Design & Development of IEEE 802.11a Architecture on Zedboard

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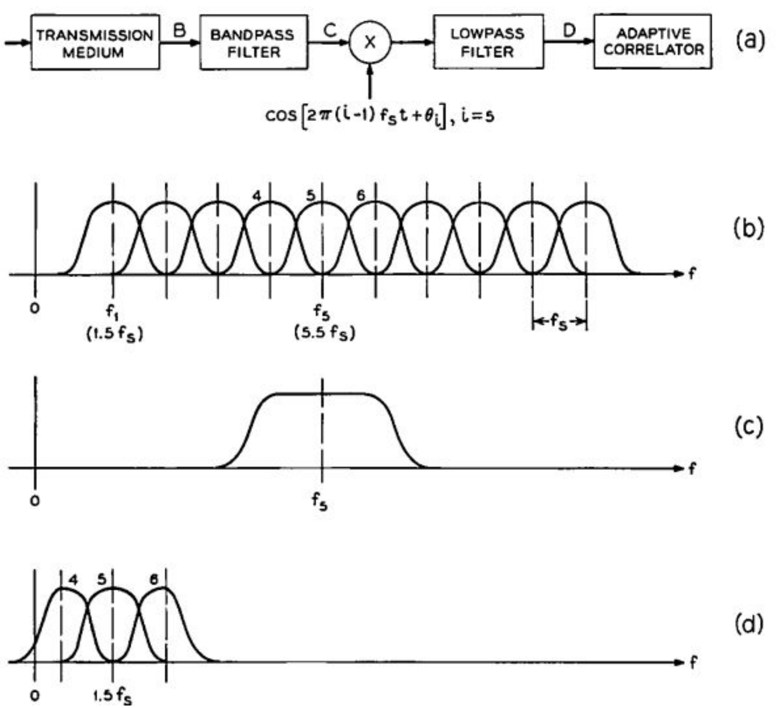
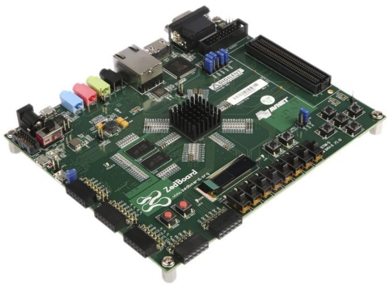
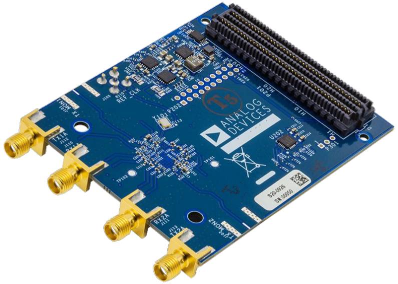
Why This Project (Evolution of OFDM)

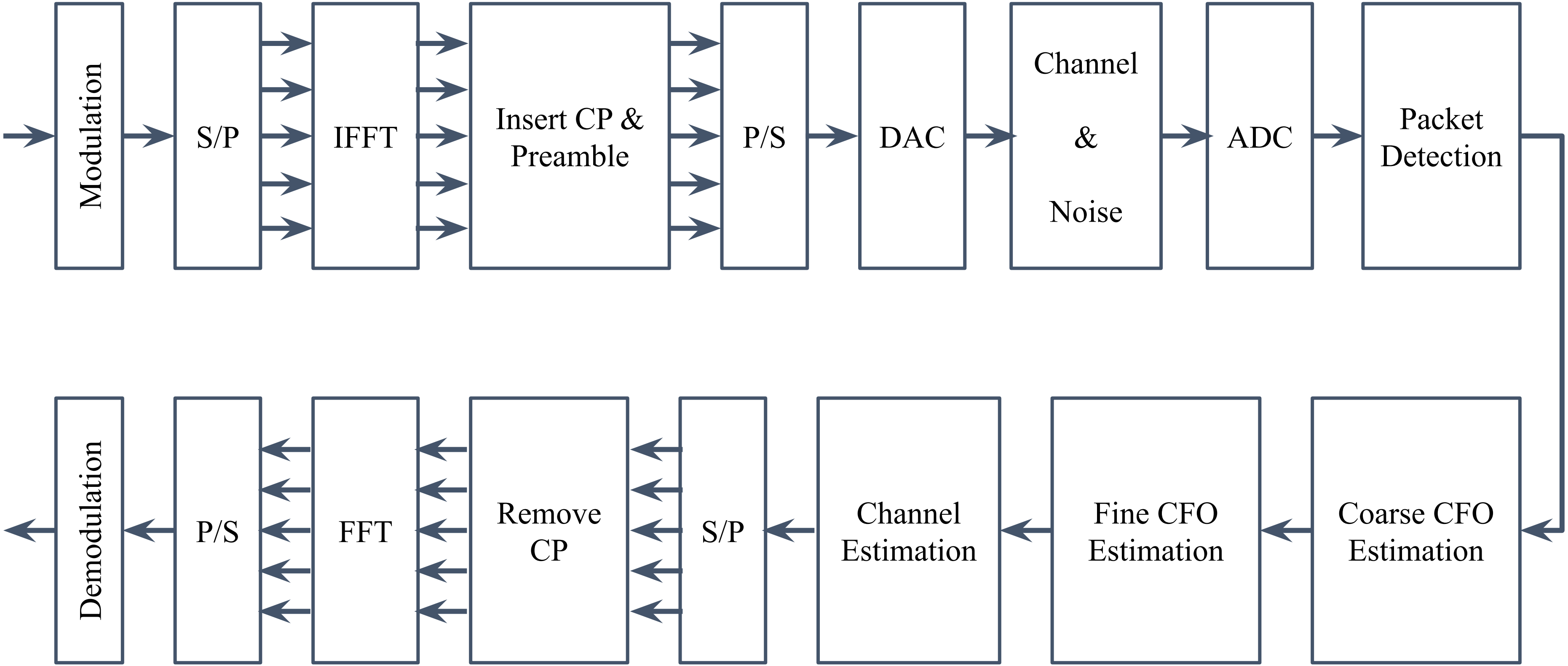






Cooley, J. W., & Tukey, J. W. (1965). "An algorithm for the machine calculation of complex Fourier series." *Mathematics of Computation*, 19(90), 297-301.

OFDM Block Design



Signal Parameters

Signal Parameters	Value
Centre Frequency	5 GHz
Bandwidth	20 MHz
Sample Time	50 ns
FFT Size	64

Short Preamble

Virtual Subcarrier [1x6]	S_k [1x53]	Virtual Subcarrier [1x5]

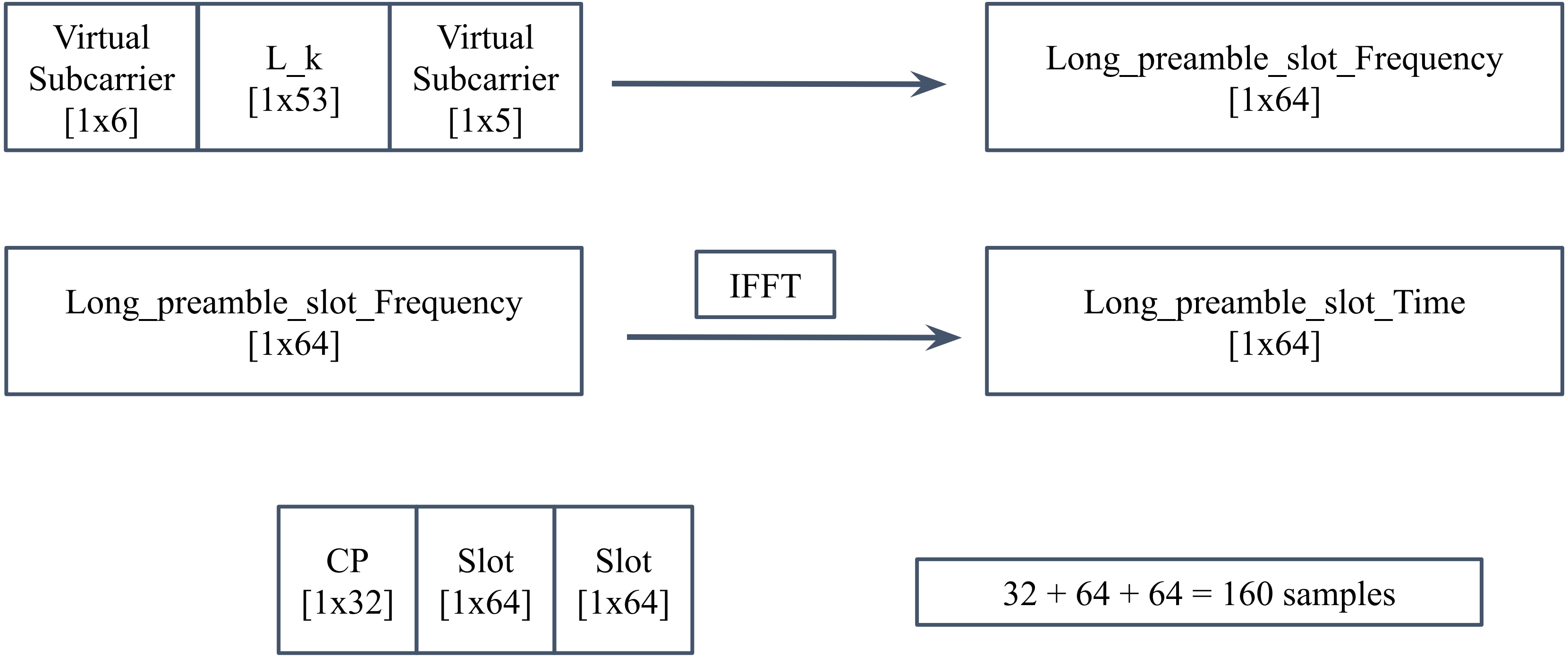
→ Short_preamble_slot_Frequency [1x64]

Short_preamble_slot_Frequency [1x64] $\xrightarrow{\text{IFFT}}$ Short_preamble_slot_Time [1x64]

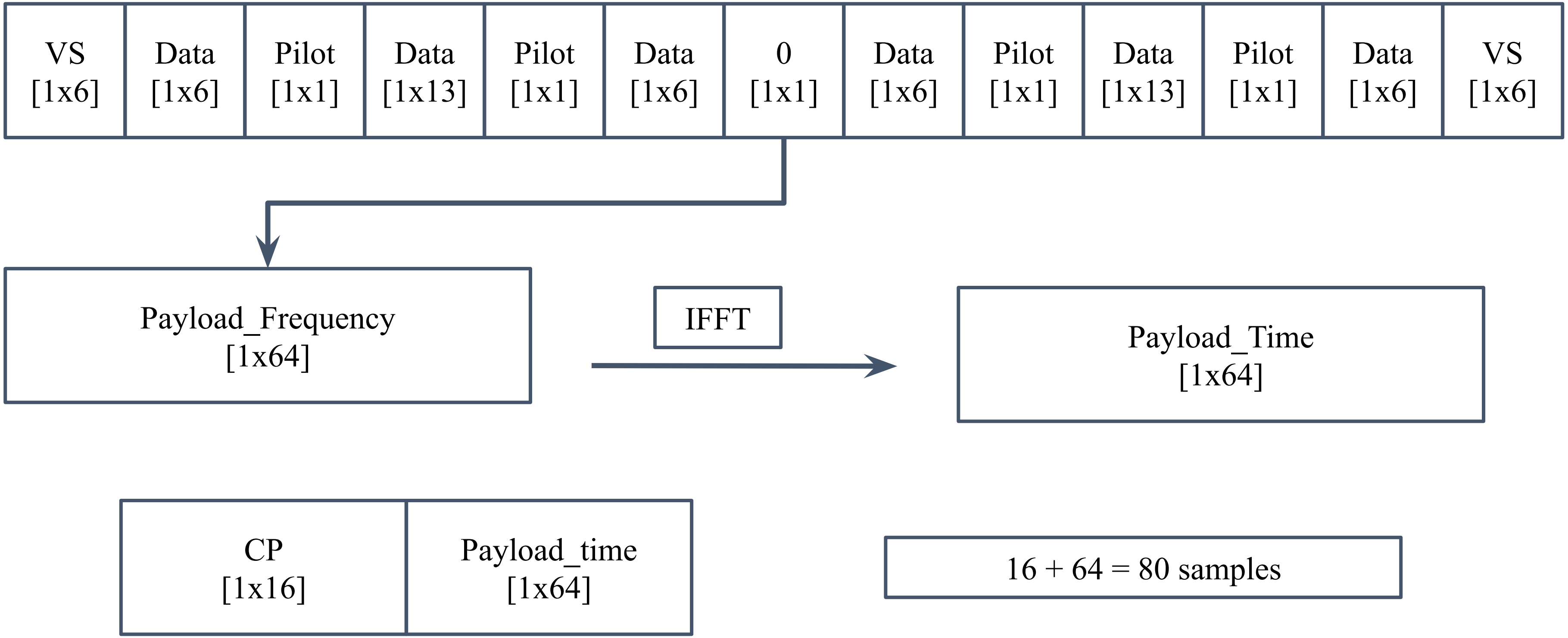
Slot [1x16]	Slot [1x16]	Slot [1x16]	Slot [1x16]	Slot [1x16]	Slot [1x16]	Slot [1x16]	Slot [1x16]	Slot [1x16]	Slot [1x16]

16 Slots repeated 10 times = 160 samples

Long Preamble



Payload


VS [1x6]
Data [1x6]
Pilot [1x1]
Data [1x13]
Pilot [1x1]
Data [1x6]
0 [1x1]
Data [1x6]
Pilot [1x1]
Data [1x13]
Pilot [1x1]
Data [1x6]
VS [1x6]
Payload_Frequency [1x64]
IFFT
Payload_Time [1x64]
CP [1x16]
Payload_time [1x64]
16 + 64 = 80 samples

QPSK Modulation & Demodulation

Bits	Symbols	Constellation Points
00	0	0.707 + i 0.707
01	1	- 0.707 + i 0.707
10	2	-0.707 - i 0.707
11	3	0.707 - i 0.707

Frame Designing / Transmit Signal

Short Preamble [1x160]	Long Preamble [1x160]	Payload 1 [1x80]	Payload 2 [1x80]

160 + 160 + 80 + 80 = 480 samples

→ Oversample by 2

Short Preamble [1x320]	Long Preamble [1x320]	Payload 1 [1x160]	Payload 2 [1x160]

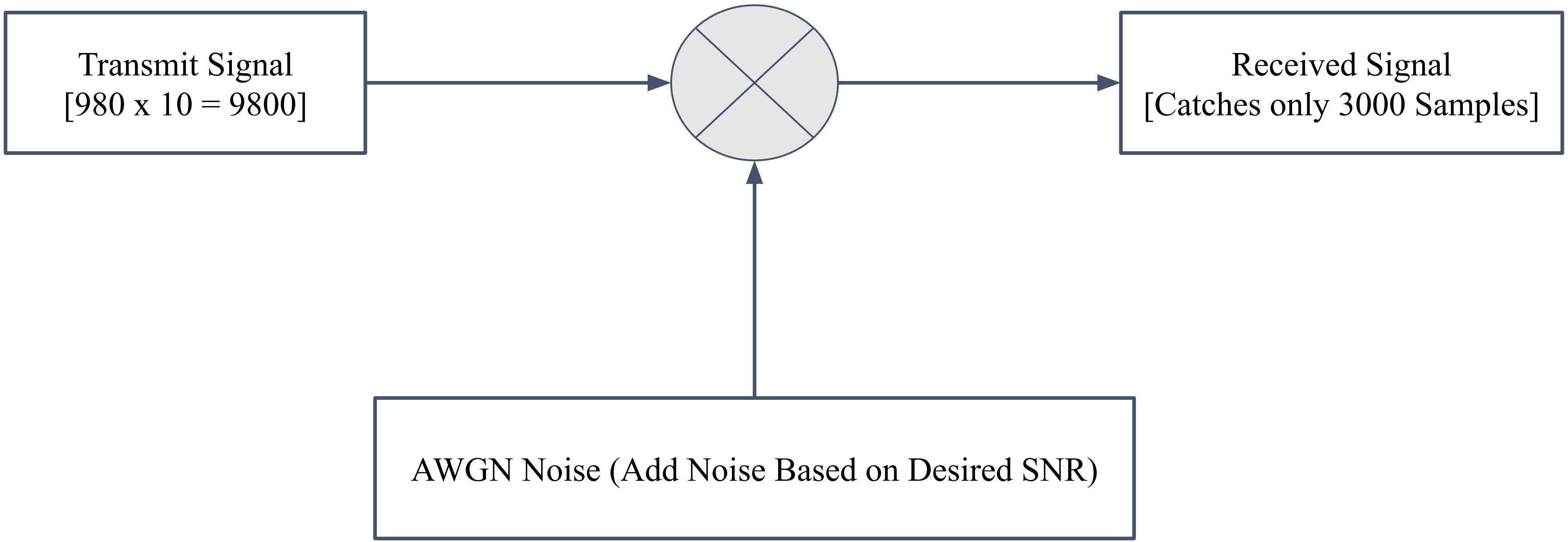
320 + 320 + 160 + 160 = 960 samples

Apply RRC Filter

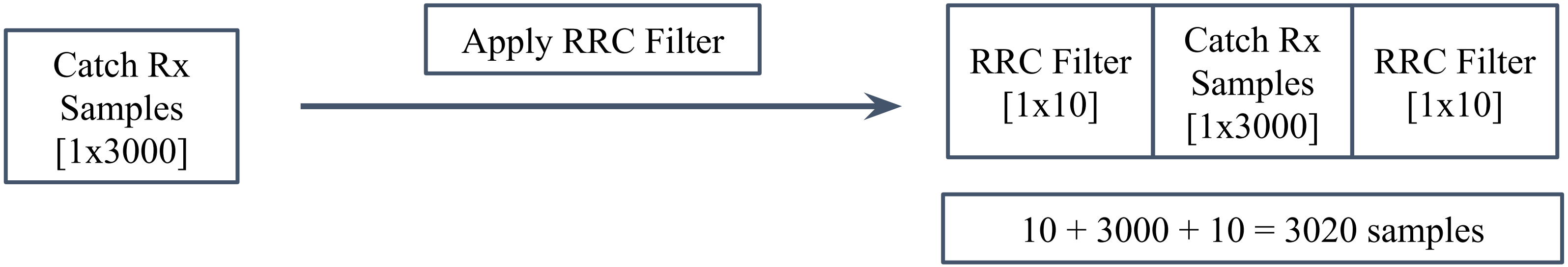
RRC Filter [1x10]	Short Preamble [1x320]	Long Preamble [1x320]	Payload 1 [1x160]	Payload 2 [1x160]	RRC Filter [1x10]

10 + 320 + 320 + 160 + 160 + 10 = 980 samples

Channel Model

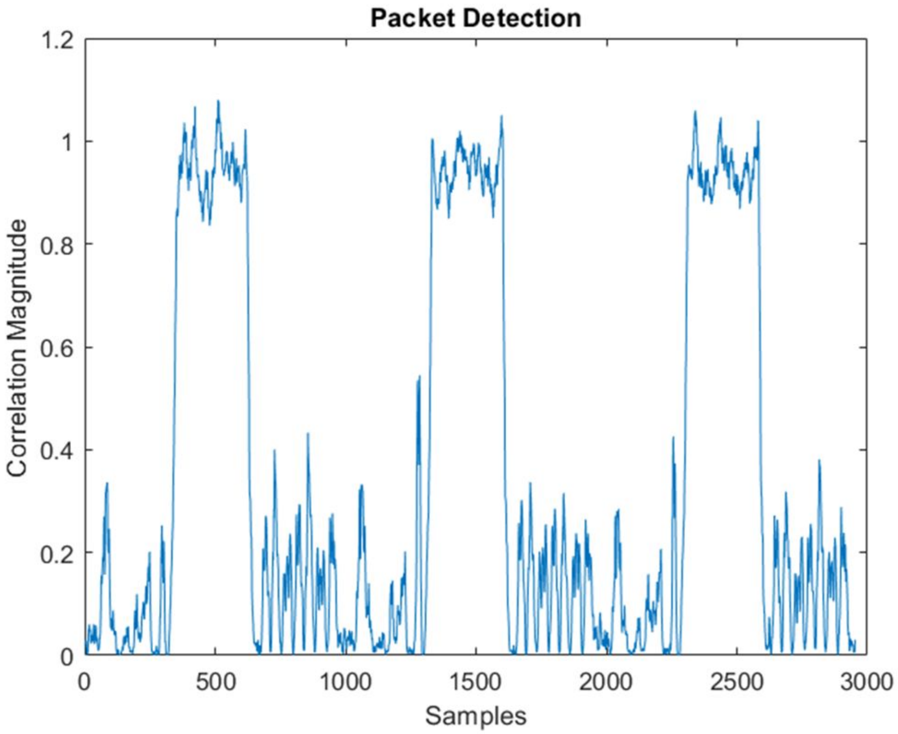


Received Signal



Packet Detection (Delay & Correlate)

1. Perform Correlation
2. Find Power
3. Normalize



Coarse / Fine CFO Estimation

1. Calculation of Complex Conjugate
2. Coarse CFO Estimation
3. Apply Coarse CFO to Rx Frame

1. Calculation of Complex Conjugate
2. Fine CFO Estimation
3. Apply Fine CFO to Rx Frame

Channel Estimation & Equalizer

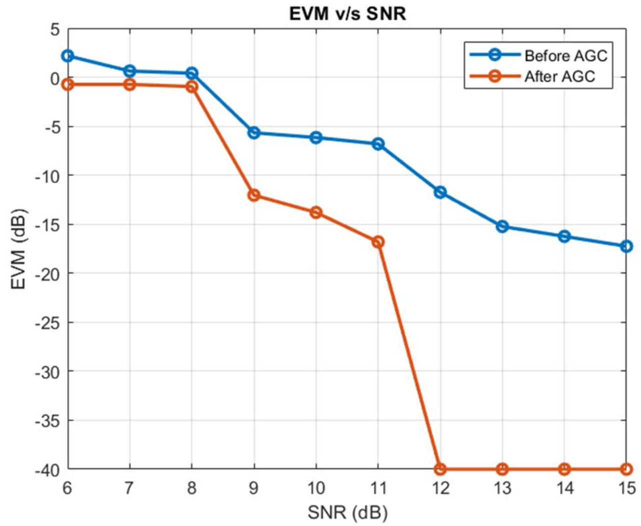
1. Extract sections of fine CFO
2. Perform FFT
3. Average the FFT of both Long preamble sections and taking the conjugate of the Short preamble.
4. Perform IFFT to get the channel estimate in the time domain
5. Divide the received frame with the channel estimates.

Automatic Gain Control (AGC)

1. If real part of received signal as well as imaginary part > 0, then map to 0.707 + i 0.707
2. If real part < 0 and imaginary part > 0, then map to -0.707 + i 0.707
3. If real part < 0 and imaginary part < 0, then map to -0.707 - i 0.707
4. If real part > 0 and imaginary part < 0, then map to 0.707 - i 0.707

Error Vector Magnitude (EVM)

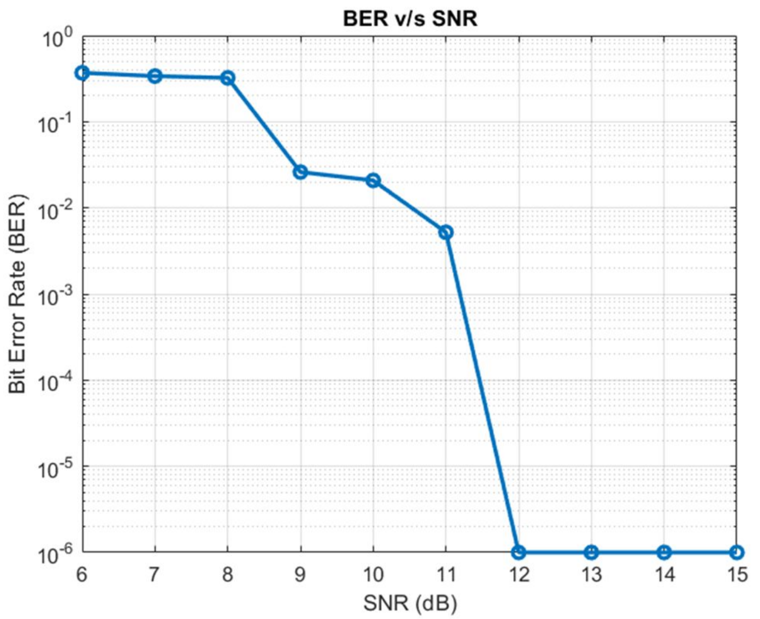
1. Error = QPSK_MODULATED_Data_Rx - QPSK_Modulated_Data_Tx (Calculate Error)
2. Calculate RMS value of the error magnitude normalized by RMS value of transmitted symbols
3. Perform 20*log10(ans) to convert to dB scale.



Bit Error Rate (BER)

1. Bit_Error = Data_Rx - Data_Tx (Calculate Error)

2. Divide the number of bits in error with total number of bits.



Deliverables (Till Midsem)

1. Implement the IEEE 802.11a transceiver on processor
2. Calculate EVM for different SNRs
3. Calculate BER for different SNRs
4. Calculate the PS execution time

Deliverables (Till Endsem)

1. Design the IP for QPSK modulation
2. Design the IP for packet detection (Correlation)
3. Design the IP for Coarse CFO estimation (Angle calculation)
4. Design the IP for Fine CFO estimation (Angle calculation)
5. Design the IP for channel estimation & equalization
6. Design the IP for QPSK demodulation
7. Calculate EVM for different SNRs
8. Calculate SNR for different SNRs
9. Calculate & compare the PS & PL execution time

Thank You

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