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UL-DMRS Based NB-IoT Uplink System and its Performance Analysis Toward 5G Machine Type Communications

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ABSTRACT
As we know, world is moving into the era of modern digital technology and looking forward to massive machine type communications (mMTC), which is an integral part of Internet of Things (IoT). The current technology supporting mMTC market are not standardized; therefore, there are many short comings from physical layer which includes complexity in deployment, poor reliability, lesser flexibility, security threats and high maintenance cost. To address all these challenges in 5G machine type communication (MTC), the 3rd Generation Partnership Project (3GPP) in release 13has standardized Narrowband Internet of Things (NB-IoT) as a better choice in deployment of 5G MTC. NB-IoT has been recommended by ITU as a 5G standard and this recognition of NB-IoT as a core technology in massive machine type communication will impact the telecommunication industry. NB-IoT mainly works on low power wide area networks (LPWAN), which is considered as a major technology driver in 5G wireless technologies. Initially, we have compared a spectrum power of NB-IoT with W-Fi ac considering their own bandwidth and specifications as per 3GPP and IEEE 802.11, respectively. As per analysis, we found many advantages of deploying NB-IoT in 5th generation wireless technology including ubiquitous coverage, low power consumption, less transmission power and better interference rejection. Considering thisfact of NB-IoT, we proposed and design a NB-IoT uplink system using NPUSCH, UL-SCH and UL-DMRS as per 3GPP 5G specifications and performance analysis has been carried out.

Key words: IoT, 5G, NB-IoT, MTC, 3GPP, NPUSCH, UL-DMRS, UL-SCH, LPWA

1. INTRODUCTION

The Internet of Things (IoT) in this modern generation is upgrading. So far, billions of devices and services related to IoT are expected to connect anytime, anywhere and with anything. The cellular industry has introduced a new technology called massive machine type communications (mMTC) to realize various 5G use cases. As per our findings, NB-IoT meets the requirement of 5G visions in deploying enhanced machine type communications (eMTC)and is expected around 30 billion devices will be connected by 2025 qualifying as a 5G standard. NB-IoT in 5G improves the energy and spectral efficiencies. The inclusion of NB-IoT in 5G MTC provides a significant impact on IoT industries such as Smart cities, e-health, e-education, smart agriculture, logistics etc. Machine type communications are expected to play a vital role in deployment of 5G IoT. Since 5G is reliable on Low Power Wide Area Networks (LPWAN)Hence, NB-IoT is perfect choice for 5G MTC.

The innovation in 5G MTC will give rise in revenue generation by adopting this new technology in industrial application and other commercial IoT application through mobiles, laptops, communication between human and device, device to device (D2D) communication and machine to machine (M2M) communication. The existing technology such as GSM, 3G, and LTE cannot fulfill the promising demand in MTC; hence 3GPP has standardized NB-IoT for LPWAN which counters many digital services with better efficiency and reliability [7]. Many mobile industries have set up a MTC unit to advance the business benefit that IoT brings. NB-IoT is standardized for low power wide area (LPWA) connectivity for machine type communication in IoT. The main objective of 5G MTC is to connect billions of devices with high data rates, low latency, and better efficiency with global standard. The main challenge in deploying 5G MTC is the proper understanding of driving technologies, understanding between service providers and costumers and more importantly the organization should accept conditions from regulatory bodies. NB-IoT in 5G can be deployed within a narrowband (i.e., 200 kHz) in both uplink and downlink, which provides coverage up to 164dB, latency>1ms and longer battery life [12]. NB-IoT uses orthogonal frequency division multiplexing (OFDMA) in downlink whereas single carrier frequency division multiple access (SC-FDMA) is used in uplink [23]. In 5G NB-IoT, 3.75 kHz and 15 kHz sub carrier spacing is introduced [7]. Comparing NB-IoT with other LPWA technologies like SigFox, LoRa and ZigBee, it offers better system performance, low latency, and better reliability [6]. Analyzing all the LPWA technologies in terms of coverage, network data rates, the most promising technology is NB-IoT and can be deployed in 5G machine type communications (MTC) [31]. The major contribution of this paper is summarized as under:

1. Motivation and objectives of 5G MTC are discussed and spectrum comparison between NB-IoT with Wi-Fi ac is carried out to find a better choice for MTC.
2. Brief overview of 3GPP NB-IoT is provided and summary of 3GPP NB-IoT in deployment of MTC in 5G scenario presented.
3. The Design Frame Structure and Resource unit required for 5G MTC is highlighted.
4. NB-IoT uplink system is designed using NPUSCH with HARQ support, UL-SCH and Uplink Demodulation Reference Signal (UL-DMRS).
5. System simulation is performed, and various parameters are analyzed and discussed especially for NB-IoT in 5G machine type communication.

2. MOTIVATION AND CHALLENGES

As per the initiative of Government of India in executing highly innovative projects such as Digital India and Make in India, we are highly motivated to contribute something in developing the dream project of our nation. The objective of this article is to support the future technologies in developing smart cities project undertaken by Government in different parts of the country and to provide technologies for various commercial industries to deploy 5G communication technology. The main motive of this work is to provide future technologies to meet the social and industrial expectation beyond 2022. This work is highly dedicated in designing 5GNB-IoT uplink system to meet the various challenges that exists in present technologies.

As per 3GPP and ITU, 5G in MTC operates on LPWA networks [1]. Initially, we have compared the spectrum power of NB-IoT (3GPP standard) over Wi-Fi ac (IEEE 802.11). We have compared both this LPWA technologies considering their own standardizations. The spectrum graph obtained after simulation are shown in figure 1 (a) and (b) respectively.

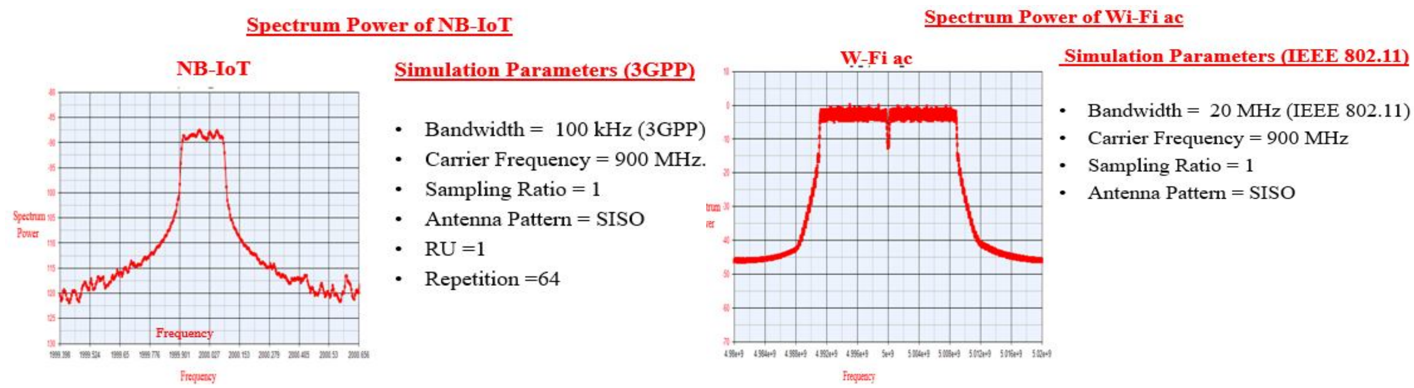

Figure 1 (a): Spectrum Power of NB-IoT at 180 kHz**Figure 1 (b):** Spectrum Power of Wi-Fi ac at 20 MHz

We have analyzed NB-IoT at 100 kHz bandwidth and Wi-Fi ac at 20 MHz and found that the range of signal reception is more in NB-IoT as compared to Wi-Fi ac. From the graph shown above, we can compare that the transmit signal power is more in Wi-Fi ac than NB-IoT. The interference and noise rejection are more in narrowband operation. NB-IoT signal occupies less frequency bands and require less transmission power which results in low deployment cost and increased signal propagation. The SNR is also low in NB-IoT that allows better system performance with increased coverage and low latency. NB-IoT operates in licensed band only which means only allocated spectrum bands can be occupied but Wi-Fi and other LPWA technologies operates in both licensed and unlicensed band that allows more signal loss and interference. Considering all these facts, NB-IoT is better choice in 5G MTC as compared to Wi-Fi and other LPWA technologies.

3. OVERVIEW OF 3GPPNB-IoT TECHNOLOGY

As per 3GPP, NB-IoT is a best choice in designing 5G machine type communication (MTC). In this section, we will be discussing technologies behind NB-IoT and its impact in 5G MTC. There are many LPWA networks that are used in Internet of things (IoT), but NB-IoT is chosen as suitable low power radio access technology (RAT) in 5G machine type communications (MTC) [9]. Different radio operates in different frequency band on both licensed and unlicensed spectrum bands. As per 3GPP, NB-IoT in 5G technology operates in licensed spectrum. Thus, the impact of NB-IoT in 5G is that the spectrum can be reused with improved coverage, better efficiency, and high security. 5G NB-IoT can be deployed in narrow system bandwidth (i.e., 200 kHz) both in uplink and downlink but it uses only 180 kHz bandwidth. NB-IoT is expected to provide enhanced coverage. The evolution of 3GPP standardization for different LPWA and their specifications are summarized in table 1. [8][13][28][17].

Table 1: Comparison of different NB-IoT Technologies

Release 13 NB-IoT	**Release 14 eNB-IoT**	**Release 15 FeNB-IoT**	**Release 16 NB-IoTenh3**	**Release 17 NB-IoTenh4**
Cat NB-1	Cat NB-2	Mixed Mode Multicarrier	Co-Existence with New Radio (NR)	Increase of Data Rates
Standalone/Guard band/In-Band	Enhance TBS/ Dual HARQ	SR Report	Connection to 5G Core	64 QAM Carrier Aggregation
Coverage Extension	Release Assistance Indicator	Wake Up Signal	Improve Multi carrier Operation	Power Enhancements
UL3.75 kHz and 15 kHz	Reconnection with RLF	Early Data Transmission	Mobile-Terminated (MT) Early Data Transmission	
Single Tone/Multi Tone	Positioning	New PRACH format	Enhance of SPS	
CP/UP	Measurement Report	Small Cell Support	Inter RAT-Cell Selection	
Multi-Carrier	Non-Anchor Carrier	TDD Support	UE group Wake up Signal	
PSM (Power Save Mode)	Single Cell Multicast	Reduced System Acquisition Time	SON	
eDRX	Maximum Tx Power 14dBm	UE Differentiation		

As per 3GPP, NB-IoT can be deployed in three modes: standalone, in-band and guard band mode. The entire deployment mode has its own features and specialization. The unique feature of NB-IoT is that it can offer up to 20 dB coverage in the entire deployment mode [14]. To cater more use cases in 5G such as smart cities, smart homes, e-education, e-health, and several new functionalities are added in 3GPP release 14 and release 15. Since, NB-IoT has a bandwidth of 200 kHz but it only occupies 180 kHz which is equal to one resource as compared to LTE. Different modes of NB-IoT are shown in figure 2. and their operation is discussed.

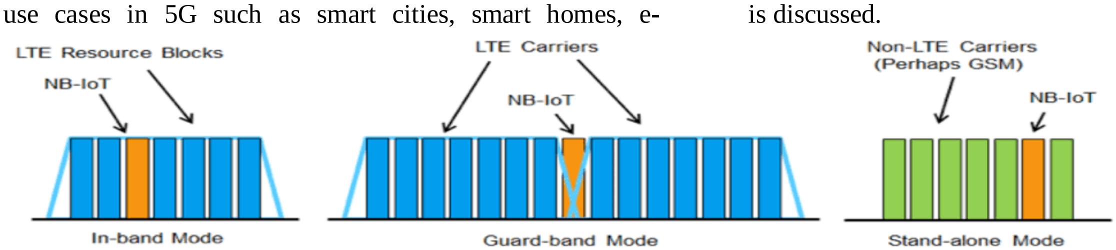

Figure 2: NB-IoT modes of operation: (a) in-band, (b) guard-band, and (c) standalone

In standalone mode, NB-IoT operates independently; in this mode, 200 kHz bandwidth provides a 10 kHz guard buffer on both sides to its neighboring GSM channels. In Guard-band mode, NB-IoT utilizes resource block in the guard band of an LTE channel. In In-Band mode, it reuses frequencies which are not used by LTE inside the LTE bandwidth. NB-IoT operates in FDD mode only with half duplex transmission. NB-IoT in MTC uses OFDM with 15 kHz and 3.75 kHz subcarrier spacing which are ideal for low power scenario like machine type communications. There are several challenges in 5G MTC; some of the important challenges in designing 5G MTC are discussed below:

<u>Density:</u> The technology should accommodate and support maximum number of devices/cells. It should support data rate of 1-100 kbps and latency of >1ms. The design should be low frequency of connection.

<u>Low Cost:</u> The deployment and maintenance cost should be minimum as much as possible. The design should be reliable and stable.

<u>Low Power Consumption and Better Battery Life:</u> 5G MTC must support low power wide area networks (LPWAN) in licensed spectrum bands and the battery life must last up to 10+ years.

<u>Extreme Coverage:</u> The coverage should be 10X faster than the existing technologies and it should provide 20dB extreme coverage. The technologies must support in remote places and in areas of difficult access.

<u>Up-gradation</u>: The NB-IoT is guided by 3GPP; hence it is necessary to upgrade the technology as per global standard guidelines. Also, the design should be flexible to upgrade in existing radio access network (RAN) structure. As per 3GPP release 16, 5G NR (New Radio) is considered as the global 5G standard radio technology, but presently it covers only eMBB (Enhanced Mobile Broadband) and URLLC (Ultra Reliable Low Latency Communication) use cases [1]. It is not standardized for Machine type communication until 3GPP release 17. NB-IoT has considered as the suitable

candidate solution to meet the demands of 5G machine type communications. It shows that NB-IoT has the ability for efficient transition into 5G and provides the solid base for designing 5G MTC and aims to provide diversity in LPWA services in the 5G era.

4. UL-DMRS NB IoT UPLINK SYSTEM DESIGN

In this section, NB-IoT Uplink system is designed with NPUSCH with HARQ support and UL-DMRS with necessary channel estimation and equalization which is shown in Figure3. The NB-IoT uplink transmitter is designed using UL-SCH (Uplink Shared Channel) also called as transport channel and NPUSCH called as data channel. Due to low bandwidth, low out of –band rejection is designed for NB-IoT uplink. Also, the PAPR is a major concern while designing uplink transmitter, hence it is necessary to design low-cost transmitter. The PAPR can be reduced by techniques such as FFT and CP insertion. The modulation used in designing transmitter is π/4 QPSK which are robust against PAPR. This modulation technique applies constellation rotation which helps in smoothing transition between constellation points.

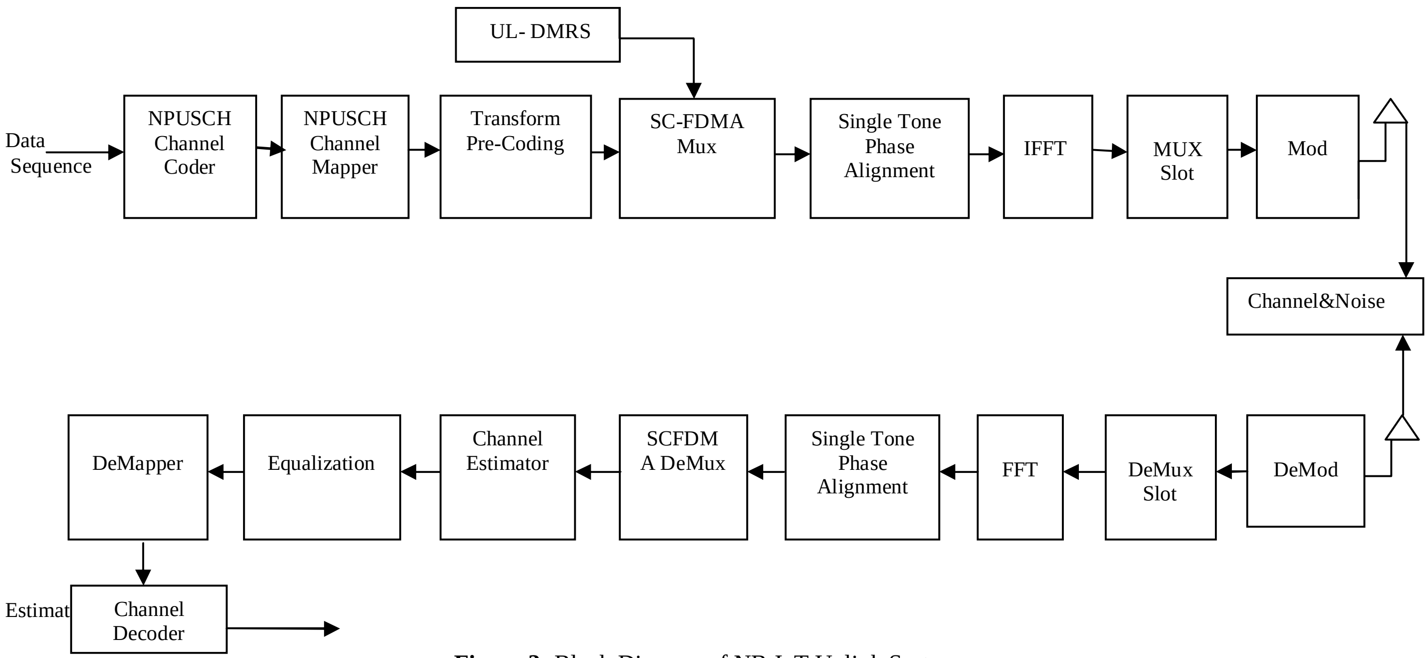

Figure 3: Block Diagram of NB-IoT Uplink System

The NB-IoT UL transmitter consists of UL-DMRS and it is used to generate demodulation reference signal (DMRS) associated with transmission of PUSCH and sounding reference for a single antenna port. The UL-DMRS generates signal when,N_{sc}^{RU}=1 for PUSCH for one TBS and the sequence generation can be written as,

$$\bar{r}_u(n)=1/\sqrt{2}(1+j)\,(1-2c\,(n))\,\omega\,(n \bmod 16),$$
$$0\leq n<MN_{slots}^{RU}N_{RU} \quad \ldots\ldots\ldots\ldots (i)$$

Where, ‘c (n)’ is a binary sequence defined by gold sequence and ‘M’ is the repetition number of the same signal.
‘N_{slots}^{RU}’ is is the number of slots in resource units. ‘u’ is the base sequence index and is given by u=N_{ID}^{Ncell} mode 16 for NPUSCH format 1, which has been considered in designing this system.
Thus, the UL-DMRS for NPUSCH format 1 can be written as, $r_u(n)=\bar{r}_u(n)$ ………………. *(ii)*
The UL-DMRS sequence for sub carrier greater than one is given by, $r_u(n)=e^{j\alpha n}e^{j\varphi(n)\pi/4}$, $0\leq n<N_{sc}^{RU}$ ………………. *(iii)*
This signal generated by UL-DMRS is a pilot signal, transmitted with a user data to determine channel impulse ratio (CIR) in uplink NB-IoT system. The IFFT in the transmitter is performed to convert UL-DMRS reference signal into time domain reference sequence followed by insertion of cyclic prefix (CP). In channel coder data streams are encoded to offer transport services over the radio transmission link. It consists of UL-SCH which consist of transport block and it performs cyclic redundancy check (CRC) based on turbo coding with HARQ controller and this channel coding is a combination of error detecting, error correcting, interleaving, rate matching and transport channel mapping onto physical channels. The transform precoding is used to generate SC-FDMA symbols. SC-FDMA Mux is used to multiplex uplink SC-FDMA symbols of one TBs transmission in frequency domain. Data for NPUSCH and reference signals are mapped onto the allocated physical resources. The frame structure for 3.75 kHz and 15 kHz sub carrier spacing used in designing uplink NB-IoT system is shown in figure 4.

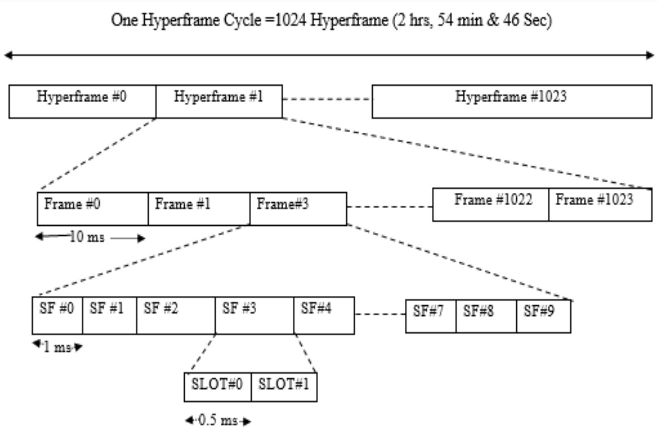

Fig 4 (a): NB-IoT Frame Structure for 15 kHz Sub Carrier Spacing

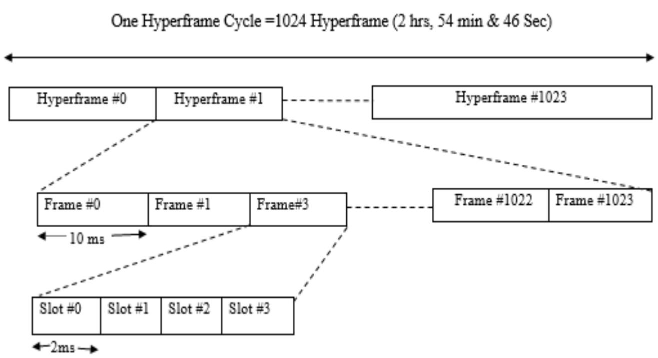

Fig 4(b): NB-IoT Frame Structure for 3.75 kHz Sub Carrier Spacing

Figure 4: Frame Structure of NB-IoT sub carrier spacing used in MTC.

Here numbers of REs per TBs are produced, where Number REs per TBS is the total number of REs in each TBS transmission. NumberREsperTBS =SubCarrierNumperSymbol * 7 (symbol number in one slot) * Number ofSlotperRU * Number ofRUperTB * Numberof TB Repetition.Single tone phase alignment is used to apply phase alignment at the symbol boundary for single tone signal. For single tone transmission,π/4-QPSK is used to reduce the peak to average power ratio (PAPR). However, due to the cyclic prefix (CP), the phase transition at symbol boundary between preceding symbol and subsequent CP is not equal to the corresponding symbol phase difference as observed in the respective IFFT windows at symbol mapper in TX and FFT output in RX. This must be considered in the SC-FDMA-based implementation of UL-TX and RX so that the correct symbol phase transitions are realized at the symbol boundary for π/4-QPSK. Without such phase alignment, the modulation is not true for π/4-QPSK in single tone transmission. The NB-IoT MUX slot is used to multiplex NB-IoT symbols into uplink/downlink slots by inserting cyclic prefix.The NB-IoT frame for NPUSCH format 1 starts with hyperframe having 1024 frames. NB-IoT in sub carrier spacing of 15 kHz supports uplink and downlink having 20 slots in each frame. Each frame is divided in 5 slots each of 10 ms, each slot in 15 kHz sub carrier spacing is divided in subframe of 1 ms and each subframe is divided into slots of 0.5 ms. In 3.75 kHz of sub carrier spacing there is no sub frame concept as shown in fig 4. (a). The resource unit (RU) number depends upon the sub carrier spacing, number of tones and repetition settings. The number of frame cycles can be determined as,

Duration of Frame Cycle = (No. of Frame in one cycle) * (Duration of one Frame)

For 1024 frame the duration of frame cycle is calculated as

Duration of Frame Cycle = 1024*10 ms = 10240 ms
= 10.24 seconds.

The hyperframe duration of NPUSCH frame structure for both 15 kHz and 3.75 kHz can be determined as,

Duration of Hyperframe cycle = (No. of hyperframe in one cycle) * Duration of one hyperframe)

Therefore, duration of hyperframe cycle can be calculated as,

Duration of hyperframe cycle = 1024 *10.24 seconds.
= 104857.60 seconds

The total hyperframe duration is 2 hours, 54 minutes and 56 seconds as shown in Fig 4. The total length of the NPUSCH transmission must be ≤ 356 ms, when sub carrier spacing is 3.75 kHz, Resource Unit (RU) number * repetition must be ≤ 8 and when sub carrier spacing is 15 kHz, resource unit (RU) number *Repetition must be ≤ 32 for single tone. The constellation mapping of NPUSCH transmission is modulated by deploying low PAPR modulation scheme likeπ/4 QPSK. The NPUSCH source signal is followed by IFFT operation which converts the data into time domain signal. The physical resource mapping is done by assigning frequency domain data symbols and UL-DMRS signal with uplink time frequency grid. After mapping to ‘n’ number of slots can be defined with the equation,

$$N_{slots} = \begin{cases} 1 & \Delta f = 3.75\ kHz \\ 2 & \Delta f = 15\ \ kHz \end{cases} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (iv)$$

The time domain baseband signal is transmitted through multipath fading channel. The received signal comprises of signal from different path and noise. The channel response of multipath fading channel can be written as,

$$h\ (t) = \sum_{i=0}^{L-1} \beta_i \delta\,(t - \tau_i)\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (v)$$

Where, β_i and τ_i are the attenuation and delay of the path. Therefore, the received signal comprising of noise and delay at the receiver is given by,

For single tone transmission

$$y_{single}\ (t) = \sum_{i=0}^{L-1} \beta_i x_{k,l}\ (t - \tau_i) + n\ (t)\ \ldots\ldots\ldots\ldots\ldots\ (vi)$$

After removal of cyclic prefix, the receiver performs inverse operation of NPUSCH. In addition to this, frequency domain channel estimation and equalization assisted by UL-DMRS are performed.

5. RESULTS AND DISCUSSION

Firstly, we have calculated the SNR and FER of the system depending upon the sub carrier spacing which contains a UL-DMRS sequence of NPUSCH. In this paper, we have used MMSE interpolation method of channel estimation which is widely used in low power wireless communication. This method estimates NB-IoT uplink channel response (CR) with the DMRS signal in the time and frequency occupied by NPUSCH. In each firing, it estimates the uplink CR for all the resource occupied by NPUSCH in one TBS transmission. The received pilot signal from UL-DMRS in the frequency domain can be expressed as,

$R = [R(0), R(1) \ldots\ldots\ldots R(N_{SC}^{RU} - 1)]$ ………. *(viii)*

Where, N_{SC}^{RU} is the scheduled number of subcarriers in resource unit (RU).

For the pilot signal 'R', we consider H_R as a true channel response, where G_R represents Gaussian Noise vector and σ^2_{HR} represents noise variance, then estimated channel response can be found as,

$\hat{H}_R = H_R + G_R = F_R H + G_R$ ……………………… *(ix)*

Where, 'F_R'is the Rx L matrix and 'H' is the channel coefficient matrix. In this article we have investigated and performed detailed analysis of the UL-DMRS assisted NB-IoT uplink system.

Different parameters and their values used in simulation are shown in table 2.

Table 2: Simulation Parameters

Parameter	Value
System Bandwidth	`180 kHz
Carrier Bandwidth	900 MHz
NPUSCH Format	Format 1
Resource Unit Type	0:1_16
Channel Coding	Turbo Coding
Modulation Type	π/4QPSK
Over-Sampling Ratio	Ratio 1
Sub- Carrier Spacing	3.75 kHz, 15 kHz
Channel Estimation	MMSE
Payload Bits	264
Transmission Mode	Single Tone
NPUSCH Repetition	64
Resource Unit (RU)	1

We have considered UL-DMRS based uplink system and the parameters have been selected as per 3GPP specifications for NB-IoT uplink system. In this simulation, we have selected SISO (Single Input Single Output) antenna pattern for both transmission with sub carrier spacing of 15 kHz and 3.75 kHz. The simulation result of 15 kHz sub carrier spacing using π/4QPSK modulationis shown in figure 5 and figure 6.

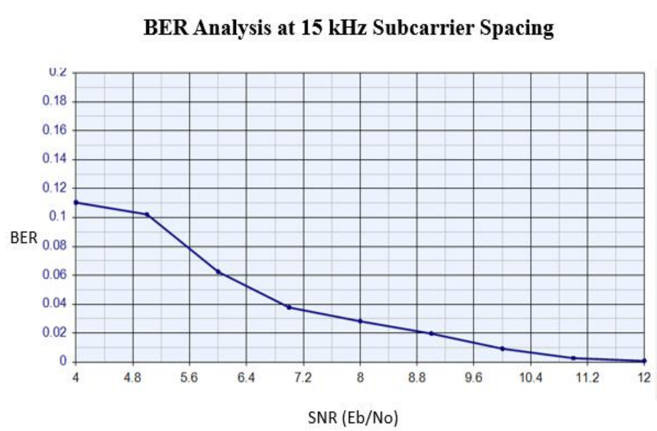

Figure 5 (a): BER at 15 kHz, π/4 QPSK, RU =1 Repetition =64, Single tone Transmission

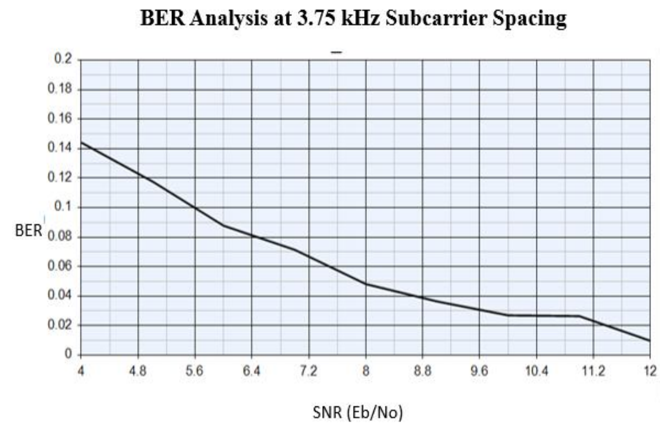

Figure 5 (b): BER at 3.5 kHz, π/4 QPSK, RU =1 Repetition =64, Single tone Transmission

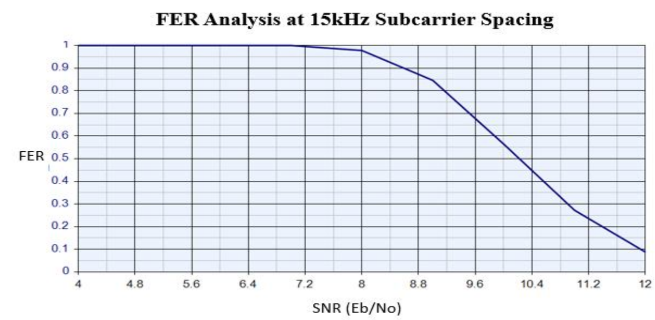

Figure 6 (a):FER at 15 kHz, π/4 QPSK, RU =1 Repetition =64, Single tone Transmission

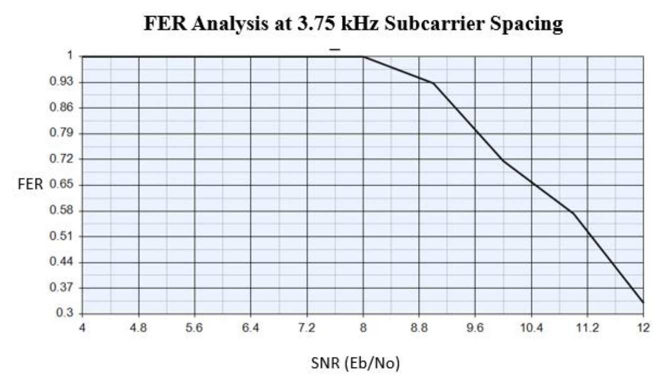

Figure 6 (b):FER at 3.5 kHz, π/4 QPSK, RU =1 Repetition =64, Single tone Transmission

From the simulation result, it is found that when SNR increases BER and FER of the system decreases which shows that the system performs well in sub carrier spacing of 15 kHz and 3.75 kHz in low power MTC. We have found that the performance of the system with 15 kHz is slightly better as compared to 3.75 kHz.

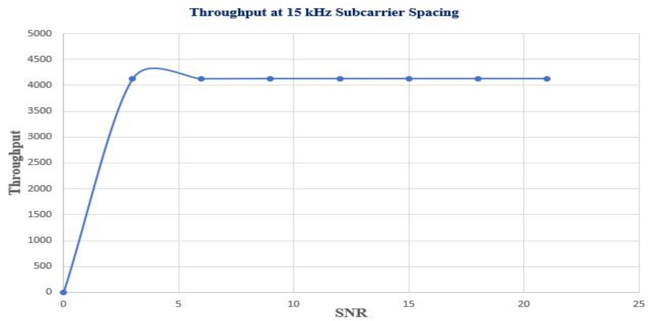

Figure 7 (a): Throughput at 15 kHz, π/4 QPSK, RU =1 Repetition =64, Single tone Transmission

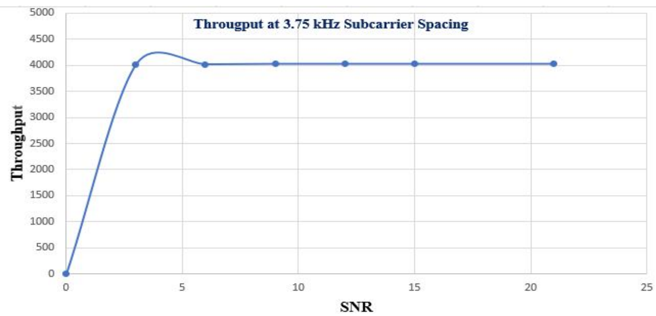

Figure 7 (b): Throughput at 3.5 kHz, π/4 QPSK, RU =1 Repetition =64, Single tone Transmission

The throughput analysis for both the sub carrier spacing has been carried out and is shown in figure 7. Low PAPR modulation scheme has been used for both the transmission mode and it is found that the throughput for both the sub carrier spacing has been found to be suitable for low power transmission in MTC and the average throughput for 15 kHz is found as 4.1 kbps and the throughput in case of 3.75 kHz was found to be 4.0 kbps which are acceptable throughput in case of narrowband operation in MTC applications. It is observed that the throughput in both the sub carrier cases is greatly improved because of narrow bandwidth. Finally, we can conclude that the UL-DMRS based Uplink NB-IoT in low power wide area (LPWA) use cases can ensure successful and efficient data transmission in both 15 kHz and 3.75 kHz sub carrier spacing in single tone transmission with less signal distortion and transmission power providing better coverage and reliability. Thus, we can say that the system efficiently suits for machine type communication in 5G.

6. FUTURE RESEARCH DIRECTION

Since LPWAN is the most preferred radio technologies in 5G. According to research, by 2025, 30 billion of smart devices are expected to connect in LPWA networks and it has found that half of these devices will relate to NB-IoT platform. The adaptation of IoT will create new opportunities to innovate and generate ideas in both people's daily life and industrial use cases. The next generations IoT will give tremendous growth to advance technology such as artificial intelligence (AI), cloud computing, edge computing, industrial Ethernet, robotic internet and augmented reality (AR) which can generate huge opportunities in research and employment. According to 5G MTC perspective, the main research topics are summarized below:

- Drastic improvement in energy efficiency and lowering the power consumption is necessary.
- Innovative approach to develop new technical architecture which includes artificial intelligence and neural processing unit.
- Efficient development of power amplifier and microcontroller devices supporting highly advanced technology in IoT deployments.
- To minimize the network overload, the critical research on the reduction of bandwidth by IoT devices is to be carried out.
- Integration of real time IoT solutions, Image, Voice, Object, Deep Learning, and proper communication network.
- Next generation IoT can be deployed into Industrial IoT (IIoT), Medical IoT (MIoT) including Tele Surgery.

6. CONCLUSION

In this article, we have discussed the brief overview of 3GPP NB-IoT and its deployment mode. Also, the frame structure of NB-IoT for 15 kHz and 3.75 kHz sub carrier spacing is discussed for narrowband operation. Both this sub carrier spacing are preferred for LPWA application in 5G. The uplink NB-IoT system is designed using UL-DMRS, UL-SCH and NPUSCH and low PAPR modulation scheme of π/4 QPSK since we have considered for single tone transmission. The system is designed considering SISO system which is suitable in NB-IoT system. To estimate the transmitted data successfully, we have used MMSE as a channel estimation technique. We have simulated the system as per 3GPP specifications and BER and FER of the system is analyzed and found that data is transmitted successfully in both the sub carrier spacing. We have considered 15 kHz and 3.75 kHz as a subcarrier spacing because it is the 3GPP specification for NB-IoT system in 5G technology. Furthermore, we have analyzed the throughput of both the sub carrier spacing and it is found to be almost same which signifies the UL-DMRS based uplink system performs well in both the sub carrier and can be suitable in 5G machine type communication.

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