Aggregation of Carrier Components with Optimization for Improving Capacity in LTE-A Downlink System

Prem Chandra Gupta
M.Tech Scholar, Electronics & Communication Engineering Deptt.
National Institute of Technical Teachers Training and Research, Chandigarh

Mrs. Garima Saini
Assistant Professor, Electronics & Communication Engineering Deptt.
National Institute of Technical Teachers Training and Research, Chandigarh

***Abstract*—** The primary goal of this work is to enhance limit of framework by decreasing high PAPR value by appropriate approach under downlink framework in LTE-A framework. It can be done by improving equivalent capacity of system. SCDMA is utilized as a part of uplink while OFDM is utilized as a part of downlink framework. Three kinds of regulations are utilized here QPSK, 16QAM and 64 QAM. It likewise gives an answer for finding ideal outcome for high information rate LTE downlink collector. For high information rate, high regulation organization will be used. The framework gives the execution examination of various strategies for lessening high PAPR esteem. For PAPR decrease, diverse procedures were examined. In this work, it used all of three modulations with both filters and compared the results of all graphs. Both PAPR and limit are between related. From results, it concludes that the value of PAPR is lower in case of 64 QAM modulation with proposed technique and capacity is higher in case of 64 QAM modulation. In the event that PAPR is low for framework, at that point its ability is better when contrasted with other. All the simulations has been done in the MATLAB software.

Keywords- OFDM System, LTE, LTE-A, PAPR in OFDM etc.

I. INTRODUCTION

With the extension of cell phones, the request of high information rate and QOS increments quickly. In this way, 3GPP has indicated new models for versatile correspondence on GSM (Global System for portable correspondence)/EDGE and Universal Mobile Telecommunications System (UMTS). In the correspondence framework, the structure with high information rate participate an imperative part in day by day era. The massive number of uses regarding plan with elevated information speed through it important to accomplish the best achievable execution with the slightest likely cost. This causes the truth that collector is being not ready to isolate not at all like images as a result of postponement happened in each duplicate of image which is transmitted and touched base at recipient. Consequently it requires equalizers at collectors end [1]. The answer for this issue is given by utilization of OFDM framework.

In its Release 8, third Generation Partnership Project (3GPP) [1] has institutionalized Long Term Evolution as the successor of the Mobile Telecommunications System standard. LTE was composed with the end goal that every one of its administrations would be parcel exchanged not the circuit exchanged. In this way, it gives the pattern from advancement of GSM (Global System for Mobile correspondences) to GPRS (General Packet Radio Service), High-Speed Packet Access and UMTS and so on.

Amid this improvement, the fundamental concentration has been moving towards availability of broadband correspondences notwithstanding voice and content correspondence capacities. From early bundle administrations of versatile, it expanded the throughput, because of this idleness gets diminished. In early days, 2G frameworks like GPRS offered information rates of 10 Kbits/sec. Presently days, HSPA gives top speed of 80 Mbit/sec by consolidated utilization of 5 KHz bearer and MIMO strategies.

LTE gives effortlessness in engineering when contrasted with past frameworks that advanced this design while in transit to less complex and viable level framework. The principle point of LTE is to give streamlining to bundle exchanging administrations which is essential for advanced throughput and high information rates and furthermore change in parcel conveyance delay. There is likewise thought of enhancement of between systems administration with other stage like distinctive access systems. Advanced UMTS Terrestrial Radio Access Network is utilized at base station level that comprises of wise base stations called developed Node B (eNodeB). E-UTRAN relates to a straightforward matrix of eNodeBs sorted out by the X2 interface.

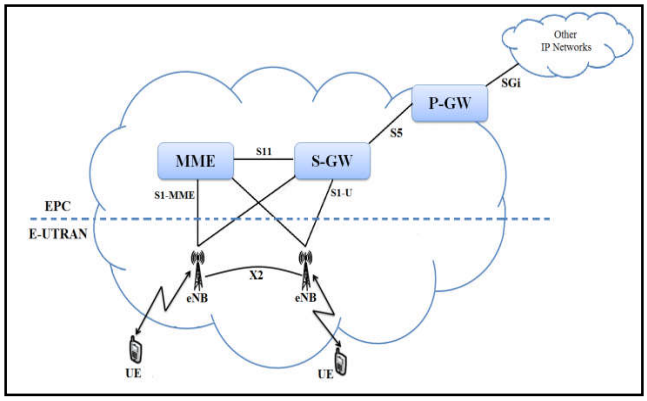

Figure 1: LTE-Advanced Network Architecture [2]

The LTE depends on OFDMA in the Downlink, and transporter FDMA in the Uplink, which switch the wide-band recurrence segregating channel into an arrangement of blurring sub channels through a Cyclic Prefix (CP). On account of MIMO transmission, ideal collectors can be actualized with sensible intricacy, as clashing to frameworks, where space evening out be alluring. Besides, OFDM considers recurrence space planning, structure it conceivable to allocate substantial assets to clients with ideal control conditions. That gives colossal potential throughput picks up in the Downlink due to multi-client extend.

Incited by the rising interest for broadband administrations of portable, 3GPP began activity on LTE standard, as well as on the "Framework Architecture Evolution" (SAE), as a result of reason of characterizing center of system framework. The components and necessities that will fill in as a reason for cutting edge systems were characterized by 3GPP in its Release 8. In the viewpoint of 4G frameworks, both air interface and access organize are being progressed. Then again, the center system design is going through slight changes from the effectively uniform SAE engineering. As spoke to in Figure 1, the SAE is comprised of a center framework, to be specific the "Developed Packet Core" and a radio access arrange.

In E-UTRAN design, the fundamental part is improved Node B which is the headway of NodeB in a third era (3G) framework. It can deal with at least one E-UTRAN cells at one time and speaking with client supplies. These hubs are clearly connected to each other (that expanded flagging activities) through X2 interface. The EPC is IP based center structure that predefined to save E-UTRAN through a lessening in number of components in arrange and give flag associations and different techniques for handoff to other settled line and remote access advances, giving the providers the ability to convey an impeccable development encounter.

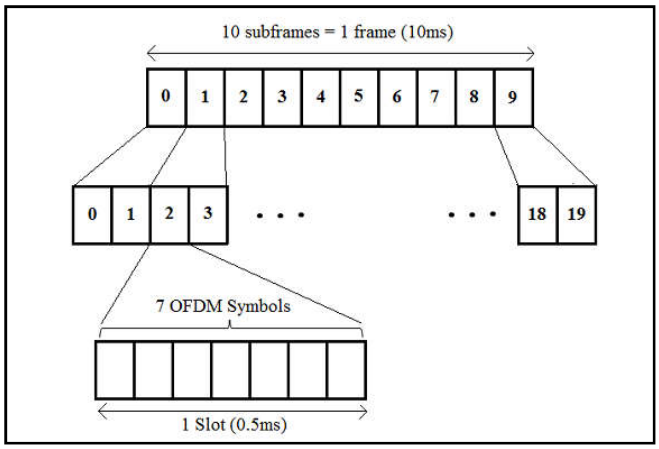

Figure 2: LTE Downlink Frame Structure [3]

In this structure, the radio casing structure in LTE takes the 0.5 ms space structure and uses the 2 opening (1 sub outline) portion time. It takes 10 ms term (i.e. 10 sub outlines) per outline. In including, each space is taking 6 or 7 Orthogonal Frequency Division Multiplexing (OFDM) images for each sub-outline, for the Downlink relying upon which kind of cyclic prefix is utilized whether expand or short, with a correspondence Time span of 1 ms. A few User Equipments can appropriate open assets inside each TTI. The slightest asset part that can be allocated to a User Equipment for transmission of data is known as Physical Resource Block that is gathered by 12 progressive subcarriers and takes a data transmission of 180 kHz in recurrence area.

The idea of successful data transfer capacity has been acquainted with outline client throughput necessity into the transmission capacity prerequisite thinking about the remote channel insights. In this, clients didn't have MIMO capacities. At that point, shut shape articulations of Capacity is been determined with the ordinary binomial estimation. Relative reasonable plan manages ghastly productivity and reasonableness however never thinks about any QoS parameter, so does not provide any assurance regarding flow with priority. It provide a method to calculate capacity under LTE uplink on receiver side. It provides a interleaving approach to enhance stability of system. It uses the LDPC coding method for high data rate sustainability.

In this case, the value of PAPR is quite high that reduces the efficient energy of system. The high traffic in the system consumes high energy that degrades the performance of system. The capacity under secondary transmission becomes poorer or performance degrades when there is an improvement in throughput value of system and system performance becomes zero when ratio for improvement in throughput becomes higher than set point.

This paper is composed as takes after. In Section II, It depicts review of LTE framework. In Section III, it shows the depiction of proposed framework. Results are clarified in area IV. At last, conclusion is given in Section V.

II. INTRODUCTION TO LTE SYSTEM

The work uses OFDM and SC-FDMA system in the communication process. CP is a basic prefix added to the OFDM image, replicated from finish of a similar image. The flag will pick up an occasional nature, permitting discrete Fourier activities, subsequently maintaining a strategic distance from Inter Symbol Interference. CP utilization is tended to in the edge structure later on. In an OFDM framework, the accessible transmission capacity is separated into different sub-transporters that can be regulated freely [3].

The principle reason that legitimizes distinctive access systems for the UL and DL is the way that SC-FDMA improves range and power utilization at the UE, while OFDMA limits beneficiary many-sided quality and empowers recurrence area planning with adaptability in asset designation. OFDMA is a multi-transporter transmission plot contrary to SC-FDMA. Both permit various client get to, contingent upon the accessible data transmission, by progressively apportioning every client to a particular time-recurrence asset, contingent upon which Duplexing is conveyed. OFDM requires a huge unique range because of high PAPR. Since SC-FDMA is OFDM with pre-coding, the use of SC-FDMA uncovers a 2 dB improvement of PAPR contrasted with OFDMA.

LTE uses Duplexing techniques mainly Frequency Division and Time Division Duplexing, despite the fact that FDD is the most embraced system in the lion's share of European systems. Concerning the physical stations, there are just two sorts of edge structures: the Type 1, material to FDD; and the Type 2, relevant to FDD. Each radio casing has 10 ms term.

Table 1: LTE Key Parameters [2]

Bands (frequency)	450 MHz, 800 MHz, 900 MHz, 1800 MHz, 2.1 GHz, 2.6 GHz					
Bandwidth (Channel)	1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
Modulation Schemes	Downlink: QPSK, 16 QAM, 64 QAM					
	Uplink: QPSK, 16 QAM, 64 QAM					
Multiple Access	Downlink: OFDMA					
	Uplink: SC-FDMA					
Peak Data Rate	Downlink: 150/300 Mbps					
	Uplink: 75Mbps					

LTE utilizes QPSK, 16QAM and 64QAM regulation plans. Much like other 3GPP frameworks, LTE has Adaptive Modulation and Coding that altogether enhances information throughput. The difference of the downlink tweak coding plan, in light of the channel condition for every client, brings about self-enhancement which is one of LTE's most noteworthy highlights.

The new LTE standard uses the OFDM and SC-FDMA methods for enhancing efficiency of system. The OFDM choice is frequently used. The subcarriers use 15 KHz separation and image rate of 66.7 μs for symmetrical purpose. Every subcarrier provides a 20 MHz speed for data transfer.

One of the essential explanations behind utilizing OFDM as a tweak design inside LTE (and numerous different remote frameworks so far as that is concerned) is its versatility to multipath deferrals and spread. Anyway it is as yet important to actualize strategies for adding flexibility to the framework. This defeats the between image obstruction (ISI) that outcomes from this. In territories where between image obstruction is normal, it can be maintained a strategic distance from by embeddings a watch period into the planning toward the start of every datum image. It is feasible to duplicate some part of symbol from one to other called cyclic prefix. At receiver side, it samples the signal in given optimal time and then helps to reduce ISI problem in system. The duration of CP is critical in this work.

OFDM Cyclic Prefix in LTE System

One of the essential purposes behind utilizing OFDM as a balance arrange inside LTE (and numerous different remote frameworks so far as that is concerned) is its strength to multipath postponements and spread. Anyway it is as yet important to actualize strategies for adding flexibility to the framework. This defeats the between image impedance (ISI) that outcomes from this. In regions where between image obstruction is normal, it can be kept away from by embeddings a watch period into the planning toward the start of every datum image. It is then conceivable to duplicate a segment from the finish of the image to the start. The standard length of CP is 4.69 μs.

OFDMA in Downlink

The flag of OFDM utilized as a part of LTE involves a most extreme of 2048 diverse sub-bearers having a dividing of 15 kHz. Despite the fact that it is obligatory for the mobiles to have ability to have the capacity to get each of the 2048 sub-transporters, not all should be transmitted by the base station which just should have the capacity to help the transmission of 72 sub-bearers. Along these lines all mobiles will have the capacity to converse with any base station. Inside the OFDM flag it is conceivable to pick between three kinds of adjustment for the LTE flag:

1. QPSK/ 4QAM 2 bits/symbol
2. 16QAM 4 bits/symbol
3. 64QAM 6 bits/symbol

SC-FDMA in Uplink

For uplink, an alternate idea is utilized for the entrance method. Albeit as yet utilizing a type of OFDMA innovation, the usage is called Single Carrier Frequency Division Multiple Access (SC-FDMA). The signal $x(t)$ is being represented by:

$$x(t) = \sum_{k=0}^{N-1} a_k \exp\,(j2\pi(f_c + k\Delta f)t)$$

$$= \exp\,(j2\pi f_c t) \sum_{k=0}^{N-1} a^k \exp\,(j2\pi k\Delta f t)$$

$$= \exp(j2\pi f_c t)\, a(t), \qquad (1)$$

where $ak, 0 \le k \le N-1$ are the constellation points that represents data used in the system.

III. DESCRIPTION OF PROPOSED SYSTEM

The major problem in this work is the value of high PAPR that causes the problem of decreasing capacity of system. It can cause limits of improvement in capacity by affecting the power of signal. The genuine convenience of OFDMA is on a very basic level the same as OFDM, in OFDM structure the single customer is get data at whatever point on all sub-bearers while OFDMA scatter the sub-transporters meanwhile to all customers ; thusly OFDMA takes inclination of the symmetry between sub-carrier to direct the between picture impedance. Figure exhibits the essential squares of OFDMA system Model. The general structure demonstrates resembles that in OFDM.

In the first place the high rate transmitting game plans of data bit stream is experienced serial to parallel convertor for change onto M parallel sub-bearers. After serial to parallel convertor the course of action is mapped into staggered complex numbers by using particular change designs, for instance, (BPSK, QPSK, M-QAM).

Figure 3 demonstrates the square chart of transmission framework utilizing OFDM. At the transmitter as appeared in Figure, the high rate advanced information stream is part into N parallel streams. Each stream is mapped to an image stream utilizing some tweak plot (QAM, PSK, and so on). The images are tweaked onto the subcarriers utilizing the backwards discrete Fourier change (IDFT). IDFT activity is a change of the OFDM image from the recurrence space to time area. The opposite quick Fourier change (IFFT) plays out an indistinguishable task from an IDFT, with the exception of that it is substantially more computationally effectiveness. After the IDFT task, a cyclic prefix is added to the OFDM image preceding advanced to-simple converter (DAC). The DAC yield is a baseband simple flag which is then up-changed over in recurrence and transmitted.

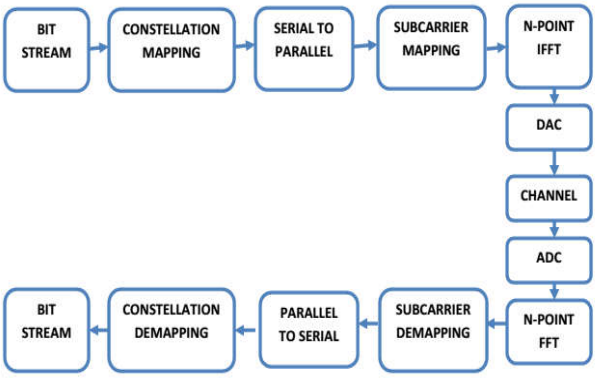

Figure 3: OFDM System Model

At the beneficiary as appeared in Figure 3, the got flag is down-changed over to baseband. At that point the flag is changed over from simple to computerized utilizing a simple to advanced converter (ADC). In the wake of expelling watch interim, the examples are encouraged into the discrete Fourier change (DFT) to be changed over to recurrence area.

In this work, it research the PAPR for both SC-FDMA and OFDMA in LTE structures and gained the results examination. Two sorts of holding channel raised cosine and root raised cosine were used to diminish the PAPR. After this, other PAPR lessening frameworks are in like manner associated and differentiated and the proposed one. By then breaking point change water filling computation is associated with find out the equivalent furthest reaches of structure. A Matlab program is used to achieve the execution of the say systems.

An irregular information stream is produced by information generator for LTE framework. There are different information parameters which are utilized like recurrence, transfer speed, no. of PRBs, bearer parts and so on. After this, FDMA plot is utilized as a part of uplink side and OFDMA conspire is utilized as a part of downlink side. Just single transporter is utilized as a part of uplink side and multi-bearer symmetrical flag is given in downlink side. The primary issue in downlink is the issue of PAPR esteem. High PAPR causes decrease in limit of framework that influences the execution of framework. Because of this, appropriate PAPR strategy is required to decrease its esteem. The PAPR is presented as:

$$PAPR(x[n]) = \left(\frac{max\{|x[n]|^2\}}{E\{|x[n]|^2\}}\right), \quad (3)$$

Where E[.] is the desire administrator. It merits specifying here that PAPR is assessed per OFDM image. x(n) Represent the plentifulness of the intricate pass band flag. Such high pinnacles will create flag journeys into nonlinear area of activity of power enhancer (PA) at the transmitter, in this manner prompting nonlinear mutilations and phantom spreading. The distinctive systems utilized for PAPR lessening are:

Clipping and Filtering

This technique utilizes a scissors that restrains the flag envelope to a foreordained cutting level (CL) if the flag surpasses that level; generally, the scissors passes the flag without change. Cut-out is a non-straight process that prompts both in-band and out-of-band twists. The out-of-band twisting causes unearthly spreading and can be killed by separating the flag subsequent to cut-out however the in-band mutilation can corrupt the BER execution and can't be diminished by sifting.

Selective Mapping (SLM)

The fundamental thought in SLM strategy is to create an arrangement of adequately unique competitor information obstructs by the transmitter where every one of the information squares speaks to an indistinguishable data from the first information square and select the good having the slightest PAPR for transmission

Raised Cosine (RC) filter

Raised Cosine is seen as the most surely understood sort of pulse shaping channel and it is extensively used for remote correspondence system. The time region baseband beat depiction is:

$$\mathrm{pRC(t)} = (\sin \pi t/T)/(\pi t/T)] * [(\cos \pi at/T)\,/(1\left(\frac{2a}{T}\right)2)]$$

(4)

Where α is the move of factor, 0≤α≤1, and it is portrayed as a piece of the total picture time allotment and it checks the sharpness of the repeat response traits of the beat framing channel.

Proposed Scheme for PAPR

In the wake of setting the parameters, FDMA conspire is utilized as a part of uplink side and OFDMA plot is utilized as a part of downlink side. Just single bearer is utilized as a part of uplink side and multi-transporter symmetrical flag is given in downlink side. The principle issue in downlink is the issue of PAPR esteem. High PAPR causes diminishment in limit of framework that influences the execution of framework. Because of this, appropriate PAPR strategy is required to diminish its esteem.

In Proposed plot, similar to PTS, a data bit of length N is allocated into different disjoint sub-squares. By then every one of these sub-squares are padded with zeros and weighted by a phase factor. low computational disperse quality PTS scheme is proposed where two interest steps are used to find a subset of stage turning vectors with extraordinary PAPR diminishing execution. In beginning advance, groupings with low association or quaternary progressions are used as initial stage turning vectors for proposed plot.

In the second means, to find additional stage rotating vectors, an area look for is performed in perspective of the fundamental stage vectors with awesome PAPR diminish execution. The PAPR is interrelated with limit of framework. As the PAPR esteem is high, it influences the debasement of execution of framework.

Carrier Aggregation

After PAPR diminishment by proposed technique, its capacity is utilized to figure proportionate limit of framework. It implies that if framework has vast PAPR esteem then its equal limit is lower when contrasted with other. It utilizes 5 bearer parts for transporter total. It utilizes the psychological data transfer capacity distribution since it has more grounded flexibility in catching the time-fluctuating activity requests of various clients, therefore having higher transmission capacity use. The pick up increments as the no. of PRBs per client or no. of collected CCs increments. LTE Advanced offers stunningly higher data rates than even the fundamental entries of LTE. While the range usage capability has been upgraded, this without anyone else's input can't give the required data rates that are being highlighted for 4G LTE Advanced.

For development in proportional limit, it utilizes water filling calculation which is an advancement calculation. It repeats the power until the point that it compasses to its objective point. In water-Filling estimation, which is perfect power task figuring in standard OFDM structure, we use the total power apportioning by uniform stacking as the power basic. the apportioned power in the ith subcarrier by virtue of the ith subcarrier due to the lth impedance prerequisite is made as (5):

$$Pi = \frac{P}{Ki} \quad (5)$$

where P can be calculated by assuming strict equality in the lth interference constraint.
Using Eq., in this equality constraint

$$Pi*Ki(l)*Ni=1=Ith(l)/[2\lambda l2(-\ln(1-a)] \quad (6)$$

IV. RESULTS OF PROPOSED SYSTEM

OFDM is one of the numerous multicarrier regulation strategies, which gives high unearthly effectiveness, low execution intricacy, less defenceless ness to echoes and non– direct mutilation. Because of these points of interest of the OFDM framework, it is boundlessly utilized as a part of different correspondence frameworks. Be that as it may, the real issue one appearances while actualizing this framework is the high pinnacle – to – normal power proportion of this framework. It watches the after effect of this activity and that the flag "transporters" utilizes T/2 as its day and age. The initial step is to deliver a persistent time flag and to apply a channel g(t), to the unpredictable flag "bearers". The drive reaction, or heartbeat shape.

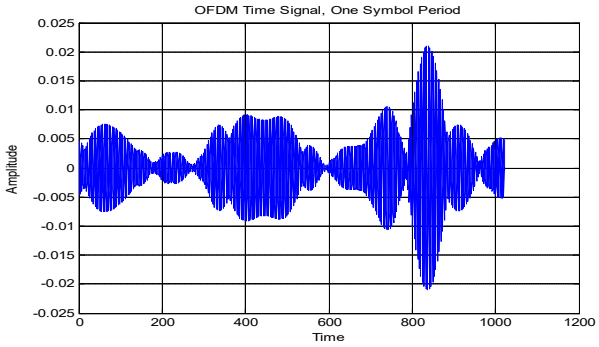

Figure 4: OFDM System Response

What's more, OFDM framework requires tight recurrence synchronization in contrast with single bearer frameworks, in light of the fact that in OFDM, the subcarriers are narrowband. Thusly, it is touchy to a little recurrence counterbalance between the transmitted and they got flag. The recurrence counterbalance may emerge because of Doppler Effect or because of confound amongst transmitter and collector neighbourhood oscillator frequencies. Customary OFDM framework utilized IFFT and FFT to multiplex the signs in parallel with diminished multifaceted nature calculation at the transmitter and beneficiary individually. The framework utilizes watch interim and cyclic prefix (CP) with the goal that the postpone spread of the channel turns out to be longer than the channel motivation reaction. The reason is to limit between image impedance between images.

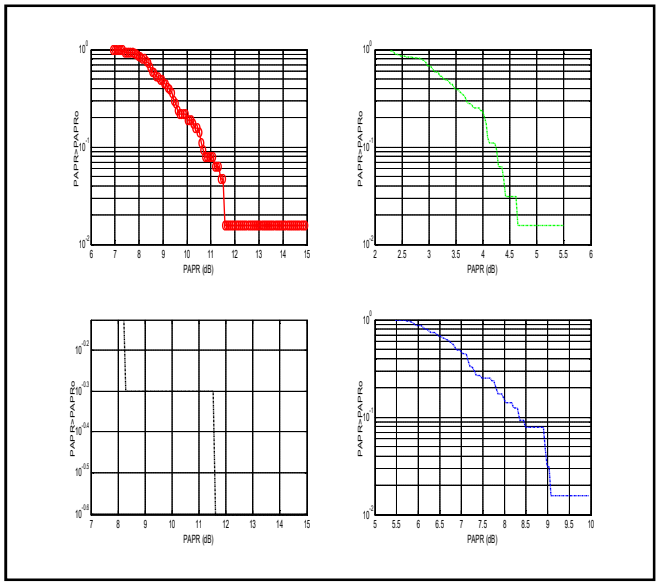

Figure 5: PAPR Comparison of Different Techniques

OFDM is an extremely alluring strategy for multicarrier transmission and has turned out to be one of the standard decisions for high – speed information transmission over a correspondence channel. It has different points of interest; yet additionally has one noteworthy disadvantage: it has a high PAPR. PAPR is by and large used to describe the envelope change of the OFDM flag and it is characterized as the proportion of the most extreme immediate capacity to its normal power. Nearness of vast number of autonomously regulated sub-transporters in an OFDM framework the pinnacle estimation of the framework can be high when contrasted with the normal of the entire framework. This proportion of the crest to normal power esteem is named as Peak-to-Average Power Ratio. Intelligent expansion of N signs of same stage delivers a pinnacle which is N times the normal flag. The significant impediments of a high PAPR is the expanded unpredictability in the simple to computerized and advanced to simple converter and second is the diminishment is productivity of RF enhancers. The execution examination of various procedures is appeared in table 1 and results demonstrate that the proposed method gives better PAPR esteem when contrasted with different systems.

Table 2: Performance Comparison of PAPR Response

S.N.	METHOD	PAPR VALUE
1	ORIGINAL SIGNAL	12.063
2	AMPLITUDE CLIPPING	12.352
3	SELECTIVE MAPPING	9.191
4	PROPOSED TECHNIQUE	4.679

The figure 6 shows the equivalent capacity relates with no. of carrier components. In this, as no. of carrier components increases, its value of capacity also increases. In this work, it also compares the performance with analytic results and proposed shows the better improvement in values as compared to analytic results.

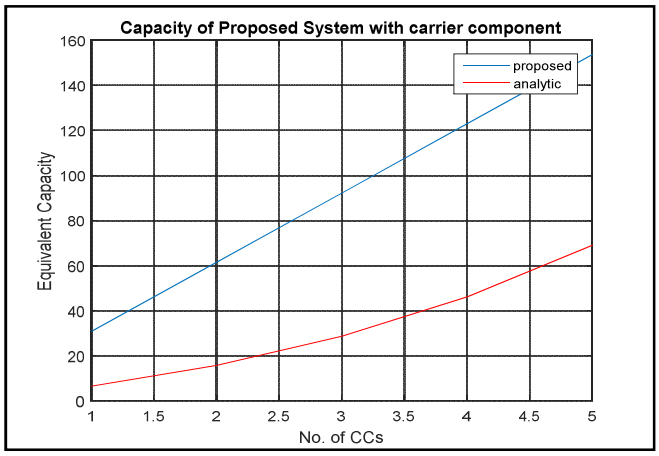

Figure 6: Equivalent Capacity Performance of Proposed System with Analytic Performance

Table 3: Equivalent Capacity Comparison of System

S.N.	Modulation	Equivalent Capacity
1	QPSK	150
2	16-QAM	320
3	64-QAM	460

As appeared in the figures the limit of the OFDMA framework is higher if there should arise an occurrence of the 64QAM regulation. The PAPR in OFDMA is bring down in 16 QAM when 128 subcarriers and 32 information square size is utilized and as we expands the no of subcarriers and information square size the estimation of PAPR lessens in 64 QAM balance. So it is relies upon the necessities that if the client needs to enhance the limit of the framework or execution in control by lessening the PAPR esteem.

V. CONCLUSION

In this work, we have concentrated on the execution investigation of SC-FDMA and OFDMA frameworks as far as PAPR, distinctive heartbeat melding channels have additionally been broke down. What's more, extraordinary kinds of regulation systems (QPSK, 16QAM, and 64QAM) are utilized here with various subcarriers and diverse square sizes. If there should be an occurrence of including raised cosine channel, the PAPR execution of OFDMA framework enhanced in examination with the framework without channel. Besides the SC-FDMA indicates better execution as contrasted and OFDMA. The principle objective is to lessen high PAPR esteem by reasonable separating approach under downlink framework. RC(raised cosine) and RRC(root raised cosine) channels are utilized as a part of this work to conquer the estimation of PAPR if there should be an occurrence of OFDMA system. Three kinds of regulations are utilized here QPSK, 16QAM and 64 QAM. We have utilized all of three adjustments with the two channels and looked at the after-effects everything being equal and reasoned that the estimation of PAPR is bring down in the event of 64 QAM regulation with proposed system and limit is higher if there should be an occurrence of 64 QAM tweak. Both PAPR and limit are between related.

In the event that PAPR is low for framework, at that point its ability is better when contrasted with other. Every one of the reproductions has been done in the MATLAB programming. In future, The proposed PAPR diminishment strategy can be utilized with MIMO OFDMA framework. The proposed timing counterbalance and estimator can be utilized for MIMO OFDMA framework.

REFFERENCES

[1] *3GPP, Feasibility study for Further Advancements for E-UTRAN (LTE-Advanced), TR 36.912, Ver 9.3.0, June 2010*

[2] *3GPP, LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment radio transmission and reception (Release 10), Ver 10.3.0, June 2011*

[3] *3GPP, Evolved Universal Terrestrial Radio Access; Relay radio transmission and reception, TS 36.116, Ver. 11.0.0, June 2012*

[4] *Cheng-Chung Lin, "On the performance of capacity integrated CoMP handover algorithm in LTE-Advanced", 18th Asia-Pacific Conference on Communications , pp. 871-876, Oct 2012*

[5] *Cheng-Chung Lin, K Sandrasegaran, "Handover Algorithm with Joint Processing in LTE-Advanced", IEEE International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology, pp. 978-981, May 2012*

[6] *X. Zhang, Q. Li, X. Gu, "The Study of Load Balancing Based on the Network Flow Theory in LTE-A systems", IEEE 24th International Symposium on Personal, Indoor and Mobile Radio Communications, pp. 91-95, Sep 2013*

[7] *S Thiagarajah, A. Ting, "User Data Rate Enhancement Using Heterogeneous LTE-802.11n Offloading in Urban Area", IEEE Symposium on Wireless Technology and Applications, pp.11-16, September 2013*

[8] *J Xu, Lun Tang, Q. Chen, "Study on Based Reinforcement Q-Learning for Mobile Load Balancing Techniques in LTE-A Het Nets", IEEE 17th International Conference on Computational Science and Engineering, pp. 1766-1771, Dec 2014.*

[9] *Jean Avocanh, M. Abdennebi, "A New Two-Level Scheduling Algorithm for the Downlink of LTE Networks", IEEE Global Communications Conference (GLOBECOM), pp. 4519-4523, Dec 2013*

[10] *S. Zhao, B. Zhou, "A Novel Frequency Selective Sounding Scheme for TDD LTE-Advanced Systems", IEEE Global Communications Conference, pp. 1364-1369, Dec 2014.*

[11] *Xuanli Wu, L. Sun, "User-Satisfaction-Based Weighted SLNR Beamforming in TD-LTE-A System", IEEE International Conference on Communications (ICC), pp. 1284-1289, June 2014*

[12] *Su Yi, Yu Zhang, Z. Sun, "Channel Measurement and Channel Quality Reporting in LTE-Advanced Relaying Systems", IEEE IEEE Vehicular Technology Conference (VTC Fall), pp. 1881-1885, September 2012*

[13] *Lexi Xu, Y. Chen, "User Relay assisted Traffic Shifting in LTE-Advanced Systems", IEEE IEEE 77th Vehicular Technology Conference, pp. 6337-6342, June 2013*

[14] *S. H. Song, A. Almutairi, "Outage-Capacity Based Adaptive Relaying in LTE-Advanced Networks", IEEE Transactions on Wireless Communications, Vol. 12, No. 9, pp. 4778-4787, September 2013*

[15] *Felipe Cuba, Francisco J. Castno, "Improving Third-Party Relaying for LTE-A: A Realistic Simulation Approach", IEEE International Conference on Communications (ICC), pp. 2344-2350, June 2014.*