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OFDM MODEM

Introduction

A **Multi-Mode Orthogonal Frequency Division Multiplexing (OFDM) Modem** is a versatile communication device designed to support multiple allowing it to operational adapt to modes, various communication standards and channel conditions. It uses OFDM technology, which divides a data stream into multiple closely spaced subcarriers for parallel transmission, offering several benefits like high data rates, resistance to multipath fading, and efficient spectrum usage.

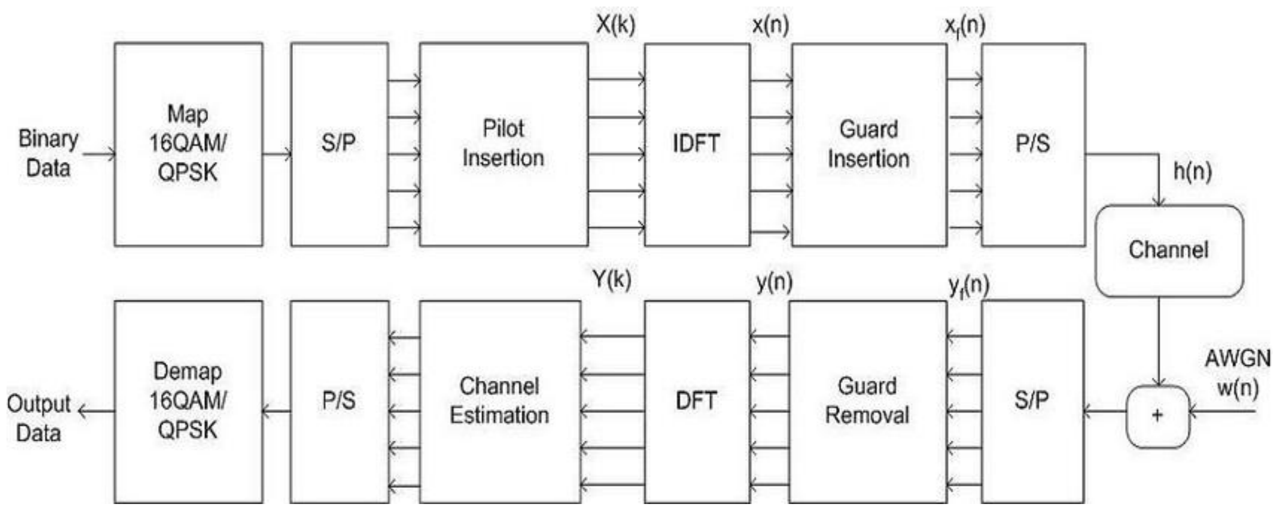
Features

- **High Data Rates:** Efficient transmission by dividing the channel into multiple orthogonal subcarriers.
- **Spectral Efficiency:** Optimized bandwidth usage with overlapping subcarriers.
- **Flexible Modulation:** Supports QPSK, QAM, and other modulation schemes for varying data requirements.
- **Error Correction:** Integrates FEC (Forward Error Correction) like LDPC or Turbo codes for enhanced reliability.
- **Scalability:** Adaptable for various bandwidths and subcarrier configurations.
- **Application Versatility:** Widely used in 4G/5G, Wi-Fi, DVB, and LTE systems.
- **Support for MIMO:** Compatible with multiple-input, multiple-output (MIMO) systems for higher capacity and performance.

Specifications

SN	Specification	Details
1.	Max Speed of the Platform	1 Mach ≈ 1225 km/hr. ≈ 337 m/s
2.	Available Bandwidth	Maximum 40 MHz
3.	Operating Frequency	5 GHz
4.	Doppler Spread	+/-20 KHz [For all data rate]
5.	Doppler Rate	1 KHz/Sec [For all data rate]
6.	Delay Spread	20 μs & 35 μs
7.	Mode of Operation	SISO, SIMO, and MISO
8.	Modulation	QPSK & 16QAM [for all Data Rates]
9.	Modulator Input Interface	Continuous Serial Bit stream
10.	Modulator Output Interface	14-bit I & 14-bit-Q
11.	Data Rate before FEC	2.112 & 16.896 Mbps
12.	FEC Block Size	512/1024/2048/4096
13.	Demodulator Input Interface	14-bit I & 14-bit Q
14.	FEC Scheme	Turbo convolutional code [1/3,1/2,2/3,3/4] All code rate shall be with all data rate and both the modulation scheme
15.	FEC Coding Gain	Within 0.5 dB of its theoretical value for any particular combination of block length and code rate
16.	AGC dynamic range (Within demodulator)	≥ 30dB
17.	PAPR	≤ 10dB
18.	Resource Utilization	≤ 65% resource of the specified FPGA

Architectural Overview



This architecture is the backbone of OFDM systems used in technologies like Wi-Fi, LTE, and 5G.

Transmitter Architecture:

1. **Mapping (16-QAM/QPSK):** It Converts binary data into complex symbols using modulation techniques like QPSK or QAM.
2. **Serial-to-Parallel (S/P):** It Converts serial data stream into parallel data for multiple subcarriers.
3. **Pilot Insertion:** Adds pilot signals for channel estimation and synchronization purposes.
4. **Inverse Discrete Fourier Transform:** It transforms frequency-domain data into time-domain signals to enable transmission over subcarriers.
5. **Guard Insertion:** Adds a cyclic prefix to mitigate inter-symbol interference caused by multipath propagation.
6. **Parallel-to-Serial (P/S):** Converts parallel streams back to a single serial stream for transmission over the channel.
7. **Channel with AWGN:** It transmitted signal passes through a channel with effects such as multipath fading (h(n)) and Additive White Gaussian Noise (AWGN, w(n)).

Receiver Architecture:

1. **Serial-to-Parallel (S/P):** It converts received serial data stream back into parallel streams for processing.
2. **Guard Removal:** Strips off the cyclic prefix to isolate the OFDM symbols.
3. **Discrete Fourier Transform:** Converts time-domain signals back to the frequency domain.
4. **Channel Estimation:** Utilizes pilot signals to estimate and compensate for channel effects like fading and distortion.
5. **Parallel-to-Serial (P/S):** Converts parallel data streams back to a single serial stream for demodulation.
6. **Demapping (16-QAM/QPSK):** Decodes the received symbols back into binary data using the specified modulation scheme.