. Set delay to 1.
(7) Add **Multiply Conjugate** block. Connect the **Delay** block output and **Throttle** block output to the inputs of **Multiply Conjugate** block. Ensure that the Throttle, Delay and Multiply Conjugate blocks type are in Complex.
(8) Finally, connect the output of the **Multiply Conjugate** block to the **Complex to Arg** block and then to **WX GUI Scope Sink** and **WX GUI FFT Sink** to view the demodulated signals. Ensure that both of this block's type is in Float.
(9) Save the flow graph and execute. Observe the demodulated signals in both time and frequency domains. Take the snapshot, analyze and compare with Experiment 1.1.1.
(10) Change the value of frequency of carrier signals and cut off frequency of LPF. Discuss what happen to the signals. Analyze and discuss in your pre-lab report.
(11) Repeat for file **FMmusicwave.dat** from Experiment 1.1.1. (Hint: Add an **Audio Sink** block to hear the music. Set Sample Rate to 32 kHz). Observe the different from previous Step (9). Discuss in your pre-lab report.

Additional Hint:

1. **WX GUI Notebook** block enables to show several plots in a single window using different tabs.
2. **WX GUI Slider** block enable to change the values of any variables that you want. Example: modulation frequency, modulation factor or USRP gain.

Discussion and Analysis

1. What are the advantages and disadvantages of FM over AM?
2. How does the amplitude of the modulating signal affect the FM signal?
3. What is the role of the modulation index in FM, what happens when its value changes, and which block in GNU radio represents this function?
4. How can the modulation factor (index) be determined from the frequency spectrum?
5. How does changing the modulating frequency (while keeping the amplitude constant) affect the FM signal and modulation index?