ECSE 308:
Introduction to
Communication Systems and Networks

L2: Analog Modulation Techniques

Part 1: Amplitude Modulation (AM)
Part 2: Frequency Modulation (FM)

CEAB Data – Engineering tools

- The following engineering tools are used in this laboratory:
  - MATLAB and SIMULINK
  - Software signal generator
  - Power Spectrum analyzer
  - AM & FM modulation

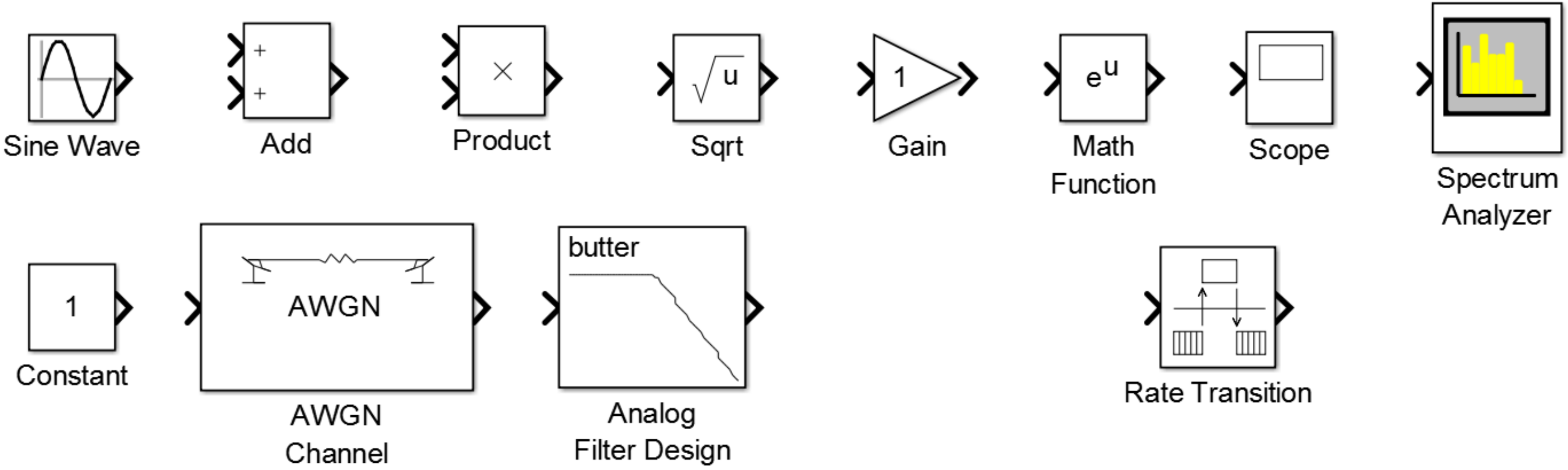
Part 1: Amplitude Modulation (AM)

Objectives:

- To understand the basic principles of amplitude modulation and demodulation

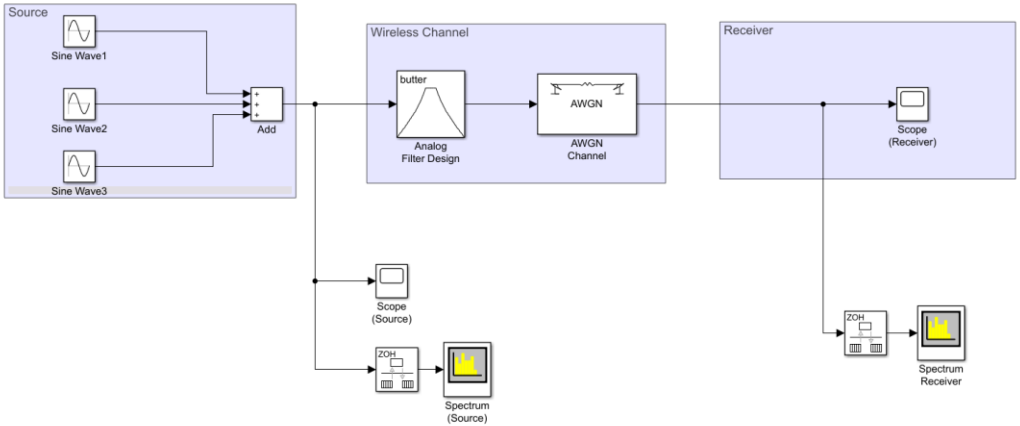
Preparation

- For this lab, the following Simulink blocks will be used.



I. Communication System

- Build the a wireless link as illustrated.



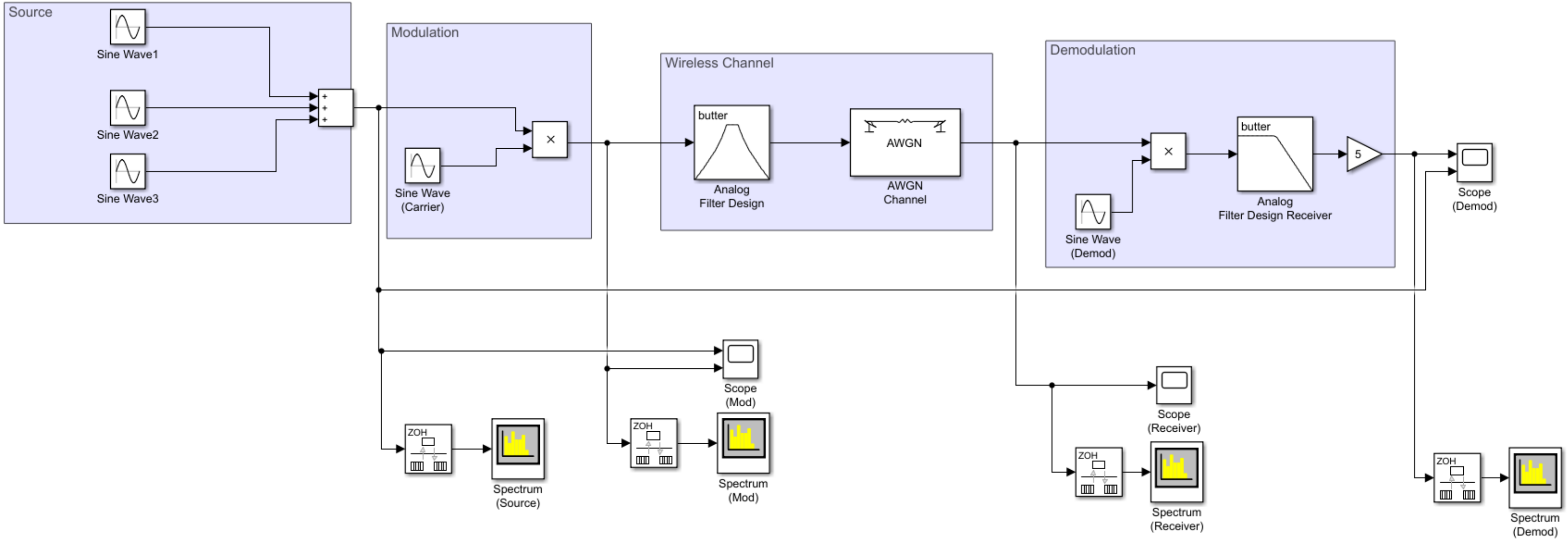
1. Observe the Source and Receiver **Scopes** and **Spectrum Analyzers**, comment on the issues you observe and suggest an engineering solution.

Communication System

- Parameter setup:
  - **Sine Wave 1: Sine type:** Time based | Amplitude: 0.5 | Frequency (rad/sec): 1000*pi
  - **Sine Wave 2: Sine type:** Time based | Amplitude: 0.2 | Frequency (rad/sec): 600*pi
  - **Sine Wave 3: Sine type:** Time based | Amplitude: 0.3 | Frequency (rad/sec): 1200*pi
  - **AWGN Channel:** Initial seed: randseed | Mode: Variance from mask | Variance: 1e-3
  - **Analog Filter Design:** Design method: Butterworth | Filter type: Bandpass | Filter order: 8 | Lower passband edge frequency (rad/s): 2e4*pi | Upper passband edge frequency (rad/s): 4e4*pi
  - **Rate Transition:** Output port sample time: 1/50000
  - **Stop Time**: 1

II. DSB-SC Modulation

- Build the double-sideband (DSB) suppressed-carrier (SC) AM system as illustrated.



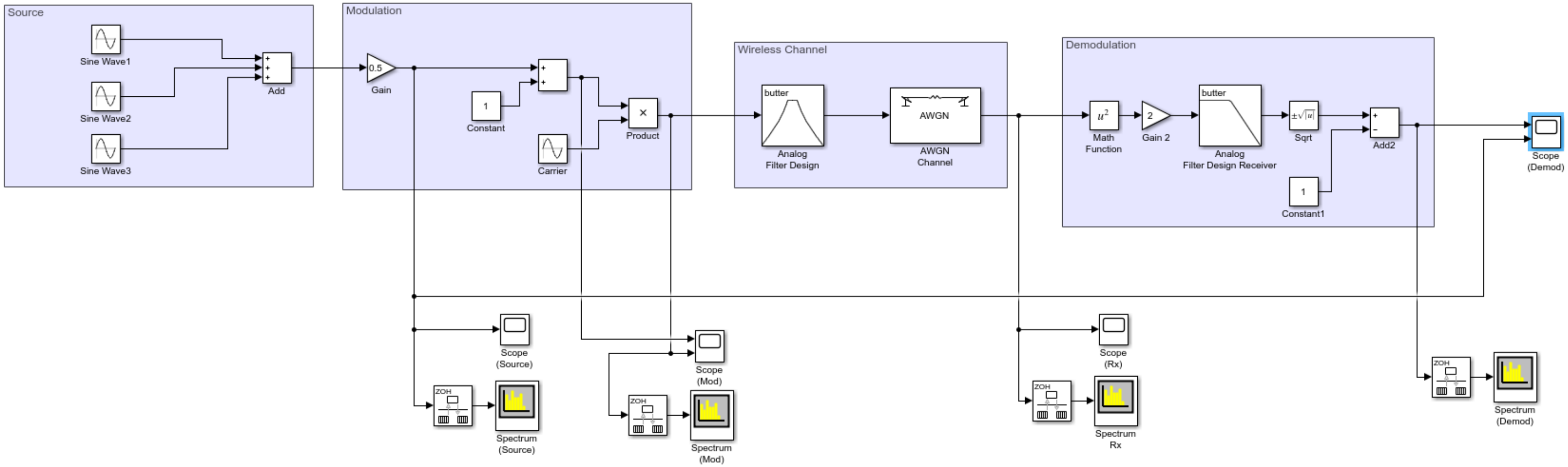
DSB-SC Modulation

- Parameter setup:
  - **Carrier and Demod: Sine type:** Time based | Amplitude: 1 | Frequency (rad/sec): 30000*pi | Phase (rad): pi/2
  - **Analog Filter Design Receiver:** Design method: Butterworth | Filter type: Lowpass | Filter order: 8 | Passband edge frequency (rad/s): 1e4*pi
  - **Stop Time**: 1

2. Observe the outputs on **Scope (Source)** and **Scope (Mod).** Explain the concept of DSB-SC modulation.
3. Observe the outputs on **Spectrum (Source)** and **Spectrum (Mod)**. Explain the relationship between the spectrum of the DSB-SC signal and that of the source signal. Comment on the transmission bandwidth of DSB signals.
4. Compare the outputs on **Spectrum (Rx)** and **Spectrum (Source)** Comment on what information is needed to filter out the noise without distorting the desired signal.
5. Observe **Scope (Demod)** and explain the DSB-SC demodulation technique.
6. Change the frequency of the Demod sine wave by 1% and observe how it affects demodulated signal on **(Demod) Scope.**
7. Change the phase of the Demod sine wave by 1% and observe how it affects demodulated signal on **(Demod) Scope.**
8. Comment on the shortcomings of DSB modulation and suggest an engineering solution.

III. DSB-LC AM System

- Build the double-sideband (DSB) large-carrier (LC) AM system as illustrated.



DSB-LC AM System

- Parameter setup:
  - **Carrier: Sine type:** Time based | Amplitude: 1 | Frequency (rad/sec): 30000*pi | Phase (rad): pi/2
  - **Constant (DC Bias):** Constant value: 1
  - **Analog Filter Design Receiver:** Design method: Butterworth | Filter type: Lowpass | Filter order: 8 | Passband edge frequency (rad/s): 1e4*pi
  - **Math Function:** Function: square
  - **Sqrt Function:** signedSqrt
  - **Stop Time**: 1

DSB-LC AM System

9. Observe the outputs on **Scope (Source)** and **Scope (Mod).** Explain the concept of AM modulation.
10. Observe the outputs on **Spectrum (Source)** and **Spectrum (Mod)**. Explain the relationship between the spectrum of the AM signal and that of the source signal. Comment on the transmission bandwidth of AM signals.
11. Observe **Scope (Demod)** and explain the AM demodulation technique.
12. Change the value of Constant (DC Bias), and observe how it affects the signal recovered from Envelope Detector in comparison with the source signal. Explain what is a feasible DC bias in relation to the amplitude of the source signal so that successful demodulation can be guaranteed.
13. Explain the differences between DSB-SC and DSB-LC in terms of modulation. Explain how such differences affect the transmit power efficiency and the demodulation process at the receiver.

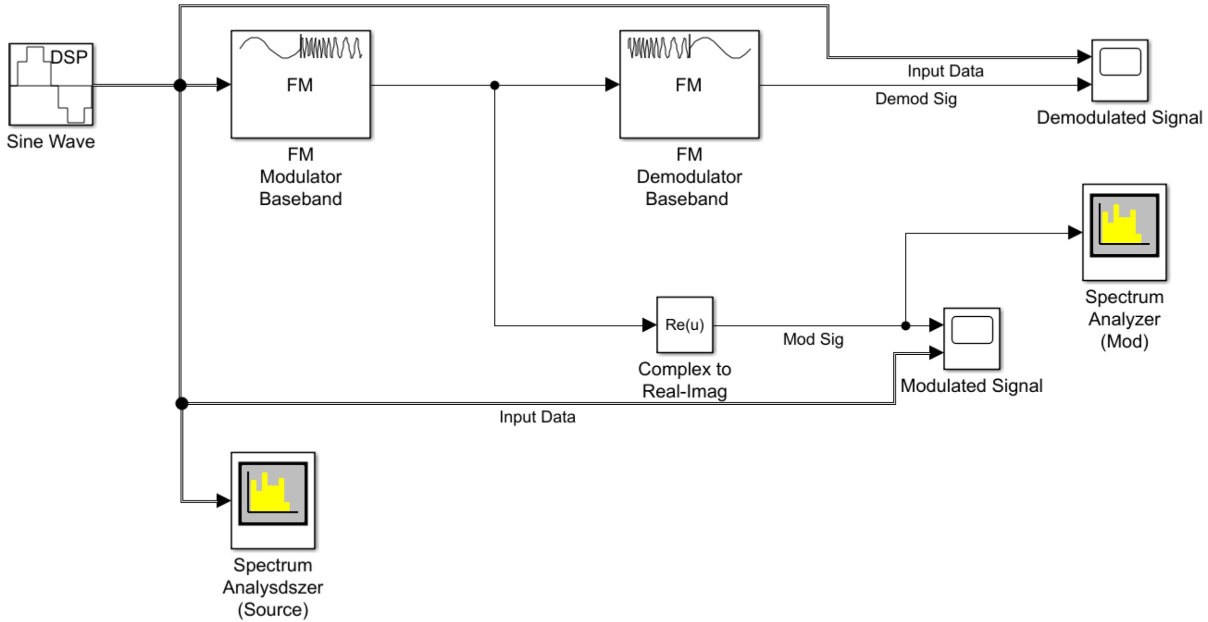
Part 2: Frequency Modulation (FM)

Objectives:

- Understand the basic principles of frequency modulation and demodulation

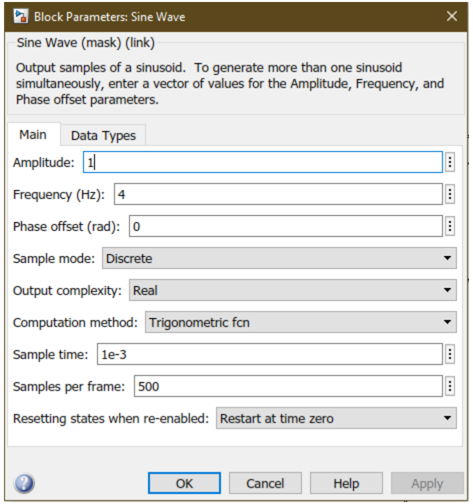
I. FM System

- Build the FM system as illustrated.



FM System

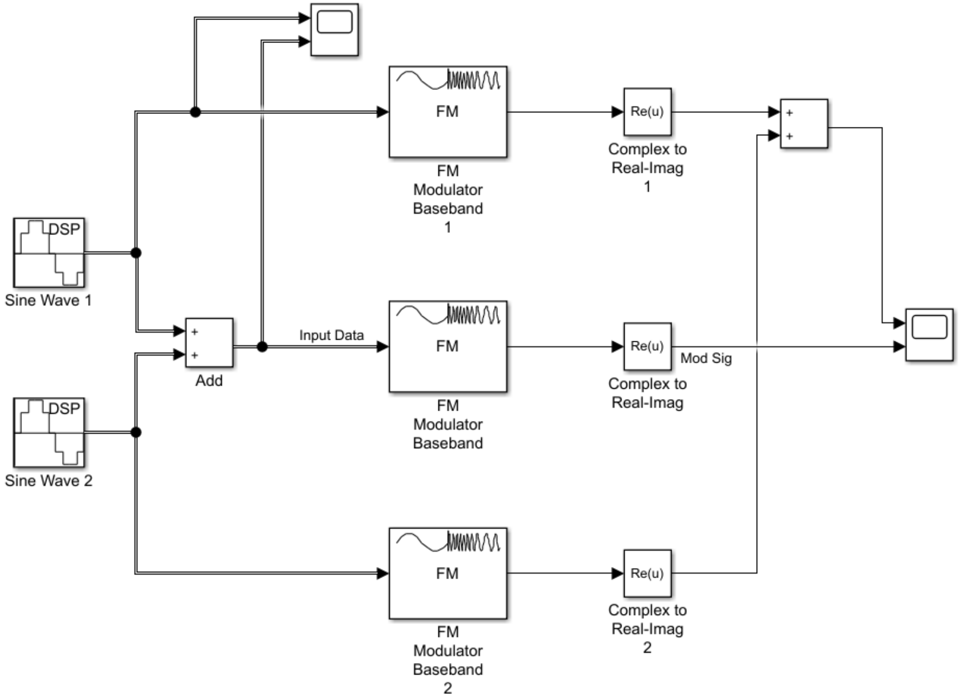
- Parameter setup:
  - **FM Modulator/Demodulator:** Frequency deviation: 50 | Simulate using: Interpreted
  - **Complex to Real-Imag:** output: Real
  - **Since wave:** as shown here



- **Important:** Before running the block, open scope, in view\Configuration Properties
  - Input processing: Column as channels

14. Briefly, describe in mathematical terms the process of FM modulation and demodulation.
15. Observe the output on Scope (Mod). Explain how the FM signal is related to the modulating signal in the time domain.
16. Use a sum signal of two sine waves (add another sine wave with Frequency 8Hz) as a modulating signal, and compare the output with the sum of those when each of the sine wave is used as a modulating signal separately. Comment on the linearity of FM modulation in comparison with AM modulation.
17. Vary the modulating frequency (Frequency deviation) and the amplitude of Sine Wave (Modulating Signal). Observe the variations of the spectrum on Spectrum (Mod). Explain how the transmit power changes accordingly and why.
18. Comment on the differences between an FM signal and an AM signal in terms of transmit power in relation to the modulating signal.

- Build the FM system as illustrated.



- **Sine wave 1**: Frequency 4 Hz
- **Sine wave 2**: Frequency 8 Hz | Phase: pi/4

19. Use a sum signal of two sine waves as a modulating signal, and compare the output with the sum of those when each of the sine wave is used as a modulating signal separately. Comment on the linearity of FM modulation in comparison with AM modulation.