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Towards 6G: Next Generation Wireless Systems

Abstract: - 5G will only be able to meet some of the demands of the coming technological advances in 2030 and beyond. Compared to 5G networks, sixth-generation (6G) networks are expected to introduce novel use cases and performance metrics, such as global coverage, cost efficiency, increased radio spectrum, energy intelligence, and safety. The growing global demand for ultra-high spectral efficiencies, data rates, speeds, and bandwidths in next-generation wireless networks motivates researchers to investigate the peak capabilities of massive MIMO (multiple input multiple outputs) and new technique filter bank multi-carrier (FBMC). Lower out-of-band emissions are observed in the FBMC technique compared to orthogonal frequency division multiplexing (OFDM), an essential requirement of upcoming next-generation wireless systems. This paper compares the spectral efficiency for Massive MIMO uplink in a single-cell scenario using linear detectors at the BS with perfect CSI. Arbitrarily larger SNR values are obtained with a higher number of BS antennas in Massive MIMO, which helps to increase the data rate. This paper also demonstrates how linear detectors can help to reduce the symbol error rate (SER) in a Massive MIMO. This paper demonstrates that with the same number of BS antennas and user combinations ZF detector outperforms the MRC detector.

Keywords: 5th Generation (5G), Filter Bank Multi Carrier (FBMC), Orthogonal Frequency Division Multiplexing (OFDM), Massive MIMO

I. INTRODUCTION

Analog voice communication capabilities were simple yet revolutionary in the first generation of cellular systems. In comparison to the previous generation, the second generation has digitalized voice to boost capacity, improve the battery life of the device, and improve the quality of service (QoS). At the time, the third generation enabled mobile Internet connectivity and data rates comparable to wired systems. Smartphones with massive storage and processing capabilities, high-definition cameras, and social networks turning mobile users into content providers have pushed fourth-generation devices further towards higher speeds. The fifth generation (5G) targets an exponential increase in data rate, device-to-device (D2D) communication, machine-to-machine (M2M) and the health sector [1],[2]. Fig. 1 illustrates the list of some of the 5G objectives. Fifth-generation cellular technology will be replaced by sixth-generation wireless, or 6G, in the future. The bandwidth of 6G [3],[4] networks will be significantly higher than those of 5G networks due to their ability to operate at higher frequencies. The 6G computational infrastructure, in conjunction with artificial intelligence (AI), will be able to decide where computing should occur, including decisions regarding data storage, processing, and sharing. It is important to keep in mind that 6G is still a developing technology, and some companies are making investments in the sixth generation.

The 4G mobile communication system employs OFDM modulation technology. Due to higher out-of-band emissions, OFDM is unlikely to be considered for the next-generation wireless communication systems in which the rectangular shape filter is used, which is replaced by a new waveform in the FBMC technique. OFDM filters the entire band, while FBMC, which is the generalisation of OFDM, filters each subcarrier independently. FBMC is proposed as an alternative to OFDM, which does not use a cyclic prefix (CP). Hence, it is more spectrally efficient than OFDM.

To serve tens of users, Massive MIMO uses a few hundred or more antennas at the BS to reduce intra-cell interference. Many antennas at the BS will aid in creating pair-wise orthogonal random channel vectors between the BS and the users. BS having infinite number of antennas completely vanishes uncorrelated noise and intra-cell interferences. Massive MIMO uses more antennas to achieve massive spatial multiplexing benefits, resulting in a multi-fold increase in cellular network capacity.

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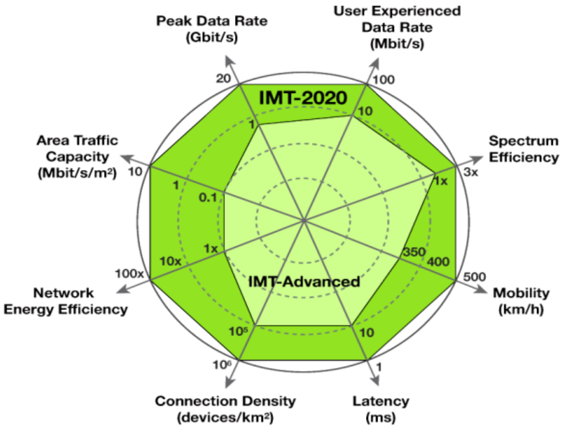

Fig.1:Key parameters for international mobile telecommunications (IMT) 2020[5]

Authors in [6] have shown that FBMC offers better spectral properties compared to OFDM. The modulation and demodulation processes of FBMC-OQAM and OFDM differ slightly. In comparison among CP-OFDM, FBMC with a PHYsical layer for DYnamic spectrum AccesS and cognitive radio (PHYDYAS) prototype filter proven best performance in terms of spectral properties. The authors of [7] conducted a spectral efficiency analysis for Massive MIMO uplink employing OFDM and FBMC with a Zero forcing linear detector in a single-cell scenario.

This paper compares OFDM and FBMC techniques, concentrating on Filter-Bank Multicarrier (FBMC) as a potential modulation technology for 6G.This paper compares the spectral efficiency parameter for Massive MIMO uplink in a single-cell scenario employing two linear detectors at the BS with perfect CSI using MATLAB code. This study also illustrates that arbitrarily larger SNR value obtained with higher number of BS antennas in Massive MIMO. This paper also demonstrates how linear receivers, in conjunction with ZF and MRC detectors, can help to lower the symbol error rate (SER) in a Massive MIMO setting.

II. BEYOND 5G

India, like the rest of the globe, is thinking about the next generation of telecom technologies and the transformations they are expected to bring. Since wireless communication technology requires many resources, more spectrum is required to handle higher data rates. This is especially true as the technology advances. The utilization of spectrum is expanding to higher frequency bands as mobile communication technologies advance to new generations. While 5G was the first to employ mm Wave frequency bands, 6G is anticipated to investigate even higher frequency bands, such as (sub-) THz. Although low and mid-band frequencies are crucial for mobile communication systems to attain widespread coverage. The mm Wave band has greater technical challenges compared to low and mid bands because of more severe radio propagation characteristics. By using Massive MIMO networks and sub-THz transmission with maximum bandwidth, spectral efficiency can be improved. Tables 1 and Table II indicate the critical parameters such as bandwidth requirements, data rates, and features for each generation.

TABLE I: BANDWIDTH OF EACH GENERATION

Sr. No.	Generation	Bandwidth
1	2G	200 KHz
2	3G	5 MHz
3	4G	20 MHz
4	5G	100 MHz
5	6G	500 MHz-1GHz

TABLE II: EVOLUTION OF WIRELESS TECHNOLOGIES

Sr. No.	Generation	Commencement year	Data rates	Features
1	1G	1980	2.4kbps	Voice service
2	2G	1992	200kbps	Voice service, Data service
3	3G	2000	30Mbps	Voice service, Data service, Video call
4	4G	2010	1Gbps	Voice service, Data service, Video call,

5	5G	2020	20Gbps	DVB, HD TV Voice service, Data service, Video call, DVB, HD TV, AR/VR, Smart City
6	6G	2030(Expected)	1Tbps	Voice service, Data service, Video call, DVB, HD TV, AR/VR/XR, IoE, AI-enabled Smart City, Edge AI, Block chain

III. 6G TECHNOLOGY

The next edition of virtual augmented reality (VAR) demands Tbps data throughput and ultra-low latency, which are incompatible with the 5G system's new frequency ranges. The expansion in industrial automation, as well as the shift from Industry 4.0 to Industry X.0, will result in huge connectivity considerably exceeding the standards for 5G that were initially anticipated. Increased connection density will increase the requirement for higher energy efficiency, which 5G does not provide. Table III summarizes the key performance indices for 4G, 5G, and 6G technology.

TABLE III. COMPARISON OF 4G, 5G AND 6G

Key performance Index	**4G**	**5G**	**6G**
Peak data rate	1Gbps	10 Gbps	1 Tbps
Latency	100 ms	1 ms	0.1 ms
Maximum spectral efficiency	15 bps/Hz	30 bps/Hz	100 bps/Hz
AI	No	Partial	Fully
Autonomous Vehicle	No	Partial	Fully
Extended Reality	No	Partial	Fully
Service Level	Video	VR,AR	Tactile
Architecture	MIMO	Massive MIMO	Intelligent surface
Maximum Frequency	6 GHz	90 GHz	10 THz

4G uses MIMO technology with only 8 antennas. Later, it was upgraded to 256-1,024 antennas for 5G. 6G is projected to use over 10,000 antenna elements using Massive MIMO using spatial multiplexing with narrow beams, resulting in increased spectrum efficiency and lower propagation loss for high-frequency communications [8].

IV. FILTER BANK MULTI-CARRIER(FBMC)

This section covers the potential of Filter Bank Multicarrier (FBMC) modulation as an alternative to be used in the future generation wireless systems in which Massive MIMO will be deployed. Orthogonal frequency division multiplexing (OFDM) is a type of multichannel system, which is similar to the filtered multi-tone (FMT) transmission scheme in the sense that it employs multiple subcarriers. Fig. 2 depicts the block diagram of an OFDM transceiver. The multiple orthogonal subcarrier signals overlapped in the spectrum, can be produced using the fast Fourier transform (FFT) and inverse FFT (IFFT) processes. In FBMC, a set of parallel data symbols transmitted through a bank of modulated filters, as shown in Fig. 3, and, thus, the transmitted signal is synthesized using a synthesis filter bank (SFB). The key distinction is that the synthesis filter bank (SFB) replaces the inverse fast Fourier transform (IFFT) plus cyclic prefix (CP), whereas the FFT plus cyclic prefix out is replaced by the analysis filter bank (AFB). The difference between OFDM and FBMC lies in the choice of the transmitter and receiver prototype filters. OFDM uses rectangular filters at the transmitter and receiver ends, while FBMC uses non-rectangular filters, so different characteristics could be obtained according to the filters used.

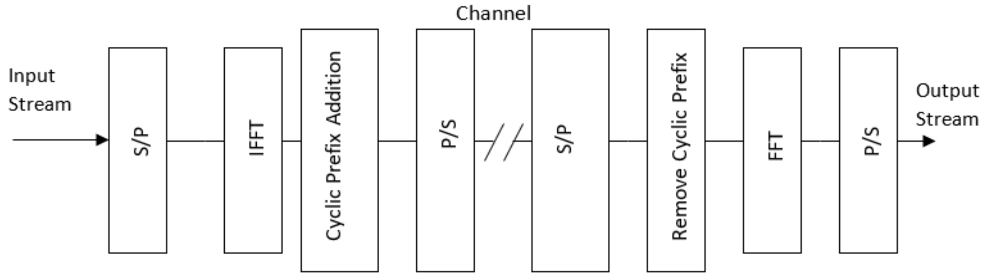

Fig. 2: Block diagram of an OFDM transceiver

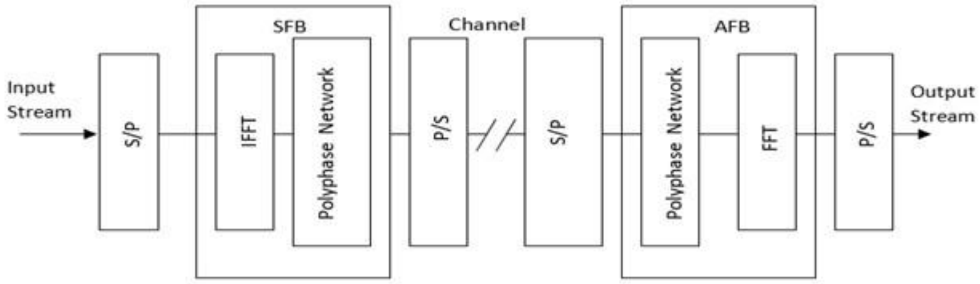

Fig.3: Block diagram of a FBMC

FBMC uses different types of filters such as root-raised-cosine (RRC), Hermite, and PHYDYAS prototype filters to cater different types of requirements. Frequency domain responses are plotted in Fig. 4 and it is observed that the PHYDYAS prototype filter has shown the lowest out of band emissions.

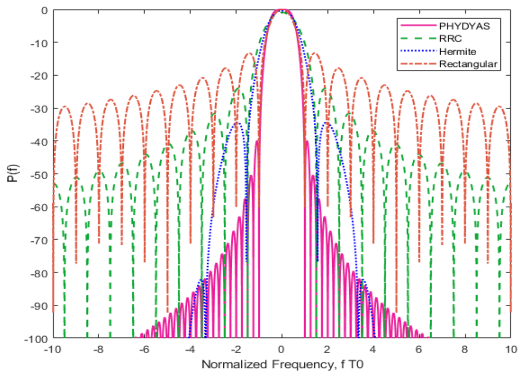

Fig. 4: Frequency domain representation of rectangular, RRC, Hermite and PHYDYAS prototype filters

FBMC with PHYDYAS has shown the best performance compared to conventional FBMC using a Hermite and OFDM with rectangular as depicted in Fig.5. PHYDYAS-based FBMC produces 50 dB lower out-of-band emissions than CP-OFDM. It outperformed traditional FBMC with a Hermite filter, as seen in Fig. 5.

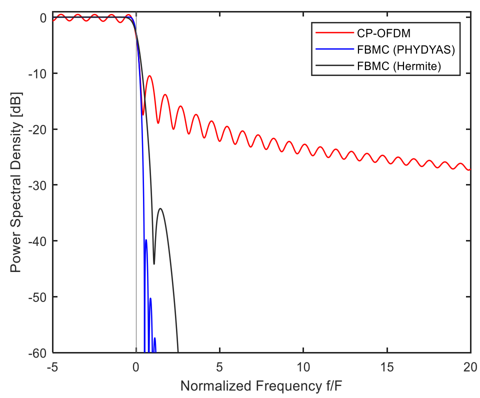

Fig. 5: Comparison of the PSD for FBMC and OFDM

V. MASSIVE MIMO

Massive MIMO extends the MIMO system by including a significantly greater number of antennas on the base station. The “massive” number of antennas helps focus energy, which brings drastic improvements in throughput and efficiency. The Massive MIMO model is described as shown in Fig. 6, where BS contains M antennas that serve K single antenna users where $M \gg K$[9],[10].

Uplink: BS receives the signal described as [11],[12]:

$$y = \sqrt{p_u} G x + n \tag{1}$$

$p_u$is the transmit power of each user, $x = [x_1, x_2, . x_K]^T$ is the vector of information symbols transmitted by K single antenna users, where x_K is the data transmitted by the single antenna K^{th} user. The Channel matrix between M antennas at the BS and K users is represented by $G \in \mathbb{C}^{M \times K}$ and $g_{mk} \triangleq [G]_{mk}$. The $\sqrt{p_u}x$ is the vector of symbols transmitted by the K users and n is a vector of additive white Gaussian noise with zero mean and variance 1.The channel matrix G models independent fast fading, geometric attenuation, and log-normal shadow fading. The coefficient g_{mk} can be represented as

$$g_{mk} = h_{mk} \sqrt{\beta_k} \tag{2}$$

h_{mk} is the fast fading coefficient between the k^{th} user to the m^{th}antenna and $\sqrt{\beta_k}$represents the shadow fading and geometric attenuation which is assumed to be independent over m. In addition, users and the BS are separated by a much greater distance than the separation between the antennas and the β_k changes slowly with time[11]:

$$G = H\sqrt{D} \tag{3}$$

H is the $M \times K$ matrix of fast fading coefficients between the K users and the BS, then $[H]_{mk=}h_{mk}$ and D is a $K \times K$ diagonal matrix, where $[D]_{kk=}\beta_k$

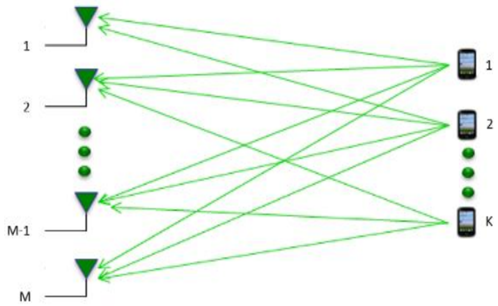

Fig. 6: Massive MIMO architecture

Less complex linear processing techniques like zero forcing (ZF) and maximum ratio combining (MRC) perform well to find spectral efficiency with perfect channel state information if BS has M antennas that serve K single antenna users for $M \gg K$[11], [13],[14],[15],[16].The received signal at the BS is represented by the mathematical expression given as:

$$r = A^H y \tag{4}$$

Where$A^H$is the matrix transpose and $M \times 1$ received vector at the BS is y.

For MRC: $$A = G \tag{5}$$

For Zero Forcing: $$A = G(G^H G)^{-1} \tag{6}$$

From (1) and (4) the received vector at the BS using the linear detector is

$$r = A^H(\sqrt{p_u} G x + n) \tag{7}$$

Consideringr_k is the k^{th} element of $K \times 1$ vector r and x_k is the k^{th} element of $K \times 1$vector x then

$$r_k = \sqrt{p_u} a_k^H g_k x_k + \sqrt{p_u} \sum_{i=1, i\neq k}^{K} a_k^H g_i x_i + a_k^H n \tag{8}$$

Where a_k and g_k are the k^{th} columns of the matrices $A\ and\ G$ respectively.For a fixed channel realization, the noise plus interference term is a random variable with zero mean and variance $p_u \sum_{i=1,i\neq k}^{K} |a_k^H g_i|^2 + \|a_k\|^2$. Signal to noise plus interference ratio is denoted by

$$SINR = \frac{Signal\ power}{Interference\ power + Noise\ power} \tag{9}$$

$$= \frac{p_u |a_k^H g_k|^2}{p_u \sum_{i=1,i\neq k}^{K} |a_k^H g_i|^2 + \|a_k\|^2} \tag{10}$$

Where $\|a_k\|$ represents the norm of a_k.
By modelling $p_u \sum_{i=1,i\neq k}^{K} |a_k^H g_i|^2 + \|a_k\|^2$term as additive gaussian noise independent of x_k, we can determine a lower bound on the achievable rate as below.
Ergodic achievable uplink rate of the k^{th}user is

$$R_{P,k} = \mathbb{E}\left\{\log_2\left(1 + \frac{p_u |a_k^H g_k|^2}{p_u \sum_{i=1,i\neq k}^{K} |a_k^H g_i|^2 + \|a_k\|^2}\right)\right\} \tag{11}$$

MRC
Maximum ratio Combining (MRC), $A = G$ and $a_{k=}g_k$ then achievable uplink rate for k^{th} user is[11],

$$R_{P.k}^{MRC} = \mathbb{E}\left\{\log_2\left(1 + \frac{p_u \|g_k\|^4}{p_u \sum_{i=1,i\neq k}^{K} |g_k^H g_i|^2 + \|g_k\|^2}\right)\right\} \tag{12}$$

$$= \log_2\left(1 + \left(\mathbb{E}\left\{\frac{p_u \sum_{i=1,i\neq k}^{K} |g_k^H \widetilde{g}_\iota|^2 + \|g_k\|^2}{p_u \|g_k\|^4}\right\}\right)^{-1}\right)$$

$$= \log_2\left(1 + \left(\mathbb{E}\left\{\frac{p_u \sum_{i=1,i\neq k}^{K} |\widetilde{g}_\iota|^2 + 1}{p_u \|g_k\|^2}\right\}\right)^{-1}\right) \tag{13}$$

$\widetilde{g}_\iota$ is a Gaussian random variable with zero mean and variance β_i which does not depend on g_k.

$$\mathbb{E}\left\{\frac{p_u \sum_{i=1,i\neq k}^{K} |\widetilde{g}_\iota|^2 + 1}{p_u \|g_k\|^2}\right\}$$

$$= \mathbb{E}\left\{p_u \sum_{i=1,i\neq k}^{K} |\widetilde{g}_\iota|^2 + 1\right\} \mathbb{E}\left\{\frac{1}{p_u \|g_k\|^2}\right\}$$

$$= \left(p_u \sum_{i=1,i\neq k}^{K} \mathbb{E}\{|\widetilde{g}_\iota|^2\} + 1\right) \mathbb{E}\left\{\frac{1}{p_u \|g_k\|^2}\right\}$$

$$= \left(p_u \sum_{i=1,i\neq k}^{K} \beta_i + 1\right) \mathbb{E}\left\{\frac{1}{p_u \|g_k\|^2}\right\}$$

Using wishart Lemma

$$\mathbb{E}\left\{\frac{1}{p_u\|g_k\|^2}\right\} = \frac{1}{p_u(M-1)\beta_k}$$

$$= \left(p_u \sum_{i=1, i\neq k}^{K} \beta_i + 1\right)\left(\frac{1}{p_u(M-1)\beta_k}\right)$$

$$\mathbb{E}\left\{\frac{p_u \sum_{i=1,i\neq k}^{K} |\tilde{g}_i|^2 + 1}{p_u\|g_k\|^2}\right\} = \left(p_u \sum_{i=1, i\neq k}^{K} \beta_i + 1\right)\left(\frac{1}{p_u(M-1)\beta_k}\right)$$

$$\tilde{R}_{P.k}^{MRC} = \log_2\left(1 + \left(\mathbb{E}\left\{\frac{p_u \sum_{i=1,i\neq k}^{K} |\tilde{g}_i|^2 + 1}{p_u\|g_k\|^2}\right\}\right)^{-1}\right)$$

Uplink achievable rate from the k^{th} user using MRC can be lower bounded by perfect CSI Rayleigh fading[11],

$$R_{P.k}^{MRC} = \log_2\left(1 + \frac{p_u(M-1)\beta_k}{p_u \sum_{i=1,i\neq k}^{K} \beta_i + 1}\right) \tag{14}$$

ZF

Zero forcing receiver, $A^H = (G^H G)^{-1} G^H$ and $A^H G = I_K$, so $a_k^H g_i = \delta_{ki}$

$$\delta_{ki} = \begin{cases} 1, & k = i \\ 0, & otherwise \end{cases}$$

The uplink rate for k^{th} user is[11]

$$R_{P.k}^{ZF} = \mathbb{E}\left\{\log_2\left(1 + \frac{p_u}{[(G^H G)^{-1}]_{kk}}\right)\right\} \tag{15}$$

The uplink rate for k^{th} user is lower bounded by ZF in a Rayleigh fading for $M \geq K + 1$[11]

$$R_{P.k}^{ZF} = \log_2\left(1 + \mathbb{E}\left\{\frac{p_u}{[(G^H G)^{-1}]_{kk}}\right\}\right)$$

$$= \log_2\left(1 + p_u \mathbb{E}\left\{\frac{1}{[(G^H G)^{-1}]_{kk}}\right\}\right)$$

For $\mathbb{E}\{[(G^H G)^{-1}]_{kk}\}$

$G = HD^{\frac{1}{2}}$ and $[D]_{kk=}\beta_k$

$$\mathbb{E}\{[(G^H G)^{-1}]_{kk}\} = \frac{1}{\beta_k}\mathbb{E}\{[(H^H H)^{-1}]_{kk}\}$$

$$= \frac{1}{K\beta_k}\mathbb{E}\{tr[(H^H H)^{-1}]\}$$

$$= \frac{1}{(M-K)\beta_k}$$

$$R_{P.k}^{ZF} = \log_2(1 + p_u(M-K)\beta_k) \tag{16}$$

VI. SPECTRAL EFFICIENCY IN MASSIVE MIMO

In a single cell environment, linear detectors like MRC and ZF could be used to enumerate the value of spectral efficiency (SE) in the Massive MIMO uplink.

MRC

Analysis of spectral efficiency in Massive MIMO uplinks for maximum ratio combining (MRC) by [11],[17]:

$$SE_{MRC} = \sum_{k=1}^{K} \log_2 \left(1 + \frac{p_u \|g_k\|^4}{p_u \sum_{i=1,i\neq k}^{K} |g_k^H g_i|^2 + \|g_k\|^2}\right) \tag{17}$$

The MRC can be approximated by a lower bounded by [11]:

$$SE_{MRC} = \sum_{k=1}^{K} \log_2 \left(1 + \frac{p_u (M-1)\beta_k}{p_u \sum_{i=1,i\neq k}^{K} \beta_i + 1}\right) \tag{18}$$

ZF

Massive MIMO uplink with zero forcing (ZF) has the following spectral efficiency[11],[17]:

$$SE_{ZF} = \sum_{k=1}^{K} \log_2 \left(1 + \frac{p_u}{[(G^H G)^{-1}]_{kk}}\right) \tag{19}$$

In Rayleigh fading with ZF, for $M \geq K+1$it is lower bounded by[11],[17]:

$$SE_{ZF} = \sum_{k=1}^{K} \log_2 (1 + p_u (M-K)\beta_k) \tag{20}$$

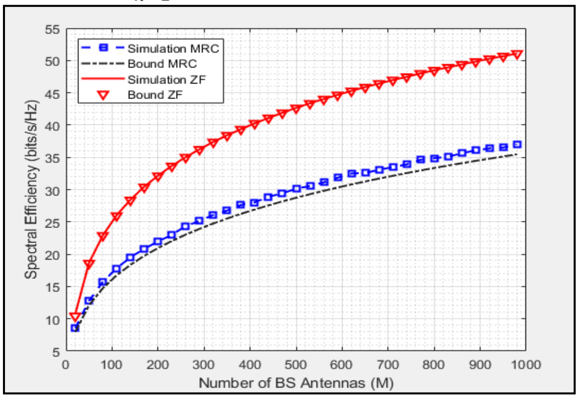

Fig. 7: Spectral efficiency in perfect CSI for K = 10 users with MRC and ZF linear detectors using numerically evaluated values and lower bounds for different number of BS antennas

The spectral efficiency in Massive MIMO environment has been calculated using capacity bound and numerically evaluated values for linear detectors MRC and ZF with perfect CSI for $p_u = 10$ dB and $K = 10$ users for various numbers of BS antennas [18] as shown in Fig. 7.

The users are evenly distributed throughout a hexagonal cell with a radius of 1000 meters.

$\beta_k$is characterized by[11].

$$\beta_k = \frac{z_k}{\left({r_k}/{r_h}\right)^{v}} \tag{21}$$

Where r_k is the distance between base station and k^{th}user

$v$is the path loss exponent=3.8.

we assume that no user is closer to the BS than $r_h = 100$meters.

z_k is a lognormal random variable with standard deviation $\sigma_{shadow} = 8$ dB

As shown in Fig. 7, the simulation result shows that with a higher number of BS antennas all bounds are found to be tight. In same scenario MMSE and ZF give approximately the same spectral efficiency values. MMSE is represented by $(\mathrm{H^H H} + \frac{1}{\mathrm{SNR}}\mathrm{I})^{-1}\mathrm{H^H}$.The $\mathrm{H^H}$ provides the complex conjugate of a channel matrix H. With infinite value of SNR equation results in to $(\mathrm{H^H H})^{-1}\mathrm{H^H}$, which represents zero forcing (ZF) receiver. That's why ZF and MMSE give nearly similar values of spectral efficiency parameters at higher SNR, so we have taken ZF for simulation in this paper. Comparing (18) and (20), in reference to Massive MIMO spectral efficiency with $SE_{SISO} = log_2(1+SNR)$ we have observed that $\frac{p_u(M-1)\beta_k}{p_u \sum_{i=1,i\neq k}^{K}\beta_i+1}$is analogous to SNR per user for MRC if the modulated signals are Gaussian distributed and $p_u(M-K)\beta_k$is analogous to SNR per user for ZF if the modulated signals are Gaussian distributed. By evaluating SNR in a Massive MIMO utilizing MRC and ZF linear detectors, it is shown that SNR improves as the number of antennas at BS grows, as shown in Fig. 8.

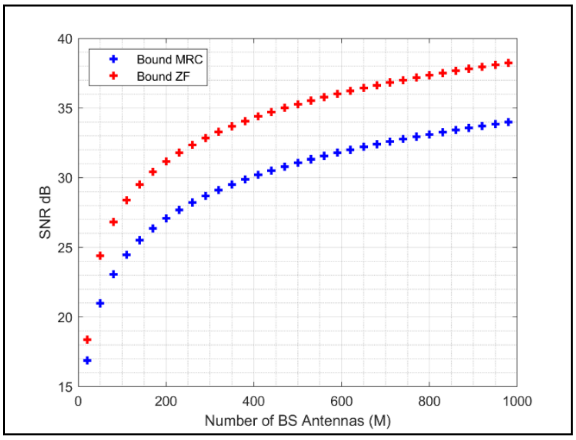

Fig. 8: SNR performance with M number of BS antennas for K = 10 users using MRC and ZF linear detectors

By using this method, it becomes possible to achieve the maximum spectral efficiency values for OFDM and FBMC modulation systems using more number of antennas at BS.

VII. MASSIVE MIMO DETECTION

The maximum likelihood detector (MLD) provides the optimal results but it requires complicated signal processing techniques at the BS. On the other hand ZF and MRC linear detectors provide suboptimal results, with less complicated signal processing at BS [11], [19],[20],[21]. With hundreds of antennas at BS serving ten of users, functioning of linear receivers found is adequate[22]. So due to having lower complexity at BS, we carried out simulations for symbol error rate (SER) using ZF and MRC.

The received signal at the BS is represented by the mathematical expression given as:

$$r = Ay \tag{24}$$

For MRC:

$$A = G^H \tag{25}$$

For Zero Forcing:

$$A = (G^H G)^{-1} G^H \tag{26}$$

From (1), (24) and (25), the received vector for MRC is described as

$$r = G^H(\sqrt{p_u} Gx + n) \tag{27}$$

Users $x_1, x_2, \dots \dots . x_K$ are assumed independent.

Using (1), (24) and (26), ZF linear detector is represented as

$$r = \sqrt{p_u}\, x + (G^H G)^{-1} G^H n \tag{28}$$

TABLE IV. MASSIVE MIMO DETECTION PARAMETERS

Description	Parameters
No. of antennas at BS $=M$	64,128,256
No. of users $=K$	16
SNR in dB	1:10
Linear detectors	MRC, ZF

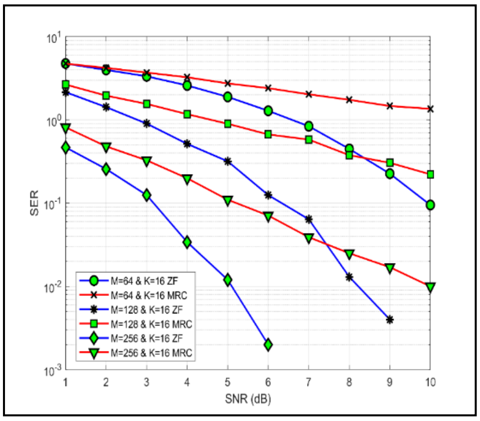

Fig. 9: SER performance in Massive MIMO detection using MRC and ZF detectors for different number of antennas at BS

Table IV summarizes the parameters used in the detection of Massive MIMO with ZF and MRC linear detectors. Symbol error rate (SER) performance has been plotted for different number of antennas at BS using MRC and ZF linear detectors in Fig.9.We conclude that SER value of 10^{-3}at ≈6 dB can be achieved using 256 Antennas at BS for 16 users in ZF, while to achieve the same SER we required ≈10 dB for 128 antennas at BS to serve same no. of users, hence the performance improvement possibility of 4 dB exists by doubling the number of antennas at BS. We also observed that for the same number of BS antennas and user combinations ZF detector outperformed than MRC detector.

VIII. CONCLUSION

Lower out-of-band emissions is observed in FBMC technique compared to OFDM, which is an essential requirement of upcoming next generation wireless systems. FBMC can eventually replace the OFDM as its viable alternative. FBMC is a well-designed multicarrier communication system employing the filtering strategy to overcome the most of issues encountered by OFDM.

Linear detectors provide better spectral efficiency in the uplink of Massive MIMO single-cell environment in perfect CSI conditions. Massive number of antennas at BS will help to increase SNR, which will increase spectral efficiency using linear detectors. Such arrangement can also help in reducing the symbol error rate (SER) using linear detectors in the detection of Massive MIMO. We have also observed that with the same number of BS antennas and user combinations ZF detector outperformed than MRC detector.

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