

PROCEEDING

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Co-Host :



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Welcome Message from General Chair

The 11th Comnetsat 2022

(Thursday – Saturday), 03th – 05th November 2022



On behalf of the Organizing Committee, I am very delighted to welcome you all keynote speakers, presenters, and participants to the 11th 2022 IEEE International Conference on Communications, Network, and Satellite (IEEE Comnetsat 2022). IEEE Comnetsat is an annual conference of the IEEE Communications Society (ComSoc) Indonesia Chapter, the IEEE Indonesia Section, and the IEEE AESS/GRSS Indonesia Joint Chapter. This year, IEEE Comnetsat 2022 is organized by Institut Teknologi Telkom Purwokerto (ITTP) and Universitas Semarang (USM).

IEEE Indonesia Section has conducted many activities over 30 years in Indonesia. Regarding collaboration, the IEEE Indonesia section has a good and mutual relationship with ICT organizations, Industries, Governments, Universities, and the Community in Indonesia. We hope other high-quality conferences will be continued and strengthened so that the result will benefit and positively impact human beings, especially Indonesian people.

The core purpose of IEEE is to foster technological innovation and excellence for the benefit of humanity. Here, researchers, scientists, students, and practitioners come together to participate and present their latest research findings, developments, and applications related to the various aspects of the current state of technology and the outcome of ongoing research in the area of Communications, Networks, and Satellite Systems.

Despite the challenges, the IEEE Comnetsat 2022 Organizing Committee and volunteers worked very hard to complete the conference program, uphold the quality of conferences, and meet authors' expectations. IEEE Comnetsat 2022 aims to address the current state of technology and the outcome of ongoing research in the application of computer and communication, networks, satellite systems, broadband photonic systems, data science, and artificial intelligence.

Last but not least, I would also like to express sincere and special thanks to the IEEE Communications Society (ComSoc) Indonesia Chapter, the IEEE Indonesia Section, and the IEEE AESS/GRSS Indonesia Joint Chapter, which have shown great support to this event.

I hope you will benefit from this conference and enjoy networking with colleagues from across the globe for future collaboration globally. Your support will also make this a memorable and successful event.

Wishing you all to join us to make IEEE Comnetsat 2022 a successful and safe event. Thank you.

Sincerely,

Dr. Arfianto Fahmi, S.T., M.T.

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Selanjutnya kepada personil yang ditugaskan agar dapat segera menyampaikan hasil pelaksanaan kegiatan.

Demikian surat tugas ini diberikan untuk dilaksanakan sebaik-baiknya dengan penuh rasa tanggung jawab.

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FER Polar Codes Performances Using 5G Broadband Channel with CP-OFDM Techniques at 2.3 GHz Frequency

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Abstract— The use of high frequencies in the 5G system resulting in the sensitivity of the surrounding environment and attenuation such as human blockage. This study analyzed the performance of frame error rate (FER) based on polar code and without polar code on broadband channels that are affected by human blockage using a frequency of 2.3 GHz, bandwidth of 99 MHz, and the CP-OFDM technique. The purpose of this research is to determine the FER performances using polar codes and without polar codes on 5G network broadband channels that are affected by human blockage which has been validated with outage performances. Broadband channels on the 5G network are presented in a representative Power Delay Profile (PDP) with the influence of human blockage obtained as many as 41 paths with multiple delays of 10 ns on each path. This research was also used the scaling method on representative PDP because it could adjust the use of FFT of 128 blocks and the results of this scaling showed that there are 9 paths with multiple delays of 50 ns. This research evaluates the average FER of 10^{-3} . FER performance without a polar code is affected by human blockage ($R=1$) and required a Signal to Noise (SNR) of 41 dB. However, by using a polar code $R = \frac{1}{2}$ required an SNR of 20.1 dB. The results showed that the utilization of cyclic prefix (CP)-OFDM with channel coding helps the diversity effect of 5G transmissions to be achievable.

Keywords—FER, Polar Codes, Outage Performances, OFDM, 2.3 GHz

I. INTRODUCTION

The COVID-19 pandemic has caused all economy sectors (local and abroad) suffer losses. Despite unfavorable condition, the telecommunications technology sector is actually growing very swiftly and the need for communication is driving the growth of technology,

especially in the field of cellular communications to develop and fulfill the needs of mobile internet services. People now tend to take advantage of internet-based services such as video streaming, video conference and similar services that require a stable connection, large data consumption, and high reliability hence cellular communication services are needed. The internet telecommunications service will be optimized by implementing the 5G cellular network.

The development of cellular technology has now reached the fifth generation (5G), which has been released from 2020. Until now, the research into 5G is still ongoing. The implementation of 5G technology certainly requires good preparation in terms of infrastructure and parameter design based on the broadband channel model [1]. Broadband channels apply an introduction system that has very wide channels so the accommodated capacity is greater than the narrowband channels used in low-speed systems [2]. 5G technology uses a very high spectrum band, which uses frequencies between 1 GHz to 100 GHz [3]. One of the 5G frequencies applied in Indonesia is 2.3 GHz which was used in this research. The 5G system is very sensitive to the environmental change and its surroundings. Factors that affect attenuation of 5G system include temperature, humidity, air pressure, rainfall, and vegetation thickness. Apart from the factor of environment conditions, one factor that is no less important is a human blockage, which is caused by humans blocks nearby the mobile phones and buildings blocks that create shadowing loss within a few hundred milliseconds [4].

Research related to channel modeling of previous 5G networks [5] on human blockage due to crowds or pedestrians around the site showed an impact on the 5G network millimeter wave (mmWave) communication system. That research used electrically controllable and narrow bandwidth antenna arrays. The models presented in our research are valuable for extending the statistical channel model in mmWave to accurately simulate real-world pedestrian

blockages when designing fifth-generation (5G) wireless systems. Research [1] conducted channel modeling on 5G networks using the Statistical Channel Model (SSCM) technique. This study used a bandwidth of 200 MHz and a frequency of 28 GHz and parameters of air pressure of 924.1 mBar, humidity of 77.87% and average temperature of 23.65 °C. Based on the evaluation of the 5G wireless network performance in Indonesia with the environmental parameters of Bandung city, it was found that the 5G channel can be modeled and represented by multipath fading with 18 lanes and delay interval of 10 ns. Research [6] a channel performance on a 5G communication system was influenced by the maximum and minimum temperatures and each city has different environmental data parameter as well as the selection of coding rates to be more efficient. On wireless communication systems it is necessary to take into account many factors and parameters that cannot be ignored. Outage probability is one of them. Several other factors such as interference and transmission capacity are closely related to the outage probability. Outage Probability is one of the parameters to determine the good and bad performance of the network system wireless. Therefore the Outage Probability channel can be used to evaluate the performance of systems wireless.

This research evaluated the 5G network broadband channel at a frequency of 2.3 GHz and a bandwidth of 99 MHz by looking at the effect of human blockage using a channel simulator. The test was carried out using the OFDM numerology concept in the 5G NR standard with a cyclic prefix (CP) size and BPSK modulation. The performance of the broadband channel was done by evaluating the Frame Error Rate (FER) which was validated with outage performance within tested parameters using polar channel coding. This method could correct errors in data transmission so that the reliability of the 5G cellular communication system can increase.

II. RESEARCH METHODOLOGY

A. Broadband Channel

Fig. 1 showed a broadband communication system on the sending and receiving sides which had H as a broadband channel. This research was conducted using channel broadband with human blockage effects. The capacity for broadband channels can be calculated using [7]

$$C \approx B \sum_{n=1}^N \log_2(1 + |\psi_n|^2 \cdot \gamma), \quad (1)$$

B showed bandwidth, γ is signal to noise ratio. The symbol ψ_n represent the eigenvalue of parallel channel.

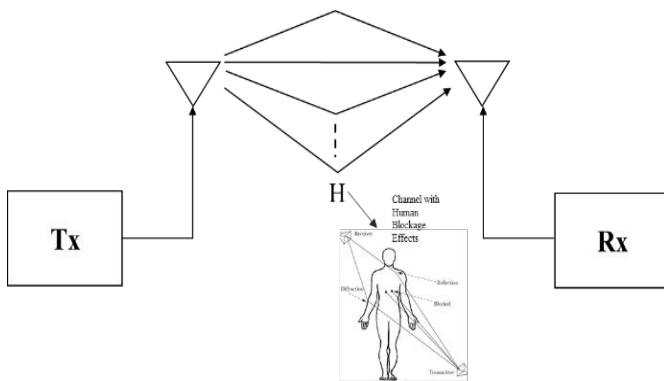


Fig. 1. The 5G Network Broadband Channel With Human Blockage Effects

From this research, the broadband channel would be represented by a PDP representative. PDP representative was the intensity derived from the signal received by the receiver via a multipath channel with a certain delay. PDP representatives in this study were the results of calculations after getting PDP instantaneous [8]. The following are the steps taken in presenting the PDP [9]

1. Rounding off for each PDP with the rounding range around $\Delta T \leq 1/B$, this research used a bandwidth (B) of 99 MHz, therefore $\Delta T \approx 10$ ns.
2. Adding all paths at the same time delay τ for all PDP_{*i*}.
3. Using the Cumulative Distribution Function (CDF) percentile of 90 of all power according to PDP.
4. Using a threshold of -140 dB from a PDP representative. The threshold is assumed to be a 5G NR sensitivity device.
5. Using the scaling method to obtain the required FFTsize (FFT_{ori}) so the obtained paths which meet the CP length requirements must be greater than or equal to the original total path ($Q \geq \sum \text{Path}_{ori}$). This research was using an FFTsize of 128, the scaling method is calculated by (2)

$$\begin{aligned} \sum \text{Path}_{\text{modif}} &= \frac{\text{FFT}_{\text{modif}}}{\text{FFT}_{\text{real}}} \cdot \text{PDP}_{\text{real}} \quad (2) \\ &= \frac{128}{570} \cdot 41 \\ &= 9.20 \approx 9 \text{ path} \end{aligned}$$

6. Normalize the path to get the final PDP or PDP representative.

The data needed to get a broadband channel on the 5G network were environmental data in the form of rainfall, air pressure, temperature and humidity in the city of Yogyakarta. This environmental data is obtained from the Meteorology, Climatology and Geophysics Agency (BMKG) as input parameters on the simulator channel. This study was used a frequency of 2.3 GHz with a bandwidth of 99 MHz, the distance between the transmitter and receiver was 100 meters and a broadband channel which affected by human blockage for 5G cellular communication in the Yogyakarta area. Environmental data taken from January-May which has been obtained from BMKG will be input to the simulator by taking the average value of each environmental parameter. Table 1 shows the environmental data parameters of the city of Yogyakarta, Indonesia.

TABLE 1. INPUT PARAMETERS AT CHANNEL SIMULATOR

Channel Parameters	Value
Frequency (GHz)	2,3 GHz
Radio Frequency (RF) Bandwidth	99 MHz
Scenario	Urban Microcell (UMi)
Environment	Non Line of Sight (NLOS)
Tx Power	30 dBm
Tx-Rx Separation Distance Lower dan Upper Bound	100 meter
Air pressure	990,1 mbar
Humidity	82,5 %

Temperature	26,5°C
Rain Rate	10,08 mm/hr
Polarization	Co-Pol (Co-Polarization)
Foliage Loss	-
Distance Within Foliage	0 m
Foliage Attenuation	0,4 dB/m
Number of Rx Location	1000

B. Orthogonal Frequency Division Multiplexing (OFDM)

OFDM has a correlation between sub-channels that did not interfere with each other. Each data was sent with CP to avoid inter-symbol interference (ISI) and inter-channel interference (ICI) [4]. The application of 5G NR access radio technology has the option of a frequency category below 6 GHz, so a different service support was needed. OFDM could not meet the needs of the performance of all implemented frequency ranges so that the OFDM numerology was needed for 5G radio access technology (RAT) issued by 3GPP which was shown in Table 2. This study was using OFDM numerology 1 and FFT size of 128.

TABLE 2. OFDM NUMEROLOGY USED IN 5G TECHNOLOGY

Parameters/Numerology (μ)	0	1	2	3	4
Subcarrier Spacing (KHz)	15	30	60	120	240
OFDM Symbol Duration (μ s)	66.67	33.33	16.67	8.33	4.17
Cyclic Prefix Duration (μ s)	4.69	2.34	1.17	0.57	0.29
OFDM Symbol incl. CP (μ s)	71.35	35.68	17.84	8.92	4.46
Bandwidth minimum (MHz)	4.32	8.64	17.28	34.56	69.12
Bandwidth minimum (MHz)	49.5	99	198	396	397.44

C. Complex- Binary Phase Shift Keying

This research was C-BPSK modulation. C-BPSK modulation produces symbols with complex values (real and imaginary). In C-BPSK modulation, bits of information $b(i)$ are mapped into a complex value modulation symbol which can be expressed as [10]

$$x = \frac{1}{\sqrt{2}} [(1 - 2b(i)) + j(1 - 2b(i))]. \quad (3)$$

D. Polar Codes

Polar Codes were classified as linear block codes based on a phenomenon known as channel polarization. Polar codes were first known to be capable of reaching Shannon capacity for Binary Discrete Memoryless Channel (BDMC) input [11]. Fig. 2. shows the structure of polar codes if it has a block length of 2 bits U_0, U_1 . It is the bit sent which will be operated with $X \oplus R$ and produce output bit X_0, X_1 . [12]

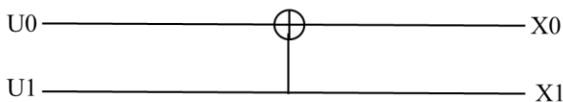


Fig. 2. Polar Code Structure with Block Length is Two

E. Outage Performances

The outage probability (P_{out}) is expressed as

$$P_{out} = \Pr(R > C), \quad (4)$$

\Pr means probability, R is rate, and C is capacity. The outage probability indicating when C is dropped under channel coding rate R . Thus, if $R \leq C$, the transmission considered a success with error close to zero. Unfortunately, Shannon's theorem was not a constructive proof, it merely states that such a coding method exists [13].

F. Frame Error Rate (FER)

FER analysis using polar codes and CP-OFDM system can be calculated as

$$FER = \frac{\sum Fe}{\sum Ft} \quad (5)$$

where Fe is total of error frame in receive and Ft is total of transmitted frame.

III. RESULT AND ANALYSIS

A. 5G Broadband Channel

The results of the data from the simulation with 1000 receivers on the channel simulator obtained instantaneous PDP1 to PDP1000 with scenarios influenced by human blockage. Fig. 3. shows the x axis represents delay in units of ns and the y axis states receive power in units of dB. This study obtained a PDP representative of 41 paths on channel which was affected by human blockage. Each path has a delay of 10 ns as shown in Fig. 3.

On OFDM, the number of paths must be less than or equal to the length of CP. For OFDM numerology 1, the CP length was $Q \approx 9$. Because the number of paths more than Q , it was necessary to scale method with an interval of 50 ns by reducing the number of paths. Fig. 4. shows the PDP scaling results into a number of 9 paths. The delay in PDP scaling each path has a multiple of 50 ns.

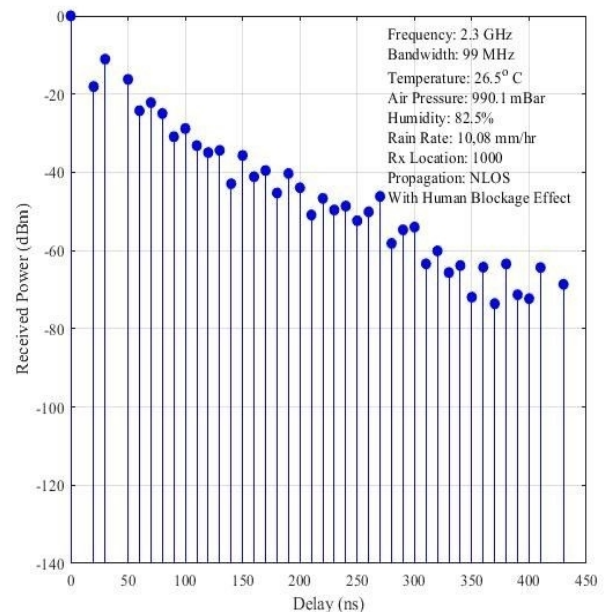


Fig. 3. Representative PDP Using 5G Network Broadband Channel

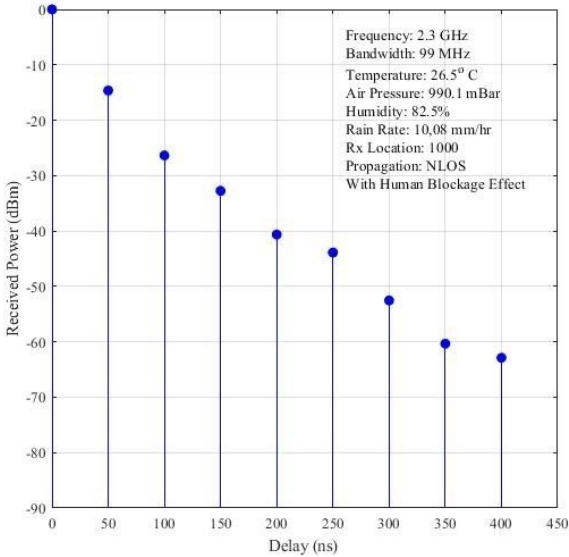


Fig. 4. Modified PDP Using 5G Network Broadband Channel

B. Outage Performances

This research aims to evaluate the performances of broadband channel in terms of outage performances. As shown in Fig.5, this research was compared theoretical outage with FER based on the simulation. The outage performances of 5G broadband channel was obtained by taking value on a particular R for each SNR. The theoretical outage was a benchmark for possible outage performance regarding the Shannon capacity calculation.

The outage probability of 10^{-3} from 5G system can be achieved with SNR of 19.9 dB on $R = 1$ and SNR of 18.4 dB on $R = 1/2$. The SNR gab between outage probability of 10^{-3} is 1.5 dB. These outage performance and SNR value are to be a theoretical for validation FER.

C. FER Performances

To evaluate the validity of theoretical outage performance 5G broadband channel, obtained directly from the PDP, this research evaluated the FER using CP-OFDM with numerology 1, modulated by C-BPSK and coding rate =

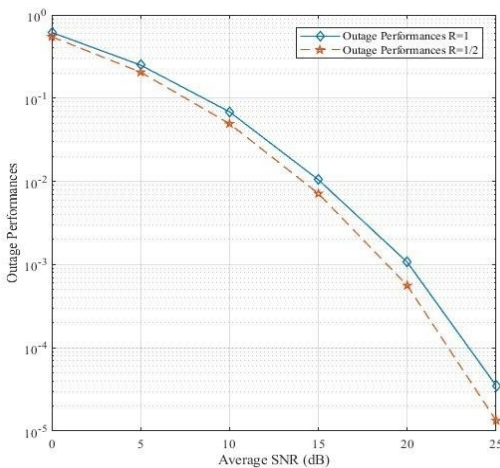


Fig. 5. Outage Performances R=1 and R=1/2

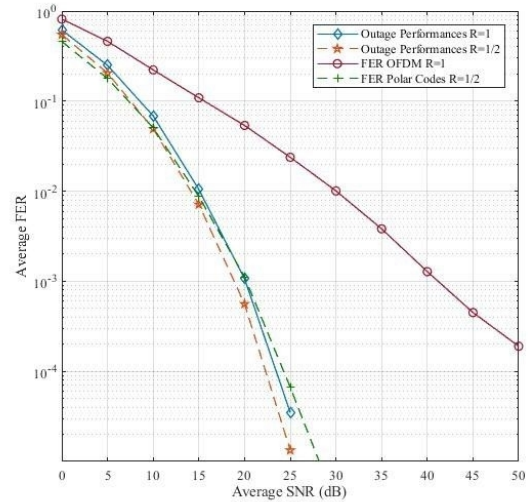


Fig.6. FER Performances Using Polar Codes and Uncoded

$\{1, 1/2\}$. The considered channel coding scheme are polar codes.

This research evaluated the FER performances of the 5G with polar codes and showed rate of $R = 1/2$. Uncoded CP-OFDM performances was also shown as a baseline comparison. The diversity effect could be captured using channel coding. This research found that slopes for FER of polar codes was closer to the slope of theoretical performances due to better error correcting capability of the polar codes.

Fig.6. shows the FER of 10^{-3} is achieved at SNR of 20.1 dB for polar codes and SNR of 41 dB for un-coded CP-OFDM. The SNR gab between FER of 10^{-3} is 20.9 dB. Stronger coding should be utilized to confirm the validity of the theoretical outage performances.

IV. CONCLUSION

This research evaluated broadband channels on 5G networks to see their effect on human blockage by using polar codes $R = 1/2$ and un-coded $R = 1$. The broadband channel showed an average FER of 10^{-3} with SNR of 20.1 dB for polar codes and SNR of 41 dB for un-coded CP-OFDM. The SNR gab between FER of 10^{-3} is 20.9 dB. However, the polar codes has better error of correcting capability indicated by closer performances to the theoretical outage.

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