



ECE 525E– WIRELESS & MOBILE COMMUNICATIONS

LAB 02 - ORTHOGONAL FREQUENCY DIVISION MULTIPLEX (OFDM)

Issued: Monday, 07 April 2025

1.0 OBJECTIVE

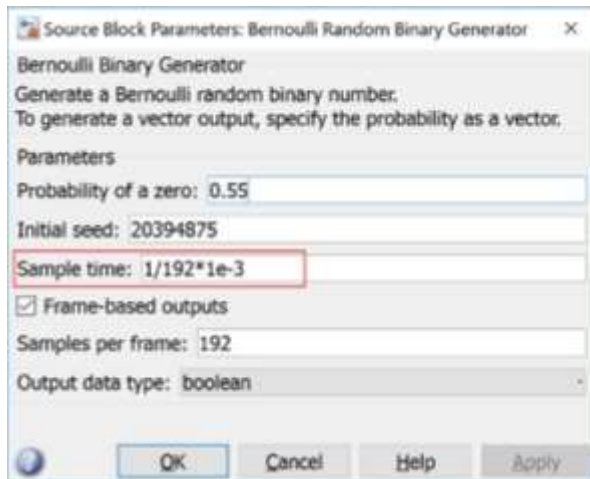
To build the OFDM modulation and demodulation building Simulink simulation and to understand the impact of key parameters on the system performance.

2.0 PRELAB

- 1) Read the following OFDM tutorial to understand [the basic concept of OFDM modulation found here.](#)
- 2) Simulation time and actual clock time are not the same. For example, running a simulation for 10 seconds usually does not take 10 seconds as measured on an actual clock. The amount of time it takes to run a simulation depends on many factors including the complexity of the model, the step sizes, and the computer speed. Therefore, when we talk about data rate, the time we are referring to is based on the simulation (Simulink) clock.

3.0 UNDERSTANDING MODIFIABLE PARAMETERS

3.1 Bernoulli Random Binary Generator block



Sample time value determines the bit rate of the source block. Here the bit rate is $1/(1/192 \times 10^{-3}) = 192$ kbps.

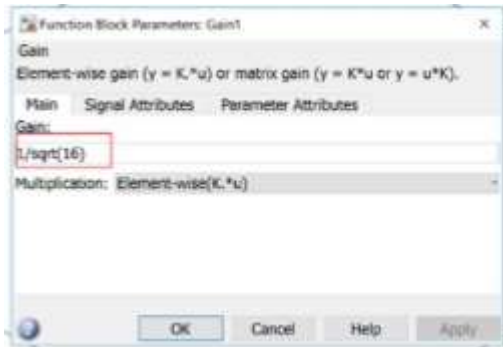
Sample per frame determines the number of bits carried by one OFDM symbol. This value needs to be consistent with the value of bits per symbol in AWGN block. Here the sample time is 192.

3.2 QAM modulation and Demodulation Blocks

M-ary value determines the number of bits on each subcarrier. If, for instance, M-ary is set to 16 then the number of bits per subcarrier is $\log_2(16) = 4$.

3.3 Normalize and Denormalize blocks.

Gain is used to guarantee the same transmitted signal power for different modulation schemes. For example gain can be set to **$1/\sqrt{16}$** corresponding to the 16-QAM. If 64-QAM is applied, the gains need to be changed to **$1/\sqrt{64}$** and **$\sqrt{64}$** , respectively.



3.4 OFDM Transmitter Block

Data subcarrier indices of OFDM transmitter. Here we have 48 data subcarriers, 4 pilot subcarriers and a DC subcarrier inserted among data subcarriers. If the FFT length is 64, the number of guard bands will be $64 - 48 - 4 - 1 = 11$.

3.5 AWGN Channel

Function Block Parameters: AWGN Channel

AWGN Channel (mask) (link)

Add white Gaussian noise to the input signal. The input signal can be real or complex. This block supports multichannel processing.

When using either of the variance modes with complex inputs, the variance values are equally divided among the real and imaginary components of the input signal.

Parameters

Input processing: Columns as channels (frame based)

Initial seed: 67

Mode: Signal to noise ratio (Eb/No)

Eb/No (dB): 10

Number of bits per symbol: 192

Input signal power, referenced to 1 ohm (watts): 1

Symbol period (s):

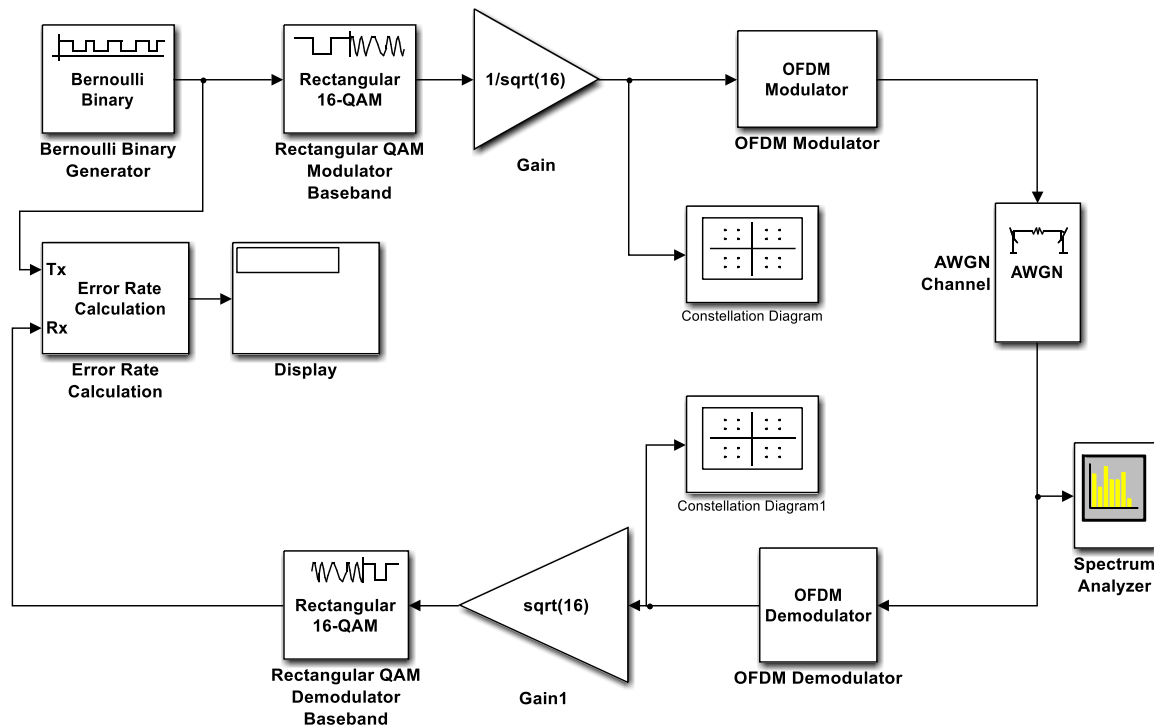
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Eb/No is the signal-to-noise ratio per bit. Eb/No is useful when comparing the bit error rate (BER) performance of different digital modulation schemes without taking bandwidth into account.

Number of bits per symbol is corresponding to the value of samples per frame in Bernoulli Random Binary Generator block. Symbol period of AWGN block needs be consistent with the symbol period defined in OFDM transmitter block.

4. LAB PROCEDURE

1. Select blocks from the library and link the Simulink model as shown below.



2. Set the value of "Samples per frame" in Bernoulli Random Binary Generator block to 192. With 16QAM, $\frac{192}{\log_2(16)} = 48$ symbols are generated and assigned on 48 data subcarriers.
3. Set the value of "M-ary number" in Rectangular QAM Modulator Baseband block to 16. For BPSK or QPSK, this block needs to be changed.
4. Set the value of "Gain" in Normalize block to $1/\sqrt{16}$. For BPSK, QPSK, or 64QAM, the gain needs to be changed correspondingly.
5. Set the value of "Gain" in Denormalize block to $\sqrt{16}$. For BPSK, QPSK, or 64QAM, the gain needs to be changed correspondingly.

Based on the OFDM-16QAM setting, you need to finish the following lab tasks:

1. Change the value of "Eb/No" in the AWGN block from 5 to 15, increment by 1 in each step. Check the value of BER. Plot the curve of BER vs. Eb/No for OFDM-16QAM.
2. Based on the settings of OFDM-16QAM, modify the parameters correspondingly to simulate OFDM-64QAM, OFDM-QPSK, OFDM-BPSK. Plot the curves of BER vs. Eb/No for OFDM-64QAM, OFDM-16QAM, OFDM-QPSK, OFDM-BPSK.
3. Based on the plots in task 2, explain which modulation scheme is more appropriate in terms of different distance and channel conditions.