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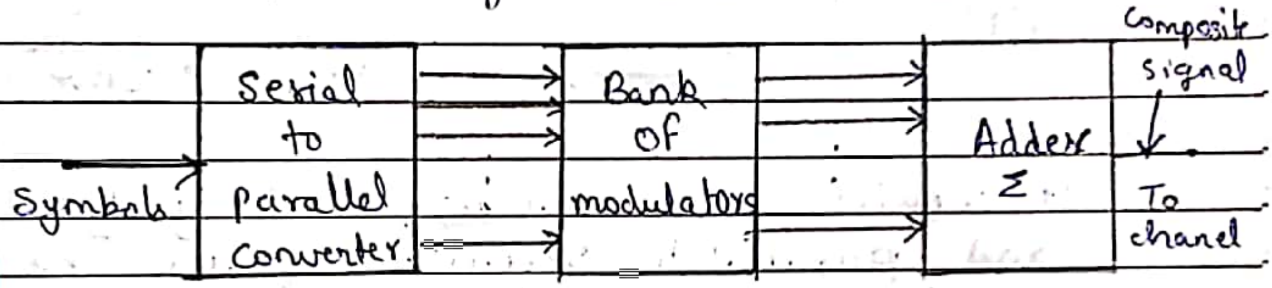
# * Test-II on Unit-2 *

Q.2 Draw block diagram to describe each components of Multicarrier Modulation transmitter and reciever

→ Multicarrier Modulation Transmitter :-

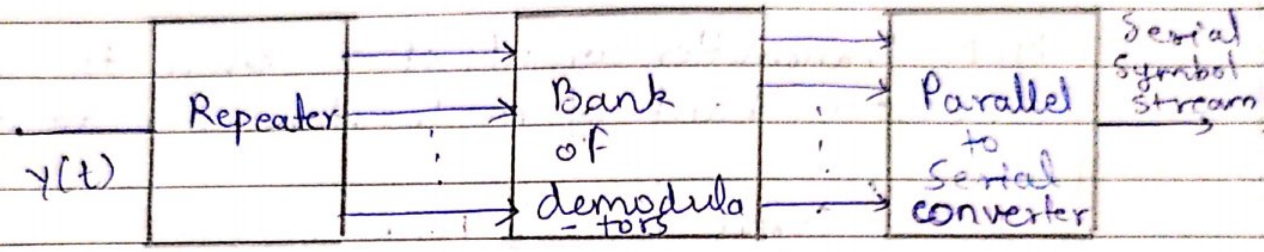
- MCM transmitter consists of a serial-to-parallel converter, bank of modulators, and an adder




- Serial to parallel converter is used to transmit the N information symbols ~~to~~ serial from serial to parallel. Thus there are N numbers of data streams
- The modulator modulates the $i^{th}$ data stream onto the $i^{th}$ subcarrier
- Adder will make the sum of all such sub-carriers
- The sum of all the subcarriers will be then transmitted over the channel as composite signal
- Consider the different modulated signals $s_i(t)$ corresponding to the N different subcarriers
- The composite signal $s(t)$ is formed by superposing modulated signals at the transmitter is given by, $s(t) = \sum_i s_i(t)$

- This composite signal s(t) is then transmitted over the wireless channel
- Thus, in the ~~ov~~ MCM system N different data streams are transmitted over N subcarriers in parallel.

- Multicarrier modulation Reciever :-




- It consists of a reciever, bank of demodulator and parallel to serial converter. The recieved signal y(t) is applied to repeater stage. At the reciever end composite signals are amplified first
- Repeater is an antenna that simultaneously recieves, amplifies and transmits a signal.
- It is passed on to the bank of demodulators and the data is converted to serial from parallel forming a symbol stream

Q.1. Draw neat diagram and explain the working operation of OFDM transmitter and reciever with FFT

→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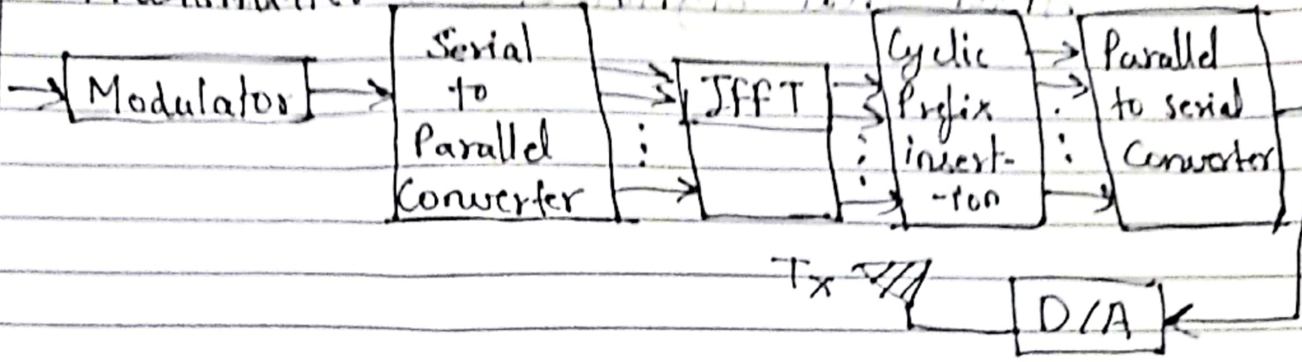
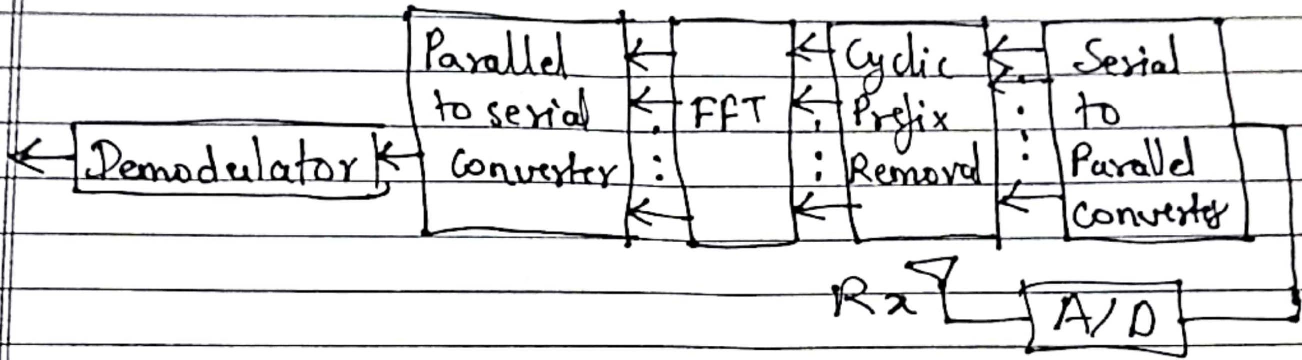
→ Transmitter:




Reciever :-




- Transmitter :-
- As shown in Fig the OFDM transmitter and recievers consists of IFFT & FFT respectively
- In transmitter the signal is ~~tra~~ modulated and passed to convert serial data to parallel
- That data ~~sig~~ or signal is passed to IFFT
- After IFFT the cyclic prefix is inserted to the signal
- And Lastly the data is converted from parallel to serial simultaneously after it digital to analog.
- Reciever :-
- OFDM Reciever acts in opposite as that of transmitter
- Firstly data is converted from ~~f~~ digital to analog
- It is converted to parallel
- Here cyclic prefix is removed and applied to FFT

- After it is converted to serial the signal is demodulated

## Operation :-

- Since we assumed there are N subcarriers allowed for the OFDM transmission, we name them from 0 to N-1
- Let s(t) is MCM signal it is bandlimited to total Bandwidth B
- The eqn is given as:-

Nyquist sampling rate = B

$$\therefore T_s = \frac{1}{B}$$

- Consider complete MCM signal : $\sum_i X_i e^{j 2\pi f_i (B/N) t}$

- The $\mu^{th}$ sample at time instant $\mu T_s = \mu / B$ is given by

$$s(\mu T_s) = x(\mu) \sum_i X_i e^{j2\pi f_i (B/N)(\mu/B)}$$

$$x(\mu) = \sum_i X_i \underbrace{e^{j2\pi (f_i \mu / N)}}_{DFT}$$

- $y_n = h(0)x(n) + \underbrace{h(1)\, x(n-1) + \dots + \Sigma h(L-1)\, x(n-L)}_{ISI\ component}$

Q.3) Compute the MIMO zero forcing reciever for channel matrix H given as ~~Max~~

$$H = \begin{bmatrix} 2 & 3 \\ 1 & 3 \\ 4 & 2 \end{bmatrix}$$

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$$H^T = \begin{bmatrix} 2 & 1 & 4 \\ 3 & 3 & 2 \end{bmatrix}$$

$$H^T H = \begin{bmatrix} 2 & 1 & 4 \\ 3 & 3 & 2 \end{bmatrix} \begin{bmatrix} 2 & 3 \\ 1 & 3 \\ 4 & 2 \end{bmatrix}$$

$$= \begin{bmatrix} 4+1+16 & 6+3+8 \\ 6+3+8 & 9+9+4 \end{bmatrix}$$

$$H^T H = \begin{bmatrix} 21 & 17 \\ 17 & 22 \end{bmatrix}$$

$$= \frac{1}{21 \times 22 - 17 \times 17} \begin{bmatrix} 22 & -17 \\ -17 & 21 \end{bmatrix}$$

$$= \frac{1}{462 - 289} \begin{bmatrix} 22 & -17 \\ -17 & 21 \end{bmatrix}$$

$$= \frac{1}{173} \begin{bmatrix} 22 & -17 \\ -17 & 21 \end{bmatrix}$$

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \begin{bmatrix} 2 & 3 \\ 1 & 3 \\ 4 & 2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

$$y_1 = 2x_1 + 3x_2$$
$$y_2 = x_1 + 3x_2$$
$$y_3 = 4x_1 + 2x_2$$

$$\hat{x} = (H^T H)^{-1} H^T y$$

$$= \frac{1}{173} \begin{bmatrix} 22 & -17 \\ -17 & 21 \end{bmatrix} \times \begin{bmatrix} 2 & 1 & 4 \\ 3 & 3 & 2 \end{bmatrix}$$

$$= \frac{1}{173} \begin{bmatrix} -7 & -29 & 54 \\ -29 & 46 & -26 \end{bmatrix}$$

$$\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} -0.0404 & -0.16761 & 0.31211 \\ -0.1676 & 0.2658 & -0.1502 \end{bmatrix} \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix}$$

$$x_1 = -0.04\, y_1 - 0.17\, y_2 + 0.31\, y_3$$

$$x_2 = -0.17\, y_1 + 0.27\, y_2 - 0.15\, y_3$$

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Q.3 For Wimax the total number of subcarriers $N = 256$, with a bandwidth of $15.625$ kHz per subcarrier and employs a cyclic prefix which is $12.5\%$ of the symbol time. Find Wimax OFDM symbol ~~at~~ with cyclic prefix

→ Given $N = 256$

$BW = 15.625\,kHz = 15.625 \times 10^3\,Hz$

Cyclic Prefix length = $12.5\%$ of the symbol time

- Symbol Time :-

$$T_s = \frac{1}{15.625 \times 10^3}$$

$\therefore T_s = 6.4 \times 10^{-5} = 64\,\mu s$

- $\therefore$ Cyclic Prefix length $= \frac{12.5}{100} \times 6.4 \times 10^{-5}$

$T_{cp} = 8 \times 10^{-6} = 8\,\mu s$

- Total Symbol Time $= T_s + T_{cp}$

$= (6.4 \times 10^{-5}) + (8 \times 10^{-6})$

$T_{total} = 7.2 \times 10^{-5} = 72\,\mu s$

- Total symbol samples

$N_{Total} = T_{Total} \times$ Sampling Rate

(~~Symbol rate = 1~~) (Sampling rate)

$\therefore N_{Total} = 7.2 \times 10^{-5} \times 1 = \underline{72\,\mu s}$

~~$= 7.2 \times 10^{-5}$~~

$\therefore$ Wimax OFDM Symbol with cyclic prefix is $\underline{72\,\mu s}$


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