OFDM QAM Transceiver

Under Supervision:

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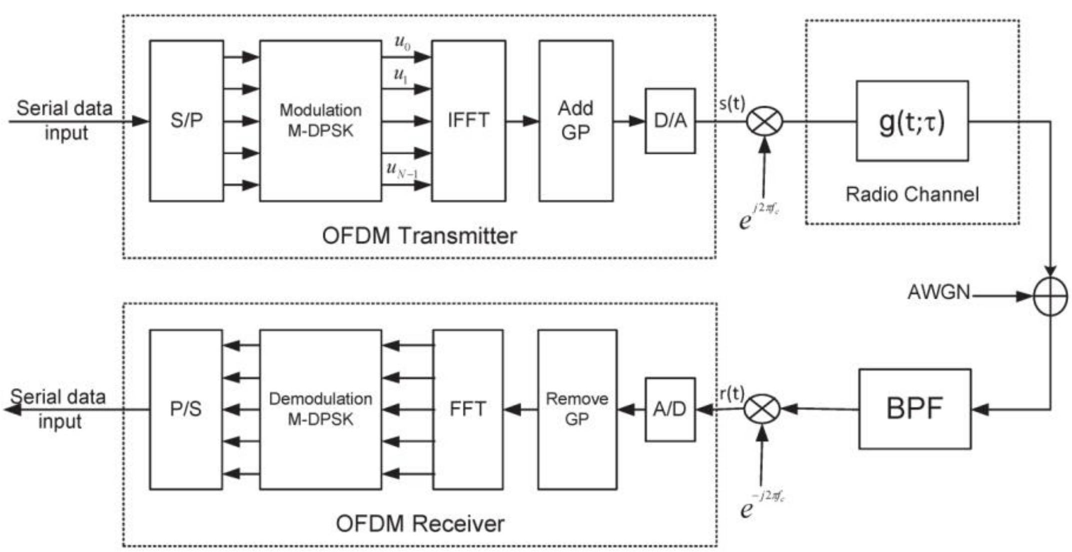
Introduction:

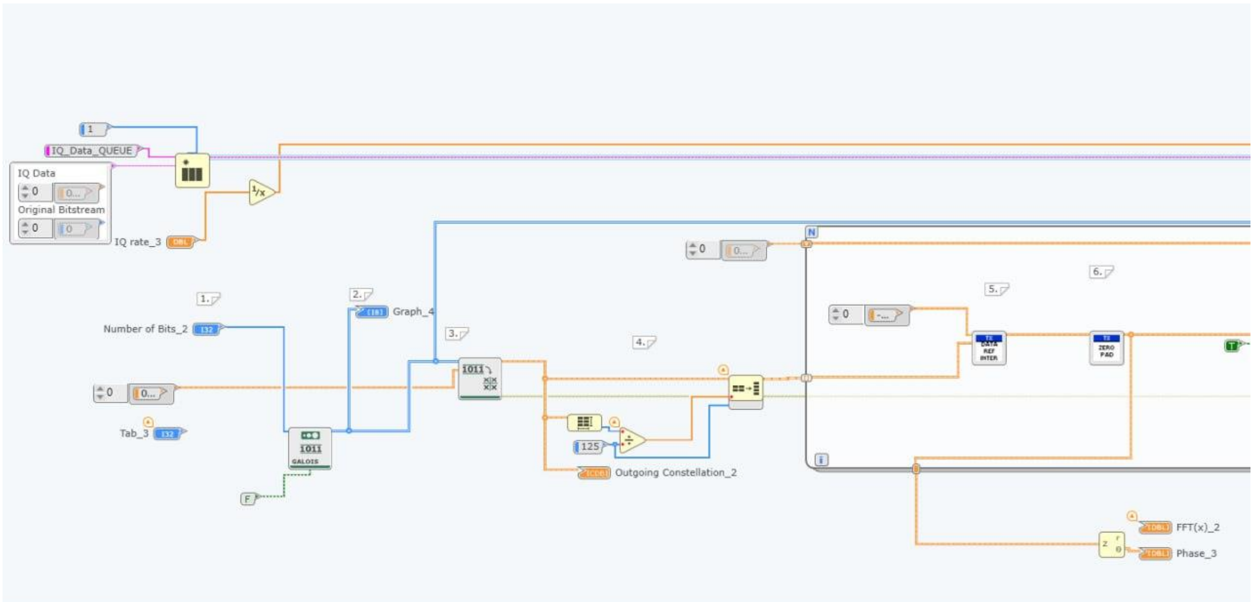
OFDM, also known as Orthogonal Frequency Division Multiplexing, is a signal waveform or modulation technique that offers great advantages for data links. It finds extensive application in wireless systems with wide bandwidth and high data rates, such as Wi-Fi, cellular telecommunications, and more. By utilizing numerous carriers, each carrying low bit rate data, OFDM demonstrates exceptional resilience against selective fading, interference, and multipath effects, while also achieving a high level of spectral efficiency. Although early implementations of OFDM required significant processing, technological advancements have minimized the processing challenges associated with OFDM.

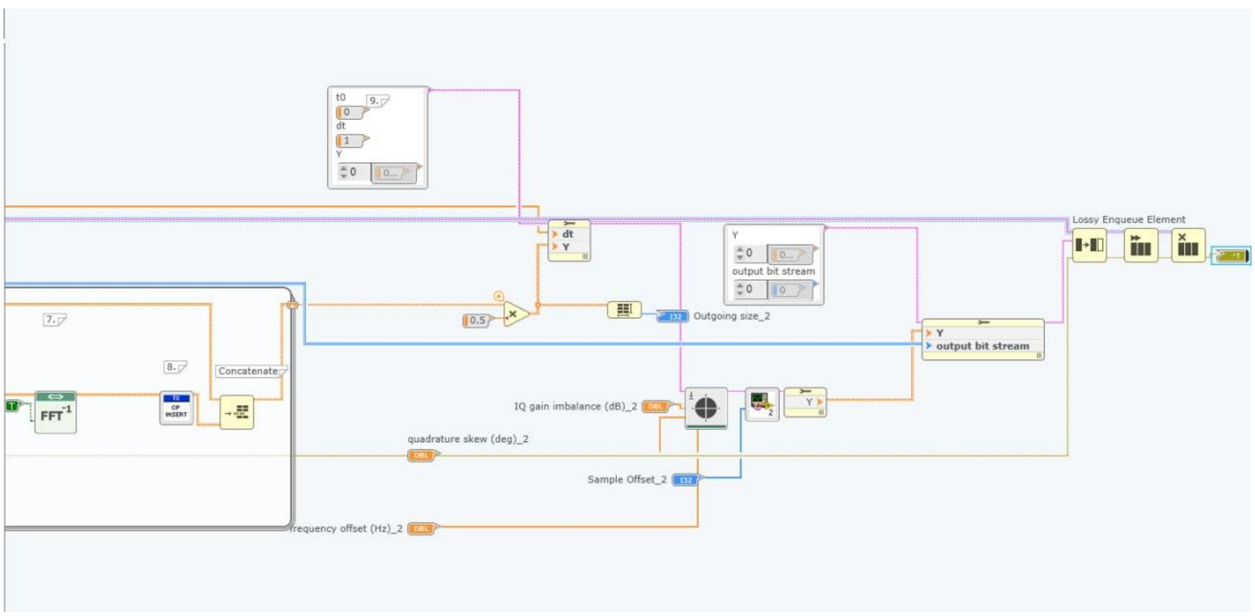
It uses multicarrier modulation. An OFDM signal consists of a number of closely spaced modulated carriers. When modulation of any form - voice, data, etc. is applied to a carrier, then sidebands spread out either side. It is necessary for a receiver to be able to receive the whole signal to be able to successfully demodulate the data. As a result, when signals are transmitted close to one another they must be spaced so that the receiver can separate them using a filter and there must be a guard band between them. This is not the case with OFDM. Although the sidebands from each carrier overlap, they can still be received without the interference that might be expected because they are orthogonal to each another. This is achieved by having the carrier spacing equal to the reciprocal of the symbol period.

- OFDM Block diagram:



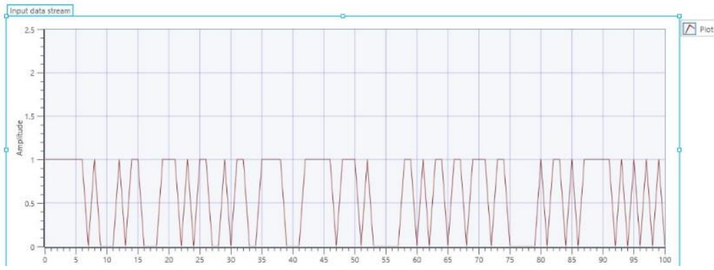
Steps of TX:





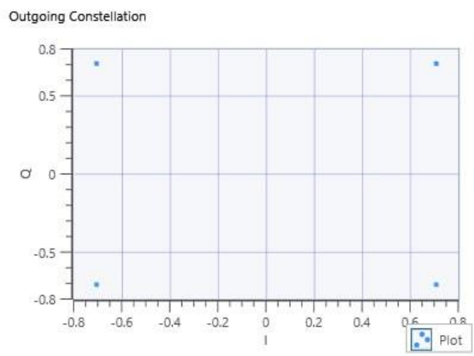
1. **Initialize the number of bits and QAM map locations:**
   assign OFDM symbols to individual subcarriers within the frequency domain.

2. Generate random data bits (PN Sequence) (1250 bits).



3. Map bits to symbols (625 symbols):

4-QAM: 4 is the 2nd power of 2, so each symbol can carry 2-bit data.



4. Divide the array of symbols into 5 sets of 125-point data sets and build OFDM symbols (125 pts per OFDM symbol).

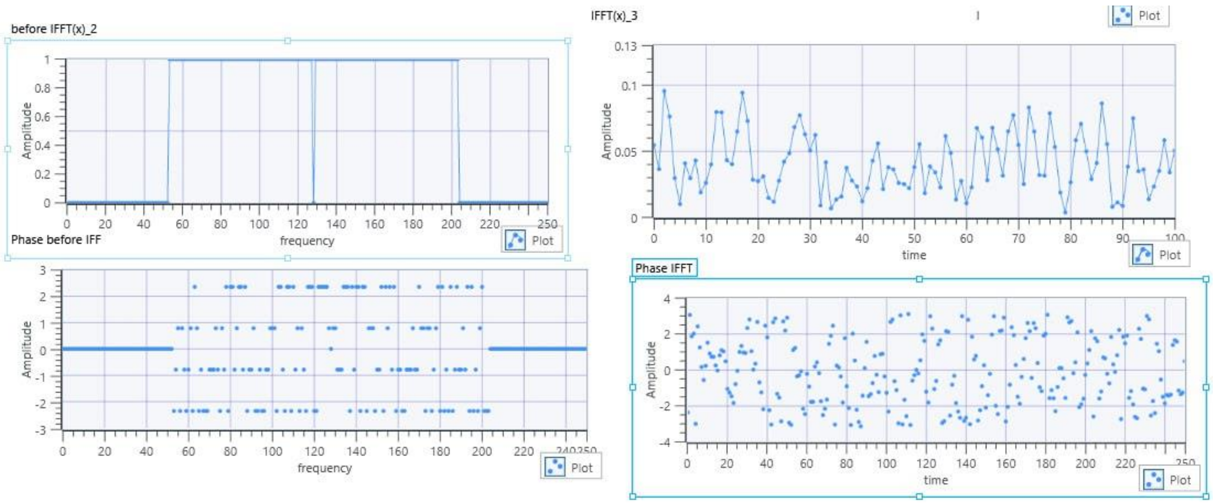
5. Insert one of 25 reference symbol after every 6th data symbol (150 pts per OFDM symbol):

reference symbols are used to improve the performance of parallel data processing. It reduces synchronization overhead and improves overall efficiency.

6. Insert 53 zeroes at the edges of the pass band and at 1 zero at DC (256 pts per OFDM symbol):

to increase the length of a signal by appending zeros to the existing data. This process can be applied before performing a Fourier Transform (FT), by adding zeros to the signal, the frequency resolution of the resulting spectrum is improved.

7. Perform an Inverse FFT to convert the frequency domain design to a time domain signal (256-point IQ time domain waveform):



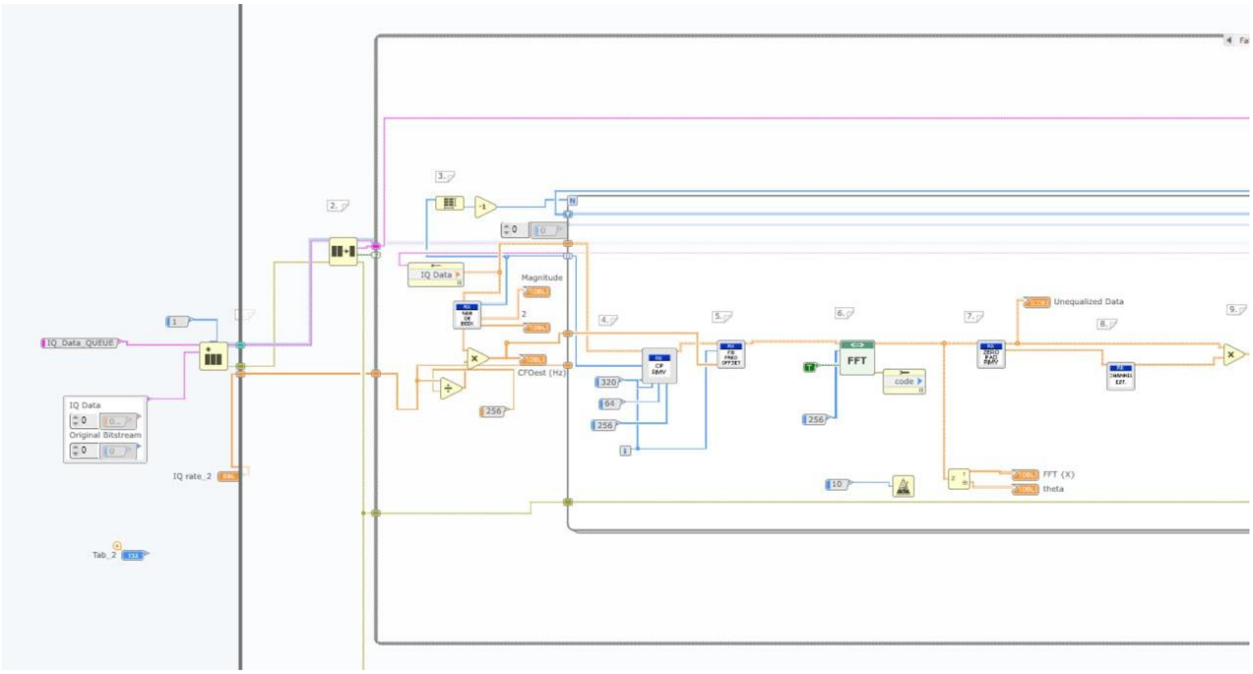
8. Insert a 64-point cyclic prefix by duplicating the last 64 points of the array at the beginning (320-point IQ time domain waveform):

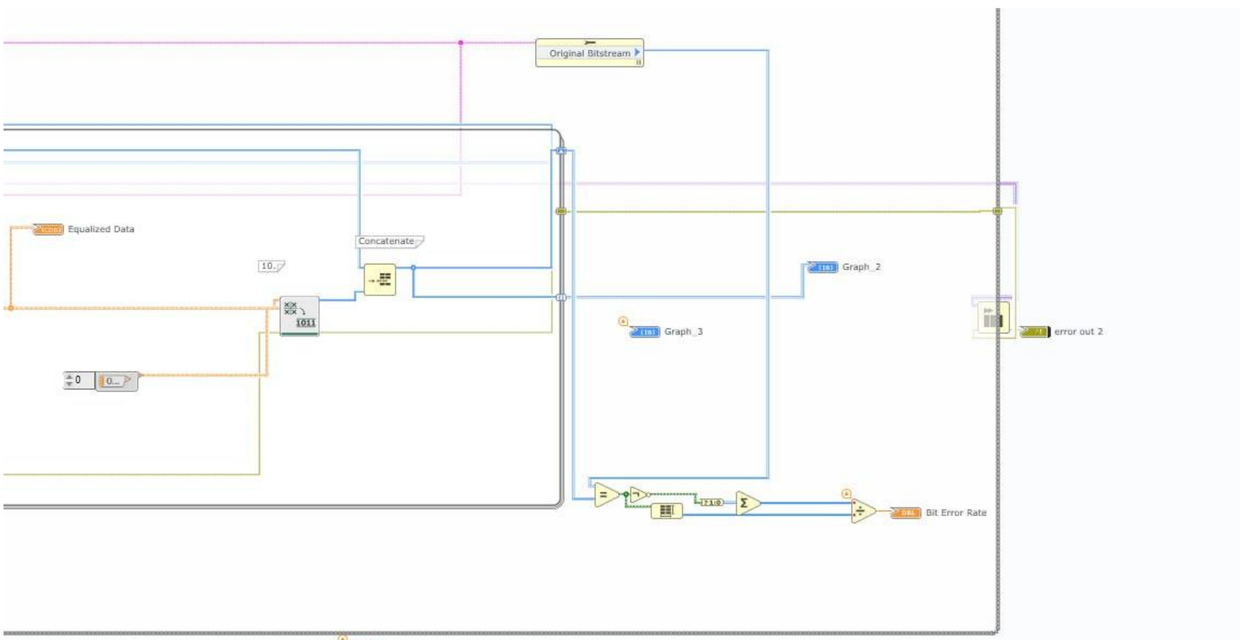
Cyclic prefix fills in the guard time between the OFDM symbols and is inserted to preserve orthogonality.

9. Scale the 5-time domain OFDM waveforms to a complex magnitude below 1, typically below 0.7 for each I and Q (1600-point IQ time domain waveform).

10. Add mt IQ apply imparities block to simulate the wireless channel imparities in real life.

Steps of RX:





1. Initialize QUEUE:

Which stores transmitted bitstream (First in, first out).

2. Dequeue IQ data.

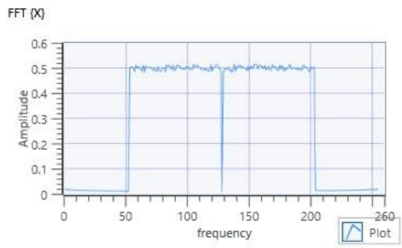
3. Use the Van De Beek algorithm:

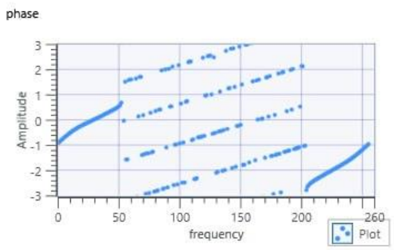
to detect the cyclic prefix locations for synchronization and estimate frequency offset**.**

4. Remove the cyclic prefix

5. Remove the frequency offset from the incoming signal

6. Compute the FFT converting the time domain OFDM symbol to the frequency domain:



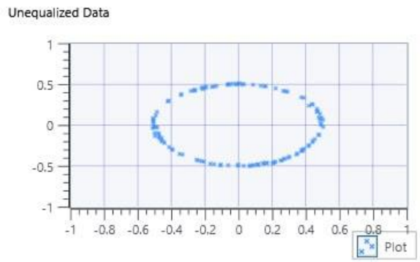


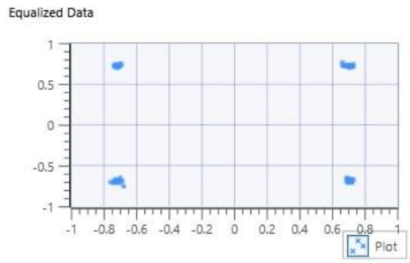
7. Separate data bits, reference bits, and remove zero padding

8.Compute equalization coefficients using a linear fit for both I and Q based on reference symbols:

To reduce the effect of channel impairments. Interpolation is a technique is used between received signal samples.

9. Apply the equalization to the data symbols.





10. Convert data symbol mapping back to data bits